SECTION 11

RADIOACTIVE WASTE MANAGEMENT

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SECTION 11

RADIOACTIVE WASTE MANAGEMENT

11.1 SOURCE TERMS

This section gives noble gas source terms based on an off-gas nominal release rate of 0.1 Ci/s at 30 minutes decay, General Electric (GE) design basis. The corresponding reactor coolant concentrations are also given. The shielding design basis source terms given in Section 12.2.1 and the design basis source terms for the waste management systems were derived from this information. The shielding and waste management system design basis source terms correspond to an off-gas release rate of 0.5 Ci/s (five times the nominal off-gas release rate) at 30 minutes decay, Hope Creek Generating Station (HCGS) design basis. The expected source terms, as used in Section 11 for 10CFR50, Appendix I, evaluations and in Section 12.2.2 for inplant airborne activity and exposure estimates, are based on the source terms in ANSI Standard N237-1976, as incorporated into NUREG-0016 and in accordance with Regulatory Guide 1.112. These source terms correspond to an off-gas release rate of 0.05 Ci/s at 30 minutes decay.

GE has evaluated radioactive material sources (activation products and fission products released from fuel) in operating boiling water reactors (BWRs). These source terms are reviewed and periodically revised as necessary to incorporate up to date information. Release of radioactive material from operating BWRs has resulted in doses to persons offsite that are only a small fraction of 10CFR20 doses, or of natural background doses.

The information provided in this section defines the design basis radioactive material levels in the reactor water, steam, and off-gas. The various radioisotopes listed have been grouped as coolant activation products, noncoolant activation products, and

fission products. The fission product levels are based on measurements of BWR reactor water and off-gas at several stations through mid 1971. Emphasis was placed on observations made at KRB and Dresden 2. The design basis radioactive material levels do not necessarily include all the radioisotopes observed or theoretically predicted to be present. The radioisotopes included are considered significant to one or more of the following criteria:

1. Plant equipment/system design

2. Shielding design

3. Understanding of system operation and performance

4. Measurement practicability

5. Radiological consequences of radioactive material releases to the environment.

For halogens, radioisotopes with half lives of less than 3 minutes have been omitted. For other fission product radioisotopes in reactor water, radioisotopes with half lives of less than 10 minutes are not considered.

11.1.1 Fission Products

11.1.1.1 Noble Radiogas Fission Products

The noble radiogas fission product source terms observed in operating BWRs are generally complex mixtures, whose sources vary from miniscule defects in cladding to "tramp" uranium on external cladding surfaces. The relative concentrations or amounts of noble radiogas isotopes can be described as follows:

$$\text{Equilibrium:} \quad R_g \simeq k_1 y \qquad (11.1\text{-}1)$$

$$\text{Recoil:} \quad R_g \simeq k_2 y \lambda \qquad (11.1\text{-}2)$$

The nomenclature in Section 11.1.1.4 defines the terms in these and succeeding equations. The constants k_1 and k_2 describe the fractions of the total fissions that are involved in each of the releases. The equilibrium and recoil mixtures are the two extremes of the mixture spectrum that are physically possible. When a sufficient time delay occurs between the fission event and the release of the radiogases from the fuel to the coolant, the radiogases approach equilibrium levels in the fuel and the equilibrium mixture results. When there is no delay or impedance between the fission event and the release of the radiogases, the recoil mixture is observed.

Prior to Vallecitos Boiling Water Reactor (VBWR) and Dresden 1 experience, it was assumed that noble radiogas leakage from the fuel would be the equilibrium mixture of the noble radiogases present in the fuel. VBWR and early Dresden 1 experience indicated that the actual mixture most often observed approached a distribution that was intermediate in character to the two extremes, as discussed in Reference 11.1-1. This intermediate decay mixture is termed the "diffusion" mixture. It must be emphasized that this diffusion mixture is merely one possible point on the mixture spectrum ranging from the equilibrium to the recoil mixture, and does not have the absolute mathematical and mechanistic basis for the calculational methods possible for equilibrium and recoil mixtures. However, the diffusion distribution pattern described in Reference 11.1-1 is as follows:

$$\text{Diffusion:} \quad R_g \simeq k_3 y \lambda^{0.5} \qquad (11.1\text{-}3)$$

The constant k_3 describes the fraction of total fissions that are involved in the release. The value of the exponent of the decay constant, λ, is midway between the values for equilibrium, 0, and recoil, 1.

Although the previously described diffusion mixture has been used by GE as a basis for design since 1963, the design basis release magnitude used has varied from 0.5 Ci/s to 0.1 Ci/s, as measured after a 30-minute decay (t = 30 minutes). The noble radiogas source term rate after a 30-minute decay has been used as a conventional measure of the design basis fuel leakage rate, since it is conveniently measurable and consistent with the nominal design basis 30-minute gaseous radwaste system holdup system used in a number of plants. Since about 1967, the GE design basis release magnitude used (including the 1971 source terms) is an annual average of 0.1 Ci/s (t = 30 minutes). This is considered to be an annual average, with some time above and some time below this value. This value was selected on the basis of operating experience, rather than predictive assumptions. Several judgment factors, including the significance of environmental release, reactor water radioisotope concentrations, liquid radwaste handling and effluent disposal criteria, building air contamination, shielding design, and turbine and other component contamination affecting maintenance, have been considered in establishing this level.

Noble radiogas source terms from fuel above 0.1 Ci/s (t = 30 minutes) can be tolerated for reasonable periods of time. Continual assessment of these values is made on the basis of actual operating experience in BWRs discussed in Reference 11.1-9.

While the noble radiogas source term magnitude had been established at 0.1 Ci/s (t = 30 minutes), it was recognized that there may be a more statistically applicable distribution for the noble radiogas mixture. Sufficient data were available from KRB operations from 1967 to mid-1971, along with Dresden 2 data from operation in 1970 and several months in 1971, to more accurately characterize the noble radiogas mixture pattern for an operating BWR.

The basic equation for each radioisotope used to analyze the collected data is:

$$R_g = K_g y\lambda \left[1-e^{-\lambda T}\right]\left[e^{-\lambda t}\right] \qquad (11.1\text{-}4)$$

With the exception of Kr-85 (with a half-life of 10.74 years), the noble radiogas fission products in the fuel are essentially at an equilibrium condition after an irradiation period of several months (rate of formation is equal to the rate of decay). So for practical purposes, the term $(1-e^{-2T})$ approaches 1 and can be neglected when the reactor has been operating at steady-state for long periods of time. The term $(e^{-\lambda t})$ is used to adjust the releases from the fuel (t = 0) to the decay time for which values are needed. Historically, t = 30 minutes has been used. When discussing long term, steady state operation and leakage from the fuel (t = 0), the following simplified form of Equation 11.1-4 can be used to describe the leakage of each noble radiogas:

$$R_g = K_g y\lambda^m \qquad (11.1\text{-}5)$$

The constant, K_g, describes the magnitude of leakage. The relative rates of leakage of the different noble radiogas isotopes is accounted for by the variable exponent, m, of the decay constant, λ.

Dividing both sides of Equation 11.1-5 by y, the fission yield, and taking the logarithm of both sides results in the following equation:

$$\log (R_g/y) = m \log (\lambda) + \log (K_g) \qquad (11.1\text{-}6)$$

Equation 11.1-6 represents a straight line when log (R_g/y) is plotted versus log (λ); m is the slope of the line. This straight line is obtained by plotting (R_g/y) versus (λ) on logarithmic graph paper. By fitting actual data from KRB and Dresden 2 (using least squares techniques) to the equation, the slope, m, can be obtained. This can be estimated on the plotted graph. With radiogas leakage at KRB (over the nearly 5-year period) varying from 0.001 Ci/s to 0.056 Ci/s (t = 30 minutes), and with radiogas leakage at Dresden 2 varying from 0.001 Ci/s to 0.169 Ci/s (t = 30 minutes), the average value of m was determined. The value for m is 0.4, with a standard deviation of ±0.07. This is illustrated on Figure 11.1-1 as a frequency histogram. As can be seen from this figure, variations in m were observed in the range m = 0.1 to m = 0.6. After establishing the value of m = 0.4, the value of K_g can be calculated by selecting a value for R_g, or as has been done historically, the GE design basis is set by the total source term magnitude at t = 30 minutes. With ΣR_g at 30 minutes = 0.1 Ci/s, K_g can be calculated as being 2.6×10^7 and Equation 11.1-4 becomes:

$$R_g = 2.6 \times 10^7 \; y\lambda^{0.4} \left[1-e^{-\lambda T} \right] \left[e^{-\lambda t} \right] \quad (11.1\text{-}7)$$

This updated noble radiogas source term mixture has been termed the "1971 mixture" to differentiate it from the "diffusion mixture." The noble radiogas source term for each isotope can be calculated from Equation 11.1-7. The resultant source terms are presented in Table 11.1-1 as leakage from fuel (t = 0) and after a 30-minute decay. While Kr-85 can be calculated using Equation 11.1-7, the number of confirming experimental observations is limited by the difficulty of measuring very low release rates of this isotope. Therefore, the table provides an estimated range for Kr-85 based on a few actual measurements.

Normal operational release rates to the primary coolant are expected to be approximately 0.025 Ci/s of the 13 commonly considered noble radiogases (as evaluated at 30 minutes) and 0.0001 Ci/s of I-131. These values can be compared to the GE-design-basis values of 0.1 Ci/s for the summation of the same 13 radiogases, and 0.0007 Ci/s for I-131. Table 11.1-2 presents the source terms released to the reactor pressure vessel (RPV) as a consequence of a power isolation event, which is the only anticipated operational occurrence in which significant activity is expected to be released.

11.1.1.2 Radiohalogen Fission Products

Historically, the radiohalogen design basis source term was established by the same equation as that used for noble radiogases. In a fashion similar to that used with gases, a simplified equation can be shown to describe the release of each halogen radioisotope:

$$R_h = K_h y \lambda^n \qquad (11.1\text{-}8)$$

The constant, K_h, describes the magnitude of leakage from fuel. The relative rates of halogen radioisotope leakage are expressed in terms of n, the exponent of the decay constant, λ. As is done with the noble radiogases, the value of n is determined to be 0.5, with a standard deviation of ± 0.19. This is illustrated on Figure 11.1-2 as a frequency histogram. As can be seen from this figure, variations in n were observed in the range of $n = 0.1$ to $n = 0.9$.

It appeared that the use of the previous method of calculating radiohalogen leakage from fuel was overly conservative. Figure 11.1-3 relates KRB and Dresden 2 noble radiogas leakage versus I-131 leakage. While it can be seen from Dresden 2 data, during the period August 1970 to January 1971, that there is a relationship between noble radiogas and I-131 leakage under one fuel condition, there is no simple relationship for all fuel

conditions experienced. Also, it can be seen that during this period, high radiogas leakages were not accompanied by high radioiodine leakage from the fuel. Except for one KRB datum point, all steady state I-131 leakages observed at KRB or Dresden 2 were equal to or less than 505 μCi/s. Even at Dresden 1 in March 1965, when severe defects were experienced in stainless steel clad fuel, I-131 leakages greater than 500 μCi/s were not experienced. Figure 11.1-3 shows that these higher radioiodine leakages from the fuel were related to noble radiogas source terms of less than the GE design basis value of 0.1 Ci/s (t = 30 minutes). This may be partially explained by inherent limitations due to internal plant operational problems that caused plant derating.

In general, it would not be anticipated that operation at full power would continue for any significant time period with fuel cladding defects that would be indicated by I-131 leakage from the fuel in excess of 700 μCi/s. When high radiohalogen leakages are observed, other fission products will normally be present in greater amounts.

Using these judgment factors and experience to date, the GE design basis radiohalogen source terms from fuel were established based on I-131 leakage of 700μCi/s. This value, as shown on Figure 11.1-3, accommodates the experience data and the GE-design-basis noble radiogas source term of 0.1 Ci/s (t = 30 minutes). With the GE I-131 design-basis source term established, is calculated as being 2.4 x 10^7, and halogen radioisotope release can be expressed by the following equation:

$$R_h = 2.4 \times 10^7 \, y\lambda^{0.5} \left[1 - e^{-\lambda T}\right] \left[e^{-\lambda t}\right] \qquad (11.1\text{-}9)$$

Concentrations of radiohalogens in reactor water can be calculated using the following equation:

$$C_h = \frac{R_h}{(\lambda+\beta+\gamma)M} \qquad (11.1\text{-}10)$$

Although carryover of most soluble radioisotopes from reactor water to steam is observed to be <0.1 percent (<0.001 fraction), the observed carryover for radiohalogens varies from 0.1 percent to about 2 percent on newer plants. The average of observed radiohalogen carryover measurements is 1.2 percent by weight of reactor water in steam, with a standard deviation of ± 0.9. In the present source term definition, a radiohalogen carryover of 2 percent (0.02 fraction) is used.

The radiohalogen release rate from the fuel can be calculated from Equation 11.1-9. Concentrations in reactor water can be calculated from Equation 11.1-10. The resultant concentrations are presented in Table 11.1-3.

11.1.1.3 Other Fission Products

The observations of other fission products (and transuranic nuclides, including Np-239) in operating BWRs are not adequately correlated by simple equations. For these radioisotopes, design basis concentrations in reactor water have been estimated conservatively from experience data and are presented in Table 11.1-4. Carryover of these radioisotopes from the reactor water to the steam is estimated to be <0.1 percent (<0.001 fraction). In addition to carryover, however, decay of noble radiogases in the steam leaving the reactor results in production of noble gas daughter radioisotopes in the steam and condensate systems.

Some daughter radioisotopes, e.g., yttrium and lanthanum, are not listed as being in reactor water. Their independent leakage to the coolant is negligible. However, these radioisotopes may be observed in some samples in equilibrium, or approaching equilibrium, with the parent radioisotope.

Except for Np-239, trace concentrations of transuranic isotopes have been observed in only a few samples where extensive and complex analyses were carried out. The predominant alpha emitter present in reactor water is Cm-242 at an estimated concentration of 10^{-6} μCi/g or less, which is below the maximum permissible concentration in drinking water continuously used by the general public. The concentration of alpha emitting plutonium radioisotopes is more than one order of magnitude lower than that of Cm-242.

Plutonium-241, a beta emitter, may also be present in concentrations comparable to the Cm-242 level.

11.1.1.4 Nomenclature

The following list of nomenclature defines the terms used in equations for source term calculations:

R_g - leakage rate of a noble gas radioisotope, μCi/s
R_h - leakage rate of a halogen radioisotope, μCi/s
y - fission yield of a radioisotope, atoms/fission
λ - decay constant of a radioisotope, s^{-1}
T - fuel irradiation time, s
t - decay time following leakage from fuel, s
m - noble radiogas decay constant exponent, dimensionless
n - radiohalogen decay constant exponent, dimensionless
K_g - a constant establishing the level of noble radiogas leakage from fuel, dimensionless
K_h - a constant establishing the level of radiohalogen leakage from fuel, dimensionless
C_h - concentration of a halogen radioisotope in reactor water, μCi/g
M - mass of cooling water in the operating reactor, g
β - Q/M - cleanup system removal constant, s^{-1}
Q - cleanup system flow rate, g/s
γ - $\frac{C\ W}{C\ M}$ - halogen steam carryover removal constant, s^{-1}

C_s - concentration of halogen radioisotope in steam, μCi/g
W - steam flow rate, g/s

11.1.2 Activation Products

11.1.2.1 Coolant Activation Products

The coolant activation products are not adequately correlated by simple equations. The Hope Creek Generating Station (HCGS) design basis concentrations in reactor water and steam are estimated conservatively from experience data. The resultant concentrations are presented in Table 11.1-5.

11.1.2.2 Noncoolant Activation Products

The activation products formed by activation of impurities in the coolant, or by corrosion of irradiated system materials, are not adequately correlated by simple equations. The HCGS design basis source terms for noncoolant activation products are estimated conservatively from experience data in Reference 11.1-8. The resultant concentrations in reactor water are presented in Table 11.1-6. Carryover of these isotopes from the reactor water to the steam is estimated to be ≤0.1 percent (≤0.001 fraction) by weight of reactor water as mentioned in Reference 11.1-8.

11.1.3 Tritium

In a BWR, tritium is produced by three principal methods:

1. Activation of naturally occurring deuterium in the reactor coolant

2. Nuclear ternary fission of UO_2 fuel

3. Neutron reactions with boron used in reactivity control rods.

The control rod formed tritium, which may be released from a BWR liquid or gaseous effluents, is believed to be negligible. A prime source of tritium available for release from a BWR is that produced from activation of deuterium in the reactor coolant. Some ternary fission product tritium may also transfer from the fuel to the reactor coolant. This discussion is limited to the uncertainties associated with estimating the amounts of tritium available for release.

All of the tritium produced by activation of deuterium in the reactor coolant is available for release in liquid or gaseous effluents. The tritium formed in a BWR from deuterium activation can be calculated using the equation:

$$R_{act} = \frac{\Sigma \Phi V \lambda}{3.7 \times 10^{4} P} \qquad (11.1\text{-}11)$$

where:

R_{act} - tritium formation rate by deuterium activation, μCi/s/MWt

Σ - macroscopic thermal neutron cross section, cm^{-1}

Φ - thermal neutron flux, neutrons/cm^2-s

V - coolant volume in core, cm^3

λ - tritium radioactive decay constant, 1.78×10^{-9} s^{-1}

P - reactor power level, MWt

For representative BWR designs, R_{act} is about $(1.3 \pm 0.4) \times 10^{-4}$ μCi/s/MWt. The uncertainty indicated is derived from the estimated errors in selecting values for the coolant volume

in the core, coolant density in the core, abundance of deuterium in light water (some additional deuterium is present because of the $H(n,\gamma)D$ reaction), thermal neutron flux, and microscopic cross section for deuterium.

It is more difficult to estimate the fraction of ternary fission produced tritium that may transfer from the fuel to the reactor coolant (and is then available for release in liquid and gaseous effluents). However, since zircaloy clad fuel rods are used in BWRs, essentially all fission product tritium remains in the fuel rods unless defects are present in the cladding material, as discussed in Reference 11.1-4.

Reference 11.1-5 discusses a study made at Dresden 1 in 1968 by the U.S. Public Health Service (USPHS) that suggests that essentially all of the tritium released from the plant could be accounted for by the deuterium activation source. For purposes of estimating the leakage of tritium from defective fuel, it can be assumed that it leaks in a manner similar to the leakage of noble radiogases. Thus, the empirical relationship for "diffusion mixture," described in Section 11.1.1.1, also can be used for predicting the source term of individual noble gas radioisotopes. The equation that describes this relationship is:

$$R_{dif} = KY\lambda^{0.5} \qquad (11.1\text{-}12)$$

where:

R_{dif} = leakage rate of tritium from fuel, µCi/s

Y = fission yield fraction, atoms/fission

λ = radioactive decay constant, s^{-1}

K = a constant related to total tritium leakage rate, dimensionless

If the total noble radiogas source term is 0.1 Ci/s GE design basis after a 30-minute decay, leakage from fuel can be calculated to be about 0.24 μCi/s of tritium. To place this value in perspective, in the USPHS study, the observed leakage rate of Kr-85 (which has a half-life similar to that of tritium) was 0.06 to 0.4 times that calculated using the "diffusion mixture" relationship. This would suggest that the actual tritium leakage rate might range from 0.015 to 0.10 μCi/s. Since the annual average noble radiogas leakage from a BWR is expected to be less than 0.1 Ci/s (t = 30 minutes), the annual average tritium release rate from the fission source can be conservatively estimated at 0.12 $\pm$0.12 μCi/s, or 0.0 to 0.24 μCi/s.

Based on this approach, the estimated total tritium appearance rate in reactor coolant and release rate in the effluent is about 10 Ci/yr.

Tritium formed in the reactor is generally present as tritiated oxide (HTO), and to a lesser degree as tritiated gas (HT). The tritium concentration (on a weight basis) in the steam formed in the reactor is the same as in the reactor water at any given time. This tritium concentration is also present in condensate and feedwater. Since radioactive effluents generally originate from the reactor and power cycle equipment, radioactive effluents also have this tritium concentration. The condensate storage tank (CST) receives treated water from the liquid waste management system and rejects water from the condensate system. Thus, all plant process water has a common tritium concentration.

Off-gases released from the plant contain tritium, which is present as HT (resulting from reactor water radiolysis), as well as HTO. In addition, tritium is contained in water vapor from the turbine gland seal steam packing exhauster, and a lesser amount is present in ventilation air due to process steam and liquid radwaste leaks or evaporation from sumps, tanks, and spills on floors. The remainder of the tritium leaves the plant in liquid effluents and with solid wastes. Essentially, all tritium in the reactor

coolant is eventually released to the environs, either as water vapor and gas to the atmosphere, as liquid effluent to the plant discharge, or as solid waste.

Recombination of radiolysis gases in the air ejector off-gas system forms water, which is condensed and returned to the main condenser. This tends to reduce the amount of tritium leaving in gaseous effluents. Reducing the gaseous tritium release results in a slightly higher tritium concentration in the plant process water. Reducing the amount of liquid effluent discharged also results in a higher process coolant equilibrium tritium concentration. Reduction due to radioactive decay is negligible, due to the 12-year half-life of tritium.

The USPHS study at Dresden 1, included in Reference 11.1-5, estimated that approximately 90 percent of the tritium release was observed in liquid effluent, with the remaining 10 percent leaving as gaseous effluent. Efforts to reduce the volume of liquid effluent discharges may change this distribution so that a greater amount of tritium will leave as gaseous effluent. From a practical standpoint, the fraction of tritium leaving as liquid effluent may vary between 60 and 90 percent, with the remainder leaving in gaseous effluent.

11.1.4 Fuel Fission Production Inventory and Fuel Experience

11.1.4.1 <u>Fuel Fission Product Inventory</u>

Fuel fission product inventory information is used in establishing fission product source terms for accident analysis and is therefore discussed in Section 15.

11.1.4.2 <u>Fuel Experience</u>

A discussion of BWR fuel experience, including fuel failure experience, burnup experience, and thermal conditions under which

the experience was gained is presented in References 11.1-2, 11.1-3, and 11.1-6.

11.1.5 Process Leakage Sources

Process leakage results in potential release paths for noble gases and other volatile fission products via ventilation systems. liquid from process leaks is collected and routed to the Liquid Waste Management System (LWMS). Radioactive releases from the Liquid Waste Management System are discussed in Section 11.2. Radionuclide releases via ventilation paths have been at extremely low levels and have been insignificant compared to process off-gas from operating BWR plants. However, because the implementation of improved process off-gas treatment systems makes the ventilation release relatively significant, GE has conducted measurements to identify and quantify these low level releases and release paths through the ventilation systems. GE has maintained an awareness of measurements by the Electric Power Research Institute (EPRI) and other organizations and routine measurements by utilities with operating BWRs.

Leakage of fluids from the process systems may result in the release of radionuclides into plant buildings. In general, noble radiogases remain airborne and are released to the atmosphere with little delay via the building ventilation exhaust ducts. Other radionuclides are partitioned between air and water, and some amount of airborne radioiodines may plateout on metal surfaces, concrete, and paint, while some amount of radioiodine may be desorbed from the collecting surfaces and becomes airborne. Radioiodines are found in ventilation air as methyl iodide and as inorganic iodine, which is defined here as particulate, elemental, and hypoiodous acid forms of iodine. Particulates are also present in the ventilation exhaust air.

The airborne radiological releases from BWR building Heating, Ventilating, and Air Conditioning (HVAC) Systems and the main condenser mechanical vacuum pump have been evaluated using

NUREG 0016, Reference 11.1-10, with supporting information obtained from NEDO-21159, Reference 11.1-7. Radioactive releases from ventilation systems are evaluated in Section 11.3 for compliance with 10CFR50, Appendix I. Exposures due to airborne radioactivity are evaluated in Section 11.3.4.

11.1.6 References

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11.1-10 F.P. Cardile and R.R. Bellamy, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-GALE Code)," NUREG-0016, Nuclear Regulatory Commission, January 1979.

TABLE 11.1-1

NOBLE RADIOGAS SOURCE TERMS
(GE DESIGN BASIS) (2)

Isotope	Half-Life	Source Term t = 0 (μCi/s)	Source Term t = 30 min (μCi/s)
Kr-83m	1.86 h	3.4 E3	2.9 E3
Kr-85m	4.4 h	6.1 E3	5.6 E3
Kr-85	10.74 yr	10 to 20(1)	10 to 20(1)
Kr-87	76.0 min	2.0 E4	1.5 E4
Kr-88	2.79 h	2.0 E4	1.8 E4
Kr-89	3.18 min	1.3 E5	1.8 E2
Kr-90	32.3 s	2.8 E5	-
Kr-91	8.6 s	3.3 E5	-
Kr-92	1.84 s	3.3 E5	-
Kr-93	1.29 s	9.9 E4	-
Kr-94	1.0 s	2.3 E4	-
Kr-95	0.5 s	2.1 E3	-
Kr-97	1.0 s	1.4 E1	-
Xe-131m	11.96 day	1.5 E1	1.5 E1

TABLE 11.1-1 (Cont)

Isotope	Half-Life	Source Term t = 0 (μCi/s)	Source Term t = 30 min (μCi/s)
Xe-133m	2.26 day	2.9 E2	2.8 E2
Xe-133	5.27 day	8.2 E3	8.2 E3
Xe-135m	15.7 min	2.6 E4	6.9 E3
Xe-135	9.16 h	2.2 E4	2.2 E4
Xe-137	3.82 min	1.5 E5	6.7 E2
Xe-138	14.2 min	8.9 E4	2.1 E4
Xe-139	40 s	2.8 E5	-
Xe-140	13.6 s	3.0 E5	-
Xe-141	1.72 s	2.4 E5	-
Xe-142	1.22 s	7.3 E4	-
Xe-143	0.96 s	1.2 E4	-
Xe-144	9.0 s	5.6 E2	-
Totals		≃ 2.5 E6	≃ 1.0 E5

(1) Estimated from experimental observations.

(2) Above values are for thermal power of 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

TABLE 11.1-2

POWER ISOLATION EVENT - ANTICIPATED OCCURRENCE

Isotope	Isotopic Spiking Activity (Ci)/Bundle
I-131	2.1
I-132	3.2
I-133	5.0
I-134	5.4
I-135	4.8
Kr-83m	0.9
Kr-85m	2.2
Kr-85	0.5
Kr-87	4.3
Kr-88	6.1
Kr-89	8.0
Xe-131m	0.1
Xe-133m	0.3
Xe-133	11.6
Xe-135m	1.8
Xe-135	11.0
Xe-137	10.5
Xe-138	10.6

TABLE 11.1-3

HALOGEN RADIOISOTOPES IN REACTOR WATER
(GE DESIGN BASIS)

Isotope	Half-Life		Concentration (μCi/g)(1)
Br-83	2.40	h	1.5 E-2
Br-84	31.8	min	2.7 E-2
Br-85	3.0	min	1.7 E-2
I-131	8.065	day	1.3 E-2
I-132	2.284	h	1.2 E-1
I-133	20.8	h	8.9 E-2
I-134	52.3	min	2.4 E-1
I-135	6.7	h	1.3 E-1

(1) Above values are for thermal power of 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

TABLE 11.1-4

OTHER FISSION PRODUCT RADIOISOTOPES IN REACTOR WATER
(GE DESIGN BASIS)

Isotope	Half-Life		Concentration (μCi/g) (1)
Sr-89	50.8	day	3.1 E-3
Sr-90	28.9	yr	2.3 E-4
Sr-91	9.67	h	6.9 E-2
Sr-92	2.69	h	1.1 E-1
Zr-95	65.5	day	4.0 E-5
Zr-97	16.8	h	3.2 E-5
Nb-95	35.1	day	4.2 E-5
Mo-99	66.6	h	2.2 E-2
Tc-99m	6.007	h	2.8 E-1
Tc-101	14.2	min	1.4 E-1
Ru-103	39.8	day	1.9 E-5
Ru-106	368	day	2.6 E-6
Te-129m	34.1	day	4.0 E-5
Te-132	78.0	h	4.9 E-2

Isotope	Half-Life		(µCi/g) (1)
Cs-134	2.06	yr	1.6 E-4
Cs-136	13.0	day	1.1 E-4
Cs-137	30.2	yr	2.4 E-4
Cs-138	32.3	min	1.9 E-1
Ba-139	83.2	min	1.6 E-1
Ba-140	12.8	day	9.0 E-3
Ba-141	18.3	min	1.7 E-1
Ba-142	10.7	min	1.7 E-1
Ce-141	32.53	day	3.9 E-5
Ce-143	33.0	h	3.5 E-5
Ce-144	284.4	day	3.5 E-5
Pr-143	13.58	day	3.8 E-5
Nd-147	11.06	day	1.4 E-5
Np-239	2.35	day	2.4 E-1

(1) Above values are for thermal power of 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

TABLE 11.1-5

COOLANT ACTIVATION PRODUCTS IN REACTOR WATER AND STEAM

Isotope	Half-Life	Steam Concentration (μCi/g) (2)	Reactor Water Concentration (μCi/g) (2)
N-13	9.99 min	7 E-3 (1)	4 E-2
N-16	7.13 s	5 E1 (1)	4 E1
N-17	4.14 s	2 E-2 (1)	6 E-3
O-19	26.8 s	8 E-1	7 E-1
F-18	109.8 min	4 E-3	4 E-3

---

(1) For HWC operation at a nominal 35 scfm of H_2 multiply steam concentration source term by a factor of 4.3.

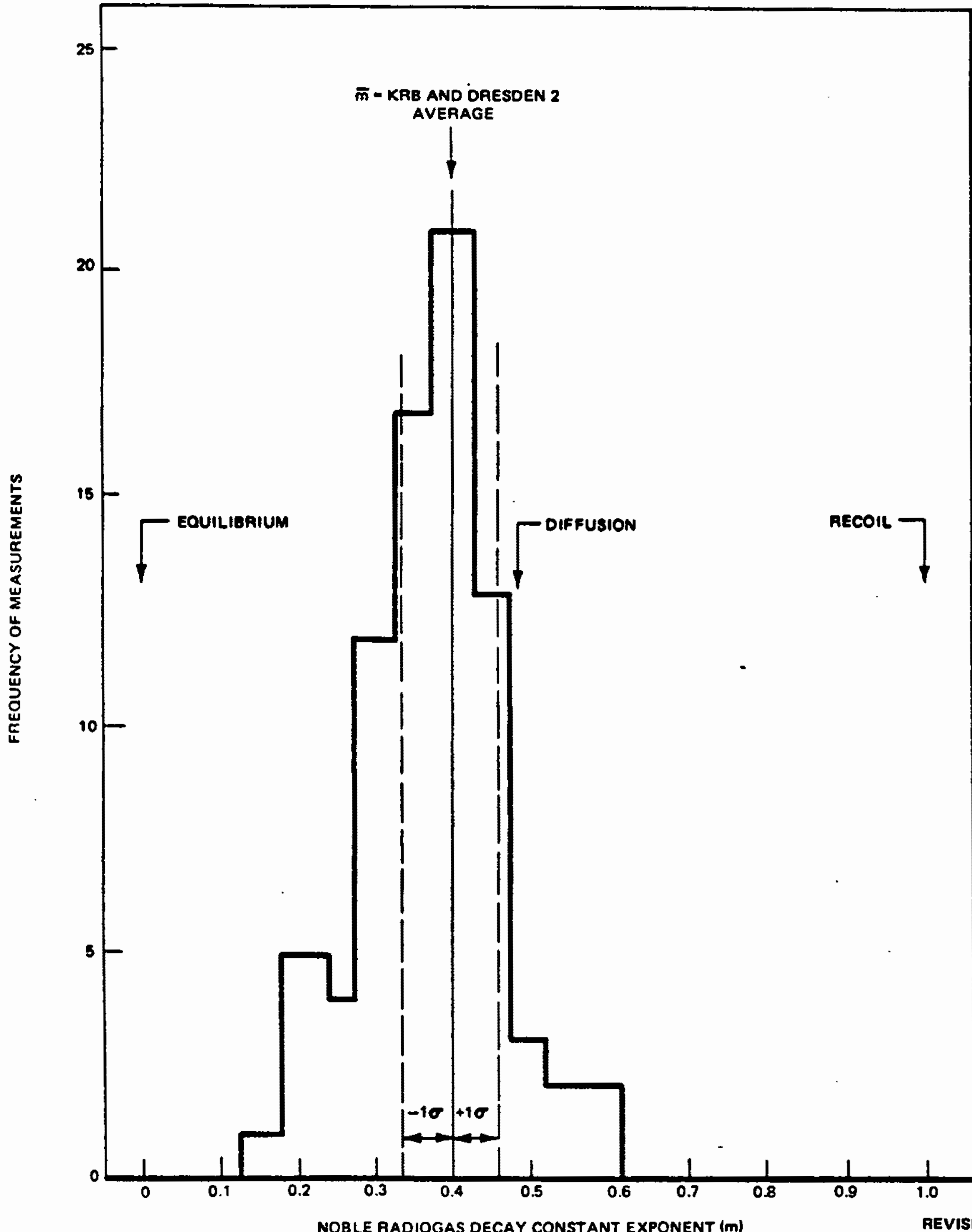
(2) Above values are for thermal power of 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

TABLE 11.1-6

NONCOOLANT ACTIVATION PRODUCTS IN REACTOR WATER

Isotope	Half-Life		Concentration (μCi/g) (1)
Na-24	15.0	h	2.0 E-3
P-32	14.31	day	2.0 E-5
Cr-51	27.8	day	5.0 E-4
Mn-54	313.0	day	4.0 E-5
Mn-56	2.582	h	5.0 E-2
Co-58	71.4	day	5.0 E-3
Co-60	5.258	yr	5.0 E-4
Fe-59	45.0	day	8.0 E-5
Ni-65	2.55	h	3.0 E-4
Zn-65	243.7	day	2.0 E-6
Zn-69m	13.7	h	3.0 E-5
Aq-110m	253.0	day	6.0 E-5
W-187	23.9	h	3.0 E-3

(1) Above values are for thermal power of 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.



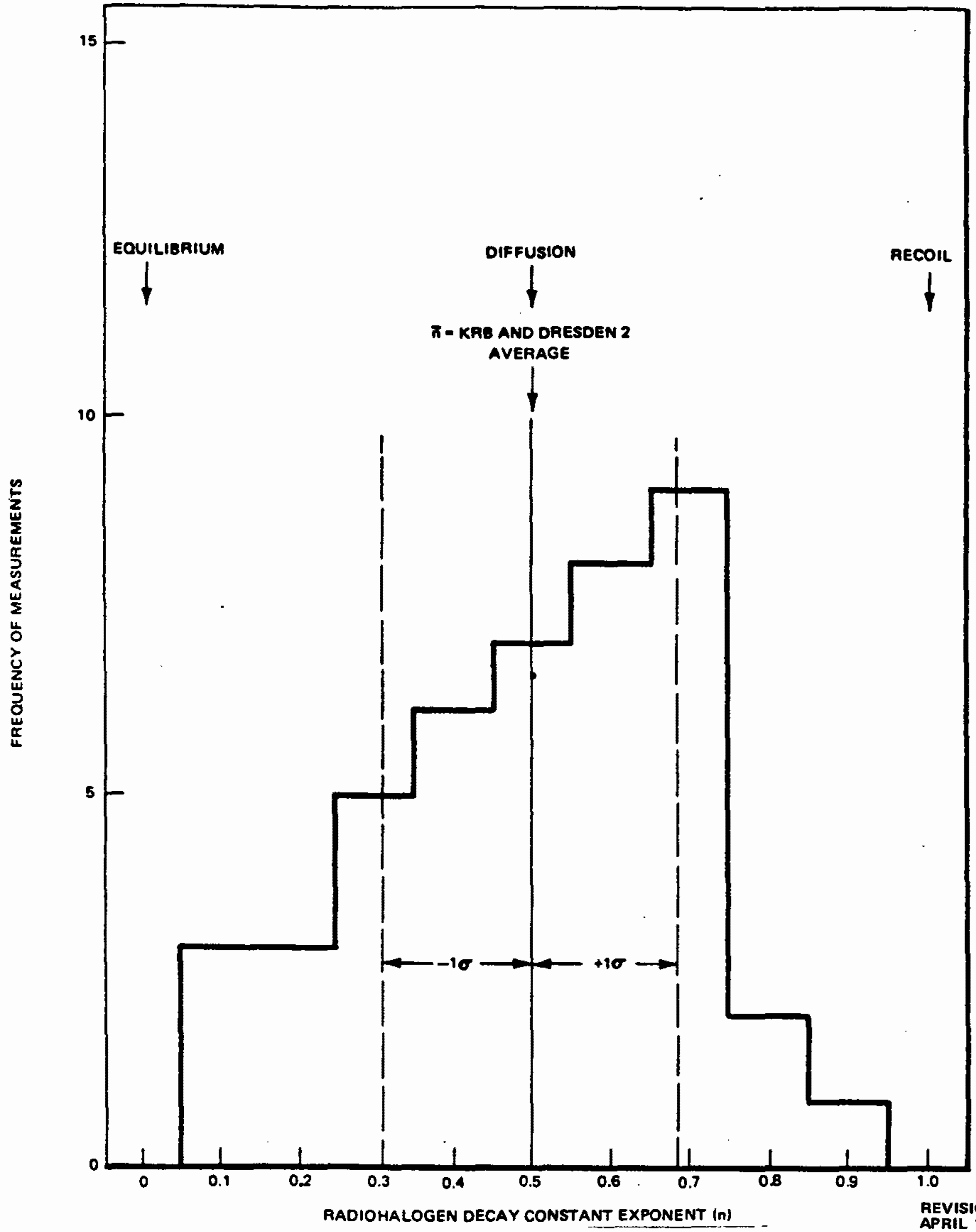
REVISION 0
APRIL 11, 1988

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK NUCLEAR GENERATING STATION

NOBLE RADIOGAS DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM

UPDATED FSAR

FIGURE 11.1-1



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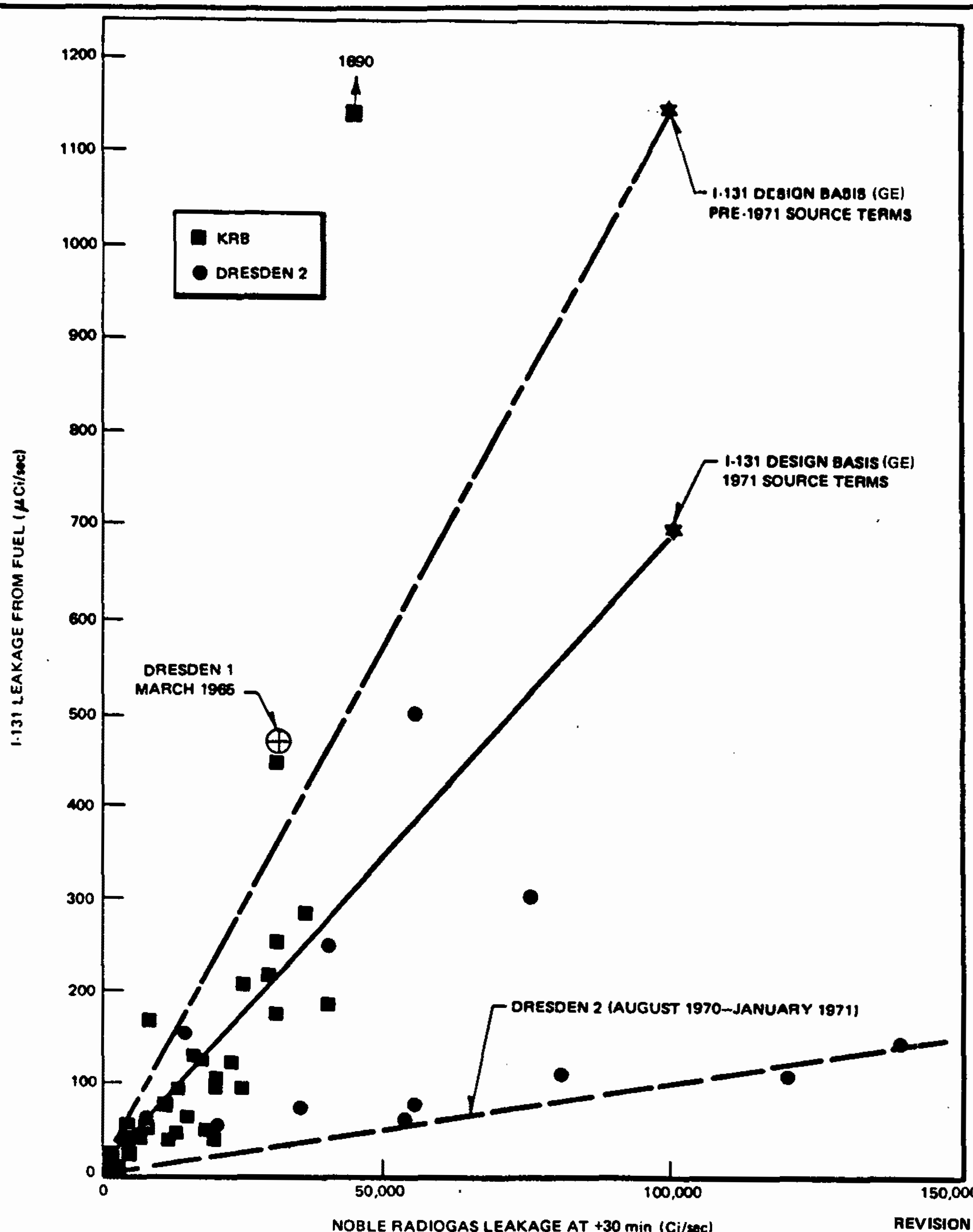
HOPE CREEK NUCLEAR GENERATING STATION

RADIOHALOGEN DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM

UPDATED FSAR

FIGURE 11.1-2



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PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK NUCLEAR GENERATING STATION

NOBLE RADIOGAS LEAKAGE VERSUS I-131 LEAKAGE

UPDATED FSAR

FIGURE 11.1-3

(Historical Information)

11.2 LIQUID WASTE MANAGEMENT SYSTEM

The Liquid Waste Management System (LWMS) is designed to collect, store, process, and dispose of or recycle all radioactive or potentially radioactive liquid waste generated by plant operation or maintenance.

