APPENDIX B

RADIATION PROTECTION MANUAL

VOLUME 10

PLANT OPERATING MANUAL

CHEM-NUCLEAR SYSTEMS, INC.

PROCESS CONTROL PROGRAM

USING

CNSI PORTABLE SOLIDIFICATION SYSTEM

FOR

SOLIDIFICATION OF WET RADIOACTIVE WASTE

AT

TROJAN NUCLEAR POWER PLANT

July 19, 1979

Revision 19

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of the Process Control Program is to:

Provide reasonable assurance of the satisfactory solidification of wet radioactive waste and assure the absence of significant free water in such waste prior to transport and disposal.

The program consists of:

1.1 A basic description of the solidification system and facility interfaces including operational methodologies.

1.2 Procedures for sample collection and analysis.

1.3 Procedures for test solidification of waste specimens.

1.4 Acceptance criteria and process parameters.

2.0 SYSTEM DESCRIPTION

The Chem-Nuclear Systems, Inc., Portable Solidification System utilizes Urea Formaldehyde as the solidification agent.

Sulfuric acid is normally added to a mixture of waste and Urea Formaldehyde as a catalyst for solidification.

The Portable Solidification System consists of a portable solidification skid, UF storage tanks, acid storage tanks and a fill head.

2.1 Waste Transfer System

The waste transfer system consists of a 2-inch, teflon-lined, stainless steel hose, and a waste header with a second teflon-lined, stainless steel hose connecting the waste transfer header to the filling head.

2.2 Resin Transfer and Dewatering System

The resin transfer system consists of the resin inlet to unit valve and a teflon-lined, stainless steel hose for supply while the dewatering system consists of a dewatering pump with hose to return flush water to the facility.

2.3 Catalyst Addition System

The catalyst addition system transfers acid to a disposable solidification liner through an air sparge header or may be used to allow catalyst to be added to the top of the waste. The catalyst is transferred by a pump mounted on a catalyst storage tank.

2.4 Air Sparging System

The air sparge system is used to mix the Urea Formaldehyde and radioactive waste. This is performed by bubbling air through the mixture which causes the solution to become homogeneous. The air sparge system consists of an air sparge header, which is placed inside the disposable liner, a control regulator, and gauge located at the control panel.

2.5 Off-gas Vent System

The off-gas vent system creates a slight vacuum at the top of the liner to draw off any radioactive airborne contamination or other vapors. Components of the off-gas vent system are a blower, moisture separator, and charcoal filters which are normally located on the solidification skid.

2.6 Pneumatic Control Panel

The pneumatic control panel lines up and delivers pressurized air at 100 ± 20 psig for sparge air, camera air, and valve operating air. The sparge air and valve operating air functions are equipped with a pressure regulator and a pressure gauge.

2.7 Electrical Control Console

The electrical control console receives 120 volts AC power from the utility to power the following components:

1. UF pump controller
2. Dewater pump controller
3. Acid pump controller
4. Vent blower controller
5. Crimp-a-Cap controller
6. 120 volt AC to 25 volt AC transformer

2.8 Fill Head Assembly

The fill head assembly is mounted atop the disposable liner and directs the flow of waste or resin, catalyst, and sparging air to the liner. The fill head also contains ultrasonic level detection equipment and a television camera, which is used for remote viewing. The fill head is equipped with two air-operated valves and one manually-operated valve. These valves direct the flow of waste, resin and catalyst.

3.0 SAMPLE COLLECTION AND ANALYSIS

3.1 Sample Procedure Overview and Implementation

3.1.1 This section and Section 4 of the Process Control Program establish the program of sampling, analysis, test solidification, and evaluation which is necessary to insure complete solidification of each type of wet radioactive waste.

3.1.2 The minimum sampling requirement for test solidification is the first batch and every tenth batch thereafter of each type of wet radioactive waste (filter sludges, spent resins, evaporator bottoms, boric acid solutions, sodium sulfate solutions, and filter media).

3.1.3 Batch is defined as the waste required to fill one disposable liner to the level of the waste level probe. There will be two (2) methods of sampling the waste:

1. For a continuous single transfer, a sample will be obtained from valve WS-4.

2. For a multiple transfer to a liner, samples will be obtained from valve WS-4 and a composite sample prepared.

3.1.4 If any test specimen fails to solidify, the batch in the liner should not be solidified until a new test specimen can be obtained, alternative solidification parameters can be determined, and a subsequent test verifies solidification. Solidification of the batch may then be resumed using the alternative solidification parameters determined.

3.1.5 If the first test specimen from a batch of waste fails to verify solidification, a sample will be collected and analyzed in accordance with the Process Control Program from each consecutive batch of the same type of wet waste until three (3) consecutive test specimens demonstrate solidification. At this point, the sampling requirement is again every tenth batch of each type of wet waste.

3.2 Obtaining Test Specimens

3.2.1 Radiological Precautions

1. All samples must be handled with proper radiological considerations to minimize personnel exposure and to prevent the spread of contamination.

2. All requirements set forth by the facility's Radiation Protection Department must be complied with.

3. Disposal of completed test samples will be in the liner to be solidified. A record of volume and description of the sample will be maintained on the PCP data sheet.

3.2.2 CNSI Form PCP-1

1. CNSI Form PCP-1 will be used to collect data from each test specimen and will be maintained on file with the current sheet on top. A copy of CNSI Form PCP-1 will be maintained for each of the types of wet radioactive waste.

2. The following information is required on each test specimen:

   a. pH of waste
   b. Waste oil content
   c. Waste/UF ratio
   d. UF/Acid ratio

3. The following information will be required for all solidification evolutions:

   a. Waste type
   b. Level probe set points
   c. Sparge air pressure, flow rate, sparging time
   d. Total waste received
   e. Total UF added
   f. Total catalyst added
   g. Percentage of free-standing water
   h. Batch number

4. The batch number will range from 1 through 10 and on each tenth batch of each type of wet radioactive waste, a new set of process parameters will be determined. This practice will be followed for each type of wet radioactive waste.

3.2.3 Sampling Continuous Transfers of Waste

1. Evaporator bottoms or other hot samples should be collected in stainess steel thermos bottles.

2. Resins and other sludges should be collected in wide mouth bottles or other such containers from which the sample may be readily removed.

3. In the cases of resins or other waste in which large volumes of flush water are involved, several consecutive samples may have to be taken and the flush water decanted from the sample before a sufficient quantity of sample is obtained.

4. Sample volumes should normally be 1 liter; however, if radiation levels make this impractical small samples may be obtained as appropriate.

5. Obtain the sample from valve WS-4 after sufficient waste has been transferred to the liner so that a representative sample is in the transfer line. In any case, at least 1/5 of the anticipated volume of waste to be transferred should have been received prior to taking the sample.

3.2.4 Sampling Multiple Transfers of Waste Per Batch

1. The sampling techniques of 3.2.3 above are applicable.

2. Each sample of the partial batch will be placed in appropriate storage until the entire batch of waste has been transferred to the liner.

3. For each partial transfer an estimate of the volume will be made. This estimate should be obtained based on the best data obtainable at the time of transfer.

4. Prepare a composite sample by determining the fraction which each transfer contributed to the total batch. Using the total sample volume required, multiply each transfer fraction by this volume to give the volume of each sample which is to be added to the composited sample.

3.3 Sample Analysis

3.3.1 General Sample Analysis Considerations

1. Specific techniques for chemistry analysis are not included in this program since there are several acceptable procedures for many of the analyses that may be required.

2. The solidification agents will require certain analysis and are included in this section for convenience.

3. All analytical results are to be recorded in a lot maintained for that purpose.

3.3.2 Each new shipment of UF and periodically thereafter for UF and storage, a sample should be analyzed for specific gravity and pH. Record any manufacturer's lot numbers and production dates which may be available.

3.3.3 Each container of catalyst prior to use should be analyzed for specific gravity and color (visual).

3.3.4 Evaporator bottoms should be analyzed for as many of the following as practical:

1. pH.
2. Specific gravity
3. Oil
4. Sulfates
5. Boron
6. Detergents

3.3.5 Filter and other sludges should be analyzed for oil and detergents.

3.3.6 Resin beads will be characterized by analyzing the water surrounding the beads for oil, detergents, and pH.

3.3.7 All waste should have a qualitative test for foaming upon the addition of the catalyst. This can be accomplished by the addition of the catalyst to a small quantity of the waste in a beaker and visually observing the results.

4.0 TEST SOLIDIFICATION AND ACCEPTANCE CRITERIA

4.1 General Solidification Considerations

4.1.1 The standard ratios of UF/Waste which are to be used on the first test solidification (unless other data shows different ratios should be used) are as follows:

1. Resin beads or other waste with a high percentage of solid material with a defined shape, use a ratio of one to three.

2. Filter sludges, evaporator bottoms or other waste with a high percentage of dissolved or suspended solids use a ratio of one to two.

4.1.2 If the pH of any waste was less than three, a caustic should be added to increase the pH to greater than three prior to the addition of the UF. Record the sample size and the amount of caustic added.

4.1.3 If foaming occurred in the waste sample, an antifoaming agent should be added to the waste prior to the addition of the UF. Record the sample size and the amount of antifoaming agent added.

4.1.4 If the oil analysis indicated oil concentrations greater than 1%, attempts to remove the oil should be initiated. This may be accomplished by skimming the top of the liquid or by the addition of demulsification agent(s).

4.2 Test Solidification

4.2.1 The waste sample should have the required pretreatment accomplished prior to the test solidification.

4.2.2 Prepare the test solidification vessel (normally a 1000-ml disposable beaker) with a mixing device. This may be a disposable magnetic stirrer, a miniature air sparge system or other mechanical means of mixing the waste to UF. Smaller samples may be utilized if radiation levels prohibit the use of 1000-ml samples.

4.2.3 Transfer a known representative volume of the waste to the test solidification vessel. A typical volume is normally 400-ml.

4.2.4 Add the appropriate amount of UF as determined by the applicable ratio. For example, 200-ml of UF would be added to 400-ml of evaporator bottoms.

4.2.5 Initiate mixing the waste and UF. After a homogeneous mixture is obtained (normally allow at least 10 minutes), begin the catalyst addition until a pH of approximately 2 is obtained, at which time discontinue the addition of the catalyst.

4.2.6 As soon as the mixture begins to thicken, secure the mixing and allow the sample to remain undisturbed for at least 30 minutes.

4.2.7 If any free-liquid is noted on top of the sample, transfer the liquid, by draining, into a clean-disposable volumetric beaker and record the amount of liquid transferred. Calculate and record the percent of free-liquid present. For example, if 6-ml of liquid was obtained from a 600-ml total volume, this would represent 1% free water.

4.2.8 Add a sufficient quantity of cascamite (CR-10) to the liquid in the beaker to absorb all the liquid. Record the amount of cascamite added. Note and record if any liquid remains. Calculate the percent of free-liquid of the entire volume of solidified waste if any liquid was present.

4.3 Solidification Acceptability

4.3.1 The sample solidification will be considered acceptable if the amount of free-liquid following cascamite addition was less than 0.1%.

4.3.2 The waste solidification will be considered acceptable from a solid mass standpoint if it is evident from its physical appearance that the solidified waste would maintain its shape if moved from the vessel. This may be determined for example, by simply prodding with a stick or other rigid device and observing significant resistance to penetration.

4.3.3 If one or more of the above tests fails to meet the stated criteria, additional solidification parameters must be determined. This will also require the initiation of the additional solidification testing requirements for the next three batch types of waste which failed to solidify.

4.4 Alternate Solidification Parameter Selection

4.4.1 If unacceptable solidification resulted from excessive foaming, the following items should be explored to reduce subsequent foaming. Solidification testing, as specified in Step 4.3 above, must be repeated and results recorded.

1. Adding additional or different antifoaming agent.
2. Lowering the pH of the waste prior to the addition of the UF.
3. Reduce the addition rate of the catalyst.

4.4.2 If unacceptable solidification resulted from excessive free-liquid or too soft matrix, the UF/Waste ratios should be adjusted in increments of 0.5. For example, if the UF/Waste ratio was 1 to 3 and the results were unsatisfactory, a ratio of 1 to 2.5 should be used. Solidification testing as specified in Step 4.3 above must be repeated and results recorded.

FORM PCP-1

Date ____________

1. Waste Type ____________
2. Batch Number ____________
3. Process Parameters:
   - a. pH ____________
   - b. Oil ____________%
   - c. Boron ____________ppm *
   - d. Sulfates ____________ppm *
   - e. Detergents ____________% *
   - f. Waste: UF Ratio ____________
   - g. Catalyst ____________gal
   - h. UF ____________gal
   - i. Waste ____________gal
   - j. Cascamite ____________lbs
   - k. Free Liquid ____________%
4. Batch:

   1 2 3 4 5 6 7 8 9
5. Sparging:
   - a. Air Pressure ____________
   - b. Flow Rate ____________
   - c. Time ____________

*As Necessary

PGE-1021

OFFSITE DOSE CALCULATION MANUAL

TROJAN NUCLEAR PLANT

Portland General Electric Company
121 S. W. Salmon Street
Portland, Oregon 97204

June 1979

OFFSITE DOSE CALCULATION MANUAL

CONTENTS

OFFSITE DOSE CALCULATION MANUAL

CONTENTS

OFFSITE DOSE CALCULATION MANUAL

TABLES

FIGURES

2088 290

1.0 INTRODUCTION

The purpose of this manual is to provide methods for demonstrating compliance with the dose requirements of the Technical Specifications. Each method is based on Plant specific applications of the dose models presented in Regulatory Guide 1.109 (Rev. 1, 10/77).

Under normal operations, experience has shown that the Plant will be operated at a small fraction of the dose limits imposed by the Technical Specifications. For this reason, the dose evaluations are applied with different levels of sophistication. The first method being the most conservative, but simplest to use, while the subsequent method(s) are more entailed and more realistic.

2088 291

2088 292

2.0 LIQUID EFFLUENT DOSE CALCULATIONS

2.1 INTRODUCTION

Cumulative quarterly dose contributions due to radioactive liquid effluents released to unrestricted areas will be determined at least once per 31 days assuming the maximum exposed individual is an adult whose exposure pathways include potable water and fish consumption. These dose contributions will be calculated for all radionuclides identified in liquid effluents released to the unrestricted area using the following general equation:

$$D_j = \sum_i \left[A_{ij} \sum_{\ell=1}^{m} \Delta T_\ell \, C_{i\ell} \, F_\ell \right] \qquad (2\text{-}1)$$

where

D_j = the cumulative quarterly dose commitment to any organ j, from liquid effluent for total time period $\sum_{\ell=1}^{m} \Delta T_\ell$, in mrem

ΔT_ℓ = the length of release period over which $C_{i\ell}$ and F_ℓ are averaged, in hours

$C_{i\ell}$ = average concentration of nuclide i, during time period ΔT_ℓ, in μCi/ml. The term $C_{i\ell}$ is the undiluted concentration of radioactive material in liquid waste determined in accordance with Table 4.11-1 of the Technical Specifications

A_{ij} = ingestion dose factor for any organ j for each identified nuclide i, listed in Table 2-1, in mrem/hr per μCi/ml

F_ℓ = the near field average dilution factor for $C_{i\ell}$ during any liquid release. Defined as the ratio of the volume of liquid waste discharged during release to the product of the Plant discharge volume to the unrestricted area multiplied by 16 (16 is the Plant specific factor for the mixing effect of the diffuser pipe).

2088 293

The term F_ℓ, the near field average dilution factor, is determined as follows for time period ΔT_ℓ:

$$F_\ell = \frac{\text{liquid radioactive waste discharge volume}}{\text{total Plant discharge volume} \times \frac{1000 \times 7.48 \times 60}{28{,}492}}$$

$$= \frac{\text{liquid radioactive waste discharge volume}}{\text{total Plant discharge volume} \times 16}$$

where

1000 = typical total Plant discharge flow rate for a once thru cooling plant, in cfs

28,492 = the Trojan annual average total Plant discharge flow rate, gpm

7.48 = conversion factor, gal/ft^3

60 = conversion factor, sec/min.

The term A_{ij}, the ingestion dose factors for any organ, are tabulated in Table 2-1. For simplicity and conservatism, a single maximum organ dose factor for each nuclide was calculated using the critical o[illegible] for each nuclide. The following equation was used in calculating the ingestion dose factors:

$$A_{ij} = k_o \left[\frac{U_W}{D_W} + U_F \ BF_i \right] DF_i \qquad (2\text{-}2)$$

where

A_{ij} = composite dose parameter for total body or maximum organ of an adult for nuclide i, in mrem/hr per μCi/ml

2088 294

k_o = conversion factor, $1.1 \times 10^5 = 10^6$ pCi/μCi x 10^3 ml/kg ÷ 8760 hr/yr

U_W = 730 kg/yr, adult maximum annual water consumption rate

U_F = 21 kg/yr, adult maximum annual fish consumption rate

BF_i = bioaccumulation factor for nuclide i, in fish, pCi/kg per pCi/ℓ (from Reg. Guide 1.109, Rev. 1, 10/77)

DF_i = dose conversion factor for nuclide i, for adults - total body or maximum organ in mrem/pCi (from Reg. Guide 1.109, Rev. 1, 10/77)

D_W = dilution factor for the Plant diffuser pipe to the nearest potable water intake, 230 = 230,000 cfs average river flow ÷ 1000 cfs effective Plant discharge flow.

2.2 TECHNICAL SPECIFICATION 3.11.1.2

This Section will be used to demonstrate compliance with the following Limiting Condition for Operation (LCO) 3.11.1.2 at least once per 31 days.

2.2.1 METHOD 1

The following Plant specific applications of Equation 2-1 will be used in Method 1:

Total Body

$$D_{TB} = \sum_{\ell} \frac{\Delta T_{\ell}}{16V_{\ell}} \sum_{i} A_{TB_i} \times Q_{i\ell} \qquad (2\text{-}3)$$

Maximum Organ

$$D_{MO} = \sum_{\ell} \frac{\Delta T_{\ell}}{16V_{\ell}} \sum_{i} A_{MO_i} \times Q_{i\ell} \qquad (2\text{-}4)$$

where

D_{TB} = cumulative quarterly total body dose, mrem/quarter

D_{MO} = cumulative quarterly maximum organ dose, mrem/quarter

ΔT_{ℓ} = the ℓth time period in a calendar quarter over which release occurs, hr

V_{ℓ} = volume of total Plant discharge flow for time ΔT_{ℓ}, ml

16 = Plant specific dilution factor

A_{TB_i} = total body dose parameter for nuclide i, mrem/hr per μCi/ml

2088 296

A_{MO_i} = maximum organ dose parameter for nuclide i, mrem/hr per μCi/ml

$Q_{i\ell}$ = activity released of nuclide i, over time period ΔT_{ℓ}, μCi.

Doses from isotopes for which Technical Specifications require quarterly analysis of composite samples shall be included in the computations for the last time period of the calendar quarter.

Nuclides contributing less than 10 percent of the total body or maximum organ dose need not be included in the 31-day dose calculation.

2.2.2 METHOD 2 (Optional)

Should the dose limits of LCO 3.11.1.2 be exceeded using Method 1, a more accurate dose calculation may be made using the methodology in Regulatory Guide 1.109 (Rev. 1, 10/77) to demonstrate compliance.

Nuclides contributing less than 10 percent of the total body or maximum organ dose need not be included in the 31-day dose calculation.

2.3 TECHNICAL SPECIFICATION 3.11.1.3

This Section is used to demonstrate compliance with the Limiting Condition for Operation (LCO) 3.11.1.3 at least once per 31 days.

The dose limits for LCO 3.11.1.3 will be administered on a time proportional basis so that the radwaste treatment systems will be used to ensure that the quarterly design objectives are not exceeded under normal operations. The dose computation method is identical to that described in Section 2.2.

The Plant operating philosophy is to keep liquid effluent releases as low as is reasonably achievable. Management control of releases is maintained procedurally in two ways: 1) waste which results in exceeding the time proportional dose limit of LCO 3.11.1.3 will be processed; and 2) waste not processed to below a specified fraction of the quarterly dose limits will require additional management approval. With these procedural controls, both high activity single releases and significant long-term releases are controlled and processed.

A flow diagram of the liquid radwaste treatment system, as applicable to LCO 3.11.1.3, is shown in Figure 2-1.

2088 298

2.4 TECHNICAL SPECIFICATION 6.9.1.5.4

This Section describes the method that will be used to calculate doses from liquid effluents, as required by Technical Specification 6.9.1.5.4 (Semiannual Radioactive Effluent Release Report).

2.4.1 GENERAL METHODOLOGY

The models and non-Plant/site specific model parameters of Appendices A and E to Regulatory Guide 1.109 (Rev. 1, 10/77) will be utilized to compute doses from liquid effluents for this Technical Specification. Computer codes utilized in the calculations will be documented, verified and controlled in accordance with written departmental or branch procedures.

2.4.2 PLANT/SITE SPECIFIC ASSUMPTIONS

Hydrologic dilution factors will be based on actual river flow rates and effluent flow rates during the reporting period. Drinking water and agricultural exposure pathways will assume dilution into the full river flow. Other exposure pathways will assume dilution into the mixing zone, as defined in Environmental Technical Specification 1.7.

