South Carolina Electric & Gas Company

Application for Approval to Incinerate Oii Contaminated with Very Low Levels of Licensed Radioactive Material

V. C. SUMMER NUCLEAR STATION
SOUTH CAROLINA ELECTRIC AND GAS COMPANY

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1.0 Introduction

Pursuant to 10CFR20, Sections 20.305 and 20.302(a), South Carolina Electric & Gas Company (SCE&G) requests approval to incinerate oil contaminated with very low levels of licensed radioactive materials. Incineration of oil is a proven disposal technology which has been Commission approved for use by several nuclear power plant licensees with inconsequential radiological impact on the health and safety of the public. Other disposal options for waste oil are currently limited to solidification and burial at a licensed near surface land disposal site or incineration at a licensed commercial incinerator facility. While both of the latter disposal options involve inordinate costs, shallow land burial would also represent inefficient use of the limited burial ground space.

Onsite incineration represents the most cost effective disposal alternative and would reduce the risk from toxic and fire hazards associated with storage as well as risk associated with transportation to licensed disposal facilities. Additionally, the Environmental Assessment presented in Appendix A of the Proposed Amendment to 10CFR 20.305 "Disposal of Waste Oil by Incineration" (53 FR 32917) states that incineration of oil in industrial boilers has been the EPA's preferred method of disposal of used oil based on nonradiological considerations and concludes that onsite incineration would not result in significant radiological effects on the quality of the human environment. Therefore, onsite incineration of slightly contaminated

waste oil represents the most economical and safe (both radiologically and non-radiologically) method of disposal currently available.

This application addresses the specific information required by 10CFR 20, Section 20.302(a) as related to the alternate disposal of licensed byproduct material. This application also addresses conformance with the new National Emission Standard for Hazardous Air Pollutants (NESHAP) for radionuclide emissions from NRC licensed facilities (40CFR 61, Subpart I) as announced by the EPA on November 1, 1989 (Docket No. A-70-11). Even though this new rule has not been published in the Federal Register and the EPA has announced a 90 day stay to reconsider the application of the standard in Subpart I to NRC licensees, the analysis presented in this application demonstrates that this proposed disposal method would not require prior approval by the EPA based on the exemption criteria in section 61.106 of the new rule.

2.0 Waste Stream Description

Since initial start-up, V. C. Summer Nuclear Station (VCSNS) has generated approximately 2000 gallons of spent lubricating oil which is slightly contaminated with radioactive material. The current generation rate of contaminated oil is about 100 gallons per month. Two primary sources of contaminated oil have been identified at VCSNS: the reactor coolant pump (RCP) motor oil and oil skimmed from the turbine building surge basin. Oil from the RCP motors becomes contaminated because the oil reservoirs are exposed to the containment atmosphere through a breather line. Generally, oil from one RCP motor is changed during each refueling outage and results in about 250 gallons per year. Oil from the turbine building surge basin becomes slightly contaminated due to small amounts of primary-to-secondary leakage which have occurred at VCSNS. Oil is introduced into the surge basin via the turbine building sump due to incidental leakage from various motors and pumps located in the turbine and auxiliary buildings.

Radionuclides identified in waste oil generated to date include Co-58, Co-60, Cs-134, Cs-137, Mn-54, and Fe-55. Typical concentrations of these radionuclides are presented in Table 1 below.

Table 1

Typical Isotopic Concentrations in Oil

Nuclide	Concentration (uCi/ml)
Co-58	1.00E-7
Co-60	1.90E-7
Cs-134	2.59E-8
Cs-137	4.51E-8
Mn-54	1.73E-8
Fe-55	1.91E-7

2.1 Physical Properties of the Waste Oil

The waste stream is composed of spent lubricating oils with viscosities ranging from SAE 10 to SAE 50 weight and densities ranging from 53 to 55 pounds per cubic foot. Solids will be typically less than 10% by volume. Additionally, the candidate waste oil will not exhibit any of the characteristics of hazardous waste identified in Subpart C of 40CFR 261, "Characteristics of Hazardous Waste".

2.2 Sampling and Analysis of Oil

The process for incineration will require oil analyses to determine the presence of radionuclides listed in 10CFR 61.55, Table 1 and Table 2. Even though 10CFR 61 pertains only to land disposal of radioactive waste, Table 1 and Table 2 provide a complete listing of radionuclides that must be considered for the protection of the general population. The lower limit of detection (LLD) for direct measurement of 10CFR 61.55 radionuclides will be consistent with the guidance provided in "Technical Position on Radioactive Waste Classification" Revision 0, May 1983 issued by the Nuclear Regulatory Commission Low-Level Waste Licensing Branch of the Division of Waste Management (BTP). As stated in the BTP, the LLDs will be no more than 0.01 times the concentration for that radionuclide listed in Table 1, and 0.01 times the smallest concentration for that radionuclide listed in Table 2. For this application, the definition of lower limit of detection is consistent with the definition provided by U. S. Nuclear Regulatory Commission, "Radiological Effluent Technical Specifications for PWR's", NUREG-0472 (as revised), July 1979. An inferential measurement program will be implemented whereby concentrations

of radioisotopes which cannot be readily measured will be ratioed in a manner consistent with the BTP criteria. All radionuclides detected by direct measurement as well as inferred radionuclides will be considered to determine the acceptability of oil for incineration.

Prior to incineration representative samples of candidate oil will be obtained by methods described in ASTM D 4057-81, Volume 05.03, "Standard Practice for Manual Sampling of Petroleum and Petroleum Products".

3.0 Description of the Proposed Disposal Method

The proposed disposal method involves incineration in a dual chamber incinerator. Waste oil is collected in tanks and locations in accordance with applicable Health Physics, Industrial Safety, and Fire Protection Procedures and South Carolina Department of Health and Environmental Control (SCDHEC) requirements. An incinerator permit will be obtained from the SCDHEC Bureau of Air Quality Control prior to operation.

A feed tank will be utilized for injecting waste oil into the incinerator. Oil may be collected in a feed tank or transferred to a feed tank from other collection tanks. Prior to incineration, the feed tank will be isolated from any further collection of oil or licensed materials and representative samples will be obtained as described in section 2.2. The feed tank will then be transported to the incineration facility provided the oil is acceptable for incineration. Onsite gamma spectral analysis will be performed on the samples and the results input into the inferential measurement program to determine the isotopes present and assure acceptability of the oil for incineration as described in section 3.3.

The incinerator will typically be operated eight hours or more per day at a rate of ten gallons per hour until the contents of the feed tank are consumed. All transportation and incineration will be accomplished within the licensee owned and controlled area and will be in accordance with all applicable station Health Physics, Industrial Safety, and Fire Protection procedures and SCDHEC requirements. Ash from the incinerator will be handled as dry active waste (DAW) and will be disposed in accordance with 10CFR 20.301 requirements at a NRC licensed facility.

3.1 Description of Incinerator

The incinerator is comprised of two chambers; the lower chamber is approximately 30 cubic feet in volume and the upper chamber is 20 cubic feet. The lower chamber is designed to operate at 1400°F and the upper chamber at 1800°F. Residence time of exhaust gases in the upper chamber will be a minimum of one second which will assure acceptable opacity of stack emissions. Both chambers are fired with #2 fuel oil with automatic temperature controls and safety shut down interlocks if the system runs out of fuel oil. Waste oil will be atomized, prior to burning, with 100 PSI to 250 PSI air. The control design for the upper and lower chambers also include safety interlocks with less than 100 PSI of atomizing air pressure or loss of waste oil feed.

3.2 Incineration Facility Location

The proposed incineration facility is situated approximately 2500 feet south-west of the VCSNS Reactor Building and is contained within the Site Area Boundary, Exclusion Area and Plant Property Line. Figure 1 illustrates the location of the facility with respect to the generating station. The natural topography surrounding the area has an elevation range between 250 and 450 feet above mean sea level (MSL). The elevation of the proposed facility is about 450 feet above MSL.

The incinerator will be located within a cinder block building with outside dimensions of 16 feet by 13 feet. The roof of the building is approximately 17 feet above grade. The floor of the building is concrete which will be sealed for ease of maintenance. Auxiliary fuel and waste feed tanks will include secondary containment features and be located outside the building

1

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

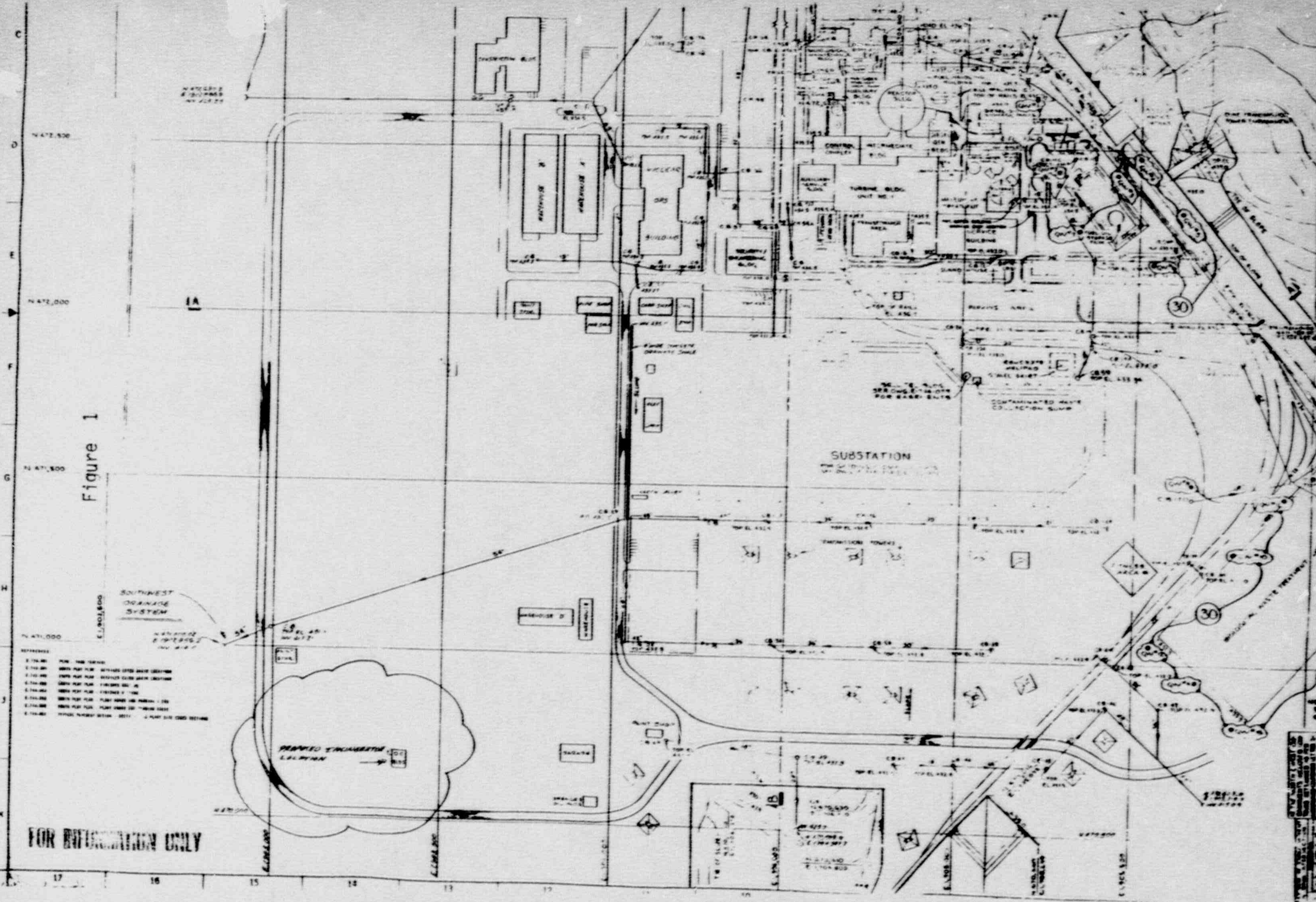

SUBSTATION
CONTAMINATED WASTE
COLLECTION SUMP
SOUTHWEST
DRAINAGE
SYSTEM
PARKING AREA
TRANSMISSION TOWERS
FOR INFORMATION ONLY

Figure 1

for additional safety. Supply lines from tanks to the incinerator will be double walled with safety shut off valves at either end. The building will have dikes at each entrance for additional spill protection.

3.3 Administrative Controls

Prior to incineration, each feed tank will be sampled and analyzed to ensure conformance with the limits presented in Attachment 1 of this request. These results and other pertinent data will be documented and retained by the licensee and made available for review and audit upon request. As stated in Section 2.0, the generation/disposal rate is not expected to exceed 100 gallons per month, however, this does not imply an annual volume limit for disposal. The volume of oil incinerated will be limited by the allowable quantities of radioactivity in oil as derived in Attachment 1 of this request. Similarly, as stated in Section 3.2, the typical burn rate is 10 gallons per hour, however, the actual burn rate will be limited by 1 percent of VCSNS Technical Specification 3.11.2.1 as derived in Attachment 1 of this request (i.e. as specific activity of the oil decreases, the burn rate may be increased). The incinerator is expected to be utilized for oil disposal for the full operational life of VCSNS.

The basis for the limits presented in Attachment 1 include the assumption that the total quantity of radionuclides identified in oil will be released to the atmosphere during incineration. This is a conservative approach since a significant portion of the radioactivity will be retained in the ash residue. This assumption combined with the extremely low quantities of radioactivity allowed in oil prepared for incineration eliminates the need for sampling, filtering and/or monitoring of actual stack emissions.

The limits presented in Attachment 1 will ensure the resulting annual dose to the maximum exposed individual in the public from oil incineration does not exceed a whole body dose of 0.1 mrem or 0.15 mrem to any organ. In addition, these controls shall ensure the dose rate at the site boundary due to oil incineration is maintained less than 1% of the limits specified in VCSNS Technical Specification 3.11.2.1. The low levels of licensed materials involved in the oil incineration process should negate the need for personnel monitoring of occupational radiation exposure and the posting and labeling requirements of 10CFR 20.203(e) and (f). Radiation levels in the incineration facility and from storage tanks are not expected to exceed the limits for permissible levels of radiation in unrestricted areas as defined by 10CFR 20.105. The level of radioactivity in oil should be well below the exemption criteria for labeling as defined by 10CFR 20.203 (f) (3). However, the incinerator access doors for ash removal will be labeled for containing radioactive material since concentration of the radioactivity due to incineration may produce quantities of radioactivity greater than the values listed in 10CFR 20, Appendix C. Removal and disposal of ash residue will be conducted in accordance with Health Physics procedures currently used at the V. C. Summer Nuclear Station. Routine surveys will be performed in accordance with 10CFR 20.201 to verify that additional controls are not required. Additional controls will be established as necessary to ensure compliance with 10CFR 20 based on routine survey results.

Access control to the incinerator facility and oil storage tanks will be established to prevent unauthorized removal of licensed materials as required by 10CFR 20.207. In addition, the soil and grounds in the immediate

vicinity of the incinerator facility will be surveyed to detect any concentration effect of radioactivity in the soil due to deposition from the incinerator exhaust. Corrective actions will be taken as necessary upon identification of any adverse trends. The frequency and extent of these surveys will be established based on the potential for radiation hazards to be present and may be adjusted as experience is gained from the incineration process.

The low levels of licensed material and resultant doses negates the need for inclusion of these emissions in the Semiannual Radioactive Effluent Release Report required by VCSNS Technical Specification 6.9.1.8 and negates the need for considering the impact of oil incineration on the instantaneous dose rate limits of VCSNS Technical Specification 3.11.2.1. Therefore, revision to the VCSNS Offsite Dose Calculation Manual (ODCM) should not be necessary for allowing disposal of contaminated oil by incineration.

4.0 Evaluation of the Radiological Impacts of Waste Disposal

To evaluate the radiological impacts of a waste disposal method, a target dose is established below which the radiological impacts may be considered negligible. For purposes of this application, a value of 0.1 mRem/yr to the total body of the maximum exposed individual and 0.15 mRem/yr to the maximum exposed organ have been chosen because these values represent a small fraction (one percent) of annual releases defined under 10CFR50 Appendix I as being As Low As Reasonably Achievable (ALARA).

Several values have been suggested by various agencies as being doses which represent negligible risk and are therefore referred to as "de minimus dose". A value of 1 mRem/yr to the maximum exposed individual has been justified in some detail in IAEA-TECDOC-282 "De Minimis Concepts in Radioactive Waste Disposal" issued by the International Atomic Energy Agency, Vienna, 1983. Thus, choosing a value ten times lower than that recommended by IAEA will assure that the radiological impacts of the proposed alternate disposal method are negligible.

4.1 Identification of Potential Pathways

Evaluation of the potential exposure pathways generates a long list of exposure scenarios. Using the guidance of NUREG-0133, "Preparation of Radiological Effluent Technical Specification for Nuclear Power Plants", October, 1978, many of the pathways may be eliminated. The decision making process for pathway analysis resulting from atmospheric releases of radioactive materials in particulate form is discussed in the VCSNS Offsite Dose Calculation Manual Revision 12, September 1987 (ODCM) and controlling

pathways for atmospheric releases are presented in Section 2.2.2.b and Table 2.2-2 of the ODCM. Guidance provided in IAEA-TECDOC-282 states that individual dose rates below 1 mRem/yr are low enough such that no significant population doses are likely. Therefore, only individual exposure pathways are considered in this application. Doses will be calculated for the maximum exposed individual outside the site boundary using methodology described by the VCSNS ODCM, Section 2.2.2.b.

The ODCM in Section 2.2.2.b provides methodology for calculating maximum organ dose to an individual from atmospheric release of radioactive materials in particulate form. Atmospheric dispersion and deposition parameters ($\overline{X/Q}'$ and $\overline{D/Q}'$ respectively) are provided for the controlling receptors, locations, and pathways as explained in Tables 2.2-7 and 2.2-8 of the ODCM. It should be noted that the location of the incinerator stack is approximately 2500 feet (750 meters) in the South West direction from the main plant vent. Therefore, an evaluation was performed to determine appropriate $\overline{X/Q}'$ and $\overline{D/Q}'$ values to use for the actual incinerator location. The distance of each critical receptor with respect to the proposed incinerator location was determined and $\overline{X/Q}'$ and $\overline{D/Q}'$ values for each location were calculated by interpolation of Tables 6.10-10 and 6.1-14 contained in the Operating License Environmental Report (OLER). A comparison was then made between the $\overline{X/Q}'$ and $\overline{D/Q}'$ values for the incinerator location and the main plant vent. For the controlling receptor and pathways, the $\overline{X/Q}'$ and $\overline{D/Q}'$ values given in the ODCM for the main plant vent were higher than those calculated for the incinerator location due to the fact that the controlling

receptor did not change but the distance from the release point increased from 1.1 to 1.3 miles. Therefore, the more conservative ODCM values are used for dose calculations in this application. The annual land use census is performed to verify the receptor location. When the land use census indicates significant changes to receptor location, dispersion and deposition parameters will be adjusted as necessary.

As indicated in Table 2.2-2 of the VCSNS ODCM, the controlling receptor is a child eating vegetables from a garden located 1.1 miles (1,800 meters) from the main plant vent in the East-South-East Sector. The limiting pathways for this receptor include inhalation of airborne particulates, direct radiation from ground plane deposition, and ingestion of particulates deposited on leafy vegetables. All three of these pathways are additive and maximum annual organ and total body doses are calculated by methodology described in Attachment I of this request.

4.2 Dose Evaluation

For purposes of this request, the total quantity of activity potentially released to the atmosphere from incineration of contaminated oil each year was calculated such that the target doses discussed in Section 4.0 would not be exceeded. With the exception of Co-60, the organ dose criteria is most limiting. The allowable quantity of Co-60 which may be released was based on limiting the total body dose to 0.1 mRem/year (Attachment I). Since most of the waste oil contains multiple isotopes, compliance with the dose criteria will be demonstrated by maintaining a calendar year inventory for each isotope. Prior to each burn, calculations will be performed to assure

off-site doses will not exceed the criteria specified. Actual quantities of each isotope released, Q_{ia}, will be compared with the allowable quantity, $\tilde{Q}'_{io}$ (Attachment 1), and the fraction of actual release compared to the allowable release for each isotope, i, will be summed. The sum of the fractions must equal less than one before incineration is permitted.

Specifically, incineration will be permitted provided the following condition is met:

$$\sum_i \frac{Q_{ia}}{\tilde{Q}'_{io}} < 1$$

In addition to the annual dose criteria, the instantaneous dose rate criteria at the plant boundary (i.e. 1 percent of VCSNS Technical Specification 3.11.2.1 and 10CFR 20 Appendix B, Table II, Col 1 concentrations) will be satisfied by limiting the specific activity of the candidate oil and the burn rate as necessary (see Attachment 1). The maximum instantaneous release rate will be limited to 9.0×10^{-2} uCi/sec.

4.3 Summary of Limiting Conditions

As a result of the exposure pathway analysis and subsequent dose calculations, the following limiting conditions are imposed:

A. An annual running inventory will be maintained and the total quantities of all isotopes, i, released will be such that in a calendar year the following condition will be satisfied,

$$\sum_i \frac{Q_{ia}}{\tilde{Q}'_{io}} < 1$$

B. Burn rate and specific activity of the oil will be controlled to assure the instantaneous release rate does not exceed 9.0 X 10^{-2} uCi/sec.

C. Annual land use census will be performed, per technical specifications, to verify appropriately conservative X/Q, $\overline{X/Q}'$, and $\overline{D/Q}'$ parameters are used.

D. If isotopes not identified in this application are detected in candidate oil, an evaluation will be performed and documented to assure that doses from these isotopes are accounted for and the dose and dose rate criteria given in Section 3.3 are not exceeded.

E. Disposal activities will be conducted according to applicable station Health Physics procedures as discussed in Section 3.3.

F. Residual ash will be disposed of as dry active waste in accordance with 10CFR 20.301 and applicable disposal site criteria.

4.4 Comparison of Radionuclide Emissions to 40CFR 61, Subpart I

On November 1, 1989, the Environmental Protection Agency (EPA) announced the National Emission Standard for Hazardous Air Pollutants (NESHAP) under Section 112 of the Clean Air Act for licensees of the Nuclear Regulatory Commission. Although the EPA has announced a 90 day stay to reconsider the application of the standard to NRC licensees, an analysis was performed using methods described in 40CFR 61.103 to determine eligibility for exemption from prior approval by the EPA based on criteria delineated in Section 61.106 of the new standard.

Demonstration of compliance with the exemption criteria has been determined by utilization of the COMPLY computer code supplied by the EPA (EPA/520/1-89-003, January 1989). For each radionuclide, the $\tilde{Q}_o'$ (total allowable quantity derived in Attachment 1) value was input together with appropriate building and stack heights, source to receptor distance, mean wind speed, and pathway information.

The input parameters and results are as follows:

- Release height 7 meters.
- Building height 5 meters.
- The source and receptor are not on the same building.
- Distance from the source to the receptor is 2092 meters.
- Building width is 6 meters.
- Default mean wind speed not used. Mean wind speed is 3.34 m/sec.
- He produces his own VEGETABLES at home.
- Distance from the SOURCE to the FARM producing MILK is 5000 meters.
- Distance from the SOURCE to the FARM producing MEAT is 5000 meters.

Nuclide	Release ($\tilde{Q}_o'$) Curies/Year	Whole Body Dose (mrem/Year)
Co-58	0.5060	4.1E-2
Co-60	0.0142	5.1E-2
Cs-134	0.0163	2.6E-2
Cs-137	0.0156	5.7E-2
Mn-54	0.2080	4.9E-2
Fe-55	0.6780	3.5E-3

For each nuclide the whole body dose is less than 0.1 mrem. Therefore, when the summation criteria in Section 4.3.A is met, the total doses from all radionuclide releases will remain less than 0.1 mrem per year.

Section 61.106, "Applications to Construct or Modify", states the following:

(b) An application under 61.107 does not need to be filed for any new construction of or modification within an existing facility if one of the following conditions is met:

(1) The effective dose equivalent calculated by using methods described in 61.103, that is caused by all emissions from the facility including those potentially emitted by the proposed new construction or modification, is less than 10% of the standard prescribed in 61.102.

(2) The effective dose equivalent calculated by using methods described in 61.103, that is caused by all emissions from the new construction or modification, is less than 1% of the limit prescribed in 61.102. A facility is eligible for this exemption only if the facility, based on its last annual report, is in compliance with this subpart.

The limit stated in 61.102 is 10 mrem per year. Therefore, a construction or modification application would not be required, under (2) above, as long as the total dose equivalent caused by all emissions from the facility remain below 10 mrem per year and the

dose equivalent caused by emissions from the incinerator remain less than 0.1 mrem per year. Administrative controls placed on VCSNS by Technical Specification 3.11.2.2, 3.11.2.3 and release criteria for incinerator operation given in Section 4.3 will assure compliance with the EPA exemption conditions in section 61.106.

5.0 Environmental Impact Assessment

5.1 Geology and Water Usage

Operation of the proposed oil incinerator should have no significant regional or local environmental impacts. Since the disposal method involves atmospheric releases, the geology and water usage of the region will not be impacted. The small quantities of dry waste generated will be insignificant when compared to the total quantities of dry active waste routinely generated at VCSNS. For additional information on geology and water usage, refer to Sections 2.4 and 2.5 of the VCSNS FSAR.

5.2 Meteorology

The meteorology of the region (average wind speeds and directions and atmospheric stability) is constantly monitored as part of the environmental monitoring program. Any significant changes identified will be documented and an evaluation will be performed to assure the controlling receptors and pathways are appropriately selected. Therefore, the local meteorology will have no significant adverse impact on the proposed method of disposal. For additional information regarding meteorology, refer to Section 2.3 of the VCSNS FSAR.

5.3 Nearby Facilities and Communities

The proposed disposal site is located on licensee owned and controlled property, within the Exclusion Area for the VCSNS and about one half mile southwest of the VCSNS Reactor Building. It is located about one half mile south of the Monticello Impoundment, 1

mile south east of Fairfield Pumped Storage Facility and 1 mile east of the Broad River and Parr Hydro and Steam Plant. There are no other large industrial facilities located within 5 miles of the proposed disposal site (see Figure 2).

The only significant transportation facilities located nearby are South Carolina Highways 213 and 215 and the Southern Railways Parr-Blair corridor.

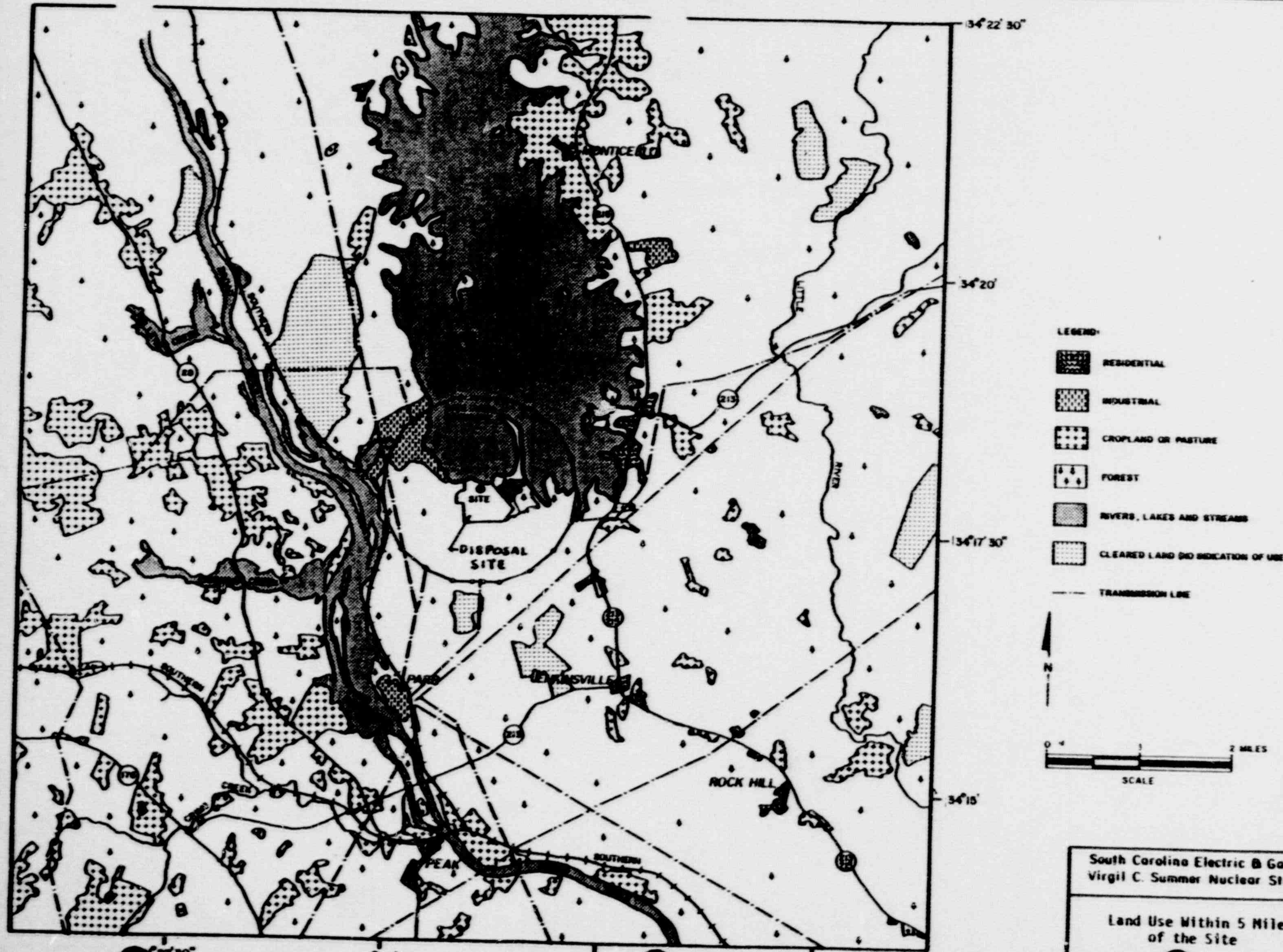
Communities near the proposed incinerator facility site are Jenkinsville (2 miles east southeast), Monticello (5 miles north northwest), Peak (3 miles south) and Pomaria (5 miles west).

