TECHNICAL REPORT TITLE PAGE

Generic ALARA Review for Final Status Survey of Soil at YNPS

Title

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Technical Report Number

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Executive Summary

In addition to the requirement to limit the dose from residual, plant-related radioactivity in soil to members of the critical group to 25 mrem in any year, the License Termination Plan (LTP) requires an evaluation demonstrating that these levels are as low as reasonably achievable (ALARA). If compliance with the ALARA criterion cannot be demonstrated, remediation of the soil is required, even though this would further reduce the otherwise acceptable exposure to the critical group to levels below those required. This report is intended to provide a generic ALARA review to bound the conditions under which no further remediation is necessary for soils. Calculations were performed using LTP equations and conservative assumptions. The conclusion is that it is not cost-beneficial to remediate soil in which the levels of residual, plant-related radioactivity are below LTP release criteria.

The State of Massachusetts requirement limits dose to 10 mrem/year. Remediation below this level would be even less practical.

Introduction

Section 4.3.1 of the LTP [1] states that a generic ALARA evaluation for soils will be developed to determine if the clean up of soils beyond the DCGLs will be cost-beneficial for YNPS. Appendix 4A of the LTP [1] provides an equation and default values for this calculation. This process will be followed, assuming that the soil is at the DCGL and using conservative estimates of costs, distances and other inputs that the worksheet requires. The equation will calculate an action level (AL) that represents the ratio of concentration to the DCGL that would be cost-beneficial to remediate. If that ratio is greater than 1, remediation is not cost-beneficial.

This calculation is meant to apply to areas of any MARSSIM class and any size. In a Class 1 area, where values of residual contamination may exceed the $DCGL_W$ in limited areas, the mean concentration may never exceed the $DCGL_W$. Since it is assumed that the entire volume of soil removed is at $DCGL_W$, the assumed mean will be at $DCGL_W$. Therefore, the assumed case will be bounding.

Discussion

The total cost ($Cost_T$) will be calculated using LTP equation B-2 (from Appendix 4, section 4.A.1.1 of the LTP[1]):

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose}$$

These terms are defined and their values calculated as follows:

Cost of performing remediation work ($Cost_R$):

- Initially it will be assumed that the job is big enough to require earthmoving equipment. At a minimum, this would be either an excavator or a loader and truck. This turns out not to be a constraint, as explained later.
- To come up with a conservative scenario, the cost of remediating one square meter from a larger project is calculated. Any smaller job by, itself, would have planning and administration costs that would be dominant. Factors contributing to $Cost_R$ are identified in Attachment 1. The initial estimate for $Cost_R$ is based on a job to

remediate 2000 square meters of soil, but to make it comparable to the other costs, that value is adjusted to reflect the cost of 1 square meter.

- The adjusted value of $Cost_R$ is \$7.32 to remediate 1 square meter of soil.
- Rounding down to the dollar, $Cost_R$ = \$7

Note: The value of $Cost_R$ calculated above bounds the cost of a smaller excavation, e.g., one that doesn't require earthmoving equipment. For example, two workers who take an hour to dig up some soil and bring it back in wheelbarrow, with no work order or other formal planning, would cost the project about \$100 in labor costs (assuming the cost to the project is \$50/hr). So, the constraint that this only applies to jobs big enough to require earthmoving equipment can be removed.

Cost of waste disposal ($Cost_{WD}$):

- As above, it will be assumed that one square meter of surface soil is to be remediated. Surface soil is considered to be the top 15 cm. The estimated waste volume will therefore be 15 cm times the area of 1 m^2. This comes to 0.15 m^3.
- The current cost of waste disposal for radiologically contaminated soil is \$19 per cubic foot [2]. This includes burial fees and shipping.
- Since 1 ft^3 equals .0283 m^3, this comes to \$100.70 to dispose of the assumed volume.
- Rounding down to the dollar, $Cost_{WD}$ = \$100

Cost of workplace accident ($Cost_{ACC}$):

- $Cost_{ACC}$ = (\$3,000,000)x(4.2E-8/h)x(Time to perform remediation) ... (Equation 4A-4, LTP[1])
- \$3,000,000 is the monetary value of a fatality equivalent to \$2000 per person-rem.
- 4.2E-8 is the workplace fatality rate, in fatalities per hour worked.
- For a 1 square meter excavation, this would not be more than a few person-hours. (Assume Time = 2 hr)
- (\$3,000,000) x (4.2E-8/h) x (2 h) = \$0.25
- Rounding down to the dollar, $Cost_{ACC}$ = \$0