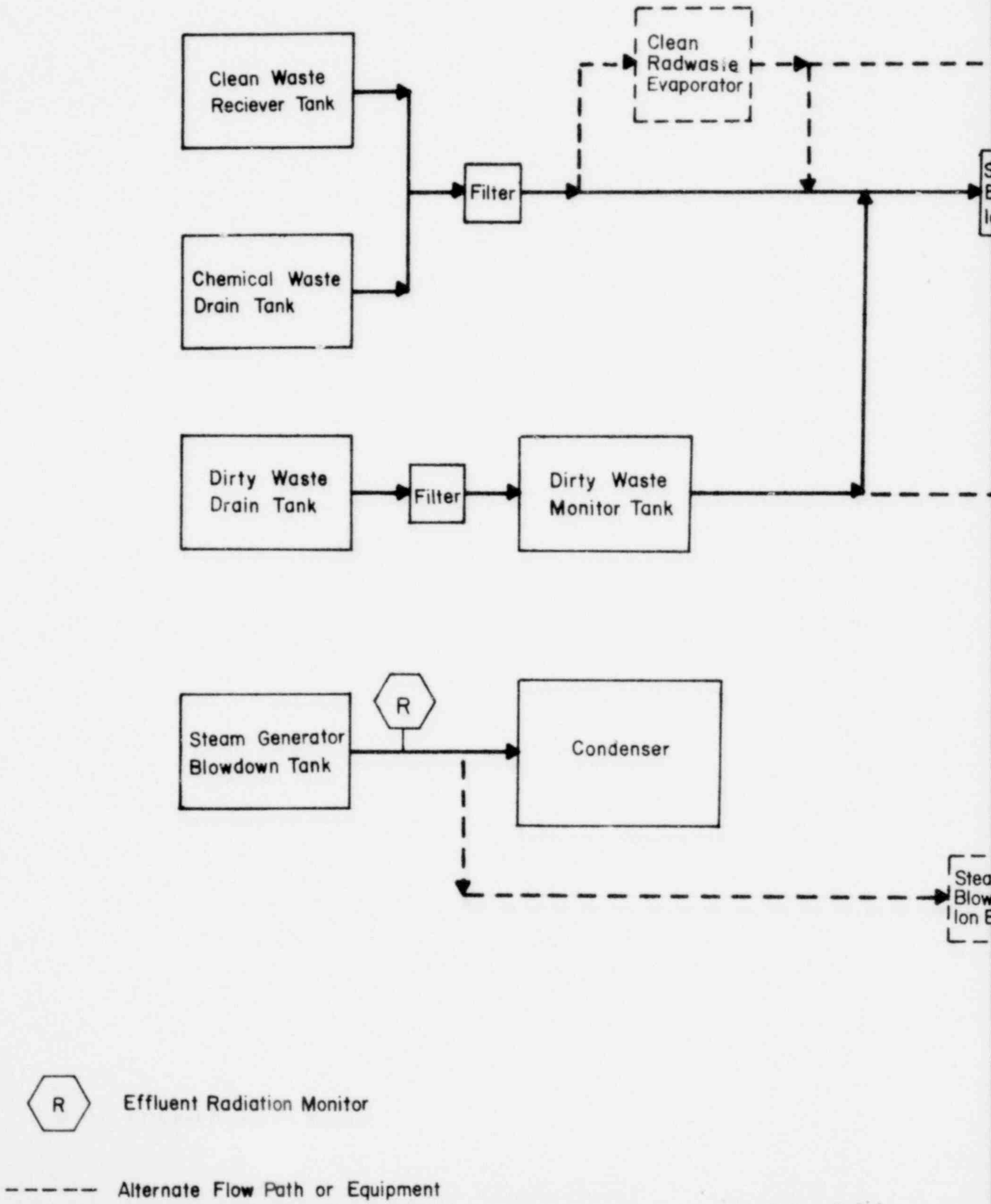
TABLE 2-1

LIQUID EFFLUENT
ADULT INGESTION DOSE FACTORS
(mrem/hr per μCi/ml)

Nuclide	Total Body A_{TB_i}	Maximum Organ A_{MO_i}	Nuclide	Total Body A_{TB_i}	Maximum Organ A_{MO_i}
H-3	2.7E-1	2.7E-1	Ru-103	1.9E+0	5.2E+2
Na-24	3.9E+2	3.9E+2	Ru-105	0	2.2E+2
P-32	1.7E+6	4.4E+7	Ru-106	8.2E+0	4.2E+3
Cr-51	1.2E+0	3.1E+2	Te-125m	3.3E+2	1.0E+4
Mn-54	8.0E+2	1.3E+4	Te-127	2.2E+1	8.0E+3
Mn-56	1.8E+1	3.4E+3	Te-127m	7.7E+2	2.6E+4
Fe-55	1.0E+2	6.5E+2	Te-129	7.1E+0	1.2E+2
Fe-59	9.0E+2	7.9E+3	Te-129m	1.7E+3	5.4E+4
Co-58	2.0E+2	1.7E+3	Te-131	5.7E+0	7.9E+1
Co-60	5.4E+2	4.6E+3	Te-131m	6.6E+2	7.8E+4
Ni-63	1.0E+3	3.0E+4	Te-132	1.4E+3	7.1E+4
Ni-65	7.2E+0	3.9E+2	I-130	3.1E+1	6.6E+3
Cu-64	4.5E+0	8.2E+2	I-131	1.2E+2	7.0E+4
Zn-65	3.2E+4	6.9E+4	I-132	6.6E+0	6.6E+2
Br-83	3.9E+1	5.6E+1	I-133	2.6E+1	1.3E+4
Br-84	5.0E+1	5.0E+1	I-134	3.5E+0	1.7E+2
Br-85	2.0E+0	2.0E+0	I-135	1.5E+1	2.7E+3
Rb-86	4.5E+4	9.7E+4	Cs-134	5.5E+5	6.9E+5
Rb-88	1.5E+2	2.8E+2	Cs-136	8.8E+4	1.2E+5
Rb-89	1.3E+2	1.8E+2	Cs-137	3.3E+5	5.1E+5
Sr-89	6.1E+2	2.2E+4	Cs-138	2.5E+2	5.1E+2
Sr-90	1.3E+5	5.3E+5	Ba-139	0	1.6E+0
Sr-91	1.6E+1	1.9E+3	Ba-140	1.2E+1	4.0E+2
Sr-92	6.5E+0	3.0E+3	La-140	0	5.4E+3
Y-90	0[a]	5.8E+3	La-142	0	2.5E+1
Y-91	0	4.5E+3	Ce-141	0	6.4E+1
Y-92	0	8.7E+2	Ce-143	0	1.2E+2
Y-93	0	4.9E+3	Ce-144	0	4.5E+2
Zr-95	0	2.5E+2	Pr-143	0	2.3E+3
Zr-97	0	8.8E+2	Nd-147	0	2.0E+3
Nb-95	1.3E+2	1.5E+6	W-187	8.3E+1	7.8E+4
Mo-99	1.9E+1	2.3E+2	Np-239	0	5.6E+2
Tc-99m	0	1.4E+1			

2088 300

[a] Zero in this table is <1.0 except H-3.


Clean Waste Reciever Tank
Chemical Waste Drain Tank
Filter
Clean Radwaste Evaporator
Dirty Waste Drain Tank
Filter
Dirty Waste Monitor Tank
Steam Generator Blowdown Tank
R
Condenser
R
Effluent Radiation Monitor
Alternate Flow Path or Equipment

2088 301

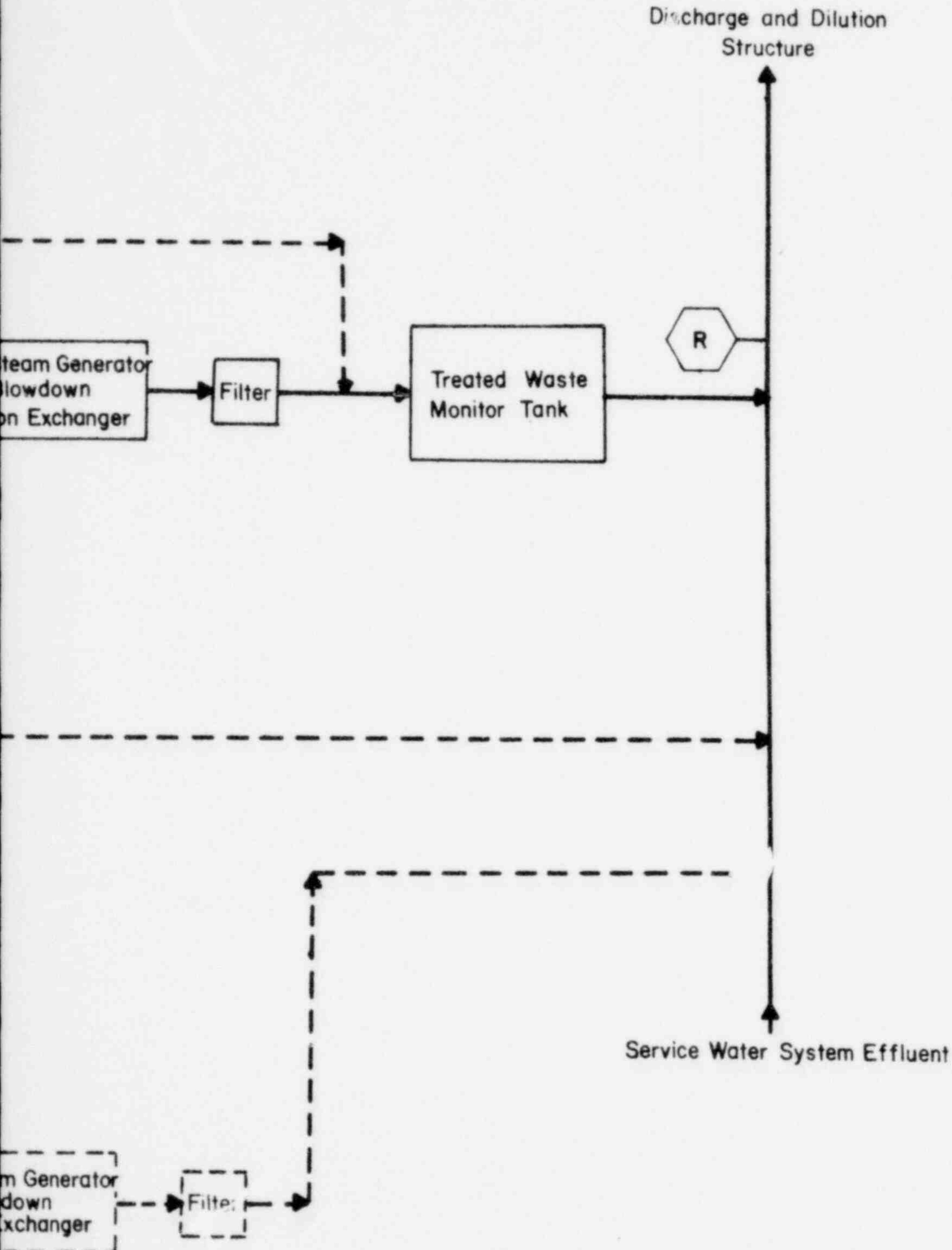


Figure 2-1 Liquid Radwaste Treatment System

2088 303

3.0 GASEOUS EFFLUENT DOSE CALCULATIONS

3.1 INTRODUCTION

Cumulative quarterly dose contributions due to radioactive gaseous effluents released to unrestricted areas will be determined at least once per 31 days.

The noble gas dose contributions will be determined using the following general equations:

Gamma air dose, D_a^{γ}, mrad

$$D_a^{\gamma} = 3.2 \times 10^{-5} \sum_i M_i \times Q_i \qquad (3\text{-}1)$$

Beta air dose, D_a^{β}, mrad

$$D_a^{\beta} = 3.2 \times 10^{-5} \sum_i N_i \times Q_i \qquad (3\text{-}2)$$

Skin dose, D_S, mrem

$$D_S = 3.2 \times 10^{-5} \sum_i (L_i + 1.1 \times M_i) \times Q_i \qquad (3\text{-}3)$$

Total body dose, D_{TB}, mrem

$$D_{TB} = 3.2 \times 10^{-5} \sum_i K_i \times Q_i \qquad (3\text{-}4)$$

where

K_i = total body dose factor due to gamma emissions for nuclide i, rem/yr per Ci/sec

L_i = skin dose factor due to beta emissions for nuclide i, rem/yr per Ci/sec

M_i = air dose factor due to gamma emissions for nuclide i, rad/yr per Ci/sec

N_i = air dose factor due to beta emissions for nuclide i, rad/yr per Ci/sec

Q_i = noble gas activity released of nuclide i, Ci

3.2×10^{-5} = (10^3 mrad/rad) ÷ 3.15×10^7 sec/yr

1.1 = constant, rem/rad.

The values of K_i, L_i, M_i, and N_i are listed in Table 3-1. Derivation of these values is presented in Appendices A and C.

For purposes of simplifying the dose calculations for noble gases, it may be conservatively assumed that all noble gas activity consists of the single nuclide Kr-89.

The iodine and particulate ($T_{1/2}$ > 8 days) dose contributions will be determined using the following general equations:

Dose at controlling exposure location, D_{IPC}, mrem

$$D_{IPC} = 3.2 \times 10^{-5} \sum_i R_i \times Q_i \quad (3\text{-}5)$$

Dose at site boundary, D_{IPS}, mrem

$$D_{IPS} = 3.2 \times 10^{-5} \sum_i P_i \times Q_i \quad (3\text{-}6)$$

where

R_i = dose factor for nuclides other than noble gases at the controlling exposure location (as determined in the Annual Land Use Census) for critical organ and age group, rem/yr per Ci/sec

P_i = dose factor for nuclides other than noble gases at the maximum site boundary location for critical organ and infant age group, rem/yr per Ci/sec

Q_i = iodine and particulate activity released of nuclide i, Ci.

The values of R_i and P_i are listed in Table 3-2. Derivation of these values is presented in Appendix D.

3.2 TECHNICAL SPECIFICATION 3.11.2.1

This Section, together with Section 4.0, will be used to demonstrate compliance with Limiting Condition for Operation (LCO) 3.11.2.1.

3.2.1 BATCH RELEASES

Allowable discharge rates for batch releases from Containment and waste gas decay tanks will be computed such that the dose rate limits of LCO 3.11.2.1 are not exceeded. The allowable discharge rate is the lower of the three values computed as follows (based on Equations 3-3, 3-4 and 3-6):

Noble gases

$$F = \frac{LCO_S}{1000 \sum_i (L_i + 1.1\,M_i)\,C_i} \qquad (3\text{-}7)$$

$$F = \frac{LCO_{TB}}{1000 \sum_i K_i\,C_i} \qquad (3\text{-}8)$$

Iodine and Particulates

$$F = \frac{LCO_{IP}}{1000 \sum_i P_i\,C_i} \qquad (3\text{-}9)$$

where

F = allowable discharge rate before dilution, m^3/sec

LCO_S = LCO 3.11.2.1 dose rate limit for skin, mrem/yr

LCO_{TB} = LCO 3.11.2.1 dose rate limit for total body, mrem/yr

2088 307

LCO_{IP} = LCO 3.11.2.1 dose rate limit for iodine and particulates, mrem/yr

K_i, L_i, M_i, P_i = dose factors for nuclide i, rem/yr per Ci/sec

C_i = undiluted concentration of nuclide i, μCi/ml

1000 = mrem/rem conversion.

Iodines, particulates and tritium need not be included in the computations for the waste gas decay tanks since they are included in the Fuel and Auxiliary Building exhaust continuous release.

The total concentration of iodine and particulates can be used in the computations for Containment purging, using the dose factor for I-131. Tritium can be deleted from the computation if the allowable discharge rate is reduced by 5 percent (historical data for Trojan gaseous effluent indicates that tritium contributes less than 5 percent of the total dose from iodines and particulates; see Table 3-3).

Containment pressure relief releases, due to low system flow rates, will be excluded from demonstrating compliance with LCO 3.11.2.1 when the Containment effluent radiation monitors are in operation and indicate readings less than the following:

PRM-1A (particulate)	$<1 \times 10^6$ cpm	(basis: I-131)
PRM-1B (iodine)	$<1 \times 10^6$ cpm/min	(basis: I-131)
PRM-1C (low-gas)	$\leq 1 \times 10^6$ cpm	(basis: Kr-88)
PRM-1D (high-gas)	$<4 \times 10^2$ cpm	(basis: Kr-88)

3.2.2 ALL RELEASES

Doses from total Plant gaseous effluents shall be computed using Equations 3-3, 3-4, and 3-6. The allowable values for determining the applicability of the Action Statement in LCO 3.11.2.1 are 1/12 of the annual LCO 3.11.2.1 dose limits.

Doses from nuclides for which Technical Specifications require quarterly analysis of composite samples shall be included in the computations for the last time period of the calendar quarter.

3.3 TECHNICAL SPECIFICATION 3.11.2.2

This Section will be used to demonstrate compliance with Limiting Condition for Operation 3.11.2.2 at least once per 31 days.

Beta and gamma air doses from noble gases released in gaseous effluents will be computed at least once per 31 days using Equations 3-1 and 3-2 together with the dose factors in Table 3-1.

3.4 TECHNICAL SPECIFICATION 3.11.2.3

This Section will be used to demonstrate compliance with Limiting Condition for Operation (LCO) 3.11.2.3 at least once per 31 days.

3.4.1 METHOD 1

This simplified method derives a cumulative quarterly maximum organ dose computation for total iodines, particulates, and nuclides other than noble gases, based on conservative assumptions which will ensure that the dose limit of LCO 3.11.2.3 is not exceeded.

The following equation will be used (based on Equation 3-5) to determine maximum organ dose at the controlling offsite exposure location:

$$D_{IP} = (3.2 \times 10^{-5})(1.05)\, R_{131} \sum_i Q_i \qquad (3\text{-}10)$$

where

D_{IP} = cumulative quarterly maximum organ dose from iodines, particulates, and nuclides other than noble gases, mrem

R_{131} = Dose factor for I-131, rem/yr per Ci/sec from Table 3-2

Q_i = cumulative quarterly release of each iodine and particulate nuclide i (excluding tritium), Ci

1.05 = factor of conservatism to allow for dose from tritium.

All radioiodine and particulate activity is conservatively assumed to be I-131 (the nuclide having the highest dose factor in Table 3-2 which has been identified in plant effluents).

Based on historical data presented in Table 3-3, the iodine and particulate activity contributes more than 95 percent of the maximum organ dose and tritium contributes less than 5 percent. The dose computed with

Equation 3-10 therefore includes a factor of 1.05 to account for the dose contribution from tritium which is not specifically included in the computation.

3.4.2 METHOD 2 (Optional)

Method 2 is similar to Method 1, but will utilize the actual iodine, particulate, and tritium releases to determine compliance with LCO 3.11.2.3 as follows (based on Equation 3-5):

$$D_{IP} = 3.2 \times 10^{-5} \sum_i R_i Q_i \qquad (3\text{-}11)$$

where

D_{IP} = cumulative quarterly maximum organ dose from iodines, particulates, and nuclides other than noble gases, mrem

R_i = dose factor for nuclide i, rem/yr per Ci/sec from Table 3-2

Q_i = cumulative quarterly release of each iodine, particulate, and tritium nuclide i, Ci.

Doses from nuclides for which Technical Specifications require quarterly analysis of composite samples shall be included in the computations for the last time period of the calendar quarter.

3.4.3 METHOD 3 (Optional)

Should the dose limits of LCO 3.11.2.3 be exceeded using Methods 1 and 2, a more accurate dose calculation may be made using the methodology specified in Section 3.6 to demonstrate compliance.

3.5 TECHNICAL SPECIFICATION 3.11.2.4

This Section will be used to demonstrate compliance with Limiting Condition for Operation (LCO) 3.11.2.4 at least once per 31 days.

Flow diagrams of the gaseous radwaste treatment system and the ventilation exhaust treatment system, as applicable to LCO 3.11.2.4, are shown in Figures 3-1 and 3-2.

3.5.1 NOBLE GASES

The beta and gamma air dose limits for LCO 3.11.2.4 will be administered on a time proportional basis so that the gaseous radwaste treatment system will be used to ensure that the quarterly design objectives are not exceeded under normal operations. The dose computation method is identical to that described in Section 3.3.

The Plant operating philosophy is to keep gaseous releases as low as reasonably achievable. Management control of releases is maintained procedurally by requiring additional management approval of all wastes not processed to below a specified fraction of the quarterly dose limits of LCO 3.11.2.4. With these procedural controls, high activity single releases are processed and controlled.

3.5.2 IODINE AND PARTICULATE

The organ dose limits for LCO 3.11.2.4 will be administered on a time proportional basis so that the Containment ventilation exhaust treatment system will be used to ensure that the quarterly design objectives are not exceeded under normal operation. The dose computation method is identical to that described in Section 3.4.

The Plant operating philosophy is to keep particulate and iodine releases as low as reasonably achievable. Management control of releases is maintained procedurally in two ways: 1) waste which results in exceeding the time proportional dose limit of LCO 3.11.2.4 will be processed; and

2) waste not processed to below a specified fraction of the quarterly dose limits will require additional management approval. With these procedural controls, both high activity single releases and significant long-term releases are controlled and processed.

3.6 TECHNICAL SPECIFICATION 6.9.1.5.4

This Section describes the method that will be used to calculate doses from gaseous effluents, as required by Technical Specification 6.9.1.5.4 (Semiannual Radioactive Effluent Release Report).

3.6.1 GENERAL METHODOLOGY

The models and non-Plant/site specific model parameters of Appendices B, C, and E to Regulatory Guide 1.109 (Rev. 1, 10/77) will be utilized to compute doses from gaseous effluents for this Technical Specification. Computer codes utilized in the calculations will be documented, verified and controlled in accordance with written departmental or branch procedures.

3.6.2 PLANT/SITE SPECIFIC ASSUMPTIONS

Meteorological dispersion and deposition factors will be based on hourly meterological data from the Trojan meteorological monitoring system during the reporting period. Separate meteorological factors will be derived for batch and continuous releases. The meteorological model described in Appendix C will be used. Dose receptor locations will be based on the results of the Land Use Census required by Technical Specification 3.12.2.

