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Reference: (a) License No. DPR-3 (Docket No. 50-29)

Subject: **Technical Report – Dose Due to Tritium in Groundwater for the YNPS License Termination Plan (LTP)**

This letter provides a hardcopy of a technical report in support of the LTP[1] for the Yankee Nuclear Power Station (YNPS). The specific report provided is:

(1) YA-REPT-00-003-04, "Estimate of Dose Due to Tritium in Groundwater at the EPA's Maximum Contaminant Level (MCL)"

In the YNPS LTP, a commitment has been made to meet the EPA's maximum contaminant level (MCL) for H-3 (20,000 pCi/l) in groundwater by the time of license termination. During a February 2004 public meeting, the NRC asked Yankee to calculate the dose that a resident farmer might receive from groundwater containing H-3 at the EPA's MCL. The enclosed technical report provides the calculation and the resulting dose was determined to be 0.77 mrem/yr.

[1] YAEC Letter to USNRC, "Submittal of YNPS License Termination Plan and Proposed Revision to Possession Only License," dated November 24, 2003, BYR 2003-080.

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This technical report is provided for your review. If you have any questions, please contact us.

Sincerely,

YANKEE ATOMIC ELECTRIC COMPANY

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Principal Licensing Engineer

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TECHNICAL REPORT TITLE PAGE

Estimate of Dose Due to Tritium in Groundwater at the EPA's Maximum Contaminant Level (MCL)

Title

YA-REPT-00-003-04

Technical Report Number

Approvals	(Print & Sign Name)	
Preparer: Alice Carson	Alice Carson	Date: 4/23/2004
Reviewer: Estella Keefer		Date:
Reviewer: Ron Cardarelli		Date:
Approver (Cognizant Manager):	Greg Babineau GREG BABINEAU	Date: 4/27/04

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Approver (Cognizant Manager):		Date:

Executive Summary

Tritium (H-3) has been identified in the groundwater at the Yankee Nuclear Power Station (YNPS) site. In the License Termination Plan (LTP), Yankee Atomic Energy Company (YAEC) made a commitment to meet the EPA's maximum contaminant level (MCL) for H-3 in groundwater by the time of license termination. During a February 2004 public meeting, the NRC asked YAEC to calculate the dose that a resident farmer might receive from groundwater containing H-3 at the EPA's MCL. Although YAEC has not calculated site-specific groundwater concentrations corresponding to 25 mrem/yr for the YNPS site, Connecticut Yankee (CY) did provide groundwater derived concentration guideline levels (DCGLs) for a dose of 25 mrem/yr in its approved LTP. Therefore, the CY DCGL for H-3 was used to calculate the dose corresponding to 20,000 pCi/l—the EPA's MCL for H-3. The dose was determined to be 0.77 mrem/yr.

Introduction

During groundwater sampling at YNPS, H-3 was detected. Additional drilling and sampling were performed to define the extent and magnitude of the contamination. Currently, H-3 is the only radionuclide related to the operation of YNPS that has been positively identified in the groundwater. The highest level of H-3 was found adjacent to the Spent Fuel Pit (SFP), and this was approximately 45,000 pCi/l. The SFP and the adjacent Ion Exchange Pit are the suspected sources of the contamination. Because the SFP has been drained already and remediation activities are planned for soil and concrete in that area, it is anticipated that the source of the contamination will be eliminated and that, therefore, the levels of H-3 in groundwater will steadily decrease over time.

Because the levels of H-3 in the groundwater are already relatively low and believed to be declining, no DCGLs have been calculated for groundwater at the YNPS site. Rather, in the LTP (Reference 1), a commitment was made to sample onsite wells in order to confirm "that the concentration of well water available, based upon the well supply requirements assumed in Section 6 for the resident farmer, is below the EPA MCLs".