The LWMS consists of three process subsystems, each for collecting, storing, processing, monitoring, and disposal of specific types of liquid wastes in accordance with their conductivity, chemical composition, and radioactivity. These systems are:

1. Equipment drain (high purity waste)

2. Floor drain (low purity waste)
   - Regenerant waste (high conductivity waste)
   - Chemical waste (decontamination solution waste and chemistry lab drains)

3. Detergent drain waste (laundry waste and personnel decontamination drains).

These systems are shown on Plant Drawings M-62-0, M-63-0, M-64-0 and M-65-0. Equipment locations are shown on drawings provided in Section 1.2. The Radioactive Waste Drainage System, a major input source to the LWMS, is described in Section 9.3.3. The Equipment and Floor Drainage Collection System in shown on Plant Drawings M-61-0 and M-61-1.

Sufficient treatment capability is available to process liquid waste to meet demineralized water quality requirements for plant reuse (conductivity value of $\leq$1.0 µmho/cm at 25°C). Liquid wastes that cannot be processed to meet the quality requirement for reuse are released with excess water. Excess water is

(Historical Information)

released in a controlled and monitored manner into the cooling tower blowdown line for dilution and then discharged to the Delaware River.

The process and effluent radiological monitoring and sampling systems for the LWMS are described in Section 11.5. The LWMS has no safety-related function.

11.2.1 Design Bases

Design bases for the LWMS are as follows:

1. The system has the capability to process the maximum anticipated quantities of liquid waste without impairing the operation or availability of the plant during both normal and expected occurrence conditions, satisfying the requirements of 10CFR20 and 10CFR50.

2. Alternate process routes, subsystem crossties, and adequate storage volumes are included in the system design to provide for operational and anticipated surge waste volumes, which could occur during refueling, abnormal leakage, decontamination activities, and equipment maintenance.

3. The system is designed so that no potentially radioactive liquids can be discharged to the environment unless they have been processed, monitored, and diluted by mixing with the cooling tower blowdown release. This results in offsite radiation exposures on an annual average basis within the limits of 10CFR20 and 10CFR50.

4. The LWMS design meets the requirements of General Design Criteria (GDC) 60 and 61 and Regulatory Guides 1.21, 1.26, and 1.143 to the extent described in Section 1.8.1.143.

(Historical Information)

5. The LWMS is designed to keep the exposure to plant personnel "as low as is reasonably achievable" (ALARA) during normal operation and plant maintenance, in accordance with Regulatory Guide 8.8.

6. Expected radionuclide activity concentrations in the LWMS process equipment are based on 50,000 μCi/s noble gas release rate, measured after 30 minutes decay. The maximum radionuclide concentrations are based on a corresponding noble gas release rate of 500,000 μCi/s after 30 minutes decay (design basis).

   The concentration of radioactivity at the point of discharge shall not exceed concentration limits specified in 10CFR20, on an annual average basis.

7. All piping and equipment in the LWMS are non-Seismic Category I with the exception of the primary containment.

   The seismic category, quality group classification, and corresponding codes and standards that apply to the design of the LWMS are discussed in Section 3.2.

8. Design features that reduce maintenance, equipment downtime, liquid leakage, or gaseous releases of radioactive materials to the building atmosphere, to facilitate cleaning or otherwise improve radwaste operations, are discussed in Section 12.3.

9. All atmospheric liquid radwaste tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is connected below the tank vent and above the high-level alarm setpoint. It is routed to the nearest drainage system compatible with its purity and chemical content.

(Historical Information)

10. Processed wastes are collected in sample tanks prior to their reuse as demineralized water or discharged in a controlled manner into the cooling tower blowdown line for dilution before entering the Delaware River.

11. The expected and maximum radionuclide activity inventories for LWMS components containing significant amounts of radioactive liquids are shown in Tables 11.2-8 and 11.2-9. They are based upon the assumptions given in Table 11.2-1 and upon the following:

    a. Expected flow rates for the radwaste streams shown on Figure 11.2-5 are given in Table 11.2-2.

    b. Design basis reactor coolant radionuclide activity concentrations are listed in Tables 11.1-1 through 11.1-5. Expected reactor water radionuclide activity concentrations are listed in Table 11.2-3.

    c. Decontamination factors for process components within the LWMS are given in Table 11.2-4.

    d. During the batch collection of waste streams in the collection tanks, the radionuclide inventory in the tanks undergoes radioactive decay. Expected holdup times are shown in Table 11.2-5.

    e. The planned refueling cycle is 18 months; however, for conservatism, one refueling shutdown per year is assumed.

The expected daily inputs and activity levels for each of the subsystems are shown in Tables 11.2-6 and 11.2-7.

The implementation of item 10 above, in conjunction with the isolation function of the radiation monitoring system, will

(Historical Information)

minimize the potential for uncontrolled release due to operator error or equipment malfunction.

Control, monitoring, and sampling of radioactive release in accordance with GDC 60 and 64 of 10CFR50, Appendix A are discussed in Sections 11.2.3 and 11.5.

A summary of the design parameters for major components is provided in Table 11.2-10.

11.2.2 System Description

The Liquid Waste Management System (LWMS) collects, monitors, processes, stores, and disposes of the potentially radioactive liquid wastes collected throughout the plant. Sources of waste influent are:

1. Floor drains in controlled access areas that may generate potentially radioactive waste.

2. Tanks and sumps that collect potentially radioactive wastes.

3. Piping and equipment that contain potentially radioactive wastes.

Plant drainage systems are discussed in Section 9.3.3.

These potentially radioactive liquid wastes are collected in tanks located in the Auxiliary Building. System components are designed and arranged in shielded enclosures to minimize exposure to plant personnel during operation, inspection, and maintenance. Tanks, processing equipment, pumps, valves, and instruments that may contain radioactivity are located in controlled access areas.

(Historical Information)

The LWMS normally operates on a batch basis. Protection against accidental discharge is provided by detection and alarm of abnormal conditions and by administrative controls.

The LWMS is divided into several subsystems, so that the liquid wastes from various sources can be segregated and processed separately, based on the most economical and efficient process for each specific type of impurity and chemical content. Cross connections between subsystems provide additional flexibility in processing the wastes by alternate methods and provide redundancy if one subsystem is inoperative.

11.2.2.1 System Operation

11.2.2.1.1 Equipment Drain Processing Subsystem

The waste collector tanks in the equipment drain subsystem receive waste inputs from the clean radwaste (CRW) sumps in the plant and from other inputs listed in Table 11.2-7. These waste inputs have a high chemical purity and are processed on a batch basis through a precoat filter and a mixed bed demineralizer. Cross connections with the floor drain subsystem allow processing through the floor drain filter and demineralizer.

The processed wastes are collected in one of the two waste sample tanks for chemical and radioactivity analysis. If acceptable, the tank contents are returned to the condensate storage tank (CST) for plant reuse. A recycle routing from the waste sample tank allows the sampled water that does not meet demineralized water quality requirements to be pumped back to a waste collector tank for additional processing by filtration and demineralization, or to the waste surge tank for transfer to and processing in the regenerant waste subsystem. If the plant condensate inventory is high, the sampled waste water is discharged to the cooling tower blowdown line for dilution prior to discharge to the Delaware River.

(Historical Information)

Additional collection capacity is also provided by a waste surge tank tied to the common inlet header of the waste collector tanks.

11.2.2.1.2 Floor Drain Processing System

The floor drain collector tanks receive low purity waste inputs from various floor drain, dirty radwaste (DRW), sumps in each plant enclosure and other inputs listed in Table 11.2-7.

The floor drain subsystem consists of two floor drain collector tanks, a precoat filter, a mixed bed demineralizer train, and two sample tanks. The wastes collected in the floor drain collector tank are processed on a batch basis. Cross connections with the equipment drain subsystem also allow processing through the waste filter and demineralizer train.

The floor drain sample tanks collect the processed wastes, so that a sample may be taken for chemical and radioactivity analysis before discharge. The discharge path depends on the water quality, cooling tower blowdown availability, and plant water inventory. The treated floor drains may be discharged from the plant to the Delaware River after mixing with the cooling tower blowdown. Off standard quality water can be recycled to the floor drain collector tanks or to the waste neutralization tanks. If the treated wastes meet the standards for demineralized water used in the plant, and if the water inventory permits their recycle, the processed floor drain waste can be discharged to the CST for plant reuse.

11.2.2.1.3 Regenerant Waste Processing Subsystem

The regenerant waste subsystem collects wastes from

(Historical Information)

the high conductivity drain sumps in the radwaste area of the Auxiliary Building and the Turbine Building. These wastes are collected in the waste neutralizer tanks where they are neutralized before being processed through the floor drain system.

A bypass of both waste evaporators is provided to allow for processing of waste collected in the waste neutralizer tanks (by a portable radwaste system. In addition, the high conductivity drain sump can be discharged to the floor drain sump via a temporary hose, for processing waste in the floor drain processing system.

11.2.2.1.4 Chemical Waste Processing Subsystem

Chemical wastes collected in the chemical waste tank consist of laboratory wastes, decontamination solutions, and sample rack drains. After accumulating in the chemical waste tank, these wastes are neutralized to a pH value of 7 to 10.

A cross connection with the floor drain subsystem allows the

chemical wastes to be processed through the floor drain system. The chemical waste tank can be drained to the central radwaste high conductivity sump.

11.2.2.1.5 Detergent Waste Processing Subsystem

Detergent containing waste water from the controlled laundry and personnel decontamination facilities throughout the plant is collected in the double compartmented detergent drain tank. In addition, other miscellaneous sources of high conductivity, low activity water may be deposited in the detergent waste subsystem. The detergent wastes are processed by filtration.

The effluent from the detergent drain filter is monitored for radioactivity and discharged to the cooling tower blowdown for dilution and controlled release to the Delaware River.

11.2.2.2 Process Equipment Description

The major components of the LWMS are described in the following paragraphs.

11.2.2.2.1 Pumps

Three types of pumps used in the LWMS are as follows:

1. Sump pumps - The LWMS sump pumps are vertical centrifugal, with a cast iron casing, stainless steel 316L shaft, and bronze impellers, with a packing seal. High conductivity sump pumps are all stainless steel. Each sump is provided with two pumps. All the sump pumps except the drywell and Reactor Building sump pumps are controlled from the radwaste main control panel.

(Historical Information)

2. Process pumps - The LWMS process pumps are horizontal centrifugal, manufacturer-standard with a stainless steel ASA-351 casing and stainless steel A561 shaft, and are provided with mechanical seals.

3. Metering pumps - Neutralization chemicals, buffering compounds, and body feed of filter aid to the filters in the LWMS are added with reciprocating positive displacement pumps.

11.2.2.2.2 Tanks

Tanks are sized to accommodate the expected volumes of waste generated in the five subsystems mentioned in Section 11.2.2.1. The tanks are constructed of stainless steel to provide a low corrosion rate during normal operation. They are provided with mixing eductors or air spargers. All radwaste tanks are vented to the radwaste tank vent filtration unit and discharged to the south plant vent. The liquid radwaste tanks are designed in accordance with API 620 code for 0 to 15 psig storage tanks.

11.2.2.2.3 Filters

Filters for the LWMS are as follows:

1. Equipment and floor drain filters - The waste collector and floor drain filters are pressure type with filter elements. Depending on the type of filter element used, these filters can be operated in either a non-precoat or in a precoat mode. Both filters are provided with a common precoat tank and filter aid tank (for body feed), but with individual pumps. An individual filter holding pump is also provided for each filter.

   The filter precoat needs to be changed when the differential pressure across the filter exceeds a preset limit and initiates an alarm. The precoat is then backwashed to the waste sludge phase separator.

2. Detergent drain filter - The detergent drain process uses a cartridge filter that is replaced when the differential pressure across the filter exceeds a preset limit and initiates an alarm.

The filter vessels are constructed of stainless steel and are designed in accordance with ASME B&PV Code, Section VIII, Division 1. Each filter is located in a separate, shielded room to minimize exposure to personnel during operation and routine maintenance.

11.2.2.2.4 Demineralizers

The equipment and floor drain demineralizers are mixed-bed or mixed-bed and filter media type. The filter media should make up no more than 30% of the bed by volume. The resin or resin and filter media are typically replaced when the effluent conductivity exceeds a preset conductivity limit or ionic concentration, as well as upon high differential pressure.

The carbon steel demineralizer vessels are rubber lined. Fine mesh strainers are provided in the vessel discharge and in the downstream piping to prevent resin fines from being carried over to the sampling tanks.

When the resin or resin and filter media are exhausted, they are discharged to the spent resin tank for radioactivity decay and then transferred for offsite burial.

Each demineralizer vessel is located in a separate shielded room to minimize exposure to personnel during operation and routine maintenance. The demineralizer vessel is designed per ASME B&PV Code, Section VIII, Division I.

(Historical Information)

A bypass of both waste evaporators is provided to allow for processing of the waste collected in the waste neutralizer tanks by a portable radwaste system.

11.2.3 Radioactive Releases

During liquid processing by the Liquid Waste Management System (LWMS), radioactive contaminants are removed so that the bulk of the liquid is restored to demineralized water quality, which is either returned to the condensate storage tank (CST) or discharged to the environment via the cooling tower blowdown line. The radioactivity removed from the liquid wastes is concentrated in the filter media and ion exchange resins. If the liquid is recycled to the plant, it meets the purity requirements for CST makeup, as discussed in Section 9.2.3. If the liquid is discharged, the activity concentration is consistent

(Historical Information)

with the discharge criteria of 10CFR20. Tritiated water that is discharged from the systems is consistent with the discharge criteria of 10CFR20.

The resulting doses from radioactive effluents are within the guideline values of Appendix I of 10CFR50. In addition to the radioactivity limitations on releases, water quality standards for discharge and heat content may necessitate recycling of the water rather than discharging.

The processed liquid radwaste that is not recycled in the plant is discharged into the cooling tower blowdown line on a batch basis at flow rates up to 176 gpm for the low purity waste subsystem and 25 gpm for the laundry drain waste subsystem.

(Historical Information)

Flow control valves are set to control the discharge flow. Therefore, the actual flow could be substantially less.

The expected monthly average total cooling tower blowdown flow of 1.9E4 gpm dilutes the above discharge rates by at least a factor of 100 for the low purity waste, and 750 for the detergent drain waste streams. Adequate flow instrumentation is provided at the cooling tower basin weir to measure the cooling tower blow down flow. This flow signal is transmitted to the LR-RMS local radiation processor where it is combined with the measurement from the radiation element in the LWMS discharge line to calculate the final diluted concentration. When the cooling tower blowdown flow is below the minimum setpoint, the signal initiates the closing of the LWMS discharge line isolation valve. This dilution occurs within the site boundary and is used in determining specific activity concentrations for the releases. It does not include the near field dilution of 10 assumed in the calculation of doses. These design basis concentrations and a comparison to 1988 10CFR20 limits are given in Table 11.2-12.

The buried discharge line from the LWMS to the cooling tower blowdown line is shown on Figure 11.2-6. No actual leak detection methods have been employed but several design measures have been implemented to preclude leakage or the consequences of any leakage. These measures include: the use of stainless steel piping, sampling the radwaste tanks prior to discharge, discharging only neutral (pH 6 to 9) liquids to minimize the internal pipe corrosion process, hydrostatically testing the pipe prior to burying, burying the pipe in granular bedding or sandcrete, and supplying the piping with impressed current cathodic protection to preclude external galvanic type corrosion.

(Historical Information)

11.2.4 Estimated Doses

Dose calculations to ensure compliance with Appendix I of 10CFR50, based on the liquid source terms described above, are performed in accordance with Regulatory Guide 1.109 by use of the NRC computer code LADTAP II. For these purposes, doses are calculated to a maximum exposed individual consuming aquatic biota and receiving shoreline exposure at the edge of the initial mixing zone. There is no potable water or irrigation pathway for liquid effluents from HCGS. Input data for these calculations are given in Table 11.2-13. The calculated doses are 0.0267 mrem/yr to the total body of an adult and 0.383 mrem/yr to the bone of a child. These doses are well within the Appendix I design guides of 3.0 and 10.0 mrem/yr to the total body and any organ, respectively.

Total person-rem and person-rem-thyroid dose to the 50-mile population from liquid effluents from HCGS are estimated to be 0.260 and 0.766, respectively. Using the methodology presented in Regulatory Guide 1.110, additional equipment can be justified if its total annual cost is less than one thousand 1975 dollars per person-rem or person-rem-thyroid saved. The smallest total annual cost per person-rem or person-rem-thyroid saved (even assuming that the equipment would totally eliminate all 50 mile population doses) is estimated to be $14,500 (1975). Since this is greater than $1,000 (1975), it is concluded that no additional equipment can be justified. Thus the Liquid Waste Management System is judged to be designed in accordance with the applicable position of Appendix I to 10CFR50.

(Historical Information)

TABLE 11.2-1

ASSUMPTIONS AND PARAMETERS USED FOR EVALUATION OF RADIOACTIVE RELEASES

Item		Value or Reference	Source
1.	General		
a.	Maximum core thermal power (MWt) evaluated for safety considerations (105 percent of design thermal power)	3458	FSAR 4.4
b.	Total quantity of tritium released-liquid pathway (Ci/yr)	51	NUREG-0016
2.	Nuclear Steam Supply System		
a.	Total steam flow (lb/h)	1.4E7[1]	FSAR 5.1
b.	Mass of reactor coolant (lb) in vessel at full power	3.8E5	FSAR 5.1
3.	Reactor Water Cleanup System		
a.	Average flow rate (lb/h)	1.3E5	FSAR 5.4.8
b.	Powdex demineralizer size (ft^2)	135	FSAR 5.4.8
c.	Replacement frequency (days)	3.4	FSAR 11.2
d.	Backwash volume (gal/event)	1080	FSAR 11.2
4.	Condensate Demineralizers		
a.	Average flow rate (lb/h) total for 6 vessels	1.4E7 (100 percent of steam flow)	FSAR 5.1
b.	Deep bed demineralizer size (ft^3 of resin per vessel)	312	FSAR 10.4.6
c.	Number of demineralizers	6 plus 1 standby	FSAR 10.4.6
d.	Regeneration frequency (days)[2]	5	FSAR 11.2
e.	Regeneration time (days)	30 (5 day regeneration frequency times 6 demineralizers)	-
f.	Is ultrasonic resin cleaning (URC) used? If so, state amt.of waste liquid per cycle	Yes, 22,200 gal./cycle[3][4]	-

TABLE 11.2-1 (Cont)

	Item	Value or Reference	Source
g.	Regenerant volume (gal./event)	59,400	–
	Regenerant activity (μCi/cc)	Table 11.2-2	FSAR 11.2
5.	Liquid Waste Processing System		
a.	(1) Sources, flow rates, and expected activities in flow streams	Table 11.2-2	FSAR 11.2
	(2) Holdup times for collection, processing, and discharge	Table 11.2-5	FSAR 11.2
	(3) Capacities of tanks and processing equipment	Table 11.2-10	FSAR 11.2
	(4) Decontamination factors	Table 11.2-4	NUREG-0016, FSAR 11.2
	(5) Fraction from each stream discharged		
	High Purity Waste Processing Stream	0.01	NUREG-0016, FSAR 11.2
	Low Purity Waste Processing Stream	0.5	NUREG-0016, FSAR 11.2
	Chemical Waste Processing Stream	0.10	NUREG-0016, FSAR 11.2
	Regenerant Waste Processing Stream	0.10	NUREG-0016, FSAR 11.2
	Laundry Drain Waste Processing Stream	1.0	NUREG-0016, FSAR 11.2
	(6) Radwaste demineralizer regeneration frequency (days)	52	FSAR 11.2
	Radwaste floor drain demineralizer regeneration frequency (days)	25	
	Radwaste high conductivity demineralizer regeneration volume (gal/event)	22,478	FSAR 11.2
	Radwaste low conductivity demineralizer regeneration frequency (gal/event)	30,950	
	(7) Liquid source terms for normal operation	Table 11.2-6	FSAR 11.2
b.	P&IDs and process flow drawings for liquid radwaste system	Figures 11.2-1 through 11.2-5	FSAR 11.2
6.	Main Condenser and Turbine Gland Seal Air Removal Systems		
a.	Holdup time for off-gas prior to off-gas treatment (h)	0.17	FSAR 11.3
b.	Description of Off-gas Treatment System	FSAR 11.3	FSAR 11.3

TABLE 11.2-1 (Cont)

Item	Value or Reference	Source
c. Off-gas treatment systems (charcoal delay system)		
(1) Mass of charcoal (lb)	322,000	FSAR 11.3
(2) Operating/dew point temperatures (°F)	65/40	FSAR 11.3
(3) Dynamic absorption coeff. Xe, Kr (cm^3/g)	330/18.5	FSAR 11.3
d. Gland seal steam flow (lb/h) and source	2.2E4, nonradioactive steam	FSAR 10.4.3
e. Gland seal holdup time (h)	NA	NA
f. Radioactive iodine reduction systems for the gland seal system	NA	NA
g. P&IDs and process flow drawings for gaseous waste systems	Figures 11.3-1 through 11.3-5	
7. Ventilation and Exhaust Systems		
a. Provisions to reduce releases in individual buildings	Table 11.3-8	FSAR 9.4, 11.3
b. Decontamination factors in individual buildings	Table 11.3-8	NUREG-0016, ETSB BTP 11-2
c. Release rates Ci/yr	Table 11.3-2	FSAR 11.3
d. Release points - heights, temperatures, size, and shape of orifices	Table 11.3-7	FSAR 11.3
e. Containment purge frequency (per year)	-	FSAR 11.3
Expected Radionuclide Activity Concentrations in Reactor Coolant and Main Steam Used For Evaluation of Radioactive Releases	Table 11.2-3	NUREG-0016, FSAR 11.2

Input File Used for Gale Code Determination of Annual Liquid and Gaseous Releases

```
LIQUID GALE CARDS                                          2
0.632    0.333    2.0     1.0E-25   092382 1 0 0
CARD  1  NAME     NAME OF REACTOR HOPE CREEK GEN STA        TYPE = BWR
```

TABLE 11.2-1 (Cont)

Item			Value or Reference	Source
CARD 2	POWTH	THERMAL POWER LEVEL (MEGAWATTS)		3458
CARD 3	GTO	TOTAL STEAM FLOW (MILLION LBS/HR)		14.
CARD 4	WL1Q	MASS OF WATER IN REACTOR VESSEL (MILLION LBS)		0.38
CARD 5	GDE	CLEAN UP DEMINERALIZERS FLOW (MILLION LBS/HR)		0.13
CARD 6	REGENT	CONDENSATE DEMINERALIZER REGENERATION TIME (DAYS)		30.
CARD 7	FFCDM	FRACTION FEED WATER THROUGH CONDENSATE DEMIN		1.00
CARD 8		HIGH PURITY WASTE INPUT 32359. GPD AT .136 PCA		
CARD 9		DFI = 1.0E02DFCS = 1.0E01DFO = 1.0E02		
CARD 10		COLLECTION 0.761 DAYS PROCESS 0.0895DAYS FRACT DISCH		0.01
CARD 11		LOW PURITY WASTE INPUT 5700. GPD AT .001		
CARD 12		DFI = 1.0E02DFCS = 2.0E00DFO = 1.0E02		
CARD 13		COLLECTION 2.105 DAYS PROCESS 0.0718DAYS FRACT DISCH		0.5
CARD 14		CHEMICAL WASTE INPUT 600. FPD AT .02 PCA		
CARD 15		DFI = 1.0E00DFCS = 1.0E00DFO - 1.0E00		
CARD 16		COLLECTION 2.667 DAYS PROCESS .655 DAYS FRACT DISCH		0.1
CARD 17		REGENERATION SOLTNS INPUT GPD		6285.
CARD 18		DFI = 1.0E03DFCS = 1.0E04DFO = 1.0E04		
CARD 19		COLLECTION 3.18 DAYS PROCESS .437 DAYS FRACT DISCH		0.1
CARD 20	GGS	GLAND SEAL STEAM FLOW (THOUSAND LBS/HR)		0.0
CARD 21	TIM3	GLAND SEAL HOLDUP TIME (HOURS)		0.0
CARD 22	TIM4	AIR EJECTOR OFFGAS HOLDUP TIME (HOURS)		.17
CARD 23		CONTAINMENT BLDG. CHARCOAL 00.0 HEPA?99.0		
CARD 24		TURBINE BLDG. CHARCOAL 00.0 HEPA?00.0		
CARD 25	FIL3	GLAND SEAL VENT, IODINE PF		00.0
CARD 26	FIL4	AIR EJECTOR OFFGAS IODINE PF		1.0
CARD 27		AUXILIARY BLDG. CHARCOAL 00.0 HEPA?99.0		
CARD 28		RADWASTE BLDG. CHARCOAL 70.0 HEPA?99.0		
CARD 29	KCHAR	CHARCOAL DELAY SYSTEM 0=NO,1=YES,2=CRYOGENIC DISTILL		1.
CARD 30	KKR	KRYPTON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)		18.5
CARD 31	KXE	XENON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)		330.0
CARD 32	KMASS	MASS OF CHARCOAL (THOUSAND LBS)		322.
CARD 33	PFLAUN	DETERGENT WASTE DECONTAMINATION FACTOR		1.0

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(1) Typical: 1.4E7 means $1.4x10^{7}$.
(2) The regeneration frequency for the condensate demineralizer will be 30 days per vessel with ultrasonic resin cleaning (URC) cycles between regenerations.
(3) Spent resins from the radwaste demineralizer are sluiced to the SWMS.
(4) Two in-place scrubs/URC cycle generate 7500 gallons of wastewater each. One URC operation generates 7200 gallons of wastewater. The total waste per cycle is 22,200 gallons.

(Historical Information)

TABLE 11.2-2

LIQUID WASTE MANAGEMENT SYSTEM FLOWS[1]

Subsystem	Stream No.	Average Batch Interval for Normal Operation (days)	Volume per Batch (gal.)	Nominal Flow Rate (gpm)	Average Volume Per Day for Normal Operation (gal.)	Normal Activity Concentration (µCi/cc)	Maximum Activity Concentration (µCi/cc)	Comments
Equipment drain	1	-	-	-	83,500	1.2×10^{-2}	9.4×10^{-1}	Max act. some flows NA
Equipment drain	2	0.164	13,660	182	83,500	1.09×10^{-2}		9.24×10^{-4}
Equipment drain	3	0.164	13,660	182	83,500	5.45×10^{-3}		9.19×10^{-1}
Equipment drain	4	0.164	13,660	182	83,500	1.09×10^{-4}		9.19×10^{-3}
Equipment drain	5	1.164	13,660	450	83,500	1.09×10^{-5}		9.19×10^{-3}
Floor drain	6	-	-	-	10,400	2.88×10^{-6}		1.5×10^{-3}
Floor drain	7	0.76	7908	176	10,400	2.88×10^{-6}		3.46×10^{-4}
Floor drain	8	0.76	7908	176	10,400	1.44×10^{-6}		3.46×10^{-4}
Floor drain	9	0.76	7908	176	10,400	2.88×10^{-8}		3.46×10^{-6}
Floor drain	10	0.76	7908	176	10,400	2.88×10^{-8}		3.46×10^{-5}
Regenerant waste	11	-	-	-	12,360	-	-	Flows NA
Regenerant waste	12	1.07	13,180	40	12,360	1.46×10^{-4}		2.58
Regenerant waste	13	1.07	12,515	35	11,730	1.7×10^{-4}	2.2×10^{4}	
Regenerant waste	14	1.07	12,515	50	11,730	1.7×10^{-4}	2.2×10^{4}	
Regenerant waste	15	1.07	709	50	664	2.71×10^{-3}		4.8×10^{1}

TABLE 11.2-2 (Cont)

Subsystem	Stream No.	Average Batch Interval for Normal Operation (days)	Volume per Batch (gal.)	Nominal Flow Rate (gpm)	Average Volume Per Day for Normal Operation (gal.)	Normal Activity Concentration (μCi/cc)	Maximum Activity Concentration (μCi/cc)	Comments
Regenerant waste	16	1.07	709	40	664	NA	8.48×10^{-1}	
Chemical waste	17	NA	-	-	NA	NA	NA	
Chemical waste	18	1	4000	3	NA	1.60×10^{-2}	1.6×10^{-24}	
Chemical waste	19	NA	110	NA	NA	5.83×10^{-1}	5.83×10^{1}	
Chemical waste	20	NA	110	NA	NA	5.83×10^{-1}	5.83×10^{-1}	
Chemical waste	21	NA	NA	-	NA	-	1.77×10^{-2}	
Detergent drain waste	22	1	1500	-	1500	1.03×10^{-5}	7.88×10^{-3}	
Detergent drain waste	23	1	1500	25	1500	7.81×10^{-6}	3.53×10^{-4}	
Detergent demin waste	24	1	1500	25	1500	1.56×10^{-14}	1.00×10^{-7}	

(1) Refer to Figure 11.2-5, sheets 1 and 2.

(Historical Information)

TABLE 11.2-3

EXPECTED RADIONUCLIDES ACTIVITY CONCENTRATIONS IN REACTOR COOLANT AND MAIN STEAM[1] USED FOR EVALUATION OF RADIOACTIVE RELEASES, μCi/g

Isotope	Reactor[2] Coolant	Reactor Steam
Noble gases:		
Ar-41	-	0
Kr-83m	-	9.1(-3)[3]
Kr-85m	-	1.6(-3)
Kr-85	-	5.0(-6)
Kr-87	-	5.5(-3)
Kr-88	-	5.5(-3)
Kr-89	-	3.4(-2)
Xe-131m	-	3.9(-6)
Xe-133m	-	7.5(-5)
Xe-133	-	2.1(-3)
Xe-135m	-	7.0(-3)
Xe-135	-	6.0(-3)
Xe-137	-	3.9(-2)
Xe-138	-	2.3(-2)
Halogens[4][5]:		
Br-83	1.1(-3)	1.7(-5)
Br-84	1.4(-3)	3.0(-5)
I-131	1.9(-3)	3.0(-5)
I-132	1.1(-2)	1.7(-4)
I-133	8.0(-3)	1.2(-4)

(Historical Information)

TABLE 11.2-3 (Cont)

Isotope	Reactor[2] Coolant	Reactor Steam
Halogens[4][5]:		
I-134	1.4(-2)	3.0(-4)
I-135	8.0(-3)	1.2(-4)
Cesium		
Cs-134	3(-5)	3(-8)
Cs-136	8(-5)	8(-8)
CS-137	2(-5)	2(-8)
Cs-138	1(-2)	1(-5)
Tritium[6]:		
H-3	1(-2)	1(-2)
Other nuclides:		
Na-24	9(-3)	9(-6)
P-32	2(-4)	2(-7)
Cr-51	6(-3)	6(-6)
Mn-54	7(-5)	7(-8)
Mn-56	5(-2)	5(-5)
Fe-55	9(-4)	9(-7)
Fe-59	3(-5)	3(-8)
Co-58	2(-4)	2(-7)
Co-60	4(-4)	4(-7)
Ni-65	3(-4)	3(-7)
Cu-64	3(-2)	3(-5)

(Historical Information)

TABLE 11.2-3 (Cont)

Isotope	Reactor[2] Coolant	Reactor Steam
Other nuclides:		
Zn-65	2(-4)	2(-7)
Zn-69m	2(-3)	2(-6)
Sr-89	9(-5)	9(-8)
Sr-90	7(-6)	7(-9)
Sr-91	4(-3)	4(-6)
Sr-92	1(-2)	1(-5)
Y-91	4(-5)	4(-8)
Y-92	6(-3)	6(-6)
Y-93	4(-3)	4(-6)
Zr-95	7(-6)	7(-9)
Nb-95	7(-6)	7(-9)
Nb-98	4(-3)	4(-6)
Mo-99	2(-3)	2(-6)
Tc-99m	2(-2)	2(-5)
Tc-104	8(-2)	8(-5)
Ru-103	2(-5)	2(-8)
Ru-105	2(-3)	2(-6)
Ru-106	3(-6)	3(-9)
Ag-110m	9(-7)	9(-10)
Te-129m	4(-5)	4(-8)
Te-131m	9(-5)	9(-8)
Te-132	9(-6)	9(-9)
Ba-139	1(-2)	1(-5)
Ba-140	4(-4)	4(-7)

(Historical Information)

TABLE 11.2-3 (Cont)

Isotope	Reactor[2] Coolant	Reactor Steam
La-142	5(-3)	5(-6)
Ce-141	3(-5)	3(-8)
Ce-143	3(-5)	3(-8)
Ce-144	3(-6)	3(-9)
Pr-143	4(-5)	4(-8)
W-187	3(-4)	3(-7)
Np-239	8(-3)	8(-6)

(1) The reactor coolant concentration is specified at the nozzle where reactor water leaves the reactor vessel. Similarly, the reactor steam concentration is specified at time 0 at the nozzle.

(2) Normal expected concentrations correspond to 50,000 μCi/s. offgas release rate at 30 min.

(3) 9.1(-3) = 9.1×10^{-3}.

(4) All halogen concentrations have been adjusted lower to account for the reduced I-131 source term, which was reported in Revision 1 of NUREG-0016.

(5) Halogen concentrations listed in reactor steam are based on a carryover of 0.015. For a carryover of 0.004, the halogen reactor steam concentrations would be reduced proportionately.

(6) Measured values increased to account for liquid recycle.

(Historical Information)

TABLE 11.2-4

DECONTAMINATION FACTORS USED FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10CFR50[1]

	Filter	Evaporator	Demineralizer	Total DF
High purity waste subsystem:				
Halogen	1		100	100
Cs, Rb	1		10	10
Other nuclides	1		100	100
Low purity waste subsystem:				
Halogens	1		100	100
Cs, Rb	1		2	2
Other nuclides	1		100	100
Chemical waste subsystem:				
Halogens		1[2]		1[2]
Cs, Rb		1[2]		1[2]
Other nuclides		1[2]		1[2]
Regenerant waste subsystem:				
Halogens		1,000		1,000
Cs, Rb		10,000		10,000
Other nuclides		10,000		10,000

(Historical Information)

TABLE 11.2-4 (Cont)

	Filter	Evaporator	Demineralizer	Total DF
Detergent waste subsystem:				

A DF of 1 is used for the detergent waste filter for all nuclides

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(1) From NUREG 0016 Revision 1.

(2) It is possible that detergent based decontamination solutions could be used; therefore, the more conservative decontamination factors for detergent wastes are used for the chemical waste subsystem.

(Historical Information)

TABLE 11.2-5

EXPECTED HOLDUP TIMES FOR COLLECTION, PROCESSING, AND DISCHARGE USED FOR EVALUATION OF RADIOACTIVE RELEASES FOR COMPLIANCE WITH APPENDIX I OF 10CFR50

Process	Holdup Time (Days)
High purity waste subsystem:	
Collection	0.761
Processing	0.895
Discharge time	0.0
Total	0.851
Low purity waste subsystem:	
Collection	2.105
Processing	0.0473
Discharge time	0.0245 [1]
Total	2.177
Chemical waste subsystem:	
Collection	2.667
Processing	0.655
Discharge time	0.0
Total	3.322
Regenerant waste subsystem:	
Collection	3.18
Processing	0.437
Discharge time	0.0
Total	3.62

(Historical Information)

TABLE 11.2-5 (Cont)

(1) NUREG-0016, Revision 1, recommends the use of T= (T processing + 1/2 T discharge) for the sum of processing and discharge time entry. This value of 0.0245 for discharge is 1/2 T discharge.

(Historical Information)

TABLE 11.2-6

AVERAGE DAILY INPUTS AND ACTIVITIES TO THE LIQUID WASTE MANAGEMENT SYSTEM

Source	Expected Daily Input Flow Rate (gal./day)	Fraction of Primary Coolant (PCA)[1]
High purity waste subsystem:		
Equipment drains		
Drywell	3,400[1]	1.00
Reactor Building	3,700[1]	0.1
Auxiliary Building, radwaste area	1,100[1]	0.1
Turbine Building	3,000[1]	0.001
Ultrasonic resin cleaner	10,212	0.05
Resin rinse	8,979	0.002
Cleanup phase separator	640[1]	0.002
Radwaste demineralizer regeneration	1,328	0.003
Total	32,359	0.136

TABLE 11.2-6 (Cont)

Source	Expected Daily Input Flow Rate (gal./day)	Fraction of Primary Coolant (PCA)[1]
Low purity waste system:		
Floor drains		
Drywell	700[1]	0.001
Reactor Building	2,000[1]	0.001
Auxiliary Building, radwaste area	1,000[1]	0.001
Turbine Building	2,000[1]	0.001
Total	5,700	0.001
Chemical waste system:		
Lab drains	500[1]	0.02
Chemical lab waste	100[1]	0.02
Total	600	0.02
Regenerant waste subsystem	6,285	(2)
Detergent waste subsystem	1,000[1]	-

(1) Obtained from NUREG 0016 Revision 1.

(2) Calculated by the GALE Code.

(Historical Information)

TABLE 11.2-7

BATCHED INPUTS TO THE LIQUID WASTE MANAGEMENT SYSTEM FROM THE SOLID WASTE MANAGEMENT SYSTEM FOR NORMAL OPERATION

	First Intermediate Collector Input			Second Intermediate Collector Input			Liquid Radwaste Input To Equipment Drain Collection Tank From Each Second Intermediate Collector	
Source	Collector	Batch Size (gal.)	Batch Frequency Per Collector (days)	Collector	Batch Size (gal.)	Batch Frequency Per Collector days)	Batch Size (gal.)	Batch Frequency (days)
RWCU filter demineralizers	RWCU back-wash receiv-ing tank	1100	1/3.4 (1)	RWCU phase separator	2200	1/6.8	2000	1/6.8
Fuel pool filter demin-eralizers	Waste sludge phase se-parator	2160	1/10.4	-	-	-	2135	1/10.4
Radwaste filters	Waste sludge phase se-parator	1748	3.5/1	-	-	-	1736	3.5/1
** Evaporator bottoms								
** a. Crystallizer mode	Concentra-ted tank	10,500	1/7	Crystallizer	10,500	1/7	9253 (process) 10,729 (condensate)	1/7
** b. Evap/extruder mode	Concentra-ted tank	1540	1/7	Evaporator/ extruder	3080	1/14	1156	1/14
RWCU phase separator								
** a. Centrifuge mode	Centrifuge feed tank	990	1/20	Centrifuge	990	1/20	885	1/20
** b. Evap/extruder mode	-	-	-	Evaporator/ extruder	-	1/20	56	1/20

** Abandoned in place

(Historical Information)

TABLE 11.2-7 (Cont)

Source	First Intermediate Collector Input: Collector	First Intermediate Collector Input: Batch Size (gal.)	First Intermediate Collector Input: Batch Frequency Per Collector (days)	Second Intermediate Collector Input: Collector	Second Intermediate Collector Input: Batch Size (gal.)	Second Intermediate Collector Input: Batch Frequency Per Collector days)	Liquid Radwaste Input To Equipment Drain Collection Tank From Each Second Intermediate Collector: Batch Size (gal.)	Liquid Radwaste Input To Equipment Drain Collection Tank From Each Second Intermediate Collector: Batch Frequency (days)
Waste sludge phase separator								
** a. Centrifuge mode	Centrifuge feed tank	957	1/1.5	Centrifuge	957	1/1.5	855	1/1.5
** b. Evap/extruder mode	-	-	-	Evap/extruder	-	1/1.5	54	1/1.5
Spent resin tank								
** a. Centrifuge mode	Centrifuge feed tank	929	1/12.2	Centrifuge	929	1/12.2	633	1/12.2
** b. Evap/extruder mode	-	-	-	Evap/extruder	-	1/12.2	157	1/12.2

(1) 1/3.4 means 1 batch per 3.4 days.

