# Review of the Revised Decommissioning Plan for the Cabot Corporation Reading Slag Pile Site, Reading, Pennsylvania

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# ABSTRACT

Sandia National Laboratories (SNL) reviewed the revised Decommissioning Plan for a facility located within the Reading, PA urban area that had been operated by Cabot Corporation. The plan proposed an unrestricted termination of the NRC license for handling radioactive elements within a slag pile in which the naturally-occurring thorium and uranium have been concentrated. The slag pile is a result of a process for refining tantalum from low-grade iron ore and tantalum ore that took place in the late 1960s. This slag had been placed on piles of preexisting slag, and building rubble and tin slag had then been placed on top of the radioactive slag. The top of the slag pile is a level area with an elevation approximately the same as an area upon which unoccupied industrial facilities are now located. The site is heavily vegetated with mature trees and thick brush. The total area of contamination is estimated to be 1859 $m^2$. Unrestricted license termination requires that an "average member of the critical group" receive a peak total effective dose equivalent of less than 25 mrem/y. Cabot Corporation's consultant, STEP, Inc. corporation, proposed six scenarios that would allow their license to be terminated without restrictions. These scenarios, involving workers, trespassers, and a recreational walker, are based on continued industrial use and limited occupancy of the land. A resident garden analysis was presented as part of a sensitivity analysis, but was not considered as a feasible scenario.

SNL agreed with STEP, Inc. that groundwater pathways and pathways involving agricultural animals could be eliminated from the scenarios, but believes that further justification is needed for excluding the garden scenario and that, for the garden sensitivity analysis that was done, further justification would be needed for the use of garden parameters including factors related to plant mass loading, the area of the garden, consumption rates, and division of the produce between two occupants. SNL does not believe that STEP, Inc. has presented sufficient justification for the assumption that this site will remain purely industrial throughout the next 1000 years. NRC guidelines do not allow current land practices to be used as justification for future land use where the radionuclides involved persist for longer than 100 years. The isotopes present at this site will not decay significantly within the 1000-year period of consideration.

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# EXECUTIVE SUMMARY

This report provides the Nuclear Regulatory Commission (NRC) with a review of the revised Decommissioning Plan prepared by ST Environmental Professionals (STEP, Inc.) for Cabot Corporation Performance Materials for their Reading, PA facility. The contaminated area consists of a slag pile composed of materials from metal processing activities performed in the late 1960s that left a glass-like silica gangue in which the naturally-occurring thorium and uranium have remained. The total contaminated area is estimated to be 1859 $m^2$ (20010 $ft^2$). This site is located in the Reading urban area, where the current land use is industrial or related to a transportation corridor that runs along the Schuylkill River. The top of the slag pile is a level area of approximately the same elevation at the area upon which unoccupied industrial facilities are located. The site is heavily vegetated with mature trees and thick brush.

NRC requires that the "average member of the critical group" receive a peak total effective dose equivalent (TEDE) of less than 25 mrem/y for unrestricted release of the site. If the site is released with restrictions, it must meet this basic dose limit with restrictions in place. If the restrictions fail, the TEDE must not exceed 100 or 500 mrem/y. These requirements must be met for the next 1000 years.

In the revised Decommissioning Plan, STEP, Inc. has proposed scenarios that would allow the license to be terminated without restrictions. This report documents the Sandia National Laboratories' (SNLs') review of the revised plan.

The scenarios contained in the Decommissioning Plan are based on the continued industrial use and limited occupancy of the land. Dose is assessed for workers, trespassers, and a recreational walker. Although dose is assessed for a resident gardener scenario in the revised Radiological Assessment, the results are not presented in the Decommissioning Plan. The doses to workers and trespassers are computed under both the current state and a future state where the slag pile has eroded. The two worker scenarios involve limited occupancy of a small structure on top of the slag pile (180 h/y) and limited occupancy of the sloped part of the slag pile (20 h/y). In all of these scenarios, TEDE is well below the NRC regulatory requirements. In these scenarios, the possibility of a subgrade structure (e.g., a structure with an occupied basement) on the site was not analyzed.