The proposed incinerator will have no significant impact on these facilities or communities, nor will they impact the proposed method of disposal.

For more information regarding nearby facilities and communities, refer to Section 2.1 and 2.2 of the VCSNS FSAR.

5.4 Conclusion

The proposed activity represents the preferred method of disposal of used oil and will result in negligible radiological impacts on flora, fauna and man. Also, incineration of oil would result in the more appropriate usage of established low level waste facility resources. Therefore, a finding of no significant environmental impact is appropriate.



South Carolina Electric & Gas Co.
Virgil C. Summer Nuclear Station

Land Use Within 5 Miles
of the Site

Fig[illegible]2

ATTACHMENT 1

DOSE CALCULATIONS FOR OIL INCINERATION

1.0 Discussion

Administrative controls will be established to ensure the resulting annual dose to the maximum exposed individual in the public from oil incineration does not exceed a whole body dose of 0.1 mrem or 0.15 mrem to any organ. In addition, these controls shall ensure the dose rate in unrestricted areas due to oil incineration is maintained less than 1% of the limits specified in VCSNS Technical Specification 3.11.2.1.

2.0 Administrative Limits

2.1 Annual Dose

The total quantity of radioactivity in incinerated oil will be limited to ensure compliance with the above dose limits. Table 2.0-1 lists the quantity of each radionuclide that, if released during incineration, results in either a whole body dose of 0.1 mrem or an organ dose of 0.15 mrem, whichever is most limiting. Since more than one radionuclide is normally present, the total quantity of radioactivity in incinerated oil will be limited by summing the ratios of the quantity of each radionuclide present in incinerated oil to the applicable value for each radionuclide presented in Table 2.0-1. This summation shall not be allowed to exceed 1.0 during any calendar year. The radionuclides listed in Table 2.0-1 are those normally present above LLD values in contaminated oil. In the event that other radionuclides are identified during future operations, station procedures will be revised to incorporate the value for each radionuclide using the same methodology as described in this attachment.

2.2 Instantaneous Dose Rate

The release rate of gross radioactivity during oil incineration shall be limited to 9.0 X 10-2 uCi/sec. This limit shall be procedurally controlled by adjusting the burn rate based on the concentration of radioactive material present in the oil.

TABLE 2.0-1

ALLOWABLE RELEASE QUANTITIES OF RADIONUCLIDES IN OIL

Nuclide	~/ Q_{io}, uCi
Co-58	5.06E5
Co-60	1.42E4
Cs-134	1.63E4
Cs-137	1.56E4
Mn-54	2.08E5
Fe-55	6.78E5

Quantities of radionuclides released during a calendar year shall be limited by:

$$\sum_i \frac{Q_{ia}}{\tilde{Q}_{io}} < 1.0$$

where Q_{ia} = total quantity of radionuclide i released during the calendar year

3.0 Derivation of Administrative Limits

3.1 References

3.1.1 Regulatory Guide 1,109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR 50, Appendix I, Rev. 1 October 1977.

3.1.2 Offsite Dose Calculation Manual (ODCM) for South Carolina Electric & Gas Company, V. C. Summer Nuclear Station Rev. 12, September 1987.

3.1.3 NUREG-0133, Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants, October, 1978.

3.2 Assumptions

3.2.1 Oil is burned at a rate of 10 gallons per hour.

3.2.2 All activity in the oil is released to atmosphere during incineration.

3.2.3 Dose to the maximum exposed individual will be calculated using methodology described in ODCM Sec. 2.2.2.b.

3.2.4 Organ doses will be calculated using the limiting pathways and dose conversion factors shown in Table 2.2-2 of the ODCM.

3.2.5 Total body doses will be calculated for the pathways shown in Table 2.2-2 of the ODCM using dose conversion factors derived by methodology described in Section 5.3.1.1 (Inhalation) and 5.3.1.5 (Vegetation) of Ref. 3.1.3.

3.2.6 Ground plane dose factors given in Table 2.2-2 (ODCM) are for total body.

3.2.7 $(BR)_a$ = The breathing rate of the receptor of age group (a), in m^3/yr (Table E-5, Ref. 3.1.1).

3.2.8 $(DFA_i)_a$ = The total body inhalation dose factor for the receptor of age group (a) for the i^{th} radionuclide, in mrem/pCi (Table E-10, Ref. 3.1.1).

3.3 Organ Dose

Maximum organ doses are calculated pursuant to Section 2.2.2.b of Ref. 3.1.2.

Dp = Maximum organ dose to an individual from radionuclides in particulate form, with half lives greater than eight days (mrem).

$$= 3.17 \times 10^{-8} \sum_{ij} R_{ij} W'_{ij} \tilde{Q}'_i \qquad \text{(eq. 1)}$$

where:

W_{ij}' = Relative concentration or relative deposition for the maximum exposed individual, as appropriate for exposure pathway j and radionuclide i.

= $\frac{\bar{X}'}{\bar{Q}}$ for inhalation pathway = 2.2×10^{-6} sec/m^3 = relative concentration for the location occupied by the maximum exposed individual.

= $\frac{\bar{D}'}{\bar{Q}}$ for inhalation pathways = 8.4×10^{-9} sec^{-2} = annual average relative deposition at the location occupied by the maximum exposed individual.

R_{ij} = Dose factor for radionuclide i and pathway j, mrem/yr per uCi/m^3 or m^2 - mrem/yr per uCi/sec

$\tilde{Q}'_i$ = Cumulative release of radionuclide i over period of interest (uCi).

3.17×10^{-8} = the fraction of one year per one second.

3.3.1 Calculation of Allowable Release Quantity

Quantities of each radionuclide are calculated which, if released, would result in a maximum organ dose of 0.15 mrem.

The dose equation presented above will be utilized for each radionuclide by setting D_p = 0.15 mrem and solving for $\tilde{Q}'_i$.

EXAMPLE:

For Co-58, Organ Dose

$$\overset{\text{INHALATION}}{0.15\ mrem = 3.17 \times 10^{-8}\frac{yr}{sec}\left|1.106E6\frac{mrem-m^3}{uCi-yr}\right.(2.2E-6\frac{sec}{m^3})} + \overset{\text{GROUND PLANE}}{4.464E8\frac{m^2-mrem-sec}{uCi-yr}} \bullet$$

$$(8.4E-9\,m^{-2}) + \overset{\text{VEGETATION}}{3.771E8\frac{m^2-mrem-sec}{uCi-yr}(8.4E-9m^{-2})}\left.\right|\tilde{Q}'_o\,uCi$$

Solving for $\tilde{Q}'_o$

$\tilde{Q}'_o = 5.06 \times 10^5$ uCi

Therefore, $\tilde{Q}'o$ for 0.15 mrem to maximum exposed organ is

Nuclide	$\tilde{Q}'_o$ uCi
Co-58	5.06E5
Co-60	1.93E4
Cs-134	1.63E4
Cs-137	1.56E4
Mn-54	2.08E5
Fe-55	6.78E5

3.4 Total Body Dose

Since Technical Specification 3.11.2.2 limits organ doses to controlling receptors, total body dose factors for particulate releases are not used in the VCSNS ODCM. Therefore, the total body dose factors for inhalation and vegetation pathways are derived in the following sections (3.4.1 and 3.4.2 respectively) to be used in equation 1 to demonstrate compliance with the 0.1 mRem total body dose criteria. The child represents the most sensitive receptor since the infant does not consume vegetation and there is not a grass-cow-milk receptor within 5 miles of VCSNS.

3.4.1 Total Body Dose Factors Inhalation Pathway

$$R^{I} = BR \times DFA \times K^{I}$$

where,

BR = Child Breathing Rate = 3700 m^3/yr

DFA = Total Body Inhalation Dose Factor (Table E-9, Ref. 3.1.1)

K^{I} = Constant of Unit Conversion, 10^6 pCi/uCi

Nuclide	R^{I} $\frac{mRem \cdot m^3}{uCi \cdot yr}$
Co-58	3.16E3
Co-60	2.26E4
Cs-134	2.25E5
Cs-137	1.28E5
Mn-54	9.51E3
Fe-55	7.77E3

3.4.2 Total Body Dose Factors for Vegetation Pathway

$$R_i^{V}[D/Q] = K^{I}\left[\frac{(r)}{Y_v(\lambda_i + \lambda_w)}\right](DFL_i)_a\left[U_a^L f_L e^{-\lambda_i t_L} + U_a^s f_g e^{-\lambda_i t_h}\right] \quad \text{eq. 2}$$

(m^2 · mrem/yr per uCi/sec)

Section 5.3.1.5, Ref. 3.1.3

where,

Parameter	Value	Description and Source
K^{I}	10^6 pCi/uCi	Constant of unit conversion
U_a	26 kg/yr	Consumption rate of fresh leafy vegetation for child, (Table E-5, Ref. 3.1.1)
U_a	520 kg/yr	Consumption rate of stored vegetation for child, (Table E-5, Ref. 3.1.1)
f_L	1.0	Dimensionless default value for fraction of the annual intake of fresh leafy vegetation grown locally (Section 5.3.1.5, Ref. 3.1.3)
f_g	0.76	Dimensionless default value for fraction of the annual intake of stored vegetation grown locally (Section 5.3.1.5, Ref. 3.1.3)

Parameter	Value	Description and Source
t_L	8.6 X 10^4 sec	Average time between harvest of leafy vegetation and its consumption (Section 5.3.1.5, Ref. 3.1.3)
t_h	5.18 X 10^6 sec	Average time between harvest of stored vegetation and its consumption (Section 5.3.1.5, Ref. 3.1.3)
Y_v	2.0 kg/m^2	Vetation area density (Section 5.3.1.5, Ref. 3.1.3)
$(DFL_i)_a$	Co-58 5.51E-6 Co-60 1.56E-5 Cs-134 8.10E-5 Cs-137 4.62E-5 Mn-54 2.80E-6 Fe-55 1.89E-6	Total body ingestion dose factor for child (Table E-13, Ref. 3.1.1) mrem/pCi
λ_i	Co-58 1.13E-7 Co-60 4.17E-9 Cs-134 1.07E-8 Cs-137 7.28E-10 Mn-54 2.57E-8 Fe-55 8.14E-9	Decay constant for the i^{th} nuclide (C. D. Kocher, Decay Tables, 1981), sec^{-1}
λ_w	5.73E-7 sec^{-1}	Decay constant for removal of activity on leaf and plant surfaces by weathering (Section 5.3.1.5, Ref. 3.1.3)
r	0.2	Fraction of deposited activity retained on crops, leafy vegetables, or pasture grass for particulates (Table E-15, Ref. 3.1.1)

THEREFORE, substituting in equation 2 dose factors for total body of child due to the vegetation pathway are,

Nuclide	R_i^v [D/Q] $\frac{m^2 \cdot mrem \cdot sec}{yr \cdot uCi}$
Co-58	1.97E8
Co-60	1.12E9
Cs-134	5.55E9
Cs-137	3.38E9
Mn-54	1.74E8
Fe-55	1.32E8

3.4.3 Total Body Dose Factors for Ground Plane Exposure Pathway (Table 2.2-2, Ref. 3.1.2)

Nuclide	R^{GP} $\frac{m^2 \cdot mrem \cdot sec}{yr \cdot uCi}$
Co-58	4.464E8
Co-60	2.532E10
Cs-134	8.007E9
Cs-137	1.201E10
Mn-54	1.625E9
Fe-55	0.0

3.4.4 Total Body Dose Calculation

Total body doses may now be calculated for the values of $\tilde{Q}_o'$ derived above using equation 1 from 3.3.

D_{PTB} = Total body dose due to release of Q_{io}

$$D_{PTB} = 3.17 \times 10^{-8} \frac{yr}{sec} \left| R_i^I \frac{\bar{\bar{X}}'}{Q} + R_i^{GP} \frac{\bar{\bar{D}}'}{Q} + R_i^V \frac{\bar{\bar{D}}'}{Q} \right| \tilde{Q}_{io}$$

EXAMPLE

For Co-58

INHALATION GROUND PLANE

$$D_{PTB} = 3.17 \times 10^{-8} \frac{yr}{sec} \left| 3.16E3 \frac{mrem - m^3}{uCi - yr} (2.2E-6 \frac{sec}{m^3}) + 4.464E8 \frac{m^2 - mrem - sec}{uCi - yr} \right.$$

VEGETATION

$$\left. (8.4E-9\, m^{-2}) + 1.97E8 \frac{m^2 - mrem - sec}{uCi - yr} (8.4E-9 m^{-2}) \right| 5.06E5\, uCi$$

D_{PTB} = 8.68E-2 mrem

Therefore, total body dose (D_{PTB}) for each nuclide is as follows for specific $\tilde{Q}_o'$ value derived in section 3.3.1

Nuclide	$D_{PTB}(\tilde{Q}_o')$
Co-58	8.68E-2 mrem
Co-60	1.36E-1 mrem
Cs-134	5.91E-2 mrem
Cs-137	6.41E-2 mrem
Mn-54	9.98E-2 mrem
Fe-55	2.43E-2 mrem

As shown in the above, $\tilde{Q}_o'$ derived for a maximum organ dose of 0.15 mRem is limiting in all cases except Co-60. $\tilde{Q}_o'$ of 1.93E4 uCi will result in a total body dose of

0.136 mrem which is above the limiting condition of 0.1 mrem total body. Therefore, the value of $\tilde{Q}'_o$ for Co-60 will be reduced such that the corresponding total body dose will be limited to 0.1 mrem.

Specifically,

$$\frac{1.36E-1}{1.00E-1} = \frac{1.93E4\ uCi}{X\ \ uCi}$$

Solve for X

$$X = 1.42E4\ uCi$$

Therefore, for Co-60

$$\tilde{Q}'_o = 1.42E4\ uCi$$

In summary then,

Nuclide	$\tilde{Q}'_o$ uCi
Co-58	5.06E5
Co-60	1.42E4
Cs-134	1.63E4
Cs-137	1.56E4
Mn-54	2.08E5
Fe-55	6.78E5

3.5 Total Body Dose Rate Calculation

The following calculation will determine the release rate for radionuclides from the oil incinerator which would result in a maximum dose rate to an individual at the site boundary equal to 1 percent of Tech. Spec. 3.11.2.3. Therefore, concentrations of radionuclides at the site boundary would be limited to 1 percent of the concentrations of 10CFR 20, Appendix B, Table II, Column 1 (see section 3/4.11.2.1 of VCSNS Technical Specifications).

Isotope	10CFR 20 App. B MPC Table II, Col. 1	1 Percent of MPC
Co-58	2E-9 uCi/ml	2E-11 uCi/ml
Co-60	3E-10 uCi/ml	3E-12 uCi/ml
Cs-134	4E-10 uCi/ml	4E-12 uCi/ml
Cs-137	5E-10 uCi/ml	5E-12 uCi/ml
Mn-54	1E-9 uCi/ml	1E-11 uCi/ml
Fe-55	3E-8 uCi/ml	3E-10 uCi/ml

The total gross activity concentration in waste oil to be incinerated will be limited to a value which will assure that airborne concentrations will be less

than or equal to 1 percent of the values listed in 10CFR 20, Appendix B, Table II, Col.1. The following simplifying and conservative assumptions are made.

- Since Co-60 has the most limiting MPC value, all activity in the oil is assumed to be Co-60.

- Incineration rate is 10 gal/hr.

- All activity in oil is assumed released to atmosphere

- From section 2.1.1 of the VCSNS Offsite Dose Calculation Manual (ODCM), the highest annual average relative concentration at the site boundary, X/Q, is equal to 5.3E-6 sec/m3. However, for this application, 3.3×10^{-5} sec/m3 will be used based on the fact that the site boundary is closer to the incinerator stack than is the reactor building. The value of 3.3×10^{-5} sec/m3 was calculated by using actual distance to the site boundary (0.53 miles) and interpolation using the Operating License Environmental Report (OLER) Tables 6.10-10 and 6.1-14 and removing the building wake effect.

Calculate the gross activity in waste oil which if incinerated at a rate of 10 gal/hr would result in a concentration at the site boundary of 3E-12 uCi/ml.

$$C_{PB} = \dot{Q} \cdot X/Q$$

where,

C_{PB} = Concentration at plant boundary = 3E-12 uCi/ml

$\dot{Q}$ = Average release rate in uCi/sec
= Concentration in oil, C_{OIL}, times burn rate, R,

Substituting,

$$C_{PB} = C_{OIL} \cdot R \cdot X/Q$$

or

$$C_{OIL} = \frac{C_{PB}}{R \cdot X/Q}$$

$$= \frac{(3E\text{-}12\ uCi/ml)(3600\ sec/hr)(10^6\ ml/m^3)}{(10\ gal/hr)(3785\ ml/gal)(3.3E\text{-}5\ sec/m^3)}$$

$$C_{OIL} = 8.65 \times 10^{-3}\ uCi/ml$$

The corresponding maximum allowable release rate would then be:

$$\dot{Q} = (8.65 \times 10^{-3}\ uCi/ml)(3785\ ml/gal)(10\ gal/hr) / (3600\ sec/hr)$$

$$= 9.09 \times 10^{-2}\ uCi/sec$$

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OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

REVISION 12

September 1987

Approved by the PSRC

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REFERENCES

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INTRODUCTION

The OFFSITE DOSE CALCULATION MANUAL is a supporting document of the RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS. As such the ODCM describes the methodology and paramenters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints. The ODCM contains a list and graphical description of the specific sample locations for the radiological environmental monitoring program. Configurations of the liquid and gaseous radwaste treatment systems are also included.

The ODCM will be maintained at the Station for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas. Computer software to perform the described calculations will be maintained current with this ODCM.

1.0 LIQUID EFFLUENTS

The Virgil C. Summer Nuclear Station is located on the Monticello Reservoir which provides supply and discharge for the plant circulating water. This reservoir also provides supply and discharge capacity for the Fairfield Pumped Storage Facility. The Parr Reservoir located below the pumped storage facility is formed by the Parr Dam.

There are two basic release pathways and sources of dilution for liquid effluents: the circulating water discharge canal and the liquid effluent line to the penstocks of the pumped storage facility. All liquid effluent pathways discharge to either one or the other release point. Generally speaking, very low concentrations of radioactive waste are discharged to the circulating water discharge while generally higher concentrations of radioactive waste are released to the penstocks of the pumped storage facility during the generation cycle.

1.1 Liquid Effluent Monitor Setpoints

The calculated setpoint values will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value. Setpoints may be established at values lower than the calculated values if desired.

1.1.1 Liquid Radwaste Effluent Line Monitors

(RM-L5, RM-L7, RM-L9)

Liquid Radwaste Effluent Line Monitors provide alarm and automatic termination of release functions prior to exceeding the concentration limits specified in 10CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. To meet this specification, the alarm/trip setpoints for liquid effluent monitors and flow measurement devices are set to assure that the following equation is satisfied:

$$C \geq \frac{cf}{F + f} \qquad (1)$$

where:

C = the effluent concentration limit (Technical Specification 3.11.1.1) implementing 10CFR 20 for the site, corresponding to the specific mix of isotopes in the effluent stream being considered for discharge, in uCi/ml.

c = the setpoint, in uCi/ml, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the effluent line and proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentrations exceeding the limits of 10CFR 20 in the unrestricted area.

f = the effluent line flow setpoint as determined at the radiation monitor location, in volume per unit time, but in the same units as F, below.

F = the dilution water flow setpoint as determined prior to the release point, in volume per unit time.

At the Virgil C. Summer Nuclear Station the Liquid Waste Processing System (LWPS) and the Nuclear Blowdown System (NBS) both discharge to the penstocks of the Fairfield Pumped Storage (FPS) Facility through a common line. The available dilution water flow (F_{ap}) is assumed to be 90 percent of the flow through the FPS penstock(s) to which liquid effluent is being discharged and is dependent upon operational status of the FPS Station. The waste tank flow rates (f_{dm}, f_{db} and f_{dc}) and the monitor setpoints (c_M, c_B and c_C) are set to meet the condition of equation (1) for a given effluent concentration, C. The three monitor setpoints are determined in accordance with the monitor system configuration for this

discharge pathway. The LWPS discharges through RM-L5, which has setpoint c_M for alarm/control functions over releases from either Waste Monitor Tanks 1 or 2. The Nuclear Blowdown discharges through RM-L7, which has setpoint c_B for alarm/ control functions over releases from the Nuclear Blowdown Monitor Tank. These two release pathways merge into a common line monitored by RM-L9, which has setpoint c_C for control functions over the common effluent line. Although the piping is arranged so that simultaneous batch releases from the two systems could be practiced, operational releases shall be from only one of the two batch systems at any given time. The method by which their setpoints are determined is as follows:

1) The isotopic concentration for a waste tank to be released is obtained from the sum of the measured concentrations as determined by the analysis required in the Radiological Effluent Technical Specifications Table 4.11-1:

$$\sum_i C_i = \sum_g C_g + C_a + C_s + C_t + C_f \qquad (2)$$

where:

C_i = the concentration of nuclide i as determined by the analysis of the waste sample.

C_f* = the concentration of Fe-55 in liquid waste as determined by analysis of the quarterly composite sample.

$\sum_g C_g$ = the sum of the concentrations C_g of each measured gamma emitting nuclide observed by gamma-ray spectroscopy of the waste sample.

C_a* = the measured concentrations C_a of alpha emitting nuclides observed by gross alpha analysis of the monthly composite sample.

C_s^* = the measured concentrations of Sr-89 and Sr-90 in liquid waste as determined by analysis of the quarterly composite sample.

C_t^* = the measured concentration of H-3 in liquid waste as determined by analysis of the monthly composite sample.

The C_g term will be included in the analysis of each batch; terms for alpha, strontium, Fe-55, and tritium shall be included as appropriate. Isotopic concentrations for both the Waste Monitor Tanks (WMT) and the Nuclear Blowdown Monitor Tank (NBMT) may be calculated using equation (2).

Prior to being sampled for analysis, the contents of a tank shall be isolated and recirculated. The minimum recirculation time shall be:

$$t_r = 2V/f_r \qquad (3)$$

where:

V = the volume of liquid in the tank to be sampled, gal.

f_r = the recirculation flow rate being used to mix the tank gal/min.

This is to ensure that a representative sample will be obtained. Mechanical mixers shall ensure a similar minimum turnover.

2) Once isotopic concentrations for either Waste Monitor Tank or the Nuclear Blowdown Monitor Tank have been determined, these values are used to calculate a Dilution Factor, DF, which is the ratio of dilution flow rate to tank flow rate(s) required to assure that the limiting concentration of 10CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge for whichever tank is having its contents discharged.

---

* Values for these concentrations will be based on most recent available previous composite sample analyses as required by Table 4.11-1 of the Radiological Effluent Technical Specifications.

$$DF = \left| \sum_i \frac{C_i}{MPC_i} \right|_x \div SF \quad (4)$$

$$DF = \left| \sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_f}{MPC_f} + \frac{C_t}{MPC_t} \right|_x \div SF \quad (5)$$

where:

$\left| \sum_i \frac{C_i}{MPC_i} \right|_x$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC for the tank whose contents are being considered for release. For a WMT, X = M. For the NBMT, X = B.

MPC_i = MPC_g, MPC_a, MPC_s, MPC_f, and MPC_t = limiting concentrations of the appropriate gamma emitting, alpha emitting, and strontium radionuclides, Fe-55, and tritium, respectively, given in 10CFR, Part 20, Appendix B, Table II, Column 2. For gamma-emitting noble gas radionuclides MPC_i is to be set equal to 2×10^{-4} µCi/ml, according to the Radiological Effluent Technical Specifications.

SF = the safety factor; a conservative factor used to compensate for engineering and measurement uncertainties.

= 0.5, corresponding to a 100 percent variation.

3) The maximum permissible discharge flow rate, f_t, may be calculated for the release of either the WMT or NBMT. First the appropriate Dilution Factor is calculated by applying equation (4), using the appropriate concentration ratio term (i.e. M or B).

then,

$$f_t = \frac{F_{dp} + f_{dx}}{DF} = \frac{F_{dp}}{DF} \quad \text{for } F_{dp} >> f_{dx} \tag{6}$$

where:

F_{dp} = dilution flow rate to be used in effluent monitor setpoint calculations, based on 90 percent FPS Station expected flow rate, as corrected for any recirculated radioactivity:

$$F_{dp} = (0.9) F_t \left(1 - \sum_i \frac{C_{ir}}{MPC_i}\right) \tag{7}$$

where:

F_t = the flow rate through the FPS Station penstock(s) to which radioactive liquids are being discharged. F_t should normally fall between 2500 and 44800 cfs.

C_{ir} = the concentration of radionuclide i in the intake of FPS Station (that is, in the Monticello Reservoir). Inclusion of this term will correct for possible long-term buildup of radioactivity due to recirculation and for the presence of activity recently released to the Monticello Reservoir by plant activities. For expected discharges of liquid wastes, the summation will be much less than 1.0 and can be ignored (Reference 6).

f_{dx} = the flow rate of the tank discharge, either f_{dm} or f_{db}.

f_{db} = flow rate of Nuclear Blowdown Monitor Tank discharge. (Conservatively this value will be either zero, if no release is to be conducted from this system, or the maximum measured capacity of the discharge pump if a release is to be conducted.)

f_{dm} = flow rate of Waste Monitor Tank discharge. (Conservatively this value will either be zero, if no release is to be conducted from this system, or the maximum measured capacity of the discharge pump if a release is to be conducted.)

DF = the Dilution Factor from Step 2.

If $f_t \geq f_{dx}$, the release may be made as planned and the flow rate monitor setpoints should be established as in Step 4 (below). Because F_{dp} is normally very large compared to the maximum discharge pump capacities for the Waste Monitor Tank and the Nuclear Blowdown Monitor Tank, it is extremely unlikely that $f_t < f_{dx}$. However, if a situation should arise such that $f_t < f_{dx}$, steps must be taken to assure that equation (1) is satisfied prior to making the release. These steps may include decreasing f_{dx} by decreasing the flow rate of f_{dm} or f_{db}, and/or increasing F_{dp}.

When new candidate flow rates are chosen, the calculations of Step 3 should be repeated to verify that they combine to form an acceptable release. If they do, the establishment of flow rate monitor setpoints may proceed as in Step 4. If they do not, the choice of candidate flow rates must be repeated until an acceptable set is identified.

Note that if DF $\leq$ 1, the waste tank concentration for which the calculation is being performed includes safety factors in Step 2 and meets the limits of 10CFR 20 without further dilution. Even though no dilution would be required, there will be no discharge if minimum dilution flow is not available, since the penstock minimum flow interlock will prevent discharge.

4) The dilution flow rate setpoint*, F, is established at 90 percent of the expected available dilution flow rate:

$$F = (0.9)\,F_t \qquad (8)$$

The flow rate monitor setpoint* for the effluent stream shall be set at the selected discharge pump rate (normally the maximum discharge pump rate or zero) f_{dm} or f_{db} chosen in Step 3 above.

5) The radiation monitor setpoints may now be determined based on the values of ΣC_i, F, and f which were specified to provide compliance with the limits of 10CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation, therefore, the actual setpoint is based on ΣC_g.

The setpoint concentration, c, is determined as follows:

$$c \leq \sum_g C_g \times A \qquad (9)$$

A = Adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$A = f_t / f_{dx} \qquad (10)$$

If $A \geq 1$, Calculate c and determine the maximum value for the actual monitor setpoint (cpm) from the monitor calibration graph.

If $A < 1$, No release may be made. Re-evaluate the alternatives presented in Step 3.

---

* Set points for flow rates are administrative limits.

NOTE: If calculated setpoint values are near actual concentrations planned for release, it may be impractical to set the monitor alarm at this value. In this case a new setpoint may be calculated following the remedial methodology presented in Step 3 for the case $f_t < f_{dx}$.

Within the limits of the conditions stated above, the specific monitor setpoints for the three liquid radiation monitors RM-L5, RM-L7, and RM-L9 are determined as follows:

RM-L5, Waste Monitor Tank Discharge Line Monitor:

$$C_M \leq \left| \sum_g C_g \right|_M \times A \tag{11}$$

NOTE: If no discharge is planned for this pathway or if $\Sigma C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

RM-L7, Nuclear Blowdown Monitor Tank Discharge Line Monitor:

$$C_B \leq \left| \sum_g C_g \right|_B \times A \tag{12}$$

NOTE: In no case should discharge be made directly from the Nuclear Blowdown Holdup Tank. Its contents should always be processed via the Nuclear Blowdown Monitoring Tank.

NOTE: If no discharge is planned for this pathway or if $\Sigma C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

RM-L9, Combined Liquid Waste Processing System and Nuclear Blowdown Waste Effluent Discharge Line Monitor

The monitor setpoint on the common line, c_C, should be the same as the setpoint for the monitor on the active individual discharge line (i.e., c_M, or c_B as determined above):

(13)

$$c_C \leq MAX\ (c_M\ , c_B)$$

NOTE: If no discharge is planned for this pathway or if $\Sigma\ C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

NOTE: In all cases, c_M, c_B, and c_C are the setpoint values in uCi/ml. The actual monitor setpoints (cpm) for RM-L5, RM-L7, and RM-L9 are determined from the calibration graph for the particular monitor. Initially, the calibration curves were determined conservatively from families of response curves supplied by the monitor manufacturers. A sample is shown in Figure 1.0-1. As releases occurred, a historical correlation will be prepared and placed in service when sufficient data are accumulated.