** Abandoned in place

TABLE 11.2-8

EXPECTED RADIONUCLIDE ACTIVITY INVENTORIES OF LIQUID WASTE MANAGEMENT SYSTEM COMPONENTS,[1] Ci

Isotope	Floor Drain Collector Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Br-83	1.17-03[2]	1.17-05	1.18-01	5.71-05	1.19-01	6.12-04	5.70-04	1.88-01	-	3.75-07
Br-84	4.86-04	4.86-06	4.86-02	1.20-05	4.86-02	2.52-04	2.34-04	-	-	1.54-07
Br-85	-	-	-	-	-	-	-	-	-	-
I-131	4.08-03	4.10-05	7.05-01	4.26-04	1.65+00	3.26-03	1.60-02	4.03+01	3.89+02	2.15-06
I-132	2.06-02	2.06-04	3.12-00	1.82-03	6.10+00	1.48-02	4.81-02	4.44+00	1.53+01	9.62-06
I-133	2.30-02	2.30-04	3.43-00	2.02-03	5.28+00	1.65-02	2.86-02	2.58+01	2.83+01	1.06-05
I-134	6.82-03	6.82-05	6.82-01	2.29-04	6.82-01	3.53-03	3.28-03	1.39-01	-	2.16-06
I-135	2.19-02	2.19-04	2.63-00	1.47-03	2.84+00	1.33-02	1.37-02	9.40+00	6.24+00	8.27-06
Rb-89	-	-	-	-	-	-	-	-	-	-
Cs-134	1.29-05	2.57-05	-	2.75-04	2.27-02	-	2.51-03	1.27-01	1.38+00	-
Cs-136	8.70-06	1.74-05	-	1.84-04	1.46-02	-	1.49-03	-	3.13-01	-
Cs-137	1.80-05	3.59-05	1.36-02	4.13-04	3.40-02	-	3.78-03	1.96-01	2.12-00	1.06-05
Cs-138	3.34-03	1.67-03	3.34-01	4.16-03	3.34-01	1.73-03	1.61-03	-	-	-
Na-24	-	-	1.35-01	-	1.85-01	-	-	-	-	-
P-32	-	-	-	-	-	-	-	-	-	-
Cr-51	-	-	-	-	1.37-01	-	1.46-03	-	4.87+00	-
Mn-54	-	-	-	-	-	-	-	-	-	-
Mn-56	8.26-03	8.25-05	8.43-01	4.12-04	8.44-01	4.36-03	4.06-03	-	-	2.67-06
Fe-55	-	-	-	-	-	-	-	-	-	-
Fe-59	-	-	-	-	-	-	-	-	-	-
Co-58	3.21-03	3.21-05	5.64-01	3.42-04	1.40+00	2.60-03	1.53-02	6.19+00	6.94+01	1.72-06
Co-60	-	-	-	-	1.42-01	-	1.57-03	-	8.77+00	-
Ni-63	-	-	-	-	-	-	-	-	-	-
Ni-65	-	-	-	-	-	-	-	-	-	-
Cu-64	-	-	-	-	-	-	-	-	-	-
Zn-65	-	-	-	-	-	-	-	-	-	-
Zn-69	-	-	-	-	-	-	-	-	-	-
Sr-89	1.03-03	1.03-05	1.80-01	1.09-04	4.46-01	8.31-04	4.84-03	1.89+00	2.12+01	5.49-07
Sr-90	-	-	1.36-02	-	3.40-02	-	-	1.97-01	2.08+00	-
Sr-91	1.41-02	1.41-04	1.85-02	1.06-03	2.19+00	9.15-03	1.07-02	6.11-01	4.74-01	5.77-06
Sr-92	9.51-03	9.51-05	9.75-01	4.82-04	9.77-01	5.04-03	4.70-03	1.30-01	-	3.09-06
Y-91m	7.89-03	7.89-05	1.07+00	6.42-04	1.29+00	5.06-03	4.70-03	3.93-01	3.05-01	3.34-06
Y-92	8.02-03	8.02-05	9.51-01	5.68-04	8.77-01	4.84-03	6.30-03	2.80-01	1.69-01	3.00-06
Y-93	-	-	-	-	-	-	-	-	-	-
Zr-95	-	-	-	-	-	-	-	-	2.84+00	-
Zr-97	-	-	-	-	-	-	-	-	-	-
Nb-95	-	-	-	-	-	-	-	-	3.49+00	-
Nb-98	-	-	-	-	-	-	-	-	-	-
Mo-99	6.58-03	6.58-05	1.10+00	6.12-04	2.29+00	5.13-03	1.80-02	1.15+00	4.55+00	3.37-06

TABLE 11.2-8 (Cont)

Isotope	Floor Drain Collector Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Tc-99m	4.75-02	4.75-04	5.89+00	3.31-03	7.32+00	2.94-02	4.19-02	1.19+00	4.86+00	1.85-05
Tc-101	1.07-03	1.08-05	1.07-01	1.30-05	1.07-01	5.54-04	5.15-04	-	-	3.39-07
Tc-104	-	-	-	-	-	-	-	-	-	-
Ru-103	-	-	-	-	-	-	-	-	1.10-01	-
Ru-105	-	-	-	-	-	-	-	-	-	-
Ru-106	-	-	-	-	-	-	-	-	-	-
Ag-110m	-	-	-	-	-	-	-	-	-	-
Te-129m	-	-	-	-	-	-	-	-	2.17-01	-
Te-131m	-	-	-	-	-	-	-	-	-	-
Te-132	1.51-02	1.51-04	2.54+00	1.53-03	5.43+00	1.19-02	4.43-02	3.07+00	1.45+01	7.78-06
Ba-139	7.24-03	7.24-05	7.25-01	2.98-04	7.24-01	3.75-03	3.49-03	-	-	2.30-06
Ba-140	2.85-03	2.85-05	4.96-01	3.00-04	1.19-00	2.29-03	1.21-02	2.43+00	2.68+01	1.51-06
Ba-141	1.67-03	1.67-05	1.67-01	2.57-05	1.67-01	8.65-04	8.04-04	-	-	5.30-07
Ba-142	1.02-03	1.02-05	1.02-01	-	1.02-01	5.29-04	4.92-04	-	-	3.24-07
La-142	1.02-03	1.02-05	1.02-01	4.81-05	1.02-01	5.29-04	4.92-04	-	3.02+01	3.24-07
Ce-141	-	-	-	-	1.37-02	-	1.52-04	-	9.76-01	-
Ce-143	-	-	-	-	-	-	-	-	-	-
Ce-144	-	-	-	-	-	-	-	-	2.99-01	-
Pr-143	-	-	-	-	-	-	-	-	1.18-01	-
Nd-147	-	-	-	-	-	-	-	-	-	-
W-187	1.58-03	1.58-05	2.42-01	1.43-04	3.93-01	1.16-03	2.23-03	-	-	-
Np-239	7.08-02	7.08-04	1.17-01	7.03-03	2.37+01	5.48-02	2.98-01	1.05+01	3.36+01	3.59-05
Total	2.89-01	4.62-03	3.95+01	2.80-02	6.72+01	1.97-01	2.98-01	1.09+02	6.84+02	1.35-04

(1) The expected radionuclide activity inventories are based on a reactor coolant activity corresponding to a noble gas release rate of 50,000 μci/s after 30 minutes decay.

(2) 1.17-03 = 1.17×10^{-3}.

TABLE 11.2-9

MAXIMUM RADIONUCLIDE ACTIVITY INVENTORIES OF LIQUID WASTE MANAGEMENT SYSTEM COMPONENTS,[1] Ci

Isotope	Floor Drain Collector Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Br-83	1.17-02[2]	1.17-04	1.18+00	5.71-04	1.19+00	6.12-03	5.70-03	1.88+00	-	3.75-06
Br-84	4.86-03	4.86-05	4.86-01	1.20-04	4.86-01	2.52-03	2.34-03	-	-	1.54-06
Br-85	-	-	-	-	-	-	-	-	-	-
I-131	4.08-02	4.10-04	7.05+00	4.26-03	1.65+01	3.26-02	1.60-01	4.03+02	3.89+03	2.15-05
I-132	2.06-01	2.06-03	3.12+01	1.82-02	6.10+01	1.48-01	4.81-01	4.44+01	1.53+02	9.62-05
I-133	2.30-01	2.30-03	3.43+01	2.02-02	5.28+01	1.65-01	2.86-01	2.58+02	2.83+02	1.06-04
I-134	6.82-02	6.82-04	6.82+00	2.29-03	6.82+00	3.53-02	3.28-02	1.39+00	-	2.16-05
I-135	2.19-01	2.19-03	2.63+01	1.47-02	2.84+01	1.33-01	1.37-01	9.40+01	6.24+01	8.27-05
Rb-89	-	-	-	-	-	-	-	-	-	-
Cs-134	1.29-04	2.57-04	-	2.75-03	2.27-01	-	2.51-03	1.27+00	1.38+01	-
Cs-136	8.70-05	1.74-04	-	1.84-03	1.46-01	-	1.49-03	-	3.13+00	-
Cs-137	1.80-04	3.59-04	1.36-01	4.13-03	3.40-01	-	3.78-03	1.96+00	2.12+01	1.06-05
Cs-138	3.34-02	1.67-02	3.34+00	4.16-02	3.34+00	1.73-02	1.61-02	-	-	-
Na-24	-	-	1.35-01	-	1.85-01	-	-	-	-	-
P-32	-	-	-	-	-	-	-	-	-	-
Cr-51	-	-	-	-	1.37-01	-	1.46-03	-	4.87+00	-
Mn-54	-	-	-	-	-	-	-	-	-	-
Mn-56	8.26-03	8.25-05	8.43-01	4.12-04	8.44-01	4.36-03	4.06-03	-	-	2.67-06
Fe-55	-	-	-	-	-	-	-	-	-	-
Fe-59	-	-	-	-	-	-	-	-	-	-
Co-58	3.21-03	3.21-05	5.64-01	3.42-04	1.40+00	2.60-03	1.53-02	6.19+00	6.94+01	1.72-06
Co-60	-	-	-	-	1.42-01	-	1.57-03	-	8.77+00	-
Ni-63	-	-	-	-	-	-	-	-	-	-
Ni-65	-	-	-	-	-	-	-	-	-	-
Cu-64	-	-	-	-	-	-	-	-	-	-
Zn-65	-	-	-	-	-	-	-	-	-	-
Zn-69	-	-	-	-	-	-	-	-	-	-
Sr-89	1.03-02	1.03-04	1.80+00	1.09-03	4.46+00	8.31-03	4.84-02	1.89+01	2.12+02	5.49-06
Sr-90	-	-	1.36-01	-	3.40-01	-	-	1.97+00	2.08+01	-
Sr-91	1.41-01	1.41-03	1.85-01	1.06-02	2.19+01	9.15-02	1.07-01	6.11+00	4.74+00	5.77-05
Sr-92	9.51-02	9.51-04	9.75+00	4.82-03	9.77+00	5.04-02	4.70-02	1.30+00	-	3.09-05
Y-91m	7.89-02	7.89-04	1.07+01	6.42-03	1.29+01	5.06-02	4.70-02	3.93+00	3.05+00	3.34-05
Y-92	8.02-02	8.02-04	9.51+00	5.68-03	8.77+00	4.84-02	6.30-02	2.80+00	1.69+00	3.00-05
Y-93	-	-	-	-	-	-	-	-	-	-
Zr-95	-	-	-	-	-	-	-	-	2.84+00	-
Zr-97	-	-	-	-	-	-	-	-	-	-
Nb-95	-	-	-	-	-	-	-	-	3.49+00	-
Nb-98	-	-	-	-	-	-	-	-	-	-
Mo-99	6.58-02	6.58-04	1.10+01	6.12-03	2.29+01	5.13-02	1.80-01	1.15+01	4.55+01	3.37-05

TABLE 11.2-9 (Cont)

Isotope	Floor Drain Collec-tor Tank	Floor Drain Sample Tank	Waste Collec-tor Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutra-lizer Tank	Concen-trated Waste Tank	Detergent Drain Tank
Tc-99m	4.75-01	4.75-03	5.89+01	3.31-02	7.32+01	2.94-01	4.19-01	1.91+01	4.86+01	1.85-04
Tc-101	1.07-02	1.08-04	1.07+00	1.30-04	1.07+00	5.54-03	5.15-03	-	-	3.39-06
Tc-104	-	-	-	-	-	-	-	-	-	-
Ru-103	-	-	-	-	-	-	-	-	1.10+00	-
Ru-105	-	-	-	-	-	-	-	-	-	-
Ru-106	-	-	-	-	-	-	-	-	-	-
Ag-110m	-	-	-	-	-	-	-	-	-	-
Te-129m	-	-	-	-	-	-	-	-	2.17+00	-
Te-131m	-	-	-	-	-	-	-	-	-	-
Te-132	1.51-01	1.51-03	2.54+01	1.53-02	5.43+01	1.19-01	4.43-01	3.07+01	1.45+02	7.78-05
Ba-139	7.24-02	7.24-04	7.25+00	2.98-03	7.24+00	3.75-02	3.49-02	-	-	2.30-05
Ba-140	2.85-02	2.85-04	4.96+00	3.00-03	1.19+01	2.29-02	1.21-01	2.43+01	2.68+02	1.51-05
Ba-141	1.67-02	1.67-04	1.67+00	2.57-04	1.67+00	8.65-03	8.04-03	-	-	5.30-06
Ba-142	1.02-02	1.02-04	1.02+00	-	1.02+00	5.29-03	4.92-03	-	-	3.24-06
La-142	1.02-02	1.02-04	1.02+00	4.81-04	1.02+00	5.29-03	4.92-03	-	3.02+02	3.24-06
Ce-141	-	-	-	-	1.37-01	-	1.52-03	-	9.76+00	-
Ce-143	-	-	-	-	-	-	-	-	-	-
Ce-144	-	-	-	-	-	-	-	-	2.99+00	-
Pr-143	-	-	-	-	-	-	-	-	1.18+00	-
Nd-147	-	-	-	-	-	-	-	-	-	-
W-187	1.58-03	1.58-05	2.42-01	1.43-04	3.93-01	1.16-03	2.23-03	-	-	-
Np-239	7.08-01	7.08-03	1.17+02	7.03-02	2.37+02	5.48-01	-	1.05+02	3.36+02	3.59-04
Total	2.81+00	4.55-02	3.95+02	2.73-01	6.51+02	1.91+00	4.56+00	1.07+03	5.99+03	1.23-03

(1) The maximum radionuclide activity inventories are based on a reactor coolant activity corresponding to a noble gas release rate of 500,000 μci/s after 30 minutes decay.

(2) 1.17-02 = 1.17×10^{-2}.

TABLE 11.2-10

LIQUID WASTE MANAGEMENT SYSTEM COMPONENT PARAMETERS

Component	Quantity	Design Press/Temp (psig/°F)	Type	Material	Capacity, each (gal.)	Diam/Height	Code
Tanks							
Waste collector	2	15/200	Vert/cyl	304 L SS	32,000	16'-0"/26'-0"	API 620
Floor drain collector	2	15/200	Vert/cyl	304 L SS	17,000	12'-6"/23'-1"	API 620
Waste surge	1	3/200	Vert/cyl	304 L SS	67,500	29'-0"/26'-0"	API 620
Waste neutralizer	2	15/200	Vert/cyl	316 L SS	27,500	15'-0"/26'-3"	API 620
Concentrated waste	2	15/200	Vert/cyl	316 L SS	12,000	10'-3"/23'-7"	API 620
Detergent drain	1	15/200	Hor/cyl	304 L SS	2000	6'-6"/9'-2"(1)	API 620 & ASME VIII
** Decontamination solution concentrated waste	1	15/200	Vert/cyl	316 L SS	700	4'-0"/10'-7"	API 620
Chemical waste	1	15/200	Vert/cyl	316 L SS	4500	7'-0"/19'-0"	API 620
** Waste sample	2	15/200	Vert/cyl	304 L SS	17,000	12'-6"/22'-10"	API 620
Floor drain sample	2	15/200	Vert/cyl	304 L SS	17,000	12'-6"/22'-10"	API 620
** Waste evaporator distillate	2	15/200	Hor/cyl	304 L SS	1100	4'-6"/10'-0"	API 620
Chemical addition	3	Atm	Vert/cyl	316 L SS	250	3'-6"/6'-0"	API 650
Anti-foamant addition	1	Atm	Vert/cyl	316 L SS	10	1'-0"/2'-6"	API 650
** Waste evaporator condensate return	1	Atm	Hor/cyl	Galv Steel	430	3'-6"/6'-4"	ASME, Sect VIII
** Decontamination solution evaporator condensate return	1	Atm	Hor/cyl	Galv Steel	30	1'-4"/3'-6"	ASME, Sect VIII

** Abandoned in place

(Historical Information)

TABLE 11.2-10 (Cont)

Component	Quantity	Type	Rated Flow (gpm)	Rated Head TDH (ft)	Rated Power (hp)	Design Pressure/Temp (psig/°F)	Code
Pumps							
Waste collector	2	Hor, cent	182	275	40	240/210	Mfg Std
Waste surge	1	Hor, cent	182	275	40	240/210	Mfg Std
Floor drain collector	2	Hor, cent	176	260	40	240/210	Mfg Std
Waste neutralizer	2	Hor, cent	176	55	5	170/210	Mfg Std
Concentrator feed	2	Hor, cent	40	100	5	150/210	Mfg Std
Concentrated waste	2	Hor, cent	40	215	15	170/210	Mfg Std
Chemical waste	1	Hor, cent	176	150	20	170/210	Mfg Std
** Decontamination conc waste	1	Hor, cent	27	145	7.5	150/210	Mfg Std
Detergent drain	2	Hor, cent	25	175	7.5	150/210	Mfg Std
** Waste sample	2	Hor, cent	515	370	75	200/210	Mfg Std
Floor drain sample	2	Hor, cent	176	310	30	240/210	Mfg Std
** Waste evaporator dist transfer	2	Hor, cent	50	66.7 max	5	170/210	Mfg Std
** Waste evaporator conc waste transfer	2	Hor, cent	50	11.6	1	150/230	Mfg Std
** Waste evaporator recycle	2	Hor, cent	50	15.4 max	1	150/210	Mfg Std
** Decontamination solution evap conc waste transfer	1	Hor, cent	34	6.5	1	150/230	Mfg Std
** Decontamination solution evap recycle	1	Hor, cent	50	13.8 max	1	150/230	Mfg Std

** Abandoned in place

TABLE 11.2-10 (Cont)

Component	Quantity	Type	Rated Flow (gpm)	Rated Head TDH (ft)	Rated Power (hp)	Design Pressure/Temp (psig/°F)	Code
Pumps (Continued)							
** Waste evaporator condensate return	2	Hor, cent	200	120	15	150/210	Mfg Std
** Decontamination solution evap/condensate return	2	Hor, cent	10	140	2	150/210	Mfg Std
** Waste evaporator recirculation	2	Hor, cent	9000	35	150	64/274	Mfg Std
Waste filter aid	1	Positive displacement	154 gph, max	150 psig max	1	150/250	Mfg Std
Floor drain filter aid	1	Positive displacement	154 gph, max	150 psig max	1	150/250	Mfg Std
Chemical addition	3	Positive displacement	247 gph, max	100 psig max	2	100/200	Mfg Std
Radwaste demin regen acid	2	Positive displacement	90 gph, max	110 psig max	0.5	110/200	Mfg Std
Radwaste demin regen caustic	2	Positive displacement	90 gph, max	110 psig max	0.5	110/200	Mfg Std
Waste filter holding	1	Hor, cent	75	50	3	150/220	Mfg Std
Waste precoat	2	Hor, cent	325	50	7.5	150/150	Mfg Std
Floor drain filter holding	1	Hor, cent	75	50	3	150/220	Mfg Std

** Abandoned in place

Component	Quantity	Type Diam/Height (ft)	Material Type/Number	Rated Flow Each (gpm)	Equipment Parameter	Design Pressure/Temp (psig/°F)	Code
Processing Equipment							
Waste filter	1	Non-precoat, or precoat, 3'-6"/10'	Polymer or Wedge wire element vessel SA-240, 304L	180		150/220	ASME, Sect VIII Div I
Floor drain filter	1	Precoat 3'-6"/10'	Wedge wire element 304 L SS, 52 ea vessel SA 240, 304L	180	Filter surface area = 188 ft^2	150/220	ASME, Sect VIII Div I
Detergent drain filter	1	Cartridge	ASME SA 516 Gr 65	25	Replaceable cartridge filter	150/212	ASME, Sect VIII Div I
Waste demineralizer	1	Mixed bed 7'/10'	CS ASME SA-516/rubber-lined	180	190 ft^3 stoichiometric mixture-resin or resin plus filter media	150/150	ASME, Sect VIII Div I
Floor drain demineralizer	1	Mixed bed 7'/10'	CS ASME SA-516/rubber-lined	180	190 ft^3 stoichiometric mixture-resin or resin plus filter media	150/150	ASME, Sect VIII Div I
** Waste evaporators	2	Forced circulation Vapor body: 7'x2"x9" 6'/20'-0" Heater:	ASME SA-240 316 L SS	40	NA_2SO_4 conc to 25 percent BW External HX	30/274	ASME, Sect VIII Div I
** Decontamination solution evaporator	1	Natural circulation Vertical HX (No passes) 4'x17'	ASME SA-240 316 L SS	3	Internal HX Bottom conc 10%	30/274	ASME, Sect VIII Div I TEMA Class C

** Abandoned in place

(Historical Information)

TABLE 11.2-10 (Cont)

Component	Quantity	Type Diam/Height (ft)	Material Type/Number	Rated Flow Each (gpm)	Equipment Parameter	Design Pressure/Temp (psig/°F)	Code
Radwaste demineralizer regeneration system:	1	-	-	-	One complete regeneration per 7 hours	-	ASME, Sect VIII
Cation vessel	1	7'/2' 6-3/4" Vert/cyl	CS SA-515 Gr 70/rubber-lined	-	-	125/150	ASME, Sect VIII Div I
Anion vessel	1	7'/2' 6-3/4" Vert/cyl	CS SA-515 Gr 70/rubber-lined	-	-	125/150	ASME, Sect VIII Div I
Caustic dilution hot water tank	1	4'/10' Vert/cyl	CS SA-515 Gr 70	-	-	150/200	ASME, Sect VIII Div I

(Historical Information)

TABLE 11.2-11

EXPECTED YEARLY ACTIVITY RELEASED FROM LIQUID RADWASTE MANAGEMENT SUBSYSTEMS FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10CFR50, Ci

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing Stream	Subtotal	Adjusted Total	Detergent Wastes	Total
Corrosion and activation products							
Na-24	3.5E-3	1.3E-4	2.4E-3	6.0E-3	9.3E-3	0	9.3E-3
P-32	1.1E-4	6.9E-6	3.4E-4	4.6E-4	7.0E-4	0	7.0E-4
Cr-51	3.4E-3	2.1E-4	1.1E-2	1.5E-2	2.3E-2	0	2.3E-2
Mn-54	3.9E-5	2.6E-6	1.5E-4	1.9E-4	3.0E-4	1.0E-3	1.3E-3
Mn-56	3.4E-3	8.9E-3	6.8E-5	3.5E-3	5.4E-3	0	5.4E-3
Fe-55	5.6E-4	3.7E-5	2.2E-3	2.8E-3	4.3E-3	0	4.3E-3
Fe-59	1.7E-5	1.1E-6	6.0E-5	7.8E-5	1.2E-4	0	1.2E-4
Co-58	1.1E-4	7.2E-6	4.1E-4	5.3E-4	8.2E-4	4.0E-3	4.8E-3
Co-60	2.3E-4	1.5E-5	8.8E-4	1.1E-3	1.7E-3	8.7E-3	1.0E-2
Ni-65	2.0E-5	5.3E-7	3.9E-7	2.1E-5	3.2E-5	0	3.2E-5
Cu-64	9.7E-3	3.5E-4	5.6E-3	1.6E-2	2.4E-2	0	2.4E-2
Zn-65	1.1E-4	7.3E-6	4.3E-4	5.5E-4	8.5E-4	0	8.5E-4
Zn-69m	6.7E-4	2.5E-5	4.2E-4	1.1E-3	1.7E-3	0	1.7E-3
Zn-69	7.1E-4	2.6E-5	4.5E-4	1.2E-3	1.8E-3	0	1.8E-3
Zr-95	0	0	0	0	0	1.4E-3	1.4E-3
Nb-95	0	0	0	0	0	2.0E-3	2.0E-3
W-187	1.2E-4	5.5E-6	1.3E-4	2.6E-4	4.1E-4	0	4.1E-4
Np-239	3.5E-3	1.9E-4	6.4E-3	1.0E-2	1.5E-2	0	1.5E-2
Fission Products							
Br-83	2.3E-4	6.0E-6	3.5E-6	2.4E-4	3.6E-4	0	3.6E-4
Br-84	8.8E-6	3.6E-7	1.3E-13	9.1E-6	1.4E-5	0	1.4E-5
Sr-89	5.7E-5	3.7E-6	2.0E-4	2.6E-4	4.1E-4	0	4.1E-4
Sr-90	4.0E-6	2.6E-7	1.5E-5	2.0E-5	3.0E-5	-	3.0E-5
Y-90	4.5E-7	6.2E-8	8.9E-6	9.4E-6	1.4E-5	-	1.4E-5
Sr-91	1.1E-3	3.5E-5	4.4E-4	1.6E-3	2.4E-3	0	2.4E-3
Y-91m	7.0E-4	2.2E-5	2.8E-4	1.0E-3	1.5E-3	0	1.5E-3

TABLE 11.2-11 (Cont)

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing Stream	Subtotal	Adjusted Total	Detergent Wastes	Total
Y-91	3.1E-5	2.2E-6	1.4E-4	1.7E-4	2.6E-4	0	2.6E-4
Sr-92	7.2E-4	1.9E-5	1.8E-5	7.6E-4	1.2E-3	0	1.2E-3
Y-92	1.7E-3	4.4E-5	1.7E-4	1.9E-3	2.9E-3	0	2.9E-3
Y-93	1.1E-3	3.7E-5	4.9E-4	1.7E-3	2.6E-3	0	2.6E-3
Zr-95	4.5E-6	2.9E-7	1.6E-5	2.1E-5	3.3E-5	0	3.3E-5
Nb-95	4.5E-6	2.9E-7	1.7E-5	2.2E-5	3.4E-5	0	3.4E-5
Nb-98	2.8E-5	9.4E-7	3.4E-10	2.9E-5	4.5E-5	0	4.5E-5
Mo-99	1.0E-3	5.6E-5	2.0E-3	3.1E-3	4.7E-3	0	4.7E-3
Tc-99m	4.4E-3	1.5E-4	2.6E-3	7.1E-3	1.1E-2	0	1.1E-2
Ru-103	1.1E-5	7.2E-7	3.9E-5	5.1E-5	7.9E-5	1.4E-4	2.2E-4
Rh-103m	1.1E-5	7.2E-7	4.0E-5	5.1E-5	7.9E-5	0	7.9E-5
Tc-104	8.3E-6	5.3E-7	1.5E-19	8.9E-6	1.4E-5	0	1.4E-5
Ru-105	2.8E-4	7.3E-6	2.7E-5	3.1E-4	4.8E-4	0	4.8E-4
Rh-105m	2.8E-4	7.3E-6	2.7E-5	3.1E-4	4.8E-4	0	4.8E-4
Rh-105	9.4E-5	5.3E-6	1.8E-4	2.8E-4	4.3E-4	0	4.3E-4
Ru-106	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.3E-5	2.4E-3	2.4E-3
Rh-106	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.3E-5	0	1.3E-5
Ag-110m	5.6E-7	3.6E-8	2.2E-6	2.8E-6	4.2E-6	4.4E-4	4.4E-4
Te-129m	2.2E-5	1.4E-6	7.8E-5	1.0E-4	1.6E-4	0	1.6E-4
Te-129	1.4E-5	9.2E-7	5.0E-5	6.5E-5	1.0E-4	0	1.0E-4
Te-131m	4.4E-5	2.1E-6	5.7E-5	1.0E-4	1.6E-4	0	1.6E-4
Te-131	8.1E-6	3.8E-7	1.0E-5	1.9E-5	2.9E-5	0	2.9E-5
I-131	9.9E-4	6.1E-5	6.6E-2	6.7E-2	1.0E-1	6.2E-5	1.0E-1
Te-132	5.1E-6	2.9E-7	1.1E-5	1.6E-5	2.5E-5	0	2.5E-5
I-132	2.1E-3	5.7E-5	3.9E-5	2.2E-3	3.4E-3	0	3.4E-3
I-133	1.0E-2	4.3E-4	1.8E-2	2.9E-2	4.4E-2	0	4.4E-2
I-134	5.8E-4	1.9E-5	1.0E-8	6.0E-4	9.1E-4	0	9.1E-4
Cs-134	1.7E-4	5.5E-5	5.7E-5	2.8E-4	4.3E-4	1.3E-2	1.3E-2
I-135	5.7E-3	1.6E-4	1.3E-3	7.1E-3	1.1E-2	0	1.1E-2
Cs-136	4.4E-4	1.4E-4	1.2E-4	7.0E-4	1.1E-3	0	1.1E-3
Cs-137	1.1E-4	3.7E-5	3.8E-5	1.9E-4	2.9E-4	2.4E-2	2.4E-2
Ba-137m	1.1E-4	3.4E-5	3.6E-5	1.8E-4	2.7E-4	0	2.7E-4
Cs-138	1.6E-4	3.4E-5	3.1E-13	2.0E-4	3.0E-4	0	3.0E-4

(Historical Information)

TABLE 11.2-11 (Cont)

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing Stream	Subtotal	Adjusted Total	Detergent Wastes	Total
Ba-139	2.2E-4	6.5E-6	1.9E-4	2.3E-4	3.5E-4	0	3.5E-4
Ba-140	2.2E-4	1.4E-5	6.6E-4	9.0E-4	1.4E-3	0	1.4E-3
La-140	3.9E-5	4.9E-6	4.3E-4	4.7E-4	7.3E-4	0	7.3E-4
La-141	1.0E-4	2.7E-6	7.5E-1	1.1E-4	1.7E-4	0	1.7E-4
Ce-141	1.9E-5	1.2E-6	6.7E-5	8.6E-5	1.3E-4	0	1.3E-4
La-142	1.6E-4	4.6E-6	2.7E-7	1.7E-4	2.5E-4	0	2.5E-4
Ce-143	1.4E-5	6.6E-6	1.9E-5	3.3E-5	5.0E-5	0	5.0E-5
Pr-143	2.2E-5	1.4E-6	7.1E-5	9.5E-5	1.5E-4	0	1.5E-4
Ce-144	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.3E-5	5.2E-3	5.2E-3
Pr-144	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.3E-5	0	1.3E-5
All Others	5.9E-5	1.4E-6	1.3E-5	2.8E-5	4.3E-5	0	4.3E-5
Total (Except Tritium)	5.9E-2	2.6E-3	1.3E-1	1.9E-1	2.9E-1	6.2E-2	3.5E-1
Tritium Release							51

(Historical Information)

TABLE 11.2-12

EXPECTED ACTIVITY CONCENTRATIONS
FOR EVALUATIONS OF RADIOACTIVITY RELEASES TO THE
DELAWARE RIVER
(BASED ON 10CFR20 1988 EDITION)

Isotope	Concentration μCi/ml(1)	MPC, μCi/ml 10CFR20 Table II Col 2	Fraction of MPC
Na-24	3E-9	2E-4	2E-5
P-32	2E-10	2E-5	1E-5
Cr-51	8E-9	2E-3	4E-6
Mn-54	4E-10	1E-4	4E-6
Mn-56	2E-9	1E-4	2E-5
Fe-55	1E-9	8E-4	1E-6
Fe-59	4E-11	6E-5	7E-7
Co-58	2E-9	1E-4	2E-5
Co-60	3E-9	5E-5	6E-5
Ni-65	1E-11	1E-4	1E-7
Cu-64	8E-9	3E-4	3E-5
Zn-65	3E-10	1E-4	3E-6
Zn-69m	6E-10	7E-5	9E-6
Zn-69	6E-10	2E-3	3E-7
W-187	1E-10	7E-5	1E-6
Np-239	5E-9	1E-4	5E-5
Br-83	1E-10	3E-6	3E-5
Br-84	5E-12	3E-6	2E-6
Sr-89	1E-10	3E-6	3E-5
Sr-90	1E-11	3E-7	3E-5
Y-90	5E-12	2E-5	3E-7

(Historical Information)

TABLE 11.2-12 (Cont)

Isotope	Concentration µCi/ml[1]	MPC, µCi/ml 10CFR20 Table II Col 2	Fraction of MPC
Sr-91	8E-10	7E-5	1E-5
Y-91m	5E-10	3E-3	2E-7
Y-91	9E-11	3E-5	3E-6
Sr-92	4E-10	7E-5	6E-6
Y-92	1E-9	6E-5	2E-5
Y-93	9E-10	3E-5	3E-5
Zr-95	5E-10	6E-5	8E-6
Nb-95	7E-10	1E-4	7E-6
NB-98	1E-11	3E-6	3E-6
Mo-99	2E-9	2E-4	1E-5
Tc-99m	4E-9	6E-3	7E-7
Ru-103	7E-11	8E-5	9E-7
Rh-103m	3E-11	1E-2	3E-9
Tc-104	5E-12	3E-6	2E-6
Ru-105	2E-10	1E-4	2E-6
Rh-105m	2E-10	3E-6	7E-5
Rh-105	1E-10	1E-4	1E-6
Ru-106	8E-10	1E-5	8E-5
Rh-106	4E-12	3E-6	1E-6
Ag-110m	1E-10	3E-5	3E-6
Te-129m	5E-11	3E-5	2E-6
Te-129	3E-11	8E-4	4E-8
Te-131m	5E-11	6E-5	8E-7

(Historical Information)

TABLE 11.2-12 (Cont)

Isotope	Concentration μCi/ml[1]	MPC, μCi/ml 10CFR20 Table II Col 2	Fraction of MPC
Te-131	1E-11	3E-6	3E-6
I-131	3E-8	3E-7	1E-1
Te-132	8E-12	3E-5	3E-7
I-132	1E-9	8E-6	1E-4
I-133	1E-8	1E-6	1E-2
I-134	3E-10	2E-5	2E-5
Cs-134	4E-9	9E-6	4E-4
I-135	4E-9	4E-6	1E-3
Cs-136	4E-10	9E-5	4E-6
Cs-137	8E-9	2E-5	4E-4
Ba-137m	9E-11	3E-6	3E-5
Cs-138	1E-10	3E-6	3E-5
Ba-139	1E-10	3E-6	3E-5
Ba-140	5E-10	2E-5	3E-5
La-140	2E-10	2E-5	1E-5
La-141	6E-11	3E-6	2E-5
Ce-141	4E-11	9E-5	4E-7
La-142	8E-11	3E-6	3E-5
Ce-143	2E-11	4E-5	5E-7
Pr-143	5E-11	5E-5	1E-6
Ce-144	2E-9	1E-5	2E-4
Pr-144	4E-12	3E-6	1E-6

(Historical Information)

TABLE 11.2-12 (Cont)

Isotope	Concentration μCi/ml(1)	MPC, μCi/ml 10CFR20 Table II Col 2	Fraction of MPC
All Others	1E-11	3E-8	3E-4
H3	9E-6	3E-3	3E-3
Total	1E-7	-	1E-1

(1) Annual average concentration after dilution by the expected monthly flow of 1.9E4 gpm cooling tower blowdown adjusted for an 80 percent capacity factor. Concentrations have also been adjusted to reflect the fact that the releases presented in Table 11.2-13 are based on 50,000 μCi/s noble gas off-gas rate (at 30 min delay). The concentrations in this table are based on a 500,000 μCi/s rate.

(Historical Information)

TABLE 11.2-13

INPUT DATA FOR AQUATIC DOSE CALCULATIONS

HOPE CREEK GENERATING STATION - LIQUID DOSE CALCULATIONS

1	42.3	1.0	0	5.97E06

HCGS Source Term - One Unit With Multiplier of 1.0

H 3	51.
Na24	.0093
P 32	.00070
Cr51	.023
Mn54	.0013
Mn56	.0054
Fe55	.0043
Fe59	.00012
Co58	.0048
Co60	.01
Ni65	.000032
Cu64	.024
Zn65	.00085
Zn69M	.0017
Zn69	.0018
W 187	.00041
Np239	.015
Br83	.00036
Br84	.000014
Sr89	.00041
Sr90	.000030
Y 90	.000014
Sr91	.0024
Y 91M	.0015

(Historical Information)

TABLE 11.2-13 (Cont)

Y 91	.00026
Sr92	.0012
Y 92	.0029
Y 93	.0026
Zr95	.0014
Nb95	.002
Nb98	.000045
Mo99	.0047
Tc99M	.011
Ru103	.00022
Rh103M	.000079
Tc104	.000014
Ru105	.00048
Rh105M	.00048
Rh105	.00043
Ru106	.0024
Rh106	.000013
Ag110M	.00044
Te129M	.00016
Te129	.000100
Te131M	.00016
Te131	.000029
I 131	.100
Te132	.000025
I 132	.0034
I 133	.044
I 134	.00091
Cs134	.013
I 135	.011
Cs136	.0011
Cs137	.024
Ba137M	.00027
Cs138	.00030

TABLE 11.2-13 (Cont)

Ba139	.00035
Ba140	.0014
La140	.00073
La141	.00017
Ce141	.00013
La142	.00025
Ce143	.000050
Pr143	.00015
Ce144	.0052
Pr144	.000013

1	0.2	10.0	10.0	10.0	10.0	0.0
21.0	5.0	0.0	0.0	12.0	100.0	100.0
16.0	3.8	0.0	0.0	67.0	100.0	100.0
6.9	1.7	0.0	0.0	14.0	100.0	100.0

1862.	33820	206.7
3453.	147.	160.4
4522.	101.	122.5
6118.	11.	66.9
9310.	3.9	22.3
11704.	3.5	16.9
19950.	6.0	47.4
46284.	74.	100.8
77938.	2289.	164.
84854.	1175.	232.9
5530.	33820.	206.7
10270.	147.	160.4
13430.	101.	122.5
18170.	11.	66.9
27650.	3.9	22.3
34760.	3.5	16.9
59250.	6.0	47.4

TABLE 11.2-13 (Cont)

137460.	74.	100.8		
231470.	2289.	164.		
252010.	1175.	232.9		
273.	33820.	206.7		
507.	147.	160.4		
663.	101.	122.5		
897.	11.	66.9		
1365.	3.9	22.3		
1716.	3.5	16.9		
2925.	6.0	47.4		
6786.	74.	100.8		
11427.	2289.	164		
12441.	1175.	232.9		
11200.	33820.	206.7		
20800.	147.	160.4		
27200.	101.	122.5		
36800.	11.	66.9		
56000.	3.9	22.3		
70400.	3.5	16.9		
120000.	6.0	47.4		
278400.	74.	100.8		
468800.	2289.	164.		
510400.	1175.	232.9		
368000.	33820.	206.7	0.2	REGION U5
340000.	147.	160.4	0.2	REGION U4
368000.	101.	122.5	0.2	REGION U3
368000.	11.	66.9	0.2	REGION U2
400000.	3.9	22.3	0.2	REGION U1
340000.	3.5	16.9	0.2	REGION D1
460000.	6.0	47.4	0.2	REGION D2
364000.	74.	100.8	0.2	REGION D3

(Historical Information)

TABLE 11.2-13 (Cont)

436000.	2289.	164.	0.2	REGION D4
556000.	1175.	232.9	0.2	REGION D5

202400.	33820.	206.7	REGION U5
187000.	147.	160.4	REGION U4
202400.	101.	122.5	REGION U3
202400.	11.	66.9	REGION U2
220000.	3.9	22.3	REGION U1
187000.	3.5	16.9	REGION D1
253000.	6.0	47.4	REGION D2
202000.	74.	100.8	REGION D3
239800	2289.	164.	REGION D4
305800.	1175.	232.9	REGION D5

6720.	33820.	206.7	REGION U5
12480.	147.	160.4	REGION U4
16320.	101.	122.5	REGION U3
22080.	11.	66.9	REGION U2
33600.	3.9	22.3	REGION U1
42240.	3.5	16.9	REGION D1
72000.	6.0	47.4	REGION D2
167040.	74.	100.8	REGION D3
281280.	2289.	164.	REGION D4
306240.	1175.	232.9	REGION D5

(Historical Information)

TABLE 11.2-14

LIVE VOLUME CAPACITIES OF TANKS AND DESIGN OF PROCESS EQUIPMENT CONSIDERED IN THE CALCULATION OF HOLDUP TIMES

Item	Number	Live Volume Capacity, gal.	Rated Flow Rate (gpm) @ TDH(feet)
Tanks			
Waste collector tank	2	29,000	
Floor drain collector tank	2	15,000	
Waste surge tank	1	54,000	
Waste neutralizer tank	2	25,000	
Concentrated waste tank	2	10,550	
** Decontamination solution concentrated waste tank	1	600	
Chemical waste tank	1	4,000	
Waste and floor drain sample tanks	4	15,550	
** Waste evaporator distillate storage tank	2	1,100	
** Decontamination solution evaporator condensate return tank	1	30	
Pumps			
Waste collector tank pump	2		182 @ 275
Waste surge tank pump	1		182 @ 275
Floor drain collector tank pump	2		176 @ 260
Concentrator feed pump	2		40 @ 100
Concentrated waste pump	2		40 @ 215

** Abandoned in place

(Historical Information)

TABLE 11.2-14 (Cont)

Item	Number	Live Volume Capacity, gal.	Rated Flow Rate (gpm) @ TDH(feet)
Pumps			
Chemical waste pump	1		176 @ 150
** Decontamination concentrated waste pump	1		27 @ 145
Waste sample tank pump	2		450 @ 375
Floor drain sample tank pump	2		176 @ 310
** Concentrated waste transfer pump	1		34 @ 6.5
** Waste evaporator distillate transfer pump	2		50 @ 66.7 max
** Waste evaporator concentrated waste transfer pump	2		50 @ 11.6
Filters			
Waste filter	1		180
Floor drain filter	1		180
Demineralizers			
Waste demineralizer	1		180
Floor drain demineralizer	1		180
Evaporators			
** Decontamination solution evaporator	1		3
** Waste evaporators	2		40

** Abandoned in place

Figure F11.2-1 SH 1-2 intentionally deleted.