During a February 2004 meeting to discuss the LTP, the NRC asked YAEC to estimate the dose contribution attributable to groundwater containing H-3 at the EPA's MCL. The NRC stated that preparing site-specific DCGLs for YNPS was not necessary and that approved DCGLs, such as those already prepared at CY, could be used to determine the dose contribution. The following discussion first addresses the appropriateness of applying CY groundwater DCGLs at YNPS. Then, the discussion describes the results of calculations that use these CY DCGLs to estimate the dose contribution of groundwater at the EPA's MCL for H-3.

Discussion

Evaluating the validity of applying CY Groundwater DCGLs at YNPS

In order to determine if the CY DCGLs for groundwater apply to YNPS, the assumptions and important parameter values underlying dose calculations were identified from their respective sensitivity analyses and DCGL calculations. These assumptions and parameters were compared in order to determine if CY DCGLs for groundwater could be validly applied to YNPS. The CY dose analyses addressed groundwater doses in two parts:

1. Dose contribution from groundwater contamination due to leaching of radionuclides from the soil to the groundwater (addressed by soil analyses) and

2. Dose contribution due to initially contaminated groundwater (addressed by groundwater analysis).

The methodology used at CY combined doses to ensure that the total dose (all pathways and media) remained at, or below, 25 mrem/yr. As appropriate, the assumptions and parameter values used in the CY soil analysis were maintained consistently in the CY groundwater analysis. Thus, the assumptions and parameters used for the CY groundwater analysis should be consistent with those used in the YNPS soil analysis.

The resident farmer scenario was used to model the dose due to contaminated groundwater at the CY site and the computer code used to calculate the doses in this model was RESRAD. The same scenario and computer code were used to model contaminated soils at the YNPS site.

The method of selecting parameter values was very similar for the CY and YNPS analyses. For both analyses, values for metabolic and behavioral parameters were taken from Volume 3 of NUREG/CR-5512. The difference between the two analyses is the method of selecting parameter values for physical parameters.

For both CY and YNPS, a sensitivity analysis was used to identify sensitive parameters, and conservative values (defined as the 25^{th} % or 75^{th} % value of the distribution, or the mean if more conservative) were used for these parameters. However, a difference exists in the ways that CY and YNPS assigned values to parameters that were not sensitive. Specifically, the CY analyses used a default value, median value, or literature value as the input for insensitive parameters. In contrast, the YNPS analysis employed a probabilistic version of the code, and a distribution was used as the input for parameters that were not sensitive.

Table 1 provides information about the sensitivity of input parameters (as determined in the sensitivity analyses) and the input values used for calculating the DCGLs in the CY soil and groundwater evaluations and the YNPS soil analysis. For the CY soil analysis, the sensitive parameters are the distribution coefficient of H-3, the thickness of the contaminated zone, the contaminated zone hydraulic conductivity, and the depth of roots. Similarly, for the YNPS soil analysis, the sensitive parameters are the distribution coefficient of H-3, the thickness of the

contaminated zone, and the depth of roots. For the CY groundwater analysis, there are no sensitive parameters related to H-3.

Sensitive parameters for H-3 were carefully reviewed to assess relevance to groundwater use. It should be noted that three of the four sensitive parameters identified in the CY soil analysis and all three of the sensitive parameters identified in the YNPS soil analysis are either not used or given a value of 0.0 in the groundwater analysis. These values were altered for the groundwater dose calculation to ensure that the calculated dose originates entirely from existing water-dependent pathways and not from contamination leaching into the groundwater from the soil (dose determined in the soil analysis). The remaining sensitive parameter from the CY soil analysis, the contaminated zone hydraulic conductivity, was determined to be insensitive in the YNPS soil analysis. The CY soil and groundwater analyses use the same parameter value for hydraulic conductivity. Because that parameter was identified as being insensitive in the YNPS soil analysis, it is expected that a change to this parameter would have little affect on dose.