1.1.2 Liquid Waste Discharge Via Industrial and Sanitary Waste System (RM-L5)

In the Virgil C. Summer Nuclear Station liquid waste effluent system design, there exists a mechanism for discharging liquid wastes via the Industrial Sanitary Waste System. The sample point prior to discharge is one of the Waste Monitor Tanks. The analysis requirements are the requirements listed in the Radiological Effluent Technical Specifications, Table 4.11-1.

This effluent pathway shall only be used when the following condition is met for all radionuclides, i:

(14)

$$\left| c_i \right|_M \leq \left| c_i \right|_{LLD}$$

$\left|C_i\right|_M$ = the concentration of radionuclide i in the waste contained within the Waste Monitor Tank serving as the holding facility for sampling and analysis prior to discharge.

$\left|C_i\right|_{LLD}$ = the Lower Limit of Detection, (LLD) for radionuclide i in the liquid waste in the Waste Monitor Tank as determined by the analysis required in the Radiological Effluent Technical Specification, Table 4.11-1.

When the condisitons of equation (14) are met, liquid waste may be released via the Industrial and Sanitary Waste System pathway. The RM-L5 setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent high concentration release occur.

1.1.3 Steam Generator Blowdown, Turbine Building Sump, and Condensate Demineralizer Backwash Effluent Lines (RM-L3, RM-L10, RM-L8, RM-L11)

Concentrations of radionuclides in the liquid effluent discharges made via the Turbine Building Sump, Steam Generator Blowdown, and Condensate Demineralizer Backwash are expected to be very low or nondetectable. The first two releases are expected to be continuous in nature and the last a batch release. All will be sampled in an appropriate manner as specified in Table 4.11-1 of the RETS. The Steam Generator Blowdown Monitors, the Turbine Building Sump Monitor, and the Condensate Demineralizer Backwash Monitor provide alarm and automatic termination of release prior to exceeding the concentration limits specified in 10CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. In reality, all of these effluent pathways utilize the

circulating water as dilution to the effluent stream, with the circulating water discharge canal being the point of release into an unrestricted area. However, to compensate for uncertainties in the transit times of activity discharge to the Industrial and Sanitary Waste System, discharges to that system will not be credited with dilution for the purpose of monitor setpoint calculations.

The Steam Generator Blowdown Effluent may be released to the Circulating Water either directly in the Condenser outflow or via the ponds and sumps of the Industrial and Sanitary Waste System; the latter path is preferred for chemical reasons in the first hours following startup. The Turbine Building Sump and Condensate Demineralizer Backwash Effluents enter the Circulating Water through the Waste Lagoons.

For the sake of clarity, two mutually exclusive setpoint calculation processes are outlined below. Section 1.1.3.1 is to be used whenever Steam Generator Blowdown in being released directly to the Circulating Water in the Condenser outflow, which is the normal mode. Section 1.1.3.2 is to be used whenever Steam Generator Blowdown is being released to the Industrial and Sanitary Waste System, or diverted to the Nuclear Blowdown Processing System, both of which are alternate modes. Each section covers all four monitors (RM-L3, RM-L8, RM-L10 and RM-L11).

NOTE: When Circulating Water is unavailable for effluent dilution, releases containing activity above LLD should be discouraged via pathways which lead to it. Steam Generator Blowdown should be diverted to the Nuclear Blowdown Processing System. Condensate Demineralizer Backwash may be diverted to the Turbine Building Sump or not released. Turbine Building Sump effluent should be diverted to the Excess Liquid Waste Processing System. (These steps are to keep the calculated dose to individuals as low as reasonably achievable.) Furthermore, sampling and analysis of the Industrial and Sanitary Waste System is to be initiated and the measured concentrations used in the dose calculations of Section 1.2.

1.1.3.1 Steam Generator Blowdown Effluent Direct to Circulating Water (Normal Mode)

Equation (1) is again used to assure that effluents are in compliance with the aforementioned specification:

$$\frac{cf}{(F+f)} \leq C$$

where: c, f, F, and C are the same generic terms discussed in Section 1.1.1.

The available dilution water flow (F_{dc}) is dependent upon the mode of operation of the Circulating Water System. Any change in this value will be accounted for in a recalculation of equation (1). The Steam Generator Blowdown flow rate (f_{ds}) and the Steam Generator Blowdown monitor setpoints (c_{S_a} and c_{S_b}) are set to meet the condition of equation (1). The Turbine Building Sump and Condensate Dimeneralizer effluents will be limited to concentrations less than MPC without claiming dilution (see below). Therefore, it is not necessary to consider their flow rates or concentrations in determining the required dilution and monitor setpoints for Steam Generator Blowdown.

For conservatism, the Turbine Building Sump and Condensate Demineralizer Backwash monitor setpoints (c_T and c_D) will claim no dilution from the Circulating Water, and will be set at the applicable concentration limit. That is:

$$c \leqq C \qquad (15)$$

where: c and C are the generic terms discussed in Section 1.1.1.

RM-L8, the Turbine Building Sump monitor alarms and terminates release upon exceeding the monitor setpoint (c_T). The discharge can then be manually diverted to the Excess Waste Processing System. RM-L3, the first monitor in the Steam Generator Blowdown discharge pathway, alarms and terminates release of the stream. The discharge is then automatically diverted to the Nuclear

Blowdown Processing System. RM-L10, the last monitor in the Steam Generator Blowdown discharge pathway, alarms and terminates the release. Thus, RM-L10 is redundant to RM-L3 and the setpoint (c_{s_b}) will be determined in the same manner as RM-L3 (c_{s_a}). RM-L11, the Condensate Demineralizer Backwash monitor, alarms and terminates release upon exceeding the monitor setpoint (c_D). The discharge may then be manually diverted to the Turbine Building Sump or simply delayed. The method by which the monitor setpoints are determined is as follows:

1) The isotopic concentrations for any release source to be or being released are obtained from the sum of the measured concentrations as determined in the Radiological Effluent Technical Specifications Table 4.11-1. Equation (2) is again employed for this calculation:

$$\sum_i C_i = \sum_g C_g + C_a + C_s + C_t + C_f$$

where:

ΣC_i = the sum of the measured concentrations as determined by the analysis of the waste sample.

ΣC_g = the sum of the concentrations C_g of each measured gamma emitting nuclide observed by gamma-ray spectroscopy of the waste sample.

C_a = the measured concentration C_a of alpha emitting composite sample.

C_s = the measured concentrations of Sr-89 and Sr-90 in liquid waste as determined by analysis of the most recent available quarterly composite sample.

C_t = the measured concentration of H-3 in liquid waste determined by analysis of the monthly composite sample.

C_f = the measured concentration of Fe-55 in liquid waste as determined by analysis of the most recent available quarterly composite sample.

Isotopic concentrations for the Steam Generator Blowdown System effluent, the Turbine Building Sump Effluent, and the Condensate Demineralizer Backwash effluent may be calculated using equation (2).

2) Once isotopic concentrations for the Steam Generator Blowdown have been determined, these values are used to calculate a Dilution Factor, DF, which is the ratio of the total dilution flow rate to effluent stream flow rate required to assure that the limiting concentrations of 10CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge.

$$DF = \left| \sum_i \frac{C_i}{MPC_i} \right|_s \div SF \quad (16)$$

$$DF = \left| \sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_f}{MPC_f} + \frac{C_t}{MPC_t} \right|_s \div SF \quad (17)$$

where:

C_i = C_g, C_a, C_s, C_f, and C_t; measured concentrations as defined in Step 1. Terms C_a, C_s, C_f, and C_t will be included in the calculation as appropriate.

$\left[\sum_i \frac{C_i}{MPC_i} \right]_s$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Steam Generator Blowdown effluent.

MPC_i = MPC_g, MPC_a, MPC_s, MPC_i, and MPC_t are limiting concentrations of the appropriate radionuclide from 10CFR, Part 20, Appendix B, Table II, Column 2 limits. For gamma-emitting noble gas radionuclides, MPC_i is to be set equal to 2×10^{-4} uCi/ml, according to the Radiological Effluent Technical Specifications.

SF = the same generic term as used in Section 1.1.1, Step 2.

= 0.5

3) The maximum permissible effluent discharge flow rate, f_d, may now be calculated for a release from the Steam Generator Blowdown.

(18)

$$f_d = \frac{F_{dc} + f_{ds}}{DF} \approx \frac{F_{dc}}{DF} \quad \text{for } F_{dc} >> f_{ds}$$

where:

F_{dc} = Dilution flow rate for use in effluent monitor setpoint calculations, based on 90 percent of the expected flow rate of the Circulating Water System during the time of release and corrected for any recirculated activity:

(19)

$$F_{dc} = (0.9) F_d \left[1 - \sum_i \frac{C_{ir}}{MPC_i} \right]$$

where:

F_d = the flow rate of the Circulating Water System during the time of the release. F_d should normally fall between 1.78×10^5 and 5.34×10^5 gpm.

C_{ir} = the concentration of radionuclide i in the Circulating Water System intake, (that is, in the Monticello Reservoir). Inclusion of this term will correct for posible long-term buildup of radioactivity due to recirculation and for the presence of activity recently released to the Monticello Reservoir by plant activities. For expected discharges of liquid wastes, the summation will be much less than 1.0 and can be ignored (Reference 6).

f_{ds} = Flow rate of Steam Generator Blowdown discharge. (This value normally will be either zero, if no release is to be conducted, or the maximum rated capacity of the discharge pump (250 gpm), if a release is to be conducted.)

DF = the Dilution Factor from Step 2.

Note that the equation is valid only for DF > 1; for DF $\leqq$ 1, the effluent concentration meets the limits of 10CFR 20 without dilution as well as being in compliance with the conservatism imposed by the Safety Factor in Step 2.

If $f_d \geqq f_{ds}$, releases may be made as planned. Because F_{dc} is normally very large compared to the maximum discharge pump capacity of the Steam Generator Blowdown System, it is extremely unlikely that $f_d < f_{ds}$. However, if a situation should arise such that $f_d < f_{ds}$, steps must be taken to assure that equation (1) is staisfied prior to making the release. These steps may include diverting Steam Generator Blowdown to the Nuclear Blowdown Processing System or decreasing the effluent flow rate.

When new candidate flow rates are chosen, the calculations of Step 3 should be repeated to verify that they combine

to form an acceptable release. If they do, the establishment of flow rate monitor setpoints should proceed as in Step 4. If they do not provide an acceptable release, the choice of candidate flow rates must be repeated until an acceptable set is identified.

4) The dilution flow rate setpoint for minimum flow rate, F, is established at 90 percent of the expected available dilution flow rate:

$$F = (0.9)(F_d) \qquad (20)$$

Flow rate monitor setpoints for the Steam Generator Blowdown effluent stream shall be set as the selected discharge pump rate (normally the maximum discharge pump rate) f_{ds} chosen in Step 3 above.

5) The Steam Generator Monitor setpoints may be specified based on the values of ΣC_i, F, and f which were specified to provide compliance with the limits of 10CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation, therefore, the actual setpoint is based on ΣC_g. The monitor setpoint in cpm which corresponds to the calculated value c is taken from the monitor calibration graph. (See NOTE, page 1.0-10.) The setpoint concentration, c, is determined as follows:

$$c \leq \sum_g C_g \times B \qquad (21)$$

B = Adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$= f_d/f_{ds} \qquad (22)$$

If $B \geqq 1$, Calculate c and determine the maximum value for the actual monitor setpoint (cpm) from the monitor calibration graph.

If B < 1, No release may be made. Re-evaluate the alternatives presented in step 3.

NOTE: If the calculated setpoint value is near actual concentrations being released or planned for release, it may be impractical to set the monitor alarm at this value. In this case a new setpoint may be calculated following the remedial methodology presented in steps 3 and 4 for the case $f_d < f_{ds}$.

Within the limits of the conditions stated above, the specific monitor setpoints for the two Steam Generator Blowdown monitors RM-L3 and RM-L10 are determined as follows:

For RM-L3, Steam Generator Blowdown Discharge initial monitor, and for RM-L10, Steam Generator Blowdown Discharge final monitor:

(23)

$$c_{S_a} \text{ or } c_{S_b} \leq \left| \sum_g C_g \right|_s \times B$$

$\left| \sum_g C_g \right|_s$ = the isotopic concentration of the Steam Generator Blowdown effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

NOTE: If no discharge is planned for this pathway or if $\Sigma C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

6) The Turbine Building Sump and Condensate Demineralizer Backwash monitor setpoints are to be established independently of each other and without crediting dilution. They are to be based on the measured radio-

nuclide concentrations of the effluent stream and are to ensure compliance with the limits of 10CFR 20, Appendix B, Table II, Column 2 prior to discharge.

For each effluent stream, a concentration factor CF must be calculated, measuring the nearness of approach of the undiluted waste stream to the specified limiting condition of the Maximum Permissible Concentration. That is,

(24)

$$CF = \left| \sum_i \frac{C_i}{MPC_i} \right| \div SF$$

(25)

$$CF_T - = \left| \sum_i \frac{C_i}{MPC_i} \right|_T \div SF$$

(26)

$$CF_D = \left| \sum_i \frac{C_i}{MPC_i} \right|_D \div SF$$

where:

$\left| \sum_i \frac{C_i}{MPC_i} \right|_T$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Turbine Building Sump effluent.

$\left| \sum_i \frac{C_i}{MPC_i} \right|_D$ = the sum of the measured concentration of nuclide i (in liquid only) to its limiting value MPC_i for the Condensate Demineralizer Backwash effluent.

CF_T = the concentration factor for the Turbine Building Sump Effluent.

CF_D = the concentration factor for the Condensate Demineralizer Backwash Effluent.

SF = the generic engineering safety factor used in Section 1.1.1, Step 2.

= 0.5

If CF $\leq$ 1, calculate c and determine the actual monitor setpoint (cpm) from the calibration curve.

If CF > 1, no release may be made via this path. The release must either be delayed or diverted for additional processing. Because of spurious alarms, these remedial steps may be required if the monitor setpoints are only near the actual concentrations being released.

Within the above limitation, setpoints may now be calculated for the two effluent monitors. Because they are primarily sensitive to gamma radiation, their setpoints will be based on the concentrations of gamma emitting radionuclides as follows:

For RM-L8, Turbine Building Sump Discharge Monitor:

$$c_T \leq \left| \sum_g C_g \right|_T \div CF_T \quad (27)$$

Where:

$\left| \sum_g C_g \right|_T$ = The gamma isotopic concentration of the Turbine Building Sump effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

CF_T = The Turbine Building Sump Effluent Concentration Factor from equation (25).

NOTE: If no discharge is planned for this pathway or if $\Sigma C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

For RM-L11, Condensate Demineralizer Backwash Discharge Monitor:

$$c_D \leq \left| \sum_g C_g \right|_D \div CF_D \tag{28}$$

where:

$\left| \sum_g C_g \right|_D$ = The gamma isotopic concentration of the Condensate Demineralizer Backwash effluent (including solids) as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

CF_D = The Condensate Demineralizer Backwash Effluent Concentration Factor from equation (26).

NOTE: If no discharge is planned for this pathway or if $\Sigma C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

1.1.3.2 Steam Generator Blowdown Effluent Not Directly to Circulating Water (Alternate Mode)

Equation (15) is again used to assure that effluents are in compliance with the aforementioned specification before dilution in the receiving water:

$$c \leqq C$$

where c and C are the generic terms discussed in Section 1.1.1. Because dilution is not considered in the setpoint calculation, it is not necessary to calculate maximum permissible discharge flowrates or anticipated available dilution flow rate.

The functions of the four monitors whose setpoints are to be established are describe in Section 1.1.3.1 above. The method for the determination is as follows:

1) If a release is found to be permissible, flow rate monitors for the active effluent streams (Steam Generator Blowdown - f_{ds}, Turbine Building Sump - f_{dt}, and Condensate Demineralizer - f_{dd}) may have their setpoints established at any operationally convenient value. Since 10CFR 20 is to be complied with before dilution, the flow rate of discharges is irrelevant.

2) The Concentration Factor of equations (24) - (26) is again used to ensure the permissibility of the release:

$$CF = \left| \sum_i \frac{C_i}{MPC_i} \right| \div SF$$

$$CF_T = \left| \sum_i \frac{C_i}{MPC_i} \right|_T \div SF$$

$$CF_D = \left| \sum_i \frac{C_i}{MPC_i} \right|_D \div SF$$

$$CF_S = \left| \sum_i \frac{C_i}{MPC_i} \right|_S \div SF \qquad (29)$$

in which all terms are defined in subsection 1.1.3.1 and subscripts T, D, and S refer respectively to the Turbine Building Sump Effluent, the Condensate Demineralizer Backwash Effluent, and the Steam Generator Blowdown Effluent.

If CF ≦ 1, calculate c and determine the actual monitor setpoint (cpm) from the calibration curve.

If CF > 1, no release may be made via this path. The release must either be delayed or diverted for additional processing. Because of spurious alarms, these remedial steps may be required if the monitor setpoints are only near the actual concentrations being released.

Within the above limitation, setpoints may now be calculated for the four effluent monitors. Because they are primarily sensitive to gamma radiation, their setpoints will be based on the concentrations of gamma emitting radionuclides as follows:

For RM-L8, Turbine Building Sump Discharge Monitor (using equation (27) above):

$$c_T \leq \left| \sum_g C_g \right|_T \div CF_T$$

where:

$\left| \sum_g C_g \right|_T$ = The gamma isotopic concentration of the Turbine Building Sump effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

CF_T = The Turbine Building Sump Effluent Concentration Factor from equation (25).

NOTE: If no discharge is planned for this pathway or if $\Sigma\ C_g = 0$, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

For RM-L11, Condensate Demineralizer Backwash Discharge Monitor (using equation (28) above):

$$c_D \leq \left| \sum_g C_g \right|_D + CF_D$$

where:

$\left| \sum_g C_g \right|_D$ = the gamma isotopic concentration of the Condensate Demineralizer Backwash effluent (including solids) as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

CF_D = The Condensate Demineralizer Backwash Effluent Concentration Factor from equation (26).

NOTE: If no discharge is planned for this pathway or if Σ Cg = 0, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

For RM-L3, Steam Generator Blowdown Discharge initial monitor, and RML-10, Steam Generator Blowdown Discharge final monitor:

$$c_{S_a} \text{ or } c_{S_b} \leq \left| \sum_g C_g \right|_S + CF_S \quad (30)$$

where:

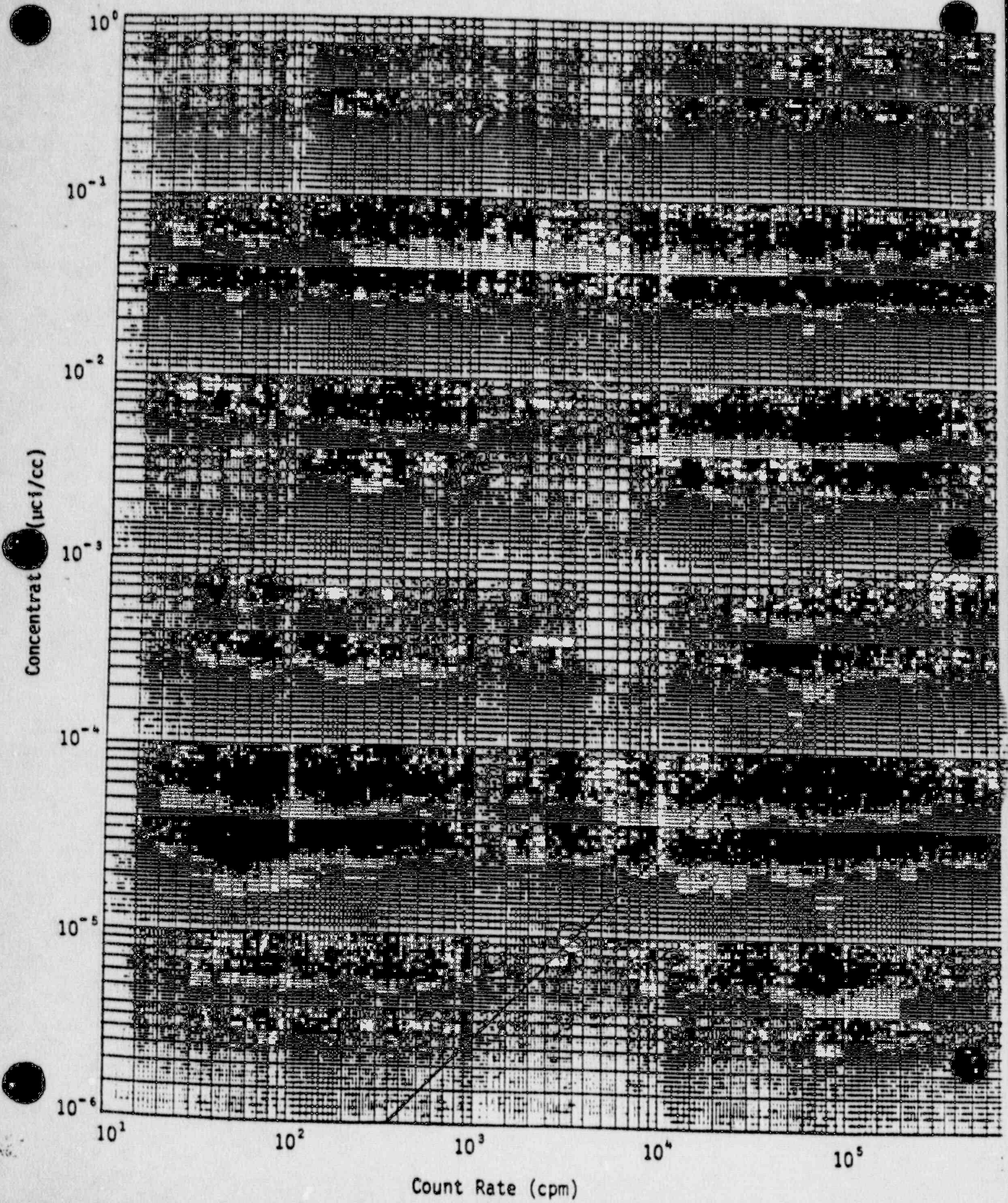
$\left| \sum_g C_g \right|_S$ = The isotopic concentration of the Steam Generator Blowdown effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

CF_S = The Steam Generator Blowdown Effluent Concentration Factor from equation (29).

NOTE: If no discharge is planned for this pathway or if Σ C_g = 0, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

FIGURE 1.0-1

EXAMPLE CALIBRATION CURVE FOR LIQUID EFFLUENT MONITOR



1.? Dose Calculation For Liquid Effluents

The method of this section is to be used in all cases for calculating doses to individuals from routine liquid effluents. Four notes at the end of the section confirm the values which certain parameters are to be assigned in some special cases.

The dose contribution from all radionuclides identified in liquid effluents released to unrestricted areas is calculated using the following expression:

$$D_\tau = \sum_i \left[A_{i\tau} \sum_{k=1} \Delta t_k C_{ik} F_k \right] \tag{31}$$

where:

D_τ = the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period $\Sigma \Delta t_k$ in mrem (Reference 1).

Δt_k = the length of the kth time period over which C_{ik} and F_k are averaged for all liquid releases, in hours.

C_{ik} = the average concentration of radionuclide, i, in undiluted liquid effluent during time period Δt_k from any liquid release, in uCi/ml.

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ, τ, for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-uCi.

$$A_{i\tau} = K_o \left((U_w/D_w) + U_F BF_i \right) DF_i \tag{32}$$

F_k = the near field average dilution factor for C_{ik} during any liquid effluent release. Defined as the ratio of the maximum undiluted liquid waste flow during release to the product of the average flow from the discharge structure to unrestricted receiving water times Z.

$$F_k = \frac{\text{(average undiluted liquid waste flow)}}{\text{(average flow from the discharge structure)} \times (Z)}$$

where:

$Z = 1$ = applicable factor when no additional dilution is to be considered. (Reference 1; Section 4.3)

K_o = units conversion factor 1.14×10^5

= $((10^6 \text{ pCi/uCi}) \times (10^3 \text{ml}/\ell) \div (8760 \text{ hr/yr}))$

U_F = 21 kg/yr, fish consumption (adult). (Reference 3)

BF_i = Bioaccumulation Factor for nuclide i, in fish, pCi/Kg per pCi/l, from Table 1.2-1, (taken from reference 3, Table A-1).

$DF_{i\tau}$ = Dose conversion factor for nuclide i, for adults in preselected organ, τ, in mrem/pCi, from Table 1.2-2 (taken from reference 3, Table E-11).

U_w = 730 ℓ/yr, water consumption (adult). (Reference 3)

D_w = Dilution Factor from the near field area within one-quarter mile of the release points to the potable water intake for adult water consumption; for V. C. Summer, $D_w = 1$. (Reference 1)

NOTE 1: If radioactivity in the Monticello Reservior (C_{ir}) becomes > the LLD specified in Radiological Effluent Technical Specification, Table 4.11-1, that concentration must be included in the Dose determination. For this part of the dose calculation, $F_k = 1$ and Δt_k = the entire time period for which the dose is being calculated.

NOTE 2: During periods when the Circulating Water Pumps are not in operation, the possibility of leakage of activity from the Industrial Water System will be accounted for as follows. Sampling of the liquid in the Sanitary and Industrial Waste System will be initiated, and the measured concentrations of radionuclides will be used in the dose calculations with $F_k = 1$ and Δt_k = the entire time period for which the dose is being calcualted.

NOTE 3: During periods when the Circulating Water Pumps are in operation, any releases to the Sanitary and Industrial Waste System are to be credited with dilution in Circulating Water for dose calculation purposes, even though such dilution was not claimed in the setpoint calculation. When taken in union with the note above, this procedure results in some overestimation of dose to the population because discharges made to the Sanitary and Industrial Waste System just before loss of Circulating Water will be counted twice in the dose calculation process.

NOTE 4: If radioactivity in the Service Water becomes > LLD as determined by the analysis required by Radiological Effluent Technical Specification, Table 4.11-1, that concentration must be included in the Dose determination. For this part of the dose calculation, $F_k = 1$ and Δt_k = the entire time since the last Service Water sample was taken.

TABLE 1.2-1
BIOACCUMULATION FACTORS*
(pCi/kg per pCi/liter)

ELEMENT	FRESHWATER FISH
H	9.0E-01
C	4.6E 03
Na	1.0E 02
P	1.0E 05
Cr	2.0E 02
Mn	4.0E 02
Fe	1.0E 02
Co	5.0E 01
Ni	1.0E 02
Cu	5.0E 01
Zn	2.0E 03
Br	4.2E 02
Rb	2.0E 03
Sr	3.0E 01
Y	2.5E 01
Zr	3.3E 00
Nb	3.0E 04
Mo	1.0E 01
Tc	1.5E 01
Ru	1.0E 01
Rh	1.0E 01
Te	4.0E 02
I	1.5E 01
Cs	2.0E 03
Ba	4.0E 00
La	2.5E 01
Ce	1.0E 00
Pr	2.5E 01
Nd	2.5E 01
W	1.2E 03
Np	1.0E 01

*Values in Table 1.2-1 are taken from Reference 3, Table A-1.