Cost of traffic fatality ($Cost_{TF}$):

- $Cost_{TF}$ = (\$3,000,000)x(3.8E-8/km)x(Volume)x(Distance)/(Volume/shipment) … (Equation 4A-5, LTP[1].)
- Round trip distance from YNPS to Memphis, TN: 2550 km/shipment … (from Yahoo Maps)
- Waste volume per shipment: 13.6 m^3/shpmt … (default in LTP [1], section 4.A.1.1 and consistent with YNSD shipping agent's [3] figure of 500 ft^3 or 14 m^3)
- (\$3,000,000)x(3.8E-8/km)x(0.15 m^3)(2550 km/shpmt)/(13.6 m^3/shpmt) = \$3.21
- Rounding down to the dollar, $Cost_{TF}$ = \$3

Cost of worker dose ($Cost_{WDose}$):

- $Cost_{WDose}$ = ($2000/person-rem)x(Worker dose rate)x(Time) … (Equation 4A-6, LTP[1]).
- Dose rates would be insignificant. (Assume dose rate = 0.1 mrem/h = 1E-4 rem/h)
- ($2000/person-rem) x (1E-4 rem/h) x (2 h) = $0.40
- Rounding down to the dollar, $Cost_{WDose}$ = $0

Cost of Dose to the Public ($Cost_{PDose}$):

- $Cost_{DP}$ is assumed to be no more than the $Cost_{WD}$.
- Assumed $Cost_{PDose}$ = $0

Total $Cost_T$:

- $Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose}$
- $Cost_T$ = $110

Calculation

ALARA Action Level (AL):

$$AL = \frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times PD \times 0.025 \times F \times A} x \frac{r + \lambda}{1 - e^{-(r+\lambda)N}}$$ (LTP [1], Equation 4A.1)

where:

- $Cost_T$ has been calculated above
- $2000 is the monetary value of one person-rem (Section 4A.1, LTP[1])
- F = removable fraction = 1 … (most conservative possible)
- 0.025 is the annual dose in rem to an average member of critical group from residual radioactivity (This is the LTP[1] limit, state of Massachusetts limit is 0.010, which would make the remediation less practical.)
- r = monetary discount rate = 0.03/y … (Table 4A-1, LTP [1])
- N = Number of years over which the collective dose is calculated = 1000 y … (Table 4A-1, LTP [1])
- PD = Population density for the critical group = 0.0004 people/m^2 … (Table 4A-1, LTP [1])
- A = Area being evaluated = 1 m^2
- Most conservative nuclide of concern is that with the longest half-life, Tc-99, with a half-life of 2.13E5 years (Table 2-6, LTP[1]) and a decay constant (λ) of 3.254E-6 y^{-1} (Note: With the values for other variables used for this calculation, the 1-e… term equals 1 for any value of λ. Therefore, the smallest AL, which is the most conservative, will occur when λ, in the top of the equation, is smallest.)

Applying these values to the equation:

$$AL = \frac{\$110}{\$2000 \times 0.0004 \times 0.025 \times 1 \times 1} \times \frac{0.03 + 3.254E-6}{1 - e^{-(0.03+3.254E-6)1000}}$$

$\underline{AL = 165}$

If Tc-99 were at DCGL:

- Sum of DCGL Fractions = 1

Since AL is greater than the Sum of DCGL Fractions, remediation is not cost-beneficial. In fact, remediation would not be cost-beneficial unless the concentration of any LTP nuclide in soil were at least 165 times the DCGL.

Conclusions

Based upon the results of this ALARA evaluation, it is not cost-beneficial to remediate soil in which the levels of residual, plant-related radioactivity are below LTP release criteria.

References

1. YNPS License Termination Plan
2. Interview with Rod Dee, Contracts Administrator, 1/13/05.
3. Interview with Don Maffei, YNSP Shipping Agent, 1/11/05.

ATTACHMENT 1

Cost estimate for remediation work ($Cost_R$)

Assume larger project, to dilute fixed costs: 2000 m^2, removing the top 15 cm of soil

	Time (hr)	Rate ($/hr)	Cost
Const. Planner, Rad engineer	50	$100.00	$5,000.00
Supervision/management	1	$200.00	$200.00
Resurvey	50	$50.00	$2,500.00
Additional off-site analysis (2 samples)			$2,440.00
Additional 0n-site analysis (15 samples)			$1,500.00
Equip + operators	10	$250.00	$2,500.00
HP coverage	10	$50.00	$500.00
Total for 2000 m^2:			$14,640.00
Cost per m^2:			$7.32