In its analysis of the site characterization data, SNL did find it reasonable to eliminate groundwater pathways and to eliminate pathways involving agricultural animals. SNL believes that further justification is needed for the garden analysis that was presented in the Radiological Assessment as part of the sensitivity analysis. A resident gardener scenario was not considered as a possible scenario, because STEP, Inc. considers the future use of the site by a residential gardener in the next 1000 years is unlikely to occur and that if it did, it would result in a TEDE of less than 25 mrem/y. SNL believes that further justification is needed for excluding the garden scenario and for the use of garden parameters, including factors related to plant mass loading, the area of the garden, consumption rates, and division of the produce between two occupants.

SNL does not believe that STEP, Inc. has presented sufficient justification for the assumption that this site will remain purely industrial throughout the next 1000 years. NRC guidelines do not allow current land practices to be used as justification for future land use where the radionuclides involved persist for longer than 100 years. The isotopes present at this site will not decay significantly within the 1000-year period of consideration.

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# ABBREVIATIONS

| | |
|---|---|
| ALARA | as low as reasonably achievable |
| NRC | Nuclear Regulatory Commission |
| ROW | right-of-way |
| SNL | Sandia National Laboratories |
| STEP, Inc. | ST Environmental Professionals |
| TEDE | total effective dose equivalent |

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# 1 INTRODUCTION

## 1.1 Purpose

The purpose of this report is to provide the Nuclear Regulatory Commission (NRC) with a review of the revised decommissioning plan (application for license termination) for the Cabot Corporation Performance Materials Reading, PA facility: *Decommissioning Plan for Reading Slag Pile Site*, Revision 1. The Decommissioning Plan and associated Radiological Assessment were prepared for the Cabot Corporation by ST Environmental Professionals, Inc. (STEP, Inc.), (STEP, Inc., 2000a, 2000b) These are the latest in a series of reports and assessments provided to the NRC over the last three years (STEP, Inc., 1997, 1998a, and 1998b). These reports include hydrologic, geologic, and radiologic assessments, and decommissioning plans. Citing these documents, STEP, Inc. claims that the Reading site meets the regulatory requirements for license termination. The license termination criteria include a 25 mrem/y dose limit and as low as reasonably achievable (ALARA) requirements (NRC, 1997). To claim this type of compliance, plausible scenarios for activities over the next 1000 years must be developed and the resulting dose to the public calculated based on all known information about the contaminated slag.

NRC requires that the "average member of the critical group" receive a peak total effective dose equivalent (TEDE) of less than 25 mrem/y for unrestricted release of the site. If the site is released with restrictions, it must meet this basic dose limit with restrictions in place. If the restrictions fail, the TEDE must not exceed 100 or 500 mrem/y. These requirements must be met for the next 1000 years.

## 1.2 Site Description

The slag pile is located in Reading, Berks County, PA. Slag materials from metal processing activities performed in the late 1960s were deposited on a preexisting slag pile. The process operated there utilized the tantalum in low grade ores by heating a mixture of iron ore, tantalum ore, and coke in an electric arc furnace. The ores contained naturally-occurring uranium and thorium in concentrations defined as "source material" by the NRC. The possession and handling of these materials was performed under an NRC license. The tantalum alloyed with the iron, leaving a glass-like silica gangue in which the naturally-occurring thorium and uranium remained. The glass-like slag residues from processing operations were placed on a preexisting slag disposal area on an embankment at the southern end of the property. Additional material was placed there in 1977 and 1978 as a result of building decontamination activities, including sand mixed with tin slag from a location in Baltimore.

The area of contamination on top of the pile is about 223 $m^2$ (4.5 m [15 ft] by 48.5 m [162 ft]). The area of contamination presented by the slope is about 1636 $m^2$ (48.5 m[162 ft] by 33.3 m [110 ft]). The total area of contamination is estimated to be 1859 $m^2$ (20010 $ft^2$). The waste materials are assumed to have a bulk density of 1.51 $g/cm^3$.

The area is urban with land use being primarily industrial or related to the transportation corridor along the river. Between the slag pile area and the Schuylkill River is a currently undeveloped extension of the River Road right-of-way (ROW), a Norfolk Southern railroad ROW, and remnants of the former Schuylkill Canal. Another Norfolk ROW is located approximately 183 m (600 ft) to the southeast of the pile. STEP, Inc. used topographical survey information to estimate the dimensions of the radiological slag at the site. The cross-sectional areas of the slag were measured to be approximately 103 $m^2$ (1125 $ft^2$). The estimated volume is approximately 5007 $m^3$ (180,000 $ft^3$). The top of the slag pile is a level area whose elevation is approximately that of the much larger contiguous level area upon which industrial facilities are located. Currently there are no occupied buildings or apparent use within the site area. The site is heavily vegetated with mature trees and brush.