TABLE 1.2-2

ADULT INGESTION DOSE FACTORS*

(mrem/pCi ingested)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	NO DATA	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C 14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
NA 24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P 32	1.93E-04	1.20E-05	7.46E-06	NO DATA	NO DATA	NO DATA	2.17E-05
CR 51	NO DATA	NO DATA	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
MN 54	NO DATA	4.57E-06	8.72E-07	NO DATA	1.36E-06	NO DATA	1.40E-05
MN 56	NO DATA	1.15E-07	2.04E-08	NO DATA	1.46E-07	NO DATA	3.67E-06
FE 55	2.75E-06	1.90E-06	4.43E-07	NO DATA	NO DATA	1.06E-06	1.09E-06
FE 59	4.34E-06	1.02E-05	3.91E-06	NO DATA	NO DATA	2.85E-06	3.40E-05
CO 58	NO DATA	7.45E-07	1.67E-06	NO DATA	NO DATA	NO DATA	1.51E-05
CO 60	NO DATA	2.14E-06	4.72E-06	NO DATA	NO DATA	NO DATA	4.02E-05
NI 63	1.30E-04	9.01E-06	4.36E-06	NO DATA	NO DATA	NO DATA	1.88E-06
NI 65	5.28E-07	6.86E-08	3.13E-08	NO DATA	NO DATA	NO DATA	1.74E-06
CU 64	NO DATA	8.33E-08	3.91E-08	NO DATA	2.10E-07	NO DATA	7.10E-06
ZN 65	4.84E-06	1.54E-05	6.96E-06	NO DATA	1.03E-05	NO DATA	9.70E-06
ZN 69	1.03E-08	1.97E-08	1.37E-09	NO DATA	1.28E-08	NO DATA	2.96E-09
BR 83	NO DATA	NO DATA	4.02E-08	NO DATA	NO DATA	NO DATA	5.79E-08
BR 84	NO DATA	NO DATA	5.21E-08	NO DATA	NO DATA	NO DATA	4.09E-13
BR 85	NO DATA	NO DATA	2.14E-09	NO DATA	NO DATA	NO DATA	LT E-24
RB 86	NO DATA	2.11E-05	9.83E-06	NO DATA	NO DATA	NO DATA	4.16E-06
RB 88	NO DATA	6.05E-08	3.21E-08	NO DATA	NO DATA	NO DATA	8.36E-19
RB 89	NO DATA	4.01E-08	2.82E-08	NO DATA	NO DATA	NO DATA	2.33E-21
SR 89	3.08E-04	NO DATA	8.84E-06	NO DATA	NO DATA	NO DATA	4.94E-05
SR 90	7.58E-03	NO DATA	1.86E-03	NO DATA	NO DATA	NO DATA	2.19E-04
SR 91	5.67E-06	NO DATA	2.29E-07	NO DATA	NO DATA	NO DATA	2.70E-05
SR 92	2.15E-06	NO DATA	9.30E-08	NO DATA	NO DATA	NO DATA	4.26E-05
Y 90	9.62E-09	NO DATA	2.58E-10	NO DATA	NO DATA	NO DATA	1.02E-04
Y 91M	9.09E-11	NO DATA	3.52E-12	NO DATA	NO DATA	NO DATA	2.67E-10
Y 91	1.41E-07	NO DATA	3.77E-09	NO DATA	NO DATA	NO DATA	7.76E-05
Y 92	8.45E-10	NO DATA	2.47E-11	NO DATA	NO DATA	NO DATA	1.48E-05
Y 93	2.68E-09	NO DATA	7.40E-11	NO DATA	NO DATA	NO DATA	8.50E-05
ZR 95	3.04E-08	9.75E-09	6.60E-09	NO DATA	1.53E-08	NO DATA	3.09E-05
ZR 97	1.68E-09	3.39E-10	1.55E-10	NO DATA	5.12E-10	NO DATA	1.05E-04
NB 95	6.22E-09	3.46E-09	1.86E-09	NO DATA	3.42E-09	NO DATA	2.10E-05
MO 99	NO DATA	4.31E-06	8.20E-07	NO DATA	9.76E-06	NO DATA	9.99E-06
TC 99M	2.47E-10	6.98E-10	8.89E-09	NO DATA	1.06E-08	3.42E-10	4.13E-07
TC101	2.54E-10	3.66E-10	3.59E-09	NO DATA	6.59E-09	1.87E-10	1.10E-21
RU103	1.85E-07	NO DATA	7.97E-08	NO DATA	7.06E-07	NO DATA	2.16E-05
RU105	1.54E-08	NO DATA	6.08E-07	NO DATA	1.99E-07	NO DATA	9.42E-06

*Values in Table 1.2-2 are taken from Reference 3, Table E-11

TABLE 1.2-2 (Continued)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
RU106	2.75E-06	NO DATA	3.48E-07	NO DATA	5.31E-06	NO DATA	1.78E-04
AG110M	1.60E-07	1.48E-07	8.79E-08	NO DATA	2.91E-07	NO DATA	6.04E-05
TE125M	2.69E-06	9.71E-07	3.57E-07	8.06E-07	1.09E-05	NO DATA	1.07E-05
TE127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	NO DATA	2.27E-05
TE127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	NO DATA	8.68E-06
TE129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	NO DATA	5.79E-05
TE129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	NO DATA	2.37E-08
TE131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	NO DATA	8.40E-05
TE131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	9.63E-08	NO DATA	2.79E-09
TE132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	NO DATA	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	NO DATA	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	NO DATA	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	NO DATA	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	NO DATA	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	NO DATA	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	NO DATA	1.31E-06
CS134	6.22E-05	1.48E-04	1.21E-04	NO DATA	4.79E-05	1.59E-05	2.59E-06
CS136	6.51E-06	2.57E-05	1.85E-05	NO DATA	1.43E-05	1.96E-06	2.92E-06
CS137	7.97E-05	1.09E-04	7.14E-05	NO DATA	3.70E-05	1.23E-05	2.11E-06
CS138	5.52E-08	1.09E-07	5.40E-08	NO DATA	8.01E-08	7.91E-09	4.65E-13
BA139	9.70E-08	6.91E-11	2.84E-09	NO DATA	6.46E-11	3.92E-11	1.72E-07
BA140	2.03E-05	2.55E-08	1.33E-06	NO DATA	8.67E-09	1.46E-08	4.18E-05
BA141	4.71E-08	3.56E-11	1.59E-09	NO DATA	3.31E-11	2.02E-11	2.22E-17
BA142	2.13E-08	2.19E-11	1.34E-09	NO DATA	1.85E-11	1.24E-11	3.00E-26
LA140	2.50E-09	1.26E-09	3.33E-10	NO DATA	NO DATA	NO DATA	9.25E-05
LA142	1.28E-10	5.82E-11	1.45E-11	NO DATA	NO DATA	NO DATA	4.25E-07
CE141	9.36E-09	6.33E-09	7.18E-10	NO DATA	2.94E-09	NO DATA	2.42E-05
CE143	1.65E-09	1.22E-06	1.35E-10	NO DATA	5.37E-10	NO DATA	4.56E-05
CE144	4.88E-07	2.04E-07	2.62E-08	NO DATA	1.21E-07	NO DATA	1.65E-04
PR143	9.20E-09	3.69E-09	4.56E-10	NO DATA	2.13E-09	NO DATA	4.03E-05
PR144	3.01E-11	1.25E-11	1.53E-12	NO DATA	7.05E-12	NO DATA	4.33E-18
ND147	6.29E-09	7.27E-09	4.35E-10	NO DATA	4.25E-09	NO DATA	3.49E-05
W 197	1.03E-07	8.61E-08	3.01E-08	NO DATA	NO DATA	NO DATA	2.82E-05
NP239	1.19E-09	1.17E-10	6.45E-11	NO DATA	3.65E-10	NO DATA	2.40E-05

TABLE 1.2-3

SITE RELATED INGESTION DOSE COMMITMENT FACTOR, $A_{i\tau}$*

(mrem/hr per µCi/ml)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
C-14	3.15E+04	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03
Na-24	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02	5.40E+02
P-32	4.62E+07	2.87E+06	1.79E+06	0.00E+00	0.00E+00	0.00E+00	5.20E+06
Cr-51	0.00E+00	0.00E+00	1.49E+00	8.94E-01	3.2[illegible]E-01	1.98E+00	3.76E+02
Mn-54	0.00E+00	4.76E+03	9.08E+02	0.00E+00	1.42E+03	0.00E+00	1.46E+04
Mn-56	0.00E+00	1.20E+02	2.12E+01	0.00E+00	1.52E+02	0.00E+00	3.82E+03
Fe-55	8.87E+02	6.13E+02	1.43E+02	0.00E+00	0.00E+00	3.42E+02	3.52E+02
Fe-59	1.40E+03	3.29E+03	1.26E+03	0.00E+00	0.00E+00	9.19E+02	1.10E+04
Co-58	0.00E+00	1.31E+02	2.93E+02	0.00E+00	0.00E+00	0.00E+00	2.66E+03
Co-60	0.00E+00	4.34E+02	9.50E+02	0.00E+00	0.00E+00	0.00E+00	8.16E+03
Ni-63	4.19E+04	2.91E+03	1.41E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+02
Ni-65	1.70E+02	2.21E+01	1.01E+01	0.00E+00	0.00E+00	0.00E+00	5.61E+02
Cu-64	0.00E+00	1.69E+01	7.93E+00	0.00E+00	4.26E+01	0.00E+00	1.44E+03
Zn-65	2.36E+04	7.50E+04	3.39E+04	0.00E+00	5.02E+04	0.00E+00	4.73E+04
Zn-69	5.02E+01	9.60E+01	6.67E+00	0.00E+00	6.24E+01	0.00E+00	1.44E+01
Br-83	0.00E+00	0.00E+00	4.30E+01	0.00E+00	0.00E+00	0.00E+00	6.19E+01
Br-84	0.00E+00	0.00E+00	5.57E+01	0.00E+00	0.00E+00	0.00E+00	4.37E-04
Br-85	0.00E+00	0.00E+00	2.28E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-15
Rb-86	0.00E+00	1.03E+05	4.79E+04	0.00E+00	0.00E+00	0.00E+00	2.03E+04
Rb-88	0.00E+00	2.95E+02	1.56E+02	0.00E+00	0.00E+00	0.00E+00	4.07E-09
Rb-89	0.00E+00	1.95E+02	1.37E+02	0.00E+00	0.00E+00	0.00E+00	1.13E-11
Sr-89	4.70E+04	0.00E+00	1.37E+03	0.00E+00	0.00E+00	0.00E+00	7.66E+03
Sr-90	1.18E+06	0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00	3.40E+04
Sr-91	8.79E+02	0.00E+00	3.55E+01	0.00E+00	0.00E+00	0.00E+00	4.19E+03
Sr-92	3.33E+02	0.00E+00	1.44E+01	0.00E+00	0.00E+00	0.00E+00	6.60E+03
Y-90	1.38E+00	0.00E+00	3.69E-02	0.00E+00	0.00E+00	0.00E+00	1.46E+04
Y-91m	1.30E-02	0.00E+00	5.04E-04	0.00E+00	0.00E+00	0.00E+00	3.82E-02
Y-91	2.02E+01	0.00E+00	5.39E-01	0.00E+00	0.00E+00	0.00E+00	1.11E+04
Y-92	1.21E-01	0.00E+00	3.53E-03	0.00E+00	0.00E+00	0.00E+00	2.12E+03
Y-93	3.83E-01	0.00E+00	1.06E-02	0.00E+00	0.00E+00	0.00E+00	1.22E+04
Zr-95	2.77E+00	8.88E-01	6.01E-01	0.00E+00	1.39E+00	0.00E+00	2.82E+03
Zr-97	1.53E-01	3.09E-02	1.41E-02	0.00E+00	4.67E-02	0.00E+00	9.57E+03
Nb-95	4.47E+02	2.49E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+06
Mo-99	0.00E+00	4.61E+02	8.79E+01	0.00E+00	1.05E+03	0.00E+00	1.07E+03
Tc-99m	2.94E-02	8.32E-02	1.06E+00	0.00E+00	1.26E+00	4.07E-02	4.92E+01
Tc-101	3.02E-02	4.36E-02	4.28E-01	0.00E+00	7.85E-01	2.23E-02	1.31E-13
Ru-103	1.99E+01	0.00E+00	8.54E+00	0.00E+00	7.57E+01	0.00E+00	2.31E+03
Ru-105	1.65E+00	0.00E+00	6.52E-01	0.00E+00	2.13E+01	0.00E+00	1.01E+03
Ru-106	2.95E+02	0.00E+00	3.73E+01	0.00E+00	5.69E+02	0.00E+00	1.91E+04
Ag-110m	1.42E+01	1.31E+01	7.80E+00	0.00E+00	2.58E+01	0.00E+00	5.36E+03
Te-125m	2.79E+03	1.01E+03	3.74E+02	8.39E+02	1.13E+04	0.00E+00	1.11E+04
Te-127m	7.05E+03	2.52E+03	8.59E+02	1.80E+03	2.86E+04	0.00E+00	2.36E+04
Te-127	1.14E+02	4.11E+01	2.48E+01	8.48E+01	4.66E+02	0.00E+00	9.03E+03
Te-129m	1.20E+04	4.47E+03	1.89E+03	4.11E+03	5.00E+04	0.00E+00	6.03E+04
Te-129	3.27E+01	1.23E+01	7.96E+00	2.51E+01	1.37E+02	0.00E+00	2.47E+01
Te-131m	1.80E+03	8.81E+02	7.34E+02	1.39E+03	8.92E+03	0.00E+00	8.74E+04
Te-131	2.05E+01	8.57E+00	6.47E+00	1.69E+01	8.99E+01	0.00E+00	2.90E+00
Te-132	2.62E+03	1.70E+03	1.59E+03	1.87E+03	1.63E+04	0.00E+00	8.02E+04
I-130	9.01E+01	2.66E+02	1.05E+02	2.25E+04	4.15E+02	0.00E+00	2.29E+02
I-131	4.96E+02	7.09E+02	4.06E+02	2.32E+05	1.22E+03	0.00E+00	1.87E+02
I-132	2.42E+01	6.47E+01	2.26E+01	2.26E+03	1.03E+02	0.00E+00	1.22E+01
I-133	1.69E+02	2.94E+02	8.97E+01	4.32E+04	5.13E+02	0.00E+00	2.64E+02
I-134	1.26E+01	3.43E+01	1.23E+01	5.94E+02	5.46E+01	0.00E+00	2.99E-02
I-135	5.28E+01	1.38E+02	5.10E+01	9.11E+03	2.22E+02	0.00E+00	1.56E+02
Cs-134	3.03E+05	7.21E+05	5.89E+05	0.00E+00	2.33E+05	7.75E+04	1.26E+04
Cs-136	3.17E+04	1.25E+05	9.01E+04	0.00E+00	6.97E+04	9.55E+03	1.42E+04
Cs-137	3.88E+05	5.31E+05	3.48E+05	0.00E+00	1.80E+05	5.95E+04	1.03E+04
Cs-138	2.69E+02	5.31E+02	2.63E+02	0.00E+00	3.90E+02	3.85E+01	2.27E-03
Ba-139	9.00E+00	6.41E-03	2.64E-01	0.00E+00	5.99E-03	3.64E-03	1.60E+01
Ba-140	1.88E+03	2.37E+00	1.23E+02	0.00E+00	8.05E-01	1.35E+00	3.88E+03
Ba-141	4.37E+00	3.30E-03	1.48E-01	0.00E+00	3.07E-03	1.87E-03	2.06E-09
Ba-142	1.98E+00	2.03E-03	1.24E-01	0.00E+00	1.72E-03	1.15E-03	2.78E-10
La-140	3.58E-01	1.80E-01	4.76E-02	0.00E+00	0.00E+00	0.00E+00	1.32E+04
La-142	1.83E-02	8.33E-03	2.07E-03	0.00E+00	0.00E+00	0.00E+00	6.08E+01
Ce-141	8.21E-01	5.42E-01	6.15E-02	0.00E+00	2.52E-01	0.00E+00	2.07E+03
Ce-143	1.41E-01	1.04E+02	1.16E-02	0.00E+00	4.60E-02	0.00E+00	3.90E+03
Ce-144	4.18E+01	1.75E+01	2.24E+00	0.00E+00	1.04E+01	0.00E+00	1.41E+04
Pr-143	1.32E+00	5.28E-01	6.52E-02	0.00E+00	3.05E-01	0.00E+00	5.77E+03
Pr-144	4.31E-03	1.79E-03	2.19E-04	0.00E+00	1.01E-03	0.00E+00	6.19E-10
Nd-147	9.00E-01	1.04E+00	6.22E-02	0.00E+00	6.08E-01	0.00E+00	4.99E+03
W-187	3.04E+02	2.55E+02	8.90E+01	0.00E+00	0.00E+00	0.00E+00	8.34E+04
Np-239	1.28E-01	1.25E-02	6.91E-03	0.00E+00	3.91E-02	0.00E+00	2.57E+03

*Calculated using equation (32) and Tables 1.2-1 and 1.2-2.

1.3 Definitions of Effluent Parameters (continued

Term		Definition	Section of Initial Use
$A_{i\tau}$	=	the site related ingestion dose commitment factor to the total body or any organ τ, for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-uCi.	1.2
B	=	adjustment factor which will allow the setpoint to be established in a convenient manner and to prevent spurious alarms.	1.1.3.1
BF_i	=	Bioaccumulation Factor for nuclide i, in fish, pCi/Kg per pCi/l, from Table 1.2-1.	1.2
C	=	the effluent concentration limit (Specification 3.11.1.1) implementing 10CFR 20 for the site, in uCi/ml.	1.1.1
C_a	=	the effluent concentration of alpha emitting nuclides observed by gross alpha analysis of the monthly composite sample.	1.1.1
C_f	=	the measured concentration of Fe-55 in liquid waste as determined by analysis of the most recent available quarterly composite sample.	1.1.1
C_g	=	the effluent concentration of a gamma emitting nuclide, g, observed by gamma-ray spectroscopy of the waste sample.	1.1.1
C_i	=	the concentration of nuclide, i, as determined by the analysis of the waste sample.	1.1.1
C_{ik}	=	the average concentration of radionuclide, i, in undiluted liquid effluent during time period Δt_k from any liquid released, in uCi/ml.	1.2
C_{ir}	=	the concentration of radionuclide i in the Monticello Reservoir.	1.1.1
C_s	=	the concentration of Sr-89 or Sr-90 in liquid wastes as determined by analysis of the quarterly composite sample.	1.1.1

1.3 Definitions of Effluent Parameters (continued

Term		Definition	Section of Initial Use
C_t	=	the measured concentration of H-3 in liquid waste as determined by analysis of the monthly composite.	1.1.1
c	=	the setpoint, in uCi/ml, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release.	1.1.1
c_B	=	the monitor setpoint for RM-L7, the Nuclear Blowdown Monitor Tank discharge line monitor.	1.1.1
c_C	=	the monitor setpoint for RM-L9, the combined Liquid Waste Processing System and Nuclear Blowdown System effluent discharge line monitor.	1.1.1
c_D	=	the monitor setpoint for RM-L11, the Condensate Demineralizer Backwash discharge line monitor.	1.1.3.1
c_M	=	the monitor setpoint for RM-L5, the Waste Monitor Tank discharge line monitor.	1.1.1
c_{Sa}	=	the monitor setpoint for RM-L3, the initial Steam Generator Blowdown Effluent line monitor.	1.1.3.1
c_{Sb}	=	the monitor setpoint for RM-L10, the final Steam Generator Blowdown Effluent line monitor.	1.1.3.1
c_T	=	the monitor setpoint for RM-L8, the Turbine Building Sump Effluent line monitor.	1.1.3.1
CF_D	=	the Condensate Demineralize Backwash Effluent Concentration Factor.	1.1.3.1
CF_S	=	the Steam Generator Blowdown Effluent Concentration Factor.	1.1.3.2
CF_T	=	the Turbine Building Sump Effluent Concentration Factor.	1.1.3.1

Term		Definition	Section of Initial Use
DF	=	the dilution factor, which is the ratio of the total dilution flow rate to the effluent stream flow rate(s)	1.1.1
$DF_{i\tau}$	=	a dose conversion factor for nuclide, i, for adults in preselected organ, τ, in mrem/pCi found in Table 1.2-2.	1.2
D_{τ}	=	the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period.	1.2
D_w	=	Dilution Factor from the near field area within one-quarter mile of the release points to the potable water intake for adult water consumption; for V. C. Summer, D_w = 1.	1.2
F	=	the dilution water flow setpoint as determined prior to the release, in volume per unit time.	1.1.1
F_d	=	the flow rate of the Circulating Water System during the time of release of the Turbine Building Sump and/or the Steam Generator Blowdown.	1.1.3.1
F_{dc}	=	the dilution flow rate of the Circulating Water System upon which the setpoint is based, as corrected for any recirculated radioactivity.	1.1.3.1
F_t	=	the flow rate of water through the Fairfield Pumped Storage Station penstock(s) to which radioactive liquids are being discharged during the period of effluent release.This flow rate is dependent upon operational status of Fairfield Pumped Storage Station.	1.1.1
f	=	the flow setpoint as determined for the radiation monitor location.	1.1.1
f_d	=	the maximum permissible discharge flow-rate for releases to the Circulating Water.	1.1.3.1

Term		Definition	Section of Initial Use
f_{db}	=	the flow rate of the Nuclear Blowdown Monitor Tank discharge.	1.1.1
f_{dm}	=	the flow rate of a Waste Monitor Tank discharge.	1.1.1
f_{ds}	=	the flow rate of the Steam Generator Blowdown discharge.	1.1.3.1
f_r	=	the recirculation flow rate used to mix the contents of a tank.	1.1.1
f_t	=	the maximum permissible discharge flow rate for batch releases to the penstocks.	1.1.1
F_{dp}	=	the dilution flow rate through the penstock(s) receiving the radioactive liquid release upon which the effluent monitor setpoint is based, as corrected for any recirculated radioactivity.	1.1.1
F_k	=	the near field average dilution factor for C_{ik} during any liquid effluent release.	1.2
K_o	=	1.14×10^5, units conversion factor.	1.2
MPC_i	=	MPC_g, MPC_a, MPC_s, MPC_f, and MPC_t = the limiting concentrations of the appropriate gamma emitting, alpha emitting, and strontium radionuclides, Fe-55, and tritium, respectively, from 10CFR, Part 20, Appendix B, Table II, Column 2. For gamma emitting noble gas radionuclides, $MPC_i = 2 \times 10^{-4}$ uCi/ml, according to the Radiological Effluent Technical Specifications.	1.1.1
SF	=	the safety factor, a conservative factor used to compensate for engineering and measurement uncertainties. SF = 0.5, corresponding to a 100 percent variation.	1.1.1
$[\Sigma C_i]_B$	=	the sum of the measured radionuclide concentrations of the Nuclear Blowdown Monitor Tank.	1.1.1

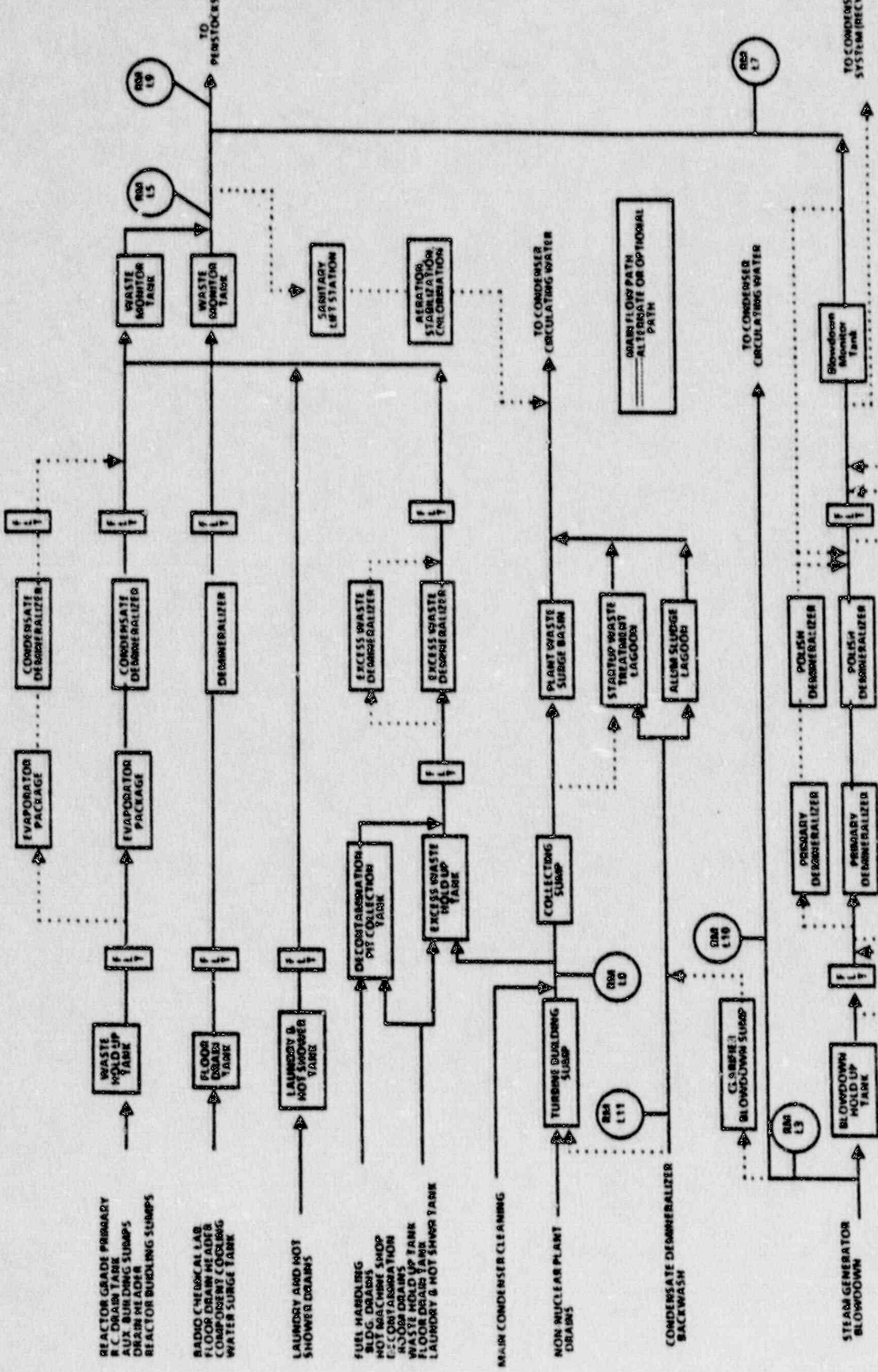
Term		Definition	Section of Initial Use
$[C_i]_{LLD}$	=	the Lower Limit of Detection, LLD, for radionuclide i in liquid waste in the Waste Monitor Tank, as determined by Technical Specifications, Table 4.11-1.	1.1.2
$[\Sigma C_i]_M$	=	the sum of the measured radionuclide concentrations for a Waste Monitor Tank.	1.1.1
$[\Sigma C_i]_S$	=	the sum of the measured radionuclide concentrations for the Steam Generator Blowdown	1.1.3.1
$[\Sigma C_i]_D$	=	the sum of the measured radionuclide concentrations for the Condensate Demineralizer Backwash.	1.1.3.1
$[\Sigma C_i]_T$	=	the sum of the measured radionuclide concentrations for the Turbine Building Sump.	1.1.3.1
$[\Sigma (C_i/MPC_i)]_B$	=	the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Nuclear Blowdown Monitor Tank.	1.1.1
$[\Sigma (C_i/MPC_i)]_M$	=	the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Waste Monitor Tank being considered for release.	1.1.1
$[\Sigma (C_i/MPC_i)]_S$	=	the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Steam Generator Blowdown Effluent.	1.1.3.1
$[\Sigma (C_i/MPC_i)]_D$	=	the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Condensate Demineralizer Backwash.	1.1.3.1
$[\Sigma (C_i/MPC_i)]_T$	=	the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Turbine Building Sump Effluent.	1.1.3.1
t_r	=	the minimum time for recirculating the contents of a tank prior to sampling.	1.1.1

1.3 Definitions of Effluent Parameters (continued

Term		Definition	Section of Initial Use
Δt_k	=	the length in hours of a time period over which concentrations and flow rates are averaged for dose calculations.	1.2
U_F	=	21 kg/yr, fish consumption (adult).	1.2
U_w	=	730 kg/yr, water consumption (adult).	1.2
V	=	the volume of liquid in a tank to be sampled.	1.1.1
Z	=	applicable near-field dilution factor when no additional dilution is to be considered; Z = 1.	1.2

1.4 LIQUID RADWASTE TREATMENT SYSTEM

Figure 1.4-1



2.0 GASEOUS EFFLUENTS

2.1 Gaseous Effluent Monitor Setpoints

The calculated setpoint values will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value.

2.1.1 Station Vent Noble Gas Monitors

For the purpose of implementation of section 3.3.3.9 of the Technical Specifications, the alarm setpoint level for the station vent noble gas monitors will be calculated as follows:

S_v = count rate of the plant vent noble gas monitor (= S_{vp} for RM-A3) or the containment purge noble gas monitor (= S_{vc} for RM-A4) at the alarm setpoint level.

$$\leq \text{the lesser of } \begin{cases} 0.25 \times R_t \times D_{TB} & (33) \\ \quad \text{or} & \\ 0.25 \times R_s \times D_{SS} & (34) \end{cases}$$

0.25 = the safety factor applied to each of the two vent noble gas monitors (plant vent and containment purge) to assure that the sum of the releases has a combined safety factor of 0.5 which allows a 100 percent margin for cumulative uncertainties of measurements.

D_{TB} = Dose rate limit to the total body of an individual
= 500 mrem/yr

R_t = count rate per mrem/yr to the total body

$$= C_v / ((\overline{X/Q}) \times F_v \times \sum_i K_i X_{iv}) \quad (35)$$

X_{iv} = the measured concentration of noble gas radionuclide i in the last grab sample analyzed for vent v, µCi/ml. (For the plant vent, grab samples are taken at least monthly. For the 6" and 36" containment purge lines, the sample is taken just prior to the release and also monthly, if the release is continuous.)

F_v = the flow rate in vent v, cc/sec. (1 cc/sec = 0.002119 cfm)

C_v = count rate of the monitor on station vent v corresponding to grab sample noble gas concentrations, X_{iv}, as determined from the monitor's calibration curve. (Initial calibration curves of the type shown in Figure 2.1-1 have been determined conservatively from families of response curves supplied by the monitor manufacturers. As releases occur, a historical correlation will be prepared and placed in service when sufficient data are accumulated.)

$\overline{X/Q}$ = the highest annual average relative concentration in any sector, at the site boundary.

= 5.3×10^{-6} sec/m^3 in the SE sector*

K_i = total body dose factor due to gamma emissions from isotope i (mrem/yr per µCi/m^3) from Table 2.1-1.

