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DOCUMENTATION REFERENCE FORM

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VERMONT YANKEE NUCLEAR POWER STATION  
RADIATION PROTECTION DEPARTMENT

Report Title: Simplified Dose Analysis for Tritium in Well GZ Wells

Report Date: April 15, 2010

Summary of subject(s) contained in this report:

Estimate the dose to a member of the public from the Tritium in GZ wells using Method 1 calculations from the Off-Site Dose Calculation Manual (ODCM). Revision 1 takes into account a higher Tritium value found in a new well (GZ-14) close to the original well, GZ-3. Revision 2 takes into account a refined estimate of groundwater flow and additional well data. Revision 3 takes into account the total activity of Tritium calculated to be in the ground water as provided by GZA.

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## Purpose of Study/Project

Perform a simplified dose analysis that will estimate the dose to a member of the public from the Tritium in the GZ wells using Method 1 calculations from ODCM.

## Methodology

ODCM Section 6.2, Method to Calculate the Total Body Dose from Liquid Releases, provides a simplified method for calculating the dose to a member of the public for liquid releases from the site. As noted in the ODCM, Method 1 was developed such that the actual exposure to an individual is unlikely to be substantially underestimated. The dose would be to a hypothetical individual whose behavior results in an unrealistically high dose.

The dose factors (DFL) chosen were for the highest of the four age groups for each radionuclide as well as assuming minimum river dilution flow. The pathways used are the consumption of fish from the Connecticut River, the ingestion of vegetables and leafy vegetation which were irrigated by river water, the consumption of milk and meat from cows and beef cattle who had river water available for drinking as well as having feed grown on irrigated land, and the direct exposure from the ground plane associated with activity deposited by water pathway.

A plant discharge flow rate of 44.6 ft<sup>3</sup>/sec (cfs) was used with a mixing ratio of 0.0356 which corresponds to a minimum regulated river flow of 1250 cfs at the Vernon Dam just below the plant discharge outfall. It was assumed that the fish would be caught between the discharge structure and the dam.

## Assumptions (Revision 0 through 2):

1. The Tritium concentration identified in well GZ-4, GZ-13 and GZ-14 were used to estimate the activity that could be entering the river. The values were 2,500 pCi/l for GZ-4, 28,600 pCi/l for GZ-13 and 92,800 pCi/l for GZ-14. It was assumed that the activity in GZ-14 was uniform on either side up to the adjacent wells (88 feet North and 92 feet South). The value for GZ-4 was assumed to continue southward for an additional 135 feet. The value for GZ-13 was assumed to continue northward for an additional 135 feet. The total shoreline impacted was 450 feet.
2. The width of the plume was bounded by the well GZ-2 to the North and well GZ-5 to the South. Well GZ-2 is the closest sample point north of well GZ-13 and no positive results have been obtained from this well. Well GZ-5 is the closest sample point south of well GZ-4 and no positive results have been obtained from this well.
3. A conservative estimate of ground water flow in the area of the plume was provided by GZA based upon initial data obtained from well testing and soil analysis performed to date. The conservatively high value used is 50 gallons/minute.
4. The release point is assumed to be concentrated at the Discharge Structure based on the ODCM model rather than dispersed across the width of the plume.

Assumptions (Revision 3):

1. A conservative estimate of the total activity in the groundwater on 2/8/10 as provided by GZA was 2.79 Ci of tritium which was the period of maximum tritium concentrations in the sample wells. It is also assumed that the vast majority of the tritium was still contained within the groundwater and any activity that had migrated to the river at that point in time would be minimal compared to the amount in the groundwater.
2. The release point is assumed to be concentrated at the Discharge Structure based on the ODCM model rather than dispersed across the width of the plume.
3. It is assumed that the entire amount in the groundwater would be released in one year.

Description

The following calculation was obtained from Calculation 6-2 of the ODCM:

$$D (mrem) = Q (Ci) \times DFL (mrem / Ci)$$

Where:

- D = Annual average total body dose (mrem)
- Q = Total Activity (Ci) released from radionuclide
- DFL = Site-Specific total body dose factor (mrem/Ci) for a liquid release from ODCM Table 1.1.11

The DFL value for Tritium is 2.06E-04 mrem/Ci.

The following calculation was used to determine the value of Q:

$$Q (Ci) = C (pCi / l) \times F (gallons / min) \times UCF$$

Where:

- C = Sample Concentration (pCi/l)
- F = Ground water flow rate (gallons/min)
- UCF = Units Conversion Factor (1.99 E-06)
- = 1.0E-12 Ci/pCi x 3.78541 liters/gallon x 60 min/hr x 24 hr/day x 365 day/yr

The following calculation was used to determine a weighted average sample concentration for Revision 0 through 2 of the calculation, the total activity for Revision 3 was provided by GZA:

$$C (pCi/l) = \frac{\sum (D_w (ft) \times C_w (pCi/l))}{D(ft)}$$

Where:

- C = Sample Concentration (pCi/l)
- C<sub>w</sub> = Concentration in Well w (pCi/l)
- D = Distance of shoreline (ft)
- D<sub>w</sub> = Distance between well with concentration C<sub>w</sub> and adjacent well (ft)