TABLE 3-1

NOBLE GAS EFFLUENT DOSE FACTORS

Nuclide	K_i Gamma Total Body Dose Factor $(\frac{rem/yr}{Ci/sec})$	L_i Beta Skin Dose Factor $(\frac{rem/yr}{Ci/sec})$	M_i Gamma Air Dose Factor $(\frac{rad/yr}{Ci/sec})$	N_i Beta Air Dose Factor $(\frac{rad/yr}{Ci/sec})$
Kr-83m	9.1E-4	0.0	2.3E-1	3.5E+0
Kr-85	1.9E-1	1.6E+1	2.0E-1	2.4E+1
Kr-85m	1.4E+1	1.8E+1	1.4E+1	2.4E+1
Kr-87	7.1E+1	1.2E+2	7.4E+1	1.2E+2
Kr-88	1.8E+2	2.9E+1	1.8E+2	3.5E+1
Kr-89	2.0E+2	1.2E+2	2.0E+2	1.3E+2
Kr-90	1.9E+2	8.8E+1	1.9E+2	9.4E+1
Xe-131m	1.1E+[illegible]	5.8E+0	1.9E+0	1.3E+1
Xe-133	3.5E+0	3.7E+0	4.2E+0	1.3E+1
Xe-133m	3.0E+0	1.2E+1	4.0E+0	1.8E+1
Xe-135	2.2E+1	2.3E+1	2.3E+1	3.0E+1
Xe-135m	3.7E+1	8.5E+0	4.1E+1	8.9E+0
Xe-137	1.7E+1	1.4E+2	1.8E+1	1.6E+2
Xe-138	1.1E+2	4.9E+1	1.1E+2	5.8E+1
Ar-41	1.1E+2	3.7E+1	1.1E+2	4.0E+1

TABLE 3-2

IODINE AND PARTICULATE DOSE FACTORS

Nuclide	P_i Dose Factor At Site Boundary $(\frac{rem/yr}{Ci/sec})$	R_i Dose Factor At Controlling Location $(\frac{rem/yr}{Ci/sec})$
H-3	6.0E+0	7.2E+1
Na-24	1.9E+3	9.1E+2
P-32	8.3E+6	2.0E+5
Cr-51	7.8E+2	7.9E+2
Mn-54	7.9E+4	1.4E+5
Mn-56	7.3E+2	1.2E+3
Fe-55	2.5E+5	4.4E+4
Fe-59	5.4E+4	6.3E+4
Co-58	4.3E+4	5.4E+4
Co-60	3.2E+5	1.5E+6
Sr-89	7.0E+5	2.0E+6
Sr-90	7.1E+6	6.3E+7
I-131	5.7E+7	2.6E+6
I-132	1.7E+3	1.8E+3
I-133	5.5E+5	7.9E+4
I-134	4.5E+2	5.0E+2
I-135	7.9E+3	7.9E+3
Cs-134	3.8E+6	1.8E+6
Cs-136	3.4E+5	2.4E+4
Cs-137	3.3E+6	1.9E+6
Cs-138	3.8E+1	2.9E+1
Ba-140	2.8E+4	3.1E+4
La-140	3.2E+3	5.0E+3

TABLE 3-3

HISTORICAL MAXIMUM ORGAN DOSE CONTRIBUTIONS FROM TRITIUM IN GASEOUS EFFLUENTS

Quarter	H-3 Dose (mrem)	Total Max. Organ Dose (mrem)	Percent H-3
1977			
1	3.8E-3	1.9E-0	0.20
2	3.2E-3	1.3E-0	0.25
3	5.2E-4	1.3E-2	4.0
4	2.3E-4	9.0E-3	2.6
1978			
1	2.9E-3	9.1E-2	3.2
2	5.8E-4	2.7E-2	2.1
3	1.6E-4	1.5E-2	1.1
4	2.0E-4	1.8E-2	1.1

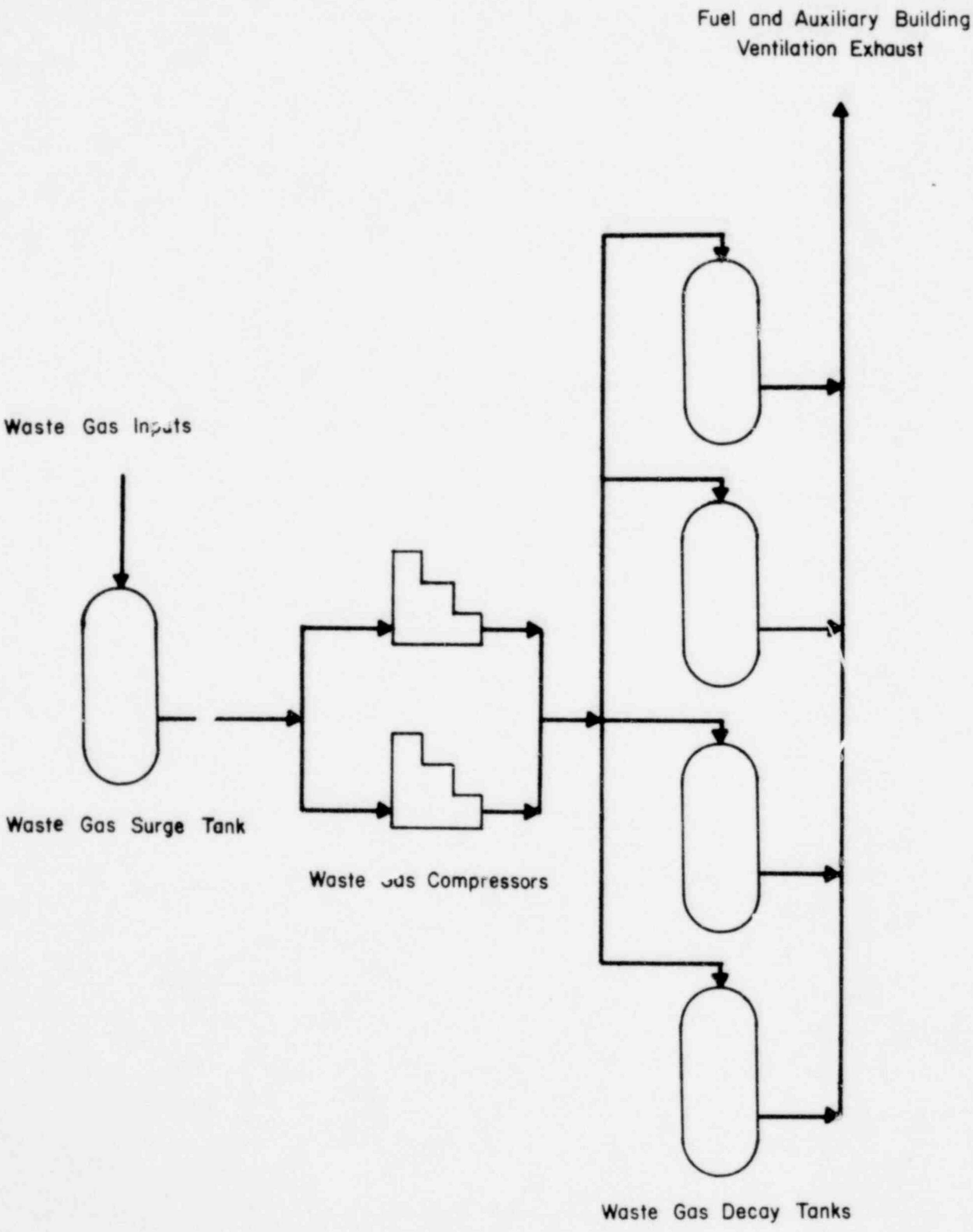
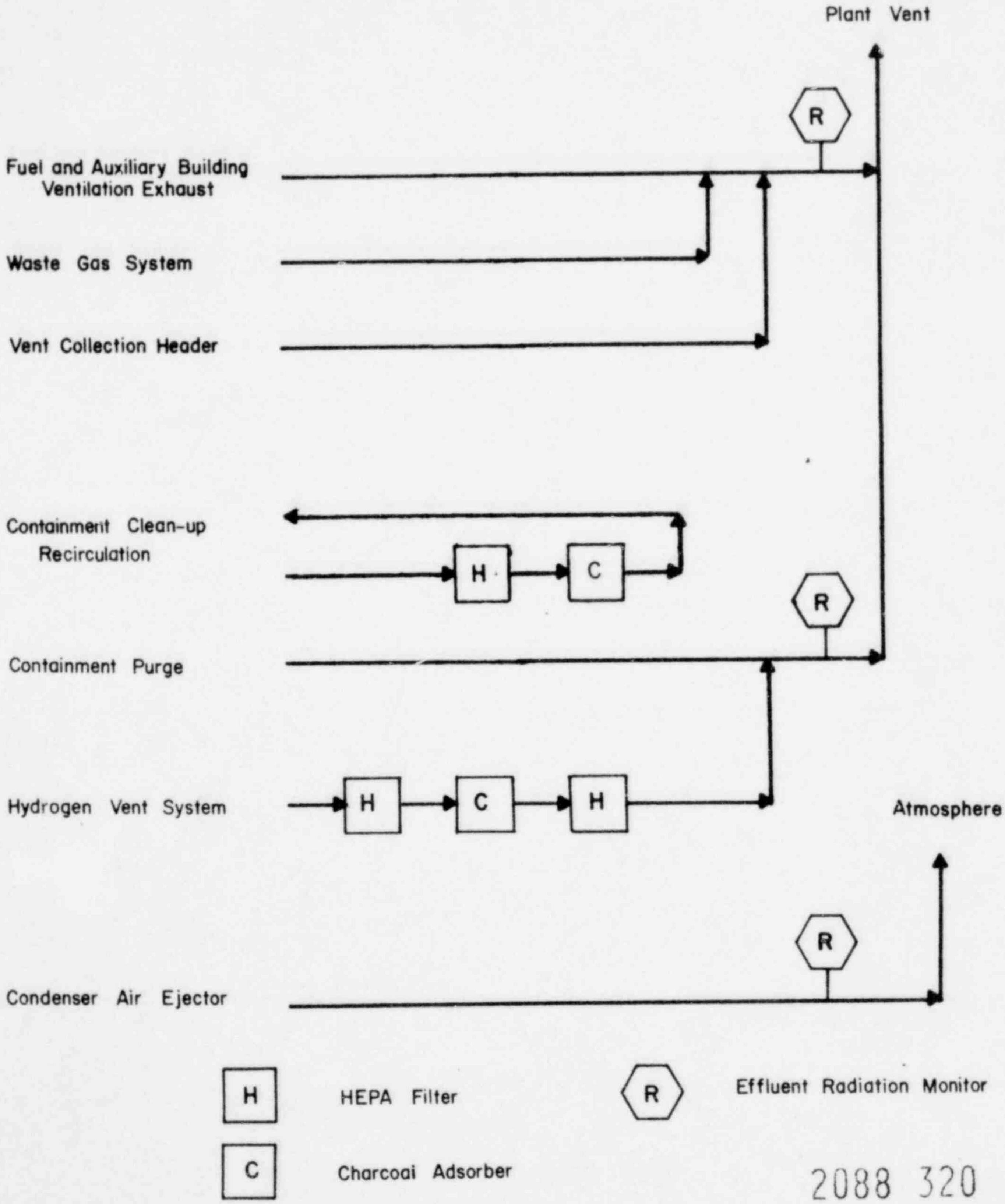


Figure 3-1 Gaseous Radwaste Treatment System



2088 320

Figure 3-2 Ventilation Exhaust Treatment System

SETPOINT CALCULATIONS

2088 321

4.0 EFFLUENT MONITOR SETPOINT CALCULATIONS

4.1 LIQUID EFFLUENT MONITORS

This Section will be used to ensure compliance with Limiting Condition for Operation (LCO) 3.11.1.1.

Fixed alarm/trip setpoints (Alert Alarm/High Alarm) will be used for continuous effluent radiation monitors. Adjustable setpoints will be used for the batch release effluent monitor.

4.1.1 STEAM GENERATOR BLOWDOWN MONITOR (PRM-10)

Steam generator blowdown can be directed to the river for purposes of secondary system chemistry control. Fixed Alert and High Alarm setpoints will ensure that the limits of LCO 3.11.1.1 are not exceeded by conservatively assuming the maximum blowdown flow rate, minimum dilution flow rate and further that all activity being discharged is I-131 (the nuclide with the lowest 10 CFR 20 concentration limit).

The setpoints are calculated as follows:

$$\text{Setpoint} = MPC_{I-131} \times \epsilon_{I-131} \times \left[\frac{3800 + 200}{200} \right] \quad (4-1)$$

where

Setpoint = High Alarm trip setpoint, net cpm

MPC_{I-131} = 10 CFR 20 concentration limit for I-131, μCi/ml

ϵ_{I-131} = detector efficiency for I-131, cpm per μCi/ml

3800 = minimum Plant dilution flow rate, gpm

200 = maximum steam generator blowdown flow rate, gpm.

The method presented above results in a High Alarm setpoint of 330 net cpm which will automatically terminate the release. The Alert Alarm setpoint is at 80 percent of the High Alarm setpoint or 265 net cpm.

This radiation monitor setpoint may be increased using a more precise evaluation. This procedure will be documented and will provide adequate assurance that the concentration limits of Technical Specification 3.11.1.1 are not exceeded at the Plant discharge and dilution structure.

4.1.2 COMPONENT COOLING WATER SYSTEM MONITORS (PRM-7 AND PRM-8)

These monitors provide indication of inleakage of activity into the Component Cooling Water System (CCWS). While the CCWS is not a normal effluent pathway, the CCWS is a potential effluent pathway should a leak exist between the CCWS and the Service Water System.

The fixed Alert and High Alarm setpoints are based on the Technical Specification 4.11.1.1 sampling criteria of 1×10^{-5} μCi/ml. The setpoints are calculated as follows, assuming all the activity is Cs-137:

$$\text{Setpoint} = 1 \times 10^{-5} \times \epsilon_{Cs-137} \qquad (4\text{-}2)$$

where

Setpoint = High Alarm setpoint, net cpm

1×10^{-5} = Technical Specification sampling criteria, μCi/ml

ϵ_{Cs-137} = detector efficiency for Cs-137, cpm per μCi/ml.

This method results in a High Alarm setpoint of 430 cpm. The Alert Alarm setpoint is set at one-half of the High Alarm or 220 cpm.

4.1.3 LIQUID RADWASTE DISCHARGE MONITOR (PRM-9)

The setpoint for liquid radwaste discharge is dependent on the actual values for radwaste discharge flow rate, Plant dilution flow rate, and isotopic composition of the effluents. Thus a variable radiation monitor setpoint must be utilized.

Prior to discharge, an isotopic analysis of the batch release will be made for principal gamma emitters to determine the required dilution ratio (DR) as follows:

$$DR = \sum_i \frac{C_i}{MPC_i} \qquad (4\text{-}3)$$

where

C_i = concentration of nuclide i in batch release, μCi/ml

MPC_i = 10 CFR 20 concentration limit for nuclide i, μCi/ml.

The maximum tank discharge flow rate (F_d) is then determined as follows:

$$F_d = \frac{K \times V_m}{DR} \qquad (4\text{-}4)$$

where

F_d = maximum tank discharge flow rate, gpm

V_m = minimum expected Plant dilution flow rate, gpm

K = fraction of discharge limit to be discharged (0.8 or less)

The radiation monitor setpoints will then be calculated as follows:

$$\text{Alert Setpoint} = 1.1 \times \sum_i C_i \times \epsilon_i \qquad (4\text{-}5)$$

$$\text{High Setpoint} = \frac{\text{Alert Setpoint}}{K} \qquad (4\text{-}6)$$

where

Alert Setpoint = radiation monitor Alert Alarm setpoint, net cpm

High Setpoint = radiation monitor High Alarm setpoint, net cpm

C_i = concentration of nuclide i in batch release, μCi/ml

ϵ_i = radiation monitor efficiency for nuclide i, cpm per μCi/ml

For batch releases of very low activity, the calculated radiation monitor setpoint may be statistically insignificant when compared to background radiation. In these cases, the radiation monitor setpoints may be calculated as follows:

$$\text{Alert Setpoint} = 1.1 \times \text{Background count rate} \qquad (4\text{-}7)$$

$$\text{High Setpoint} = 1.2 \times \text{Background count rate} \qquad (4\text{-}8)$$

4.2 GASEOUS EFFLUENT MONITORS

This Section will be used to ensure compliance with Limiting Conditions for Operation (LCO) 3.11.2.1 (noble gas dose rate limits for total body and skin).

4.2.1 SETPOINT CALCULATIONS

There are three normal Plant gaseous effluent release points: Containment ventilation (purge mode or pressure relief mode), the Fuel and Auxiliary Building ventilation exhaust, and the condenser air ejector exhaust. The radiation monitor setpoints will be based on weighted average noble gas dose factors ($\overline{K}$, $\overline{L}$, $\overline{M}$, $\overline{N}$) and weighted average monitor efficiencies which will assume a nuclide distribution consistent with the Trojan FSAR Appendix I effluent analysis. This analysis was made using the NRC computer program GALE. Tables 4-1 and 4-2 present the weighted average noble gas dose factors and weighted average monitor efficiencies, respectively. The setpoint calculations will also use the maximum annual average batch χ/Q (1.2×10^{-5} sec/m^3) at the site boundary. Setpoint calculations will be made for both total body and skin dose rate limits and the most conservative of the two will then be used for the actual High Alarm setpoint. The Alert Alarm setpoint will then be set at 10 percent of the High Alarm setpoint. To ensure that simultaneous releases from the combination of the three release points do not exceed the limits of Technical Specification 3.11.2.1, the setpoints will then be adjusted according to the fraction of the total Plant release for each release point as determined by the GALE computer program. The general equations for the monitor setpoints are as follows:

Total Body

$$\text{Setpoint} = \frac{500 \times \overline{\varepsilon} \times 60 \times 10^6 \times 10^{-3} \times f}{\overline{K} \times F \times 2.83E4}$$

$$= 1.1 \times 10^3 \; \frac{\overline{\varepsilon} \times f}{\overline{K} \times F} \qquad (4\text{-}9)$$

2088 326

where

Setpoint = High Alarm setpoint, net cpm

500 = LCO 3.11.2.1 total body dose rate limit, mrem/yr

$\bar{\epsilon}$ = weighted average radiation monitor efficiency, cpm per μCi/cc

$\bar{K}$ = weighted average total body dose factor, rem/yr per Ci/sec

F = effluent flow rate, cfm

f = fraction of total Plant release, dimensionless

60 = constant, sec/min

10^6 = constant, μCi/Ci

10^{-3} = constant, rem/mrem

2.83E4 = constant, cc/ft^3.

Skin

$$\text{Setpoint} = \frac{3000 \times \bar{\epsilon} \times 60 \times 10^6 \times 10^{-3} \times f}{\left[\bar{L} + 1.1\ \bar{M}\right] \times F \times 2.83E4}$$

$$= 6.4 \times 10^3 \times \frac{\bar{\epsilon} \times f}{\left[\bar{L} + 1.1\ \bar{M}\right] \times F} \qquad (4\text{-}10)$$

where

3000 = Technical Specification skin dose rate limit, mrem/yr

1.1 = constant, rem/rad

$\overline{L}$ = weighted average beta skin dose factor, rem/yr per Ci/sec

$\overline{M}$ = weighted average gamma air dose factor, rad/yr per Ci/sec

Table 4-3 summarizes all data required for the setpoint calculations and lists the setpoints.

These setpoints may be increased provided a more precise evaluation is performed. This evaluation may include real time information concerning flow rates, release rates, nuclide distributions, meteorological data and administrative controls. This method will be documented and will provide adequate assurance that the dose limits of Technical Specification 3.11.2.1 are not exceeded.

NOBLE

Nuclide	Dose Factors[a] K_i $(\frac{rem/yr}{Ci/sec})$	L_i $(\frac{rem/yr}{Ci/sec})$	M_i $(\frac{rem/yr}{Ci/sec})$	Containm Q_i[b] (Ci)	Qi x Ki	Q_i
Ar-41	1.1E+2	3.2E+1	1.1E+2	2.5E+1	2.8E+3	8.
Kr-83m	9.1E-4	0.0	2.3E-1	0.0	-	-
Kr-85	1.9E-1	1.6E+1	2.0E-1	1.0E+2	1.9E+1	1.
Kr-85m	1.4E+1	1.8E+1	1.4E+1	2.0E+0	2.8E+1	3.
Kr-87	7.1E+1	1.2E+2	7.4E+1	0.0	-	-
Kr-88	1.8E+2	2.9E+1	1.8E+2	2.0E+0	3.6E+2	5.
Kr-89	2.0E+2	1.2E+2	2.0E+2	0.0	-	-
Xe-131m	1.1E+0	5.8E+0	1.9E+0	5.2E+1	5.7E+1	3.
Xe-133	3.5E+0	3.7E+0	4.2E+0	5.7E+3	2.0E+4	2.
Xe-133m	3.0E+0	1.2E+1	4.0E+0	3.6E+1	1.1E+2	4.
Xe-135	2.2E+1	2.3E+1	2.3E+1	1.0E+1	2.2E+2	2.
Xe-135m	3.7E+1	8.5E+0	4.1E+1	0.0	-	-
Xe-137	1.7E+1	1.4E+2	1.8E+1	0.0	-	-
Xe-138	1.1E+2	4.9E+1	1.1E+2	0.0	-	-
Q_T				5.9E+3		

$\overline{K} = 1/Q_T \sum_i K_i \times Q_i =$

$\overline{L} = 1/Q_T \sum_i L_i \times Q_i =$

$\overline{M} = 1/Q_T \sum_i M_i \times Q_i =$

[a] See Table 3-1.
[b] PWR GALE Program (see Table 4-4).