As indicated above, only doses associated with the use of the initially contaminated groundwater are calculated. Differences existing between site-specific input values used in the CY groundwater and soil analyses and the YNPS soil analysis were evaluated for their influence on water-dependent pathways. In order to evaluate the significance of the influence, these water-dependent pathways and the fraction of dose coming from each of the pathways were first identified. For the CY groundwater evaluation:

- 77.53% of the dose was from water pathways
- 0.02% of the dose was from plant (vegetation) pathways
- 4.42% of the dose was from meat pathways
- 18.03% of the dose was from milk pathways.

The effect of the difference in input values for parameters contributing to each of these pathways (see Table 1) was reviewed and addressed as follows:

Water Pathways: The majority of the dose is due to water pathways. No differences were identified in the input parameter values for the water pathway: the drinking water consumption rates are the same in the CY and YNPS analysis, as is the fraction of onsite water used.

Plant (Vegetation) Pathways: Plant pathways contribute insignificantly to the dose. Although the CY and YNPS analyses use the plant food consumption rates from NUREG/CR-5512, Vol. 3, differences exist in the input values used for the plant transfer factors. These differences will have a minimal impact on dose calculations as these parameters have been determined to be insensitive in both analyses and plant pathways represent a very small fraction of the total dose.

Meat Pathways: Meat pathways contribute only slightly to dose. Although the CY and YNPS analyses use the meat and poultry consumption rates from NUREG/CR-5512, Vol. 3, differences exist in the meat transfer factors. These differences will have a minimal impact on dose calculations because these parameters have been determined to be insensitive in both analyses and meat pathways represent a small fraction of the total dose.

Milk Pathways: Milk pathways contribute less than 20% of the total dose. Although the CY and YNPS analyses use the milk consumption rates from NUREG/CR-5512, Vol. 3, differences exist in the milk transfer factors. These differences will have minimal impact on dose calculations because these parameters have been determined to be insensitive in both analyses and milk pathways represent a small fraction of the total dose.

The conclusion that differences in the input values between the CY and YNPS analyses do not lead to significant changes in dose is also supported by the fact that considering these differences, the YNPS soil DCGL for tritium is within 11% of the CY soil DCGL for tritium.

Thus, based upon a review of the parameter values and assumptions used in the CY groundwater analysis and upon a comparison of those same values in the YNPS soil analysis, it is concluded that the DCGLs for groundwater at CY can be validly applied at YNPS.

Calculation of Dose from Groundwater at MCL

The current MCL for tritium in drinking water was taken from the Federal Register on "National Primary Drinking Water Regulations; Radionuclides; Final Rule," 65 FR 76708 (Reference 3). The MCL for H-3 is 20,000 pCi/l.

Nuclide specific DCGL values in groundwater at CY are provided in Table 6-2 of the Haddam Neck Plant LTP (Reference 1). The value of the groundwater DCGL for H-3 is 6.52E+05 pCi/l. The following relationship was used to determine the dose corresponding to the MCL for H-3:

$$\frac{\text{Dose at MCL}}{2.0E+04\text{pCi/l}} = \frac{25\text{mrem/yr}}{6.52E+05\text{pCi/l}}$$

Or

$$\text{Dose at MCL} = \frac{25\text{mrem/yr} \times 2.0E+04\text{pCi/l}}{6.52E+05\text{pCi/l}}$$

Using this relationship, the dose associated with an MCL of 2.0E+04 pCi/l is 0.77 mrem/yr.

Conclusions

By reviewing the input parameters and assumptions of the CY and YNPS dose calculations, it has been determined that the groundwater DCGLs that were calculated at CY are, in fact, appropriate for calculating the dose from YNPS groundwater when at the EPA's MCLs. Using the CY groundwater DCGL of 6.52E+05 pCi/l (representing a dose of 25 mrem/yr), the groundwater at YNPS will result in a dose of 0.77 mrem/yr when at the EPA's MCL for H-3 (2.0E+04 pCi/l).

References

1 "Haddam Neck Plant License Termination Plan," Rev. 1a, dated October 2002.