### Results

Revision 0 through 2:

$$\begin{aligned}
 C &= (28,600 \text{ pCi/l} \times 135 \text{ ft} + 92,800 \text{ pCi/l} \times 88 \text{ ft} + 92,800 \text{ pCi/l} \times 92 \text{ ft} + \\
 &\quad 2,500 \text{ pCi/l} \times 135 \text{ ft}) / 450 \text{ ft} \\
 &= 46,450 \text{ pCi/l} \\
 Q &= 46,450 \text{ pCi/l} \times 50 \text{ gallon/minute} \times 1.99\text{E-}06 \\
 &= 4.62 \text{ Ci} \\
 D &= 4.62 \text{ Ci} \times 2.06\text{E-}04 \text{ mrem/Ci} \\
 &= 9.5 \text{ E-}04 \text{ mrem}
 \end{aligned}$$

Revision 3:

$$\begin{aligned}
 D &= 2.79 \text{ Ci} \times 2.06\text{E-}04 \text{ mrem/Ci} \\
 &= 5.75 \text{ E-}04 \text{ mrem}
 \end{aligned}$$

The results of the calculation provided above under Revision 3 is a total dose to a member of the public of 5.75 E-04 mrem using the assumptions stated above. This compares to the EPA limit of 25 mrem per year to an actual member of the public. Revision 0 through 2 assumed that the leak would continue for an entire year where as Revision 3 is based on the leak having been stopped.

**DRAFT - Estimated Total Tritium Activity in Groundwater on 2/8/10**

Vermont Yankee  
Vernon Vermont

| Contour<br>(million<br>pCi/l) | Total<br>Contour<br>Area <sup>1</sup> (ft <sup>2</sup> ) | Contour<br>Interval<br>Area <sup>2</sup> (ft <sup>2</sup> ) | Concentration Interval<br>Activity Range (pCi/L) | Average activity <sup>3</sup><br>(pCi/L) | Average<br>activity<br>(pCi/ft <sup>3</sup> ) | Est. Average<br>Contour Interval<br>Thickness <sup>4</sup> (ft) | Contour<br>Interval<br>Volume (ft <sup>3</sup> ) | Assumed<br>Porosity <sup>5</sup> | Factor of<br>Safety <sup>6</sup> | Volume of<br>tritiated Water <sup>7</sup><br>(ft <sup>3</sup> ) | Total Activity<br>per Contour<br>Interval Area<br>(pCi) |
|-------------------------------|--|---|--|--|---|---|--|----------------------------------|----------------------------------|---|---|
| 2                             | 4151   | 4151  | > 2,000,000                                      | 2,250,000                                | 63,712,913                                    | 5   | 20755  | 30%                              | 2.0                              | 12453   | 7.93E+11  |
| 1.5                           | 7991   | 3840  | 2,000,000 - 1,500,000                            | 1,750,000                                | 49,554,488                                    | 5   | 19200  | 30%                              | 2.0                              | 11520   | 5.71E+11  |
| 1                             | 11516  | 3525  | 1,500,000 - 1,000,000                            | 1,250,000                                | 35,396,063                                    | 5   | 17625  | 30%                              | 2.0                              | 10575   | 3.74E+11  |
| 0.5                           | 15853  | 4337  | 1,000,000 - 500,000                              | 750,000                                  | 21,237,638                                    | 5   | 21685  | 30%                              | 2.0                              | 13011   | 2.76E+11  |
| 0.25                          | 23357  | 7504  | 500,000 - 250,000                                | 375,000                                  | 10,618,819                                    | 5   | 37520  | 30%                              | 2.0                              | 22512   | 2.39E+11  |
| 0.1                           | 32972  | 9615  | 250,000 - 100,000                                | 175,000                                  | 4,955,449                                     | 8   | 76920  | 30%                              | 2.0                              | 46152   | 2.29E+11  |
| 0.05                          | 50110  | 17138   | 100,000 - 50,000                                 | 75,000                                   | 2,123,764                                     | 8   | 137104   | 30%                              | 2.0                              | 82262   | 1.75E+11  |
| 0.001                         | 88936  | 38826   | 50,000 - 1,000                                   | 25,500                                   | 722,080                                       | 8   | 310608   | 30%                              | 2.0                              | 186365  | 1.35E+11  |
| 0                             | 101425   | 12489   | 1,000 - 0  | 500                                      | 14,158  | 9   | 112401   | 30%                              | 2.0                              | 67441   | 9.55E+08  |
|                               |  |   |  |  |   |   |  |                                  |                                  | <b>Total (pCi):</b>   | <b>2.79E+12</b>   |
|                               |  |   |  |  |   |   |  |                                  |                                  | <b>Total (Ci):</b>  | <b>2.79E+00</b>   |

- Notes:
1. Approximate total area enclosed within identified tritium contour.
  2. Approximate net area between selected contour and the next highest contour.
  3. Estimated average tritium activity within contour interval.
  4. Estimated average thickness of saturated soil between the water table and the identified or inferred underlying low K deposit.
  5. Assumed average porosity of the saturated soil identified in 4. above.
  6. Applied Factor of Safety to account for potential migration of tritiated water into the underlying low k deposit and other estimation uncertainties.
  7. Volume of Tritiated Water: Calculated by multiplying the Contour Interval Volume by the Assumed Porosity by the Factor of Safety.
  8. Based on tritium activity data for groundwater samples collected on February 8, 2010
  9. Consistent with the application of a factor of safety of 2.0, this preliminary analysis was conducted in a conservative manner (biased high).