E 4-1

GAS MONITOR ADJUSTED DOSE FACTORS

ent		Fuel and Auxiliary Building				Condenser Air Ejector			
x L_i	Q_i x M_i	Q_i[b] (Ci)	Q_i x K_i	Q_i x L_i	Q_i x M_i	Q_i[b] (Ci)	Q_i x K_i	Q_i x L_i	Q_i x M_i
0E+2	2.8E+3	0.0	-	-	-	0.0	-	-	-
		0.0	-	-	-	0.0	-	-	-
6E+3	2.0E+1	3.9E+2	7.4E+1	6.2E+3	7.8E+1	2.0E+0	3.8E-1	3.2E+1	4.0E-1
6E+1	2.8E+1	2.0E+0	2.8E+1	3.6E+1	2.8E+1	1.0E+0	1.4E+1	1.8E+1	1.4E+1
	-	1.0E+0	7.1E+1	1.2E+2	7.4E+1	0.0	-	-	-
8E+1	3.6E+2	4.0E+0	7.2E+2	1.2E+2	7.2E	3.0E+0	5.4E+2	8.7E+1	5.4E+2
	-	0.0	-	-	-	0.0	-	-	-
0E+2	9.9E+1	6.0E+0	6.6E+0	3.5E+1	1.1E+1	1.0E+0	1.1E+0	5.8E+0	1.9E+0
1E+4	2.4E+4	3.9E+2	1.4E+3	1.4E+3	1.6E+3	2.4E+2	8.4E+2	8.9E+2	1.0E+3
3E+2	1.4E+2	5.0E+0	1.5E+1	6.0E+1	2.0E+1	3.0E+0	9.0E+0	3.6E+1	1.2E+1
3E+2	2.3E+2	7.0E+0	1.5E+2	1.6E+2	1.6E+2	5.0E+0	1.1E+2	1.2E+2	1.2E+2
	-	0.0	-	-	-	0.0	-	-	-
	-	0.0	-	-	-	0.0	-	-	-
	-	0.0	-	-	-	0.0	-	-	-
		8.1E+2				2.6E+2			
	4.0E+0				3.0E+0				5.8E+0
	4.1E+0				1.0E+1				4.6E+0
	4.7E+0				3.3E+0				6.5E+0

NOBL

Nuclide	Containment Q_i [a]	PRM-1C ϵ_i [b]	PRM-1C $Q_i \times \epsilon_i$	PRM-1D ϵ_i	PRM-1D $Q_i \times \epsilon_i$	Q_i
Ar-41	2.5E+1	0.0	0.0	0.0	0.0	0.0
Kr-83m	0.0	0.0	0.0	0.0	0.0	0.0
Kr-85	1.0E+2	7.9E+7	7.9E+9	2.5E+2	2.5E+4	3.9E
Kr-85m	2.0E+0	7.6E+7	1.5E+8	5.8E+3	1.2E+4	2.0E
Kr-87	0.0	1.6E+8	0.0	1.3E+4	0.0	1.0E
Kr-88	2.0E+0	8.4E+7	1.7E+8	3.1E+4	6.2E+4	4.0E
Kr-89	0.0	1.6E+8	0.0	3.6E+4	0.0	0.0
Xe-131m	5.2E+1	4.7E+7	2.4E+9	1.3E+2	6.8E+3	6.0E
Xe-133	5.7E+3	3.5E+7	2.0E+11	4.0E+3	2.3E+7	3.9E
Xe-133m	3.6E+1	6.1E+7	2.2E+9	8.1E+2	2.9E+4	5.0E
Xe-135	1.0E+1	9.2E+7	9.2E+8	7.7E+3	7.7E+4	7.0E
Xe-135m	0.0	2.1E+7	0.0	7.2E+3	0.0	0.0
Xe-137	0.0	1.6E+8	0.0	3.7E+3	0.0	0.0
Xe-138	0.0	1.1E+8	0.0	2.1E+4	0.0	0.0
Sum	5.9E+3		2.1E+1		2.3E+7	8.1E

PRM-1C $\bar{\epsilon} = \frac{1}{Q_T} \sum_i Q_i \times \epsilon_i = \frac{1}{5.9\ldots}$

PRM-1D $\bar{\epsilon} = \frac{1}{5.9E+3} \times 2.3E+7 =$

PRM-2C $\bar{\epsilon} = \frac{1}{8.1E+2} \times 4.7E+10 =$

PRM-2D $\bar{\epsilon} = \frac{1}{8.1E+2} \times 1.9E+6 =$

PRM-6A $\bar{\epsilon} = \frac{1}{2.6E+2} \times 9.6E+7 =$

PRM-6B $\bar{\epsilon} = \frac{1}{2.6E+2} \times 1.1E+6 =$

[a] Q - Ci/yr from PWR GALE, Table 4-4.
[b] ε - detector efficiency factor (cpm per μCi/cc).

2088 331

TABLE 4-2

GAS MONITOR ADJUSTED EFFICIENCIES

	Fuel and Auxiliary Buildings				Condenser Air Ejector				
	PRM-2C ϵ_i	PRM-2C $Q_i \times \epsilon_i$	PRM-2D ϵ_i	PRM-2D $Q_i \times \epsilon_i$	Q_i	PRM-6A ϵ_i	PRM-6A $Q_i \times \epsilon_i$	PRM-6B ϵ_i	PRM-6B $Q_i \times \epsilon_i$
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+2	7.9E+7	3.1E+10	2.5E+2	5.8E+4	2.0E+0	7.9E+7	1.6E+8	2.5E+2	5.0E+2
+0	7.6E+7	1.5E+8	5.8E+3	1.2E+4	1.0E+0	7.6E+7	7.6E+7	5.8E+3	5.8E+3
+0	1.6E+8	1.6E+8	1.3E+4	1.3E+4	0.0	1.6E+8	0.0	1.3E+4	0.0
+0	8.4E+7	4.3E+8	3.1E+4	1.2E+5	3.0E+0	8.4E+7	2.5E+8	3.1E+4	9.3E+4
	1.6E+8	0.0	3.6E+4	0.0	0.0	1.6E+8	0.0	3.6E+4	0.0
+0	4.7E+7	2.8E+8	1.3E+2	7.8E+2	1.0E+0	4.7E+7	4.7E+7	1.3E+2	1.3E+2
+2	3.5E+7	1.4E+10	4.0E+3	1.6E+6	2.4E+2	3.5E+7	8.4E+9	4.0E+3	9.6E+5
+0	6.1E+7	3.1E+8	8.1E+2	4.1E+3	3.0E+0	6.1E+7	1.8E+8	8.1E+2	2.4E+3
+0	9.2E+7	6.4E+8	7.7E+3	5.4E+4	5.0E+0	9.2E+7	4.6E+8	7.7E+3	3.9E+4
	2.1E+7	0.0	7.2E+3	0.0	0.0	2.1E+7	0.0	7.2E+3	0.0
	1.6E+8	0.0	3.7E+3	0.0	0.0	1.6E+8	0.0	3.7E+3	0.0
	1.1E+8	0.0	2.1E+4	0.0	0.0	1.1E+8	0.0	2.1E+4	0.0
+2		4.7E+10		1.9E+6	2.6E+2		9.6E+9		1.1E+6

$\frac{}{\text{E+3}} \times 2.1\text{E+11} = 3.6\text{E+7} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

$3.9\text{E+3} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

$5.8\text{E+7} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

$2.3\text{E+3} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

$3.7\text{E+5} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

$4.2\text{E+3} \frac{\text{cpm}}{\mu\text{Ci/cc}}$

2088 332

GASEO

Release Point	ε[a] ($\frac{cpm}{\mu Ci/cc}$)	f[b]	$\bar{K}$[c] Total Body ($\frac{rem/y}{Ci/se}$)
Containment:[d]			
Purge Mode, PRM-1C	3.6E+7	0.85	4.0
Pressure Relief Mode, PRM-1D	3.9E+3		4.0
Fuel and Auxiliary Building, PRM-2C	5.8E+7	0.10	3.0
PRM-2D	2.3E+3		
Condenser Air Ejector, PRM-6A	3.7E+5	0.05	5.8
PRM-6B	4.2E+3		

[a] Detector efficiency factor (See Table 4-2).
[b] Fraction of total release (See Table 4-4).
[c] Weighted average dose factors (See Table 4-1).
[d] These setpoints for the Containment radiation moni background count rate (see Technical Specificati
[e] 1.5 x background count rate.
[f] 2.0 x background count rate.

TABLE 4-3

US EFFLUENT SETPOINT CALCULATION

$\bar{L}$[c] β-skin ($\frac{rem/yr}{Ci/sec}$)	$\bar{M}$[c] γ-air ($\frac{rad/yr}{Ci/sec}$)	F (cfm)	PRM Reading At LCO Doses Total Body (cpm)	PRM Reading At LCO Doses Skin (cpm)	PRM Setpoints Alert (cpm)	PRM Setpoints High (cpm)
4.1	4.7	5.0E+4	1.7E+5	4.2E+5	1.7E+4	1.7E+5
4.1	4.7	1.4E+2	6.5E+3	1.6E+4	6.5E+2	6.5E+3
10.0	3.3	1.05E+5	2.0E+4	2.6E+4	2.0E+3	2.0E+4
			8.0E-1	1.0E+0	[e]	[f]
4.6	6.5	6.0E+1	5.8E+6	1.7E+7	5.8E+5	1.0E+6
			6.6E+2	1.9E+3	6.6E+1	6.6E+2

tors are maximum setpoints; actual setpoints are set as a function of the
n 3.3.3.1).

2088 334

TABLE 4-4

ESTIMATED ANNUAL RELEASE OF RADIONUCLIDES IN GASEOUS EFFLUENTS[a,b,c]
(Ci/yr)

Isotope	Waste Gas System	Containment Purge Exhaust	Fuel and Auxiliary Building Ventilation	Turbine Building Ventilation	Blowdown Tank Vent	Condenser Air Ejector Exhaust	Total
Noble Gases							
Ar-41	0.	2.5E+1	0.	0.	0.	0.	2.5E+1
Kr-83m	0.	0.	0.	0.	0.	0.	0.
Kr-85	3.9E+2	1.0E+2	3.0E+0	0.	0.	2.0E+0	4.9E+2
Kr-85m	0.	2.0E+0	2.0E+0	0.	0.	1.0E+0	5.0E+0
Kr-87	0.	0.	1.0E+0	0.	0.	0.	1.0E+0
Kr-88	0.	2.0E+0	4.0E+0	0.	0.	3.0E+0	9.0E+0
Kr-89	0.	0.	0.	0.	0.	0.	0.
Xe-131m	4.0E+0	5.2E+1	2.0E+0	0.	0.	1.0E+0	5.9E+1
Xe-133	5.0E+0	5.7E+3	3.8E+2	0.	0.	2.4E+02	6.3E+3
Xe-133m	0.	3.6E+1	5.0E+0	0.	0.	3.0E+0	4.4E+1
Xe-135	0.	1.0E+1	7.0E+0	0.	0.	5.0E+0	2.2E+1
Xe-135m	0.	0.	0.	0.	0.	0.	0.
Xe-137	0.	0.	0.	0.	0.	0.	0.
Xe-138	0.	0.	0.	0.	0.	0.	0.
Total	4.0E+2	5.9E+3	4.0E+2	0.	0.	2.6E+2	6.9E+3

[a] Includes anticipated operational occurrences.

[b] From FSAR Table 11.3-3, Amendment 31.

[c] 0. in this table indicates a release of less than 1.0 Ci/yr for noble gases, 0.0001 for iodines.

5.0 ENVIRONM
MONITORING

2088 336

5.0 ENVIRONMENTAL MONITORING

The radiological environmental monitoring stations are listed in Table 5-1. The location of these stations with respect to the Trojan Nuclear Plant are shown in Figures 5-1 through 5-12.

TABLE 5-1

LOCATIONS OF SAMPLE COLLECTION SITES
FOR RADIOLOGICAL MONITORING PROGRAM

Site	Radial Mileage[a]	Radial Direction[a]	Elevation (ft)	Latitude	Longitude	Sample Types[b]
1A Trojan Site	0.8	NW	20	46° 02' 55"	122° 53' 50"	b,d,f,h,j,l,m
1B Trojan Site	0.5	W	20	46° 02' 15"	122° 53' 40"	b,h,j
1C Trojan Site	0.7	SW	60	46° 02' 00"	122° 53' 30"	b,h
1D Recreation Lake	[c]	[c]	[c]	[c]	[c]	h,j,l,m
1E Trojan Site	0.8	S	20	46° 01' 50"	122° 53' 05"	b
1F Trojan Site	0.5	S	20	46° 01' 60"	122° 53' 00"	a,b,c,d,e,n
1G Trojan Site	0.1	E	10	46° 02' 10"	122° 52' 10"	i
1H Trojan Site	0.2	N	60	46° 02' 25"	122° 53' 05"	a,b,n
1I Trojan Site	0.6	NNW	20	46° 02' 35"	122° 53' 05"	a,b,d,e,f,n
1J Trojan Site	0.6	NNW	20	46° 02' 55"	122° 53' 15"	b
2 Rainier	3.8	NNW	25	46° 05' 00"	122° 55' 55"	a,b,c
3 Lindberg	2.0	NNW	185	46° 04' 00"	122° 53' 55"	a,b,d,e,i
4A Prescott	0.6	NNW	20	46° 02' 55"	122° 53' 15"	h
4C Prescott	1.3	NNW	200	46° 04' 50"	122° 53' 40"	b
5 Neer City	1.4	SW	725	46° 01' 45"	122° 54' 35"	a,b,d,e,f,n
6A Goble	1.7	SSE	20	46° 01' 00"	122° 52' 25"	i
6B Goble	1.3	SSE	120	46° 01' 20"	122° 52' 45"	a,b,n
6C Goble	1.7	SW	480	46° 00' 55"	122° 52' 30"	h
7 Shiloh Basin	5.8	SW	400	45° 58' 40"	122° 57' 50"	b,g
8 Deer Island	6.7	S	25	45° 56' 35"	122° 51' 25"	b,d,e
9B Woodland	11.1	SSE	20	45° 54' 20"	122° 48' 00"	a,b,c
10 Kalama	3.0	SE	10	46° 00' 25"	122° 50' 40"	a,b
11A Kalama	0.7	ESE	10	46° 02' 05"	122° 52' 10"	b
11B Kalama River	1.4	E	20	46° 02' 35"	122° 51' 10"	a,b,d,e,f,i,n
12 Carrolls Bluff	1.8	NNE	150	46° 03' 50"	122° 51' 55"	b
13 Vision Acres	3.4	NNE	80	46° 06' 50"	122° 52' 55"	b
14 Longview	7.8	NNW	10	46° 08' 50"	122° 56' 15"	a,b,n
15 Kelso	13.1	N	20	46° 13' 50"	122° 54' 50"	g
16 Smith Dairy	[c]	[c]	[c]	45° 54' 10"	122° 46' 50"	f,g,i
18 Standard Dairy	[c]	[c]	[c]	46° 08' 55"	122° 55' 20"	g
19 Control (St. Helens)	[c]	[c]	[c]	[c]	[c]	a,n

COLUMBIA RIVER SAMPLES

Site	Columbia River Mileage	Cross-Sectional Location	Water Depth (ft)	Latitude	Longitude	Sample Types
CR1 Rainier	68.3	West	30	46° 05' 25"	122° 55' 45"	k,l
CR1A	66.6	West	2	46° 06' 00"	122° 57' 05"	m
CR2 Lindberg	69.6	West	15	46° 04' 45"	122° 54' 10"	j,n
CR3 Trojan	72.4	West	30	46° 02' 30"	122° 52' 55"	h,j,k,l,m
CR4 Kalama	75.2	East	40	46° 02' 25"	122° 51' 00"	j,n
CR5 Woodland	81.5	East	40	46° 55' 10"	122° 48' 15"	k,l,m

[a] Measured from the Trojan Containment.

[b] Sample designations:

Terrestrial samples:

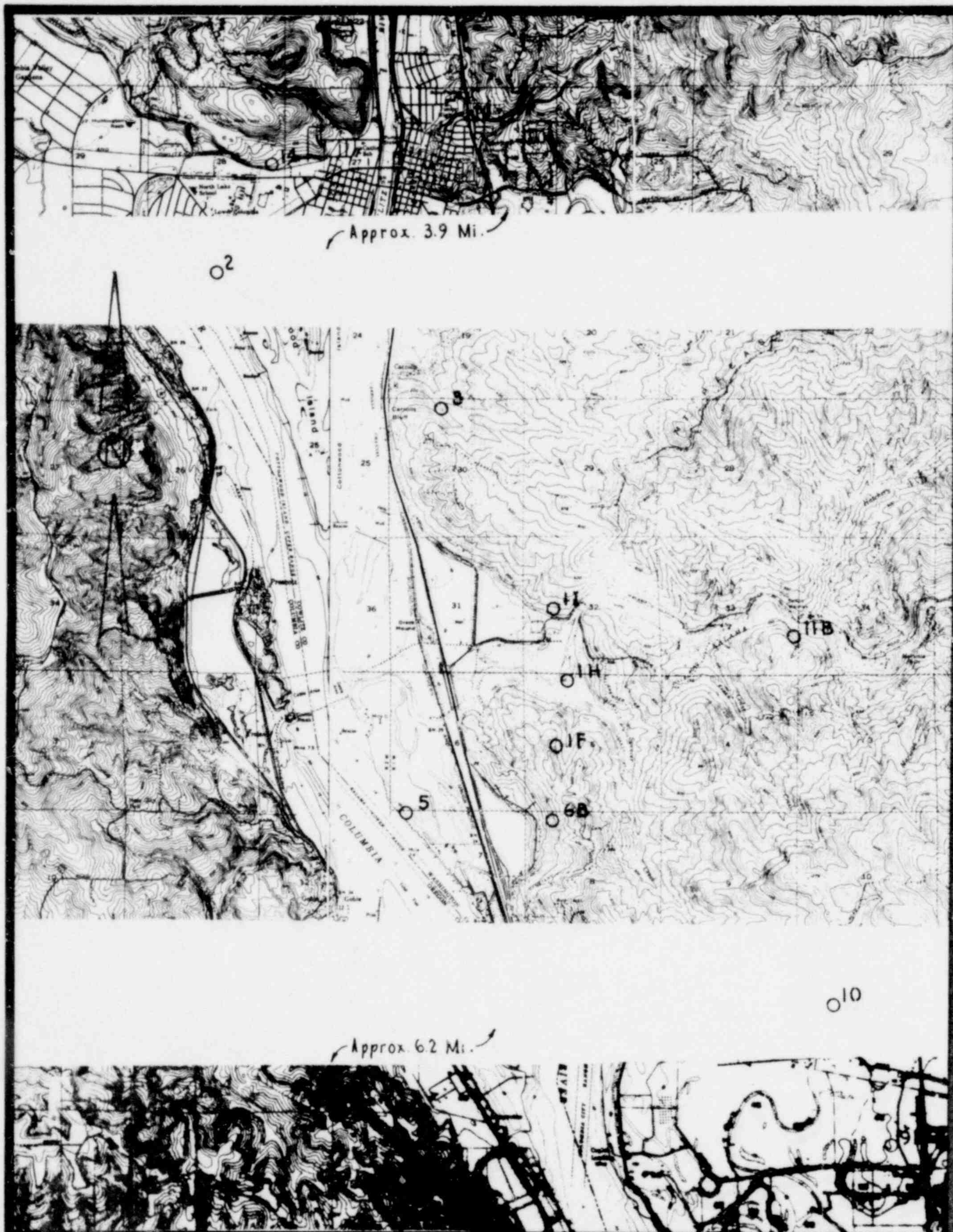
- a. Air particulate
- b. Direct radiation
- c. Rainfall
- d. Soil
- e. Vegetation
- f. Animals
- g. Milk
- n. Radioiodine

Aquatic samples:

- h. Surface water
- i. Well water
- j. Bottom sediment
- k. Shoreline soil
- l. Vegetation
- m. Fish

2088 338

[c] To be supplied later.