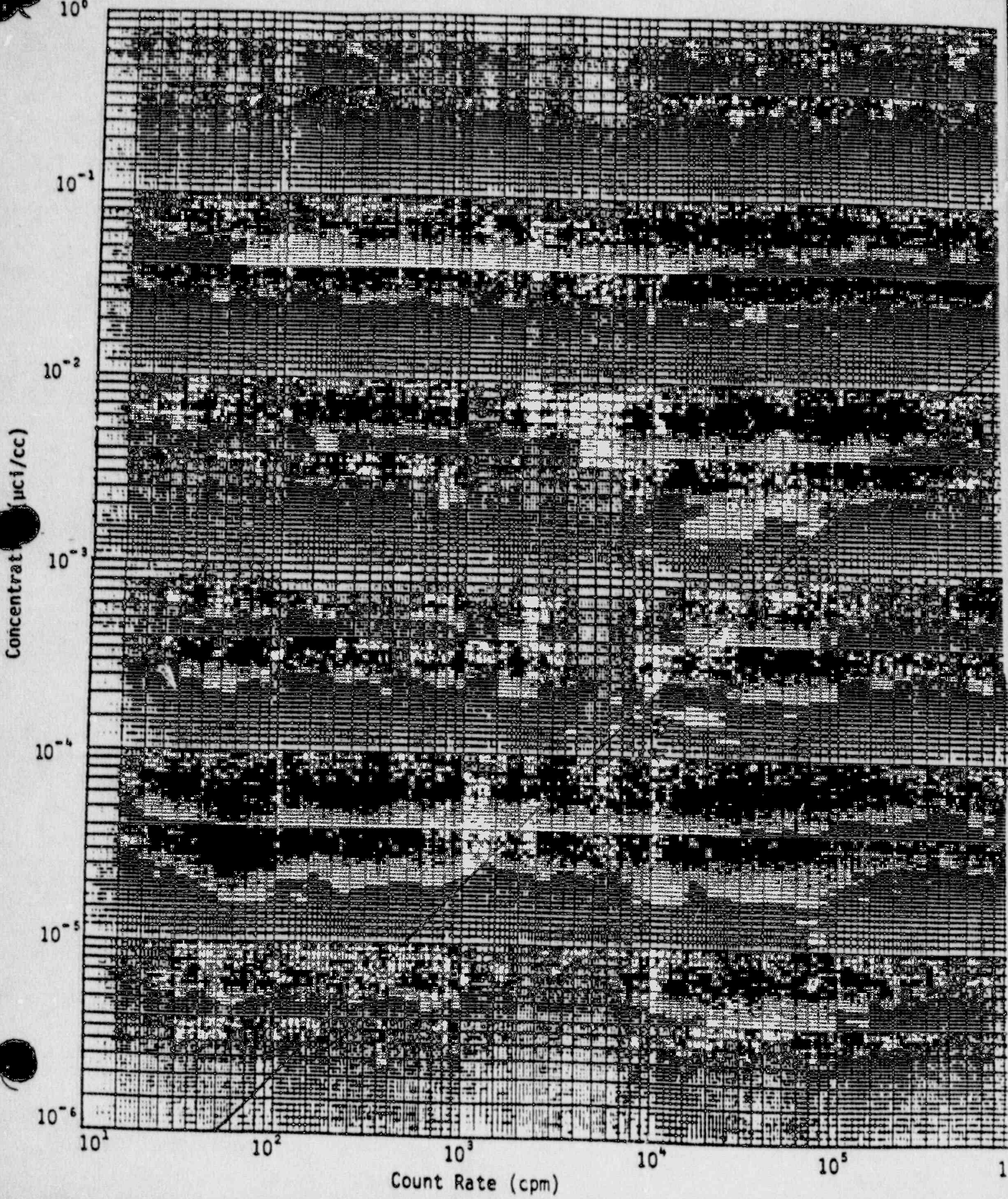
D_{SS} = Dose rate limit to the skin of the body of an individual in an unrestricted area

= 3000 mrem/year.

* Reference 4, Section 11.3.8 states that this is the annual average relative dispersion at the point on the exclusion boundary where highest concentrations may be expected.

Figure 2.1-1

Sample Noble Gas Monitor Calibration



R_s = count rate per mrem/yr to the skin

$$= Cv \div [\overline{X/Q} \times F_v \times \sum_i (L_i + 1.1M_i) X_{iv}] \quad (36)$$

L_i = skin dose factor due to beta emissions from isotope i (mrem/yr per µCi/m^3) from Table 2.1-1.

1.1 = mrem skin dose per mrad air dose

M_i = air dose factor due to gamma emissions from isotope i (mrad/yr per µCi/m^3) from Table 2.1-1.

NOTE: If two simultaneous releases out of the main plant vent should occur, calculate the setpoint for each type of release and use lowest setpoint obtained. At plant startups when no grab sample analysis is available for the continuous releases, the Alternate Methodology of Section 2.1.3 must be used.

2.1.2 Waste Gas Decay System

The permissible conditions for discharge through the waste gas decay system monitor (RM-A10) will be calculated in a manner similar to that for the plant vent noble gas monitor. In the case of the waste gas system, however, the discharge flow rate is continuously controllable by valve HCV-014 and permissible release conditions are therefore defined in terms of both flow rate and concentration. Whereas, RMA-10 is used only to insure that a representative sample was obtained.

For operational convenience, (to prevent spurious alarms due to fluctuations in background) the setpoint level will be established at 1.5 times the measured waste concentration.

The maximum permissible flow rate will be set on the same basis but include the engineering safety factor of 0.5. The RM-A10 setpoint level S_d is defined as:

$$S_d \leq 1.5c \qquad (37)$$

where:

c = count rate of the waste gas decay system monitor corresponding to the measured concentration (µCi/ml).

The maximum permissible waste gas flowrate f_w (cc/sec) is calculated from the maximum permissible dose rates at the site boundary according to:

$$f_w \leqq \text{the lesser of } f_t \text{ or } f_s \qquad (38)$$

where:

f_t = the maximum permissible discharge rate based on total body dose rate.

$$= 0.25 \times D_{TB} / [\overline{X/Q} \times 1.5 \sum_i X_{id} K_i] \qquad (39)$$

f_s = the maximum permissible discharge rate based on skin dose rate.

$$= 0.25 \times D_{SS} / [\overline{X/Q} \times 1.5 \sum_i X_{id} (L_i + 1.1M_i)] \qquad (40)$$

X_{id} = the concentration of noble gas radionuclide i in the waste gas decay tank whose contents are to be discharged, as corrected to the pressure of the discharge stream at the point of the flowrate measurement. The maximum discharge pressure as governed by the diaphragm valve, 7896, is 30 psia.

NOTE: The factor of 1.5 in the denominators of equations (39) and (40) places f_w on the same basis as S_d.

When a discharge is to be conducted, valve HCV-014 is to be opened until (a) the waste gas discharge flowrate reaches 0.9 x f_w or (b) the count rate of the plant vent noble gas monitor RM-A3 approaches its setpoint, whichever of the above conditions is reached first.

When no discharges are being made from the Waste Gas Decay System, the RM-A10 setpoint should be established as near background as practical to prevent spurious alarms and yet alarm in the event of an inadvertent release.

2.1.3 Alternative Methodology for Establishing Conservative Setpoints

A more conservative setpoint may be calculated to minimize requirements for adjustment of the monitor as follows:

For a plant vent:

R_t' = conservative count rate per mrem/yr to the total body (Xe-133 detection, Kr-89 dose).

$$= C_v' \div [\overline{X/Q} \times K_{Kr\text{-}89} \times X_v' \times F_v], \quad (41)$$

where:

X_v' = a concentration of Xe-133 chosen to be in the operating range of the monitor on vent v, µCi/cc.

C_v' = the count rate of the monitor on vent v corresponding to X_v' µCi/cc of Xe-133.

$K_{Kr\text{-}89}$ = total body dose factor for Kr-89, the most restrictive isotope from Table 2.1-1.

R_s' = count rate per mrem/yr to the skin.

$$= C_v' \div [\overline{X/Q} \times (L_{Kr\text{-}89} + 1.1M_{Kr\text{-}89}) \times X_v' \times F_v] \quad (42)$$

where:

$L_{Kr\text{-}89}$ = skin dose factor for Kr-89, the most restrictive isotope from Table 2.1-1.

$M_{Kr\text{-}89}$ = air dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1.

For the waste gas decay system:

f_t' = the conservative maximum permissible discharge rate based on Kr-89 total body dose rate.

$$= 0.25 \times D_{TB} \div [\overline{X/Q} \times 1.5 \times X_d' \times K_{Kr\text{-}89}] \quad (43)$$

f_s' = the conservative maximum permissible discharge rate based on Kr-89 skin dose rate.

$$= 0.25 \times D_{SS} \div [\overline{X/Q} \times 1.5 \times X_d' \times (L_{Kr\text{-}89} + 1.1M_{Kr\text{-}89})] \quad (44)$$

X_d' = the total concentration of noble gas radionuclides in the waste gas decay tank whose contents are to be discharged, as corrected to the pressure of the discharge stream at the point of the flow measurement.

c' = count rate of the waste gas decay system monitor corresponding to X_d' µCi/cc of Kr-85.

TABLE 2.1-1

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES.*

Nuclide	γ-Body*** (K)	β-Skin***(L)	γ-Air**(M)	β-Air**(N)
Kr-85m	1.17E+03****	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

*Values taken from Reference 3, Table B-1

** $\frac{mrad\text{-}m^3}{\mu Ci\text{-}yr}$

*** $\frac{mrem\text{-}m^3}{\mu Ci\text{-}yr}$

****1.17E+03 = 1.17×10^3

2.2 Gaseous Effluent Dose Calculations

2.2.1 Unrestricted Area Boundary Dose

2.2.1.a For the purpose of implementation of section 3.11.2.1a of the Technical Specifications, the dose at the unrestricted area boundary due to noble gases shall be calculated as follows:

D_t = current total body dose rate (mrem/yr)

$$= \overline{X/Q} \sum_i K_i \overline{\dot{Q}}_i \quad (45)$$

D_s = current skin dose rate (mrem/yr)

$$= \overline{X/Q} \sum_i (L_i + 1.1M_i) Q_i \quad (46)$$

where:

$\overline{\dot{Q}}_i$ = the release rate of noble gas radionuclide i as determined from the concentration measured in the analysis of the appropriate sample required by Radiological Effluent Technical Specification Table 4.11-2 (µCi/sec.).

$\overline{X/Q}$ = the highest annual average relative concentration in any sector, at the site boundary (for value, see Section 2.1.1).

2.2.1.b Organ doses due to radioiodines and all radioactive materials in particulate form and radionuclides (other than noble gases) with half-lives greater than eight days, will be calculated for the purpose of implementation of Technical Specification section 3.11.2.1.b as follows:

D_o = current organ dose rate (mrem/yr)

$$= \sum_i \overline{X/Q}\, P_i\, \bar{\dot{Q}}_i', \quad (47)$$

where:

$\overline{X/Q}$ = the highest annual average relative concentration in any sector, at the site boundary (for value, see Section 2.1.1)

P_i = dose parameter for radionuclide i, (mrem/yr per $\mu Ci/m^3$) for inhalation, from Table 2.2-1.

$\bar{\dot{Q}}_i'$ = the release rate of non-noble gas radionuclide i as determined from the concentrations measured in the analysis of the appropriate sample required by Radiological Effluent Technical Specification Table 4.11-2 (µCi/sec).

2.2.2 Unrestricted Area Dose to Individual

2.2.2.a For the purpose of sections 3.11.2.2 and 3.11.2.4 of the Technical Specifications, the air dose in unrestricted areas shall be determined as follows:

$D\gamma$ = air dose due to gamma emissions from noble gas radionuclide i (mrad)

$$= 3.17 \times 10^{-8} \sum_i M_i\, \overline{X/Q}\, \tilde{Q}_i \quad (48)$$

where:

3.17×10^{-8} = the fraction of one year per one second

$\tilde{Q}_i$ = cumulative release of noble gas radionuclide i over the period of interest (µCi).

D_β = air due to beta emissions from noble gas radionuclide i (mrad).

$$= 3.17 \times 10^{-8} \sum_i N_i \overline{X/Q} \widehat{Q}_i \qquad (49)$$

where:

N_i = air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per $\mu Ci/m^3$) from Table 2.1-1.

2.2.2.b Dose to an individual from radioiodines and radioactive materials in particulate form and radionuclides (other than noble gases), with half-lives greater than eight (8) days will be calculated for the purpose of implementation of section 3.11.2.3 of the Technical Specifications as follows:

D_p = dose to an individual from radioiodines and radionuclides in particulate form, with half-lives greater than eight days (mrem)

$$= 3.17 \times 10^{-8} \sum_{ij} R_{ij} \, W_{ij}' \widehat{Q}_i', \qquad (50)$$

where:

W_{ij}' = relative concentration or relative deposition for the maximum exposed individual, as appropriate for exposure pathway j and radionuclide i.

= { $\overline{X/Q}'$ for inhalation and all tritium pathways
= 2.2×10^{-6} sec/m^3

$\overline{D/Q}'$ for other pathways and non-tritium radionuclides
= 8.4×10^{-9} m^{-2} }

(See the notes to Table 2.2-7 and 2.2-8 for the origin of these factors.)

R_{ij} = dose factor for radionuclide i and pathway j, (mrem/yr per $\mu Ci/m^3$) or (m^2 · mrem/yr per $\mu Ci/sec$) from Table 2.2-2.

$\tilde{Q}_i'$ = Cumulative release of non-noble gas radionuclide i (required by Technical Specification 3.11.2.3) over the period of interest (μCi).

2.2.2.c For the purpose of initial assessments of the impact of unplanned gaseous releases required by Section 6.9.1.13 of the RETS, dose calculations for the critical receptor in each affected sector may be performed using the above equations as follows. For each location, X/Q' and D/Q' will be calculated according to the methods of Section 2.3 of this ODCM, using the measured meteorological parameters for the period of the unplanned release. The location of the critical receptors and the pathways j which should be analyzed for each are shown in Table 2.2-7. (For very rough calculations, the annual average $\overline{X/Q}$ and $\overline{D/Q}$ for each receptor are shown in Table 2.2-8.) The R_{ij} for the appropriate exposure pathways and age groups will be selected from Tables 2.2-3 through 2.2-6.

Table 2.2-1

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)*

Page 1 of 3

AGE GROUP (CHILD)

ISOTOPE	INHALATION
H-3	1.125E+03
C-14	3.589E+04
NA-24	1.610E+04
P-32	2.605E+06
CR-51	1.698E+04
MN-54	1.576E+06
MN-56	1.232E+05
FE-55	1.110E+05
FE-59	1.269E+06
CO-58	1.106E+06
CO-60	7.067E+06
NI-63	8.214E+05
NI-65	8.399E+04
CU-64	3.670E+04
ZN-65	9.953E+05
ZN-69	1.018E+04
BR-83	4.736E+02
BR-84	5.476E+02
BR-85	2.531E+01
RB-86	1.983E+05
RB-88	5.624E+02
RB-89	3.452E+02
SR-89	2.157E+06
SR-90	1.010E+08
SR-91	1.739E+05

* See note, page 2.0-16

Units - mrem/yr per $\mu Ci/m^3$

Table 2.2-1 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP (CHILD)

ISOTOPE	INHALATION
SR-92	2.424E+05
Y-90	2.679E+05
Y-91M	2.812E+03
Y-91	2.627E+06
Y-92	2.390E+05
Y-93	3.885E+05
ZR-95	2.231E+06
ZR-97	3.511E+05
NB-95	6.142E+05
MO-99	1.354E+05
TC-99M	4.810E+03
TC-101	5.846E+02
RU-103	6.623E+05
RU-105	9.953E+04
RU-106	1.432E+07
AG-110M	5.476E+06
TE-125M	4.773E+05
TE-127M	1.480E+06
TE-127	5.624E+04
TE-129M	1.761E+06
TE-129	2.549E+04
TE-131M	3.078E+05
TE-131	2.054E+03
TE-132	3.774E+05
I-130	1.846E+06

Units - mrem/yr per μCi/m^3

Table 2.2-1 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

Page 3 of 3

AGE GROUP (CHILD)

ISOTOPE	INHALATION
I-131	1.624E+07
I-132	1.935E+05
I-133	3.848E+06
I-134	5.069E+04
I-135	7.918E+05
CS-134	1.014E+06
CS-136	1.709E+05
CS-137	9.065E+05
CS-138	8.399E+02
BA-139	5.772E+04
BA-140	1.743E+06
BA-141	2.919E+03
BA-142	1.643E+03
LA-140	2.257E+05
LA-142	7.585E+04
CE-141	5.439E+05
CE-143	1.273E+05
CE-144	1.195E+07
PR-143	4.329E+05
PR-144	1.565E+03
ND-147	3.282E+05
W-187	9.102E+04
NP-239	6.401E+04

Units - mrem/yr per $\mu Ci/m^3$

NOTE: The P_i values of Table 2.2-1 were calculated according to the methods of Reference 1, Section 5.2.1, for children. The values used for the various parameters and the origins of those values are given below in Table 2.2-9 and its notes.

Table 2.2-2

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)*

(For Dose Calculations Required by TS 3.11.2.3)

Page 1 of 3

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
H-3	1.125E+03	0.000E+00	3.627E+03
C-14	3.589E+04	0.000E+00	8.894E+08
NA-24	1.610E+04	1.385E+07	3.729E+05
P-32	2.605E+06	0.000E+00	3.366E+09
CR-51	1.698E+04	5.506E+06	6.213E+06
MN-54	1.576E+06	1.625E+09	6.648E+08
MN-56	1.232E+05	1.068E+06	2.723E+03
FE-55	1.110E+05	0.000E+00	8.012E+08
FE-59	1.269E+06	3.204E+08	6.693E+08
CO-58	1.106E+06	4.464E+08	3.771E+08
CO-60	7.067E+06	2.532E+10	2.095E+09
NI-63	8.214E+05	0.000E+00	3.949E+10
NI-65	8.399E+04	3.451E+05	1.211E+03
CU-64	3.670E+04	6.876E+05	5.159E+05
ZN-65	9.953E+05	8.583E+08	2.164E+09
ZN-69	1.018E+04	0.000E+00	9.893E-04
BR-83	4.736E+02	7.079E+03	5.369E+00
BR-84	5.476E+02	2.363E+05	3.822E-11
BR-85	2.531E+01	0.000E+00	0.000E+00
RB-86	1.983E+05	1.035E+07	4.584E+08
RB-88	5.624E+02	3.779E+04	4.374E-22
RB-89	3.452E+02	1.452E+05	1.642E-26
SR-89	2.157E+06	2.509E+04	3.593E+10
SR-90	1.010E+08	0.000E+00	1.243E+12
SR-91	1.739E+05	2.511E+06	1.157E+06

* See note, page 2.0-31

Units:

Inhalation and all tritium - mrem/yr per uCi/m^3

Others - m^2 · mrem/yr per uCi/sec

Table 2.2-2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)

Page 2 of 3

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
SR-92	2.424E+05	8.631E+05	1.378E+04
Y-90	2.679E+05	5.308E+03	6.569E+07
Y-91M	2.812E+03	1.161E+05	1.737E-05
Y-91	2.627E+06	1.207E+06	2.484E+09
Y-92	2.390E+05	2.142E+05	4.576E+04
Y-93	3.885E+05	2.534E+05	4.482E+06
ZR-95	2.231E+06	2.837E+08	8.843E+08
ZR-97	3.511E+05	3.445E+06	1.248E+07
NB-95	6.142E+05	1.605E+08	2.949E+08
MO-99	1.354E+05	4.626E+06	1.647E+07
TC-99M	4.810E+03	2.109E+05	5.255E+03
TC-101	5.846E+02	2.277E+04	4.123E-29
RU-103	6.623E+05	1.265E+08	3.971E+08
RU-105	9.953E+04	7.212E+05	5.981E+04
RU-106	1.432E+07	5.049E+08	1.159E+10
AG-110M	5.476E+06	4.019E+09	2.581E+09
TE-125M	4.773E+05	2.128E+06	3.506E+08
TE-127M	1.480E+06	1.083E+05	3.769E+09
TE-127	5.624E+04	3.293E+03	3.903E+05
TE-129M	1.761E+06	2.305E+07	2.460E+09
TE-129	2.549E+04	3.076E+04	7.204E-02
TE-131M	3.078E+05	9.459E+06	2.163E+07
TE-131	2.054E+03	3.450E+07	1.349E-14
TE-132	3.774E+05	4.968E+06	3.111E+07
I-130	1.846E+06	6.692E+06	1.370E+08

Units: Inhalation - mrem/yr per μCi/m^3

Others - m^2 · mrem/yr per μCi/sec

Table 2.2-2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
I-131	1.624E+07	2.089E+07	4.754E+10
I-132	1.935E+05	1.452E+06	7.314E+03
I-133	3.848E+06	2.981E+06	8.113E+08
I-134	5.069E+04	5.305E+05	6.622E-03
I-135	7.918E+05	2.947E+06	9.973E+06
CS-134	1.014E+06	8.007E+09	2.631E+10
CS-136	1.709E+05	1.702E+08	2.247E+08
CS-137	9.065E+05	1.201E+10	2.392E+10
CS-138	8.399E+02	4.102E+05	9.133E-11
BA-139	5.772E+04	1.194E+05	2.950E+00
BA-140	1.743E+06	2.346E+07	2.767E+08
BA-141	2.919E+03	4.734E+04	1.605E-21
BA-142	1.643E+03	5.064E+04	4.105E-39
LA-140	2.257E+05	2.180E+07	3.166E+07
LA-142	7.585E+04	8.886E+05	1.582E+01
CE-141	5.439E+05	1.540E+07	4.082E+08
CE-143	1.273E+05	2.627E+06	1.364E+07
CE-144	1.195E+07	8.032E+07	1.039E+10
PR-143	4.329E+05	0.000E+00	1.575E+08
PR-144	1.565E+03	2.112E+03	3.829E-23
ND-147	3.282E+05	1.009E+07	9.197E+07
W-187	9.102E+04	2.740E+06	5.380E+06
NP-239	6.401E+04	1.976E+06	1.357E+07

Units: Inhalation - mrem/yr per μCi/m^3

Others - m^2 · mrem/yr per μCi/sec

Table 2.2-3

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

(For Dose Calculations Required by TS 6.9.1.13)

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AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
H-3	6.460E+02	0.000E+00	2.157E+03	0.000E+00	2.157E+03	0.000E+00	0.000E+00
C-14	2.646E+04	0.000E+00	2.340E+09	0.000E+00	8.109E+08	0.000E+00	0.000E+00
NA-24	1.056E+04	1.305E+07	1.542E+07	0.000E+00	2.306E-37	0.000E+00	0.000E+00
P-32	2.030E+06	0.000E+00	1.602E+11	0.000E+00	7.080E+00	0.000E+00	0.000E+00
CR-51	1.204E+04	5.506E+06	4.700E+06	0.000E+00	1.729E+05	0.000E+00	0.000E+00
MN-54	9.996E+05	1.623E+09	3.900E+07	0.000E+00	1.110E+07	0.000E+00	0.000E+00
MN-56	7.160E+04	1.060E+06	2.862E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
FE-55	8.694E+04	0.000E+00	1.351E+08	0.000E+00	4.439E+07	0.000E+00	0.000E+00
FE-59	1.015E+06	3.284E+08	3.919E+08	0.000E+00	3.304E+07	0.000E+00	0.000E+00
CO-58	7.770E+05	4.464E+08	6.055E+07	0.000E+00	8.024E+06	0.000E+00	0.000E+00
CO-60	4.500E+06	2.532E+10	2.090E+08	0.000E+00	7.107E+07	0.000E+00	0.000E+00
NI-63	3.300E+05	0.000E+00	3.493E+10	0.000E+00	1.221E+10	0.000E+00	0.000E+00
NI-65	5.012E+04	3.451E+05	3.020E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CU-64	1.490E+04	6.076E+05	3.007E+06	0.000E+00	7.934E-46	0.000E+00	0.000E+00
ZN-65	6.460E+05	8.583E+08	1.904E+10	0.000E+00	5.160E+09	0.000E+00	0.000E+00
ZN-69	1.322E+04	0.000E+00	3.055E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-83	3.000E+02	7.079E+03	9.339E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-84	4.004E+02	2.363E+05	1.256E-22	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BR-85	2.044E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.904E+05	1.035E+07	2.234E+10	0.000E+00	2.027E+08	0.000E+00	0.000E+00
RB-88	5.572E+02	3.779E+04	1.074E-44	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-89	3.206E+02	1.452E+05	4.193E-53	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	2.030E+06	2.509E+04	1.250E+10	0.000E+00	1.140E+08	0.000E+00	0.000E+00
SR-90	4.080E+07	[illegible]	5.216E+11	0.000E+00	4.230E+10	0.000E+00	0.000E+00
SR-91	7.336E+04	2.511E+06	3.215E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

* See note, page 2.0-32

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-3 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
SR-92	1.400E+05	8.631E+05	5.005E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-90	2.600E+05	5.300E+03	9.406E+05	0.000E+00	2.239E-05	0.000E+00	0.000E+00
Y-91M	2.706E+03	1.161E+05	1.076E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-91	2.450E+06	1.207E+06	5.251E+06	0.000E+00	6.324E+05	0.000E+00	0.000E+00
Y-92	1.266E+05	2.142E+05	1.026E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Y-93	1.666E+05	2.534E+05	1.776E+04	0.000E+00	1.032E-60	0.000E+00	0.000E+00
ZR-95	1.750E+06	2.037E+08	8.257E+05	0.000E+00	1.090E+05	0.000E+00	0.000E+00
ZR-97	1.400E+05	3.445E+06	4.446E+04	0.000E+00	4.900E-35	0.000E+00	0.000E+00
NB-95	4.700E+05	1.605E+08	2.062E+08	0.000E+00	3.213E+07	0.000E+00	0.000E+00
MO-99	1.340E+05	4.626E+06	3.100E+08	0.000E+00	1.523E-02	0.000E+00	0.000E+00
TC-99M	2.030E+03	2.109E+05	1.646E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TC-101	8.442E+02	2.277E+04	1.423E-56	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-103	5.516E+05	1.265E+08	1.055E+05	0.000E+00	7.573E+03	0.000E+00	0.000E+00
RU-105	4.844E+04	7.212E+05	3.204E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU-106	1.156E+07	5.049E+08	1.445E+06	0.000E+00	4.266E+05	0.000E+00	0.000E+00
AG-110M	3.660E+06	4.019E+09	1.461E+10	0.000E+00	3.904E+09	0.000E+00	0.000E+00
TE-125M	4.466E+05	2.120E+06	1.508E+08	0.000E+00	1.799E+07	0.000E+00	0.000E+00
TE-127M	1.312E+06	1.083E+05	1.037E+09	0.000E+00	2.046E+08	0.000E+00	0.000E+00
TE-127	2.436E+04	3.293E+03	1.359E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-129M	1.600E+06	2.305E+07	1.392E+09	0.000E+00	7.559E+07	0.000E+00	0.000E+00
TE-129	2.632E+04	3.076E+04	1.670E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-131M	1.900E+05	9.459E+06	2.200E+07	0.000E+00	1.653E-15	0.000E+00	0.000E+00
TE-131	8.210E+03	3.450E+07	1.304E-30	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE-132	3.402E+05	4.968E+06	6.513E+07	0.000E+00	1.041E-01	0.000E+00	0.000E+00
I-130	1.596E+06	6.692E+06	8.754E+08	0.000E+00	7.115E-45	0.000E+00	0.000E+00
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-3 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
I-131	1.484E+07	2.109E+07	1.653E+12	0.000E+00	1.567E+00	0.000E+00	0.000E+00
I-132	1.694E+05	1.452E+06	1.100E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-133	3.556E+06	2.981E+06	9.601E+09	0.000E+00	1.776E-28	0.000E+00	0.000E+00
I-134	4.452E+04	5.385E+05	8.402E-10	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I-135	6.958E+05	2.947E+06	2.002E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS-134	7.028E+05	8.007E+09	6.001E+10	0.000E+00	2.191E+10	0.000E+00	0.000E+00
CS-136	1.345E+05	1.702E+08	5.795E+09	0.000E+00	1.729E+09	0.000E+00	0.000E+00
CS-137	6.110E+05	1.201E+10	6.024E+10	0.000E+00	2.096E+10	0.000E+00	0.000E+00
CS-138	8.764E+02	4.102E+05	2.100E-22	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-139	5.096E+04	1.194E+05	2.074E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-140	1.596E+06	2.346E+07	8.410E+08	0.000E+00	6.489E+05	0.000E+00	0.000E+00
BA-141	4.746E+03	4.734E+04	3.141E-44	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA-142	1.554E+03	5.864E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-140	1.608E+05	2.180E+07	1.806E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA-142	5.950E+04	8.086E+05	6.019E-06	0.000E+00	4.563E-12	0.000E+00	0.000E+00
CE-141	5.166E+05	1.540E+07	1.366E+07	0.000E+00	7.080E+05	0.000E+00	0.000E+00
CE-143	1.162E+05	2.627E+06	1.536E+06	0.000E+00	1.839E-14	0.000E+00	0.000E+00
CE-144	9.042E+06	8.032E+07	1.334E+08	0.000E+00	3.749E+07	0.000E+00	0.000E+00
PR-143	4.326E+05	0.000E+00	7.045E+05	0.000E+00	2.771E+03	0.000E+00	0.000E+00
PR-144	4.284E+03	2.112E+03	1.171E-40	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ND-147	3.220E+05	1.069E+07	5.743E+05	0.000E+00	6.902E+02	0.000E+00	0.000E+00
W-187	3.962E+04	2.740E+06	2.501E+06	0.000E+00	5.275E-22	0.000E+00	0.000E+00
NP-239	5.956E+04	1.976E+06	9.400E+06	0.000E+00	9.684E-08	0.000E+00	0.000E+00
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-4

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

(For Dose Calculations Required by TS 6.9.1.13)