Refer to Plant Drawing M-62-0 for both sheets in DCRMS

Figure F11.2-2 SH 1-2 intentionally deleted.

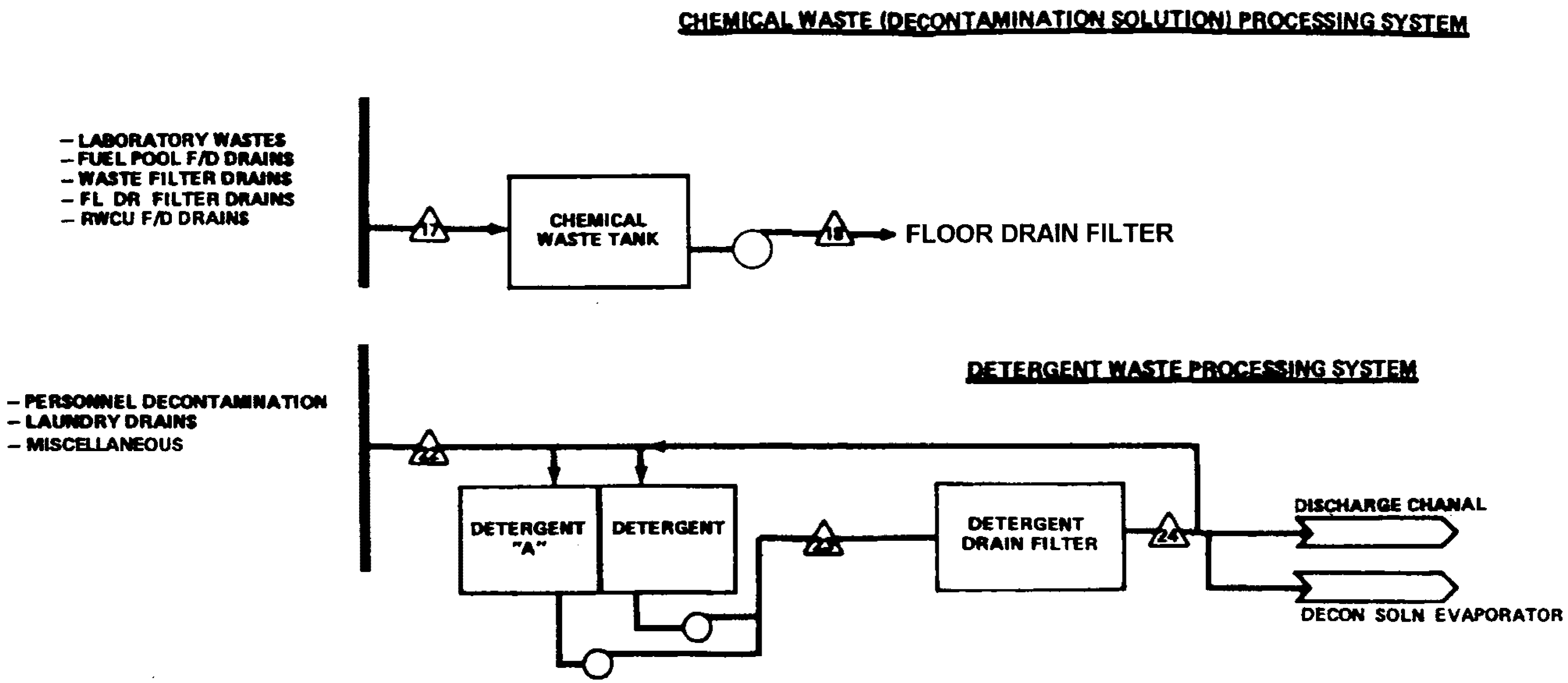
Refer to Plant Drawing M-63-0 for both sheets in DCRMS

Figure F11.2-3 intentionally deleted.

Refer to Plant Drawing M-64-0 in DCRMS

Figure F11.2-4 SH 1-3 intentionally deleted.

Refer to Plant Drawing M-65-0 for all sheets in DCRMS



NOTE: INFORMATION ON STREAM NUMBERS IDENTIFIED BY A △ IS GIVEN IN TABLE 11.2-2.

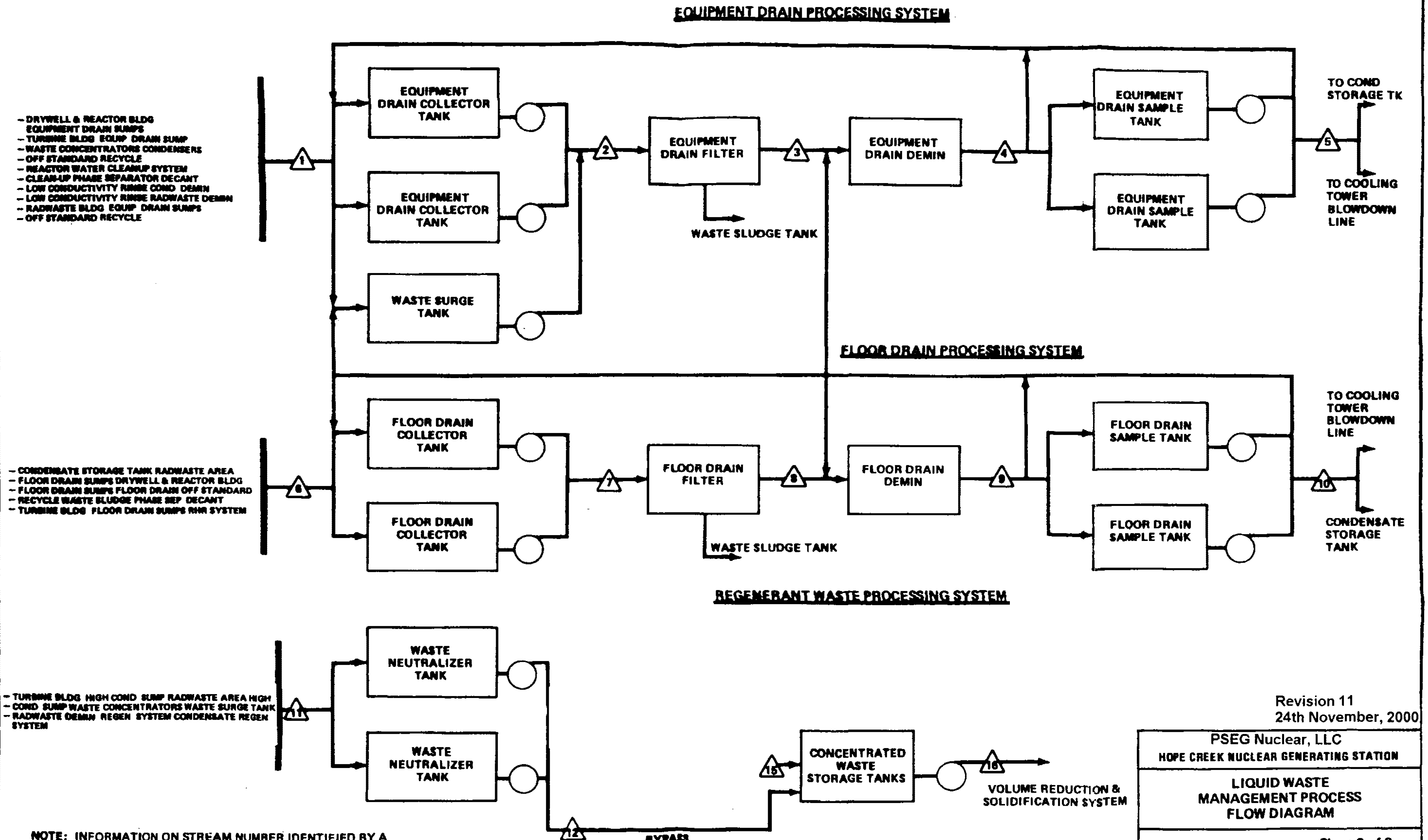
Revision 11
24th November, 2000

PSEG Nuclear, LLC
HOPE CREEK NUCLEAR GENERATING STATION

LIQUID WASTE MANAGEMENT PROCESS FLOW DIAGRAM

UPDATED FSAR

Sheet 1 of 2
FIGURE 11.2-5



NOTE: INFORMATION ON STREAM NUMBER IDENTIFIED BY A △ IS GIVEN IN TABLE 11.2-2.

Revision 11
24th November, 2000

PSEG Nuclear, LLC
HOPE CREEK NUCLEAR GENERATING STATION

LIQUID WASTE MANAGEMENT PROCESS FLOW DIAGRAM

UPDATED FSAR

Sheet 2 of 2
FIGURE 11.2-5

SECURITY - RELATED
INFORMATION WITHHELD
UNDER 10 CFR 2.390

REVISION 0
APRIL 11, 1988

PSEG NUCLEAR, L.L.C.
HOPE CREEK GENERATING STATION

LIQUID RADWASTE DRAIN
AND COOLING TOWER
BLOWDOWN PIPE LOCATIONS

Updated FSAR

Fig. 11.2-6

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

The Gaseous Waste Management Systems (GWMS) include all systems that process potential sources of airborne releases of radioactive materials during normal operation and anticipated operational occurrences. Included are the Off-gas System and various ventilation systems. These reduce radioactive gaseous releases from the plant by filtration or delay, which allows decay of radioisotopes prior to release.

The function of the Off-gas System is to collect and delay release of noncondensable radioactive gases removed from the main condenser by the air ejectors during normal plant operation. Plant ventilation systems process airborne radioactive releases from other plant sources, such as equipment leakage, maintenance activities, the mechanical vacuum pump, and the Steam Seal System.

The Explosive Gas Monitoring program, Technical Specification 6.8.4.d, is provided to ensure that the concentration of potentially explosive gas mixtures contained in the main condenser offgas system is maintained below the flammability limits of hydrogen and oxygen. Automatic control features are included in the system to prevent the hydrogen and oxygen concentration from reaching these flammability limits. These automatic control features include isolation of the source of hydrogen and/or oxygen on loss of dilution steam. Maintaining the concentration of hydrogen below the flammability limit provides assurance that the releases of radioactive materials will be controlled in conformance with the requirements of General Design Criterion 60 of Appendix A to 10 CFR Part 50.

The Off-gas System is described in detail in this section. The ventilation systems are discussed briefly in this section and in greater detail in Section 9.4.

11.3.1 Design Bases

1. The Gaseous Waste Management Systems (GWMS) are designed to control and monitor the release of radioactive materials in gaseous effluents in accordance with General Design Criteria (GDC) 60 and 64 of 10CFR50, Appendix A.

2. The Off-gas System design basis source terms corresponds to 500,000 μCi/sec of radioactive noble gases after 30-minute delay.

3. The GWMS are designed to limit offsite doses from routine plant releases to significantly less than the limits specified in 10CFR20 and to operate within the dose objectives established in 10CFR50, Appendix I.

4. The GWMS are designed with sufficient capacity and redundancy to accommodate all anticipated processing requirements of the plant during normal operation, including anticipated operational occurrences.

5. Continuous monitoring is provided for all potential pathways of airborne radioactive releases, with main control room annunciation prior to exceeding Technical Specification allowed limits.

6. Design provisions are incorporated that preclude the uncontrolled release of radioactivity to the environment as a result of any single operator error or any single active component failure.

7. The GWMS is designed to keep the exposure to plant personnel as low as is reasonably achievable (ALARA) during normal operation and plant maintenance, in accordance with Regulatory Guide 8.8.

8. The Off-gas System is designed to provide at least 35 days and 36 hours of delay time for xenon and krypton, respectively, at 75 scfm airflow rate.

9. The Off-gas System is designed in accordance with the guidelines of Regulatory Guide 1.143, with the exceptions described in Section 1.8.

10. Filtration units in the ventilation systems are designed, operated, and maintained in accordance with the guidelines of Regulatory Guide 1.140.

11. The Off-gas System is designed to maintain the concentration of hydrogen in the gases exhausted from the main condenser below flammable limits.

12. Instrumentation is provided in the Off-gas System to detect abnormal concentrations of hydrogen and other system malfunctions.

13. The Off-gas System is designed to withstand the effects of a hydrogen explosion without breach of the pressure boundary.

11.3.2 System Description

11.3.2.1 Off-gas System

Non-condensable gases are continuously removed from the main condenser by the steam jet air ejectors (SJAEs) during plant operation. The off-gas consists of activation gases, fission product gases, radiolytic hydrogen and oxygen, and condenser air inleakage.

The Off-gas System is designed to reduce off-gas radioactivity to permissible levels for release under all site atmospheric conditions.

During the hydrogen water chemistry operation, the addition of hydrogen to the feedwater causes the hydrogen/oxygen ratio in the offgas to increase. To ensure that sufficient oxygen is present in the offgas to combine with the excess hydrogen, air is injected upstream of the offgas recombiners to maintain the stoichiometric balance of oxygen and hydrogen. The Service Air or Instrument Air systems will supply air to an injection panel on the 54' elevation of the auxiliary/radwaste building. This air injection panel will supply air to the operating gaseous recombiner during the operation of the hydrogen water chemistry.

The Off-gas System uses a catalytic recombiner and a cooler condenser for control of hydrogen concentration and volume reduction, respectively. Selective adsorption of fission product noble gases (xenon and krypton) on charcoal is used to provide time for delay before release.

The location of the Off-gas System components is shown on general arrangement drawings in Section 1.2.

The seismic categories, quality group classifications, and corresponding codes and standards that apply to the design of the gaseous waste management systems are discussed in Section 3.2.

11.3.2.1.1 Process Description

Figure 11.3-1 is the process flow diagram for the Off-gas System. The process data for the maximum flow operating condition are contained in Table 11.3-1.

Plant Drawings M-69-0 and M-70-0 are the piping and instrumentation diagrams (P&IDs) for the Off-gas System.

During startup, mechanical vacuum pumps are used to draw a vacuum in the main condenser, as described in Section 10.4.2. Once condenser, vacuum has been established by the mechanical vacuum pumps, a three stage SJAE train is placed in service using auxiliary steam. Once reactor steam is available, it replaces auxiliary steam.

This steam also provides dilution to maintain the hydrogen concentration below the combustible limit. A complete description of the SJAE is given in Section 10.4.2.

The off gas stream from the third stage SJAE is treated first in the recombiner section of the Off gas System. The purpose of the recombiner section is to eliminate the potential for explosion by controlled recombination of the radiolytic hydrogen and oxygen and reduce the off gas volume. After the off gas stream has passed through the cooler condenser, the hydrogen concentration is reduced to less than 1.5 percent by volume. The off gas first passes through the preheater in order to vaporize any water droplets and to achieve a sufficient temperature to start the catalytic reaction. Steam used for preheating is provided from the nuclear boiler steam supply line or from auxiliary steam. The recombination process takes place inside the recombiner vessel. The temperature of the gases leaving the recombiner rises as a function of the influent hydrogen concentration. This temperature rise is due to the heat of reaction of the recombination process. The reaction temperature

rises approximately 135°F for each 1 percent of H_2 recombined. The catalyst is pellet type, ceramic base coated with palladium. Each recombiner has an electric heater assembly.

The moisture in the off-gas leaving the recombiner vessel is condensed in the cooler condenser and the offgas stream is cooled to approximately 120°F. The remaining noncondensable gas (principally air with traces of krypton and xenon) is delayed in a series of eight, 24-inch diameter, 55-foot long holdup pipes. At a flow rate of 75 scfm, this pipe provides a minimum of 10 minutes of delay for the off-gas prior to entering the ambient charcoal treatment section.

Further off-gas cooling and condensing of water vapor takes place in the glycol cooler condenser, where the off-gas passes through stainless steel coils submerged in a glycol bath maintained at 35°F. The off-gas exits the glycol cooler condenser at 40°F and 100 percent relative humidity.

A reheater, consisting of self-limiting heat tracing on the process pipe, heats the off-gas to 65°F, thereby lowering the relative humidity to 40 percent, the design condition for the charcoal beds.

Before entering the main charcoal vessels, the off-gas stream passes through a guard bed. The function of the guard bed is to protect the main charcoal adsorbers from moisture if a malfunction of moisture removal features occurs as well as to adsorb impurities in the process gas that might adversely affect performance of the main charcoal vessels.

After passing through the guard bed, the off-gas enters the main charcoal adsorption beds. The charcoal adsorption beds, maintained at 65°F by redundant room heating and air conditioning units, selectively adsorb and delay the xenon and krypton from the bulk carrier gas. This delay permits the xenon and krypton to decay in place. The off-gas stream then passes

through a high efficiency particulate air (HEPA) filter where radioactive particulate matter and any charcoal particles are retained.

The off-gas stream is then directed to the north plant vent where it is diluted with air from the Solid Radwaste System exhaust and chemical lab exhaust before being released. Table 11.3-2 shows the estimated annual release rate from the off-gas system.

All moisture removed from the process stream is returned to the main condenser, except for the condensate from the glycol cooler condenser, which is routed to the Clean Radwaste Drainage System (CRW).

11.3.2.1.2 System Design Considerations

11.3.2.1.2.1 Charcoal Holdup Time

The charcoal adsorber bed is designed for a delay time of 35 days for xenon under the condition of 75 scfm condenser air inleakage rate, using manufacturer's guaranteed adsorption coefficients (733 cc/g for xenon, and 32 cc/g for krypton). The required charcoal mass of 322,000 pounds is obtained by the following equation from References 11.3-1 and 11.3-2:

$$M = \frac{TV}{0.26K}$$

where:

T = holdup time (hours)

K = dynamic adsorption coefficient (cc/g)

V = air flow rate (scfm)

M = mass of charcoal (10^3 lbs).

Using the adsorption coefficients for the condition of 77°F operation, 45°F dew point, the NUREG-0016, Revision 1, mentioned in Reference 11.3-3, methodology yields delay times of 55 days and 3.1 days for xenon and krypton, respectively, for 322,000 pounds of charcoal. This estimate is very conservative since the adsorption coefficients for 65°F operation, and a 40°F dew point, should be significantly higher than the ones for 77°F operation and 45°F dew point (330 cc/g for xenon and 18.5 cc/g for krypton).

11.3.2.1.2.2 Hydrogen Detonation Resistance

The pressure boundary of the Off-gas System is designed to withstand the effects of a hydrogen detonation during all anticipated modes of operation. In addition, the system includes features that reduce the probability of an explosion. Such features include:

1. Maintenance of nonexplosive mixture throughout the system - loss of dilution steam in SJAE will actuate an alarm and the steam supply valve of SJAE will be closed to isolate the Off-gas System

2. Minimization of potential ignition sources, e.g., nonsparking valves.

3. Design with dual hydrogen analyzers which alarm the operating recombiner train when the setpoint is reached.

11.3.2.1.3 Component Description

The materials of construction, design temperatures, and pressures are listed in Table 11.3-3.

11.3.2.1.3.1 Recombiner Section

1. Preheater - The preheater is a straight tube and shell heat exchanger with the process gas on the tube side and steam on the shell side. Main steam is used to heat the process gas before entering the recombiner. The process gas enters the preheater at 221°F and is heated to 270°F. Auxiliary steam is also available for heating the process gas flow, should main steam be unavailable. Condensate from the shell side of the heat exchanger is collected in a flash pot and is routed to the main condenser.

2. Recombiner - The hydrogen and oxygen in the gas stream are recombined in the recombiner vessel by a catalyst bed made of palladium coated ceramic pellets. Electric heaters with automatic temperature control are provided on the shell of each recombiner. The heaters are used for preheating the recombiner during startup and maintaining it in a dry condition during shutdown.

3. Cooler condenser - The cooler condenser is a straight tube heat exchanger. Reactor Auxiliary Cooling System (RACS) cooling water is circulated on the tube side to condense the steam in the off-gas stream. The off-gas is cooled to 120°F and directed to the holdup pipe. Control valves are used to automatically maintain proper condensate level in the cooler condenser shell. The condensate is routed to the main condenser.

(Historical Information)

11.3.2.1.3.2 Holdup Pipe

A series of holdup pipes consisting of eight 24-inch diameter, 55-foot length pipes is between the recombiner section and the charcoal treatment section. The purpose of the holdup pipe is to

provide delay time (a minimum of 10 minutes for the design flow rate of 75 scfm) to allow N^{16} decay before entering the charcoal treatment system.

11.3.2.1.3.3 Charcoal Treatment Section

1. Glycol cooler condenser The function of the glycol cooler condenser is to condition the moisture level of the process gas to a 40°F dew point before entering the charcoal bed.

   Here, the off-gas passes through stainless steel coils submerged in a cold glycol bath, which is maintained at an average temperature of 35°F. The glycol bath temperature is maintained by the redundant refrigeration system evaporator coils, which are also submerged in the glycol bath. Natural convection circulates the glycol solution between the process coil and the refrigeration coil. Water vapor condensed inside the process coil is collected in the condensate accumulator, which is designed to prevent reentrainment and/or reevaporation of water due to heat inleakage. Condensate is automatically drained from the accumulator to the CRW system.

   The passive glycol system approach eliminates the use of glycol circulation pumps, which increases the system reliability. Also, the glycol solution mass has sufficient thermal inertia to provide temperature stability and prevent refrigerator shortcycling. The inertia is such that, at normal flow conditions, approximately 3 hours is required for a 5°F temperature change on either loss of cooling or loss of temperature control. Therefore, in the event of a malfunction, there is sufficient time to take corrective action before the performance of the system is significantly affected.

(Historical Information)

2. Guard bed - The function of the guard bed is to protect the main charcoal adsorbers from moisture in the event of a malfunction of the cooler condenser or glycol cooler condenser, and to remove contaminants which may be in the process stream that could be detrimental to the main charcoal adsorber bed. The guard bed contains approximately 200 pounds of activated charcoal. The guard bed has a differential pressure switch that alarms if the pressure drop through the guard bed becomes excessive due to moisture collection. The guard bed can be isolated and bypassed for regeneration by heated nitrogen.

3. Main charcoal adsorber bed - The main charcoal adsorber bed consists of ten, 8-foot inside diameter vessels. Each vessel contains approximately 32,200 pounds of activated charcoal. After the off-gas passes through the first vessel, three parallel paths are provided (three vessels in each path) to limit the system pressure drop. The vessels are connected at the top and bottom by 4-inch piping.

   The charcoal adsorber vessels are maintained at a temperature of $65 \pm 3^{\circ}F$ by redundant heating and air conditioning systems. In the unlikely event that both air conditioning units are unable to function, the radioactive emissions from the Off-gas System might increase slightly. However, since substantial margin exists in the off-gas system design, the releases would still be well below acceptable limits for expected air inleakage rates, radioactivity source terms, and adsorption coefficients.

4. The charcoal vessel compartment Air Conditioning System consists of two redundant refrigerators and four direct expansion fan coil units (two units for each of the two compartments). Each refrigerator handles two fan coil

units, one for each compartment in which the refrigerator is cooled by RACS cooling water.

5. Outlet HEPA filter - A high efficiency particulate air HEPA filter is provided to collect any entrained particulates or charcoal fines prior to release. These filters are individually tested using the dioctyl phthalate (DOP) method. The filters are equipped with hinged covers to facilitate removal and replacement of the filter element.

11.3.2.1.4 Leakage of Radioactive Gases

Leakage of radioactive gases from the Off-gas System is limited by the use of welded construction wherever practicable and by using valves of a bellows seal design, or valves employing double stem packing with leakoff connection being routed to the main condenser or pressurized with instrument air.

The Off-gas System operates at approximately 10 psig inlet and 0.5 psig outlet at all times, so that the differential pressure to the atmosphere is small.

All drains from the Off-gas System are directed either back to the main condenser or to CRW. During normal operation, only the drain from the condensate accumulator in the glycol cooler condenser is directed to CRW. The liquid level in the condensate accumulator is automatically maintained by a level controller and the drain valves are fail-closed. Therefore, the possibility of gas leakage to the waste collector tanks is minimal.

11.3.2.1.5 Instrumentation and Control

The Off-gas System is monitored at appropriate locations for flow, temperature, pressure, moisture, conductivity, radiation, and

(Historical Information)

hydrogen concentration to verify specified operation and control. Plant Drawings M-69-0 and M-70-0 show the process instrumentation.

All the alarms of the Off-gas System are provided on local panels adjacent to the system equipment. Also, four common system trouble alarms are used on the main control room panel: three for the recombiner section including the standby system, and one for the charcoal treatment section.

A sample is continuously collected between the fourth and fifth holdup pipe section for monitoring the gaseous radioactivity input to the Off-gas System. The sample is representative of gaseous radioactivity released from the reactor and therefore indicates the condition of the fuel cladding. Provision is made for grab sampling of the influent gases for the purpose of determining isotopic composition.

Two in-line radiation monitors are also provided downstream of the HEPA filter to continuously monitor activity released from the system. The Off-gas System process radiation instrumentation is discussed further in Section 11.5.

Dilution steam flow (third-stage SJAE motive steam) is monitored for loss of flow upstream of the preheater and alarmed in the main control room.

During certain transient modes of operation, the air ejectors may extract an air flow from the condenser in excess of the Off-gas System capacity (75 scfm). An excessive air flow higher than 75 scfm will open the valve on the bypass line from the third stage SJAE suction line to the condenser and recycle the excess air back to the condenser.

The steam supply to the preheater is controlled by the off-gas outlet temperature.

(Historical Information)

The temperatures of the recombiner vessel and the incoming gas are monitored by thermocouples, and alarms are provided to indicate a temperature condition above or below the design temperature, respectively.

Cooler condenser outlet temperature is recorded, and high temperature is alarmed at the local panel and in the main control room via a system trouble alarm. This temperature indicates if adequate cooling water flow exists in the cooler condenser.

Semi-permeable membrane covered electro-chemical type hydrogen and oxygen analyzers (two each) are used to measure the hydrogen and oxygen content in the off-gas downstream of the cooler condenser. The sample gas is returned to the main process line upstream of the preheater. The hydrogen and oxygen concentration output from the analyzers is indicated and recorded. Alarm capability is provided for high hydrogen concentration (1.5 percent) as well as low (5%) and high (30%) oxygen concentration. Alarms are also provided for high sample temperature and low flow. Each analyzer is independently calibrated. Heat tracing is not required on the inlet and return sample lines to prevent condensation. Excess moisture is removed from the sample gas by a cooler condenser and moisture separator located upstream of each analyzer cell. The condensate is returned to the main condenser.

The condensate levels in the drain pot upstream of the preheater and in the cooler condenser are maintained by level control systems. These level control systems provide drainage to the main condenser during normal operation.

Glycol cooler condenser performance is monitored by outlet temperature and moisture. High process outlet temperature is alarmed at the local panel and in the main control room via a local control panel trouble alarm. A moisture element is located downstream of the cooler condenser. The moisture element senses the process off-gas dew point temperature. This temperature is recorded at the local panel adjacent to the system equipment. High moisture in the process stream is alarmed both locally and in the main control room via a local control panel trouble alarm.

Moisture condensed from the process off-gas in the glycol cooler condenser is collected in the condensate accumulator. The

(Historical Information)

condensate level is maintained at appropriate limits by a level control system. Condensate is normally drained to CRW. A conductivity element is provided in the drain to detect glycol inleakage. If glycol inleakage is detected, drain valves will be closed, an alarm will be actuated, and the condensate will be drained manually after system shutdown.

The guard bed is provided with differential pressure indication and a temperature recorder. High differential pressure and high temperature are alarmed at the local panel and in the main control room via a system trouble alarm.

The temperature of the charcoal beds are monitored by resistance temperature detectors (RTDs) in the adsorber vessels. High temperature and low temperature are alarmed in the main control room via a system trouble alarm and at the local panel. Individual adsorber charcoal temperature is recorded at the local control panel. Each vessel is provided with at least one spare RTD that can be used if the operating RTD fails.

Differential pressure is measured across the HEPA filter. High differential pressure is alarmed locally and in the main control room via a system trouble alarm.

Process off-gas flow rate is monitored downstream of the HEPA filter. High flow rate is alarmed in the main control room via a system trouble alarm and at the local panel. Flow rate is recorded on the local panel.

Two RTDs are provided in each charcoal adsorber tank room. The RTDs automatically operate the room heating and air conditioning units to maintain room temperature at 65 ± 3°F. Room temperature is alarmed at the local panel and in the main control room via a system trouble alarm. The room temperature is also recorded on the local panel.

(Historical Information)

11.3.2.1.6 Off-gas System Operating Procedure

11.3.2.1.6.1 Startup

Before starting the Off-gas System, the following conditions are necessary:

1. Main steam or auxiliary steam is available for the SJAEs and the preheater

2. Cooling water (condensate) is supplied to the SJAE intercondenser

3. The recombiner is preheated to approximately 300°F by the electric heaters

4. RACS cooling water is supplied to the cooler condenser, glycol refrigeration units, and compartment refrigeration units

5. The glycol coolant is chilled

6. The adsorber rooms are at 65°F and air circulation fans are operating.

The SJAE train can be started up with main condenser pressure at 5 inches Hg, the vacuum initially being drawn by the mechanical vacuum pumps. The SJAE train is started by opening the third stage motive steam supply valve and discharge valve, following which the suction valve is opened. Using the same procedure, the second stage and then the first stage SJAEs are started up. During this time period, the mechanical vacuum pumps are in operation.

Initially, all the valves in the main process stream of the Off-gas System are open, except for the inlet isolation valve and the isolation valve downstream of the cooler condenser. The inlet

(Historical Information)

isolation valve is then opened and the off-gas is admitted into the recombiner section. If any unusual event occurs, the recombiner section will be shut off immediately until the event is resolved. Then the downstream isolation valve of the recombiner section is opened, and the off-gas flows through the charcoal treatment system. The condenser mechanical vacuum pumps are turned off at this point.

11.3.2.1.6.2 Normal Operation and Shutdown

After startup, the flow rate of noncondensables exhausted by the SJAE should stabilize, primarily as a function of reactor power level and condenser inleakage. The instrumentation discussed in Section 11.3.2.1.5 can be used to monitor system performance. Operator action is not required for steady state system operation, including changes in off-gas noncondensable flow rates from 0 to 75 scfm.

Normal operation is terminated following a normal reactor shutdown or a reactor scram by sequentially shutting the gas suction valves to the SJAEs, stopping steam flow to the SJAEs, and then shutting off the Off-gas System inlet valve.

The Off-gas System is kept in service after shutdown until it is necessary to break condenser vacuum or until the activity of the off-gas indicates that the condenser atmosphere activity has reached acceptably low limits, at which point mechanical vacuum pumps may be placed in service.

11.3.2.1.7 Equipment Malfunction

An equipment malfunction analysis, indicating the consequences and design precautions taken to accommodate failure of various components of the Off-gas System, is presented in Table 11.3-4.

(Historical Information)

11.3.2.1.7.1 Operator Error

The potential for operator error resulting in high offsite releases while operating the Off-gas System is small. Off-gas flow from the SJAEs must be directed through the recombiner and ambient charcoal systems. There are no system bypasses other than the mechanical vacuum pump. The systems are instrumented such that the operators can detect and correct failures of various components in the systems, as indicated in Table 11.3-4.

11.3.2.1.7.2 Serviceability and Reliability

Reliability of the Off-gas System is accomplished through redundancy and the use of passive components.

A redundant SJAE system, including an intercondenser and aftercondenser, is provided. A redundant recombiner train is provided, including a preheater, recombiner, cooler condenser, and all valving and instrumentation. The redundant recombiner train is to be in the standby mode at all times for immediate use and can be placed in or out of service from the local control panel. A redundant glycol refrigeration unit, charcoal adsorber vessels compartment refrigeration unit, and compartment fan coil units are provided.

The guard bed and the first charcoal adsorber vessel can be bypassed if they become contaminated with moisture. In the unlikely event of flooding of the guard bed and/or first charcoal vessel, they can be regenerated by heated nitrogen. The HEPA filter may also be manually bypassed temporarily if a high differential pressure condition exists. The HEPA filter is located in an individual room for serviceability during system operation.

Serviceability is enhanced, wherever possible, by using passive components and by locating equipment and instruments that are not passive or that require periodic maintenance in accessible areas.

(Historical Information)

The entire Off-gas System can be purged by nitrogen for decontamination prior to maintenance. Also, a part of the system can be purged as required without interrupting the system's operation. The redundant recombiner train can be purged while the other train is in operation. The charcoal guard bed, HEPA filter, and first main charcoal bed can also be purged individually during system operation. All the purge outlets are routed to downstream of the holdup pipes in order to be treated by the charcoal system before release.

Instruments for the recombiner system that require periodic maintenance are located outside the recombiner rooms. Instruments for the ambient charcoal system are either located outside rooms containing radioactive equipment or are shielded from radioactive equipment. Instrumentation requiring calibration is accessible during system operation.

11.3.2.2 Other Radioactive Gas Release Paths

There are three general areas that contain sources of radioactive gas: the primary containment and Reactor Building, the Turbine Building, and the radwaste area of the Auxiliary Building. The description of the ventilation systems for these buildings is presented in Section 9.4. The building volumes, flow rates, sources, and other information required to calculate the airborne concentrations of radioactive materials are discussed in Sections 12.2.2 and 12.4.

11.3.2.2.1 Primary Containment and Reactor Building

As indicated in Section 9.4, the primary containment (drywell) and Reactor Building Heating, Ventilating, and Air Condition (HVAC) Systems that are important for the treatment of potentially radioactive air are the Filtration, Recirculation, and Ventilation System (FRVS), the Containment Prepurge Cleanup System (CPCS), and the Reactor Building Ventilation System (RBVS).

(Historical Information)

Air from the Reactor Building is normally exhausted by the RBVS exhaust fans through HEPA filters. The details of the RBVS are described in Section 9.4. Radiation monitors are provided in the exhaust ductwork to isolate normal HVAC and initiate the FRVS on high radiation. Upon Reactor Building isolation, the FRVS recirculation system recirculates the reactor building air through HEPA and charcoal filters for cleanup. After reaching a steady state, approximately 250 cfm of air exhausted from the FRVS recirculation system is filtered again by the FRVS ventilation system equipped with HEPA and charcoal filters, and then released to the atmosphere through a vent at the top of the reactor building to maintain the building differential pressure equal to or greater than 0.25-inch water gauge. The FRVS Recirculation System and Ventilation System are described in Section 6.8.

During power operation, radioactivity released from minor system leakage inside the drywell is contained, except for minor releases necessary to control drywell pressure. Pressure is controlled by bleeding air from the drywell through 2-inch lines connected to the RBVS exhaust system prior to release to the environment.

Before the drywell and torus are purged by the RBVS, the containment atmosphere is recirculated through the CPCS to reduce the level of atmospheric iodine and particulate radioactivity as required. After the prepurge cleanup process, the RBVS provides the supply air to and exhausts air from the drywell for purge.

11.3.2.2.2 Radwaste Area of the Auxiliary Building

The radwaste area supply system delivers filtered and tempered air that is distributed throughout the enclosure in quantities sufficient to maintain required temperatures. The equipment compartment exhaust system consists of three 33-1/3 percent capacity fans and three 33-1/3 percent capacity filter plenums. The service area exhaust system consists of two 50 percent capacity fans without exhaust filtration since this is a non-radioactive area. The

chemical lab exhaust system consists of two 100 percent capacity fans and two 100 percent capacity filter plenums. The solid radwaste area is supplied with filtered and tempered air through the enclosure in order to maintain design temperatures. The solid radwaste area exhaust system consists of two 50 percent capacity fans and two 50 percent capacity filter plenums. Each filter plenum has a bank of prefilters and a bank of HEPA filters. This exhaust system is balanced to ensure that the flow of air within the enclosure is into areas with higher potential for airborne radioactivity contamination. The tank ventilation filter system provides a means of filtering and venting air from tanks and equipment housed in the radwaste enclosure. Two redundant fans and filter plenums are employed for this purpose. There are HEPA filters and charcoal adsorbers in each filter plenum. Since the flow of air from tanks and equipment varies, space air is admitted as required to maintain system volume.

All the exhaust system ducts transport the filtered air to either the north or south plant vents.

Each of the above exhaust systems and the respective supply systems are interlocked so that failure of the exhaust system shuts down the supply system. This condition is alarmed in the main control room.

11.3.2.2.3 Turbine Building

During plant startup, air is removed from the main condenser by two mechanical vacuum pumps. Mechanical vacuum pumps may be used to maintain condenser vacuum following a plant shutdown/scram. Each vacuum pump discharges to the south plant vent, and if excessive releases or radioactivity are detected at the vent, an alarm is actuated. For a complete description of the Main Condenser Evacuation System, see Section 10.4.2.

In the past, discharge from the steam packing exhausters has presented a source of gaseous radioactive releases in some boiling water reactors (BWR) plants. At Hope Creek Generating Station

(Historical Information)

(HCGS), however, clean steam (produced from demineralized condensate) from the steam seal evaporator is provided for sealing purposes. Therefore, essentially no activity is released from this system. Section 10.4.3 provides a detailed description of the steam seal system.

The exhaust air from the Turbine Building Ventilation System is monitored for radioactivity prior to discharge to the atmosphere.

The details of the Turbine Building Ventilation System are described in Section 9.4.4.

11.3.3 Radioactive Releases

The assumptions used in this evaluation are summarized in Table 11.2-1. The calculated annual releases are given in Table 11.3-2.

It is expected that the actual releases from the plant will be lower than those referenced above due to the more realistic parameters associated with the equipment described in this chapter. The charcoal filtration systems that reduce the airborne radioactive releases are summarized in Table 11.3-8. Table 11.3-5 presents a design basis comparison between the concentration at the site boundary (901 meters) using the annual X/Q value of 2.47 E-7 s/m^3 and the appropriate recommended concentrations listed in Table II, Column 1 of 10CFR20, as of 1988.

With the exception of the FRVS ventilation system which discharges at the top of the Reactor Building all potentially contaminated gaseous releases are through the north and south plant vents, or through the hardened torus vent. The north plant vent serves the Off-gas System, the Solid Radwaste Exhaust System, and the Chemistry Lab Exhaust System. The south plant vent serves the following systems (refer to Figure 9.4-5):

(Historical Information)

1. Reactor Building Ventilation System (RBVS)

2. Radwaste Area Exhaust (RWE) System

3. Service Area Exhaust (SAE) System

4. Turbine Building Exhaust (TBE) System

5. Turbine Building Compartment Exhaust (TBCE) System

6. Turbine Building Oil Storage Room Exhaust (TBOE) System

7. Gland Seal Exhaust

8. Mechanical Vacuum Pump Discharge

The locations of the north and south plant vents are shown on the general arrangement drawings (Plant Drawings C-0001-0, P-0007-0 and P-0010-0).

Following Type A Integrated Leakage Rate Testing, the Mark I containment drywell may be vented through the hardened torus vent.

The height, effluent flow rate, average temperature, exit velocity, heat content, and dimensions of the north and south plant vent are shown on Table 11.3-7.