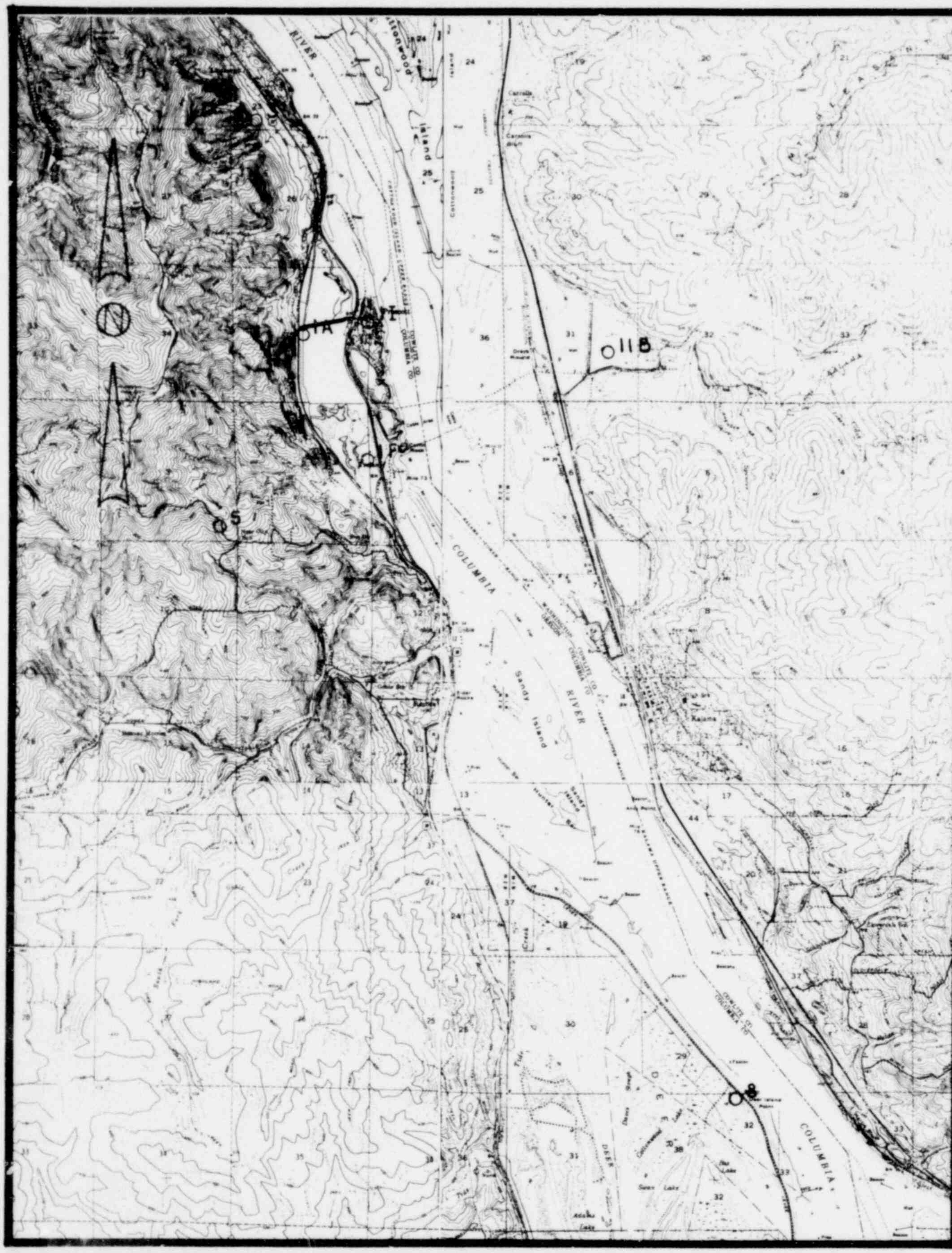


AIR PARTICULATE AND AIR RADIOIODINE STATIONS

Figure 5-1

POOR ORIGINAL

2088 339

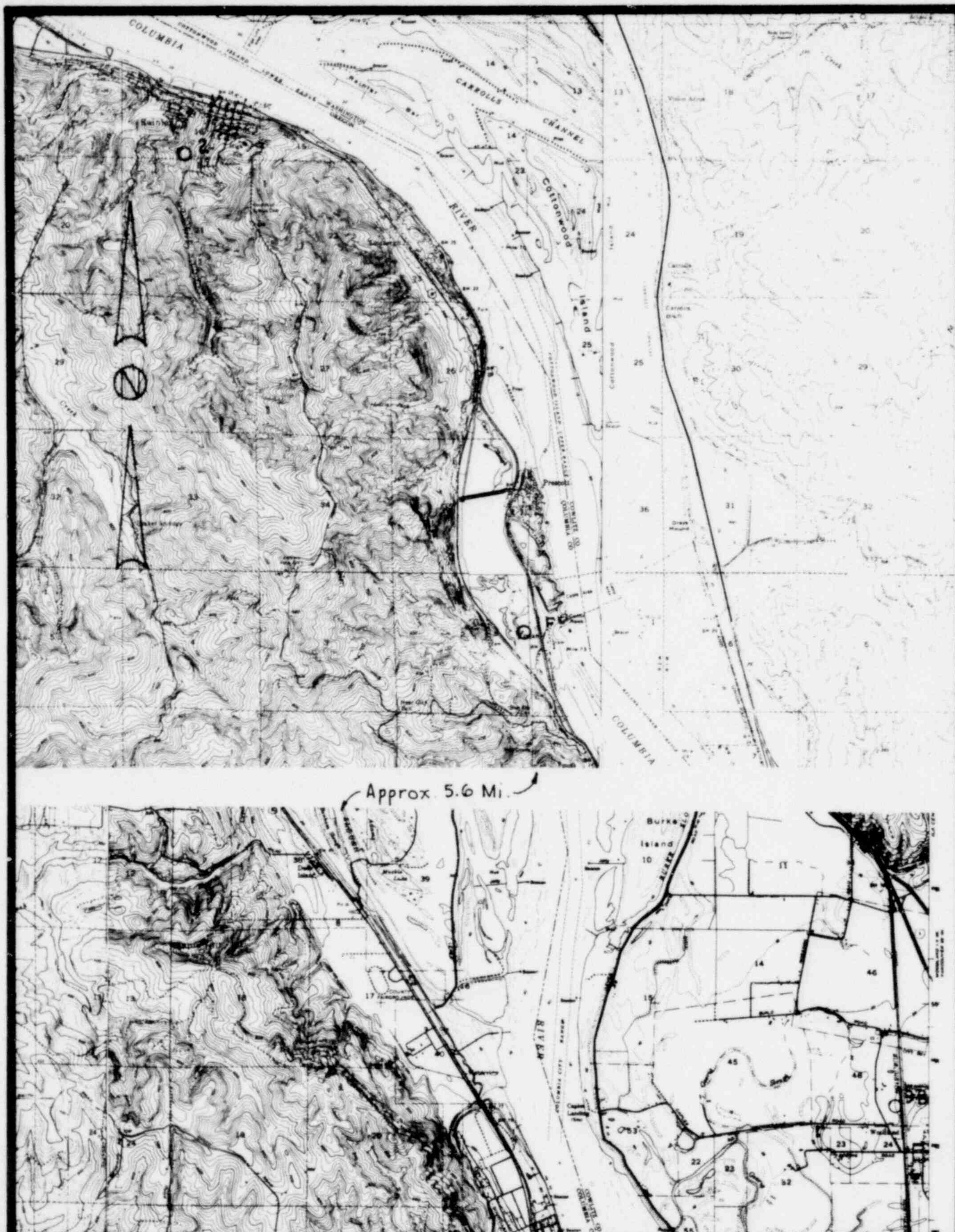


TERRESTRIAL SOIL AND VEGETATION SAMPLE STATIONS

2088 340 Figure 5-2

TERRESTRIAL ANIMAL STATIONS

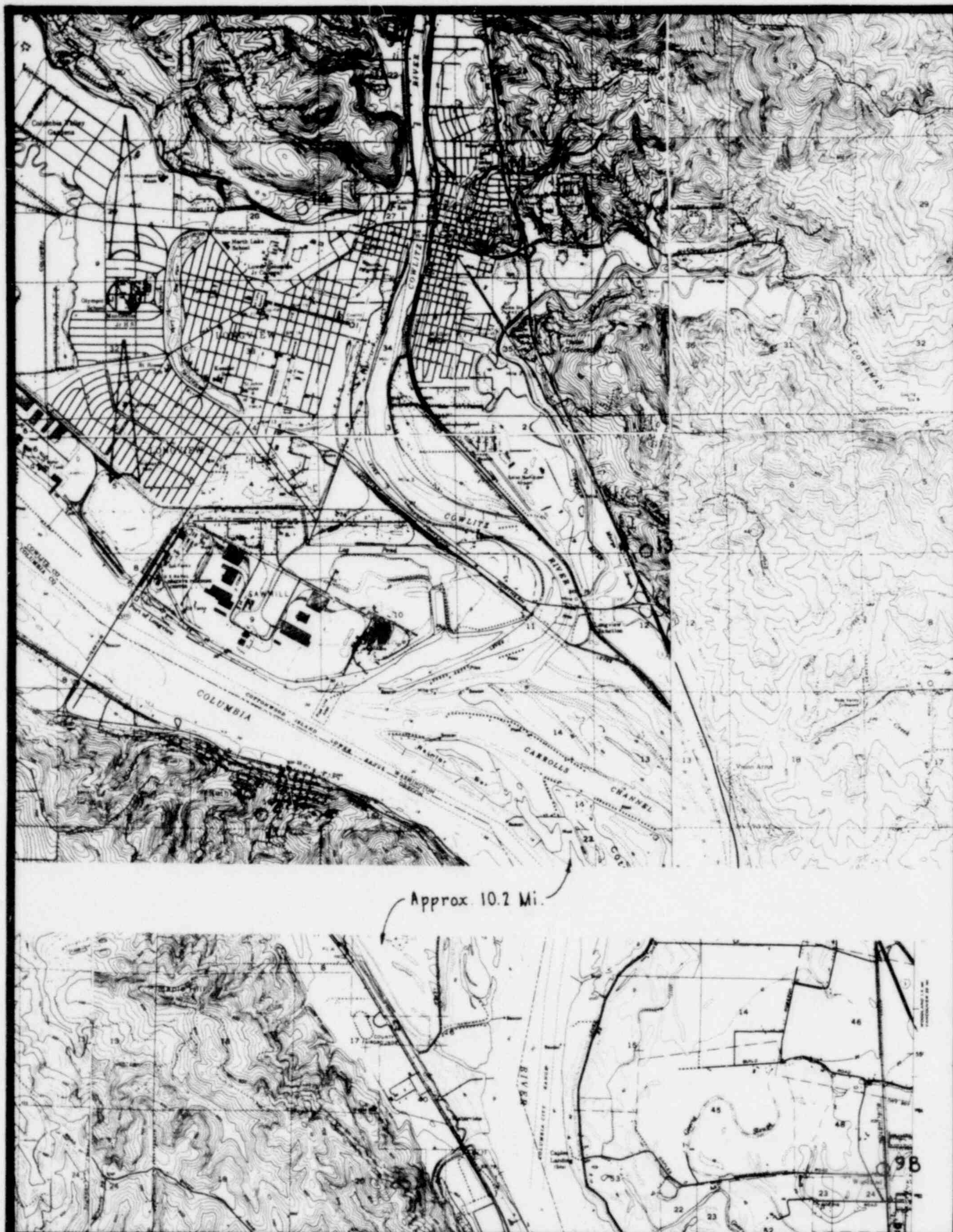
Figure 5-3



RAIN STATIONS

2088 342

Figure 5-4



TLD STATIONS

Figure 5-5

POOR ORIGINAL

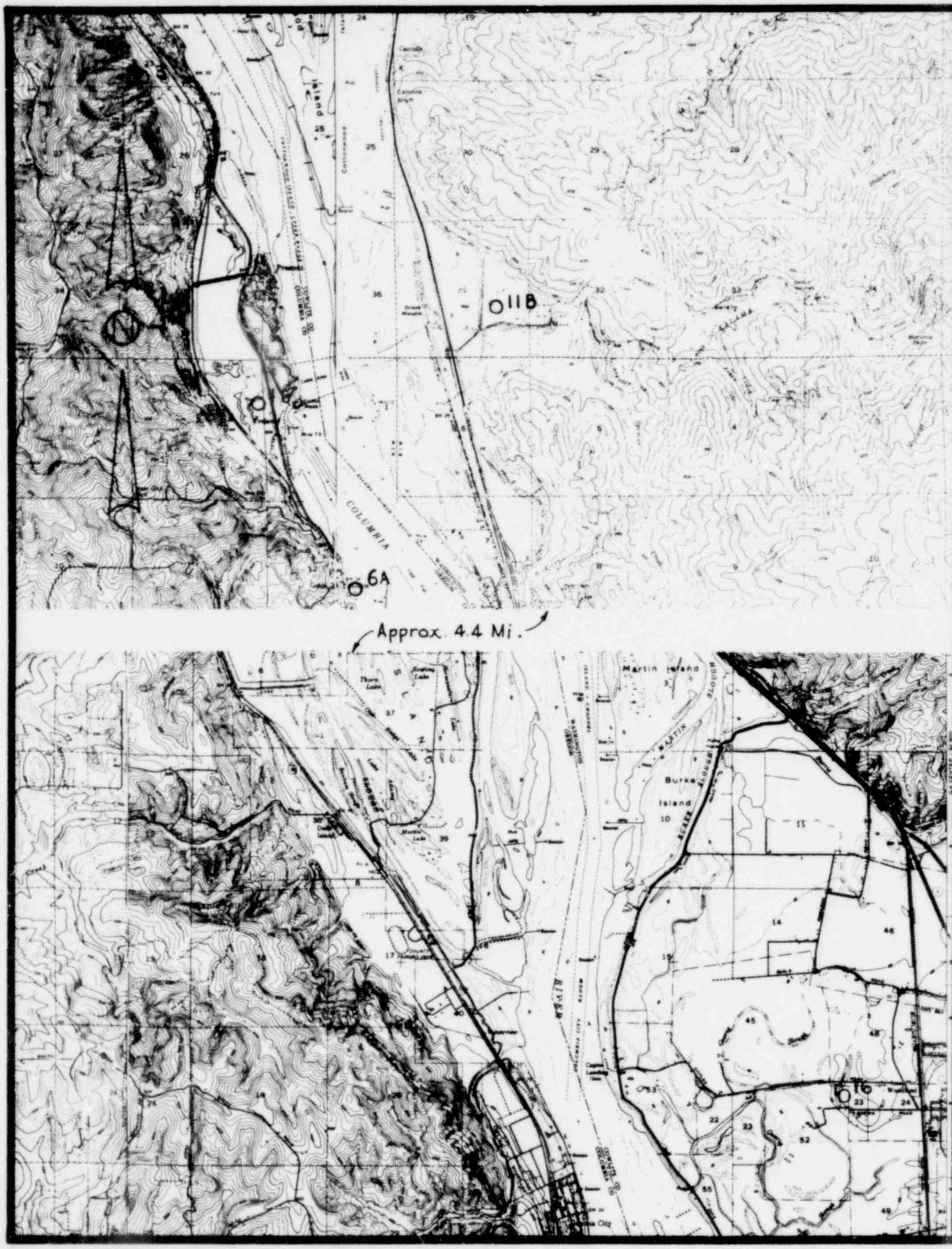
2088 343

TLD STATIONS

Figure 5-6

2088 344

POOR ORIGINAL

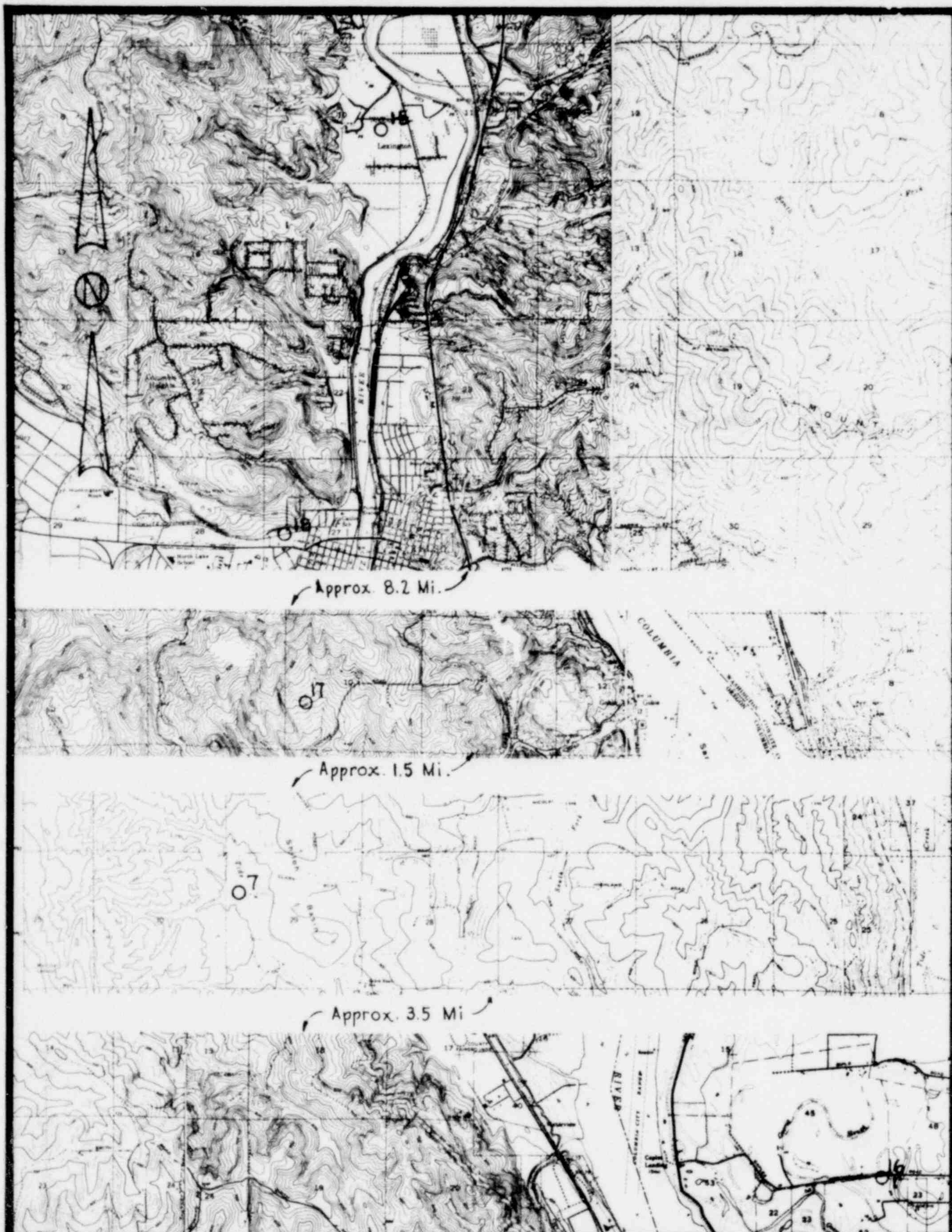


WELL WATER STATIONS

Figure 5-7

2088 345

POOR ORIGINAL

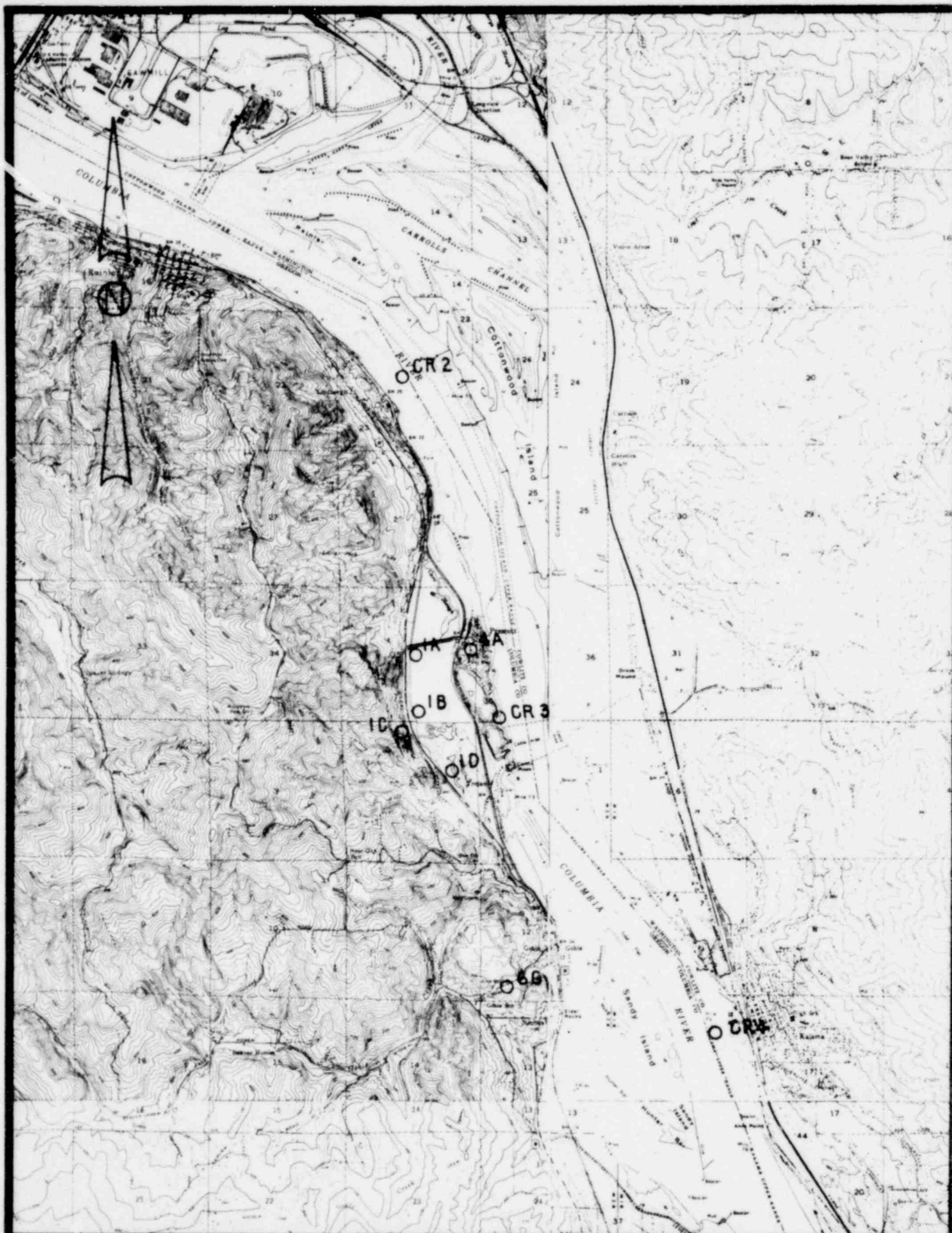


MILK STATIONS

Figure 5-8

POOR ORIGINAL

2088 346

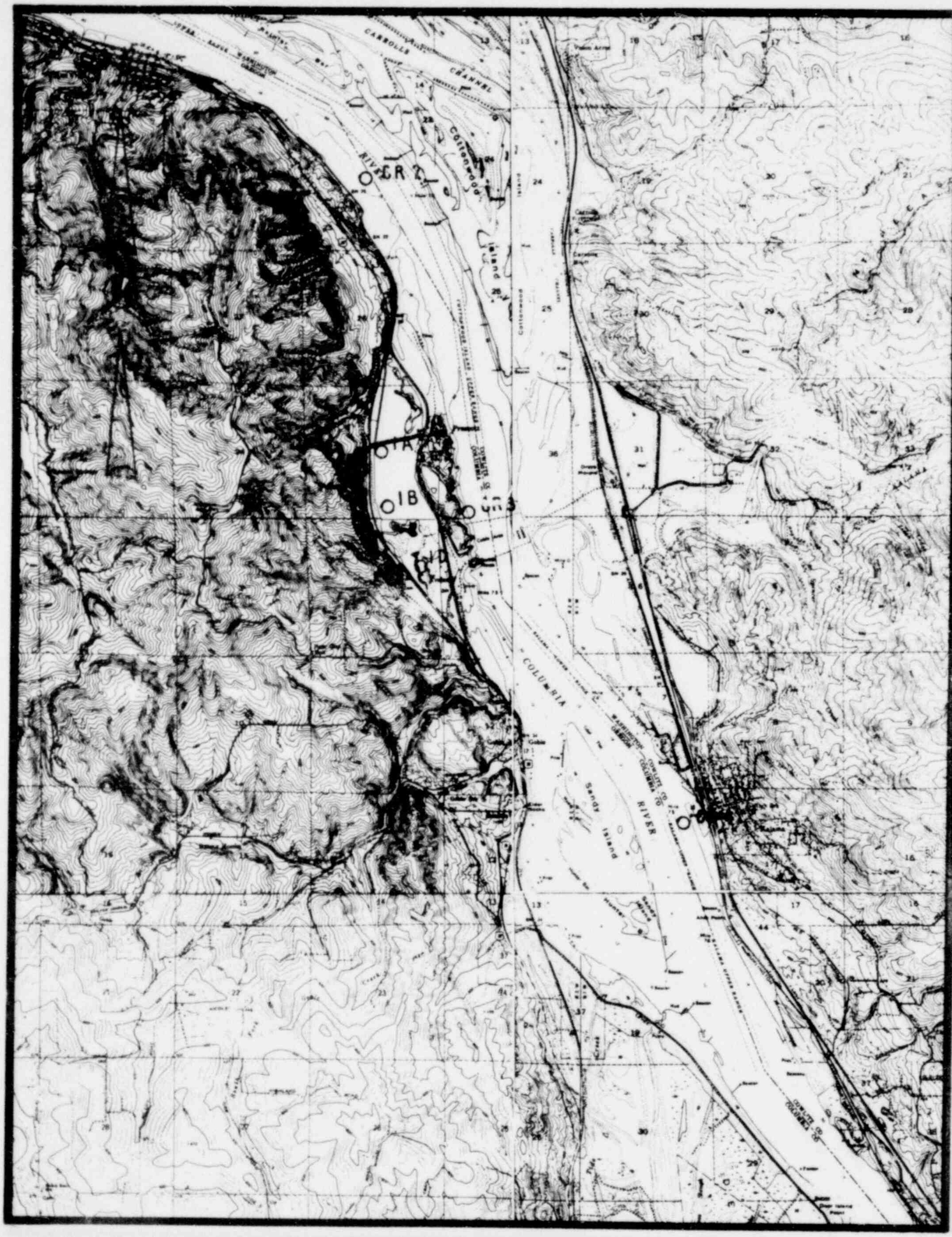


SURFACE WATER STATIONS

2088 347

Figure 5-9

POOR ORIGINAL

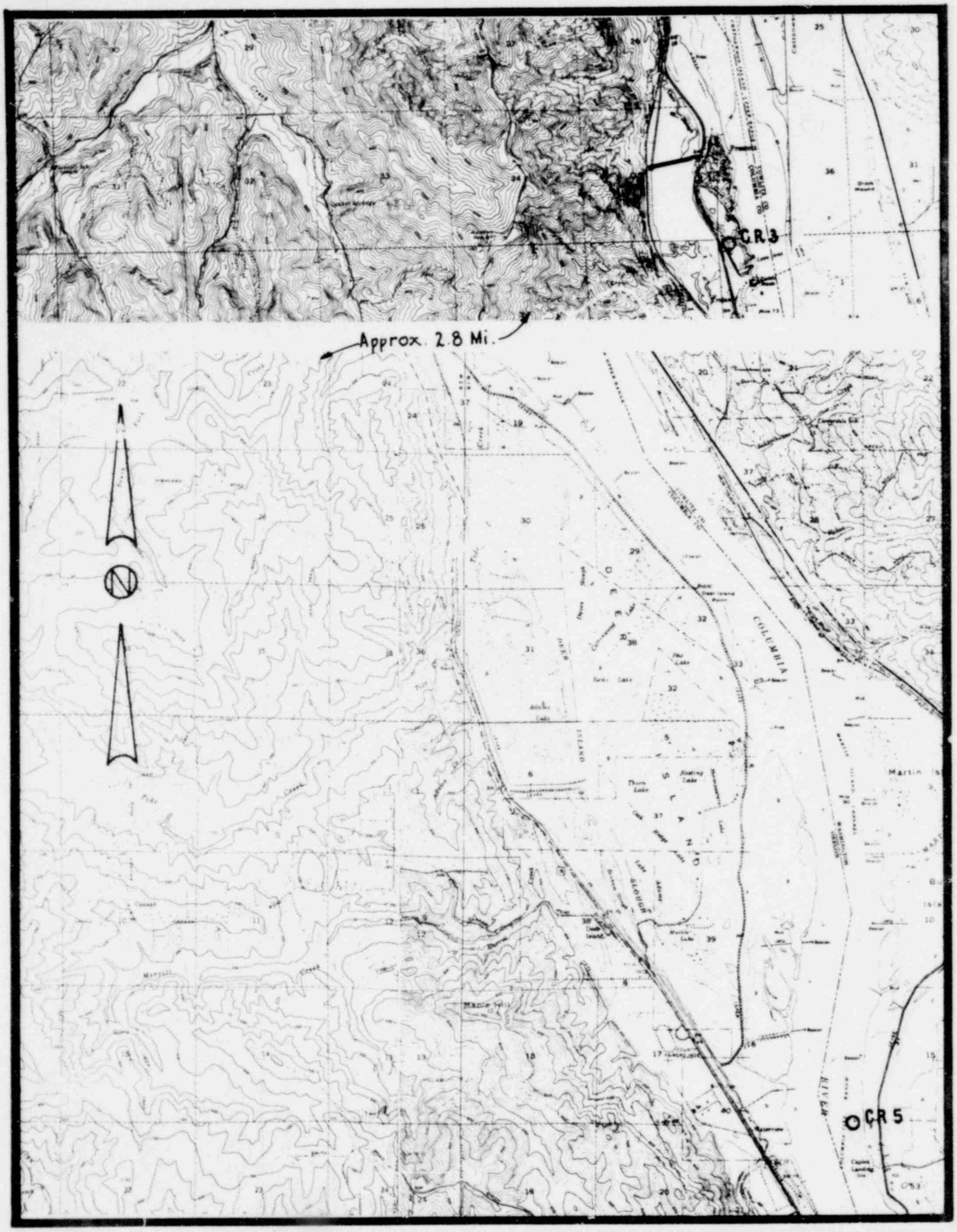


SEDIMENT SAMPLE STATIONS

2088 348

Figure 5-10

POOR ORIGINAL



SHORELINE SOIL STATIONS

2088 349 Figure 5-11

POOR ORIGINAL

AQUATIC VEGETATION STATIONS

Figure 5-12

2088 350

POOR ORIGINAL

APPENDIX A

DERIVATION OF NOBLE GAS DOSE FACTORS (K, L, M, N)

The noble gas dose factors were derived using the maximum annual average site boundary /Q for tch releases as follows:

$$K_i = DFB_i \times \chi/Q \times 10^{12} \times 10^{-3} \quad \text{(A-1)}$$

$$L_i = DFS_i \times \chi/Q \times 10^{12} \times 10^{-3} \quad \text{(A-2)}$$

$$M_i = DF_i^{\gamma} \times \chi/Q \times 10^{12} \times 10^{-3} \quad \text{(A-3)}$$

$$N_i = DF_i^{\beta} \times \chi/Q \times 10^{12} \times 10^{-3} \quad \text{(A-4)}$$

where

K_i = gamma total body dose factor for nuclide i, rem/yr per Ci/sec

L_i = beta skin dose factor for nuclide i, rem/yr per Ci/sec

M_i = gamma air dose factor for nuclide i, rad/yr per Ci/sec

N_i = beta air dose factor for nuclide i, rad/yr per Ci/sec

DFB_i = Reg. Guide 1.109 (Rev. 1, 10/77) total body dose factor, mrem/yr per pCi/m^3

DFS_i = Reg. Guide 1.109 (Rev. 1, 10/77) skin dose factor, mrem/yr per pCi/m^3

DF_i^{γ} = Reg. Guide 1.109 (Rev. 1, 10/77) gamma air dose factor, mrad/yr per pCi/m^3

DF_i^{β} = Reg. Guide 1.109 (Rev. 1, 10/77) beta air dose factor, mrad/yr per pCi/m^3

$\chi/Q = 1.2 \times 10^{-5}$ sec/m^3

10^{12} = constant, pCi/Ci

10^{-3} = constant, rem/mrem or rad/mrad.

The values of K_i, L_i, M_i, N_i and DFB_i, DFS_i, DF_i^γ, DF_i^β are given in Table A-1.

TABLE A-1

NOBLE GAS DOSE FACTORS

	Regulatory Guide 1.109 (Rev. 1, 10/77) Dose Factors							
Nuclide	DF_i^β β-air ($\frac{mrad/yr}{pCi/m^3}$)	DFS_i β-skin ($\frac{mrem/yr}{pCi/m^3}$)	DF_i^γ γ-air ($\frac{mrad/yr}{pCi/m^3}$)	DFB_i γ-body ($\frac{mrem/yr}{pCi/m^3}$)	K_i γ-body ($\frac{rem/yr}{Ci/sec}$)	L_i β-skin ($\frac{rem/yr}{Ci/sec}$)	M_i γ-air ($\frac{rad/yr}{Ci/sec}$)	N_i β-air ($\frac{rad/yr}{Ci/sec}$)
Kr-83m	2.9E-4	0.0	1.9E-5	7.6E-8	9.1E-4	0.0	2.3E-1	3.5E+0
Kr-85	2.0E-3	1.3E-3	1.7E-5	1.6E-5	1.9E-1	1.6E+1	2.0E-1	2.4E+1
Kr-85m	2.0E-3	1.5E-3	1.2E-3	1.2E-3	1.4E+1	1.8E+1	1.4E+1	2.4E+1
Kr-87	1.0E-2	9.7E-3	6.2E-3	5.9E-3	7.1E+1	1.2E+2	7.4E+1	1.2E+2
Kr-88	2.9E-3	2.4E-3	1.5E-2	1.5E-2	1.8E+2	2.9E+1	1.8E+2	3.5E+1
Kr-89	1.1E-2	1.0E-2	1.7E-2	1.7E-2	2.0E+2	1.2E+2	2.0E+2	1.3E+2
Kr-90	7.8E-3	7.3E-3	1.6E-2	1.6E-2	1.9E+2	8.8E+1	1.9E+2	9.4E+1
Xe-131m	1.1E-3	4.8E-4	1.6E-4	9.2E-5	1.1E+0	5.8E+0	1.9E+0	1.3E+1
Xe-133	1.1E-3	3.1E-4	3.5E-4	2.9E-4	3.5E+0	3.7E+0	4.2E+0	1.3E+1
Xe-133m	1.5E-3	9.9E-4	3.3E-4	2.5E-4	3.0E+0	1.2E+1	4.0E+0	1.8E+1
Xe-135	2.5E-3	1.9E-3	1.9E-3	1.8E-3	2.2E+1	2.3E+1	2.3E+1	3.0E+1
Xe-135m	7.4E-4	7.1E-4	3.4E-3	3.1E-3	3.7E+1	8.5E+0	4.1E+1	8.9E+0
Xe-137	1.3E-2	1.2E-2	1.5E-3	1.4E-3	1.7E+1	1.4E+2	1.8E+1	1.6E+2
Xe-138	4.8E-3	4.1E-3	9.2E-3	8.8E-3	1.1E+2	4.9E+1	1.1E+2	5.8E+1
Ar-41	3.3E-3	2.7E-3	9.3E-3	8.8E-3	1.1E+2	3.2E+1	1.1E+2	4.0E+1

2088 354

APPENDIX B

DERIVATION OF IODINE AND PARTICULATE DOSE FACTORS

DOSE FACTOR P_i

The term P_i is based on 1) inhalation, ground plane and food pathways; 2) the highest annual average continuous release meteorology at the site boundary; 3) the most restrictive age group (infant); and 4) the critical organ for each nuclide. The following equation is used to determine the values of P_i.

$$P_i = 10^{-3} \left[(P_i^I \times \chi/Q_c) + (P_i^G \times D/Q_c) + (P_i^F \times D/Q_c) \right] \qquad \text{(B-1)}$$

where

P_i = total dose factor for nuclide i, rem/yr per Ci/sec

P_i^I = inhalation pathway dose factor for nuclide i, mrem/yr per Ci/m^3

P_i^G = ground plane pathway dose factor for nuclide i, m^2•mrem/yr per Ci/sec

P_i^F = food pathway dose factor for nuclide i, m^2•mrem/yr per Ci/sec

χ/Q_c = maximum annual site boundary atmospheric dispersion factor for continuous release = 9.2×10^{-6} sec/m^3

D/Q_c = maximum annual site boundary atmospheric deposition factor for continuous release = 5.2×10^{-8} m^{-2}.

2088 356

The dose factors, P_i^I, P_i^G and P_i^F were derived as follows and are listed in Table B-1.

Inhalation Pathway Dose Factor P_i^I

$$P_i^I = 10^{12} \times BR \times DFA_i \qquad \text{(B-2)}$$

where

10^{12} = constant, pCi/Ci

BR = breathing rate of the infant age group, 1400 m^3/yr.

DFA_i = maximum organ inhalation dose conversion factor for the infant age group for the nuclide i, in mrem/pCi. The total body is considered as an organ in the selection of DFA_i.

Ground Plane Pathway Dose Factor P_i^G

$$P_i^G = (10^{12})(8760)(DFG_i)(1-e^{-\lambda_i t})/\lambda_i \qquad \text{(B-3)}$$

where

10^{12} = constant, pCi/Ci

8760 = constant, hr/yr

λ_i = decay constant for nuclide i, sec^{-1}

t = exposure period, 3.15×10^7 sec

(DFG_i) = ground plane dose conversion factor for nuclide i, mrem/hr per pCi/m^2.

2088 357

Food Pathway Dose Factor P_i^F

$$P_i^F = 10^{12} \frac{Q_F(U_{ap})}{Y_p(\lambda_i+\lambda_w)} F_m(DFL_i)[e^{-\lambda_i t_f}] \qquad (B-4)$$

where

10^{12} = constant, pCi/Ci

Q_F = cow's consumption rate, 50 kg/day (wet weight)