2 YNPS Calculation YA-CALC-02-001-03, "RESRAD Sensitivity Analysis for Resident Farmer Scenario—Soil."

3 Federal Register, 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule," dated December 7, 2000.

4 "Yankee Nuclear Plant Site License Termination Plan," Rev. 0, dated November 2003.

Table 1
Comparison of Parameter Sensitivities and Values

Parameter (unit)	CY Soil Eval		CY Groundwater Eval		Rowe Soil Eval	
	Sensitive Parameter?	Input Parameter Value/Distribution	Sensitive Parameter?***	Input Parameter Value/Distribution	Sensitive Parameter?	Input Parameter Value/Distribution
Soil Concentrations						
Basic radiation dose limit (mrem/y)	--	25	--	25	--	25
Initial principal radionuclide (pCi/g)	--	1	--	1	--	1
Distribution Coefficient						
H-3 (cm^3/g)	Y	0.06	--	100	Y	4.30E-02
Initial concentration of radionuclides present in groundwater (pCi/l)	--	0	--	9.97*	--	0
Time since placement of material (y)	--	0	--	1	--	0
Time for calculations (y)	--	0, 1, 3, 10, 30, 100, 300, 1000	--	0, 1	--	0, 1, 3, 10, 30, 100, 300, 1000
Area of contaminated zone (m^2)	--	15600	--	15600	--	13022
Thickness of contaminated zone (m)	Y	1.575	--	1.575	Y	2.89
Length parallel to aquifer flow (m)	--	141	--	141	--	129
Cover and Contaminated Zone Hydrogeological Data						
Cover depth (m)	--	0	--	0	--	0
Density of contaminated zone (g/cm^3)	N	1.563	--	1.56	N	Distribution Applied
Contaminated zone erosion rate (m/y)	N	1.40E-03	--	1.40E-03	--	8.5E-04
Contaminated zone total porosity	N	0.41	--	0.41	N	Distribution Applied
Contaminated zone field capacity	--	0.06	--	0.06	--	0.05
Contaminated zone hydraulic conductivity (m/y)	Y	1.03E+03	--	1.03E+03	N	Distribution Applied
Contaminated zone b parameter	N	1.36	--	1.36	N	Distribution Applied
Humidity in air (g/m^3)	--	8.00	--	--	--	6.1
Evapotranspiration coefficient	--	0.36	--	0.36	N	Distribution Applied
Average annual wind speed (m/sec)	--	1.70	--	1.70	--	2.03
Precipitation (m/y)	--	1.1	--	1.1	--	1.2
Irrigation (m/y)	--	0.1125	--	0.1125	N	Distribution Applied
Irrigation mode	--	Overhead	--	Overhead	--	Overhead
Runoff coefficient	--	0.18	--	0.18	--	0.6

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Watershed area for nearby stream or pond (m^2)	--	5.93E+05	--	5.93E+05	--	7.77E+05
Accuracy for water/soil computations	--	1.00E-03	--	1.00E-03	--	1.00E-03
Saturated Zone Hydrogeological Data						
Density of saturated zone (g/cm^3)	N	1.5635	--	1.5635	N	Distribution Applied
Saturated zone total porosity	N	0.41	--	0.41	N	Distribution Applied
Saturated zone effective porosity	N	0.35	--	0.35	N	Distribution Applied
Saturated zone field capacity	--	0.06	--	0.06	--	0.05
Saturated zone hydraulic conductivity (m/y)	N	1.03E+03	--	1.03E+03	N	Distribution Applied
Saturated zone hydraulic gradient	--	0.017	--	0.017	--	0.1
Saturated zone b parameter	N	1.36	--	1.36	N	Distribution Applied
Water table drop rate (m/y)	--	1.00e-03	--	1.00E-03	--	1.00E-03
Well pump intake depth (m below water table)	N	14.51	--	14.51	N	Distribution Applied
Model: Nondispersion (ND) or Mass-Balance (MB)	--	ND	--	MB	--	ND
Well pumping rate (m^3/y)	N	884.5	--	884.5	N	Distribution Applied
Unsaturated Zone Hydrogeological Data						
Number of unsaturated zone strata	--	1	--	0	--	1
Unsat. zone 1, thickness (m)	N	1.430	--	--	N	Distribution Applied
Unsat. zone 1, soil density (g/cm^3)	N	1.5635	--	--	N	Distribution Applied
Unsat. zone 1, total porosity	N	0.41	--	--	N	Distribution Applied
Unsat. zone 1, effective porosity	N	0.353	--	--	N	Distribution Applied
Unsat. zone 1, field capacity	--	0.06	--	--	--	0.05
Unsat. zone 1, hydraulic conductivity (m/y)	N	1.03e+03	--	--	N	Distribution Applied
Unsat. zone 1, soil-specific b parameter	N	1.36	--	--	N	Distribution Applied
Occupancy						
Inhalation rate (m^3/y)	--	8400	--	--	--	8400
Mass loading for inhalation (g/m^3)	N	2.33E-05	--	--	N	Distribution Applied
Exposure duration	--	30	--	30	--	30