11.3.4 Estimated Doses

Table 11.3-5 also presents the whole-body dose at the site boundary. Dose calculations to ensure compliance with Appendix I to 10CFR50, based on the gaseous source term referenced above, were performed in accordance with Regulatory Guide 1.109 by use of the USNRC computer code "GASPAR," revised August 19, 1977. Input data for these calculations are given in Table 11.3-6. X/Q's for the nearest residence in each of the 16 compass directions were calculated. The sector with the highest X/Q is designated the

(Historical Information)

nearest residence - 3.7 miles NW except for calculation of thyroid doses for which 3.3 miles E is designated the nearest residence (the location has a larger D/Q). It is conservatively assumed that the nearest vegetable garden, milk cow, and meat animal are also located at that residence which results in the highest calculated dose.

Maximum doses to an individual are calculated using the values for that location. These doses are calculated using the highest pathway doses regardless of age group; that is, the child thyroid dose is used for the vegetable ingestion pathway, whereas the infant thyroid dose for the cow's milk pathway is used. The calculated doses are 0.163 mrad per year beta air dose and 0.140 mrad per year gamma air dose for noble gases; the Appendix I design objectives are 20 and 10 mrad per year, respectively. Noble gas doses to the total body and skin are calculated as 0.094 mrem per year and 0.254 mrem per year, respectively; the respective objectives for these pathways are 5.0 mrem per year and 15.0 mrem per year. The Appendix I design objective for radioiodine and particulate is 15 mrem per year to any organ. The thyroid dose from this source is calculated as 0.818 mrem per year. All calculated doses are within the appropriate Appendix I design objectives.

The total person-rem and person-rem-thyroid dose to the 50-mile population from gaseous effluents from HCGS are estimated to be 15.8 and 29.7, respectively. Using the methodology presented in Regulatory Guide 1.110, additional equipment can be justified if its total annual cost is less than one thousand 1975 dollars per person-rem or person-rem-thyroid saved. The smallest total annual cost per person-rem or person-rem-thyroid saved (even assuming that the equipment would totally eliminate all 50-mile population doses) is estimated to be $1,590 (1975). Since this is greater than $1000 (1975), it is concluded that no additional equipment can be justified. Thus the gaseous waste management system is judged to be designed in accordance with the applicable position of Appendix I to 10CFR50.

(Historical Information)

11.3.5 SRP Rule Review

In SRP Section 11.3, acceptance criterion II.B.6 states that all gas analyzers shall be nonsparking.

The HCGS hydrogen gas analyzers were not purchased to be nonsparking. The following HCGS hydrogen and oxygen gas analyzers were purchased to be nonsparking:

OHAAE/AT-5738 A1, A2
OHAAE/AT-5739 A1, A2

The hydrogen analyzers provided conform to industry codes and standards, and as such, provide an acceptable degree of safety for the service intended.

11.3.6 References

11.3-1 R.D. Ackley, R.E. Adams, and W.E. Browing, Jr, "The Disposal of Radioactive Fission Gases by Adsorption," CF-59-6-47, Oak Ridge National Laboratory, 1959.

11.3-2 U.S. Atomic Energy Commission, "Final Environmental Statement Concerning Proposed Rulemaking Action:- Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," WASH-1258, Directorate of Regulatory Standards, Vol 2, July 1973, p. B-61.

11.3-3 U.S. Nuclear Regulatory Commission, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors" (BWR-GALE Code), NUREG 0016, Rev. 1, January 1979.

(Historical Information)

TABLE 11.3-1

FLOW SHEET DATA

Point	Pressure, psig	Temperature, °F	H_2, lb/h/scfm	O_2, lb/h/scfm	Air, lb/h/scfm	H_2O Vapor, lb/h/scfm	Total, lb/h/scfm
1	11	238	44/154	339/77	337/70	10,847/4017	11,567/4318
2	11	221	44/154	339/77	344/75	10,847/4017	11,574/4323
3	125	353	–	–	–	338/125	338/125
4	10.2	270	44/154	339/77	344/75	10,847/4017	11,574/4323
5	9.2	693	–	–	344/75	11,244/4164	11,574/4239
6	7.8	120	–	–	344/75	25/8	369/83
7	7.5	113	–	–	344/75	18/6	362/81
8	1.6	200	–	–	344/75	18/6	362/81
9	1.4	40	–	–	344/75	1.6/0.6	345/75
10	1.38	65	–	–	344/75	1.6/0.6	345/75
11	1.18	65	–	–	344/75	1.6/0.6	345/75
12	0.62	65	–	–	344/75	1.6/0.6	345/75
13	0.5	65	–	–	344/75	1.6/0.6	345/75

(Historical Information)

TABLE 11.3-2

EXPECTED ANNUAL ACTIVITY RELEASED FROM GASEOUS WASTE MANAGEMENT SYSTEMS (Ci)
FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10CFR50

Nuclide	Reactor Building	Turbine Building	Auxiliary Building	Radwaste Building	Steam Jet Air Ejector	Mechanical Vacuum Pump	Total Annual Release
H-3	2.6E1 (1)	2.6E1	-	-	-	-	5.2E1
C-14	-	-	-	-	-	-	9.5E0
Ar-41	1.5E1	0	0	0	0	0	1.5E1
Kr-83m	0	0	0	0	0	0	0
Kr-85m	1.0E0	2.5E1	3.0E0	0	0	0	2.9E1
Kr-85	0	0	0	0	2.2E2	0	2.2E2
Kr-87	0	6.1E1	2.0E0	0	0	0	6.3E1
Kr-88	1.0E0	9.1E1	3.0E0	0	0	0	9.5E1
Kr-89	0	5.8E2	2.0E0	2.9E1	0	0	6.1E2
Xe-131m	0	0	0	0	7.0E0	0	6.7E0
Xe-133m	0	0	0	0	0	0	0
Xe-133	2.7E1	1.5E2	8.3E1	2.2E2	6.5E1	1.3E3	1.8E3
Xe-135m	1.5E1	4.0E2	4.5E1	5.3E2	0	0	9.9E2
Xe-135	3.3E1	3.3E2	9.4E1	2.8E2	0	5.0E2	1.2E3
Xe-137	4.5E1	1.0E3	1.4E2	8.3E1	0	0	1.3E3
Xe-138	2.0E0	1.0E3	6.0E0	2.0E0	0	0	1.0E3
I-131	1.1E-2	1.2E-1	2.2E-2	3.4E-3	0	8.7E-2	2.4E-1
I-133	1.6E-1	1.7E0	3.1E-1	4.8E-2	0	9.7E-1	3.2E0
Cr-51	2.0E-6	9.0E-4	9.0E-6	7.0E-6	-	1.0E-6	9.2E-4
Mn-54	4.0E-6	6.0E-4	1.0E-5	4.0E-5	-	0	6.5E-4
Co-58	1.0E-6	1.0E-3	2.0E-6	2.0E-6	-	0	1.0E-3
Fe-59	9.0E-7	1.0E-4	3.0E-6	3.0E-6	-	0	1.1E-4
Co-60	1.0E-5	1.0E-3	4.0E-5	7.0E-5	-	5.6E-7	1.1E-3
Zn-65	1.0E-5	6.0E-3	4.0E-5	3.0E-6	-	3.4E-7	6.1E-3
Sr-89	3.0E-7	6.0E-3	2.0E-7	0	-	0	6.0E-3
Sr-90	3.0E-8	2.0E-5	7.0E-8	0	-	0	2.0E-5
Nb-95	1.0E-5	6.0E-6	9.0E-5	4.0E-8	-	0	1.1E-4
Zr-95	3.0E-6	4.0E-5	7.0E-6	8.0E-6	-	0	5.8E-5
Mo-99	6.0E-5	2.0E-3	6.0E-4	3.0E-8	-	0	2.7E-3
Ru-103	2.0E-6	5.0E-5	4.0E-5	1.0E-8	-	0	9.2E-5

(Historical Information)

TABLE 11.3-2 (Cont)

Nuclide	Reactor Building	Turbine Building	Auxiliary Building	Radwaste Building	Steam Jet Air Ejector	Mechanical Vacuum Pump	Total Annual Release
Ag-110m	4.0E-9	0	2.0E-8	0	-	0	2.4E-8
Sb-124	2.0E-7	1.0E-4	3.0E-7	7.0E-7	-	0	1.0E-4
Cs-134	7.0E-6	2.0E-4	4.0E-5	2.4E-5	-	3.2E-6	2.7E-4
Cs-136	1.0E-6	1.0E-4	4.0E-6	0	-	1.9E-6	1.1E-4
CS-137	1.0E-5	1.0E-3	5.0E-5	4.0E-5	-	8.9E-6	1.1E-3
Ba-140	2.0E-5	1.0E-2	2.0E-4	4.0E-8	-	1.1E-5	1.0E-2
Ce-141	2.0E-6	1.0E-2	7.0E-6	7.0E-8	-	0	1.0E-2

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(1) $2.6E1 = 2.6X10^{1}$

TABLE 11.3-3

OFF-GAS SYSTEM MAJOR EQUIPMENT DESCRIPTION
(Design Codes and Standards are provided in Table 3.2-11)

Equipment	Equipment Numbers	Type	Quantity	Material	Capacity	Size	Design Pressure Temp, psig/°F
Preheater	00E305 10E305	Shell and straight tube	2	Shell, channel, sheet: carbon steel (CS) Tubes: stainless steel (SS)	263,600 Btu/h	182.7 ft^2 Effective area	Shell side: 175/400 Tube side: 915/400
Cooler condenser	00E306 10E306	Shell and straight tube	2	Shell, Sheet, Channel: CS Tubes: SS	$16.07x10^6$ Btu/h	904.1 ft^2 Effective area	Shell side: 780/800 Tube side: 225/300
Recombiner	00S312 10S312	Spherical shell	2	Shell: SS Internals: Catalyst support Assembly: SS Catalyst: Palladium-coated, ceramic-base , pellet-type	2200 lb Catalyst	Vessel I.D. 78 in. Catalyst: 78 in. dia, 16 in. deep	450/900 (Vessel)
Holdup pipe	None	Straight pipe	8	CS	N/A	24 in. dia x 55' long	400/850
Outlet HEPA filter	00F327	Vertical cylinder	1	Vessel: cs Internals: C-size filter element	150 scfm at 1.2 psi	Vessel: 54 in. high, 14 in. dia Cartr: 13 in. high 11.25 in. dia	445/150
Glycol cooler condenser	00E374	Shell and circular tube	1	Glycol vessel:cs Process tubes:ss Freon tubes: Copper	56,700 Btu/h 96 in. high	Glycol vessel: 72 in. dia, 193 ft^2 Effective area (freon coil) 280 ft^2 Effective area (process gas)	Shell side: 0/150 Tube side: 715/150
Guard bed vessel	00T385	Vertical cylinder	1	CS	200 lb charcoal	31 in. diam x 80 in. high	280/150

(Historical Information)

TABLE 11.3-3 (Cont)

Equipment	Equipment Numbers	Type	Quantity	Material	Capacity	Size	Design Pressure Temp, psig/°F
Charcoal adsorber vessels	OAT384 thru OHT384, OJT384, OKT384	Vertical cylinder	10	CS	32,200 lb charcoal each	96 in. dia x 312 in. high	410/200
Charcoal bed	None	Sutcliffe Speakman 203C	322,000 lb	Activated charcoal	Adsorb coeff at design temp Xe: 733, Kr: 31.8	Mesh size 8 by 16	N/A
Refrigeration units (glycol)	OAS346 OBS346	Open	2	Freon 22 refrigerant	64,400 Btu/h	N/A	N/A
Refrigeration units (compartment cooling)	OAS348 OBS348	Open	2	Freon 22 refrigerant	127,000 Btu/h	N/A	N/A

(Historical Information)

TABLE 11.3-4

OFF-GAS SYSTEM EQUIPMENT MALFUNCTION ANALYSIS

Equipment Item	Malfunction	Consequences	Design Precautions
Piping from SJAE to and including holdup pipe	Pressure boundary leakage	Increased local airborne radioactivity levels and increased releases from plant ventilation	Ventilation releases will be monitored and alarmed. The vent gas will then be filtered by the radwaste exhaust system. Low pressure system, radiographed welds, and system is designed to withstand hydrogen detonation
Recombiner preheater	Steam leak from shell side into tube side	Increased preheater outlet temperature/increased quantity of steam in process stream	Temperature elements at pre-heater outlet regulate steam flow to preheater/additional steam flow is condensed in the cooler condenser and returned to the main condenser
	Steam failure	Recombiner preheater cools down, increasing the moisture level in the recombiner, reducing catalyst activity and causing hydrogen con-concentration to rise at the recombiner outlet	An alarm will occur as recombiner feed temperature drops, alarm will also sound on increased hydrogen concentration downstream of re-combiner (1.5 percent).
Recombiners	Catalyst deteriorates or is wetted	Recombiner outlet temperature drops/high hydrogen concentration at recombiner outlet	Recombiner temperature monitors record low temperature and alarm/analyzers record hydrogen level and alarm at 1.5 percent.
Cooler condenser	Cooling water leak (tube to shell side)	The cooling water leaks to the shell side of the heat exchanger. Liquid level in cooler condenser shell drain rises	Liquid level instruments alarm on high levels in cooler condenser. Additional liquid automatically drains to CRW
	Liquid level instrument fails	Cooler condenser shell drain level drops	Redundant level instrument alarms on low level in cooler condenser/redundant level control valve closes
	Cooling water failure	Increased cooler condenser outlet temperature	Temperature element at cooler condenser outlet alarms and shuts down the recombiner system

(Historical Information)

TABLE 11.3-4 (Cont)

Equipment Item	Malfunction	Consequences	Design Precautions
Off-gas system main process piping	Pressure boundary leakage	Release of offgas mixture to radwaste enclosure	Ventilation monitors in ducts from the off-gas area will detect leakage from off-gas piping
Glycol cooler condenser	Refrigerator failure	If glycol unit fails, the moisture content of the process stream will increase, resulting in decreased adsorption	The failure of the refrigerator will actuate alarms at a local panel and at the main control room panel system trouble alarm. A redundant glycol refrigeration unit is installed. Moisture instrumentation and temperature instrumentation are provided at the cooler condenser outlet. High outlet temperature and high moisture are alarmed at the local panel and in the main control room. High thermal inertia of glycol bath is provided
Charcoal adsorbers	Moisture in gas stream	Charcoal adsorption performance will deteriorate gradually as charcoal gets wet. Holdup times decrease and plant gaseous releases will increase	Increasing moisture in inlet stream will be detected by the moisture element. Various design precautions are included upstream to preclude moisture from entering adsorbers. Sacrificial guard beds are provided to protect main adsorber vessels
Charcoal vault air conditioning units	Mechanical failure of refrigeration units or air coolers	If ambient temperature increases, delay efficiency of charcoal beds decreases. Increased releases would occur depending on the fuel leakage rate	Redundant air conditioning units are provided. A redundant fan and cooler is provided for each cell High and low ambient temperature alarms in main control room and local panel. Ambient temperature is recorded at the local panel. There is a refrigeration trouble alarm in main control room and local panel. Refrigeration system capacity is oversized for heat load
Outlet HEPA filter	Plugging of filter media	Increasing differential pressure in HEPA will create higher system back pressure. SJAE bypass valve may open recycling offgas back to main condenser	Differential pressure is alarmed at the local panel, in main control room and indicated at the local panel. DOP test connections are provided. HEPA filter can be bypassed for servicing

(Historical Information)

TABLE 11.3-5

EXPECTED ACTIVITY CONCENTRATIONS AT THE SITE BOUNDARY FOR EVALUATION OF GASEOUS RELEASES (BASED ON 10CFR20 1988 EDITION)

Isotope	Concentration, μCi/ml(1)	MPC, μCi/ml 10 CFR 20 Table II, Column 1	Fraction of MPC	Annual external whole body dose (mrem)
I-131	2E-14	1E-10	2E-4	6E-5
I-133	3E-13	4E-10	8E-4	1E-3
H-3	4E-12	2E-7	2E-5	-
C-14	7E-13	1E-7	7E-6	-
Ar-41	1E-12	4E-8	3E-5	1E-2
Kr-85m	2E-12	1E-7	2E-5	3E-3
Kr-85	2E-11	3E-7	7E-5	3E-4
Kr-87	5E-12	2E-8	3E-4	3E-2
Kr-88	7E-12	2E-8	4E-4	1E-1
Kr-89	5E-11	3E-6	2E-5	9E-1
Xe-131m	5E-13	4E-7	1E-6	8E-5
Xe-133	1E-10	3E-7	3E-4	4E-2
Xe-135	8E-11	3E-6	3E-5	3E-1
Xe-135m	9E-11	1E-7	9E-4	2E-1
Xe-137	1E-10	3E-6	3E-5	2E-1
Xe-138	8E-11	3E-6	3E-5	7E-1
Cr-51	7E-17	8E-8	9E-10	2E-8
Mn-54	5E-17	1E-9	5E-8	3E-7
Co-58	8E-17	2E-9	4E-8	6E-7
Fe-59	9E-18	2E-9	5E-9	8E-8
Co-60	9E-17	3E-10	3E-7	2E-6
Zn-65	5E-16	2E-9	3E-7	2E-6
Sr-89	5E-16	3E-10	2E-6	3E-10
Sr-90	2E-18	3E-11	7E-8	-
Nb-95	9E-18	3E-9	3E-9	5E-8

(Historical Information)

TABLE 11.3-5 (Cont)

Isotope	Concentration, μCi/ml[1]	MPC, μCi/ml 10 CFR 20 Table II, Column 1	Fraction of MPC	Annual external whole body dose (mrem)
Zr-95	5E-18	1E-9	5E-9	3E-8
Mo-99	2E-16	7E-9	3E-8	2E-7
Ru-103	7E-18	3E-9	2E-9	3E-8
Ag-110m	2E-21	3E-10	7E-12	4E-11
Sb-124	8E-18	7E-10	1E-8	1E-7
Cs-134	2E-17	4E-10	5E-8	3E-7
Cs-136	9E-18	6E-9	2E-9	2E-7
Cs-137	9E-17	5E-10	2E-7	4E-7
Ba-140	8E-16	1E-9	8E-7	1E-6
Ce-141	8E-16	5E-9	2E-7	4E-7
Total			3E-3	2E0

(1) Concentrations have been adjusted to reflect the fact that the releases presented in Table 11.3-1 are based on 50,000 μCi/s noble gas off-gas rate at 30 minute delay. The concentrations in this table are based on a 500,000 μCi/s rate.

TABLE 11.3-6

INPUT DATA FOR ATMOSPHERIC DOSE CALCULATIONS

HOPE CREEK GENERATING STATION-AIR DOSE CALCULATIONS

640.0 0.5 0.66 0.5 0.33 8.0

YEAR 2010 POPULATION DATA FOR HCGS (HCGS FSAR)

6 10

N	0.0	0.0	0.0	0.0	0.0	455.0	
	97200.0	111400.0	117600.0	320500.0			
NNE		0.0	0.0	0.0	0.0	36.0	9802.0
	22600.0	148800.0	1198200.0	1306900.0			
NE		0.0	0.0	0.0	7.0	357.0	2268.0
	8800.0	53000.0	389200.0	602800.0			
ENE		0.0	0.0	0.0	62.0	89.0	1205.0
	7400.0	35300.0	71700.0	47500.0			
E	0.0	0.0	0.0	0.0	0.0	1062.0	
	24400.0	59100.0	48300.0	28100.0			
ESE		0.0	0.0	0.0	0.0	0.0	509.0
	13400.0	19800.0	12700.0	27900.0			
SE		0.0	0.0	0.0	0.0	0.0	45.0
	1100.0	1200.0	0.0	33800.0			
SSE		0.0	0.0	0.0	0.0	0.0	191.0
	0.0	200.0	700.0	22000.0			
S	0.0	0.0	0.0	0.0	23.0	369.0	
	13500.0	39100.0	13600.0	4800.0			
SSW		0.0	0.0	0.0	15.0	0.0	229.0
	23900.0	14700.0	27200.0	15600.0			
SW		0.0	0.0	0.0	0.0	30.0	691.0
	25700.0	5900.0	15400.0	8700.0			
WSW		0.0	0.0	0.0	0.0	15.0	1151.0
	20100.0	3300.0	10000.0	10500.0			
W	0.0	0.0	0.0	15.0	38.0	4065.0	
	16900.0	1300.0	49500.0	259400.0			
WNW		0.0	0.0	0.0	129.0	30.0	534.0
	21400.0	23700.0	46400.0	18100.0			
NW		0.0	0.0	0.0	99.0	220.0	915.0
	67400.0	30100.0	16400.0	31500.0			
NNW		0.0	0.0	0.0	4.0	296.0	2424.0
	62400.0	118700.0	49700.0	41300.0			

TABLE 11.3-6 (Cont)

HCGS AREA MILK PRODUCTION – DRESDNER 1982 SURVEY

	6 10						
N	0.0	0.0	0.0	0.0	0.0	0.0	
	2.43E6	1.96E6	2.90E4	4.90E4			
NNE		0.0	0.0	0.0	0.0	1.40E4	2.15E6
	8.10E6	3.73E6	2.00E3	4.00E3			
NE		0.0	0.0	0.0	0.0	6.00E3	1.71E6
	8.10E6	2.93E6	1.30E6	2.50E6			
ENE		0.0	0.0	0.0	0.0	0.0	6.83E6
	5.55E6	4.55E6	1.36E6	2.98E6			
E	0.0	0.0	0.0	0.0	0.0	1.43E6	
	1.22E6	2.43E6	7.34E5	2.16E5			
ESE		0.0	0.0	0.0	0.0	0.0	0.0
	8.10E5	5.24E5	8.03E5	2.61E5			
SE		0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	3.00E3			
SSE		0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	3.26E5			
S	0.0	0.0	0.0	0.0	0.0	0.0	
	3.13E6	4.68E6	8.13E6	4.75E6			
SSW		0.0	0.0	0.0	0.0	0.0	7.00E3
	3.90E6	5.33E6	1.20E7	1.39E7			
SW		0.0	0.0	0.0	0.0	7.00E3	4.59E5
	6.71E6	7.40E6	7.52E6	5.13E6			
WSW		0.0	0.0	0.0	0.0	0.0	2.48E6
	6.73E6	3.42E7	9.56E6	1.59E6			
W	0.0	0.0	0.0	0.0	4.45E5	3.48E5	
	1.95E6	3.99E6	1.05E7	1.13E7			
WNW		0.0	0.0	0.0	0.0	5.13E5	2.23E6
	2.05E6	1.99E6	1.65E7	3.09E7			
NW		0.0	0.0	0.0	0.0	0.0	1.70E6
	2.00E6	9.97E6	5.70E4	1.26E5			
NNW		0.0	0.0	0.0	0.0	0.0	0.0
	9.72E5	2.94E6	1.97E6	6.90E4			

TABLE 11.3-6 (Cont)

HCGS AREA MEAT PRODUCTION - DRESDNER 1982 SURVEY (INCLUDES POULTRY)

6 10

N	0.0	0.0	0.0	0.0	0.0	0.0	2.63E5	1.90E6	4.95E6	7.80E6
NNE	0.0	0.0	0.0	0.0	1.40E3	1.28E5	1.37E6	8.34E5	6.19E5	8.63E5
NE	0.0	0.0	0.0	0.0	1.00E2	1.33E5	2.11E6	7.49E5	8.85E6	3.53E5
ENE	0.0	0.0	0.0	0.0	0.0	1.26E5	9.06E5	6.75E5	9.09E5	4.71E5
E	0.0	0.0	0.0	0.0	0.0	1.09E5	3.05E5	4.94E5	2.95E5	1.15E5
ESE	0.0	0.0	0.0	0.0	0.0	1.17E5	2.42E5	1.57E5	2.88E5	2.05E5
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.34E5
S	0.0	0.0	0.0	0.0	0.0	0.0	1.04E6	1.62E6	3.17E6	4.21E5
SSW	0.0	0.0	0.0	0.0	0.0	1.50E5	1.11E6	1.18E6	1.24E5	1.32E6
SW	0.0	0.0	0.0	0.0	0.0	1.50E5	9.85E5	5.50E6	5.83E6	1.29E4
WSW	0.0	0.0	0.0	0.0	0.0	1.58E5	6.84E5	2.91E5	2.98E4	1.50E3
W	0.0	0.0	0.0	0.0	1.80E3	1.56E5	6.98E4	3.80E3	6.00E3	1.03E4
WNW	0.0	0.0	0.0	0.0	7.00E2	0.0	6.58E4	9.90E3	2.86E4	3.17E5
NW	0.0	0.0	0.0	0.0	0.0	0.0	5.58E4	5.01E6	1.51E7	2.88E7
NNW	0.0	0.0	0.0	0.0	0.0	0.0	1.11E4	1.59E5	1.83E5	4.45E6

TABLE 11.3-6 (Cont)

HCGS AREA VEGETABLE PRODUCTION - DRESDNER 1982 SURVEY (INCLUDES POTATOES)

6 10

N	0.0	0.0	0.0	0.0	0.0	0.0	1.51E6	2.84E6	7.53E5	1.27E6
NNE	0.0	0.0	0.0	0.0	0.0	2.63E5	2.02E6	1.42E6	1.05E5	3.89E5
NE	0.0	0.0	0.0	0.0	0.0	2.95E5	2.04E6	1.49E6	2.38E6	1.52E6
ENE	0.0	0.0	0.0	0.0	0.0	2.55E5	3.26E6	2.76E6	5.68E6	3.88E6
E	0.0	0.0	0.0	0.0	0.0	5.78E5	2.52E6	3.27E6	5.98E6	4.25E6
ESE	0.0	0.0	0.0	0.0	0.0	8.62E5	5.05E5	5.02E5	1.36E6	3.63E6
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.24E5	0.0
SSE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00E6
S	0.0	0.0	0.0	0.0	0.0	0.0	3.03E6	4.55E6	1.16E7	7.06E6
SSW	0.0	0.0	0.0	0.0	0.0	1.25E5	3.54E6	5.13E6	1.55E7	1.36E7
SW	0.0	0.0	0.0	0.0	0.0	1.70E5	4.59E6	5.32E6	7.06E6	1.30E7
WSW	0.0	0.0	0.0	0.0	0.0	1.46E5	3.31E6	6.34E6	3.59E6	9.31E5
W	0.0	0.0	0.0	0.0	0.0	1.62E5	2.77E6	1.25E5	1.68E6	1.23E6
WNW	0.0	0.0	0.0	0.0	0.0	0.0	2.64E6	5.14E5	2.57E6	3.74E6
NW	0.0	0.0	0.0	0.0	0.0	0.0	2.51E6	2.14E5	1.76E6	2.01E6
NNW	0.0	0.0	0.0	0.0	0.0	0.0	4.29E5	3.77E6	3.16E6	1.61E6

(Historical Information)

TABLE 11.3-6 (Cont)

HCGS SINGLE UNIT SOURCE TERM WITH MULTIPLIER OF 1.0

	1.0
I 131	2.4E-1
I 133	3.2E00
H 3	5.2E01
C 14	9.5E00
AR41	1.5E01
KR85M	2.9E01
KR85	2.2E02
KR87	6.3E01
KR88	9.5E01
KR89	6.1E02
XE131M	6.7E00
XE133	1.8E03
XE135M	9.9E02
XE135	1.2E03
XE137	1.3E03
XE138	1.0E03
CR51	9.2E-4
MN54	6.5E-4
CO58	1.0E-3
FE59	1.1E-4
CO60	1.1E-3
ZN65	6.1E-3
SR89	6.0E-3
SR90	2.0E-5
NB95	1.1E-4
ZR95	5.8E-5
MO99	2.7E-3
RU103	9.2E-5
AG110M	2.4E-8
SB124	1.0E-4
CS134	2.7E-4
CS136	1.1E-4
CS137	1.1E-3
BA140	1.0E-2
CE141	1.0E-2

TABLE 11.3-6 (Cont)

HCGS GROUND LEVEL X/Q (NORMAL) - HOPE CREEK GROUND LEVEL RELEASE

	6						
N	2.140E-06	4.529E-07	2.124E-07	1.300E-07	9.196E-08	4.526E-08	
	1.717E-08	8.384E-09	5.224E-09	3.668E-09			
NNE		1.819E-06	3.913E-07	1.841E-07	1.126E-07	7.958E-08	3.911E-08
	1.480E-08	7.208E-09	4.483E-09	3.144E-09			
NE		1.942E-06	4.153E-07	1.960E-07	1.203E-07	8.530E-08	4.217E-08
	1.608E-08	7.872E-09	4.913E-09	3.454E-09			
ENE		1.650E-06	3.524E-07	1.661E-07	1.017E-07	7.191E-08	3.539E-08
	1.343E-08	6.545E-09	4.075E-09	2.860E-09			
E	1.900E-06	4.042E-07	1.890E-07	1.151E-07	8.111E-08	3.964E-08	
	1.490E-08	7.231E-09	4.488E-09	3.142E-09			
ESE		2.016E-06	4.288E-07	2.001E-07	1.215E-07	8.544E-08	4.158E-08
	1.554E-08	7.507E-09	4.646E-09	3.247E-09			
SE		2.584E-06	5.589E-07	2.169E-07	1.592E-07	1.120E-07	5.459E-08
	2.041E-08	9.863E-09	6.103E-09	4.263E-09			
SSE		1.923E-06	4.122E-07	1.925E-07	1.169E-07	8.220E-08	3.998E-08
	1.492E-08	7.205E-09	4.456E-09	3.112E-09			
S	2.665E-06	5.697E-07	2.700E-07	1.657E-07	1.174E-07	5.798E-08	
	2.206E-08	1.078E-08	6.720E-09	4.719E-09			
SSW		2.116E-06	4.514E-07	2.133E-07	1.309E-07	9.272E-08	4.576E-08
	1.741E-08	8.507E-09	5.302E-09	3.724E-09			
SW		2.113E-06	4.493E-07	2.123E-07	1.305E-07	9.258E-08	4.582E-08
	1.750E-08	8.577E-09	5.356E-09	3.767E-09			
WSW		1.531E-06	3.276E-07	1.549E-07	9.508E-08	6.739E-08	3.328E-08
	1.267E-08	6.191E-09	3.860E-09	2.711E-09			
W	1.456E-06	3.130E-07	1.489E-07	9.183E-08	6.531E-08	3.248E-08	
	1.247E-08	6.132E-09	3.836E-09	2.701E-09			
WNW		1.243E-06	2.630E-07	1.260E-07	7.841E-08	5.616E-08	2.832E-08
	1.107E-08	5.510E-09	3.474E-09	2.460E-09			
NW		2.635E-06	5.355E-07	2.541E-07	1.589E-07	1.142E-07	5.806E-08
	2.298E-08	1.156E-08	7.336E-09	5.222E-09			
NNW		2.115E-06	4.403E-07	2.066E-07	1.269E-07	9.001E-08	4.458E-08
	1.707E-08	8.389E-09	5.251E-09	3.699E-09			

TABLE 11.3-6 (Cont)

HCGS GROUND LEVEL X/Q (NORMAL) - IN PLACE OF DECAYED X/Q

	6	10					
N	2.140E-06	4.528E-07	2.124E-07	1.300E-07	9.196E-08	4.526E-08	
	1.717E-08	8.384E-09	5.224E-09	3.668E-09			
NNE		1.819E-06	3.913E-07	1.841E-07	1.126E-07	7.958E-08	3.911E-08
	1.480E-08	7.208E-09	4.483E-09	3.144E-09			
NE		1.942E-06	4.153E-07	1.960E-07	1.203E-07	8.530E-08	4.217E-08
	1.608E-08	7.872E-09	4.913E-09	3.454E-09			
ENE		1.650E-06	3.524E-07	1.661E-07	1.017E-07	7.191E-08	3.539E-08
	1.342E-08	6.545E-09	4.075E-09	2.860E-09			
E	1.900E-06	4.042E-07	1.890E-07	1.151E-07	8.111E-08	3.964E-08	
	1.490E-08	7.231E-09	4.488E-09	3.142E-09			
ESE		2.016E-06	4.288E-07	2.001E-07	1.215E-07	8.544E-08	4.158E-08
	1.554E-08	7.507E-09	4.646E-09	3.247E-09			
SE		2.584E-06	5.589E-07	2.619E-07	1.592E-07	1.120E-07	5.459E-08
	2.041E-08	9.863E-09	6.103E-09	4.263E-09			
SSE		1.923E-06	4.122E-07	1.925E-07	1.169E-07	8.220E-08	3.998E-08
	1.492E-08	7.205E-09	4.456E-09	3.112E-09			
S	2.665E-06	5.697E-07	2.700E-07	1.657E-07	1.174E-07	5.798E-08	
	2.206E-08	1.078E-08	6.720E-09	4.719E-09			
SSW		2.116E-06	4.514E-07	2.133E-07	1.309E-07	9.272E-08	4.576E-08
	1.741E-08	8.507E-09	5.302E-09	3.724E-09			
SW		2.113E-06	4.493E-07	2.123E-07	1.305E-07	9.258E-08	4.582E-08
	1.750E-08	8.577E-09	5.356E-09	3.767E-09			
WSW		1.531E-06	3.276E-07	1.549E-07	9.508E-08	6.739E-08	3.328E-08
	1.267E-08	6.191E-09	3.860E-09	2.711E-09			
W	1.456E-06	3.130E-07	1.489E-07	9.183E-08	6.531E-08	3.248E-08	
	1.247E-08	6.132E-09	3.836E-09	2.701E-09			
WNW		1.243E-06	2.630E-07	1.260E-07	7.841E-08	5.616E-08	2.832E-08
	1.107E-08	5.510E-09	3.474E-09	2.460E-09			
NW		2.635E-06	5.355E-07	2.541E-07	1.589E-07	1.142E-07	5.806E-08
	2.298E-08	1.156E-08	7.336E-09	5.222E-09			
NNW		2.115E-06	4.403E-07	2.066E-07	1.269E-07	9.001E-08	4.458E-08
	1.707E-08	8.389E-09	5.251E-09	3.699E-09			

TABLE 11.3-6 (Cont)

HCGS GROUND LEVEL X/Q (DEPLETED) - HOPE CREEK SOUTH VENT

	6	10					
N	1.942E-06	3.741E-07	1.671E-07	9.898E-08	6.831E-08	3.118E-08	
	1.006E-08	4.358E-09	2.510E-09	1.662E-09			
NNE		1.650E-06	3.233E-07	1.448E-07	8.570E-08	5.192E-08	2.695E-08
	8.669E-09	3.746E-09	2.154E-09	1.424E-09			
NE		1.762E-06	3.432E-07	1.542E-07	9.160E-08	6.337E-08	2.905E-08
	9.418E-09	4.092E-09	2.360E-09	1.564E-09			
ENE		1.497E-06	2.912E-07	1.306E-07	7.739E-08	5.342E-08	2.438E-08
	7.860E-09	3.402E-09	1.958E-09	1.295E-09			
E	1.724E-06	3.340E-07	1.486E-07	8.762E-08	6.026E-08	2.731E-08	
	8.730E-09	3.758E-09	2.156E-09	1.423E-09			
ESE		1.829E-06	3.543E-07	1.574E-07	9.252E-08	6.347E-08	2.864E-08
	9.102E-09	3.902E-09	2.232E-09	1.471E-09			
SE		2.344E-06	4.618E-07	2.060E-07	1.212E-07	8.322E-08	3.761E-08
	1.196E-08	5.127E-09	2.932E-09	1.931E-09			
SSE		1.745E-06	3.406E-07	1.514E-07	8.900E-08	6.106E-08	2.754E-08
	8.743E-09	3.745E-09	2.141E-09	1.410E-09			
S	2.418E-06	4.708E-07	2.123E-07	1.261E-07	8.723E-08	3.995E-08	
	1.292E-08	5.604E-09	3.228E-09	2.138E-09			
SSW		1.920E-06	3.730E-07	1.678E-07	9.962E-08	6.888E-08	3.153E-08
	1.020E-08	4.422E-09	2.547E-09	1.687E-09			
SW		1.917E-06	3.712E-07	1.670E-07	9.934E-08	6.878E-08	3.157E-08
	1.025E-08	4.458E-09	2.573E-09	1.706E-09			
WSW		1.389E-06	2.707E-07	1.218E-07	7.238E-08	5.006E-08	2.293E-08
	7.419E-09	3.218E-09	1.854E-09	1.228E-09			
W	1.321E-06	2.586E-07	1.171E-07	6.990E-08	4.852E-08	2.238E-08	
	7.306E-09	3.187E-09	1.843E-09	1.223E-09			
WNW		1.128E-06	2.173E-07	9.908E-08	5.968E-08	4.172E-08	1.951E-08
	6.483E-09	2.864E-09	1.669E-09	1.114E-09			
NW		2.391E-06	4.425E-07	1.998E-07	1.210E-07	8.484E-08	4.000E-08
	1.346E-08	6.006E-09	3.524E-09	2.365E-09			
NNW		1.919E-06	3.639E-07	1.625E-07	9.662E-08	6.687E-08	3.072E-08
	9.998E-09	4.360E-09	2.522E-09	1.676E-09			

TABLE 11.3-6 (Cont)

HCGS D/Q CORRECTED FOR DEPLETION - HOPE CREEK SOUTH VENT
6 10

N	1.259E-08	2.025E-09	8.327E-10	4.638E-10	2.995E-10	1.232E-10	
	3.689E-11	1.505E-11	8.159E-12	5.164E-12			
NNE		1.104E-08	1.777E-09	7.306E-10	4.069E-10	2.628E-10	1.081E-10
	3.237E-11	1.321E-11	7.159E-12	4.531E-12			
NE		1.085E-08	1.746E-09	7.180E-10	3.999E-10	2.583E-10	1.062E-10
	3.181E-11	1.298E-11	7.036E-12	4.453E-12			
ENE		1.040E-08	1.673E-09	6.879E-10	3.831E-10	2.474E-10	1.018E-10
	3.047E-11	1.244E-11	6.741E-12	4.266E-12			
E	1.400E-08	2.251E-09	9.259E-10	5.157E-10	3.331E-10	1.370E-10	
	4.102E-11	1.674E-11	9.073E-12	5.742E-12			
ESE		1.625E-08	2.614E-09	1.075E-09	9.986E-10	3.866E-10	1.590E-10
	4.762E-11	1.943E-11	1.053E-11	6.666E-12			
SE		2.091E-08	3.364E-09	1.383E-09	7.705E-10	4.976E-10	2.046E-10
	6.128E-11	2.501E-11	1.356E-11	8.579E-12			
SSE		1.271E-08	2.044E-09	8.407E-10	4.682E-10	3.024E-10	1.244E-10
	3.724E-11	1.520E-11	8.237E-12	5.214E-12			
S	1.442E-08	2.320E-09	9.540E-10	5.313E-10	3.431E-10	1.411E-10	
	4.226E-11	1.724E-11	9.347E-12	5.916E-12			
SSW		1.089E-08	1.752E-09	7.204E-10	4.012E-10	2.591E-10	1.066E-10
	3.191E-11	1.302E-11	7.059E-12	4.468E-12			
SW		1.003E-08	1.613E-09	6.635E-10	3.695E-10	2.387E-10	9.814E-11
	2.939E-11	1.199E-11	6.501E-12	4.115E-12			
WSW		6.435E-09	1.035E-09	4.257E-10	2.371E-10	1.531E-10	6.297E-11
	1.886E-11	7.695E-12	4.171E-12	2.640E-12			
W	5.638E-09	9.069E-10	3.729E-10	2.077E-10	1.341E-10	5.517E-11	
	1.652E-11	6.742E-12	3.654E-12	2.313E-12			
WNW		4.962E-09	7.982E-10	3.282E-10	1.828E-10	1.181E-10	4.856E-11
	1.454E-11	5.934E-12	3.216E-12	2.036E-12			
NW		1.650E-08	2.655E-09	1.092E-09	6.080E-10	3.927E-10	1.615E-10
	4.836E-11	1.974E-11	1.070E-11	6.771E-12			
NNW		1.325E-08	2.132E-09	8.768E-10	4.883E-10	3.154E-10	1.297E-10
	3.884E-11	1.585E-11	8.591E-12	5.437E-12			
	1RESIDENCE #1	E	3.3	1.433E-07	1.433E-07	1.107E-07	6.743E-10
	1RESIDENCE #2	NW	3.7	1.477E-07	1.477E-07	1.119E-07	5.520E-10
	1BIOTA LOC.	NW	0.4	8.218E-06	8.218E-06	7.650E-06	4.887E-08
	1COW LOC. #1	NE	4.0	1.003E-07	1.003E-07	7.533E-08	3.170E-10
	1COW LOC. #2	NNE	4.5	7.958E-08	7.958E-08	5.912E-08	2.628E-10

(Historical Information)

TABLE 11.3-7

RELEASE POINT DATA

	North Plant Vent	South Plant Vent
Height of release point above grade, ft	115	115
Rate of air flow from release point, cfm	41,900 (summer)	440,180 (summer)
	41,900 (winter)	305,680 (winter)
Average Temperature, °F	106 (summer)	106.5 (summer)
	106 (winter)	90 (winter)
Exit Velocity, fpm	1000 (summer)	3060 (summer)
	1000 (winter)	2125 (winter)
Heat flow from release point, Btu/h	0.5×10^6 (summer)	5.8×10^6 (summer)
	4.6×10^6 (winter)	3.0×10^7 (winter)
Type and size of release point	Duct liner 7' x 6'	Duct liner 12' x 12'

(Historical Information)

TABLE 11.3-8

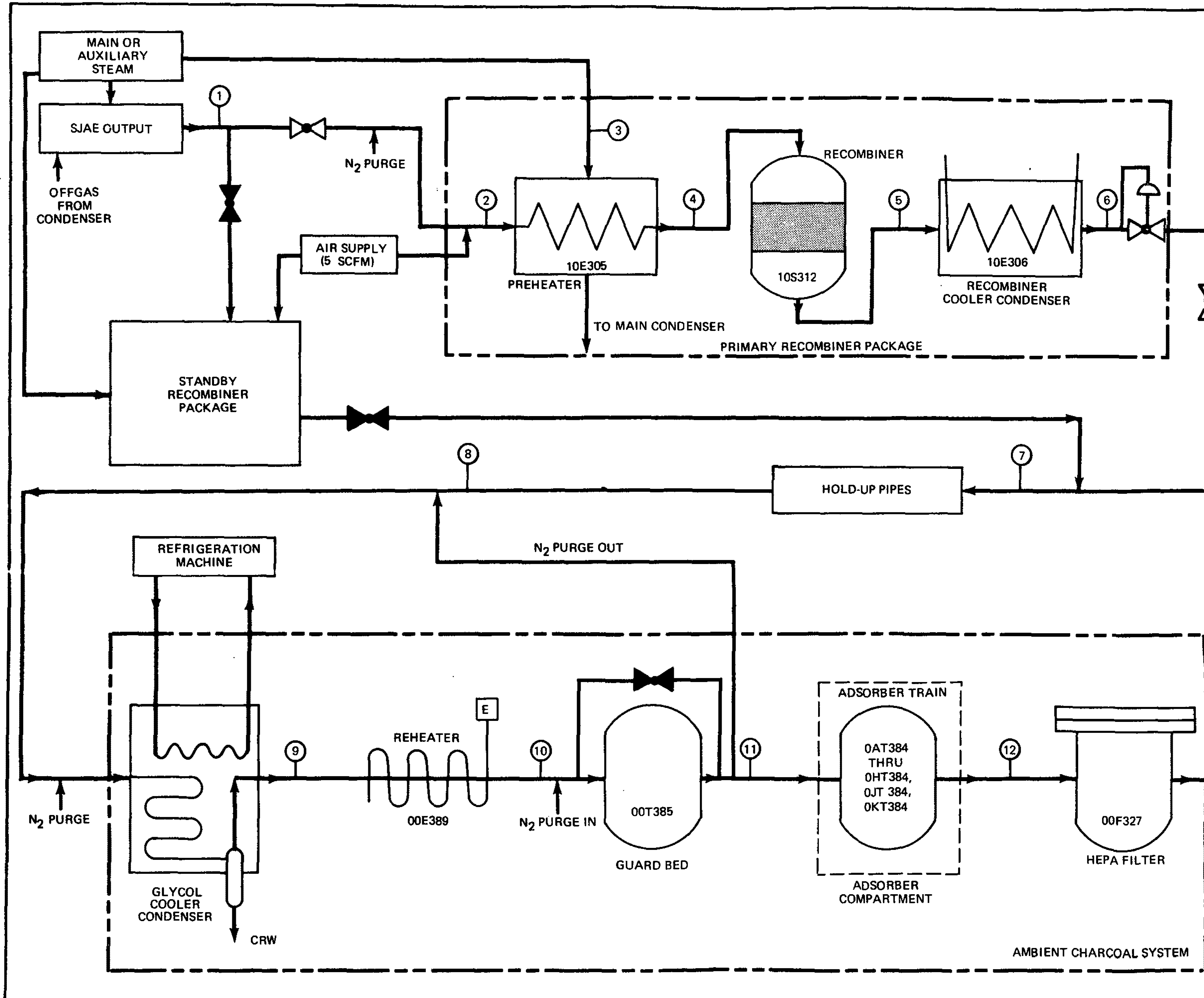
DECONTAMINATION FACTORS ASSUMED AND THE BASES
(INCLUDES CHARCOAL ADSORBERS, HEPA FILTERS,
AND MECHANICAL DEVICES)

Parameter	Value
Reactor Building	
Iodine release fraction (no charcoal adsorber)	1.0
Particulate release Fraction (HEPA)	0.01
Auxiliary Building	
Iodine release fraction (no charcoal adsorber)	1.0
Particulate release Fraction (HEPA)	0.01
Turbine Building	
Iodine release fraction (no charcoal adsorber)	1.0
Particulate release Fraction (no HEPA)	1.0
Radwaste Area	
Iodine release fraction (no charcoal adsorber)	0.3
Particulate release Fraction (HEPA)	0.01

(Historical Information)

TABLE 11.3-8 (Cont)

Parameter	Value
Mechanical Vacuum Pump (Through the turbine building ventilation system)	
Iodine release fraction (no charcoal adsorber)	1.0
Particulate release Fraction (no HEPA)	1.0



REVISION 0
APRIL 11, 1988

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK NUCLEAR GENERATING STATION

OFFGAS SYSTEM – PROCESS FLOW DIAGRAM

UPDATED FSAR

FIGURE 11.3-1

Figure F11.3-2 intentionally deleted.