U_{ap} = infant's milk consumption rate, 330 ℓ/yr

Y_p = agricultural productivity by unit area (pasture), 0.7 kg/m^2

F_m = stable element transfer coefficients, in days/ℓ

r = fraction of deposited activity retained on cow's feed grass, 1.0 for iodines, 0.2 for particulates

(DFL_i) = maximum organ ingestion dose factor for nuclide i, in mrem/pCi

λ_i = decay constant for nuclide i, sec^{-1}

λ_w = decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14-day half-time)

t_f = transport time from pasture to cow, to milk, to infant, 1.73×10^5 sec (2 days).

2088 358

The concentration of tritium in milk is based on its airborne concentration rather than the deposition rate.

$$P^F_{H-3} = (10^{12})(10^3)F_m Q_F U_{ap}(DFL_i)[0.75(0.5/H)] \qquad \text{(B-5)}$$

where

10^3 = constant, gm/kg

H = absolute humidity of the atmosphere, 8 gm/m^3

0.75 = fraction of total feed that is water

0.5 = ratio of the specific activity of the feed grass water to the atmospheric water.

2088 359

DOSE FACTOR R_i

The term R_i is based on the combination of 1) inhalation, ground plane, vegetable ingestion, meat ingestion and milk ingestion pathways which are present at the location of maximum potential dose (ie, the controlling exposure location); 2) annual average continuous release meteorology at the controlling location; 3) the most restrictive age group (child); and 4) the critical organ for each nuclide.

The controlling exposure location is dependent upon land use. Therefore, the Annual Land Use Census shall be reviewed annually to determine if any changes in land use will require modification of the R_i values.

The following general equation is used to calculate R_i values:

$$R_i = 10^{-3} \left[(R_i^I \times \chi/Q_c) + (R_i^G \times D/Q_c) + (R_i^V \times D/Q_c) + (R_i^M \times D/Q_c) + (R_i^C \times D/Q_c) \right] \quad \text{(B-6)}$$

where

R_i = total dose factor for nuclide i, rem/yr per Ci/sec

R_i^I = inhalation pathway dose factor for nuclide i, mrem/yr per Ci/m^3

R_i^G = ground plane pathway dose factor for nuclide i, mrem/yr per Ci/sec

R_i^V = vegetable ingestion pathway dose factor for nuclide i, mrem/yr per Ci/sec

R_i^M = meat ingestion pathway dose factor for nuclide i, mrem/yr per Ci/sec

2088 360

R_i^C = cow milk ingestion pathway dose factor for nuclide i, mrem/yr per Ci/sec

χ/Q_c = atmospheric dispersion factor for continuous releases at controlling exposure location, sec/m^3

D/Q_c = atmospheric deposition factor for continuous releases at controlling exposure location, m^{-2}

10^{-3} = constant, rem/mrem.

The dose factors, R_i^I, R_i^G, R_i^V, R_i^M, R_i^C were derived as follows and are listed in Table B-2.

Inhalation Pathway Dose Factor R_i^I

$$R_i^I = 10^{12}(BR)\,(DFA_i) \qquad \text{(B-7)}$$

where

10^{12} = constant, pCi/Ci

(BR) = breathing rate of the receptor of child age group = 3700 m^3/yr.

(DFA_i) = maximum organ inhalation dose factor for the receptor for nuclide i, in mrem/pCi. The total body is considered as an organ in the selection of DFA_i.

Ground Plane Pathway Factor R_i^G

$$R_i^G = (10^{12})(8760)(SF)(DFG_i)[1-e^{-\lambda_i t})/\lambda_i] \qquad \text{(B-8)}$$

2089 001

where

10^{12} = constant, pCi/Ci

8760 = constant, hr/yr

λ_i = decay constant for nuclide i, sec^{-1}

t = exposure time, 4.73×10^8 sec (15 yr)

(DFG_i) = ground plane dose conversion factor for nuclide i, mrem/hr per pCi/m^2

SF = shielding factor for residential structures, 0.7.

Vegetation Pathway Factor R_i^V

Man is considered to consume two types of vegetation, fresh and stored, that differ only in the time period between harvest and consumption, therefore:

$$R_i^V = 10^{12} \left[\frac{(r)}{Y_v(\lambda_i + \lambda_w)} \right] (DFL_i) \left[U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right] \quad \text{(B-9)}$$

where

U_a^L = consumption rate of fresh leafy vegetation by the child receptor, 26 kg/yr

U_a^S = consumption rate of stored vegetation by the child receptor, 520 kg/yr

f_L = fraction of the annual intake of fresh leafy vegetation grown locally, 1.0

f_g = fraction of the annual intake of stored vegetation grown locally, 0.76

2089 002

t_L = average time between harvest of leafy vegetation and its consumption, 8.6×10^4 sec (1 day)

t_h = average time between harvest of stored vegetation and its consumption, 5.2×10^6 sec (60 day)

Y_v = vegetation area density, 2.0 kg/m^2.

where all other terms have been defined previously.

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the R_i^V is based on χ/Q:

$$R_{H-3}^V = (10^{12})(10^3)\left[U_a^L f_L + U_a^S f_g\right](DFL_i)\ [0.75(0.5/H)] \qquad \text{(B-10)}$$

where

10^3 = constant, gm/kg

H = absolute humidity of the atmosphere, 8 gm/m^3

0.75 = fraction of total feed that is water

0.5 = ratio of the specific activity of the feed grass water to the atmospheric water.

where all other terms have been defined previously.

Grass-Cow-Meat Pathway Factor R_i^M

$$R_i^M = 10^{12}\,\frac{Q_F(U_{ap})}{\lambda_i + \lambda_w}\,(F_f)(r)(DFL_i)\left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right]e^{-\lambda_i t_f} \qquad \text{(B-11)}$$

where

F_f = stable element transfer coefficients, in days/kg

U_{ap} = child receptor's meat consumption rate, 41 kg/yr

t_f = transport time from pasture to receptor, 1.73×10^6 sec (20 days)

t_h = transport time from crop field to receptor, 7.78×10^6 sec (90 days)

Y_s = agricultural productivity by unit area (stored food), 2.0 kg/m^2

f_p = fraction of year that cow is on pasture, 0.5

f_s = fraction of cow feed that is pasture grass while cow is on pasture, 1.0.

where all terms have been defined previously.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the R_i^M is based on χ/Q:

$$R^M_{H-3} = (10^{12})(10^3)F_f Q_F U_{ap}(DFL_i)\ [0.75(0.5/H)] \quad \text{(B-12)}$$

where all terms have been defined previously.