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AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
H-3	1.125E+03	0.000E+00	1.421E+03	2.110E+02	1.421E+03	2.542E+01	3.627E+03
C-14	3.589E+04	0.000E+00	1.195E+09	3.034E+08	4.101E+08	4.601E+07	8.894E+08
NA-24	1.610E+04	1.385E+07	8.053E+06	1.725E-03	1.321E-37	2.070E-04	3.729E+05
P-32	2.605E+06	0.000E+00	7.775E+10	7.411E+09	3.440E+08	8.893E+08	3.366E+09
CR-51	1.690E+04	5.506E+06	5.390E+06	4.661E+05	[illegible]	5.593E+04	6.213E+06
MN-54	1.576E+06	1.625E+09	2.897E+07	8.011E+06	6.012E+06	9.613E+05	6.640E+08
MN-56	1.232E+05	1.060E+06	1.065E+00	2.437E-51	0.000E+00	2.924E-52	2.723E+03
FE-55	1.110E+05	0.000E+00	1.110E+08	4.571E+08	3.673E+07	5.406E+07	8.112E+08
FE-59	1.269E+06	3.204E+08	2.025E+08	5.330E+08	1.749E+07	7.605E+07	6.693E+08
CO-58	1.106E+06	4.464E+08	7.000E+07	9.596E+07	1.032E+07	1.152E+07	3.771E+08
CO-60	7.067E+06	2.532E+10	2.391E+08	3.030E+08	8.103E+07	4.609E+07	2.095E+09
NI-63	8.214E+05	0.000E+00	2.964E+10	2.912E+10	1.036E+10	3.495E+09	3.949E+10
NI-65	8.399E+04	3.451E+05	1.909E+01	4.061E-51	0.000E+00	4.873E-52	1.211E+03
CU-64	3.670E+04	6.076E+05	3.502E+06	1.393E-05	7.299E-46	1.672E-06	5.159E+05
ZN-65	9.953E+05	8.583E+08	1.101E+10	1.000E+09	2.905E+09	1.200E+08	2.164E+09
ZN-69	1.018E+04	0.000E+00	1.123E-09	0.000E+00	0.000E+00	0.000E+00	9.093E-04
BR-83	4.736E+02	7.079E+03	4.399E-01	9.519E-57	0.000E+00	1.142E-57	5.369E+00
BR-84	5.476E+02	2.363E+05	6.500E-23	0.000E+00	0.000E+00	0.000E+00	3.022E-11
BR-85	2.531E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.903E+05	1.035E+07	8.004E+09	5.816E+08	1.114E+08	6.979E+07	4.504E+08
RB-88	5.624E+02	3.779E+04	7.150E-45	0.000E+00	0.000E+00	0.000E+00	4.374E-22
RB-89	3.452E+02	1.452E+05	1.715E-53	0.000E+00	0.000E+00	0.000E+00	1.642E-26
SR-89	2.157E+06	2.509E+04	6.610E+09	4.815E+08	6.730E+08	5.770E+07	3.593E+10
SR-90	1.010E+08	0.000E+00	1.117E+11	1.040E+10	3.007E+10	1.240E+09	1.243E+12
SR-91	1.739E+05	2.511E+06	2.070E+05	5.292E-10	0.000E+00	6.351E-11	1.157E+06
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

* See note, page 2.0-32

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK (PASTURE)	GRS/COW/MEAT (PASTURE)	GRS/COW/MILK (FEED)	GRS/GOT/MEAT (PASTURE)	VEGETATION
SR-92	2.424E+05	8.631E+05	4.134E+01	3.492E-40	0.000E+00	4.191E-49	1.370E+04
Y-90	2.679E+05	5.380E+03	9.171E+05	4.079E+05	2.277E-05	5.055E+04	6.569E+07
Y-91M	2.012E+03	1.161E+05	5.190E-16	0.000E+00	0.000E+00	0.000E+00	1.737E-05
Y-91	2.627E+06	1.207E+06	5.199E+06	2.400E+00	6.261E+05	2.800E+07	2.404E+09
Y-92	2.390E+05	2.142E+05	7.310E+00	6.959E-35	0.000E+00	8.350E-36	4.576E+04
Y-93	3.005E+05	2.534E+05	1.573E+04	1.547E-07	9.134E-61	1.857E-08	4.482E+06
ZR-95	2.231E+06	2.837E+08	8.706E+05	6.106E+08	1.160E+05	7.320E+07	8.043E+08
ZR-97	3.511E+05	3.445E+06	4.199E+04	7.015E-01	4.763E-35	8.410E-02	1.240E+07
NB-95	6.142E+05	1.605E+08	2.207E+08	2.220E+09	1.346E+07	2.673E+08	2.949E+08
MO-99	1.354E+05	4.626E+06	1.730E+08	2.456E+05	8.512E-03	2.947E+04	1.647E+07
TC-99M	4.010E+03	2.169E+05	1.474E+04	6.915E-10	0.000E+00	8.290E-19	5.255E+03
TC-101	5.846E+02	2.277E+04	5.593E-58	0.000E+00	0.000E+00	0.000E+00	4.123E-29
RU-103	6.623E+05	1.265E+08	1.108E+05	4.009E+07	7.952E+03	4.011E+08	3.971E+08
RU-105	9.953E+04	7.212E+05	2.493E+00	5.805E-25	0.000E+00	7.?61E-26	5.901E+04
RU-106	1.432E+07	5.849E+08	1.437E+06	6.902E+10	4.243E+05	8.202E+09	1.159E+10
AG-110M	5.476E+06	4.319E+09	1.670E+10	6.742E+08	4.576E+09	8.090E+07	2.?01E+09
TE-125M	4.773E+05	2.120E+06	7.377E+07	5.690E+08	8.802E+06	6.820E+07	3.506E+08
TE-127M	1.480E+06	1.083E+05	5.932E+0?	5.068E+09	1.171E+00	6.072E+08	3.769E+09
TE-127	5.624E+04	3.293E+03	1.191E+05	1.607E-08	0.000E+00	1.929E-09	3.903E+05
TE-129M	1.761E+06	2.305E+07	7.961E+08	5.245E+09	4.324E+07	6.294E+08	2.460E+09
TE-129	2.549E+04	3.076E+04	6.166E-08	0.000E+00	0.000E+00	8.380E+00	7.204E-08
TE-131M	3.070E+05	9.459E+06	2.244E+07	9.015E+03	1.621E-15	1.170E+03	2.163E+07
TE-131	2.454E+03	3.450E+07	8.489E-32	0.000E+00	0.000E+00	0.000E+00	1.349E-14
TE-132	3.774E+05	4.960E+06	4.551E+07	9.325E+06	7.272E-02	1.119E+06	3.111E+07
I-130	1.846E+06	6.692E+06	3.845E+08	6.750E-04	3.125E-45	8.109E-05	1.370E+00

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-4 (Continued)
PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*
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AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
I-131	1.624E+07	2.689E+07	4.333E+11	5.513E+09	6.440E+07	6.604E+00	4.754E+10
I-132	1.935E+05	1.452E+06	5.129E-01	2.429E-57	0.000E+00	2.915E-50	7.314E+03
I-133	3.840E+06	2.981E+06	3.945E+09	1.304E+02	7.299E-23	1.564E+01	8.113E+08
I-134	5.867E+04	5.305E+05	3.624E-10	0.000E+00	0.000E+00	0.000E+00	6.622E-03
I-135	7.910E+05	2.947E+06	8.687E+06	1.039E-14	0.000E+00	1.247E-15	9.973E+06
CS-134	1.014E+06	8.087E+09	3.715E+10	1.513E+09	1.197E+10	1.016E+08	2.631E+10
CS-136	1.709E+05	1.708E+08	2.773E+09	4.426E+07	8.276E+06	5.311E+06	2.247E+08
CS-137	9.065E+05	1.201E+10	3.224E+10	1.334E+09	1.122E+10	1.600E+08	2.392E+10
CS-138	8.399E+02	4.102E+05	5.520E-23	0.000E+00	0.000E+00	0.000E+00	9.133E-11
BA-139	5.772E+04	1.194E+05	1.231E-05	0.000E+00	0.000E+00	0.000E+00	2.950E+00
BA-140	1.743E+06	2.346E+07	1.171E+08	4.304E+07	3.114E+05	5.261E+06	2.767E+08
BA-141	2.919E+03	4.734E+04	1.210E-45	0.000E+00	0.000E+00	0.000E+00	1.605E-21
BA-142	1.643E+03	5.064E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.105E-39
LA-140	2.257E+05	2.100E+07	1.094E+05	5.492E+02	4.596E-12	6.590E+01	3.166E+07
LA-142	7.505E+04	8.006E+05	2.904E-06	0.000E+00	0.000E+00	0.000E+00	1.582E+01
CE-141	5.439E+05	1.540E+07	1.361E+07	1.302E+07	6.900E+05	1.650E+06	4.082E+08
CE-143	1.273E+05	2.627E+06	1.408E+06	2.516E+02	1.066E-14	3.020E+01	1.364E+07
CE-144	1.195E+07	8.132E+07	1.326E+08	1.893E+08	[illegible]	2.271E+07	1.039E+10
PR-143	4.329E+05	0.000E+00	7.754E+05	3.609E+07	2.730E+03	4.331E+06	1.575E+08
PR-144	1.565E+03	2.112E+03	2.040E-50	0.000E+00	0.000E+00	0.000E+00	3.029E-23
ND-147	3.282E+05	1.609E+07	5.712E+05	1.505E+07	6.044E+02	1.805E+06	9.197E+07
W-187	9.102E+04	2.740E+06	8.420E+06	2.798E+00	5.103E-22	3.340E-01	5.380E+06
NP-239	6.401E+04	1.976E+06	9.130E+04	2.232E+05	9.336E-08	2.679E+02	1.357E+07
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per μCi/m^3
Other pathways for all other radionuclides - m^2 · mrem/yr per μCi/sec

Table 2.2-5

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

(For Dose Calculations Required by TS 6.9.1.13)

AGE GROUP	(TEENAGER)	(N.A.)	(TEENAGER)	(TEENAGER)	(TEENAGER)	(TEENAGER)	(TEENAGER)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
H-3	1.272E+03	0.000E+00	9.993E+02	1.754E+02	9.993E+02	2.104E+01	2.342E+03
C-14	2.600E+04	0.000E+00	4.059E+00	8.040E+00	1.700E+00	8.440E+07	3.696E+00
NA-24	1.376E+04	1.305E+07	4.255E+06	1.104E-03	6.347E-30	1.901E-04	2.309E+05
P-32	1.000E+06	0.000E+00	3.153E+10	3.931E+09	1.395E+00	4.717E+00	1.600E+09
CR-51	2.096E+04	5.506E+06	8.307E+06	9.471E+05	3.085E+05	1.137E+05	1.637E+07
MN-54	1.904E+06	1.625E+09	2.075E+07	1.436E+07	8.240E+06	1.723E+06	9.320E+08
MN-56	5.744E+04	1.060E+06	4.056E-01	8.302E-52	0.000E+00	9.962E-53	9.451E+02
FE-55	1.240E+05	0.000E+00	4.454E+07	2.302E+00	1.463E+07	2.059E+07	3.259E+00
FE-59	1.520E+06	3.204E+00	2.061E+06	1.171E+09	2.470E+07	[illegible].405E+00	9.095E+00
CO-58	1.344E+06	4.464E+00	1.095E+00	1.942E+00	1.596E+07	2.330E+07	3.034E+00
CO-60	8.720E+06	2.532E+10	3.621E+00	7.600E+00	1.227E+00	9.120E+07	3.230E+09
NI-63	5.000E+05	0.000E+00	1.102E+10	1.319E+10	4.150E+09	1.023E+09	1.606E+10
NI-65	3.672E+04	3.451E+05	4.692E+00	1.305E-51	0.000E+00	1.566E-52	3.966E+02
CU-64	6.144E+04	6.076E+05	3.293E+06	1.713E-05	6.063E-46	8.056E-06	6.465E+05
ZN-65	1.240E+06	8.503E+00	7.315E+09	6.600E+00	1.903E+09	1.043E+00	1.471E+09
ZN-69	1.504E+03	0.000E+00	1.760E-11	0.000E+00	0.000E+00	0.000E+00	2.067E-05
BR-83	3.440E+02	7.077E+03	1.790E-01	5.066E-57	0.000E+00	6.079E-50	2.911E+00
BR-84	4.320E+02	2.363E+05	2.077E-23	0.000E+00	0.000E+00	0.000E+00	2.251E-11
BR-85	1.832E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.904E+05	1.035E+07	4.746E+09	4.101E+00	6.006E+07	4.921E+07	2.772E+00
RB-88	5.456E+02	3.779E+04	3.006E-45	0.000E+00	0.000E+00	0.000E+00	3.160E-22
RB-89	3.520E+02	1.452E+05	9.774E-54	0.000E+00	0.000E+00	0.000E+00	1.247E-26
SR-89	2.416E+06	2.509E+04	2.674E+09	2.545E+00	2.719E+00	3.054E+07	1.513E+10
SR-90	1.000E+00	0.000E+00	6.612E+10	3.049E+09	2.301E+10	9.659E+00	7.507E+11
SR-91	2.592E+05	2.511E+06	2.409E+05	5.794E-10	0.000E+00	6.953E-11	1.291E+06
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

* See note, page 2.0-32

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-5 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP / ISOTOPE	(TEENAGER) INHALATION	(N.A.) GROUND PLANE	(TEENAGER) GRS/COW/MILK (PASTURE)	(TEENAGER) GRS/COW/MEAT (PASTURE)	(TEENAGER) GRS/COW/MILK (FEED)	(TEENAGER) GRS/GOT/MEAT (PASTURE)	(TEENAGER) VEGETATION
SR-92	1.192E+05	8.631E+05	2.277E+01	2.516E-40	0.000E+00	3.019E-49	1.012E+04
Y-90	5.592E+05	5.300E+03	1.474E+06	7.470E+05	2.666E-05	8.965E+04	1.025E+08
Y-91M	3.200E+03	1.161E+05	5.129E-10	0.000E+00	0.000E+00	0.000E+00	2.205E-07
Y-91	2.936E+06	1.207E+06	6.475E+06	3.910E+08	7.797E+05	4.691E+07	3.212E+09
Y-92	1.640E+05	2.142E+05	2.020E+00	3.522E-35	0.000E+00	4.226E-36	2.360E+04
Y-93	5.792E+05	2.534E+05	1.312E+04	1.600E-07	7.620E-61	2.026E-08	4.903E+06
ZR-95	2.600E+06	2.037E+08	1.201E+06	1.092E+09	1.505E+05	1.310E+08	1.253E+09
ZR-97	6.304E+05	3.445E+06	4.225E+04	9.231E-01	4.732E-35	1.100E-01	1.673E+07
NB-95	7.512E+05	1.605E+08	3.330E+08	4.251E+09	1.963E+07	5.101E+08	4.551E+08
MO-99	2.600E+05	4.626E+06	1.023E+08	1.092E+05	5.013E-03	2.270E+04	1.293E+07
TC-99M	6.120E+03	2.109E+05	1.055E+04	6.471E-10	0.000E+00	7.766E-19	5.011E+03
TC-101	6.672E+02	2.277E+04	3.207E-50	0.000E+00	6.109E+00	0.000E+00	3.229E-29
RU-103	7.032E+05	1.265E+08	1.513E+05	7.162E+09	1.006E+04	0.595E+?0	5.706E+08
RU-105	9.040E+04	7.212E+05	1.263E+00	3.900E-25	0.000E+00	4.600E-26	6.039E+04
RU-106	1.600E+07	5.049E+08	1.799E+06	1.130E+11	5.312E+05	1.356E+10	1.404E+10
AG-110M	6.753E+06	4.019E+09	2.559E+10	1.345E+09	6.902E+09	1.614E+08	4.031E+09
TE-125M	5.360E+05	2.120E+06	8.063E+07	6.941E+08	1.050E+07	1.073E+08	4.375E+08
TE-127M	1.656E+06	1.003E+05	3.420E+08	3.016E+09	6.753E+07	4.500E+08	2.236E+09
TE-127	8.000E+04	3.293E+03	9.572E+04	1.609E-08	0.000E+00	2.027E-09	4.100E+05
TE-129M	1.976E+06	2.305E+07	4.602E+08	3.966E+09	2.500E+07	4.759E+08	1.500E+09
TE-129	3.296E+03	3.076E+04	2.196E-09	0.000E+00	0.000E+00	0.000E+00	3.410E-03
TE-131M	6.200E+05	9.459E+06	2.529E+07	1.447E+04	1.027E-15	1.736E+03	3.240E+07
TE-131	2.336E+03	3.450E+07	2.079E-32	0.000E+00	0.000E+00	0.000E+00	6.099E-15
TE-132	4.632E+05	4.960E+06	8.501E+07	2.300E+07	1.371E-01	2.760E+06	7.010E+07
I-130	1.400E+06	6.692E+06	1.742E+08	4.005E-04	1.416E-45	4.006E-05	8.276E+07

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-5 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(TEENAGER)	(N.A.)	(TEENAGER)	(TEENAGER)	(TEENAGER)	(TEENAGER)	(TEENAGER)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
I-131	1.464E+07	2.809E+07	2.195E+11	3.649E+09	3.266E+07	4.375E+08	3.106E+10
I-132	1.512E+05	1.452E+06	2.242E+01	1.389E-57	0.000E+00	1.667E-58	4.262E+03
I-133	2.920E+06	2.901E+06	1.674E+09	7.234E+01	3.096E-23	0.000E+00	4.507E+00
I-134	3.952E+04	5.305E+05	1.803E-10	0.000E+00	0.000E+00	0.000E+00	3.054E-03
I-135	6.200E+05	2.947E+06	3.777E+06	5.963E-15	0.000E+00	7.156E-16	5.032E+06
CS-134	1.120E+06	8.087E+09	2.310E-10	1.231E+09	7.443E+09	1.477E+08	1.671E+10
CS-136	1.936E+05	1.708E+08	1.759E+09	3.671E+07	5.209E+06	4.405E+06	1.700E+08
CS-137	8.480E+05	1.201E+10	1.701E+10	9.634E+08	6.197E+09	1.156E+08	1.340E+10
CS-138	8.560E+02	4.102E+05	3.149E-23	0.000E+00	0.000E+00	0.000E+00	6.735E-11
BA-139	6.464E+03	1.194E+05	7.741E-07	0.000E+00	0.000E+00	0.000E+00	2.472E-01
BA-140	2.032E+06	2.346E+07	7.403E+07	3.663E+09	1.998E+05	4.396E+06	2.130E+08
BA-141	3.280E+03	4.734E+04	4.922E-46	0.000E+00	0.000E+00	0.000E+00	8.699E-88
BA-142	1.912E+03	5.064E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.269E-39
LA-140	4.072E+05	2.100E+07	2.291E+05	6.609E+02	5.960E-12	1.043E+02	5.104E+07
LA-142	1.208E+04	8.066E+05	2.574E-07	0.000E+00	0.000E+00	0.000E+00	1.060E+00
CE-141	6.136E+05	1.540E+07	1.096E+07	2.262E+07	8.700E+05	2.703E+06	5.404E+08
CE-143	2.552E+05	2.627E+06	1.671E+06	3.695E+08	1.130E-14	4.434E+01	2.540E+07
CE-144	1.336E+07	8.032E+07	1.655E+08	3.809E+08	4.658E+07	3.706E+07	1.326E+10
PR-143	4.032E+05	0.000E+00	9.553E+05	5.017E+07	3.374E+03	6.980E+06	9.318E+08
PR-144	1.752E+03	2.112E+03	1.230E-53	0.000E+00	0.000E+00	0.000E+00	3.097E-26
ND-147	3.720E+05	1.009E+07	7.116E+05	2.452E+07	8.552E+02	2.744E+06	1.424E+08
W-187	1.760E+05	2.740E+06	2.646E+06	3.909E+10	5.579E-22	4.787E-01	7.839E+06
NP-239	1.320E+05	1.976E+06	1.060E+09	3.387E+03	1.003E-07	4.0[illegible]4E+08	8.097E+07
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-6

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

(For Dose Calculations Required by TS 6.9.1.13)

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
H-3	1.264E+03	0.000E+00	6.904E+02	2.940E+02	6.904E+02	3.520E+01	2.045E+03
C-14	1.016E+04	0.000E+00	2.634E+08	2.414E+08	9.219E+07	2.097E+07	2.276E+08
NA-24	1.024E+04	1.385E+07	2.430E+06	1.356E-03	3.636E-30	1.620E-04	2.690E+05
P-32	1.320E+06	0.000E+00	1.709E+10	4.651E+09	7.559E+07	5.582E+08	1.403E+09
CR-51	1.440E+04	5.506E+06	7.107E+06	1.772E+06	2.644E+05	2.127E+05	1.160E+07
MN-54	1.400E+06	1.625E+09	2.570E+07	2.012E+07	7.309E+06	3.375E+06	9.505E+08
MN-56	2.024E+04	1.060E+06	1.320E-01	4.900E-52	0.000E+00	5.949E-53	5.002E+02
FE-55	7.200E+04	0.000E+00	2.511E+07	2.933E+08	8.250E+06	3.519E+07	2.096E+08
FE-59	1.016E+06	3.204E+08	2.326E+08	2.003E+09	2.009E+07	2.495E+08	9.075E+08
CO-58	9.200E+05	4.464E+08	9.565E+07	3.703E+08	1.394E+07	4.443E+07	6.252E+08
CO-60	5.960E+06	2.532E+10	3.082E+08	1.413E+09	1.044E+08	1.695E+08	3.139E+09
NI-63	4.320E+05	0.000E+00	6.729E+09	1.000E+10	2.351E+09	2.266E+09	1.040E+10
NI-65	1.232E+04	3.451E+05	1.219E+00	7.405E-52	0.000E+00	8.006E-53	2.026E+02
CU-64	4.096E+04	6.076E+05	2.021E+06	2.307E-09	6.233E-46	2.769E-06	7.041E+05
ZN-65	8.640E+05	8.583E+08	4.365E+09	1.132E+09	1.103E+09	1.300E+08	1.009E+09
ZN-69	9.260E+02	0.000E+00	5.207E-12	0.000E+00	0.000E+00	0.000E+00	1.202E-05
BR-83	2.400E+02	7.079E+03	1.399E-01	8.640E-57	0.000E+00	1.030E-57	4.475E+00
BR-84	3.120E+02	2.363E+05	1.609E-23	0.000E+00	0.000E+00	0.000E+00	2.475E-11
BR-85	1.280E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.352E+05	1.027E+07	2.595E+09	4.070E+08	3.201E+07	5.045E+07	2.194E+08
RB-88	3.872E+02	3.779E+04	2.139E-45	0.000E+00	0.000E+00	0.000E+00	3.420E-22
RB-89	2.560E+02	1.476E+05	4.496E-53	0.000E+00	0.000E+00	0.000E+00	3.961E-26
SR-89	1.400E+06	2.509E+04	1.451E+09	3.014E+08	1.475E+08	3.617E+07	9.961E+09
SR-90	9.920E+07	0.000E+00	4.600E+10	1.244E+10	1.620E+10	1.493E+09	6.046E+11
SR-91	1.912E+05	2.511E+06	1.377E+05	7.233E-10	0.000E+00	8.600E-11	1.451E+06
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

* See note, page 2.0-32

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-6 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
SR-92	4.304E+04	8.631E+05	9.675E+00	2.334E-40	0.000E+00	2.881E-40	8.452E+03
Y-90	5.856E+05	5.300E+03	7.511E+05	1.141E+06	1.065E-05	1.369E+05	1.410E+08
Y-91M	1.920E+03	1.161E+05	1.743E-19	0.000E+00	0.000E+00	0.000E+00	1.527E-00
Y-91	1.784E+06	1.207E+06	4.726E+06	6.231E+08	5.691E+05	7.477E+07	2.014E+09
Y-92	7.352E+04	2.142E+05	9.772E-01	2.687E-35	0.000E+00	3.100E-36	1.683E+04
Y-93	4.216E+05	2.534E+05	7.308E+03	2.875E-07	4.290E-01	2.490E-08	5.517E+06
ZR-95	1.760E+06	2.837E+08	9.507E+05	1.963E+09	1.265E+05	2.204E+08	1.190E+09
ZR-97	5.232E+05	3.445E+06	2.707E+04	1.292E+08	3.032E-35	1.550E-01	2.100E+07
NB-95	5.040E+07	1.605E+08	8.786E+08	7.740E+09	1.639E+07	9.297E+08	4.790E+08
MO-99	2.400E+05	4.626E+06	5.741E+07	8.310E+05	2.813E-03	2.701E+04	1.426E+07
TC-99M	4.166E+03	2.109E+05	5.553E+03	7.439E-10	0.000E+00	8.927E-19	5.107E+03
TC-101	3.992E+02	2.277E+04	1.013E-50	0.000E+00	0.000E+00	0.000E+00	3.582E-29
RU-103	5.640E+05	1.265E+08	1.109E+09	1.229E+10	8.537E+03	1.475E+09	5.577E+08
RU-105	4.816E+04	7.212E+05	5.240E-01	3.533E-25	0.000E+00	4.239E-26	3.294E+04
RU-106	9.360E+06	5.649E+08	1.328E+06	1.811E+11	3.090E+05	2.173E+10	1.247E+10
AG-110M	4.632E+06	4.019E+09	2.190E+10	2.583E+09	5.996E+09	3.020E+08	3.979E+09
TE-125M	3.136E+05	2.120E+06	6.626E+07	1.460E+09	7.986E+06	1.751E+08	3.927E+08
TE-127M	9.600E+05	1.803E+05	1.060E+08	4.531E+09	3.671E+07	5.437E+08	1.410E+09
TE-127	5.736E+04	3.293E+03	5.270E+04	2.034E-08	0.000E+00	2.441E-09	4.532E+05
TE-129M	1.160E+06	8.305E+07	3.020E+08	5.690E+09	1.645E+07	6.830E+08	1.261E+09
TE-129	1.936E+03	3.876E+04	9.167E-10	0.000E+00	0.000E+00	0.000E+00	2.806E-03
TE-131M	5.560E+05	9.459E+06	1.753E+07	2.190E+04	1.266E-15	2.520E+03	4.420E+07
TE-131	1.392E+03	3.450E+07	1.570E-38	0.000E+00	0.000E+00	0.000E+00	6.975E-15
TE-132	5.096E+05	4.960E+06	7.324E+07	4.207E+07	1.170E-01	5.144E+06	1.312E+00
I-130	1.136E+06	6.692E+06	1.050E+00	5.272E-04	8.535E-46	6.326E-05	9.009E+07
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

Table 2.2-6 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	GRS/COW/MILK	GRS/GOT/MEAT	VEGETATION
I-131	1.192E+07	2.089E+07	1.380E+11	5.634E+09	2.665E+07	6.640E+08	3.785E+10
I-132	1.144E+05	1.452E+06	1.342E-41	1.816E-57	0.000E+00	2.179E-58	5.016E+03
I-133	2.152E+06	2.981E+06	9.891E+00	9.336E+01	1.830E-23	1.120E+01	5.331E+00
I-134	2.984E+04	5.305E+05	9.491E-11	0.000E+00	0.000E+00	0.000E+00	4.544E-03
I-135	4.400E+05	2.947E+06	2.217E+06	7.644E-15	0.000E+00	9.172E-16	6.731E+06
CS-134	8.480E+05	8.007E+09	1.345E+10	1.565E+09	4.333E+09	1.870E+00	1.110E+10
CS-136	1.464E+05	1.702E+08	1.836E+09	4.724E+07	3.093E+06	5.669E+06	1.675E+08
CS-137	6.200E+05	1.201E+10	1.010E+10	1.193E+09	3.513E+09	1.431E+00	8.696E+09
CS-138	6.200E+02	4.102E+05	1.706E-23	0.000E+00	0.000E+00	0.000E+00	7.730E-11
BA-139	3.760E+03	1.194E+05	8.322E-08	0.000E+00	0.000E+00	0.000E+00	5.225E-02
BA-140	1.272E+06	2.346E+07	5.535E+07	5.917E+07	1.472E+05	7.100E+06	2.646E+08
BA-141	1.936E+03	4.734E+04	2.677E-46	0.000E+00	0.000E+00	0.000E+00	9.305E-28
BA-142	1.192E+03	5.664E+04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.463E-39
LA-140	4.504E+05	2.106E+07	1.672E+05	1.305[illegible]+03	4.059E-12	1.662E+02	7.327E+07
LA-142	6.320E+03	8.086E+05	3.503E-08	0.000E+00	0.000E+00	0.000E+00	4.999E-01
CE-141	3.616E+05	1.540E+07	1.253E+07	3.632E+07	6.424E+05	4.350E+06	5.097E+08
CE-143	2.264E+05	2.627E+06	1.149E+06	5.547E+02	7.760E-15	6.656E+01	2.750E+07
CE-144	7.776E+06	8.032E+07	1.209E+08	4.920E+08	3.390E+07	5.914E+07	1.112E+10
PR-143	2.808E+05	0.000E+00	6.923E+05	9.204E+07	2.445E+03	1.184E+07	2.748E+08
PR-144	1.016E+03	2.112E+03	6.716E-54	0.000E+00	0.000E+00	0.000E+00	3.303E-26
ND-147	2.200E+05	1.009E+07	5.231E+05	3.935E+07	6.206E+02	4.722E+06	1.853E+08
W-187	1.552E+05	2.740E+06	1.796E+06	5.912E+00	3.787E-22	7.094E-01	1.046E+07
NP-239	1.192E+05	1.976E+06	7.305E+04	5.152E+03	7.545E-08	6.182E+02	2.872E+07
			(PASTURE)	(PASTURE)	(FEED)	(PASTURE)	

Units: Inhalation and all tritium - mrem/yr per $\mu Ci/m^3$

Other pathways for all other radionuclides - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

NOTE: The P_i values of Table 2.2-2 through 2.2-6 were calculated in accordance with the methods of Section 5.3.1 of Reference 1. Columns in those tables marked "Pasture" are for freely-grazing animals ($f_p = f_s = 1$). Columns marked "Feed" are for animals fed solely locally-grown stored feed ($f_p = f_s = 0$). The values used for each parameter and the origins of the values are given below in Table 2.2-9 and its notes.