Refer to Plant Drawing M-69-0 SH 1 in DCRMS

Figure F11.3-3 intentionally deleted.

Refer to Plant Drawing M-69-0 SH 2 in DCRMS

Figure F11.3-4 intentionally deleted.

Refer to Plant Drawing M-70-0 SH 1 in DCRMS

Figure F11.3-5 intentionally deleted.

Refer to Plant Drawing M-70-0 SH 2 in DCRMS

Figure F11.3-6 intentionally deleted.

Refer to Plant Drawing P-9329-0 in DCRMS

Figure F11.3-7 intentionally deleted.

Refer to Plant Drawing P-9378-0 in DCRMS

11.4 SOLID WASTE MANAGEMENT SYSTEM

The Solid Waste Management System (SWMS) collects and processes wet and dry radioactive wastes generated by the plant, packages and monitors the resultant solid radioactive product, and provides temporary storage facilities prior to offsite shipment and permanent disposal. The SWMS does not have any safety-related function. Process and effluent radiological monitoring systems are discussed in Section 11.5.

Automatic fire protection sprinkler systems are provided for the solid radwaste areas. Details of the Fire Protection System are provided in Section 9.5.1.

11.4.1 Design Bases

11.4.1.1 Design Objectives

The design objectives of the Solid Waste Management System (SWMS) are to:

1. Provide collection, processing, packaging, and storage of resin and filter media slurries, and dry trash resulting from normal plant operations without limiting the operation or availability of the plant.

2. Provide reliable means for handling solid wastes and allow system operation while maintaining radiation exposure to plant personnel as low as is reasonably achievable (ALARA).

3. Package solid wastes in DOT-approved containers for offsite shipment and burial.

4. Prevent the release of significant quantities of radioactive materials to the environment so as to keep the overall exposure to the public well within 10CFR20 limits and in accordance with the limits specified in 10CFR50.

(Historical Information)

11.4.1.2 Design Criteria

1. Redundant and backup equipment, alternate process schemes, and interconnections are designed into the system to provide for operational occurrences such as refueling, abnormal leak rates, decontamination activities, equipment downtime, maintenance, and repair.

2. Equipment compartments, drainage, ventilation, and components are designed to reduce maintenance, equipment downtime, leakage, and gaseous releases of radioactive materials to the atmosphere and to improve system operations.

3. The SWMS is designed to package the wet and dry types of radioactive solid waste for offsite shipment and burial, in accordance with the requirements of applicable NRC and DOT regulations, including 10CFR61 and 71 and 49CFR170 through 178. This results in radiation exposures to individuals and the general population well within the limits of 10CFR20 and 50.

4. The seismic and quality group classification and corresponding codes and standards that apply to the design of the SWMS components and piping, and the structures housing the system are discussed in Section 3.2.

5. The expected and maximum radionuclide activity inventories of the SWMS components containing significant amounts of radioactive material are set forth in Tables 11.4-5, 11.4-6, and 11.4-9.

    a. Expected flow rates for streams shown on Figure 11.4-10 are set forth in Table 11.4-7.

    b. The design basis of the solid waste management system are set forth in Table 11.4-1.

(Historical Information)

6. Temporary storage space for over one month's volume of solidified waste, plus contingency, is provided in the Auxiliary Building. There is temporary storage capability for 233 55-gallon drums of solidified waste in the Auxiliary Building. In addition, there is temporary storage capability for 63 100-ft^3 boxes of compacted waste in the Auxiliary Building. There is also capacity to store up to 65,750 ftE3 of packaged radwaste that meets DOT and NRC shipping requirements.

7. All atmospheric collection and storage tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is routed to the nearest drainage system compatible with its purity and chemical content. Each tank room is designed to contain the maximum liquid inventory in the event that the tank ruptures.

8. Compliance with Regulatory Guide 1.143, Revision 1, October 1979, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants" is set forth in Section 1.8.1.143.

9. Remote control means are provided for flushing process lines and associated equipment exposed to radioactive material as set forth in Plant Drawings M-66-0, M-67-0 and M-68-0.

(Historical Information)

11.4.2 System Description

11.4.2.1 General

The Solid Waste Management System (SWMS) collects and packages wet and dry types of solid radioactive waste in preparation for eventual shipment offsite to a licensed burial site.

The SWMS accepts dry solid trash, powdered and bead resin, and filter media slurries from the waste sludge phase separator, cleanup phase separator, and the spent resin tank.

Dry trash is sorted and stored for shipment offsite.

A bypass of the SWMS is provided upstream of the crystallizer and centrifuge feed tank. This bypass enables the processing of solid wastes by a portable system, as discussed in Section 11.4.2.6.

Piping and instrument diagrams for solid radwaste management are shown on Plant Drawings M-66-0, M-67-0 and M-68-0. Layout of the packaging, storage, and shipment areas of the Solid Waste Management System are shown on Plant Drawings P-0033-0, P-0034-0 and P-0035-0. Equipment and floor drainage systems are discussed in Section 9.3.3.

11.4.2.2 Resin Slurries

The SWMS receives filter media, waste sludge and/or resin slurries from the waste sludge phase separator, the cleanup phase separators and the spent resin tank. These slurries are pumped from the solid radioactive waste collection subsystem directly to the portable dewatering system.

A bypass of the SWMS is provided upstream of the centrifuge feed tank. This bypass enables the processing of resins by a portable system, as discussed in Section 11.4.2.6, should the downstream portion of SWMS become unavailable for any reason.

(Historical Information)

11.4.2.3 Concentrates

A bypass of the SWMS is provided upstream of the crystallizer. This bypass enables the processing of concentrates by a portable system, as discussed in Section 11.4.2.6.

11.4.2.4 Solidification, Packaging, and Drum Handling

11.4.2.4.1 Deleted

11.4.2.4.2 Deleted

11.4.2.4.3 Deleted

11.4.2.4.4 Deleted

11.4.2.4.5 Air Handling/Filtration System

An Air Handling/Filtration System is provided to exhaust and filter any vapors from the drum filling area. Any vapors present are drawn into a vent hood installed around the extruder/evaporator discharge port. A vent hood exhaust blower provides the necessary draft. This exhaust blower is located downstream of the filter train to ensure that the filter train operates at a negative pressure relative to its environment. The filter train consists of a mesh separator, a HEPA filter, and two charcoal filters followed by another HEPA filter. Air from this system is exhausted to the north plant vent.

11.4.2.4.6 Deleted

11.4.2.4.7 Bridge Crane

The storage area bridge crane has a 7.5-ton capacity and will perform the functions of moving filled radwaste containers within the storage area, unloading of the conveyor, removal of the shipping cask lid, and loading of the truck.

Redundancy is provided through the use of independent motors for low and high speed crane movements. In the event of a complete power failure in the area, eyelets are provided on the bridge for acceptance of a hook from a winch type retrieval unit. Provisions for a hand crank on the hoist drive also have been made for manual operation of the crane hoist. Ease of manual release of hoist, trolley, and bridge brakes, including electrical release of bridge brakes, is provided by an override switch located on the control panel.

11.4.2.4.8 Remote Operation and Viewing Capability

Due to the need to observe operations occurring in radiation exposure areas, means of remote observation are provided by a Closed Circuit Television (CCTV) System. This system is supplemented by use of the shield window at the cap/swipe station.

CCTV cameras provide visual access to the following areas:

1. Two pan, tilt and zoom cameras for viewing the drum conveyor.

2. Two pan tilt and zoom cameras, one in each drum storage area.

3. One fixed-focus camera with crosshair indicator mounted on overhead crane for viewing target plates to assist in drum grab alignment and drum placement in storage.

4. Two pan, tilt and zoom cameras for viewing truck bay drum loading area.

5. Four CCTV monitors with selector controls for viewing cameras on any monitor.

Cameras in vent head area or high radiation areas to be radiation resistant. All other cameras to be high performance solid state video cameras.

11.4.2.4.9 Electrical/Control System

Controls for the overhead crane, monorail, and CCTV system, as well as four CCTV monitors, are included in this console.

11.4.2.5 Trash

The low level dry waste materials, i.e. clothing, plastics, and HEPA filters, are processed by a hydraulically operated box compactor. Containers of approximately 100 cubic feet made of metal and/or plywood lined with galvanized steel are used for storing and shipping the compacted trash. The box compactor is equipped with an external HEPA filtration system to provide a negative airflow into the container during the compacting operation.

Noncompactable trash, i.e., tools and components, is packaged in a suitable sized container, which meets DOT requirements.

11.4.2.6 Portable Dewatering System

Permanent flanged connections are provided on the south wall of the RWMS truck bay to enable processing of concentrates, filter media, waste sludge and/or resin slurries by a Portable Dewatering System. This provides maximum system flexibility and minimizes radiation exposure in the event that key portions of the SWMS become unavailable for any reason. These flanged connections may also be used to connect portable filtration equipment for processing liquid radwaste.

The following SWMS flanged connections are provided in the truck bay:

1. Concentrates feed
2. Resin/sludge feed
3. Decant return
4. Condensate supply
5. Service air supply

(Historical Information)

6. Vent filter connection

Space is provided outside the truck bay, (to the west) for a temporary control panel with an adjacent 480 V ac power supply connection. Check valves are supplied in all feed/supply lines.

11.4.2.7 Low Level Radwaste Storage Facility

The Low Level Radwaste Storage Facility (LLRSF) is located on the Hope Creek site (see Plant Drawing C-0001-0). It will be used as an interim storage facility for Salem and Hope Creek low-level radwaste when this waste cannot be shipped to a radwaste disposal facility. The facility is designed to store the waste from Salem and Hope Creek for 5 years. A maximum of 67,750 ft^3 of waste can be stored in the facility.

The facility has been designed in accordance with the guidelines provided in Generic Letter 81-38.

This facility can be used to support normal radwaste and radioactive material handling activities for Hope Creek and Salem stations (excluding wet waste processing). Examples of these activities are: prestaging waste packages awaiting shipment, accomplishing radioactive shipments using handling equipment and shielding capabilities; performing radiography; storing and working on contaminated equipment and supplies; and other activities with appropriate radiation protection controls applied.

11.4.3 References

11.4-1 Werner & Pfleiderer, "Radwaste Volume Reduction and Solidification System," Topical Report No. WPC-VRS-001, Revision 1, May 1978.

11.4-2 Public Service Electric & Gas Company Hope Creek Generating Station, Process Control Program, Revision 0, July 1985 (as submitted to W. Butler (NRC) from R.L. Mittl (PSE&G) in a letter dated August 21, 1985).

(Historical Information)

TABLE 11.4-1

DESIGN BASIS OF THE SOLID WASTE MANAGEMENT SYSTEM

<u>Concentrated Waste Tanks</u>	
Origin	Condensate and deep bed demineralizer resin regenerating systems and chemical radioactive waste drains; Decontamination areas, chemical laboratory and sampling sinks, and laundry and personnel decontamination drains in the event of high radioactivity or zero liquid release conditions.
Annual volume	168,000 gal. (25 percent b.w. concentrate) 477,600 gal. (10 percent b.w. concentrate)
Batch size and frequency	10,500 gal., total; 45 days, for 25 percent b.w. concentrate; 7 days, for 10 percent b.w. concentrate
Radioactivity	
Normal:	$<4.8 \times 10^{-5}$ µCi/cc
Maximum:	8.5×10^{-1} µCi/cc

(Historical Information)

TABLE 11.4-1 (Cont)

Concentrated Waste Tanks	
Properties	The concentrate is expected to contain primarily 10-25 percent Na_2SO_4 by weight with possible traces of oil and silica. The concentrate will be in a temperature range of 120 to 160°F The decontamination solution portion of the concentrate is expected to contain 2-10 percent by weight of varied chemical species: Acids, bases, and solvents from the chemistry laboratory Inhibited water from the closed cooling water systems Service water (river water) impurities Decontamination agents (organic solvents and detergents) The decontamination solution portion of the concentrate may contain up to 4,000 ppm of suspended solids and 4,000 ppm of phosphates.

(Historical Information)

TABLE 11.4-1 (Cont)

Concentrated Waste Tanks	
Annual volume	20,000 gals. (2 percent b.w. concentrate) without laundry wastes 60,000 gals. (2 percent b.w. concentrate) with laundry wastes
Batch size and frequency	Without laundry wastes: 600 gals., 6 weeks With laundry wastes: 600 gals., 19 days
Radioactivity	
Normal:	1.0×10^{-3} μCi/cc
Maximum:	5.8×10^{-1} μCi/cc
Waste Sludge Phase Separator	
Origin	Crud, consisting of broken resin beads and corrosion products, discharged from the ultrasonic resin cleaners in the condensate demineralizer regeneration facilities; insoluble impurities, primarily iron accumulated from the condensate pre-filter system backwash receiving tank; fouled and exhausted powdered resin discharged from the fuel pool filter demineralizer system, and the LWMS filters.

TABLE 11.4-1 (Cont)

Waste Sludge Phase Separator	
Properties	The mixture of powdered resin and ultrasonic resin cleaner (URC) crud will be transferred as a 5 percent-by-weight slurry (dry basis). The powdered resin is a 1:1 mixture by volume of powdered cation and anion resins. The powdered resins received in the waste sludge phase separator contain approximately 10 percent by weight iron oxide
Annual volume	87,430 gal.
Batch size and frequency	8500 gal., 35 days
Radioactivity	
Normal:	6.18×10^{-1} µCi/cc
Maximum:	2.03 µCi/cc
Cleanup Phase Separators	
Origin	Fouled and exhausted powdered resin discharged from the Reactor Water Cleanup System

(Historical Information)

TABLE 11.4-1 (Cont)

<u>Cleanup Phase Separators</u>	
Properties	The powdered resin material will be transferred as a 5 percent by weight slurry (dry basis). The powdered resin is a 1:1 mixture by volume of powdered cation and anion resins. The powdered resin material will contain approximately 10 percent by weight iron oxide.
Annual volume	15,660 gal.
Batch size and frequency	2610 gal., 60 days
Radioactivity	
Normal:	3.8×10^{2} µCi/cc
Maximum:	4.0×10^{2} µCi/cc
<u>Spent Resin Tank</u>	
Origin	Exhausted resin beads from the twelve on-line condensate and the two LWMS demineralizers
Properties	The spent resin batches will be mixed cation and anion resins.

(Historical Information)

TABLE 11.4-1 (Cont)

<u>Spent Resin Tank</u>	
	The cation and anion ratio may vary from 2:1 to 1:1 for the condensate demineralizers and the LWMS demineralizers. The resin batch will be transferred as a 5 to 15 percent by weight slurry (dry basis)
Annual volume	1370 ft^3 (27,710 gal. as a 15 percent by weight slurry)
Batch size and frequency	
Condensate demineralizers	12 x 312 ft^3, 3 yrs
Radwaste demineralizers	2 x 190 ft^3, 3 yrs
Radioactivity	
Normal:	$3.3x10^{-1}$ µCi/cc
Maximum:	$1.24x10^{1}$ µCi/cc
<u>Dry Trash</u>	
Origin	Operations and maintenance
Dry trash properties	Typical composition of dry trash is as follows:
	Paper, protective clothing (mostly cotton), cardboard, wood, rags, non-halogenated plastics, glass, PVC, metal,

(Historical Information)

TABLE 11.4-1 (Cont)

<u>Dry Trash</u>	
	rubber apparel, and miscellaneous items
Annual volume:	150,000 ft^3 total assuming a trash density of 6 lb/ft^3
Batch size and frequency	Variable
Radioactivity range	6.0×10^{-4} to 5.0×10^{-3} μCi/cc

TABLE 11.4-2

SOLID WASTE MANAGEMENT SYSTEM MAJOR COMPONENT DATA AND DESCRIPTION - TANKS

Tanks	Equipment No.	Capacity, gallons	Design Temperature, °F	Design Pressure, psig	Material	Type	Code
** Crystallizer condensate tank	00-T-386	105	275	30	316L stainless steel	Vertical cylinder	ASME Section VIII
** Crystallizer bottoms tank	00-T-387	3033	275	Atmospheric	Inconel 625	Vertical cylinder	ASME Section VIII
** Caustic addition tank	00-T-392	105	275	30	316L stainless steel	Vertical cylinder	ASME Section VIII
** Steam dome boilout tanks	0A-T-391 0B-T-391	5	Ambient	Atmospheric	Shell: ASTM-A376 Grade TP; Heads: ASTM-A403	Vertical cylinder	Manufacturer's Standards
** Asphalt storage tank	00-T-558	9700	425	Atmospheric	ASTM A-285-75, grade C	Vertical cylinder	API 650 App J & M
** Centrifuge feed tank	00-T-394	1331	150	15	SA-240, TP 304	Vertical cylinder	ASME Section VIII
Auxiliary boiler blowdown tank	00-T-563	135	450	90	ASTM A53B	Vertical cylinder	ASME Section VIII
Cleanup backwash receiving tank	10-T-217	3000	200	15	304L stainless steel	Horizontal cylinder	API 620
Cleanup phase separators	0A-T-316 0B-T-316	4500	150	Atmospheric	SA-240, TP304	Vertical cylinder	API 620
Waste sludge phase separator	00-T-319	12,500	150	Atmospheric	SA-240, TP304	Vertical cylinder	API 620
Spent resin tank	00-T-323	6500	200	15	304L stainless steel	Vertical cylinder	API 620

** Abandoned in place

(Historical Information)

TABLE 11.4-3

SOLID WASTE MANAGEMENT SYSTEM MAJOR COMPONENT DATA AND DESCRIPTION - PUMPS

Pumps	Equipment No.	Type	Rated Flow (gpm each)	TDH (ft)	Design Temperature (°F)	Design Pressure (psig)	Driver (hp each)	Material
** Crystallizer recirculation pump	00-P-375	Axial	8300	14	225	35	75	Alloy 20
** Crystallizer distillate pumps	0A-P-376 0B-P-376	Centrifugal	35	120	212	275	5	316 stainless steel
** Crystallizer bottoms tank recirc pumps	0A-P-377 0B-P-377	Centrifugal	75	60	225	230	5	Alloy 20
** Caustic addition pumps	0A-P-382 0B-P-382	Diaphragm	9.7 GPH	5-100 psig	90	100	0.17	316 Stainless steel
** Extruder evaporators	0A-P-380 0B-P-380	Co-rotating twin screws VRS-T-120	1	NA	435	355	100	DIN 1.8519 & 1.8550(German)
** Asphalt recirc pumps	0A-P-522 0B-P-522	Rotary, positive displacement	27	50 psig	350	150	3	Steel
** Asphalt metering pumps	0A-P-383 0B-P-383 0C-P-383 0D-P-383	Proportioning	44	25 psig	350	150	1	Steel
** Centrifuge feed tank decant pump	00-P-385	Centrifugal, in-line	30	5	140	150	1.5	316 stainless steel
** Centrifuge feed tank recirc pump	00-P-386	Progressive cavity	3000 GPH	32 psig	120	150	7.5	316 stainless steel
** Centrifuge metering pumps	0A-P-387 0B-P-387	Progressive cavity	150 GPH	3 psig	120	150	1.0	316 stainless steel
** Slurry metering pumps	0A-P-388 0B-P-388	Progressive cavity	34 GPH	4 psig	120	150	1.0	316 stainless steel
** Concentrate metering pumps	0A-P-381 0B-P-381 0C-P-381 0D-P-381	Peristaltic	42 GPH	5 psig	200	220	1.0	316 stainless steel natural rubber tube

** Abandoned in Place

(Historical Information)

TABLE 11.4-3 (Cont)

Pumps	Equipment No.	Type	Rated Flow (gpm each)	TDH (ft)	Design Temperature (°F)	Design Pressure (psig)	Driver (hp each)	Material
Cleanup backwash transfer pumps	1A-P-214 1B-P-214	Centrifugal, horizontal	100	115	210	170	10	SA351-CF3M
Cleanup decant pump	00-P-311	Centrifugal, horizontal	50	75	210	240	5	SA351-CF3M
Cleanup sludge discharge mixing pump	00-P-334	Centrifugal, horizontal	400	190	210	170	40	SA351-CF3M
Waste sludge decant pump	00-P-323	Centrifugal, horizontal	50	35	210	170	2	SA351-CF3M
Waste sludge discharge mixing pump	00-P-322	Centrifugal, horizontal	400	150	210	170	40	SA351-CF3M
Spent resin pump	00-P-317	Centrifugal, horizontal	200	210	210	240	30	SA351-CF3M

TABLE 11.4-4

SOLID WASTE MANAGEMENT SYSTEM MAJOR COMPONENT DATA AND DESCRIPTION - MISCELLANEOUS

Miscellaneous	Equipment No.	Capacity gallons	Design Temperature °F	Design Pressure psig	Material	Driver hp	Code
** Crystallizer vapor body	00-E-382	4189	275	30 To Full Vacuum	Inconel 625	NA	ASME Section VIII
** Crystallizer heater	00-E-377	2050	Shell side 365 Tube side 275	Shell side 75 Tube side 65	Inconel 625/ 316L Stainless steel	NA	ASME Section VIII
** Crystallizer entrainment separator	00-F-328	170 ft^3	275	30	Inconel 625/ 316L Stainless steel	NA	ASME Section VIII
** Crystallizer mechanical vapor compressor	00-K-307	7300 cfm at 212°F & 14.55 psia	365	14	316 stainless steel	500	Manufacturer's standards
** Crystallizer vapor condenser	00-E-379	120	Shell side 250 Tube side 200	Shell side 30 Tube side 150	SA-240, TP 316L	NA	ASME Section VIII
** Distillate subcooler	00-E-380	120	Shell side 200 Tube side 250	Shell side 150 Tube side 150	SA-240, TP 316L	NA	ASME Section VIII
** Crystallizer vent gas cooler	00-E-378	25 lb/h	Shell side 250 Tube side 320	Shell side 160 Tube side 200	Cast Steel; SA-216 316L stainless steel	NA	ASME Section VIII
** Crystallizer bottoms tank vent gas cooler	00-E-381	2.3 lb/h	Shell side 240 Tube side 300	Shell side 160 Tube side 200	Cast Steel; SA-216 316L stainless steel	NA	ASME Section VIII
Auxiliary boiler	00-S-552	1800 lb/h @ 232 psig	414	275	ASTM A516-70	NA	ASME I "S" stamp
** Centrifuge	00-S-358	2130 x gravity at 6000 rpm	Ambient	Atmospheric	316 SS	7.5	Manufacturer's standards
Box compactor	00-S-907	100 ft^3	Ambient	100,000 psig	Steel	20	Manufacturer's standards

** Abandoned In Place

TABLE 11.4-5

EXPECTED RADIONUCLIDE INVENTORIES OF SWMS COMPONENTS ACTIVITY(1), Ci (6)

Nuclide	Waste Sludge Phase Separator 00T-319	RWCU Backwash Receiving Tank 10T-217	RWCU Phase Separator 0AT-316	Crystallizer Bottoms Tank 00T-387(6)	Crystallizer Condensate Tank 00T-386(2)(6)	Spent Resin Tank 00T-323	Centrifuge Feed Tank 00T-394(3)(6)
Corrosion and Activation Products							
Na-24	-	1.52+00	1.56+00	2.53-02	2.12-07	3.58-02	1.30+00
P-32(4)	3.32-03	1.64-01	1.02+00	7.87-02	-	1.41-02	1.01+00
Cr-51	8.49-02	4.51+00	4.34+01	3.25+00	2.70-05	5.91-01	4.32+01
Mn-54	6.95-03	3.97-01	6.69+00	4.45-01	3.70-06	8.82-02	6.69+00
Mn-56	6.23-01	5.65+00	5.65+00	1.63-02	1.36-07	1.47-01	1.93+00
Fe-59	1.37-02	7.5-01	9.01+00	6.5-01	5.42-06	1.04+00	8.99+00
Co-58	8.63-01	4.8+01	6.62+02	4.63+01	3.85-04	8.86+00	6.61+02
Co-60	8.71-02	5.0+00	8.91+01	5.85+00	4.87-05	1.78+00	8.91+01
Ni-65	3.73-03	3.37-02	3.37-02	9.67-05	8.05-10	8.80-04	1.14-02
Zn-65	3.48-04	1.98-02	3.29-01	2.19-02	1.82-07	4.38-03	3.29-01
Zn-69m	1.90-03	2.07-02	2.10-02	3.32-04	2.77-09	4.97-04	1.72-02
Zn-69	1.89-03	2.08-02	2.12-02	3.57-04	2.98-09	5.01-04	1.84-02
W-187	2.76-01	4.10+00	4.26+00	8.6-02	7.17-07	9.21-02	3.79+00
Ag-110m	1.04-02	5.94-01	9.89+00	6.60-01	5.50-06	1.29-01	9.89+00
Ag-110	1.36-04	7.72-03	1.29-01	8.6-03	7.16-08	1.68-03	1.28-01
Pu-239	1.40-05	2.07-03	5.52-02	3.67-03	3.05-08	7.13-04	5.52-02
Fission Products							
Br-83	8.8-05	7.92-01	7.92-01	3.96-02	3.30-07	4.12-01	2.51-01
Br-84	3.59-01	3.14-01	3.14-01	4.48-06	3.73-11	1.38-01	1.68-03
Br-85	5.41-01	1.16-02	1.16-02	-	-	2.09-03	9.71-27
I-131	1.04+00	4.59+01	1.75+02	2.59+02	2.16-03	5.12+01	1.73+02
I-132	4.22+00	1.19+02	2.19+02	1.02+01	8.50-05	6.32+00	2.14+02
I-133	3.75+00	5.02+01	5.36+01	1.89+01	1.57-04	2.31+01	4.68+01
I-134	5.03-01	4.49+00	4.90+00	3.79-03	3.15-08	2.14+00	1.83-01
I-135	2.12+00	1.95+01	1.95+01	4.16+00	3.47-05	1.01+01	1.29+01
Sr-89	1.24+00	1.52+01	1.91+02	1.41+01	1.18-04	2.58-01	1.90+02
Sr-90	4.65-02	1.20+00	2.16+01	1.38+00	1.16-05	2.70-01	2.16+01
Sr-91	1.63+00	1.57+01	1.58+01	3.16-01	2.63-05	5.19-01	1.19+01
Sr-92	7.22-01	6.53+00	6.53+00	3.12-02	2.60-07	2.39-01	2.35+00
Sr-95	-	-	-	-	-	5.26-06	-
Zr-95	1.0+06	1.91-01	2.58+00	1.89-01	1.58-06	3.46-02	2.56+00
Zr-97	5.19-03	1.43-02	1.48+00	2.51-04	2.08-09	-	1.25-02

(Historical Information)

TABLE 11.4-5 (Cont)

Nuclide	Waste Sludge Phase Separator 00T-319	RWCU Backwash Receiving Tank 10T-217	RWCU Phase Separator 0AT-316	Crystallizer Bottoms Tank 00T-387 (6)	Crystallizer Condensate Tank 00T-386 (2) (6)	Spent Resin Tank 00T-323	Centrifuge Feed Tank 00T-394 (3) (6)
Nb-95	1.03+00	2.09-01	3.36+00	2.32-01	1.93-06	-	3.36+00
Mo-94	1.50+00	4.39+01	7.68+01	3.03+00	2.54-05	3.34-04	7.37+01
Np-239 (5)	1.04+00	2.77+01	4.37+01	1.49+00	1.245-05	1.06+01	4.16+01
Tc-99m	5.26+00	7.66+01	1.08+02	3.24+00	2.70-05	2.06+00	9.23+01
Tc-101	7.90-02	6.55-01	6.55-01	-	-	1.24-02	4.54-06
Ru-103	1.63-03	8.83-02	1.01+00	7.33-02	6.12-07	1.38-02	1.00+00
Ru-106	2.26-04	1.29-02	2.20-01	1.46-02	1.22-07	2.49-03	2.19+00
Te-129	3.07-03	-	-	9.27-02	-	1.70-02	-
Te-129m	5.01-03	1.84-01	1.96+00	1.45-01	1.20-06	2.64-02	1.95+00
Te-132	3.36+00	1.12+02	2.17+02	9.67+00	8.05-05	3.26+00	2.09+02
Cs-134	1.39-03	7.97-01	1.40-01	9.20-01	7.67-06	1.87-01	1.40+01
Cs-136	1.29-02	4.47-01	2.70+00	2.09-01	1.73-06	3.68-02	2.68+00
Cs-137	6.58-02	1.2+00	2.16+04	1.41+00	1.18-05	2.82-01	2.16+01
Cs-138	2.47-01	2.16+00	2.16+00	4.27-06	3.54-11	8.61-02	1.23-02
Ba-139	5.35-01	4.81+00	4.80+00	6.49-03	5.42-08	2.48-01	6.46-01
Ba-140	1.25+00	3.59+01	2.07+02	1.79+01	1.49-04	8.61-11	2.05+02
Ba-141	1.23-01	1.05+00	1.05+00	5.82-10	4.85-15	4.61-02	1.01-04
Ba-142	7.54-02	6.05-01	6.05-01	-	-	1.63-02	1.64-07
Cr-141	6.32-01	4.78-01	5.04+00	6.51-01	5.42-06	6.52-02	5.03+00
Ce-143	2.14-02	3.62-02	4.41-02	9.87-04	8.21-09	1.73-03	4.06-02
Ce-144	3.13-03	1.78-01	2.99+00	1.99-01	1.66-06	3.79-02	2.99+00
Py-143	4.91-01	1.66-01	1.02+00	7.86-02	6.55-07	1.59-02	1.01+00
Nd-147	1.14-03	5.41-02	2.76-01	2.10-02	1.75-07	3.88-03	2.73-01
La-140	5.09-01	1.30+01	2.21+02	2.01+01	-	-	2.20+02
La-141	1.24-01	1.13+00	1.13+00	1.59-02	1.32-07	-	5.95-01
La-142	7.42-02	6.86-01	6.86-01	8.00-04	6.66-09	2.72-02	1.27-01
Y-94	-	-	-	2.19-10	1.78-15	2.27-04	-
Y-93	-	-	-	9.86-03	8.17-08	-	-
Y-92	7.28-01	6.59+00	6.60+00	1.13+00	9.39-07	2.50-01	5.09+00
Y-91m	9.62-01	8.83-00	9.38+00	2.03-01	1.70-06	3.09-01	7.63+00
Y-91	8.2-01	1.05+00	3.00+01	3.13+00	2.60-05	5.21-01	3.0+01
Y-90	8.52-03	3.30-01	2.09+01	1.39+00	1.16-05	1.66-02	2.09+01
Y-89m	-	7.65-04	1.91-02	1.43-03	-	2.58-04	1.90-02
Total Ci	3.778+01	7.08+02	2.555+03	4.30+02	3.595-03	1.26+02	1.888+03
Volume gals (eff. Vol.)	409	2720	870	3000	50	4362	435

TABLE 11.4-5 (Cont)

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(1) The expected radionuclide activities are based on the design basis source terms in Section 11.1, but corrected for a noble gas release rate of 50,000 Ci/s after a 30-minute decay, except Np-239 (Refer to Note 5).

(2) The activities for the crystallizer condensate tank have been converted from ci/cc to ci/50 gal.

(3) The calculation of the radionuclide activity in the centrifuge feed tank is based on 30 wt percent solids. During normal operation, the centrifuge feed tank will receive a maximum of 15 wt percent solids from the spent resin slurry tank and 5 wt percent solids from the waste sludge separator and cleanup phase separators.

The calculation for the centrifuge feed tank activity assumes 4-hour decay from RWCU phase separator and adjusts the sludge volume as follows:

Sludge volume for RWCU separator with 5 wt percent solids = 2720 gal.
Sludge volume for 15 wt percent solids = 870 gal.

Therefore, sludge volume for 30 wt percent solids   435 gal.

(4) $3.32\text{-}03 = 3.32 \times 10^{-3}$

(5) The expected radionuclide activity for Np-239 is based on correcting the Hope Creek design basis value by a factor of 1/150 to reflect the more recent NUREG-0016, Rev 1, data.

(6) Abandoned in place.