Grass-Cow-Milk Pathway Factor R_i^C

$$R_i^C = 10^{12}\,\frac{Q_F(U_{ap})}{\lambda_i + \lambda_w}\,F_m(r)(DFL_i)\left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right]e^{-\lambda_i t_f} \quad \text{(B-13)}$$

2089 004

where

Q_F = cow's consumption rate, 50 kg/day (wet weight)

U_{ap} = child receptor's milk consumption rate, 330 ℓ/yr

Y_p = agricultural productivity by unit area of pasture feed grass, 0.7 kg/m^2

Y_s = agricultural productivity by unit area of stored feed, 2.0 kg/m^2

F_m = stable element transfer coefficients, in days/ℓ

r = fraction of deposited activity retained on cow's feed grass, 1.0 for iodine, 0.2 for particulates

(DFL_i) = maximum organ ingestion dose factor for the receptor for nuclide i, in mrem/pCi

λ_i = decay constant for nuclide i, in sec^{-1}

λ_w = decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14-day half-life)

t_f = transport time from pasture to cow, to milk, to receptor, 1.73×10^5 sec (2 days)

t_h = transport time from pasture, to harvest, to cow, 7.78×10^6 sec (90 days)

f_p = fraction of the year that the cow is on pasture, 0.5

f_s = fraction of the cow feed that is pasture grass while the cow is on pasture, 1.0.

2089 005

In the case that the milk animal is a goat, rather than a cow, appropriate parameter values will be taken from Regulatory Guide 1.109 (Rev. 1, 10/77).

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the R_i^C is based on χ/Q:

$$R_{H-3}^C = (10^{12})(10^3)F_m Q_F U_{ap}(DFL_i)\ [0.75(0.5/H)] \qquad (B-14)$$

where all parameters and values have been defined previously.

Determination of Controlling Exposure Location

The controlling exposure location is that offsite location where the combination of existing pathways and annual average meteorology would indicate the maximum potential dose given normal Plant effluent release rates as calculated by the NRC computer program GALE and listed in Table B-3.

Table B-4 gives the current land use distance data. The annual average meteorology at each of these distances was derived in Appendix C and is listed in Table C-3. Should the Annual Land Use Census indicate a change in Table B-4 which would affect the location of maximum potential offsite dose, the values of R_i will be recomputed and incorporated into the ODCM.

2089 006

DOSE

Nuclide	λ_i (sec^{-1})	Infant Dose Factors DFA$_i$ ($\frac{mrem}{pCi}$)	DFG$_i$ ($\frac{mrem}{pCi}$)	DFL$_i$ ($\frac{mrem}{pCi}$
H-3	1.8E-9	4.6E-7	0.0	3.1E-
Na-24	1.3E-5	7.5E-6	2.9E-8	1.0E-
P-32	5.6E-7	1.5E-3	0.0	1.7E-
Cr-51	2.9E-7	9.2E-6	2.6E-10	4.1E-
Mn-54	2.6E-8	7.1E-4	6.8E-9	2.0E-
Mn-56	7.5E-5	5.1E-5	1.3E-8	7.4E-
Fe-55	8.5E-9	6.2E-5	0.0	1.4E-
Fe-59	1.8E-7	7.3E-4	9.4E-9	5.4E-
Co-58	1.1E-7	5.6E-4	8.2E-9	9.0E-
Co-60	4.2E-9	3.2E-3	2.0E-8	2.6E-
Sr-89	1.5E-7	1.5E-3	6.5E-13	2.5E-
Sr-90	7.9E-10	2.9E-2	0.0	1.9E-
I-131	1.0E-6	1.1E-2	3.4E-9	1.4E-
I-132	8.4E-5	1.2E-4	2.0E-8	1.6E-
I-133	9.2E-6	2.5E-3	4.5E-9	3.3E-
I-134	2.2E-4	3.2E-5	1.9E-8	4.2E-
I-135	2.9E-5	5.0E-4	1.4E-8	6.5E-
Cs-134	1.1E-8	5.0E-4	1.4E-8	7.0E-
Cs-136	5.9E-7	9.6E-5	1.7E-8	1.4E-
Cs-137	7.3E-10	4.4E-4	4.9E-9	6.1E-
Cs-138	3.6E-4	6.3E-7	2.4E-8	1.3E-
Ba-140	6.3E-7	1.1E-3	2.4E-9	1.7E-
La-140	4.8E-6	1.2E-4	1.7E-8	9.8E-

[a] $\frac{mrem/yr}{Ci/m^3}$

2089 007

TABLE B-1

FACTORS FOR SITE BOUNDARY LOCATION

)	ı Retention Factor	F_m Stable Element Transfer Coefficient	P_i^I Inhalation $(\frac{mrem/yr}{Ci/m^3})$	P_i^G Ground Plane $(\frac{m^2\ mrem/yr}{Ci/sec})$	P_i^F Food $(\frac{m^2\ mrem/yr}{Ci/sec})$
7	-	1.0E-2	6.4E+8	0.0[a]	2.4E+9[a]
5	0.2	4.0E-2	1.1E+10	2.0E+13	1.5E+13
3	0.2	2.5E-2	2.1E+12	0.0	1.6E+17
7	0.2	2.2E-3	1.3E+10	7.9E+13	4.8E+12
5	0.2	2.5E-4	9.9E+11	1.3E+15	4.0E+13
5	0.2	2.5E-4	7.1E+10	1.5E+12	3.4E+6
5	0.2	1.2E-3	8.7E+10	0.0	1.4E+14
5	0.2	1.2E-3	1.0E+12	4.6E+14	4.0E+14
6	0.2	1.0E-3	7.8E+11	6.3E+14	6.2E+13
5	0.2	1.0E-3	4.5E+12	5.2E+15	2.2E+14
3	0.2	8.0E-4	2.1E+12	3.8E+10	1.3E+16
2	0.2	8.0E-4	4.1E+13	0.0	1.3E+17
2	1.0	6.0E-3	1.5E+13	3.0E+13	1.1E+18
4	1.0	6.0E-3	1.7E+11	2.1E+12	1.3E+8
3	1.0	6.0E-3	3.5E+12	4.3E+12	1.0E+16
5	1.0	6.0E-3	4.5E+10	7.6E+11	0.0
4	1.0	6.0E-3	7.0E+11	4.2E+12	2.3E+13
4	0.2	1.2E-2	7.0E+11	3.3E+15	6.9E+14
4	0.2	1.2E-2	1.3E+11	2.5E+14	6.3E+15
4	0.2	1.2E-2	6.2E+11	1.3E+15	6.2E+16
6	0.2	1.2E-2	8.8E+8	5.8E+11	0.0
4	0.2	4.0E-4	1.5E+12	3.3E+13	2.4E+14
5	0.2	5.0E-6	1.7E+11	3.1E+13	1.9E+11

Nuclide	λ_i (sec^{-1})	Child Dose Factors DFA$_i$ ($\frac{mrem}{pCi}$)	DFG$_i$ ($\frac{mrem/hr}{pCi/m^2}$)	DFL$_i$ ($\frac{mrem}{pCi}$)	Retention Factor r
H-3	1.8E-9	3.0E-7	0.0	2.0E-7	-
F-18	1.1E-4	-	-	-	0.2
Na-24	1.3E-5	4.4E-6	2.9E-8	5.8E-6	0.2
P-32	5.6E-7	7.0E-4	0.0	8.3E-4	0.2
Cr-51	2.9E-7	4.6E-6	2.6E-10	4.7E-7	0.2
Mn-54	2.6E-8	4.3E-4	6.8E-9	1.1E-5	0.2
Mn-56	7.5E-5	3.3E-5	1.3E-8	4.8E-5	0.2
Fe-55	8.5E-9	3.0E-5	0.0	1.2E-5	0.2
Fe-59	1.8E-7	3.4E-4	9.4E-9	2.8E-5	0.2
Co-58	1.1E-7	3.0E-4	8.2E-9	1.1E-5	0.2
Co-60	4.2E-9	1.9E-3	2.0E-8	2.9E-5	0.2
Sr-89	1.5E-7	5.8E-4	6.5E-13	1.3E-3	0.2
Sr-90	7.9E-10	2.7E-2	-	1.7E-2	0.2
I-131	1.0E-6	4.4E-3	3.4E-9	5.7E-3	1.0
I-132	8.4E-5	5.2E-5	2.0E-8	6.8E-5	1.0
I-133	9.2E-6	1.0E-3	4.5E-9	1.4E-3	1.0
I-134	2.2E-4	1.4E-5	1.9E-8	1.8E-5	1.0
I-135	2.9E-5	2.1E-4	1.4E-8	2.8E-4	1.0
Cs-134	1.1E-8	2.7E-4	1.4E-8	3.8E-4	0.2
Cs-136	5.9E-7	4.6E-5	1.7E-8	6.5E-5	0.2
Cs-137	7.3E-10	2.5E-4	4.9E-9	3.3E-4	0.2
Cs-138	3.6E-4	2.3E-7	2.4E-8	3.2E-7	0.2
Ba-140	6.3E-7	4.7E-4	2.4E-9	8.3E-5	0.2
La-140	4.8E-6	6.1E-5	1.7E-8	9.8E-5	0.2

[a] $\frac{mrem/yr}{Ci/m^3}$

TABLE B-2

TORS FOR CONTROLLING EXPOSURE LOCATION

Stable Element Transfer Coefficients		Dose Parameters				
Meat F_f $(\frac{day}{kg})$	Milk F_m $(\frac{day}{\ell})$	Inhalation R_i^I $(\frac{mrem/yr}{Ci/m^3})$	Ground R_i^G $(\frac{m^2 \cdot mrem/yr}{Ci/sec})$	Vegetable R_i^V $(\frac{m^2 \cdot mrem/yr}{Ci/sec})$	Meat R_i^M $(\frac{m^2 \cdot mrem/yr}{Ci/sec})$	Milk R_i^C $(\frac{m^2 \cdot mrem/yr}{Ci/sec})$
1.2E-2	1.0E-2	1.1E9	0.0[a]	5.1E9[a]	2.3E8[a]	1.5E9[a]
-	-	-	-	-	-	-
3.0E-2	4.0E-2	1.6E10	1.4E13	3.6E11	6.5E2	4.3E12
4.5E-2	2.5E-2	2.6E12	0.0	3.4E15	3.7E15	3.9E16
2.4E-3	2.2E-3	1.7E10	5.5E12	6.2E12	2.4E11	2.3E12
8.0E-4	2.5E-4	1.6E12	1.6E15	6.8E14	5.4E12	1.4E13
8.0E-4	2.5E-4	1.2E11	1.1E12	2.6E9	0.0	8.9E5
4.0E-2	1.2E-3	1.1E11	0.0	8.3E14	3.2E14	7.7E13
4.0E-2	1.2E-3	1.3E12	3.2E14	6.7E14	3.5E14	1.1E14
1.3E-2	1.0E-3	1.1E12	4.5E14	4.0E14	5.9E13	4.3E13
1.3E-2	1.0E-3	7.0E12	2.5E16	2.1E15	2.6E14	1.6E14
6.0E-4	8.0E-4	2.1E12	2.6E10	3.7E16	2.8E14	3.7E15
6.0E-4	8.0E-4	1.0E14	0.0	1.2E18	7.1E15	7.5E16
6.0E-3	6.0E-3	1.6E13	2.1E13	4.7E16	5.7E15	2.2E17
6.0E-3	6.0E-3	1.9E11	1.5E12	7.6E9	0.0	2.8E7
6.0E-3	6.0E-3	3.7E12	3.0E12	8.4E14	1.6E8	2.1E15
6.0E-3	6.0E-3	5.2E10	5.3E11	6.4E3	0.0	0.0
6.0E-3	6.0E-3	7.8E11	2.9E12	1.0E13	0.0	4.4E12
1.2E-2	1.2E-2	1.0E12	7.7E15	2.6E16	3.0E15	2.4E16
1.2E-2	1.2E-2	1.7E11	1.8E14	2.4E14	7.2E13	1.4E15
1.2E-2	1.2E-2	9.3E11	1.2E16	2.4E16	2.8E15	2.2E16
1.2E-2	1.2E-2	8.5E8	4.1E11	0.0	0.0	0.0
4.0E-4	4.0E-4	1.7E12	2.3E13	2.7E14	2.8E12	5.9E13
5.0E-6	5.0E-6	2.3E11	2.2E13	3.1E13	6.7E6	9.4E10

2087 010

TABLE B-3

ESTIMATED ANNUAL RELEASE OF RADIONUCLIDES IN GASEOUS EFFLUENTS
(Ci/yr)
(includes anticipated operational occurrences)

Isotope	Waste Gas System	Containment Purge Exhaust	Fuel and Auxiliary Building Ventilation	Turbine Building Ventilation	Blowdown Tank Vent	Condenser Air Ejector Exhaust	Total
Halogens							
I-131	0.	1.3E-2	4.3E-2	3.1E-4	0.	2.7E-2	8.3E-2
I-133	0.	5.4E-3	6.0E-2	4.1E-4	0.	3.8E-2	1.0E-1
Total	0.	1.8E-2	1.0E-1	7.2E-4	0.	6.5E-2	1.8E-1
Particulates							
Mn-54	4.5E-3	1.8E-3	1.8E-2	-	-	-	2.4E-2
Fe-59	1.5E-3	6.2E-4	6.0E-3	-	-	-	8.1E-3
Co-58	1.5E-2	6.2E-3	6.0E-2	-	-	-	8.1E-2
Co-60	7.0E-3	2.8E-3	2.7E-2	-	-	-	3.7E-2
Sr-89	3.3E-4	1.4E-4	1.3E-3	-	-	-	1.8E-3
Sr-90	6.0E-5	2.5E-5	2.4E-4	-	-	-	3.3E-4
Cs-134	4.5E-3	1.8E-3	1.8E-2	-	-	-	2.4E-2
Cs-137	7.5E-3	3.1E-3	3.0E-2	-	-	-	4.1E-2
Total	4.0E-2	1.6E-2	1.6E-1				2.2E-1
Others							
H-3	-	-	-	-	-	-	3.2E+2
C-14	-	-	-	-	-	-	8.0E+0

2089 011

TABLE B-4

DISTANCES FOR GASEOUS RADIOACTIVE
EFFLUENT EVALUATION
(meters)

Sector	Site Boundary	Nearest Residence	Nearest Garden	Nearest Meat Animal	Nearest Milk Cow	Nearest Milk Goat
N	663	692	[illegible]	>8045	>8045	>8045
NNE	683	2694	2761	3932	4002	5523
NE	820	2731	2746	2771	4112	>804[illegible]
ENE	688	3438	4346	2499	5182	>8045
E	677	960	2198	866	4596	>8045
ESE	805	945	2935	1134	4133	>8045
SE	1006	3822	3850	1524	3898	>8045
SSE	1649	2079	2728	2865	>8045	>8045
S	1332	1765	1737	3368	3447	>8045
SSW	1241	1804	1640	1640	4121	2957
SW	1320	1609	1615	1567	>8045	3539
WSW	1394	2518	2496	1394	>8045	>8045
W	951	1804	1762	1707	>8045	>8045
WNW	1021	2765	2691	2743	>8045	>8045
NW	814	3267	3231	3176	>8045	>8045
NNW	674	768	704	2957	>8045	>8045

APPENDIX C

2089 013

APPENDIX C

METEOROLOGY

ANNUAL AVERAGE CONTINUOUS RELEASE (LONG TERM) METEOROLOGY

Annual average dilution factors (χ/Q) were calculated according to Paragraph C.1.c of Regulatory Guide 1.111 (Rev. 1, 7/77) for ground-level releases. Annual average χ/Q values adjusted for temporal variations in the airflow of the site are presented in Table C-1 as a function of distance and direction. These values are based on $\Delta T_{200\ ft-30\ ft}$ stability data and 30-ft wind data for the period September 1, 1972 through August 31 1974.

Annual average deposition (D/Q) values were calculated according to Paragraph C.3.b of Regulatory Guide 1.111 (Rev. 1, 7/77) for ground-level releases. Annual average D/Q values adjusted for temporal variations in the airflow of the site are presented in Table C-2 as a function of distance and direction. These values are based on 30-ft wind direction data.

Annual average χ/Q and D/Q values at distances measured from the center of the Containment to the closest site boundary, residence, garden, meat animal, milk cow and milk goat within a 5-mile radius of the plant are given in Table C-3 for each of the 22-1/2 degree radial sectors centered on the 16 cardinal compass directions.

Model

Annual average atmospheric dilution factors, χ/Q, were conservatively calculated for the Trojan site based on onsite data for the period September 1, 1972 through August 31, 1974 by assuming a ground-level release using Equation C-1. This equation assumes a uniform horizontal distribution within a 22-1/2 degree sector. Stability is based on ΔT data. Calms were distributed based on the directional frequency of winds in the 0.6-1.5 mph range and were assigned a wind speed of 0.3 mph. Limited vertical mixing also was accounted for due to the mixing depth which was taken as an average of 1000 meters for the Trojan site. Calculations of annual average χ/Q values then were adjusted for temporal variations in the airflow of the site.

$$\left(\frac{\chi}{Q}\right)_k = \sum_{i=1}^{9} \sum_{j=1}^{7} \left[\frac{n_{ijk}}{N} \left(\frac{\chi}{Q}\right)_{ijk} \right] \qquad \text{(C-1)}$$

where

$$\left(\frac{\chi}{Q}\right)_{ijk} = \frac{2.032}{(\Sigma_{zj} u_i x)} \quad \text{if} \quad \sigma_{zj} < 0.465L \qquad \text{(C-2)}$$

$$\left(\frac{\chi}{Q}\right)_{ijk} = \frac{2.032}{(\Sigma_{zj} u_i x)} \sum_{h=0}^{6} \Delta_h \exp\left[-0.5 \left(\frac{2hL}{\Sigma_{zj}}\right)^2\right], \qquad \text{(C-3)}$$

$$\Delta_h = \begin{cases} 1, & h=0 \\ 2, & h>0 \end{cases} \quad \text{if} \quad 0.465L \leq \sigma_{zj} < 1.6L$$

$$\left(\frac{\chi}{Q}\right)_{ijk} = \frac{2.546}{(L\, u_i x)} \quad \text{if} \quad 1.6L < \sigma_{zj} \qquad \text{(C-4)}$$

$\left(\frac{\chi}{Q}\right)_k$ = relative ground-level concentration normalized by source strength Q for sector k, sec/m^3

$\left(\frac{\chi}{Q}\right)_{ijk}$ = relative ground-level concentration χ normalized by source strength Q for stability class j, wind speed class i, and wind direction sector k, sec/m^3

$$\Sigma_{zj} = \left(s_{zj}^2 + \frac{0.5H^2}{\pi}\right)^{1/2}$$

with the constraint that,

$$\Sigma_{zj} \leq \sqrt{3}\, \sigma_{zj}$$

2089 015

N = total observ tions for data pericd

n_{ijk} = total observations for stability class j, wind speed class i, and wind direction sector k

σ_{zj} = vertical stability parameter for stability class j, meters

H = height of the Containment, meters

L = mixing height, 1000 meters

x = downwind distance, meters

u_i = midpoint wind speed of wind speed class i, m/sec.

The values of σ_{zj} are based on curves presented in Regulatory Guide 1.111 (Rev. 1, 7/77).

Calculations of quarterly average D/Q values were made as follows:

$$\left(\frac{D}{Q}\right)_k = \frac{8}{\pi} \quad \frac{d}{Q} \quad \frac{f_k}{x} \qquad \text{(C-5)}$$

where

$\left(\frac{D}{Q}\right)_k$ = relative deposition per unit area for sector k, m^{-2}

x = downwind distance, meters

$\frac{d}{Q}$ = relative deposition rate per unit downwind distance, m^{-1}

f_k = relative frequency of wind direction into sector k, dimensionless.

The values of D/Q are based on the curves for ground level releases of Regulatory Guide 1.111 (Rev. 1, 7/77).

2089 016

Since the straight-line flow model does not consider the temporal variation in the airflow of the site region, terrain adjustment factors for the Trojan site were developed from calculation based on 10-min averages of wind and ΔT data, a straight-line model (Equation C-1) and the methodology presented in the NUS Corporation Topical Report NUSPUF - A Segmented Plume Dispersion Program for the Calculation of Average Concentrations in a Time-Dependent Meteorological Regime, NUS-TM-260, (March 1976). These values are based on $\Delta T_{200\ ft-30\ ft}$ stability data and 30-ft wind data for the period August 1, 1976 through July 31, 1977. Terrain adjustment factors were determined for downwind distances to 5 miles north and south of the Plant and to distances of 3 miles west and 3.5 miles east. For distances beyond the area of analysis or for those distances where the model indicated that the terrain adjustment factor would be less than 1.0, the terrain adjustment factor was conservatively set to 1.0 to adjust χ/Q and D/Q values presented in Tables C-1, C-2, and C-3. Table C-4 presents the maximum terrain adjustment factors for each annular sector for the standard population distances and for the special distances.

BATCH RELEASE (SHORT TERM) METEOROLOGY

Batch release meteorology is based on historical ratios of batch release meteorological data to continuous release meteorological data. As shown in Table C-5, meteorological data during the period 1976 to 1978 indicates that batch release χ/Q is 26 percent higher than continuous release χ/Q, and that batch release D/Q is 27 percent higher than continuous release D/Q. It will be assumed that all batch meteorological data will be 30 percent higher than the annual average data. This adjustment factor (1.30) will then be used to compute the annual average batch release meteorological data for any sector or location of interest.