Table 2.2-7

CONTROLLING RECEPTORS, LOCATIONS, AND PATHWAYS*

SECTOR	DISTANCE (METERS)	PATHWAY	AGE GROUP	ORIGIN (FOR INFORMATION ONLY)
N**	6,400	Vegetation	Child	-Vegetable Garden
NNE	5,800	Vegetation	Child	-Vegetable Garden
	5,300	Grass/Cow/Meat		-Grazing Beef Cattle
NE	4,700	Vegetation	Child	-Vegetable Garden
	4,700	Grass/Cow/Meat		-Grazing Beef Cattle
ENE	2,400	Vegetation	Child	-Vegetable Garden
E	5,000	Vegetation	Child	-Vegetable Garden
ESE	1,800	Vegetation	Child	-Vegetable Garden
SE	2,400	Vegetation	Child	-Vegetable Garden
SSE	4,300	Vegetation	Child	-Vegetable Garden
S**	6,300	Vegetation	Child	-Vegetable Garden
SSW**	5,500	Vegetation	Child	-Vegetable Garden
SW	5,300	Vegetation	Child	-Vegetable Garden
WSW	5,300	Vegetation	Child	-Vegetable Garden
W	4,300	Vegetation	Child	-Vegetable Garden
	3,400	Grass/Cow/Meat		-Grazing Beef Cattle
WNW**	7,200	Vegetation	Child	-Vegetable Garden
	7,200	Grass/Cow/Meat		-Grazing Beef Cattle
NW	6,600	Vegetation	Child	-Vegetable Garden
	6,600	Grass/Cow/Meat		-Grazing Beef Cattle
NNW	4,800	Vegetation	Child	-Vegetable Garden
	4,800	Grass/Cow/Meat		-Grazing Beef Cattle

* See note on the following page for the method of choice of these controlling receptors.

** If a cow were located at 5.0 miles (8,000 meters) in this sector, an infant consuming only its milk would receive a greater total radiation dose than would the real receptor listed. Such an infant would not be the Maximum Exposed Individual for the site.

NOTE: The controlling receptor in each sector was identified in the following way. Receptor locations and associated pathways were obtained from the August 1987 field survey. A child was assumed at each location, except that where a milk cow was listed, an infant was assumed. $\overline{X/Q}'$ for each candidate receptor was obtained by interpolation of values in Table 6.1-10 of Reference 5; $\overline{D/Q}'$ for each candidate receptor was obtained by interpolation of values in Table 6.1-13 of Reference 5. Expected annual releases of each nuclide were taken from Table 5.2-2 of Reference 5. The pathway dose factors given above in Tables 2.2-3 and 2.2-4 were then used with the referenced values in the methodology of Section 5.3 of Reference 1 to compute total annual doses at each candidate receptor site for the pathways existing at that site. The controlling receptor for each sector was then chosen as the candidate receptor with the highest total annual dose of any candidate receptor in the given sector. All listed pathways are in addition to inhalation and ground plane exposure.

Table 2.2-8

ATMOSPHERIC DISPERSION PARAMETERS
FOR CONTROLLING RECEPTOR LOCATIONS*

SECTOR	$\overline{X/Q}'$	$\overline{D/Q}'$	DISTANCE (MILES/METERS)
N	1.4 E-07	6.2 E-10	4.0 / 6,400
NNE	2.5 E-07	1.1 E-09	3.3 / 5,300
NE	3.4 E-07	1.7 E-09	2.9 / 4,700
ENE	1.2 E-06	6.8 E-09	1.5 / 2,400
E	2.4 E-06	9.6 E-10	3.1 / 5,000
ESE	2.2 E-06	8.4 E-09	1.1 / 1,800
SE	1.6 E-06	5.8 E-09	1.5 / 2,400
SSE	3.0 E-07	1.0 E-09	2.7 / 4,300
S	1.7 E-07	3.7 E-10	3.9 / 6,300
SSW	2.0 E-07	6.4 E-10	3.4 / 5,500
SW	2.6 E-07	1.0 E-09	3.3 / 5,300
WSW	2.0 E-07	8.7 E-10	3.3 / 5,300
W	3.6 E-07	1.7 E-09	2.1 / 3,400
WNW	6.6 E-07	2.5 E-10	4.5 / 7,200
NW	9.7 E-08	4.1 E-10	4.1 / 6,600
NNW	1.8 E-07	9.7 E-10	3.0 / 4,800

* Annual average relative dispersion and deposition values for the receptor locations in Table 2.2-7. Values were obtained by interpolation in Tables 6.1-10 and 6.1-14 of Reference 5. Those tables are based on one year (1975) of meteorological readings and the FSAR dispersion model (ground-level release, sector-averaged model, with open terrain recirculation factors, dry depletion by Figure 2.3-1, and using decay with a half-life of 8.0 days). As a result of the analysis described in the note to Table 2.2-7, the location of the maximum exposed individual for the site was identified as being the vegetable garden at 1.1 miles in the ESE sector. Therefore, the site $\overline{X/Q}'$ and $\overline{D/Q}'$ (Section 2.2.2.b and following) are those from this table for that location.

Table 2.2-9

PARAMETERS USED IN DOSE FACTOR CALCULATIONS

Parameter	Value	Origin of Value		
		Table in R.G. 1.109	Section of NUREG-0133	Site-Specific
	For P_i			
DFA_i	Each radionuclide	E-9		Note 2
BR	3700 m^3/yr	E-5		
	For Ri (Vegetation)			
r	Each element type	E-1		
Y_v	2.0 kg/m^2	E-15		
λw	5.73 E-7 sec^{-1}		5.3.1.3	
DFL_i	Each age group and radio-nuclide	E-11 thru E-14		Note 2
U_a^L	Each age group	E-5		
f_L	1.0		5.3.1.5	
t_L	8.6 E + 4 seconds	E-15		
U_a^S	Each age group	E-5		
f_g	0.76		5.3.1.5	
t_h	5.18 E + 6 seconds	E-15		
H	8.84 gm/m^3			Note 1
	For Ri (Inhalation)			
BR	Each age group	E-5		
DFA_i	Each age group and nuclide	E-7 thru E-10		Note 2

PARAMETERS USED IN DOSE FACTOR CALCULATIONS

Parameter	Value	Origin of Value		
		Table in R.G. 1.109	Section of NUREG-0133	Site-Specific
	For R_i (Ground Plane)			
SF	0.7	E-15		
DFG_i	Each radionuclide	E-6		
t	4.73 E + 8 sec		5.3.1.2	
	For Ri (Grass/Animal/Meat)			
Q_F (Cow)	50 kg/day	E-3		
Q_F (Goat)	6 kg/day	E-3		
U_{ap}	Each age group	E-5		
λw	5.73 E-7 sec^{-1}		5.3.1.3	
F_f (Both)	Each element	E-1		
r	Each element type	E-15		
DFL_i	Each age group and nuclide	E-11 thru E-14		Note 2
f_p	1.0			Note 3
f_s	1.0			Note 3
Y_p	0.7 kg/m^3	E-15		
t_h	7.78 E + 6 sec	E-15		
Y_s	2.0 kg/m^2	E-15		
tf	1.73 E + 6 sec	E-15		
H	8.84 gm/m^3			Note 1

Table 2.2-9

Page 3 of 4

PARAMETERS USED IN DOSE FACTOR CALCULATIONS

Parameter	Value	Origin of Value		
		Table in R.G. 1.109	Section of NUREG-0133	Site-Specific
	For R_i (Grass/Cow/Milk)			Note 4
QF	50 kg/day	E-3		
U_{ap}	Each age group	E-5		
λw	5.73 E-7 sec^{-1}		5.3.1.3	
F_m	Each element	E-1		
r	Each element type	E-15		
DFL_i	Each age group and nuclide	E-11 thru E-14		Note 2
Y_p	0.7 kg/m^2	E-15		
t_h	7.78 E + 6 sec	E-15		
Y_s	2.0 kg/m^2	E-15		
t_f	1.73 E + 5 sec	E-15		
f_p	1.0			Note 5
f_s	1.0			Note 5
f_p	0.0			Note 5
f_s	0.0			Note 5
H	8.84 gm/m^3			Note 1

NOTES

1. Site-specific annual average absolute humidity. For each month, an average absolute humidity was calculated from the 7 years of monthly average temperatures in Table 2.3-49 of Reference 4 and the 5 years of monthly average dewpoints in Table 2.3-64 of Reference 4. The 12 monthly values were averaged to obtain the annual average of 8.84 gm/m^3. (Section 5.2.1.3 of Reference 1 gives a default value of 8 gm/m^3.)

2. Inhalation and ingestion dose factors were taken from the indicated source. For each age group, for each nuclide, the organ dose factor used was the highest dose factor for that nuclide and age group in the referenced table.

3. Typically beef cattle are raised all year on pasture. Annual land surveys have indicated that the small number of goats raised within 5 miles typically are used for grass control and not food or milk. Nevertheless, the goats were treated as full meat sources where present, despite the fact that their numbers cannot sustain the meat consumption rates of Table E-5 of Reference 3.

4. According to the August 1987 land use census, no cows or goats are kept for milk within 5 miles of the Station. These values are included for reference only.

5. Two columns of R_i's were calculated - one for cows kept exclusively on local pasture ($f_p = f_s = 1$), and one for cows kept exclusively on locally grown stored feed ($f_p = f_s = 0$). See the note on page 2.0-32.

2.3 Meteorological Model

2.3.1 Atmospheric dispersion for all releases is calculated using a ground-level, wake-corrected form of the straight line flow model.

X/Q = the sector-averaged annual average relative concentration at any distance in the given sector (sec/m^3)

$$= 2.032\ \delta T \sum_{ij} \frac{n_{ij}}{N r u_i \Sigma_{zj}} \qquad (51)$$

where:

2.032 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector (0.3927 radians).

δ = plume depletion factor at distance r for the appropriate stabili.y class from Figure 2.3-1.

i = windspee[illegible] The windspeed classes are given in Table 4A of Ref[illegible] 10 as 1-3, 4-7, 8-12, 13-18, 19-24, and > 24 miles pe[illegible]

n_{ij} = number of hours meteorological conditions are observed to be in a given wind direction, windspeed class i, and atmospheric stability class j.

N = total hours of valid meteorological data.

r = distance from the containment building to location of interest (m)

u_i = wind speed (midpoint of windspeed class i) at ground level (m/sec).

Σ_z = the lesser of $(\sigma_z^2 + b^2/2\pi)^{\frac{1}{2}}$ or $\left(\sqrt{3}\,\sigma_z\right)$ (52)

where:

σ_z = vertical standard deviation of the plume (in m) at distance r for ground level releases under the stability category indicated by $\Delta T/\Delta Z$, from Figure 2.3-2.

T = terrain recirculation factor, from Figure 2.3-4

π = 3.1416

b = height of the containment building (50.9m)

$\Delta T/\Delta Z$ = temperature differential with vertical separation (°K/100m).

2.3.2 Relative deposition per unit area for all releases is calculated for a ground-level release.

D/Q = the sector-averaged annual average relative deposition at any distance in a given sector (m^{-2}).

$$= \frac{2.55\ D_g n}{r N} \qquad (53)$$

where,

D_g = deposition rate for ground-level releases relative to distance (r) from the containment building (from Figure 2.3-3).

2.55 = the inverse of the number of radians in a 22.5° sector

$$\frac{1}{(22.5°)(0.0175\ \text{Radians}/°)}$$

n = number of hours wind is in given direction (sector).

N = total hours of valid meteorological data.

Figure 2.3-1

Plume Depletion Effect for Ground Level Releases (6)

(All Atmospheric Stability Classes)

Graph taken from Reference 8, Figure 2

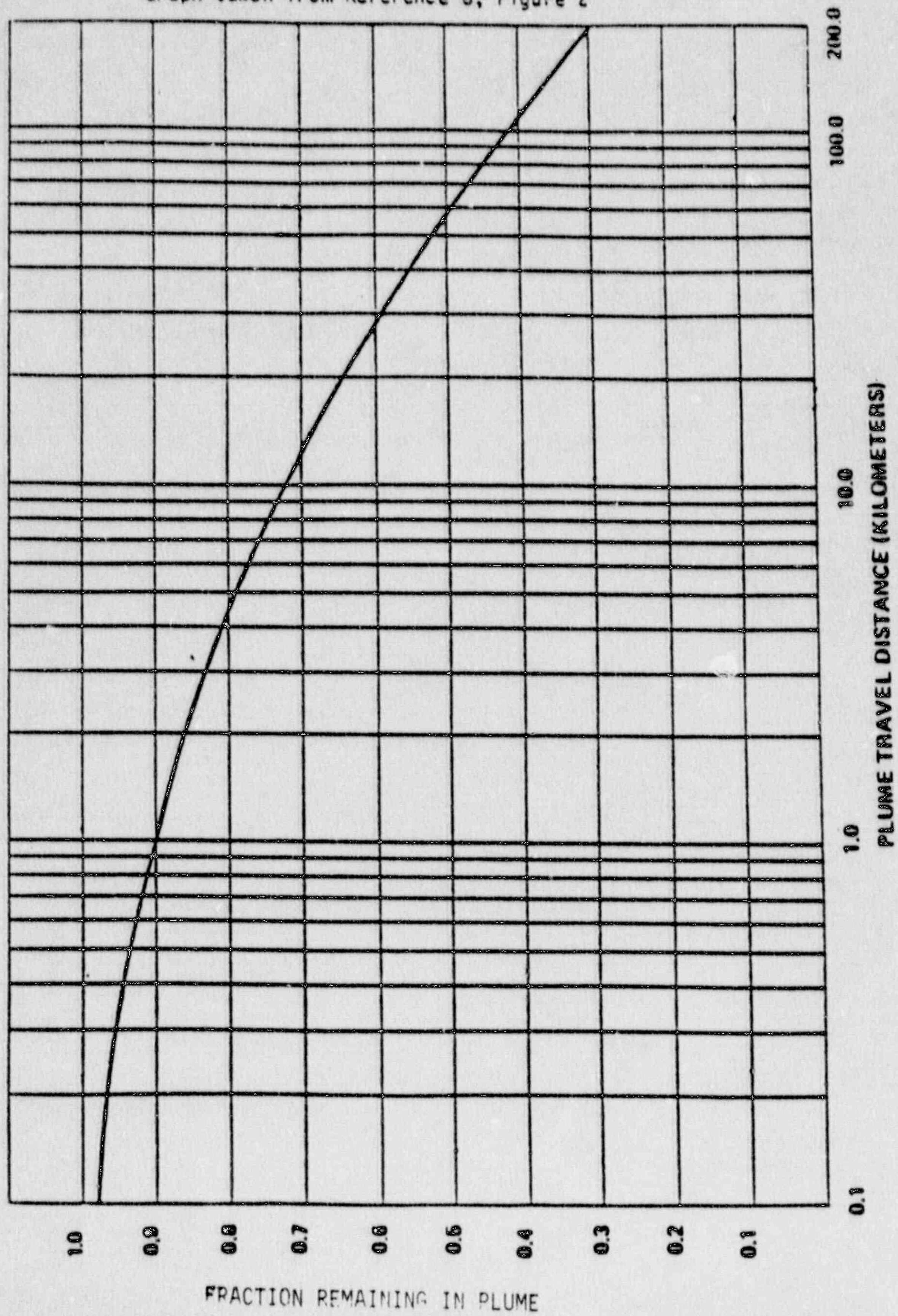
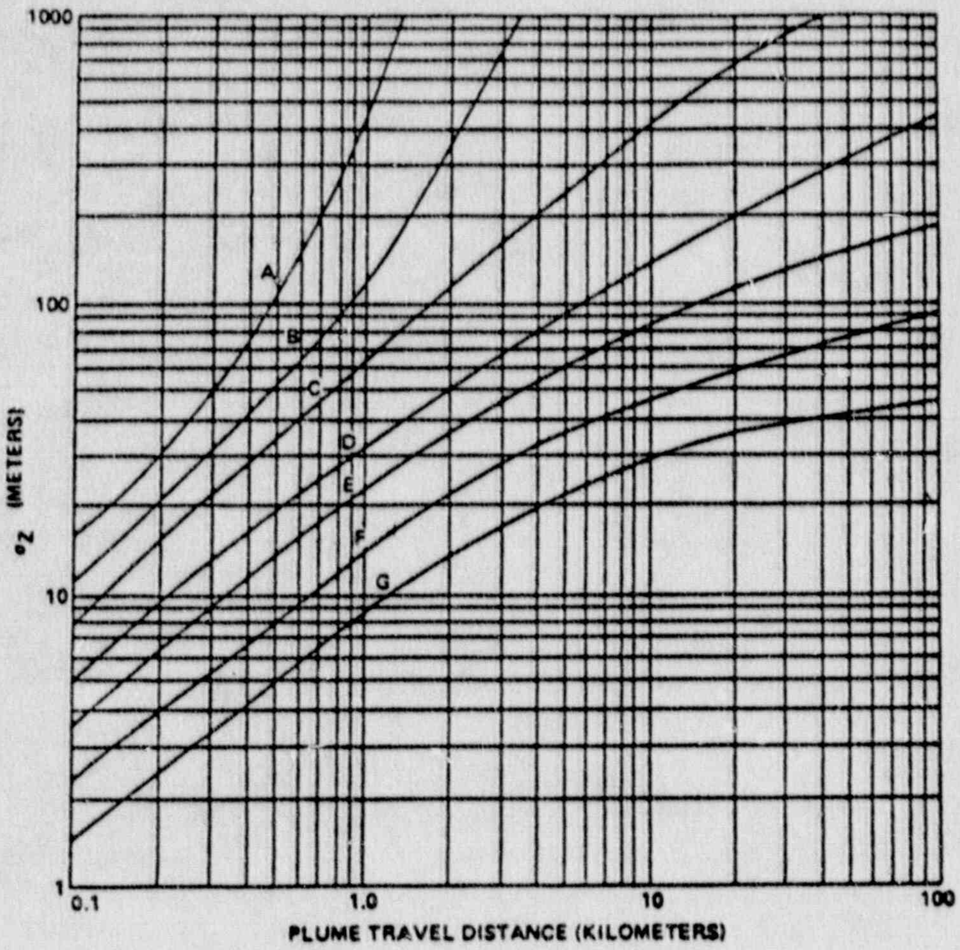


Figure 2.3-2

Vertical Standard Deviation of Material in a Plume (σ_z)

(Letters denote Pasquill Stability Class)

Graph taken from Reference 8, Figure 1



Temperature Change with Height $\Delta T/\Delta Z$ (°K/100m)	Pasquill Categories	Stability Classification
<-1.9	A	Extremely Unstable
-1.9 to -1.7	B	Moderately Unstable
-1.7 to -1.5	C	Slightly Unstable
-1.5 to -0.5	D	Neutral
-0.5 to 1.5	E	Slightly Stable
1.5 to 4.0	F	Moderately Stable
> 4.0	G	Extremely Stable

Figure 2.3-3

Relative Deposition for Ground-Level Releases (D_g)

(All Atmospheric Stability Classes)

Graph taken from Reference 8, Figure 6

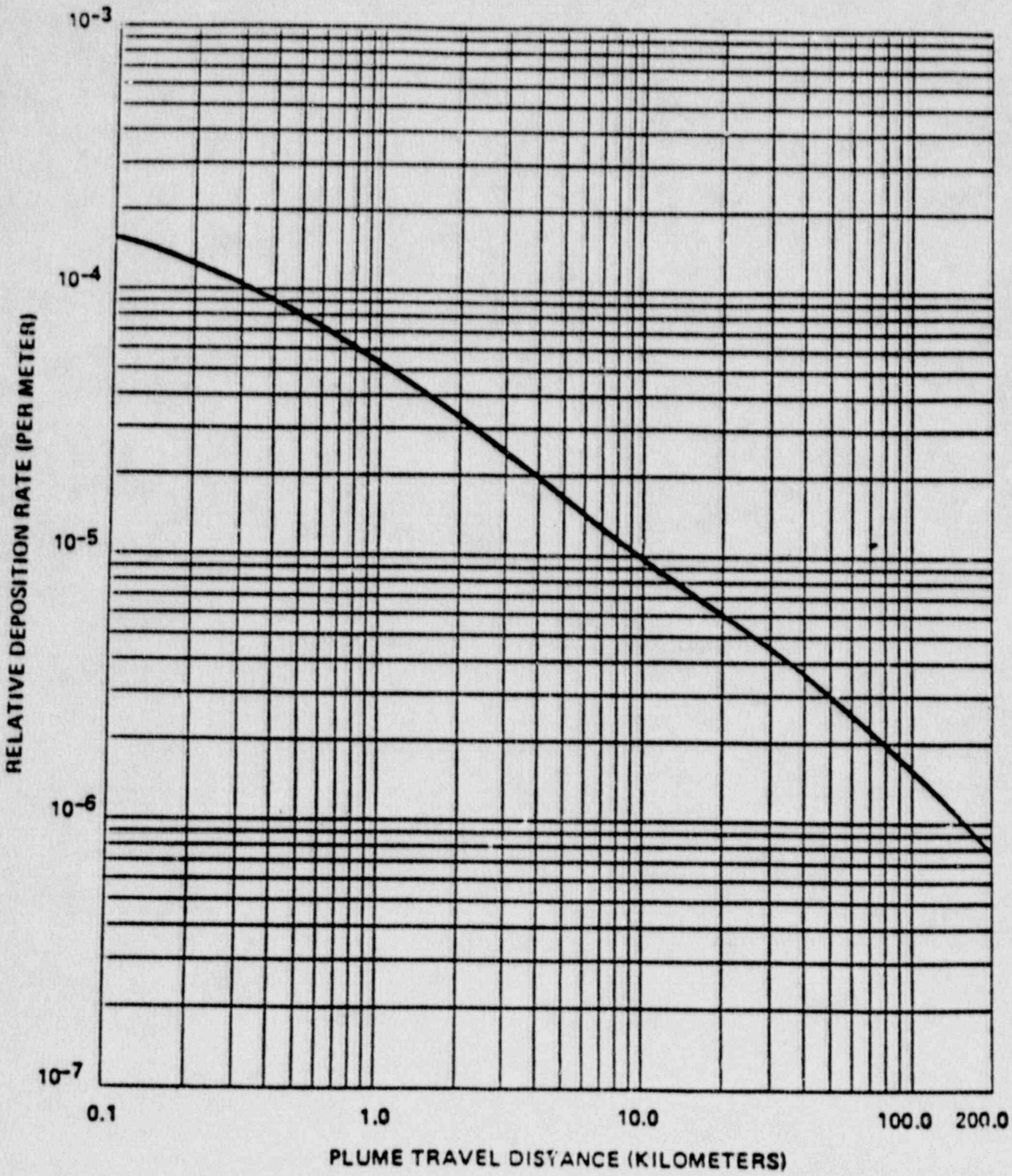
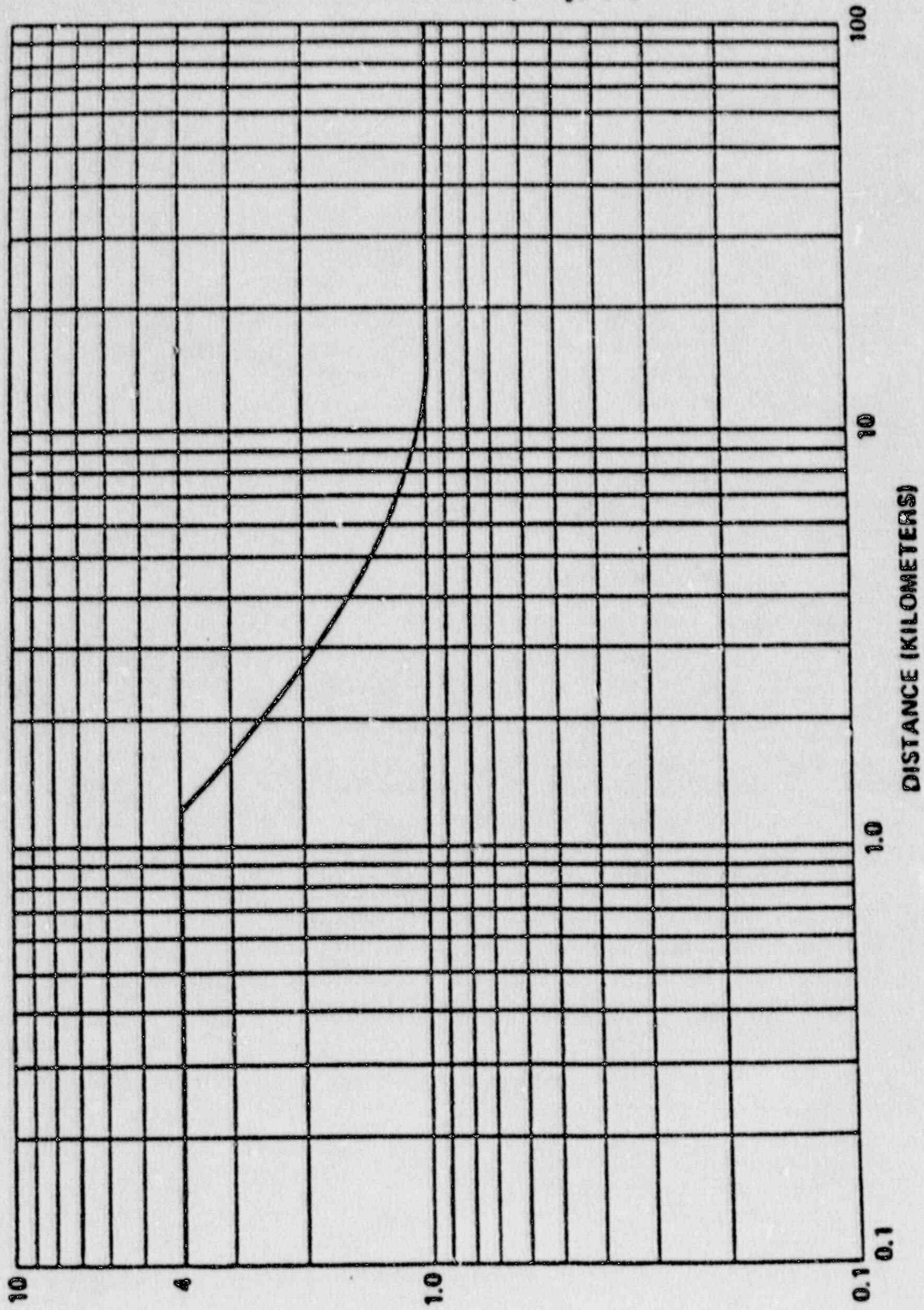


Figure 2.3-4

Open Terrain Recirculation Factor

Graph taken from Reference 7, Figure 2



CORRECTION FACTOR

2.4 Definitions of Gaseous Effluent Parameters

Term		Definition	Section of Initial Use
b	=	height of the containment building.	(2.3.1)
C_v	=	count rate of a station vent monitor corresponding to grab sample radionuclide concentrations.	(2.1.1)
C_v'	=	the count rate of the monitor on vent v corresponding to X_v' uCi/cc of Xe-133.	(2.1.3)
c	=	count rate of the gas decay system monitor for measured radionuclide concentrations corrected to discharge pressure.	(2.1.2)
c'	=	the count rate of the waste gas decay system monitor corresponding to the total noble gas concentration.	(2.1.3)
D_g	=	deposition rate for ground-level releases relative to the distance from the containment building (from Figure 2.3-3).	(2.3.2)
D_o	=	average organ dose rate in the current year (mrem/yr).	(2.2.1.b)
D_p	=	dose to an individual from radioiodine and radionuclides in particulate form and radionuclides (other than noble gases), with half-lives greater than eight days (mrem).	(2.2.2.b)
D_s	=	average skin dose rate in current year (mrem/year).	(2.2.1.a)
D_{SS}	=	limiting dose rate to the skin (3000 mrem/year).	(2.1.1)
D_t	=	average total body dose rate in the current year (mrem/yr).	(2.2.1.a)
D_{TB}	=	limiting dose rate to the total body (500 mrem/year).	(2.1.1)
D_β	=	air dose due to beta emissions from noble gas radionuclides (mrad).	(2.2.2.a)

Term		Definition	Section of Initial Use
D_γ	=	air dose due to gamma emissions from noble gas radionuclides (mrad).	(2.2.2.a)
D/Q	=	the sector averaged annual average relative deposition for any distance in a given sector (m^{-2}).	(2.3.2)
$\overline{D/Q}'$	=	annual average relative deposition at the location occupied by the maximum exposed individual.	(2.2.2.b)
δ	=	plume depletion factor at distance r for the appropriate stability class from Figure 2.3-1.	(2.3.1)
F_v	=	the flow rate in vent v (cc/sec).	(2.1.1)
f_s	=	the maximum permissible waste gas discharge rate, based on the actual radionuclide mix and skin dose rate.	(2.1.2)
f_t	=	the maximum permissible waste gas discharge rate, based on the actual radionuclide mix and total body dose rate.	(2.1.2)
f_w	=	the maximum permissible waste gas discharge rate, the lesser of f_s and f_t.	(2.1.2)
f_s'	=	the conservative maximum permissible waste gas discharge rate based on Kr-89 skin dose rate.	(2.1.3)
f_t'	=	the conservative maximum permissible waste gas discharge rate based on Kr-89 total body dose rate.	(2.1.3)
K_i	=	total body dose factor due to gamma emissions from isotope i (mrem/year per uCi/m^3) from Table 2.1-1.	(2.1.1)
K_{Kr-89}	=	total body dose factor for Kr-89, the most restrictive isotope from Table 2.1-1.	(2.1.2)
L_i	=	Skin dose factor due to beta emissions from isotope i (mrem/yr per uCi/m^3) from Table 2.1-1.	(2.1.1)
L_{Kr-89}	=	Skin dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1.	(2.1.2)
M_i	=	air dose factor due to gamma emissions from isotope i (mrad/yr per uCi/m^3) from Table 2.1-1.	(2.1.1)