(6) The values in this Table are based on 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

(Historical Information)

TABLE 11.4-6

MAXIMUM RADIONUCLIDE INVENTORIES IN SRWS COMPONENTS
ACTIVITY[1], Ci

Nuclide	Waste Sludge Phase Separator 00T-319	RWCU Backwash Receiving Tank 10T-217	RWCU Phase Separator 0AT-316	Crystallizer Bottoms Tank 00T-387[3]	Crystallizer Condensate Tank 00T-386[3]	Spent Resin Tank 00T-323	Centrifuge Feed Tank 00T-394[3]
Corrosion and Activation Products							
Na-24	-	1.52+00	1.56+00	2.53-02	2.12-07	3.58-02	1.30+00
P-32[2]	3.32-03	1.64-01	1.02+00	7.87-02	-	1.41-02	1.01+00
Cr-51	8.49-02	4.51+00	4.34+01	3.25+00	2.70-05	5.91-01	4.32+01
Mn-54	6.95-03	3.97-01	6.69+00	4.45-01	3.70-06	8.82-02	6.69+00
Mn-56	6.23-01	5.65+00	5.65+00	1.63-02	1.36-07	1.47-01	1.93+00
Fe-59	1.37-02	7.5-01	9.01+00	6.50-01	5.42-06	1.04+00	8.99+00
Co-58	8.63-01	4.8+01	6.62+02	4.63+01	3.85-04	8.86+00	6.61+02
Co-60	8.71-02	5.0+00	8.91+01	5.80+00	4.87-05	1.78+00	8.91+00
Ni-65	3.73-03	3.37-02	3.37-02	9.67-05	8.05-10	8.80-04	1.14-02
Zn-65	3.48-04	1.98-02	3.29-01	2.19-02	1.82-07	4.38-03	3.29-01
Zn-69m	1.90-03	2.07-02	2.10-02	3.32-04	2.77-09	4.97-04	1.72-02
Zn-69	1.89-03	2.08-02	2.12-02	3.57-04	2.98-09	5.01-04	1.84-02
W-187	2.76-01	4.10+00	4.26+00	8.60-02	7.17-07	9.21-02	3.79+00
Ag-110m	1.04-02	5.94-01	9.89+00	6.60-01	5.50-06	1.29-01	9.89+00
Ag-110	1.36-04	4.10+00	1.29-01	8.60-03	7.16-08	1.68-03	1.28-01
Pu-239	1.40-05	2.07-03	5.52-02	3.67-03	3.05-08	7.13-04	5.52-02
Fission Products							
Br-83	8.8-04	7.92+00	7.92+00	3.96-01	3.30-06	4.12+00	2.51+00
Br-84	3.59+00	3.14+00	3.14+00	4.48-05	3.73-10	1.38+00	1.69-02
Br-85	5.41+00	1.16-01	1.16-01	-	-	2.09-02	9.71-26
I-131	1.04+01	4.59+02	1.75+03	2.59+03	2.16-02	5.12+02	1.73+03
I-132	4.22+01	1.19+03	2.19+03	1.02+02	8.50-04	6.32+01	2.14+03
I-133	3.75+01	5.02+02	5.36+02	1.89+02	1.57-03	2.31+02	4.68+02
I-134	5.03+00	4.49+01	4.90+01	3.79-02	3.15-07	2.14+01	1.83+01
I-135	2.12+01	1.95+02	1.95+02	4.16+01	3.47-04	1.01+02	1.29+02
Sr-89	1.24+01	1.52+02	1.91+03	1.41+02	1.18-03	2.58+00	1.90+02
Sr-90	4.65-01	1.20+01	2.16+02	1.38+01	1.16-08	2.70+00	2.16+02
Sr-91	1.63+01	1.57+02	1.58+02	3.16+00	2.63-05	5.19+00	1.19+02
Sr-92	7.22+00	6.53+01	6.53+01	3.12-01	2.60-06	2.39+00	2.35+01
Sr-95	-	-	-	-	-	5.26-05	-
Zr-95	1.00+01	1.91+00	2.58+01	1.89+00	1.58-05	3.46-01	2.56+01

(Historical Information)

TABLE 11.4-6 (Cont)

Nuclide	Waste Sludge Phase Separator 00T-319	RWCU Backwash Receiving Tank 10T-217	RWCU Phase Separator 0AT-316	Crystallizer Bottoms Tank 00T-387[3]	Crystallizer Condensate Tank 00T-386[3]	Spent Resin Tank 00T-323	Centrifuge Feed Tank 00T-394[3]
Zr-97	5.19-02	1.43-01	1.48+01	2.51-03	2.08-09	-	1.25-01
Nb-95	1.03+01	2.09+00	3.36+-1	2.32+00	1.93-05	-	3.36+01
Mo-99	1.55+01	4.39+02	7.68+02	3.03+01	2.54-05	3.34-03	7.37+02
Np-239	1.04+01	2.77+02	4.37+02	1.49+01	1.245-04	1.06+02	4.16+02
Tc-99m	5.26+01	7.66+02	1.08+03	3.24+01	2.70-04	2.06+01	9.23+02
Tc-101	7.90-01	6.55+00	6.55+01	-	-	1.24-01	4.54-05
Ru-103	1.63-02	8.83-01	1.01+01	7.33-01	6.12-06	1.38-01	1.00+01
Ru-106	2.26-03	1.29-01	2.20+00	1.46-01	1.22-06	2.49-02	2.19+01
Te-129	-	-	-	7.27-01	-	1.70-01	-
Te-129m	5.01-02	1.84+00	1.96-01	1.45+00	1.20-05	2.64-01	1.95+01
Te-132	3.36+01	1.12+03	2.17+03	9.67+01	8.05-04	3.26+01	2.09+03
Cs-134	1.39-02	7.97+00	1.40+02	9.20+00	7.67-05	1.87+00	1.40+02
Cs-136	1.29-01	4.47+00	2.70+01	2.09+00	1.73-05	3.68-01	2.68+01
Cs-137	6.58-01	1.2+01	2.16+02	1.41+01	1.18-04	2.82+00	2.16+02
Cs-138	2.47+00	2.16+01	2.16+01	4.27-05	3.54-10	8.61-01	1.23-01
Ba-139	5.35+00	4.81+01	4.80+01	6.49-02	5.42-07	2.48+00	6.46+00
Ba-140	1.25+01	3.59+02	2.07+03	1.79+02	1.49-03	8.61-10	2.05+03
Ba-141	1.23+00	1.05+00	1.05+00	5.82-09	4.85-14	4.61-01	1.01-03
Ba-142	7.54-01	6.05+00	6.05+00	-	-	1.63-01	1.64-06
Ce-141	6.32+02	5.04+00	5.04+01	6.51+00	5.42-05	6.52-01	5.03+01
Ce-143	2.14-01	3.62-01	4.41-01	9.87-03	8.21-08	1.73-02	4.06-01
Ce-144	3.13-02	1.78+00	2.99+01	1.99+00	1.66-05	3.74-01	2.99+01
Pr-143	4.91+00	1.66+01	1.02+01	7.86-01	6.55-06	1.59-01	1.01+01
Nd-147	1.14-02	5.41-01	2.76+00	2.10-01	1.75-06	3.88-02	2.73+00
La-140	5.09+00	1.30+02	2.21+03	2.01+02	-	-	2.20+03
La-141	1.24+00	1.13+01	1.13+01	1.59-01	1.32-06	-	5.95+00
La-142	7.42-01	6.86+00	6.86+00	8.00-03	6.66-08	2.77-01	1.27+00
Y-94	-	-	-	2.19-09	1.78-14	2.27-03	-
Y-93	-	-	-	-	8.17-07	-	-
Y-92	7.28+00	6.59+01	6.60+01	1.13+01	9.39-06	2.50+00	5.09+01
Y-91m	9.62+00	8.83+01	9.38+01	2.03+00	1.70-05	3.09+00	7.63+01
Y-91	8.2+00	1.05+01	3.00+02	3.13+01	2.60-04	5.21+00	3.0+02
Y-90	8.52-02	3.30-02	2.09+02	1.39+01	1.16-04	1.66-01	2.09+02
Y-89m	-	7.65-03	1.91-01	1.43-02	-	2.58-03	1.90-01
Total Ci	3.60+02	6.45+03	1.805+04	3.733+03	3.166-02	1.132+03	1.135+04
Vol (gal.) (Eff. Vol.)	409	2720	870	3000	50	4362	435

(Historical Information)

TABLE 11.4-6 (Cont)

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(1) The maximum (design basis) activities are based on a noble gas release rate of 500,000 Ci/s after a 30-minute delay.

(2) 3.32-03 = 3.32 x $x10^{-3}$

(3) Abandoned in place

(Historical Information)

TABLE 11.4-7

SOLID WASTE MANAGEMENT SYSTEM FLOWS

Stream No.[1]	Average Batch Frequency For Normal Operation[2]	Volume per Batch, gal[3]	Flow Rate, gpm	Temperature, °F	Normal Activity Concentration, µ/Ci/cc (11)	Maximum Activity Concentration, µ/Ci/cc (11)
* 1A[5]	1/31.2 days[2]	10,500 @ 25 wt % Na_2 SO_4	7.1	120	1.99E1[4]	1.76E2
1B[6]	1/1.7 days	10,500 @ 1.65 wt % Na_2 SO_4	30.5	120	1.31	1.16E1
2	1/3 days	409 @ 5 wt % solids	20	Ambient	2.44E1	2.33E2
3	1/120 days	2609 @ 5 wt % solids	20	Ambient	2.59E2	1.83E3
4	1/104 days	10262 @ 5 wt % solids 50 w/o NA_2SO_4	20	Ambient	1.63	1.47E1
5	1/month	6250 ft^3	NA	Ambient	1.69E-1	1.24
6[7]	1/31.2 days	4354 @ 50 wt % solids	50	218	3.79E1	3.29E2
7[7]	1/31.2 days	6146	35	120	1.90E-2	1.67E-1
8	1/31.2 days	2177 @ 50 wt % Na_2SO_4	1.05	160	3.79E1	3.29E2
9	Variable	Variable	30	Ambient	Variable	1.83E3
12	Variable	Variable	0.53	Ambient	1.15E3	6.89E3

* Associated components abandoned in place

(Historical Information)

TABLE 11.4-7 (Cont)

Stream No.[(1)]	Average Batch Frequency For Normal Operation[(2)]	Volume per Batch, gal[(3)]	Flow Rate, gpm	Temperature, °F	Normal Activity Concentration, µ/Ci/cc (11)	Maximum Activity Concentration, µ/Ci/cc (11)
14	Variable	Variable	0.6	212	7.57E-2	1.83
15	Refer to Table 11.4-8	55 gal.	NA	Ambient	Refer to Table 11.4-9	
16	As required	NA	810 cfm	Ambient	Negligible	Negligible
17	As required	NA	800 cfm	Ambient	Negligible	Negligible
18	Refer to Table 11.4-8	100 ft^3	NA	Ambient	Refer to Table 11.4-9	
19	As required	See Stream 2, 3, 4	50 gpm	Ambient	See Stream 2, 3, 4	See Stream 2, 3, 4

(1) Refer to Figure 11.4-10 for location of stream numbers (nodes).
(2) 1/31.2 means 1 batch per 31.2 days.
(3) NA - Not Applicable
(4) 1.99E1 means 1.99x10E1
**(5) Node 1, Mode A, is based on waste evaporators 0A/0B-E-367 being operational.
(6) Node 1, Mode B, is based on waste evaporators 0A/0B-E-367 not being operational.
(7) Nodes 6 and 7 are based on inputs from Node 1, Mode A.
(8) Nodes 10, 11 and 13, Mode A, are based on inputs from Node 2.
(9) Nodes 10, 11 and 13, Mode B, are based on inputs from Node 3.
(10) Nodes 10, 11 and 13, Mode C, are based on inputs from Node 4.
(11) The values in this Table are based on 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

** Waste Evaporators abandoned in place

(Historical Information)

TABLE 11.4-8

EXPECTED ANNUAL SWMS CONTAINERS AND ACTIVITY[(1) (4)]

Solidified Waste Type	Containers/yr	Activity, Ci/Container Expected	Activity, Ci/Container Maximum	Ci/Year Expected	Ci/Year Maximum
Concentrated waste	1076(1345)[(2)]	2.2	19.1	2,367	20,552
Spent resin	71(89)	4.1	36.8	291	2,613
Waste sludge	93(117)	1.71	16.20	159	1,507
Powdex (RWCU separator)	16(20)	28.7	202.6	459	3,242
Dry trash	167[(3)]	0.43	3.15	72	526
Total containers & activity	1423(1738)	-	-	3,348	28,440

(1) No decay has been assumed for the drum filling and temporary storage before shipment. Actual activity inventories shipped will be less due to additional decay.

(2) Standard 55-gallon drum, waste dry solids to asphalt ratio of 50 to 50 by weight (values in parentheses are for 40 to 60 weight ratio).

(3) 100 cubic foot box.

(4) The values in this Table are based on 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

(Historical Information)

TABLE 11.4-9

ISOTOPIC INVENTORY OF SOLIDIFIED WASTE (BY WASTE TYPE), CURIES/DRUM (1)

	Concentrates		Spent Resin		Waste Sludge		RWCU Powdex	
	Expected	Maximum	Expected	Maximum	Expected	Maximum	Expected	Maximum
Br-83	2.03-04	2.03-03	1.33-02	1.33-01	3.96-06	3.98-05	8.90-03	8.90-02
Br-84	2.29-08	2.29-07	4.45-03	4.45-02	1.62-02	1.62-01	3.53-03	3.53-02
Br-85	-	-	6.73-05	6.73-04	2.45-02	2.45-01	1.30-04	1.30-03
I-131	1.33+00	1.33+01	1.65+00	1.65+01	4.71-02	4.71-01	1.97+00	1.97+01
I-132	5.22-02	5.22-01	2.04-01	2.04+00	1.91-01	1.91+00	2.46+00	2.46+01
I-133	9.67-02	9.67-01	7.04-01	7.44+00	1.70-01	1.70+00	6.02-01	6.02+00
I-134	1.94-05	1.94-04	6.90-02	6.90-01	2.28-02	2.28-01	5.50-02	5.50-01
I-135	2.13-02	2.13-01	3.25-01	3.25+00	9.60-02	9.60-01	2.19-01	2.19+00
Sr-89	7.21-02	7.21-01	8.31-03	8.31-02	5.61-02	5.61-01	2.16+00	2.15+01
Sr-90	7.06-03	7.06-02	8.70-03	8.70-02	2.10-03	2.10-02	2.43-01	2.43+00
Sr-91	1.62-03	1.62-02	1.67-02	1.67-01	7.38-02	7.38-01	1.77-01	1.77+00
Sr-92	1.60-04	1.60-03	7.70-03	7.70-02	3.27-02	3.27-01	7.34-02	7.34-01
Sr-95	-	-	1.68-07	1.68-06	-	-	-	-
Zr-95	9.69-04	9.69-03	1.11-03	1.11-02	4.53-02	4.53-01	2.89-02	2.89-01
Zr-97	2.18-07	2.18-06	-	-	2.35-04	2.35-03	1.66-02	1.66-01
Nb-95	1.19-03	1.19-02	-	-	4.66-02	4.66-01	3.77-02	3.77-01
Mo-99	1.55-02	1.55-01	1.08-05	1.08-04	6.79-02	6.79-01	8.63-01	8.63+00
Np-239	7.62-03	7.62-02	3.42-01	3.42+00	4.71-02	4.71-01	4.91-01	4.91+00
Tc-99m	1.66-02	1.66-01	6.64-02	6.64-01	2.38-01	2.38+00	1.21+00	1.21+01
Tc-101	-	-	4.00-04	4.00-03	3.58-03	3.58-02	7.36-03	7.36-02
Ru-103	3.75-04	3.75-03	4.45-04	4.45-03	7.38-05	7.38-04	1.13-02	1.13-01
Ru-106	7.47-05	7.47-04	8.02-05	8.02-04	1.02-05	1.02-04	2.47-03	2.47-02
Na-24	1.30-04	1.30-04	1.15-03	1.15-03	-	-	1.75-02	1.75-02
P-32	4.03-04	4.03-04	4.54-04	4.54-04	1.50-04	1.50-04	1.15-02	1.15-02
Cr-51	1.66-02	1.66-02	1.90-02	1.90-02	3.84-03	3.84-03	4.88-01	4.88-01
Mn-54	2.28-03	2.28-03	2.84-03	2.84-03	3.15-04	3.15-04	7.51-02	7.51-02
Mn-56	8.34-05	8.34-05	4.74-03	4.74-03	2.82-02	2.82-02	6.34-02	6.34-02
Fe-59	3.33-03	3.33-03	3.35-02	3.35-02	6.20-04	6.20-04	1.01-01	1.01-01
Co-58	2.37-01	2.37-01	2.85-01	2.85-01	3.91-02	3.91-02	7.44+00	7.44+00
Co-60	3.00-02	3.00-02	5.74-02	5.74-02	3.94-03	3.94-03	1.00+00	1.00+00
Ni-65	4.94-08	4.94-08	2.84-05	2.84-05	1.69-04	1.69-04	3.78-04	3.78-04
Zn-65	1.12-04	1.12-04	1.41-04	1.41-04	1.58-05	1.58-05	3.70-03	3.70-03
Zn-69m	1.70-06	1.70-06	1.60-05	1.60-05	8.60-05	8.60-05	2.36-04	2.36-04
Zn-69	1.83-06	1.83-06	1.61-05	1.61-05	8.55-05	8.55-05	2.38-04	2.38-04
W-187	4.40-05	4.40-05	2.97-03	2.97-03	1.25-02	1.25-02	4.79-02	4.79-02
Ag-110m	3.38-03	3.38-03	4.16-03	4.16-03	4.71-04	4.71-04	1.11-01	1.11-01
Ag-110	4.40-05	4.40-05	5.41-05	5.41-05	6.16-06	6.16-06	1.45-03	1.45-03
Pu-239	1.88-05	1.88-05	2.30-05	2.30-05	6.34-07	6.36-07	6.20-04	6.20-04
Te-129	4.74-04	4.74-03	5.48-04	5.48-03	1.39-04	1.39-03	-	-
Te-129m	7.42-04	7.42-03	8.51-04	8.51-03	2.27-04	2.27-03	2.20-02	2.20-01
Te-132	4.95-02	4.95-01	1.05-01	1.05+00	1.52-01	1.52+00	2.44+00	2.44+01

(Historical Information)

TABLE 11.4-9 (Cont)

	Concentrates		Spent Resin		Waste Sludge		RWCU Powdex	
	Expected	Maximum	Expected	Maximum	Expected	Maximum	Expected	Maximum
Cs-134	4.71-03	4.71-02	6.03-03	6.03-02	6.29-05	6.29-04	1.57-01	1.57+00
Cs-136	1.07-03	1.07-02	1.19-03	1.19-02	5.84-04	5.84-03	3.03-02	3.03-01
Cs-137	7.21-03	7.21-02	9.09-03	9.09-02	2.98-03	2.98-02	2.43-01	2.43+00
Cs-138	2.18-08	2.18-07	2.77-03	2.77-02	1.12-02	1.12-01	2.43-02	2.43-01
Ba-139	3.32-05	3.32-04	7.99-03	7.99-02	2.42-02	2.42-01	5.39-02	5.39-01
Ba-140	9.16-02	9.16-01	-	-	5.66-02	5.66-01	2.33+00	2.33+01
Ba-141	2.98-12	2.98-11	1.49-03	1.49-02	5.57-03	5.57-02	1.18-02	1.18-01
Ba-142	-	-	5.25-04	5.25-03	3.41-03	3.41-02	6.79-03	6.79-02
Ce-141	3.33-03	3.33-02	2.10-03	2.10-02	2.86-02	2.86-01	5.65-02	5.65-01
Ce-143	5.05-07	5.05-06	5.57-05	5.57-04	9.69-04	9.69-03	4.94-04	4.94-03
Ce-144	1.02-03	1.02-02	1.22-03	1.22-02	1.42-04	1.42-03	3.45-02	3.45-01
Pr-143	4.02-04	4.02-03	5.12-04	5.12-03	2.22-02	2.22-01	1.14-02	1.14-01
Nd-147	1.07-04	1.07-03	1.25-04	1.25-03	5.16-05	5.16-04	2.76-03	2.76-02
La-140	1.03-01	1.03+00	-	-	2.30-02	2.30-01	2.48+00	2.48+01
La-141	8.14-05	8.14-04	-	-	5.61-03	5.61-02	1.27-02	1.27-01
La-142	4.09-06	4.09-05	8.93-04	8.93-03	3.36-03	3.36-02	7.68-03	7.68-02
Y-94	1.12-12	1.12-11	7.31-06	7.31-05	-	-	-	-
Y-93	5.04-05	5.04-04	-	-	-	-	-	-
Y-92	5.78-03	5.78-02	8.06-03	8.06-02	3.30-02	3.30-01	7.39-02	7.39-01
Y-91m	1.04-03	1.04-02	9.96-03	9.96-02	4.35-02	4.35-01	1.05-01	1.05+00
Y-91	1.60-02	1.60-01	1.68-02	1.68-01	3.71-02	3.71-01	3.36-01	3.36+00
Y-90	7.11-03	7.11-02	5.35-04	5.35-03	3.86-04	3.86-03	2.34-01	2.34+00
Y-89m	7.32-06	7.32-05	8.31-06	8.31-05	-	-	2.14-04	2.14-03

(11) The values in this Table are based on 3323 MW_t. The impact of uprating to 3339 MW_t is insignificant.

Figure F11.4-1 intentionally deleted.

Refer to Plant Drawing M-66-0 in DCRMS

Figure F11.4-2 intentionally deleted.

Refer to Plant Drawing M-67-0 SH 1 in DCRMS

Figure F11.4-3 intentionally deleted.

Refer to Plant Drawing M-67-0 SH 2 in DCRMS

Figure F11.4-4 intentionally deleted.

Refer to Plant Drawing M-68-0 SH 1 in DCRMS

Figure F11.4-5 intentionally deleted.

Refer to Plant Drawing M-68-0 SH 2 in DCRMS

Figure F11.4-6 intentionally deleted.

Refer to Plant Drawing M-68-0 SH 3 in DCRMS

Figure F11.4-7 intentionally deleted.

Refer to Plant Drawing M-68-0 SH 4 in DCRMS

Figure F11.4-8 intentionally deleted.

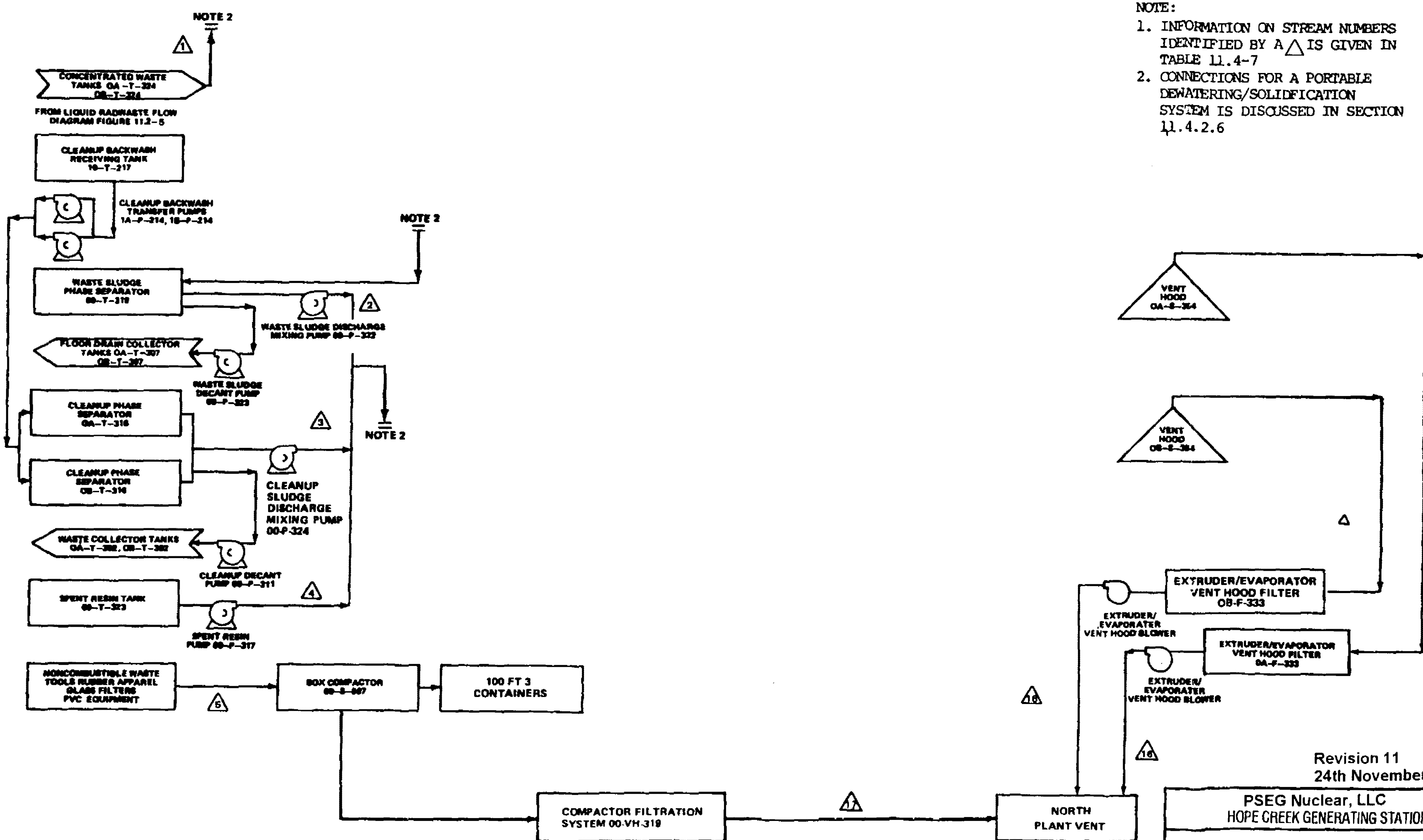
Refer to Plant Drawing M-68-0 SH 7 in DCRMS

Figure F11.4-9 intentionally deleted.

Refer to Plant Drawing M-68-0 SH 8 in DCRMS

NOTE:

1. INFORMATION ON STREAM NUMBERS IDENTIFIED BY A △ IS GIVEN IN TABLE 11.4-7
2. CONNECTIONS FOR A PORTABLE DEWATERING/SOLIDIFICATION SYSTEM IS DISCUSSED IN SECTION 11.4.2.6



Revision 11
24th November, 2000

PSEG Nuclear, LLC
HOPE CREEK GENERATING STATION

SOLID WASTE MANAGEMENT SYSTEM
PROCESS FLOW DIAGRAM

Updated FSAR

Sheet 1 of 1

Fig. 11.4-10

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

The Process and Effluent Radiological Monitoring and Sampling Systems are provided to monitor and control releases of radioactive materials generated as a result of normal operations, anticipated operational occurrences, and postulated accidents. This information allows operating personnel to take corrective action to reduce radiation levels as low as is reasonably achievable (ALARA). The systems comply with regulatory requirements for control of releases of radioactive materials in liquid or gaseous effluents. Design objective and criteria are provided below for Class 1E and non-Class 1E radiation monitoring systems.

11.5.1 Design Bases

The Radiation Monitoring Systems (RMSs) provide information to indicate plant conditions. They are designed to measure, indicate, and/or record radioactivity levels, as appropriate; to alarm on high radioactivity levels; and to measure releases of radioactive liquids, gases, and particulates. The RMSs aid in protecting the general public and plant personnel from exposures in excess of those allowed by the applicable regulations.

Detector locations on normal and potential paths for release of radioactive materials and process streams are determined as follows:

1. Process or effluent paths that may discharge radioactive materials directly or indirectly to the environment where measurement is expected to be meaningful under conditions of use These are monitored to provide radioactivity indications in the main control room and to provide local and main control room alarms when setpoints are exceeded.

2. Process lines that do not discharge directly or indirectly to the environment These are monitored to identify process malfunctions that can be detected by increases in radioactivity levels.

11.5.1.1 Design Objectives

11.5.1.1.1 Class 1E Radiation Monitoring Systems

The main objective of Class 1E RMSs is to initiate appropriate protective action to limit the release of radioactive materials and limit exposure to the main control room operators from airborne radioactive materials. These actions are taken if predetermined radiation values are exceeded in the main streamline and process streams. These RMSs are designed in conformance with IEEE 279-1971, which provides necessary redundancy and independence. These systems are available under all operating conditions, and during or after certain accidents. These systems provide control room personnel with an indication of the radiation levels in the major process streams, plus alarm annunciation if high radiation values are detected. Additional information about RMSs as initiating circuits for the reactor protection system and engineered safety features (ESFs) is provided in Sections 7.2 and 7.3, respectively.

Additional Class 1E radiation monitors are provided to determine the radiation values in the containment after a postulated accident in accordance with Regulatory Guide 1.97 "Instrumentation for Light Water Cooled Nuclear Power Plants to Assess Plant Environs Conditions During and Following an Accident." The DAPA-RMS provides indication in the main control room for the main control room operators use in assessing the nature and severity of the accident. See FSAR Section 1.8.1.97 for additional information.

The RMSs provided to meet these objectives are:

1. Process stream monitors - Main steam line RMS

2. Gaseous process stream monitors

    a. Refueling floor exhaust (RFE) RMS

    b. Reactor Building exhaust (RBE) RMS

3. Air inlet stream monitors - Control room ventilation (CRV) RMS

4. Other - Drywell atmosphere post-accident (DAPA) RMS

11.5.1.1.2 Non-Class 1E Radiation Monitoring Systems

The main objective of non-Class 1E RMSs is to provide operating personnel with measurement of the content of radioactive material in all effluent (release points) and major process streams. This provides compliance with station operating technical specifications by providing gross radiation concentration monitoring and collection of halogens and particulates on filters for the gaseous effluents, as required by Regulatory Guide 1.21. Additional objectives are to actuate the Liquid Radwaste System discharge isolation valve if predetermined radiation values are exceeded. Capabilities for grab sampling have been provided at certain radiation monitor locations, to allow determination of specific radionuclide content during normal operation and during post-accident conditions.

The RMSs provided to meet these objectives are:

1. Gaseous effluent monitors

    a. North plant vent (NPV) RMS

    b. South plant vent (SPV) RMS

c. Filtration, recirculation, and ventilation system vent (FRVSV) RMS

2. Liquid effluent streams

   a. Cooling tower blowdown (CTB) RMS

   b. Liquid radwaste (LR) RMS

   c. Turbine Building Circulating Water (TBCW) RMS

3. Gaseous process monitors

   a. Off-gas (OG) RMS

   b. Off-gas treatment (OGT) RMS

4. Gaseous ventilation monitors

   a. Reactor Building Ventilation System exhaust (RBVSE) RMS

   b. Turbine Building exhaust (TBE) RMS

   c. Turbine Building compartment exhaust (TBCE) RMS

   d. Radwaste Exhaust System (RES) RMS

   e. Radwaste area exhaust (RAE) RMS

   f. Gaseous radwaste area exhaust (GRAE) RMS

   g. Technical support center ventilation (TSCV) RMS

   h. Drywell leak detection (DLD) RMS

5. Liquid process monitors

   a. Reactor Auxiliaries Cooling System (RACS) RMS

   b. Safety Auxiliaries Cooling System (SACS) RMS

   c. Heating steam condensate, waste (HSCW) RMS

11.5.1.2 Design Criteria

11.5.1.2.1 Class 1E Radiation Monitoring Systems

The design criteria for the nuclear safety-related radioactivity monitoring systems that initiate protective action are that the systems:

1. Are protected against or designed to withstand the effect of natural phenomena, e.g., earthquakes without loss of capability to perform their functions.

2. Perform their intended safety function in environments resulting from normal and postulated accident conditions, as required.

3. Meet the reliability, testability, independence, and failure mode requirements of ESF systems.

4. Provide continuous indication on main control room panels for normal operation and, where appropriate, during abnormal operation.

5. Permit checking of the operational availability of each channel during reactor operation with provision for calibration function and instrument checks.

6. Provide redundancy and independence to assure a high probability of accomplishing their safety functions in the event of anticipated operational occurrences.

7. Initiate prompt protective action prior to exceeding plant technical specification limits.

8. Annunciate increasing radiation levels indicative of abnormal conditions.

9. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes alarm annunciation in the main control room.

10. Register full scale output if measured radiation levels exceed full scale.

11. Have sensitivities and ranges compatible with anticipated radiation levels and technical specification limits

12. Monitor a sample representative of the bulk stream or volume.

13. Provide access for grab sampling where appropriate.

The applicable GDC of 10CFR50, Appendix A are 63 and 64. Implementation of these GDCs is addressed in Sections 11.5.3 and 11.5.4. The systems meet the design requirements for Seismic Category I systems, along with the quality assurance requirements of 10CFR50, Appendix B.

The Class 1E Drywell Atmosphere Post Accident (DAPA) RMS provides Class 1E indication and non-Class 1E alarms on the main control room located display/keyboard/printer (DKP) unit. The applicable design criteria for the DAPA-RMS are 1, 2, 3, 4 and 10 described above.

11.5.1.2.2 Non-Class 1E Radiation Monitoring Systems

The design criteria for non-Class 1E RMSs are that the systems:

1. Provide continuous indication of radiation values in the main control room for normal operation and, where appropriate, during abnormal operation.

2. Annunciate increasing radiation values indicative of abnormal conditions.

3. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation, and initiation of isolation, where appropriate.

4. Monitor a sample representative of the bulk stream or volume.

5. Have provisions for calibration, function and instrumentation checks.

6. Have sensitivities and ranges compatible with anticipated radiation values and technical specification limits.

7. Register full scale output if radiation values exceed full scale.

8. Provide access for grab sampling where appropriate.

9. Initiate automatic closure of valve prior to exceeding the normal operation limits specified in the Technical Specifications or predetermined concentrations (see system descriptions as applicable).

10. Provide recording as applicable.

The RMS that monitors the discharge from the liquid radwaste treatment systems has provisions to alarm and to initiate automatic closure of the waste discharge valve prior to exceeding the normal operation limits specified in Technical Specifications. The RMS that monitors the discharge from the Turbine Building Circulating Water Dewatering Sump has provisions to alarm and to initiate sump pump trips prior to exceeding the normal operation limits specified in Technical Specifications.

The applicable GDC of 10CFR50, Appendix A, are GDCs 60, 63, and 64, as well as Regulatory Guide 1.21.

11.5.2 System Descriptions

The RMSs consist of detectors; distributed microprocessors that are local radiation processors (LRP); a redundant computer system (central radiation processors (CRP)) that is located in the upper control equipment room; and display/keyboard/printers (DKP) that are located in the main control room, RMS computer room, technical support center, and health physics offices. The Class 1E RMSs are channel independent and use the display/control stations located in the main control room RMS panel in addition to the DKP.

The LRPs process the detector data, determine if alarm setpoints have been exceeded, and perform appropriate control functions, as required. They also transmit channel status and count rates via redundant communication paths to the CRP. The Class 1E LRP processors transfer data through qualified Class 1E to non-Class 1E isolators into the CRP data base for storage. The RMS data is transferred via a redundant data link to the R*Time computer system for display on the Control Room Integrated Display System (CRIDS) and Safety Parameter Display System (SPDS).

The alarms for all RMS monitors (Class 1E and non-Class 1E) are locally displayed at the LRP and on each DKP. Additionally, all Class 1E alarms are visually and audibly displayed on separate non-Class 1E radiation trouble annunciators with the necessary isolation from the Class 1E equipment. Successive alarms will be reannunciated by the reflash function. The DKPs have a

CRT that displays information such as monitor status, trends, alarms, etc, from a menu selection. The printers will print selected data on demand, and can be used as an alarm log. Historical data (both Class 1E and non-Class 1E) are stored on the system magnetic discs for later retrieval.

The expected radioactive material concentrations in the normal releases are such that radiation levels at the site boundary are a small percent of the 10CFR20 limits for effluents to unrestricted areas (20.106) and will be within the 10CFR50, Appendix I dose design objectives.

The principal radionuclides for which monitoring capability is provided are listed in Table 11.5-1. The online monitoring capability is supplemented by laboratory analyses of grab samples taken from the same flow streams that are being monitored.

The setpoints for the effluent monitors are selected to meet the HCGS Technical Specification limits, which meet 10CFR20 limits and the 10 CFR 50, Appendix I design objectives. The setpoints for process monitors are selected to provide warning of increased radiation values in the monitored system so the operators can establish appropriate corrective action. All monitor setpoints are selected to keep offsite radioactivity concentrations within applicable regulatory limits. Setpoints can be changed only by authorized personnel in accordance with Station Administrative Procedures. Each monitor has at least three adjustable setpoints. The lowest is used as a failure alarm and is selected to be just below the normal background. Any detector malfunction will cause the detector output to go downscale and the failure alarm to be actuated. The next setpoint (alert) is set significantly higher (upscale) than the normal background and is used to alert the plant operators of abnormal conditions, so that appropriate corrective actions may be taken. The alert setpoint activates the local alarm.

The high upscale setpoint initiates the local alarm and the main control room annunciator and, in some RMSs, initiates corrective action where so designed. The RMS alarm circuits are of the latching type and are acknowledged from the DKP. The audible alarms are acknowledged at the LRP. The alarm will not reset until the radiation alert decreases below the high or alert setpoint, or increases above the fail setpoint. The main control room annunciator (not of the RMS) can be acknowledged and its audible alarm silenced by the control room operator, but the annunciator will not be cleared until the RMS alarm is cleared by the radiation data decreasing to less than the setpoint (or increasing for the fail setpoint).

The detectors are of various types: scintillation, geiger-mueller (GM), or ion chamber, as appropriate. The gamma scintillation detectors monitor gross gamma radiation. Beta scintillation detectors are used for gas radioactivity measurement. Ion chambers are used for high range and high temperature applications. The detectors are selected for the specific application and range needed. Table 11.5-1 also lists the application, type of detector, minimum detectable concentration, and range for each RMS. All detectors and monitors, with the exception of the MSLRM-RMS and OG-RMS, were initially calibrated by the manufacturer. Calibration transfer sources were used at initial plant startup to transfer this calibration data base to the plant. During plant startup, PSE&G performed primary calibrations at Hope Creek for the detectors and monitors identified in Table 11.5-1 with footnote (20). These primary calibrations were traceable to NITS (NBS) standards. Calibration transfer sources were determined as part of the primary calibrations performed at Hope Creek. These transfer sources (not the vendor supplied sources) are used to maintain the primary calibration data base determined by the on-site calibrations. These sources are owned and maintained by PSE&G so that the calibration can be duplicated in the plant periodically and after detector maintenance. Most detectors have check sources that are actuated by the operator or locally by maintenance personnel at designated intervals, according to the plant Technical Specifications. These check sources provide an operational check of the channel from the sensor through the display.

The liquid sampling systems, and all components exposed to the flow streams, are designed to be easily decontaminated in the field. The liquid monitors have isolation and sampling valves so that the monitor sample volume can be flushed with a decontamination solution. If additional decontamination is needed, the liquid monitors have replaceable liners that can be removed if needed.

The air sampling systems have a purge function so that the background radiation can be determined.

11.5.2.1 Class 1E Radiation Monitoring Systems

Information on these systems is presented in Table 11.5-1 and the arrangements are shown in Plant Drawing M-26-1.

11.5.2.1.1 Main Steam Line Radiation Monitoring System

This system monitors the radiation level next to the main steam lines. The normal radiation level is produced primarily by coolant activation products plus smaller quantities of fission products being transported with the steam. In the event of a gross release of fission products from the core, this monitoring system provides channel trip signals to the Primary Containment and Reactor Vessel Isolation Control System (PCRVICS), to initiate protective action. PCRVICS is described in Section 7.3.

The system consists of four redundant instrument channels. Each channel consists of a local detector (gamma sensitive ion chamber) and a main control room radiation monitor with an auxiliary trip unit. Power for two channels (A and C) is supplied from RPS bus A and for the other two channels (B and D) from RPS bus B, as described in Section 7.2. Channels A and C are physically and electrically independent of channels B and D.

The detectors are located physically near the main steam lines just downstream of the outboard main steam line isolation valves and upstream of the main steam stop valves.

The detectors are geometrically arranged so that this system is capable of detecting significant increases in radiation level with any number of main steam lines in operation. Table 11.5-1 lists the range of the detectors.

Each radiation monitor has four alarm signals: two upscale (high-high and high), one downscale (low) and one inoperative. Each alarm is displayed visually on the affected radiation monitor display.

A high high or Inop alarm actuates a main steam line high-high or Inop control room annunciator (common to all channels). A high alarm actuates a main steam line high radiation control room annunciator (common to all channels). A downscale alarm actuates a main steam line downscale control room annunciator common to all channels. High and low alarms do not result in a channel trip. Each radiation monitor visually displays the measured radiation flux. The main steam line RMS is an RPS and PCRVIC and is described in greater detail in Sections 7.2 and 7.3. An isolated analog signal from each MSL radiation monitor is connected to a local radiation processor and thus to the RMS-CRP for display and data storage.

11.5.2.1.2 Refueling Floor Exhaust Radiation Monitoring System

The RFE-RMS monitors the radioactivity concentration in the Reactor Building fuel handling area ventilation exhaust duct during normal and refueling conditions. The detectors are located in the RFE duct upstream of its junction with the main reactor building exhaust duct. The system consists of three channels. Each channel consists of a beta scintillation detector, a preamplifier, a remotely operated check source, a local radiation processor and a display control module located in the control room. The LRP provides data processing, display, control and alarms. Four high radiation alarms, one from each channel through Class 1E to Class 1e isolation, will be supplied to each channel of the Primary Containment Isolation System (PCIS), where

two out of three logic is used to initiate closure of the Reactor Building Containment Prepurge Cleanup System isolation dampers, and initiate startup of the FRVS.

The data from channel A is also displayed on a strip chart recorder in a main control room panel. Each local radiation processor will provide contacts which close on high, alert, and low (failure) radiation which will operate a common trouble alarm in the main control room.

11.5.2.1.3 Reactor Building Exhaust Radiation Monitoring System

The Reactor Building Exhaust (RBE) RMS monitors the radiation concentration in the Reactor Building exhaust during normal and refueling conditions. The system consists of three channels that are identical (except that the local radiation processor and the main control room located display control modules are shared) to the channels in the refueling floor exhaust (RFE) RMS (See Section 11.5.2.1.2), including the isolation logic. The RBE-RMS also initiates the Filtration, Recirculation and Ventilation System (FRVS). The RBE RMS also provides signals to the Primary Containment Isolation System (PCIS) to initiate closure of primary containment isolation valves and dampers (refer to Section 7.3.1.1.5). The detectors are located in the RBE duct upstream of the junction with the RFE duct. The data from channel A is also displayed on a strip chart recorder in a main control room panel.

11.5.2.1.4 Control Room Ventilation Radiation Monitoring System

This system monitors outside air that enters the inlet plena exterior to the Control Room Ventilation System (CRVS). No measurable radioactive materials are expected during normal operation; however, in the event of a postulated design basis accident (DBA), a high airborne radioactivity concentration in the

plena could result from fission gases from a leak or an accidental release. The resulting radioactive materials could be drawn into the main control room through the plena.

The CRVS RMS consists of two redundant, separated instrument channels. Each channel consists of two local detector assemblies (beta scintillation detectors with a remotely actuated check source and preamplifiers) and a main control room radiation display/control module. One detector from each of the two channels will be located in each of the two inlets for a total of 4 detectors. Power for one channel, C, is supplied from Class 1E bus C and for the other channel, D, from Class 1E bus D. Channels C and D are physically and electrically independent. The LRP will provide data processing, alarms and controls. The radiation data are transmitted through Class 1E to non-Class 1E isolators and recorded on the non-Class 1E RMS data processing and recording system.

Each radiation monitor provides contact actuation on upscale (high) radiation. Any one of the four detectors upscale trips initiate closure of the main control room ventilation isolation valves and start recirculation and filtration of the main control room air (refer to Section 9.4.1). If abnormal radiation is detected in any one of the two control room ventilation inlet plena, a dedicated CRV high radiation alarm in the control room will alert the operator. The low alarm is combined with the high radiation alarm.