TABLE C-1

ANNUAL AVERAGE χ/Q VALUES (sec/m^3) FOR CONTINUOUS GROUND-LEVEL RELEASES
(TROJAN SITE DATA SEPTEMBER 1, 1972 - AUGUST 31, 1974)[a]

Receptor Direction	Downwind Distance from Release (miles)										
	0.5	1.5	2.5	3.5	4.5	7.5	15.0	25.0	35.0	45.0	55.0
N	6.9E-6	1.4E-6	6.9E-7	4.3E-7	3.0E-7	1.5E-7	5.8E-8	3.0E-8	1.9E-8	1.4E-8	2.4E-9
NNE	3.5E-6	7.4E-7	3.2E-7	2.0E-7	1.4E-7	7.0E-8	2.7E-8	1.4E-8	9.1E-9	6.6E-9	1.1E-9
NE	1.9E-6	3.9E-7	1.5E-7	9.2E-8	6.5E-8	3.2E-8	1.3E-8	6.5E-9	4.3E-9	3.1E-9	5.0E-10
ENE	2.3E-6	4.8E-7	1.5E-7	8.0E-8	5.6E-8	2.8E-8	1.1E-8	5.6E-9	3.6E-9	2.6E-9	4.4E-10
E	4.6E-6	9.6E-7	4.0E-7	1.9E-7	1.0E-7	5.2E-8	2.1E-8	1.1E-8	7.0E-9	5.1E-9	7.6E-10
ESE	6.9E-6	1.4E-6	6.0E-7	3.1E-7	1.6E-7	7.8E-8	3.1E-8	1.6E-8	1.1E-8	7.8E-9	1.1E-9
SE	4.3E-6	9.6E-7	4.4E-7	2.3E-7	1.5E-7	7.4E-8	2.9E-8	1.5E-8	9.8E-9	7.2E-9	1.1E-9
SSE	3.6E-6	7.4E-7	3.6E-7	2.2E-7	1.6E-7	7.8E-8	3.1E-8	1.6E-8	1.0E-8	7.6E-9	1.4E-9
S	3.6E-6	7.3E-7	3.5E-7	2.2E-7	1.5E-7	7.5E-8	3.0E-8	1.5E-8	9.9E-9	7.2E-9	1.6E-9
SSW	1.6E-6	3.3E-7	1.6E-7	9.7E-8	6.8E-8	3.4E-8	1.3E-8	6.7E-9	4.4E-9	3.2E-9	6.6E-10
SW	7.7E-7	1.5E-7	5.9E-8	4.0E-8	2.6E-8	1.3E-8	4.9E-9	2.5E-9	1.6E-9	1.2E-9	2.4E-10
WSW	6.1E-7	1.0E-7	3.5E-8	2.2E-8	1.5E-8	7.5E-9	3.0E-9	1.5E-9	9.8E-10	7.1E-10	1.3E-10
W	1.3E-6	2.0E-7	6.6E-8	4.1E-8	2.9E-8	1.5E-8	5.8E-9	3.0E-9	2.0E-9	1.4E-9	2.2E-10
WNW	1.5E-6	2.4E-7	8.4E-8	5.2E-8	3.3E-8	1.7E-8	6.5E-9	3.4E-9	2.2E-9	1.6E-[illegible]	3.0E-10
NW	2.8E-6	5.7E-7	2.2E-7	1.3E-7	8.5E-8	4.2E-8	1.6E-8	8.4E-9	5.5E-9	4.0E-9	7.8E-10
NNW	4.9E-6	9.9E-7	4.3E-7	2.7E-7	1.9E-7	9.3E-8	3.7E-8	1.9E-8	1.2E-8	8.9E-9	1.6E-9

[a] Based upon 50 ft MSL wind and 50 - 200 ft MSL ΔT.

TABLE C-2

ANNUAL AVERAGE DEPOSITION VALUES (m^{-2}) FOR CONTINUOUS GROUND-LEVEL RELEASES (TROJAN SITE DATA SEPTEMBER 1, 1972 - AUGUST 31, 1974)[a]

Receptor	Downwind Distance from Release (miles)										
Direction	0.5	1.5	2.5	3.5	4.5	7.5	15.0	25.0	35.0	45.0	55.0
N	3.8E-8	6.0E-9	2.5E-9	1.4E-9	8.7E-10	3.5E-10	1.1E-10	4.5E-11	2.4E-11	1.5E-11	1.0E-11
NNE	1.5E-8	2.3E-9	8.7E-10	4.8E-10	3.1E-10	1.2E-10	4.0E-11	1.6E-11	8.6E-12	5.4E-12	3.6E-12
NE	5.5E-9	8.6E-10	2.7E-10	1.5E-10	9.6E-11	3.9E-11	1.2E-11	5.0E-12	2.7E-12	1.7E-12	1.1E-12
ENE	5.1E-9	8.0E-10	2.2E-10	1.0E-10	6.4E-11	2.6E-11	8.2E-12	3.3E-12	1.8E-12	1.1E-12	7.5E-13
E	9.9E-9	1.6E-9	5.4E-10	2.3E-10	1.1E-10	4.6E-11	1.5E-11	5.9E-12	3.2E-12	2.0E-12	1.3E-12
ESE	1.8E-8	2.9E-9	1.0E-9	4.6E-10	2.1E-10	8.4E-11	2.7E-11	1.1E-11	5.8E-12	3.6E-12	2.5E-12
SE	1.8E-8	3.0E-9	1.1E-9	5.3E-10	3.1E-10	1.3E-10	4.0E-11	1.6E-11	8.7E-12	5.4E-12	3.6E-12
SSE	2.2E-8	3.4E-9	1.4E-9	7.7E-10	4.9E-10	2.0E-10	6.3E-11	2.6E-11	1.4E-11	8.5E-12	5.8E-12
S	3.1E-8	[illegible].9E-9	2.0E-9	1.1E-9	7.1E-10	2.9E-10	9.1E-11	3.7E-11	2.0E-11	1.2E-11	8.3E-12
SSW	1.2E-8	1.8E-9	7.6E-10	4.2E-10	2.7E-10	1.1E-10	3.4E-11	1.4E-11	7.5E-12	4.6E-12	3.1E-12
SW	4.2E-9	6.1E-10	2.1E-10	1.3E-10	7.3E-11	3.0E-11	9.4E-12	3.8E-12	2.1E-12	1.3E-12	8.7E-13
WSW	2.0E-9	2.6E-10	7.6E-11	4.2E-11	2.7E-11	1.1E-11	3.4E-12	1.4E-12	7.5E-13	4.6E-13	3.2E-13
W	3.0E-9	3.5E-10	9.5E-11	5.3E-11	3.4E-11	1.4E-11	4.3E-12	1.8E-12	9.4E-13	5.8E-13	4.0E-13
WNW	4.7E-9	5.8E-10	1.8E-10	9.6E-11	5.6E-11	2.3E-11	7.2E-12	2.9E-12	1.6E-12	9.7E-13	6.6E-13
NW	1.3E-8	2.0E-9	6.6E-10	3.6E-10	2.1E-10	8.5E-11	2.7E-11	1.1E-11	5.9E-12	3.7E-12	2.5E-12
NNW	3.0E-8	4.7E-9	1.7E-9	9.6E-10	6.1E-10	2.5E-10	7.9E-11	3.2E-11	1.7E-11	1.1E-11	7.2E-12

[a] Based on 50 ft MSL wind.

TABLE C-3

ANNUAL AVERAGE χ/Q (sec/m^3) AND DEPOSITION (m^{-2})
FACTORS AT SITE BOUNDARY AND OFFSITE EXPOSURE LOCATIONS
FOR GROUND-LEVEL RELEASES
(TROJAN SITE DATA SEPTEMBER 1, 1972 - AUGUST 31, 1974)

Sector Direction	Wind Direction[a]		Site Boundary	Nearest Residence	Nearest Garden	Nearest Meat Animal	Nearest Milk Cow	Nearest Milk Goat
N	S	χ/Q	9.2E-6	8.6E-6	9.1E-6	>2.6E-7	>2.6E-7	>2.6E-7
		D/Q	5.2E-8	4.9E-8	5.2E-8	>7.2E-10	>7.2E-10	>7.2E-10
NNE	SSW	χ/Q	4.5E-6	6.3E-7	6.1E-7	3.3E-7	3.3E-7	2.1E-7
		D/Q	1.9E-8	1.9E-9	1.9E-9	9.1E-10	8.8E-10	5.0E-10
NE	SW	χ/Q	1.8E-6	3.3E-7	3.3E-7	3.2E-7	1.4E-7	>5.6E-8
		D/Q	5.3E-9	7.0E-10	6.9E-10	6.8E-10	2.6E-10	>7.9E-11
ENE	WSW	χ/Q	2.8E-6	1.9E-7	1.4E-7	4.5E-7	9.0E-8	>4.8E-8
		D/Q	6.5E-9	2.9E-10	1.9E-10	7.5E-10	1.2E-10	>5.3E-11
E	W	χ/Q	6.0E-6	3.6E-6	1.1E-6	4.2E-6	3.2E-7	>9.0E-8
		D/Q	1.3E-8	7.4E-9	1.8E-9	8.8E-9	4.3E-10	>9.3E-11
ESE	WNW	χ/Q	6.9E-6	5.5E-6	1.1E-6	4.2E-6	5.7E-7	>1.4E-7
		D/Q	1.8E-8	1.4E-8	2.1E-9	1.0E-8	9.6E-10	>1.7E-10
SE	NW	χ/Q	3.1E-6	4.7E-7	4.6E-7	1.7E-6	4.6E-7	>1.3E-7
		D/Q	1.2E-8	1.3E-9	1.2E-9	6.1E-9	1.2E-9	>2.6E-10
SSE	NNW	χ/Q	1.3E-6	9.2E-7	6.2E-7	5.8E-7	>1.4E-7	>1.4E-7
		D/Q	6.5E-9	4.4E-9	2.7E-9	2.5E-9	>4.0E-10	>4.0E-10
S	N	χ/Q	1.7E-6	1.2E-6	1.2E-6	4.5E-7	4.4E-7	>1.3E-7
		D/Q	1.4E-8	8.4E-9	8.6E-9	2.7E-9	2.6E-9	>5.8E-10
SSW	NNE	χ/Q	8.6E-7	5.0E-7	5.7E-7	5.7E-7	1.5E-7	2.5E-7
		D/Q	5.7E-9	3.0E-9	3.6E-9	3.6E-9	7.2E-10	1.3E-9
SW	NE	χ/Q	3.7E-7	2.8E-7	2.6E-7	2.9E-7	>2.2E-8	7.0E-8
		D/Q	1.9E-9	1.3E-9	1.2E-9	1.4E-9	>6.1E-11	2.6E-10
WSW	ENE	χ/Q	2.8E-7	9.7E-8	9.8E-8	2.8E-7	>1.3E-8	>1.3E-8
		D/Q	8.0E-10	2.4E-10	2.4E-10	8.0E-10	>2.2E-11	>2.2E-11
W	E	χ/Q	1.0E-6	3.0E-7	3.1E-7	3.3E-7	>2.5E-8	>2.5E-8
		D/Q	2.3E-9	5.8E-10	6.0E-10	6.3E-10	>2.8E-11	>2.8E-11
WNW	ESE	χ/Q	1.0E-6	1.9E-7	2.0E-7	2.0E-7	>2.9E-8	>2.9E-8
		D/Q	3.2E-9	4.6E-10	4.8E-10	4.7E-10	>4.6E-11	>4.6E-11
NW	SE	χ/Q	2.8E-6	2.9E-7	3.0E-7	3.8E-7	>7.4E-8	>7.4E-8
		D/Q	1.3E-8	9.5E-10	9.7E-10	1.3E-9	>1.7E-10	>1.7E-10
NNW	SSE	χ/Q	6.3E-6	5.2E-6	5.9E-6	7.4E-7	>1.6E-7	>1.6E-7
		D/Q	4.0E-8	3.2E-8	3.7E-8	3.3E-9	>5.1E-10	>5.1E-10

[a] Direction from which the wind blows.

TABLE C-4

TROJAN

MAXIMUM ANNUAL SECTOR

TERRAIN ADJUSTMENT FACTORS DERIVED FROM NUSPUF
WITH BUILDING WAKE ADJUSTMENT DIVIDED BY NUSOUT
FOR STANDARD POPULATION DISTANCES OF
0.5 MILE to 4.5 MILES

Receptor Direction	Distance (miles) 0.5 (805m)	1.5 (2414m)	2.5 (4023m)	3.5 (5633m)	4.5 (7242m)
N	1.0	0.9	0.9	0.8	0.7
NNE	1.1	1.1	0.9	0.7	0.6
NE	1.3	1.3	0.9	0.6	0.4
ENE	1.8	1.8	1.2	0.8	1.0[a]
E	2.0	2.0	1.7	1.3	1.0[a]
ESE	2.0	2.0	1.7	1.4	1.0[a]
SE	1.3	1.4	1.3	1.1	1.0
SSE	1.0	0.9	0.9	0.8	0.7
S	1.0	0.8	0.9	0.8	0.8
SSW	1.0	0.9	0.9	0.9	0.8
SW	1.3	1.2	1.0	1.1	1.0
WSW	1.7	1.4	1.0	1.0	1.0[a]
W	2.0	1.5	1.0	1.0	1.0[a]
WNW	1.9	1.5	1.1	1.1	1.0[a]
NW	1.4	1.4	1.1	1.1	1.0
NNW	1.1	1.1	0.9	0.8	0.8

[a] Beyond the area of analysis.

TABLE C-5

HISTORICAL CORRELATION BETWEEN BATCH AND CONTINUOUS METEOROLOGY[a]

Quarter	Batch Release		Continuous Release		Ratio: Batch/Continuous	
	χ/Q (sec/m^3)	D/Q (m^{-2})	χ/Q (sec/m^3)	D/Q (m^{-2})	χ/Q	D/Q
1976						
1	5.6E-5	4.7E-7	6.1E-5	5.7E-7	0.92	0.82
2	4.1E-5	2.0E-7	3.6E-5	2.2E-7	1.14	0.91
3	3.8E-5	2.7E-7	1.8E-5	1.0E-7	2.11	2.70
4	6.0E-5	1.3E-7	3.7E-5	2.0E-7	1.62	0.65
1977						
1	7.1E-5	3.6E-7	5.4E-5	3.0E-7	1.31	1.20
2	7.0E-5	2.6E-7	3.8E-5	1.5E-7	1.84	1.73
3	7.1E-6	5.4E-8	6.2E-6	2.9E-8	1.15	1.86
4	1.0E-5	7.0E-8	8.6E-6	6.0E-8	1.16	1.17
1978						
1	1.2E-5	5.0E-8	1.2E-5	6.5E-8	1.00	0.77
2	1.2E-5	3.9E-8	1.1E-5	3.6E-8	1.09	1.08
3	5.9E-6	2.8E-8	6.7E-6	3.1E-8	0.88	0.90
4	1.2E-5	7.3E-8	1.3E-5	5.1E-8	0.92	1.43
Average					1.26	1.27

[a] From Annual Report of Trojan Nuclear Power Plant for 1976, 1977, 1978 (PGE Reports 1015-76, 1015-77 and 1015-78). All values used for comparison are maximum values for site boundary.

APPENDIX D

2089 023

APPENDIX D

BASIS FOR DETERMINING THAT DOSES TO PERSONS UTILIZING RECREATIONAL AREAS ARE LESS THAN DOSES TO THE NEAREST RESIDENT

This analysis determines that the maximum dose to an individual utilizing the recreational areas inside the site boundary would be less than 20 percent of the maximum dose to an individual residing at the nearest residence. Thus, any reduction of the noble gas dose design objectives is not warranted.

The public recreational areas provided at Trojan Nuclear Plant include a Visitors Information Center, a recreational lake and picnic area. These are located in the west-southwest, southwest, south-southwest and south sector directions from the Trojan Containment Building. The minimum distance to the recreational areas in each of the above directions is listed in Table D-1.

Since noble gas doses are directly proportional to the atmospheric dispersion factor (χ/Q, sec/m^3), this analysis will demonstrate that the highest annual average χ/Q at the nearest residence is significantly greater than the highest recreational area χ/Q when the recreational area χ/Q is adjusted for occupancy times. The analysis assumes annual average meteorology, ground-level release sector average χ/Q (Meteorology and Atomic Energy Equation 3.144) and a recreational occupancy time of 1530 hr/yr.

The following equation was used to calculate the χ/Q values listed in Table D-1:

$$\chi/Q\ (\mathrm{sec/m^3}) = \left[\frac{2}{\pi}\right]^{1/2} \left[\frac{(0.01)\ (f)}{\sigma_z\ \bar{\mu}\ (2\ \pi\ \frac{x}{n})}\right] \left[\mathrm{OF}\right] \qquad \text{(D-1)}$$

2089 024

where

f = wind frequency, percent

$\bar{\mu}$ = mean wind speed, meters/sec

x = down wind distance, meters

n = number of cardinal compass sectors = 16

σ_z = vertical dispersion parameter

$[OF]$ = occupancy factor = $\frac{1530}{8760}$ = 0.17 for recreational areas.

From Table D-1 it is shown that for a given annual release of noble gases, the average annual dose will be highest at the nearest residence and that the noble gas dose design objectives do not need to be reduced.

TABLE D-1

ATMOSPHERIC DISPERSION FACTORS AT
NEAREST RESIDENCE AND ONSITE RECREATIONAL AREAS

Sector	Min. Dist. to Rec. Area (meters)	Wind[a] Freq. Percent	Wind[a] Speed (m/sec)	σ_z[b] (m)	χ/Q (sec/m^3)	Occupancy Factor	Adjusted χ/Q (sec/m^3)	Relative χ/Q
N	692 (residence)	19.5	4.0	18.	8.0×10^{-6}	1.0	[illegible] $\times 10^{-6}$	1.0
S	472	16.5	4.5	14.	1.1×10^{-5}	0.17	1.9×10^{-6}	0.24
SSW	305	6.0	3.6	9.1	1.2×10^{-5}	0.17	2.0×10^{-6}	0.25
SW	343	2.0	2.9	10.	4.1×10^{-6}	0.17	7.0×10^{-7}	0.09
WSW	686	1.0	1.8	18.	9.2×10^{-7}	0.17	1.6×10^{-7}	0.02

[a] Annual average.
[b] Meteorology and Atomic Energy.

2089 026

APPENDIX E

2089 027

APPENDIX E

BASIS FOR DELETION OF MAXIMUM CURIE LIMIT FOR A WASTE GAS DECAY TANK

Radioactive waste gas decay tanks are used to permit decay of accumulated radioactive gases as a means of reducing the normal release of radioactive materials to the atmosphere.

In the evaluation of the waste gas decay tank failure accident, the fission product accumulation and release assumptions of Regulatory Guide 1.24 have been used. The assumptions related to the release of radioactive gases from the postulated failure of a waste gas decay tank are:

1) The reactor has been operating at full power with 1 percent defective fuel and a shutdown to cold condition has been conducted prior to the accident.

2) All noble gases have been removed from the primary cooling system and transferred to the gas decay tank that is assumed to fail.

3) The maximum content of the decay tank assumed to fail has been used. This content is equivalent to the total noble gas inventory of the primary coolant system. No credit has been taken for the time required to transfer the noble gases from the primary system to the tank.

4) The failure is assumed to occur immediately upon completion of the waste gas transfer, releasing the entire contents of the tank to the Auxiliary Building.

5) All of the noble gases are assumed to be exhausted from the Auxiliary Building at ground level over a 2-hr time period. No decay in the Auxiliary Building is assumed.

? 28

The dose commitment for a Waste Gas Decay Tank (WGDT) failure is estimated as follows:

$$D = \frac{10^{12} \times \sum_i Q_i \times K_i \times \chi/Q}{3.2 \times 10^7} \quad \text{(E-1)}$$

where

D = total body dose, mrem

Q_i = Activity in WGDT of nuclide i, Ci

K_i = total body dose factor for nuclide i, mrem/yr per pCi/m^3

χ/Q = DBA meteorological dispersion factor, sec/m^3
= 4.3×10^{-4} sec/m^3 (FSAR Table 15.5-3)

10^{12} = conversion factor, pCi/Ci

3.2×10^7 = conversion factor, sec/yr.

The results of the above analysis are tabulated in Table E-1. It is shown that even under the most conservative assumptions, failure of a WGDT containing the maximum noble gas inventory will not result in a dose which exceeds the limits of 500 mrem site boundary total body dose. Based on this analysis, Technical Specification 3.11.2.7 of the Nuclear Regulatory Commission Effluent Standard Technical Specifications has been deleted.

TABLE E-1

DOSE FROM GASEOUS WASTE DECAY TANK FAILURE

Isoptope	Activity[a] (Ci)	K_i Total Body Dose Factor $\frac{mrem/yr}{pCi/m^3}$	Total Body Dose (mrem)
Kr-85	1.0×10^{3}	1.6×10^{-5}	2.2×10^{-1}
Kr-85m	4.5×10^{2}	1.2×10^{-3}	7.3×10^{0}
Kr-87	2.6×10^{2}	5.9×10^{-3}	2.1×10^{1}
Kr-88	7.7×10^{2}	1.5×10^{-2}	1.6×10^{2}
Xe-131m	3.8×10^{2}	9.2×10^{-5}	4.7×10^{-1}
Xe-133	5.8×10^{4}	2.9×10^{-4}	2.3×10^{2}
Xe-133m	6.4×10^{2}	2.5×10^{-4}	2.2×10^{0}
Xe-135	1.3×10^{3}	1.8×10^{-3}	3.1×10^{1}
Xe-135m	3.8×10^{1}	3.1×10^{-3}	1.6×10^{0}
Xe-138	1.4×10^{2}	8.8×10^{-3}	1.7×10^{1}
Total			4.6×10^{2}

[a] FSAR Table 15.5-6 (Amendment 31).