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	Sensitive Parameter?	Input Parameter Value/Distribution	Sensitive Parameter?***	Input Parameter Value/Distribution	Sensitive Parameter?	Input Parameter Value/Distribution
Indoor dust filtration factor	N	0.55	--	--	N	Distribution Applied
Shielding factor, external gamma	N	0.2725	--	--	N	Distribution Applied
Fraction of time spent indoors	--	0.6571	--	--	--	0.6571
Fraction of time spent outdoors (on site)	--	0.1181	--	--	--	0.1181
Shape factor flag, external gamma	--	1		--	--	Circular
Ingestion, Dietary						
Fruits, vegetables, grain consumption (kg/y)	--	112	--	112	--	112
Leafy vegetable consumption (kg/y)	--	21.4	--	21.4	--	21.4
Milk consumption (L/y)	--	233	--	233	--	233
Meat and poultry consumption (kg/y)	--	65.1	--	65.1	--	65.1
Fish consumption (kg/y)	--	20.6	--	--	--	20.6
Other seafood consumption (kg/y)	--	0.9	--	--	--	0.9
Soil ingestion rate (g/y)	--	18.26	--	--	--	18.26
Drinking water intake (L/y)	--	478.5	--	478.5	--	478.5
Contamination fraction of drinking water	--	1	--	1	--	1
Contamination fraction of household water (if used)	--	N/A	--	NA	--	NA
Contamination fraction of livestock water	--	1	--	1	--	1
Contamination fraction of irrigation water	--	1	--	1	--	1
Contamination fraction of aquatic food	--	1	--	--	--	1
Contamination fraction of plant food	--	1	--	1	--	1
Contamination fraction of meat	--	1	--	1	--	1
Contamination fraction of milk	--	1	--	1	--	1
Ingestion, Non-Dietary						
Livestock fodder intake for meat (kg/day)	--	27.1	--	27.1	--	27.1
Livestock fodder intake for milk (kg/day)	--	63.2	--	63.2	--	63.2
Livestock water intake for meat (L/day)	--	50	--	50	--	50.6
Livestock water intake for milk (L/day)	--	60	--	60	--	60