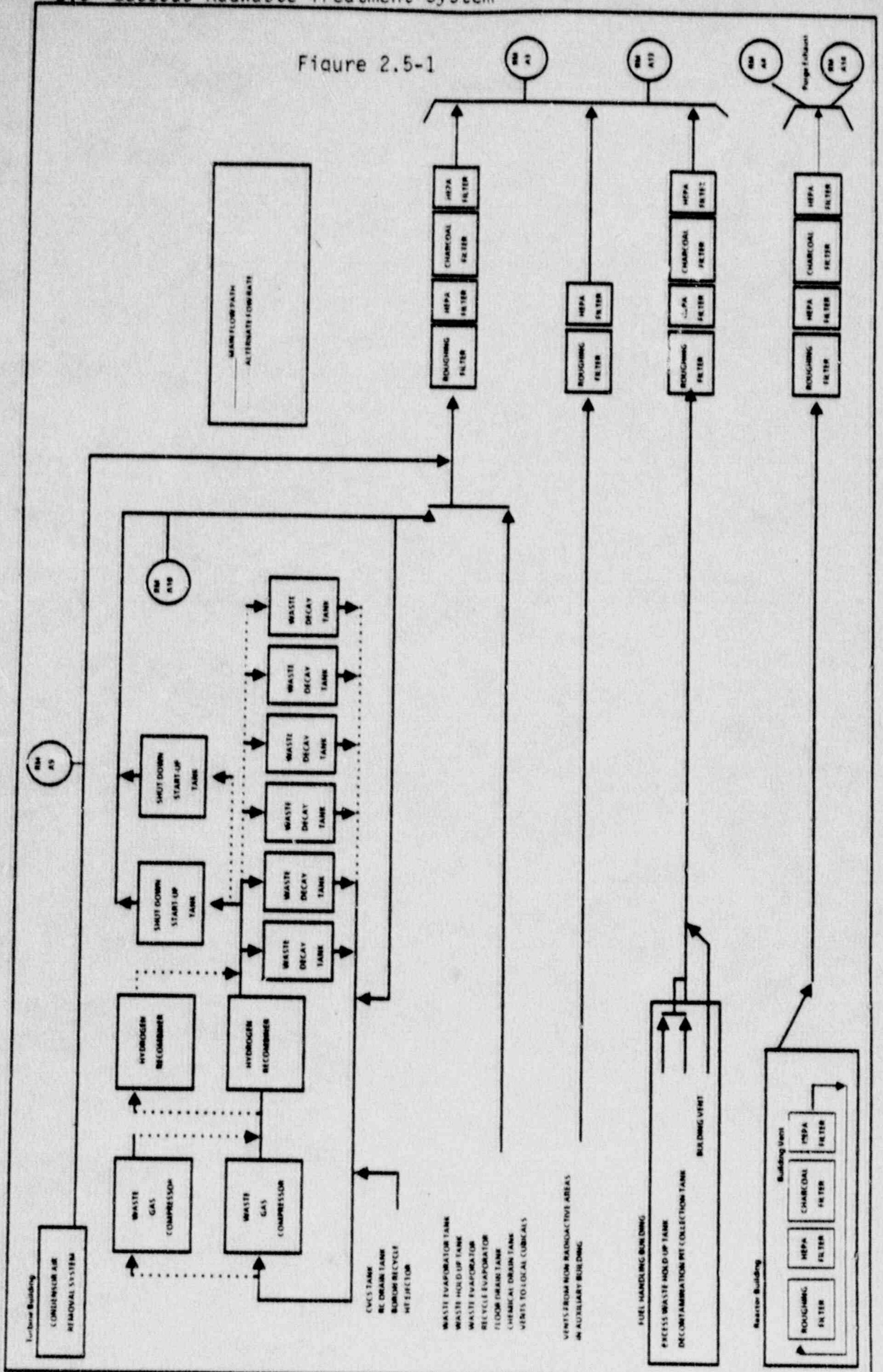
Term		Definition	Section of Initial Use
M_{Kr-89}	=	air dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1.	(2.1.2)
N_i	=	air dose factor due to beta emissions from noble gas radionuclide i (mrad per uCi/m^3) from Table 2.1-1.	(2.2.2.a)
N_{ij}	=	number of hours meteorological conditions are observed to be in a given wind direction, windspeed class i, and atmospheric stability class j.	(2.3.1)
N	=	total hours of valid meteorological data.	(2.3.1)
P_i	=	dose parameter for radionuclide i, (mrem/yr per uCi/m^3) for inhalation, from Table 2.2-1.	(2.2.1.b)
$\bar{\dot{Q}}_i$	=	the release rate of noble gas radionuclide i as determined from the concentrations measured in the analysis of the appropriate sample required by Radiological Effluent Technical Specification Table 4.11-2 (uCi/sec).	(2.2.1.a)
$\bar{\dot{Q}}_i'$	=	the release rate of non-noble gas radionuclide i as determined from the concentrations measured in the analysis of the appropriate sample required by Radiological Effluent Technical Specification Table 4.11-2 (uCi/sec).	(2.2.1.b)
$\tilde{Q}_i$	=	cumulative release of noble gas radionuclide i over the period of interest (uCi)	(2.2.2.a)
$\tilde{Q}_i'$	=	cumulative release of radionuclide i of iodine or material in particulate form over the period of interest (uCi).	(2.2.2.b)
R_{ij}	=	dose factor for radionuclide i and pathway j, (mrem/yr per uCi/m^3) or (m^2-mrem/yr per uCi/sec) from Tables 2.2-2 through 2.2-6.	(2.2.2.b)
R_s	=	count rate per mrem/yr to the skin.	(2.1.1)
R_t	=	count rate per mrem/yr to the total body.	(2.1.1)
r	=	distance from the containment building to the location of interest for dispersion calculations (m).	(2.3.1)

Term		Definition	Section of Initial Use
R_s'	=	conservative count rate per mrem to the skin (Xe-133 detection, Kr-89 dose).	(2.1.3)
R_t'	=	conservative count rate per mrem to the total body (Xe-133 detection, Kr-89 dose).	(2.1.3)
S_d	=	count rate of the waste gas decay system noble gas monitor at the alarm setpoint.	(2.1.2)
S_v	=	count rate of a station vent noble gas monitor at the alarm setpoint.	(2.1.1)
S_{vc}	=	count rate of the containment purge noble gas monitor at the alarm setpoint.	(2.1.1)
S_{vp}	=	count rate of the plant vent noble gas monitor at the alarm setpoint.	(2.1.1)
Σ_z	=	vertical standard deviation of the plume, with building wake correction applied.	(2.3.1)
σ_z	=	vertical standard deviation of the plume (in m), at distance r for ground level releases under the stability category indicated by $\Delta T/\Delta Z$, from Figure 2.3-2.	(2.3.1)
$\Delta T/\Delta Z$	=	temperature differential with vertical separation (°K/100m).	(2.3.1)
T	=	terrain recirculation factor, Figure 2.3-4.	(2.3.1)
u_i	=	wind speed (midpoint of windspeed class i) at ground level (m/sec).	(2.3.1)
W_i	=	controlling sector annual atmospheric dispersion at the site boundary, as radionuclide i.	(2.2.1.b)
W_{ij}'	=	relative dispersion for the maximum exposed individual, as appropriate for his exposure pathway j and radionuclide i.	(2.2.2.b)
X_{id}	=	the concentration of noble gas radionuclide i in a waste gas decay tank, as corrected to the pressure of the discharge stream at the point of its flow measurement.	(2.1.2)
X_{iv}	=	the measured concentration of noble	(2.1.1)

Term	Definition	Section of Initial Use
	gas radionuclide i in the last grab sample analyzed for vent v (uCi/cc).	
X_d' =	the total noble gas concentration in a waste gas decay tank, as corrected to the pressure of the discharge stream at the point of its flow measurement.	(2.1.3)
X_v' =	a concentration of Xe-133 chosen to be in the operating range of the monitor on vent v (uCi/cc).	(2.1.3)
X/Q =	the highest annual average relative concentration at any distance in a given sector. (sec/m^3).	(2.3.1)
$\overline{X/Q}$ =	the highest annual average relative concentration in any sector, at the site boundary.	(2.1.1)
$\overline{X/Q}'$ =	relative concentration for the location occupied by the maximum exposed individual.	(2.2.2.b)

2.5 Gaseous Radwaste Treatment System

Figure 2.5-1



3.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

Sampling locations as required in section 3/4.12.1 of the Radiological Effluent Technical Specifications are described in Table 3.0-1 and shown on the maps in Figures 3.0-1 and 3.0-2. As indicated by the ditto (") marks in the table, entries in the sampling frequency and analysis frequency columns apply to all samples below the entry until a new entry appears.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
AIRBORNE:					
I. Particulate	A) 3 Indicator samples to be taken at locations (in different sectors) beyond but as close to the exclusion boundary as practicable where the highest offsite sectoral ground level concentrations are anticipated.[2]	Continuous sampler operation with weekly collection.	2 5 10	1.2 SW 0.9 SE 2.5 NNE	Gross beta following filter change; Quarterly Composite (by location) for gamma isotopic.
	B) 1 Indicator sample to be taken in the sector beyond but as close to the exclusion boundary as practicable corresponding to the residence having the highest anticipated offsite ground level concentration or dose.[2]	Continuous sampler operation with weekly collection.	6	1.0 ESE	Gross beta following filter change; Quarterly Composite (by location) for gamma isotopic.
	C) 1 Indicator sample to be taken at the location of one of the dairies most likely to be affected.[2,4]	Continuous sampler operation with weekly collection.	14[4]	6.3 W	Gross beta following filter change; Quarterly Composite (by location) for gamma isotopic.
	D) 1 Control sample to be taken at a location at least 10 air miles from the site and not in the most prevalent wind direction.[2]	Continuous sampler operation with weekly collection.	17	24.7 SE	Gross beta following filter change; Quarterly Composite (by location) for gamma isotopic.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
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TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
II. Radioiodine	A) 3 Indicator samples to be taken at two locations as given in I(A) above.	Continuous sampler operation with weekly canister collection.	2 5 10	1.2 SW 0.9 SE 2.5 NNE	Gamma Isotopic for Iodine 131 weekly
	B) 1 Indicator sample to be taken at the location as given in I(B) above.	Continuous sampler operation with weekly canister collection.	6	1.0ESE	Gamma Isotopic for Iodine 131 weekly
	C) 1 Indicator sample to be taken at the location as given in I(C) above.	Continuous sampler operation with weekly canister collection.	14	6.3 W	Gamma Isotopic for Iodine 131 weekly
	D) 1 Control sample to be taken at a location similar in nature to I(E) above.	Continuous sampler operation with weekly canister collection.	17	24.7 SE	Gamma Isotopic for Iodine 131 weekly
III. Direct	A) 13 Indicator stations to form an inner ring of stations in the 13 accessible sectors within 1 to 2 miles of the plant.	Monthly or quarterly exchange[5,7]; two or more dosimeters at each location.	1,2 3,4 5,6 7,8 9,10 29 30 47	1.2 S, 1.2 SW 1.2W, 1.2 WNW 0.9S E, 1.0 ESE 1.2 E, 1.5 ENE 2.2 NE, 2.5 NNE 0.9 WSW, 1.0 SSW 1.0 NW	Gamma dose monthly or quarterly.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
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TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
	B) 16 Indicator stations to form an inner ring of stations in the 16 accessible sectors within 3 to 5 miles of the plant.	Monthly or quarterly exchange[5,7]; two or more dosimeters at each location.	12,14 32,33 34,35 36,37 41,42 43 45 46 49 53,55	4.2 N,6.3 W 4.5NNE,4.2ENE 4.8 ESE,4.8 SE 3.1 SSE, 4.9 NW 3.9 S, 3.9 SSW 5.2 SW 5.9 WSW 3.7 WNW 4.0 NNW 3.0 NE, 2.8 E	Gamma dose monthly or quarterly.
	C) 8 Stations to be placed in special interest areas such as population centers, nearby residences, schools and in 2 or 3 areas to serve as controls.	Monthly or quarterly exchange[5,7]; two or more dosimeters at each location.	11,13 15,16 17,18 31,54	3.3 N, 2.9 NNW 2.5SSW,28.0W 24.7 SE, 16.5 S 5.8NNE,1.7ENE	Gamma dose monthly or quarterly.
WATERBORNE: IV. Surface Water	A) 1 Indicator sample downstream to be taken at a location which allows for mixing and dilution in the ultimate receiving river.	Time composite samples with collection every month.[5]	21[3,6]	2.7 SSW	Gamma isotopic monthly with quarterly composite (by location) or monthly sample to be analyzed for tritium.
	B) 1 Control sample to be taken at a location on the receiving river, sufficiently far up-stream such that no effects of pumped storage operation are anticipated.	Time composite samples with collection every month.[5]	22[3]	30.0 NNW	Gamma isotopic monthly with quarterly composite (by location) or monthly sample to be analyzed for tritium.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
	C) 1 Indicator sample from a location immediately upstream of the nearest downstream municipal water supply.	Time composite samples with collection every month.[5]	17	24.7 SE	Gamma isotopic monthly with quarterly composite (by location) or monthly sample to be analyzed for tritium.
	D) 1 Indicator sample to be taken in the upper reservoir of the pumped storage facility at the plant discharge canal.	Time composite samples with collection every month.[5]	23[3]	0.5 ESE	Gamma isotopic monthly with quarterly composite (by location) or monthly sample to be analyzed for tritium.
	E) 1 Indicator sample to be taken in the upper reservoir's non-fluctuating recreational area.	Grab sampling monthly[5]	24[3]	5.5 N	As in IV(A) above
	F) 1 Control sample to be taken at a location on a separated unaffected watershed reservoir.	Grab sampling monthly[5]	18[3]	16.5 S	As in IV(A) above
V. Ground Water	A) 2 Indicator samples to be taken within the exclusion boundary and in the direction of potentially affected ground water supplies.	Quarterly grab sampling [7]	26 27	Onsite Onsite	Gamma isotopic and tritium analyses quarterly.
	B) 1 Control sample from unaffected location.	Quarterly grab sampling [7]	16	20.1 W	Gamma isotopic and tritium analyses quarterly.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
VI. Drinking Water	A) 1 Indicator sample from a nearby public ground water supply source.	Monthly grab sampling.[5]	28	2.4 SSE	Monthly gamma isotopic, gross beta and tritium analyses.
	B) 1 Indicator (finished water) sample from the nearest downstream water supply.	Monthly composite sampling.	17	24.7 S	Monthly gamma isotopic, gross beta and tritium analyses.
	C) 1 Control (finished water) sample from an unaffected water supply.	Monthly composite sampling.	39	14.0 SSE	Monthly gamma isotopic, gross beta and tritium analyses.
INGESTION: VII. Milk[4]	A) Samples from milking animals in 3 locations within 5 km having the highest dose potential. If there are none then 1 sample from milking animals in each of 3 areas between 5 to 8 km distance where doses are calculated to be greater than 1 mrem per year.[10]	Semimonthly when animals are on pasture[8], monthly other times.[5]	To be supplied when milk animals are found in accordance with criteria VII.A		Gamma isotopic and I-131 analysis semimonthly when animals are on pasture, monthly other times.
	B) 1 Control sample to be taken at the location of a dairy > 20 miles distance and not in the most prevalent wind direction.[2]	Semimonthly when animals are on pasture[8], monthly other times.[5]	16	20.1 W	Gamma isotopic and I-131 analysis semimonthly when animals are on pasture, monthly other times.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
	C) 1 Indicator grass (forage) sample to be taken at one of the locations beyond but as close to the exclusion boundary as practicable where the highest offsite sectoral ground level concentrations are anticipated.[2]	Monthly when available[5]	6	1.0 ESE	Gamma isotopic.
	D) 1 Indicator grass (forage) sample to be taken at the location of VII(A) above when animals are on pasture.	Monthly when available[5]	To be supplied when milk animals are found in accordance with criteria VII A		Gamma isotopic.
	E) 1 Control grass (forage) sample to be taken at the location of VII(B) above.	Monthly when available[5]	16	20.1 W	Gamma isotopic.
VIII. Food Products	A) Two samples of broadleaf vegetation grown in the 2 nearest offsite locations of highest calculated annual average ground level D/Q if milk sampling is not performed within 3 km or if milk sampling is not performed at a location within 5-10 km where the doses are calculated to be greater than 1 mrem/yr.[10]	Monthly when available[5]	6 8	1.0 ESE 1.5 ENE	Gamma Isotopic on edible portion.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
	B) 1 Control sample for the same foods taken at a location at least 10 miles distance and not in the most prevalent wind direction if milk sampling is not performed within 3 km or if milk sampling is not performed at a location within 5-8 km where the doses are calculated to be greater than 1 mrem/yr.[8]	Monthly when available.[5]	18	16.5 S	Gamma Isotopic on edible portion.
IX. Fish	A) 1 Indicator sample to be taken at a location in the upper reservoir.	Semiannual collection of the following specie types if available: bass; bream, crappie; catfish, carp; forage fish (shad).	23[3]	0.3-5	Gamma isotopic on edible portions semiannually.
	B) 1 Indicator sample to be taken at a location in the lower reservoir.	Semiannual collection of the following specie types if available: bass; bream, crappie; catfish, carp; forage fish (shad).	21[3]	1-3	Gamma isotopic on edible portions semiannually.
	C) 1 Indicator sample to be taken at a location in the upper reservoir's non-fluctuating recreational area.	Semiannual collection of the following specie types if available: bass; bream, crappie; catfish, carp; forage fish (shad).	24[3]	5.5-6.5	Gamma isotopic on edible portions semiannually.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number & Location	Sampling and Collection Frequency	Sample[1] Location	Locations Mi/Dir	Type & Frequency of Analysis
	D) 1 Control sample to be taken at a location on the receiving river sufficiently far upstream such that no effects of pumped storage operation are anticipated.	Semiannual collection of the following specie types if available: bass; bream, crappie; catfish, carp; forage fish (shad).	22[3]	30.0 NNW	Gamma isotopic on edible portions semiannually.
AQUATIC: X. Sediment	A) 1 Indicator sample to be taken at a location in the upper reservoir.	Semiannual grab sample.[9]	23[3]	0.5 ESE	Gamma isotopic.
	B) 1 Indicator sample to be taken at a location in the upper reservoir's non-fluctuating recreational area.	Semiannual grab sample.[9]	24[3]	5.5 N	Gamma isotopic.
	C) 1 Indicator sample to be taken on the shoreline of the lower reservoir.	Semiannual grab sample.[9]	21[3]	2.7 SSW	Gamma isotopic.
	D) 1 Control sample to be taken at a location on the receiving river sufficiently far upstream such that no effects of pumped storage operation are anticipated.	Semiannual grab sample.[9]	22[3]	30.0 NNW	Gamma isotopic.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION
TABLE 3.0-1

NOTES

(l) Location numbers refer to Figures 3.0-1 and 3.0-2.

(2) Sample site locations are based on the meteorological analysis for the period of record a presented in Chapters 5 and 6, V.C. Summer Operating License Environmental Report.

(3) Though generalized areas are noted for simplicity of sample site enumeration, airborne, water and sediment sampling is done at the same location whereas biological sampling sites are generalized areas in order to reasonably assure availability of samples.

(4) Milking animal and garden survey results will be analyzed annually. Should the survey indicate new dairying activity the owners shall be contacted with regard to a contract for supplying sufficient samples. If contractual arrangements can be made, site(s) will be added for additional milk sampling up to a total of 3 Indicator Locations.

(5 Not to exceed 35 days.

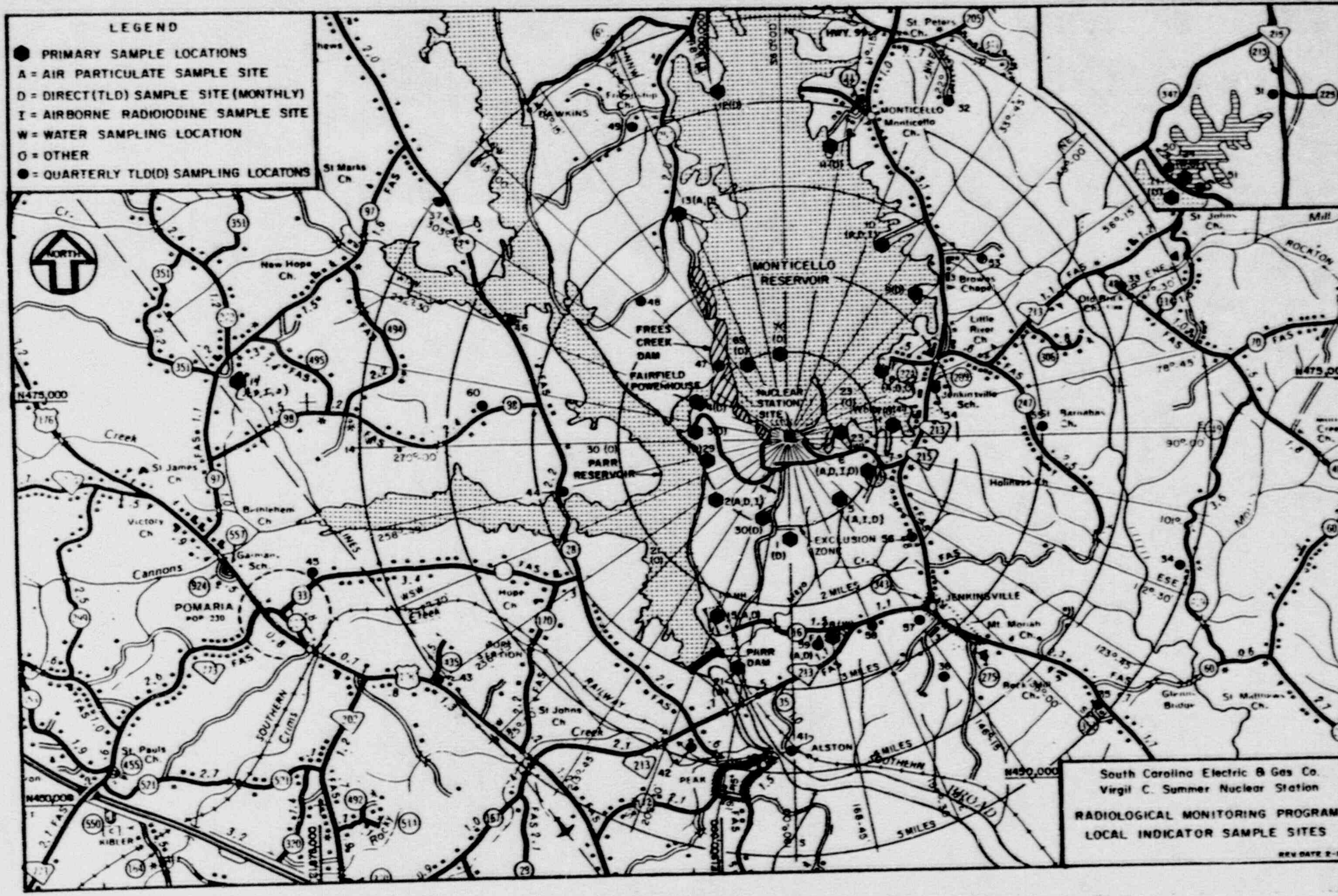
(6) ime composite samples are samples which are collected with equipment capable of collecting an aliquot at time intervals which are short (e.g. hourly) relative to the compositing period.

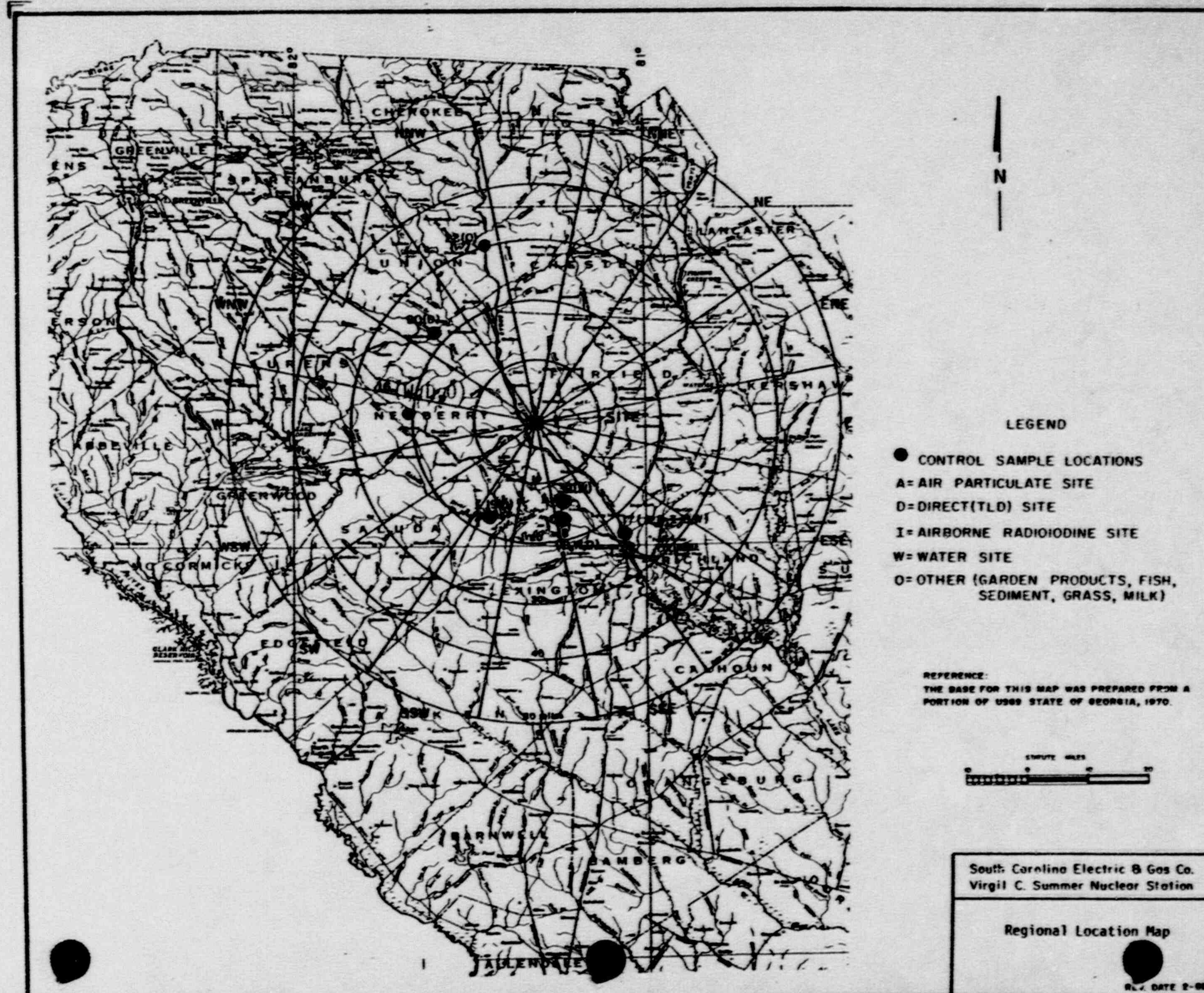
(7) At least once per 100 days.

(8) At least once per 18 days.

(9) At least once per 200 days.

(l0) The dcse shall be calculated for the maximum organ and age group, using the guidance/methodology contained in Regulatory Guide 1.109, Rev. 1 and the parameters particular to the Site.


LEGEND
PRIMARY SAMPLE LOCATIONS
A = AIR PARTICULATE SAMPLE SITE
D = DIRECT(TLD) SAMPLE SITE (MONTHLY)
I = AIRBORNE RADIOIODINE SAMPLE SITE
W = WATER SAMPLING LOCATION
O = OTHER
● = QUARTERLY TLD(D) SAMPLING LOCATONS
NORTH
MONTICELLO RESERVOIR
FREES CREEK DAM
FAIRFIELD POWERHOUSE
NUCLEAR STATION SITE
PARR RESERVOIR
EXCLUSION ZONE
PARR DAM
MONTICELLO
JENKINSVILLE
POMARIA
ALSTON
PEAK
2 MILES
5 MILES
N475,000
N450,000
South Carolina Electric & Gas Co.
Virgil C. Summer Nuclear Station
RADIOLOGICAL MONITORING PROGRAM
LOCAL INDICATOR SAMPLE SITES


N
CHEROKEE
GREENVILLE
SPARTANBURG
UNION
CHESTER
LANCASTER
LAURENS
FAIRFIELD
KERSHAW
NEWBERRY
SITE
ABBEVILLE
GREENWOOD
SALUDA
RICHLAND
McCORMICK
LEXINGTON
EDGEFIELD
CALHOUN
ORANGEBURG
BARNWELL
BAMBERG
ALLENDALE
NNW
NNE
NE
ENE
WNW
WSW
SW
SSW
ESE
LEGEND
CONTROL SAMPLE LOCATIONS
A= AIR PARTICULATE SITE
D= DIRECT(TLD) SITE
I= AIRBORNE RADIOIODINE SITE
W= WATER SITE
O= OTHER (GARDEN PRODUCTS, FISH, SEDIMENT, GRASS, MILK)
REFERENCE:
THE BASE FOR THIS MAP WAS PREPARED FROM A PORTION OF USGS STATE OF GEORGIA, 1970.
STATUTE MILES
South Carolina Electric & Gas Co.
Virgil C. Summer Nuclear Station
Regional Location Map
REV. DATE 2-88