These channels are connected to the central radiation processing computer for display and logging purposes.

11.5.2.1.5 Drywell Atmosphere Post-Accident Radiation Monitoring System

The drywell atmosphere post-accident (DAPA) RMS monitors the atmosphere in the drywell in case of a postulated accident that could release a large amount of fission products into the drywell

(primary containment). Two widely separated detectors are located such that they will be exposed to a representative volume of the primary containment atmosphere. Continuous radiation indication is available on the main control room display/control panel, and after Class 1E to non-Class 1E isolation, is stored in the CRP data base. A non-qualified strip chart recorder also displays this indication in the control room. The detectors are qualified for loss-of-coolant accident (LOCA) conditions, as well as seismic conditions that can occur at their locations in the drywell. The DAPA RMS meets the requirements of Regulatory Guide 1.97, Rev. 2, with exception of the requirement that overall system accuracy be within a factor of 2 over the entire range. A Safety Evaluation was done to document the acceptability of the additional loop error associated with the decreased cable resistance due to elevated temperatures during an accident condition. The DAPA RMS is designated Seismic Category I, but does not initiate any nuclear safety functions.

The DAPA RMS detectors are ion chambers manufactured by GA Technologies (GA) model RD23 and have a range of 10^{0}-10^{8} R/h for gamma radiation and has been installed in many nuclear plants for this service.

11.5.2.2 <u>Non-Class 1E Radiation Monitoring Systems</u>

Information on these systems is presented in Table 11.5-1 and the arrangements are shown on Plant Drawing M-26-1.

11.5.2.2.1 North Plant Vent Radiation Monitoring System

The North Plant Vent (NPV) RMS takes a continuous representative sample from the ventilation air that is exhausted from the NPV (Refer to Plant Drawing M-26-1). This sample flows through a radiation sampling system which includes a high efficiency filter and a fixed charcoal cartridge. The sample then flows through a normal and extended range noble gas monitor. Grab sampling is provided to determine radionuclide concentrations by onsite laboratory analysis.

The sample extraction system has isokinetic nozzles downstream of a flow straightening grid. The sample is transported to the filters through heat traced tubing so that condensation will be minimized. A flow velocity sensor provides a signal for measuring the effluent flow. The effluent flow signal is used to vary the sample flow with the vent flow and thus maintain isokinetic sampling conditions. This system meets the ANSI N13.1 sampling requirements. The sample flow is also controlled to compensate for filter loading. The sample is returned to the vent.

The noble gas channel is a beta detector. The extended range noble gas channel includes a gamma detector.

The NPV has the possibility of release of radioactive materials only during normal plant operation. During accident conditions, all flows from compartments that could be expected to release significant radioactive materials can be isolated. However, in accordance with Regulatory Guide 1.97, the NPV can be considered a "common plant vent," and as such, the NPV RMS is designated as Category 2 equipment. Category 2 equipment must meet the design and qualification criteria in Paragraph 1.3.2 of Regulatory Guide 1.97. This requires qualification "... in accordance with Regulatory Guide 1.89 and the methodology described in NUREG 0588." The NPV RMS location is considered a mild environment and the equipment is designed to meet the environmental conditions. The NPV RMS is not seismically qualified in accordance with Regulatory Guide 1.100 because the NPV itself is not seismically qualified. The NPV RMS conforms with Regulatory Guide 1.97, paragraph 1.3.2.f in that the monitored variables are recorded in the CRP and displayed on demand on the CRT of the DKP.

Although the NPV design is not expected to experience accident range radioactive material releases, provision is included to sample particulate and halogen concentrations, and to monitor noble gas concentrations up to 10^3 microcuries per cc (Xe-133 or

equivalent). Sample filter handling tools and portable shields are provided in case the filter loadings exceed normal values and for removal of filters for laboratory analysis. The particulate filter is 99.0 percent efficient for particles larger than 0.3 microns. The iodine filter is charcoal and has a 95 percent iodine retention capability. The iodine and particulate filter holder assembly and the filter transport holder assembly are designed to satisfy the NUREG-0737 design basis shielding envelope requirements.

The NPV RMS is powered from a non-Class 1E ac power source backed by the standby diesel generator as shown on Table 8.3-1.

NPV RMS calibration procedures are based on the requirements of the operation and maintenance manual supplied with the equipment. Calibration frequencies are provided in Section 16, "Technical Specifications."

All of the NPV-RMS channels have high, alert, and low (failure) alarms. Their function is to alert the operator of high radiation values in the NPV effluent, or failure (low alarm) of the components. This system has no isolation function.

The NPV RMS has components located at higher elevations, and there is, a possibility of lightning strikes affecting them. The system is designed and installed to limit the effects of such occurrences. All components located in the vent are grounded to the stack structure, which can drain the charge from a lightning strike.

11.5.2.2.2 South Plant Vent Radiation Monitoring System

The South Plant Vent (SPV) RMS and the NPV RMS are similar in function and equipment. The SPV RMS differs from the NPV in duct size (12 x 12 feet as compared to 7 x 6 feet for the NPV).

Like the NPV, the SPV RMS is also powered from a non-1E ac power source backed by the standby diesel generator as shown on Table 8.3-1.

11.5.2.2.3 Filtration, Recirculation, and Ventilation System Vent Radiation Monitoring System

During normal plant operations the FRVS and FRVSV are maintained in a standby condition. The normal plant operation of the FRVSV-RMS is to maintain the FRVSV-RMS in service at all times by continuously running the low range sample pump. Therefore no automatic initiation of the FRVSV-RMS is required when any plant condition, including tests, initiates the operation of the FRVSV.

The FRVSV RMS monitors releases to the environment from the FRVS during post-accident conditions (Refer to Plant Drawing M-26-1). These releases are downstream of the FRVSV high efficiency particulate air (HEPA) and charcoal filters. The releases are sampled by isokinetic nozzles in the duct.

In conformance with ANSI N13.1, FRVSV effluent flow rate is compared to FRVSV-RMS sample flow rate by the LRP which adjusts sample flow rate as necessary to maintain continuous isokinetic sampling condition. A sample splitter upstream of the sampling skid is provided to maintain system response time during the postulated high radioactivity concentrations.

Fixed particle and iodine sample filters, which can be removed for laboratory analysis, are provided. The particulate filter is fiberglass and is 99.9 percent efficient for particles larger than 0.3 microns. The iodine filter is silver zeolite and has a 99 percent iodine retention capability. The iodine and particulate filter holder assembly and the filter transport holder assembly are designed to satisfy the NUREG-0737 design basis shielding envelope requirements.

Downstream of these sample filters, a high range noble gas monitor is installed that is capable of measuring accident range (10^5 μCi/cc) gaseous releases. A normal range noble gas detector is also included. The normal range detector can measure the low concentrations that may be released during the periodic operational checks of the FRVS and the low level releases expected after considerable time has elapsed since the postulated accident.

The FRVSV RMS meets the requirements of Regulatory Guide 1.97, Revision 2, which classifies it as Category 2. The FRVS RMS, except for the sample line heat tracing, is qualified for the environmental conditions that can occur at its location and has been procured in conformance with a 10CFRPart 50, Appendix B quality assurance program.

The FRVSV RMS is powered from a battery backed uninterruptible ac power source.

Except as described above, the FRVSV-RMS components and functions are similar to the NPV and SPV-RMS components and functions.

FRVSV RMS calibration procedures are based on the requirements of the operation and maintenance manual supplied with the equipment. Calibration frequencies are provided in Section 16, "Technical Specifications."

11.5.2.2.4 Cooling Tower Blowdown Radiation Monitoring System

The Cooling Tower Blowdown (CTB) RMS monitors a sample of the cooling tower blowdown before it is discharged to the Delaware River (Refer to Plant Drawing M-09-1). The high alarm indicates that abnormally high amounts of radioactive materials are being released to the environment; however, it is recognized that the seasonal natural content of potassium-40 in the river, after concentration in the cooling tower system, may cause upscale indication greater than actual plant releases. The CTB RMS has

the same components as the liquid radwaste RMS (see Section 11.5.2.2.5), but the associated LRP does not provide a trip for valve closure or measure process flow rate.

11.5.2.2.5 Liquid Radwaste Radiation Monitoring System

The Liquid Radwaste RMS monitors the liquid radwaste sample for gamma radiation prior to discharge into the cooling tower blowdown line (Refer to Plant Drawing M-63-0). The liquid radwaste discharge is diluted by a continuous flow of water from the cooling tower basin prior to discharge into the Delaware River. A sample of the liquid radwaste discharge flows through the liquid radwaste RMS. The discharge system is described in more detail in Section 11.2.3.

Liquid radwaste can be discharged from any of several tanks collecting processed water. Prior to any release, the tank water is mixed thoroughly, sampled, and the sample is analyzed in the plant laboratory. Based on the analysis, the water is discharged at a specified dilution and release rate. The liquid radwaste discharge flow is measured and monitored for radiation. Cooling tower blowdown flow is also measured. The LRP uses liquid radwaste and cooling tower blowdown flows together with the liquid radwaste concentration to calculate radioactive concentrations discharged to the Delaware River.

The liquid radwaste RMS has the following radiation alarm signals: two upscale high and alert; and one downscale, equipment failure. Any one of the following signals originating from the local radiation processor: high radiation, equipment failure, high liquid radwaste discharge flow, low CTB flow, or loss of sample flow, will initiate liquid radwaste discharge isolation. Discharge isolation may be manually overridden at panel 0AC367 in the radwaste control room.

The liquid radwaste RMS consists of a sample chamber surrounded by a lead shield. The detector is a gamma scintillation type with

gross gamma capability. The sample chamber is designed so that the sensitive volume of the detector is surrounded by the sample. A remotely operated check source that can be operated from the LRP or any DKP is used to check operability of the channel.

11.5.2.2.6 Off-gas Radiation Monitoring System and Sampling System

The off-gas RMS monitors radioactivity in a sample from the condenser offgas at a tap upstream of the ambient charcoal treatment system in the ten minute holdup pipe of the Off-gas System (Refer to Plant Drawing M-26-1). The monitor detects the radiation concentration that is attributable to the non-condensable fission product gases that are produced in the reactor and transported with steam through the turbine to the condenser. Changes in the radiation values can be used to interpret fuel rod condition.

A continuous sample is extracted from the sample tap between the fourth and fifth holdup pipe of the Off-gas System. It is then passed through the monitor sample chamber and the sample panel before being returned to the condenser. The sample chamber is a stainless steel pipe that is internally polished to minimize plateout. It can be purged with room air to check the detector response to background radiation by using a three-way solenoid operated valve. The valve is controlled by a switch located on the local control panel. The sample panel measures and indicates sample line flow. Two detectors are positioned adjacent to the vertical sample chamber and are connected to an LRP. The radiation data are transferred to the CRP data base for display and storage through the LRP. Power for the offgas RMS is supplied from 120 V ac local busses for the sample monitor and vial sampler and the control panel.

The radiation monitor has three bistable alarms signals: two upscale (high and high-high) and one downscale (low or fail). The outputs are used for alarm function only. Each alarm is visually displayed on the radiation monitor panel and is transmitted to the

main control room. In addition, sample line flow is measured locally. This system has no isolation functions.

The radiation data from the monitor can be correlated to the concentration of the noble gases by analysis of a grab sample in an onsite laboratory. The sample is analyzed with a multichannel gamma pulse height analyzer to determine the concentration of the various noble gas radionuclides and thus permits calibration of the monitor.

11.5.2.2.7 Off-gas Treatment Radiation Monitoring System

This system monitors radioactivity in the off-gas effluent from the ambient charcoal Off-gas Treatment (OGT) System (refer to Plant Drawing M-70-0 sheet 2). Two detectors are located downstream of the Off-gas System discharge valve through which the treated off-gas is released to the NPV for release to the atmosphere.

The OGT RMS consists of two in-line samples with gamma scintillation detectors and an LRP that processes the detector data and the flow rate data. Radiation, flow and equipment malfunction alarms are provided. This system has no isolation functions.

11.5.2.2.8 Reactor Building Ventilation System Exhaust Radiation Monitoring System

The Reactor Building Ventilation System Exhaust (RBVSE) RMS is downstream of the HEPA filter through which the reactor building air is exhausted (Refer to Plant Drawing M-26-1) Other (Class 1E) systems (RBE RMS) provide trip signals for isolation of the reactor building in case of excessive radiation, and under those conditions, there will be no flow in the duct where the RBVSE RMS is located. The purpose of the RBVSE RMS is to monitor the flow during normal conditions, from the reactor building downstream of the filters. After filtration, the flow goes to the SPV for discharge to the atmosphere. Because this duct is a tributary to

the SPV, the concentrations will be undiluted, thus allowing earlier detection than when mixed with the exhausts from other locations.

The RBVSE RMS consists of a beta scintillation detector with a remotely actuated check source, and an LRP. The detector is located in the side of the RBVS exhaust duct and is exposed to a representative sample of the flow. Increases in the radiation detected that do not correlate with the RBE RMS may indicate that the HEPA filters are not functioning normally. This system has no isolation functions. Radiation and component failure alarms are provided. The RBVE detector element also is covered by a wind shield to protect the element's face from wind damage due to high duct velocities.

11.5.2.2.9 Turbine Building Exhaust Radiation Monitoring System

The Turbine Building Exhaust (TBE) RMS is located in a duct through which the turbine building is exhausted to the SPV (refer to Plant Drawing M-26-1). The TBE RMS has the same components and functions as the RBVSE RMS, described in Section 11.5.2.2.8, except that there is no filtration system upstream of its location and no wind shield. This detector has a lead shield installed around it to attenuate high background radiation caused by turbine shine. The face of the detector (which contains the beta scintillator) has a direct view of the duct at a reduced solid angle as the unshielded detectors. Installation of the lead attenuator decreases the total viewing angle of the process stream and thus the detection sensitivity. A new detector conversion factor has been incorporated to compensate for desensitization.

11.5.2.2.10 Turbine Building Compartment Exhaust Radiation Monitoring System

The Turbine Building Compartment Exhaust (TBCE) RMS is located in the exhaust duct for a compartment in which there is equipment that has a possibility of releasing airborne radioactive materials (refer to Plant Drawing M-26-1). The TBCE RMS has the same components and

functions as the RBVSE RMS described in Section 11.5.2.2.8, except that there are no filters upstream of its location and no wind shield. This detector has a lead shield installed around it to attenuate high background radiation caused by turbine shine. The face of the detector (which contains the beta scintillator) has a direct view of the duct at a reduced solid angle as the unshielded detectors. Installation of the lead attenuator decreases the total viewing angle of the process stream and thus the detection sensitivity. A new detector conversion factor has been incorporated to compensate for desensitization.

11.5.2.2.11 Radwaste Exhaust System Radiation Monitoring System

The Radwaste Exhaust System (RES) RMS is located in a duct that exhausts the radwaste processing areas of the Auxiliary Building to the south vent (refer to Plant Drawing M-26-1). The RES RMS

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has the same components and functions as the RBVSE RMS, described in Section 11.5.2.2.8, and is located downstream of HEPA and charcoal filters. Comparison of the RES RMS and radwaste area exhaust (RAE) RMS (see Section 11.5.2.2.12) data can provide information about the HEPA and charcoal filter efficiency and condition.

11.5.2.2.12 Radwaste Area Exhaust Radiation Monitoring System

The RAE RMS is located in the exhaust duct for radwaste area compartments in which there is equipment that has a possibility of releasing airborne radioactive materials (refer to Plant Drawing M-26-1). The RAE RMS is upstream of the filters and will be exposed to higher concentrations than the RES RMS, thus allowing earlier detection of any problems in the radwaste areas of the auxiliary building. The RAE RMS has the same components and functions as the RBVSE RMS described in Section 11.5.2.2.8.

11.5.2.2.13 Gaseous Radwaste Area Exhaust Radiation Monitoring System

The Gaseous Radwaste Area Exhaust (GRAE) RMS is located in the exhaust duct for the recombiner compartments (refer to Plant Drawing M-26-1). This allows earlier detection of airborne radioactive materials than is possible by downstream monitors where the concentrations are more diluted. The GRAE RMS has the same components and functions as the RBVSE RMS described in Section 11.5.2.2.8. There are no filters upstream of the location.

11.5.2.2.14 Technical Support Center Ventilation Radiation Monitoring System

The Technical Support Center Ventilation (TSCV) RMS is located in the inlet plenum for the technical support center (refer to Plant Drawing M-26-1, Sh. 2) The purpose of the TSCV RMS is to detect radioactive materials in the inlet air. The TSCV RMS has the same components as the RBVSE RMS described in Section 11.5.2.2.8. If

the concentration exceeds the trip setpoint, an alarm at the CRP alerts the operator to manually transfer from the normal air supply to an emergency recirculation and filtration mode.

11.5.2.2.15 Drywell Leak Detection Radiation Monitoring System

The Drywell Leak Detection (DLD) RMS monitors the gaseous radioactive materials in the drywell (refer to Plant Drawing M-25-1). The design objective of this system is to monitor reactor coolant pressure boundary (RCPB) leakage in accordance with Regulatory Guide 1.45. Conformance to Regulatory Guide 1.45 is discussed in Section 1.8. The capability to do so declines as the normal in-containment background of gaseous radioactive materials increases because of the accumulation from identified leaks. An air sample is extracted and returned through penetrations that are isolated by the PCIS described in Section 7.3.1.1.5. The DLD RMS components are one inlet and one outlet stub on the east side of the drywell, penetrations, and isolation valves. There is also a shield sample chamber, a beta scintillation detector, and an LRP. The high alarm indicates excessive leakage from the RCPB. The DLD RMS is seismically qualified to operate under conditions during which the reactor is operated. The functional requirements and descriptions of other leak detection equipment are discussed in Sections 5.2.5 and 7.6.1.3. Provision for a grab sample is included, as well as a provision for the temporary installation of a portable drywell supplementary oxygen monitor to permit periodic measurement of the drywell oxygen concentration during normal operation (see Section 6.2.5.2.1). The drywell supplementary oxygen analyzer is mounted on an existing electrical support adjacent to the Leak Detection System (LDS) skid. Flexible Tygon tubing with quick disconnects from the drywell supplementary oxygen analyzer can be attached to the existing two connections on the LDS skid to monitor drywell oxygen concentration whenever desired.

Testing and calibration of the DLD RMS will be in conformance with the Technical Specifications.

11.5.2.2.16 Reactor Auxiliaries Cooling System Radiation Monitoring System

The Reactor Auxiliaries Cooling System (RACS) RMS monitors a sample extracted from the RACS (refer to Plant Drawing M-26-1). The

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RACS RMS has the same components as the liquid radwaste RMS. The alert alarm indicates the beginning of tube leakage into the RACS from the heat exchangers that are serviced by the RACS.

11.5.2.2.17 Safety Auxiliaries Cooling System Radiation Monitoring System

The Safety Auxiliaries Cooling System (SACS) RMS has two monitors, A and B, one for each of the two SACS loops (refer to Plant Drawing M-26-1). The SACS RMS monitor samples extracted from the SACS. The SACS RMS components, i.e., detectors, LRP, etc, are similar to those in the liquid radwaste RMS. The SACS RMS sample chambers are part of the SACS pressure boundary and are seismically and environmentally qualified. The alert and high alarms indicate moderate and excessive leakage, respectively, into the SACS heat exchangers from the safety auxiliaries served by the Safety Auxiliaries Cooling System.

11.5.2.2.18 Heating Steam Condensate Waste Radiation Monitoring System

The Heating Steam Condensate Waste (HSCW) RMS monitors a sample of the condensate flow from the Liquid Waste Management System (refer to Plant Drawing M-65-0, Sh. 2). The high alarm/trip indicates both leakage of radioactive materials from one or both of the waste evaporators and the need for corrective action. The high alarm/trip isolates the heating steam and condensate return tank from the deaerator and trips the condensate return pump(s). The HSCW RMS has the same components as the liquid radwaste RMS. Because the temperature of the sample is high, a sample cooler is used.

11.5.2.2.19 Deleted

11.5.2.2.20 Turbine Building Circulating Water Radiation Monitoring System

The Turbine Building Circulating Water (TBCW) RMS monitors a sample of the Turbine Building circulating water sump discharge to the cooling tower (refer to Plant Drawing M-09-1). The high alarm trip indicates leakage of radioactive materials from the condenser water boxes or condensation from the HVAC supply units cooling coils. This alarm trips the TBCW sump pumps, terminating the release of radioactive materials. The TBCW RMS has the same components as the liquid radwaste RMS described in Section 11.5.2.2.5, but the associated LRP does not provide a trip for valve closure or measure process flow rate.

11.5.2.2.21 Hardened Torus Vent (HTV) Radiation Monitoring:

The hardened torus vent radiation monitoring system monitors radiation level and radiation release rate during HTV release.

The low range is monitored by an adjacent to line gamma scintillation detector. The high range is monitored by an ion chamber.

The monitor variables, low range radiation (µCi/cc), effluent release rate (µCi/sec) and process flow are displayed on demand on the CRT in the Main Control Room. High range radiation (R/hr) and process flow are continuously displayed and recorded at the Remote Shutdown Panel near the Main Control Room.

The radiation monitoring system is powered from non-safety related, battery backed vital power supply source.

HTV radiation monitoring instrumentation channel check and calibration frequencies are based on recommendation from the

equipment supplier. Calibration procedures are based on the requirements of the operation and maintenance manual supplied by the equipment supplier.

11.5.3 Effluent Monitoring and Sampling

The requirements of GDC 64 (10CFR50, Appendix A) are implemented with respect to effluent discharge paths by means of the following RMS:

1. Gaseous effluents:

    a. North plant vent (11.5.2.2.1)

    b. South plant vent (11.5.2.2.2)

    c. Filtration, Recirculation, and Ventilation System (11.5.2.2.3)

    Sample taps are provided as part of these RMS. Table 11.5-3 describes the radiological sampling and analysis program to be conducted.

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2. Liquid effluents:

   a. Cooling tower blowdown (11.5.2.2.4)

   b. Liquid radwaste (11.5.2.2.5)

   c. Turbine Building Circulating Water (11.5.2.2.20)

   A sample is provided for laboratory analysis. Table 11.5-3 describes the radiological sampling and analysis program to be conducted.

11.5.4 Process Monitoring and Sampling

The requirements of GDC 60 (10CFR50, Appendix A) are implemented by means of automatic termination of liquid effluents and manual termination of treated off-gas when excessive radioactive materials are detected by radiation monitoring systems. Radiation monitoring systems that provide automatic control of effluents or process streams are identified with their control functions in Table 11.5-2.

The requirements of GDC 63, (10CFR50, Appendix A) are implemented by monitoring radioactivity concentrations in radioactive fuel storage and radioactive waste process systems by the following monitoring RMS:

1. Refueling floor exhaust (11.5.2.1.2)
2. Reactor Building exhaust (11.5.2.1.3)
3. Radwaste Exhaust System (11.5.2.2.11)
4. Radwaste area exhaust (11.5.2.2.12)
5. Gaseous radwaste area exhaust (11.5.2.2.13).

Multiple locations exist for obtaining grab samples of various process and effluent streams. The locations where samples may be

taken are listed in Table 9.3-3 and are also shown in Plant Drawing M-23-0. The drawing illustrates that samples of the Reactor Auxiliary Cooling System (RACS), Turbine Auxiliary Cooling System (TACS), Fuel Pool Cooling and Cleanup System (FPCCS), waste collector tanks and various other systems can be obtained at a central sampling station in the Turbine Building or Auxiliary Building or at a location local to the system. Laboratory and sample system drains are directed to the systems illustrated in Figure 11.2-5 which can be sampled.

The Station Service Water System (SSWS) is a separate system used to cool the RACS and SACS heat exchangers. It is not expected to become contaminated; therefore, radiation monitors are not provided on this process system and routine sampling for radioactivity is not deemed to be necessary. However, grab samples can be obtained at test locations shown in Plant Drawing M-10-1 and the sample analyzed for gross beta activity, if necessary.

Additional sampling and analysis requirements will be listed in Section 16, Technical Specifications.

TABLE 11.5-1

HOPE CREEK RADIATION MONITORING SYSTEMS

RMS Identification Description, and Ref.	Number of Channels	Detector Type[1][14]	Detector Location[15]	Range	Minimum Detectable Concentration[11]
Main steam line[20] 11.5.2.1.1 REN006A REN006B REN006C REN006D	4	Gamma ion chamber	Downstream of outboard MSIVs El. 137, Area 26	$1-10^{6}$ mR/h	1 mR/h[11]
Refueling floor exhaust[20] 11.5.2.1.2 RE4856A RE4856B RE4856C	3	Beta-scint	Upstream of damper El. 205, Area 15	$1.69x10^{-5}$ - $2x10^{-1}$ µCi/cc Xe-133	$1.69x10^{-5}$ µCi/cc at 2.5 mR/hr MFP[5]
Reactor Building exhaust[20] 11.5.2.1.3 RE4857A RE4857B RE4857C	3	Beta-scint	Upstream of damper El. 189, Area 15	$1.69x10^{-5}$ - $2x10^{-1}$ µCi/cc Xe-133	$1.69x10^{-5}$ µCi/cc at 2.5 mR/hr MFP(5)
Control room ventilation[20] 11.5.2.1.4 RE4858C RE4858C1 RE4858D RE4858D1	2[19]	Beta-scint	Air inlet plena El. 162, Area 26	$3.4x10^{-6}$ - $2x10^{-1}$ µCi/cc Xe-133	$3.4x10^{-6}$ µCi/cc at 0.5 mR/hr MFP[5]
Drywell atmosphere post-accident 11.5.2.1.5 RE4825A RE4825B	2	Gamma ion chamber	Inside containment El. 145, Area 17	$1-10^{8}$R/h	1 R/h[12] MFP[5][8]

TABLE 11.5-1 (Cont)

RMS Identification Description, and Ref.	Number of Channels	Detector Type[13][14]	Detector Location[15]	Range	Minimum Detectable Concentration[1]
North plant vent[9] 11.5.2.2.1			Sample panel El. 137, Area 77		
Gaseous[20] RE4873B	1	Beta scint (normal range)		$1.4x10^{-7}$-$3x10^{-1}$ μCi/cc Xe-133	$1.4x10^{-7}$ μCi/cc[-2] at .5 mR/hr
RE4873C2	1	Gamma Cd-Te[10] (mid-range)		$2x10^{-4}$-$1x10^{2}$ μCi/cc Xe-133	$2x10^{-4}$ μCi/cc at .5 mR/hr
RE4873C1	1	Gamma Cd-Te (high range)		$2x10^{-4}$-$1x10^{5}$ μCi/cc Xe-133	$2x10^{-4}$ μCi/cc at 0.5 mR/hr
South plant vent[9] 11.5.2.2.2			Sample panel El. 155, Area 32		
Gaseous[20] RE4875B	1	Beta scint (normal range)		$1.4x10^{-7}$-$3x10^{-1}$ μCi/cc Xe-133	$1.4x10^{-7}$ μCi/cc(4) at 0.5 mR/hr
RE4875C2	1	Gamma Cd-Te[10] (mid-range)		$2x10^{-4}$-$1x10^{2}$ μCi/cc Xe-133	$2x10^{-4}$ μCi/cc at 0.5 mR/hr

TABLE 11.5-1 (Cont)

RMS Identification Description, and Ref.	Number of Channels	Detector Type[13][14]	Detector Location[15]	Range	Minimum Detectable Concen-tration[1]
RE4875C1	1	Gamma Cd-Te (high range)		$2x10^{-4}$-$1x10^{5}$ µCi/cc Xe-133	$2x10^{-4}$ µCi/cc at 0.5 mR/hr
Filtration, Recirc-ulation Venti-lation System[4] 11.5.2.2.3			Sample panel El. 153, Area 72		
Gaseous[20] RE4811A	1	Beta scint (normal range)		$1.4x10^{-7}$-10^{-1}[16] µCi/cc Xe-133	$1.4x10^{-7}$ µCi/cc[16] at .5 mR/hr MFP[7]
RE4811B1	1	Gamma Cd-Te (mid-range)		10^{-4}-10^{2} µCi/cc Xe-133	10^{-4} µCi/cc[16] at .5 mR/hr MFP[7]
RE4811B2	1	Gamma Cd-Te (high-range)		10^{-1}-10^{5} µCi/cc Xe-133	10^{-1} µCi/cc at 0.5 mR/hr
Cooling tower blowdown[14] 11.5.2.2.4 RE8817	1	Gamma scint	Effluent to Delaware R Building 9	$2.5x10^{-8}$-$7.8x10^{-2}$ µCi/cc, Cs-137	$2.5x10^{-8}$ µCi/cc (3)
Liquid radwaste[14] 11.5.2.2.5 RE4861	1	Gamma scint	Shielded sampler El. 58, Area 35	$2.0x10^{-7}$-$7.8x10^{-2}$ µCi/cc, Cs-137	$2.0x10^{-7}$ µCi/cc[2] at 15 mR/hr MFP[5]
Off-gas[14] 11.5.2.2.6 REN004A REN004B	2	Gamma ion chamber	Inlet to sample panel OC-335/J034 El. 87, Area 36	1-10^{6} mR/h	1 mR/hr detectable change
Off-gas Treatment System 11.5.2.2.7 RE6281 RE6282	2	Gamma scint	Downstream of outlet HEPA filter, at sampler El. 54, Area 38	$1x10^{1}$-$1x10^{7}$ counts per minuite. See note 22	N/A. See note 22
Reactor Building Ventilation System[20] exhaust 11.5.2.2.8 RE4826	1	Beta scint	Downstream of HEPA & charcoal filters El. 165, Area 32	$1.69x10^{-5}$-$1x10^{-1}$ µCi/cc Xe-133	$1.69x10^{-5}$ µCi/cc at 2.5 mR/hr MFP[5]

RMS Identification Description, and Ref.	Number of Channels	Detector Type[13][14]	Detector Location[15]	Range	Minimum Detectable Concentration[1]
Turbine Building exhaust[20] 11.5.2.2.9 RE4827	1	Beta scint	Upstream of junction with south stack El. 171, Area 10	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/h MFP[5]
Turbine Building ompartment exhaust[20] 11.5.2.2.10 RE4456	1	Beta scint	Upstream of junction with turbine bldg exhaust El. 158, Area 12	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/h MFP[5]
Radwaste exhaust system[20] 11.5.2.2.11 RE4812	1	Beta scint	Downstream of filters El. 175, Area 32	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/hr MFP[5]
Radwaste area exhaust[20] 11.5.2.2.12 RE4457	1	Beta scint	Upstream of filters El. 164, Area 35	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/hr MFP[5]
Gaseous radwaste area exhaust[20] 11.5.2.2.13 RE4828	1	Beta scint	Recombiner exhaust duct El. 70, Area 35	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/h MFP[5]
Technical support center ventilation[20] 11.5.2.2.14 RE4868	1	Beta scint	Air inlet plenum El. 162, Area 73	$1.69x10^{-5}$-$1x10^{-1}$ μCi/cc Xe-133	$1.69x10^{-5}$ μCi/cc at 2.5 mR/hr MFP[5]
Drywell leak detection[20] 11.5.2.2.15 RE4991	1	Beta scint	Sample panel El. 162, Area 17	$1.7x10^{-5}$-$5x10^{-1}$ μCi/cc Xe-133	$1.7x10^{-7}$ μCi/cc at 2.5 mR/hr MFP[5][6][7]
Reactor Auxiliaries Cooling System[14] 11.5.2.2.16 RE2534	1	Gamma scint	Shielded sampler El. 77, Area 23	$4.9x10^{-8}$-$7.8x10^{-2}$ μCi/cc, Cs-137	$4.9x10^{-8}$ μCi/cc at 2.5 mR/hr MFP[5][6]

RMS Identification Description, and Ref.	Number of Channels	Detector Type[13][14]	Detector Location[15]	Range	Minimum Detectable Concentration[1]
Safety Auxiliaries Cooling System[14] 11.5.2.2.17 RE4859A1 RE4859B1	2	Gamma scint	Shielded sampler El. 102, Area 23	$4.9x10^{-8}$-$7.8x10^{-2}$ µCi/cc, Cs-137	$4.9x10^{-8}$ µCi/cc at 2.5 mR/hr MFP[5][6]
Heating steam condensate, waste[20][21] 11.5.2.2.18 RE5534	1	Gamma scint	Shielded sampler El. 94, Area 32	$4.3x10^{-8}$-$5.4x10^{-2}$ µCi/cc, Cs-137	$4.3x10^{-8}$ µCi/cc at 2.5 mR/hr MFP[5]
Turbine Building circulating water[14] 11.5.2.2.20 RE4557	1	Gamma scint	Shielded sampler El. 58, Area 01	$4.9x10^{-8}$-$7.8x10^{-2}$ µCi/cc, Cs-137	$4.9x10^{-8}$ µCi/cc at 2.5 mR/hr MFP[5]
Hardened Torus Ventilation (Low Range) 11.5.2.2.21 RE11542	1	Adjacent to line detector Gamma scint	Vent Pipe Line upstream of rupture disc El. 102, Area 4102	$1.0x10^{-4}$-$1x10^{2}$ µCi/cc Xe-133	$1x10^{-4}$ µCi/cc at 2.5 mR/hr[5]
Hardened Torus Ventilation (High Range) 11.5.2.2.21 RE11542A	1	Shielded ion chamber	Shielded ion chamber upstream of rupture disc El 102, Area 4102	$1x10^{-2}$ -$1x10^{4}$ R/hr, Xe-133	$1x10^{-2}$ R/hr at 2.5 mR/hr[5]

(1) Minimum detectable concentration with the detector in a 1 mR/h field unless stated otherwise.

(2) The 10CFR50 Appendix I release monitoring function is performed by the NPV RMS and SPV RMS, and the liquid radwaste.

(3) The expected MFP concentrations are not expected to be measurable by the CTB RMS. Because the cooling tower will concentrate the river water by factors of 6-10, the naturally occurring K-40 concentration in the blowdown released back to the river can be as high as $1x10^{-7}$ µC/cc or about 200 times greater than the plant releases of gamma emitters.

(4) Particulates and halogens are sampled and removed for onsite analysis

(5) MFP = Mixed fission products.

(6) Mixed fission products, reactor water.

(7) Mixed fission products, reactor steam.

(8) Mixed fission products, initial post-LOCA drywell atmosphere.

(9) Particulates and halogens above normal range are sampled and removed for onsite analysis.

(10) The NPV RMS and SPV RMS gaseous monitors include an extended range monitor in order to comply with the Regulatory Guide 1.97, Revision 2, Table 1, Type E variable for other identified releases source. The RMS are Category 2.

(11) This detector is calibrated in mR/h. The MSL-RMS function is to detect major failures in the fuel cladding. Under normal conditions the fission products from fuel leakage will be masked by several orders of magnitude by the reactor coolant neutron activation products.

(12) This detector is calibrated in R/h. The function of the DAPA-RMS is to provide a radiation evaluation of the containment atmosphere during postulated post-accident conditions.

(13) Detector check sources are as follows:

Detector type	Check source isotope	Quantity in microcuries
Liquid and iodine (gamma scint)	Cs - 137	9
Gaseous (beta scint)	Cl - 36	9
Gaseous, extended range (Cd-Te G-M)	Sr - 96	0.1
DAPA-RMS	U-234/238	6.6E-5 (keep-alive source)

(14) The calibration transfer sources have been purchased by the supplier. These transfer sources are traceable to the National Bureau of Standards (NBS) either by direct NBS calibration or by comparison to NBS calibrated sources.

(15) See Figure 1.2-44 for the plant area designations.

(16) The indicated range is per Regulatory Guide 1.97.

(17) Deleted

(18) Base of fixed filter sampling mode - weekly collection period.

(19) Two detectors (one from each channel) in each plenum.

(20) The calibration transfer sources for these detectors have been purchased by PSE&G and were determined during primary calibrations conducted at Hope Creek during initial plant start up. These transfer sources are traceable to the National Institute of Tests and Standards (NIT/NBS) either by direct NITS calibration or by comparison to NITS sources.

(21) Abandoned in place.

(22) The off-gas post-treatment radiation monitoring system reports in counts per minute and is not calibrated to a detectable concentration in the treated off-gas flow.

TABLE 11.5-2

CONTROL FUNCTIONS OF RADIATION MONITORING SYSTEMS

Radiation Monitoring System	Description Reference	Control Function
Main steam line	11.5.2.1.1	Reactor water sample valve isolation, Mechanical Vacuum Pump trip
Refueling floor exhaust	11.5.2.1.2	Isolate Reactor Building and initiate FRVS
Reactor Building exhaust	11.5.2.1.3	Isolate normal ventilation of Reactor Building, primary containment purge exhausts and initiate FRVS
Control room ventilation	11.5.2.1.4	Isolate normal ventilation of control room and initiate CREF
Liquid radwaste[(1)]	11.5.2.2.5	Isolate liquid radwaste discharge
Heating steam condensate waste	11.5.2.2.18	Isolate condensate return
Turbine Building circulation water	11.5.2.2.20	Shut off TBCW sump pumps

(1) Provides automatic termination of releases prior to exceeding the limits of 10CFR Part 20.

TABLE 11.5-3

RADIOACTIVE SAMPLING AND ANALYSIS PROGRAM

Effluent or Process Stream	Sampling Frequencies	Minimum Analysis Frequency	Type of Activity Analysis	Sensitivity pCi/cc
I. GASEOUS[1]				
a. North and South Plant Vent	Monthly grab sample	Monthly	Principal Gamma Emitters Tritium	100.0 1.0
	Continuous	Weekly Charcoal Analysis	I-131	10^{-6}
	Continuous	Weekly Particulate Analysis	Principal Gamma Emitters	10^{-5}
	Continuous	Monthly Composite Particulate Analysis	Gross Alpha	10^{-5}
	Continuous	Quarterly Composite Particulate Analysis	Sr-89, Sr-90	10^{-5}
	Continuous	Noble Gas Monitor	Noble Gases	1
b. FRVS (whenever there is flow)	Continuous	As needed	Principal Gamma Emitter	100.0
c. Containment Purge	Each Purge	Each Purge	Principal Gamma Emitters	100.0
II. LIQUID				
a. Liquid Process Streams[3]				
1. Cooling Tower Blowdown	Monthly Grab Sample	Monthly	Dissolved and Entrained Noble Gases and Tritium Gross Alpha	10.0 0.1
2. Turb. Bldg. Circulating Water Dewatering Sump	Composite sample while pumps are running	Monthly	Principal Gamma Emitters I-131 Sr-89, Sr-90 Tritium Gross Alpha Dissolved & Entrained Noble Gases	0.5 1.0 0.05 10.0 0.1 10.0

TABLE 11.5-3 (Cont)

Effluent or Process Stream	Sampling Frequencies	Minimum Analysis Frequency	Type of Activity Analysis	Sensitivity pCi/cc
b. Batch Releases[3]				
1. Floor Drain Sample Tanks, Equipment Drain Sample Tanks, and Detergent Tanks[(2)]	Prior to discharge to river	Prior to discharge	Principal Gamma Emitters I-131	0.5 1.0
	Prior to discharge one batch per month	Monthly	Dissolved and Entrained Noble Gases	10.0
	Prior to discharge	Composite of monthly sample	Tritium Alpha Gross	10.0 0.1
	Prior to discharge	Composite of Quarterly Sample	Sr-89, Sr-90	0.05

(1) The following process streams are routed to the either the north plant vent or the south plant where they are sampled as indicated and where they are continuously monitored for radioactivity as indicated in Tables 11.5-1 and 11.5-2:

a. Ventilation from Turbine Building
b. Ventilation from radwaste area
c. Ventilation from fuel handling area
d. Ventilation from evaporators exhaust and off-gas systems
e. Treated off-gas is routed to the north plant vent.

f. Containment pre-purge is operated when it is necessary to enter the containment after operation. The containment atmosphere is processed by the containment pre-purge cleanup system (CPCS) and then is passed through the RBVS duct and released to the environment through the SPV.

(2) Waste from laboratory and sample systems are routed to the tanks listed where they are effectively monitored and sampled before they are discharged.

(3) The following process streams are continuously monitored for radioactivity as indicated in Tables 11.5-1 and 11.5-2:

a. Cooling tower blowdown
b. Liquid radioactive waste
c. Turbine Building circulating water.

Figure F11.5-1 SH 1-2 intentionally deleted.

Refer to Plant Drawing M-26-1 for both sheets in DCRMS

FIGURE DELETED

PUBLIC SERVICE ELECTRIC AND GAS COMPANY HOPE CREEK NUCLEAR GENERATING STATION	Updated FSAR Figure 11.5-2 Revision 8 September 25, 1996

Figure F11.5-3 SH 1-3 intentionally deleted.

Refer to Plant Drawing M-25-1 for all sheets in DCRMS