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Parameter (unit)	CY Soil Eval		CY Groundwater Eval		Rowe Soil Eval	
	Sensitive Parameter?	Input Parameter Value/Distribution	Sensitive Parameter?***	Input Parameter Value/Distribution	Sensitive Parameter?	Input Parameter Value/Distribution
Livestock soil intake (kg/day)	--	0.5	--	0.00	--	0.5
Mass loading for foliar deposition (g/m^3)	--	4.00E-04	--	0.00	--	4.00E-04
Depth of soil mixing layer (m)	N	0.23	--	0.23	N	Distribution Applied
Depth of roots (m)	Y	2.15	--	0.00**	Y	1.17E+00
Drinking water fraction from ground water	--	1	--	1	--	1
Household water fraction from ground water (if used)	--	NA	--	--	--	NA
Livestock water fraction from ground water	--	1	--	1	--	1
Irrigation fraction from ground water	--	1	--	1	--	1
Wet weight crop yield for Non-Leafy (kg/m^2)	N	1.75	N	1.75	N	Distribution Applied
Wet weight crop yield for Leafy (kg/m^2)	--	2.88921	--	2.88921	--	2.88921
Wet weight crop yield for Fodder (kg/m^2)	--	1.8868	--	1.8868	--	1.8868
Growing Season for Non-Leafy (years)	--	0.246	--	0.246	--	0.246
Growing Season for Leafy (years)	--	0.123	--	0.123	--	0.123
Growing Season for Fodder (years)	--	0.082	--	0.082	--	0.082
Translocation Factor for Non-Leafy	--	0.1	--	0.1	--	0.1
Translocation Factor for Leafy	--	1	--	1	--	1
Translocation Factor for Fodder	--	1	--	1	--	1
Weathering Removal Constant for Vegetation (1/y)	N	32.97	N	32.97	N	Distribution Applied
Wet Foliar Interception Fraction for Non-Leafy	--	0.35	--	0.35	--	0.35
Wet Foliar Interception Fraction for Leafy	N	0.58	N	0.58	N	Distribution Applied
Wet Foliar Interception Fraction for Fodder	--	0.35	--	0.35	--	0.35
Dry Foliar Interception Fraction for Non-Leafy	--	0.35	--	0.35	--	0.35
Dry Foliar Interception Fraction for Leafy	--	0.35	--	0.35	--	0.35
Dry Foliar Interception Fraction for Fodder	--	0.35	--	0.35	--	0.35
Storage Times of Contaminated Foodstuffs (days)						
Fruits, non-leafy vegetables, and grain	--	14	--	14	--	14
Leafy vegetables	--	1	--	1	--	1

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Parameter (unit)	CY Soil Eval		CY Groundwater Eval		Rowe Soil Eval	
	Sensitive Parameter?	Input Parameter Value/Distribution	Sensitive Parameter?***	Input Parameter Value/Distribution	Sensitive Parameter?	Input Parameter Value/Distribution
Milk	--	1	--	1	--	1
Meat and poultry	--	20	--	20	--	20
Fish	--	7	--	7	--	7
Crustacea and mollusks	--	7	--	7	--	7
Well water	--	1	--	1	--	1
Surface water	--	1	--	1	--	1
Livestock fodder	--	45	--	45	--	45
Dose Conversion Factors (Inhalation mrem/pCi)						
H-3	--	6.40E-08	--	6.40E-08	--	6.40E-08
Dose Conversion Factors (Ingestion, mrem/pCi)6.40E-08						
H-3	--	6.40E-08	--	6.40E-08	--	6.40E-08
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)						
H-3	--	4.8E+00	--	4.8E+00	N	Distribution Applied
Meat Transfer Factors (pCi/kg)/(pCi/d)						
H-3	--	1.2E-02	--	1.2E-02	N	Distribution Applied
Milk Transfer Factors (pCi/l)/(pCi/d)						
H-3	--	1.0E-02	--	1.0E-02	N	Distribution Applied
Bioaccumulation Factor for Fish (pCi/kg)(pCi/o)						
H-3	--	1.0E+00	--	--	N	Distribution Applied
Bioaccumulation Factor for Crustacea and Mollusks (pCi/kg)(pCi/o)						
H-3	--	1.0E+00	--	--	--	1.00E+00

* Indicated in CY analysis as the equilibrium ground water concentration and that this value would not affect results.
**Indicated in CY analysis that value was selected to ensure contributions to dose were from water-dependent pathways only.
*** "—" indicates that sensitivity analysis was not performed on the subject parameter; "N" indicates that sensitivity analysis was performed on parameter and results indicate it is not sensitive; "Y" indicates that sensitivity analysis was performed on parameter and results indicated it is sensitive.