## 1.3 Background

Sandia National Laboratories (SNL) reviewed STEP, Inc.'s initial decommissioning plan and associated submittals (STEP, Inc., 1997, 1998a, 1998b) and prepared a report for NRC, *Preliminary Assessment of the Cabot Corporation Reading Slag Pile Site, Reading, Pennsylvania* (SNL, 1999). The 1999 SNL Assessment documented their initial review of the Cabot Corporation proposal and identified several outstanding issues that they felt needed to be resolved. NRC summarized some of these issues in an October 19, 1999, letter to Cabot Corporation (NRC, 1999). On December 15, 1999, a meeting was

held between NRC and Cabot Corporation to discuss the issues that NRC felt needed to be resolved.

In the review of the initial decommissioning plan, SNL did not find a reasonable basis for eliminating exposure scenarios involving occupancy of an industrial or residential structure with or without a basement in the contaminated area on top of the slag pile.

This report documents the review of the revised Decommissioning Plan with respect to the issues raised by NRC (NRC, 1999), the SNL Assessment (SNL, 1999), and the December 1999 meeting between NRC and Cabot Corporation. This review was carried out with respect to the regulations and guidance for license termination set forth by the NRC (NRC, 1997, 1998a, 1998b).

The Cabot Corporation is proposing to terminate the radioactive materials license that they currently possess at the Reading site. In order to do this, they must document the status of the site and demonstrate that it meets the requirements for termination. The NRC has asked SNL to review the Cabot Corporation's revised Decommissioning Plan. This report represents the results of SNL's review, and is intended to assist the NRC in making a decision regarding the final status of the Reading site.

# 2 SITE CHARACTERIZATION

The slag pile and the River Road ROW area have been characterized by borings, surface soil samples, seep analyses, sediment samples, groundwater samples, and direct gamma measurements. In addition, the site and its environs have been characterized through analysis of the topography, climate, geology, and hydrology.

SNL finds that the concentrations and volumes of radioactive materials in the slag pile and surrounding areas have been adequately characterized. SNL disagrees with numerous claims made by STEP, Inc. in relation to groundwater-related pathways. The specific points of disagreement are summarized in Section 7.1 of the SNL Assessment (SNL, 1999). However, none of these areas of disagreement are germane to the current evaluation given the evidence presented in the revised Decommissioning Plan characterizing the thickness and limited production of this aquifer.

## 2.1 Slag Pile Characterization

Radiological surveys were conducted to identify and determine the quantities of radionuclides in the slag. Radionuclide concentrations were estimated by direct radiation measurements over the ground surface and by sampling and analyzing soil and slag samples using standard radiometric techniques. The concentrations of radionuclides estimated from direct radiation measurements were lower than corresponding concentrations from radiometric measurements on soil samples. The authors of the report, *Radiological Assessment for Reading Slag Pile Site*, Revision 1, (STEP, Inc., 2000a), determined that the direct radiation measurements represent actual exposure rates at the site and, therefore, adjusted the soil concentration measurements to match the actual exposure rates.

## 2.2 ROW Characterization

Radiological surveys of the River Road ROW indicated that the radionuclide concentrations were similar to corresponding radionuclide concentrations in the slag pile.

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# 3 BASIS FOR LICENSEE'S DOSE ASSESSMENT

## 3.1 Scenario Overview

The Decommissioning Plan (STEP, Inc., 2000a) includes six scenarios proposed by STEP, Inc.. These scenarios are summarized as:

1. Worker - Current Conditions,
2. Worker - Eroded Slope,
3. Trespasser - Current Conditions,
4. Trespasser - Eroded Slope,
5. Recreational Walker - ROW,
6. Excavation Worker - ROW.

The two Worker scenarios involve limited occupancy of a small structure on top of the slag pile (180 h/y) and limited occupancy of the sloped part of the slag pile (20 h/y). The two trespasser scenarios involve outdoor exposure to an individual that loiters in the contaminated area of the slag pile three hours per week for 26 weeks per year. Each of these scenarios are presented under current and eroded surface conditions. The worker scenarios are discussed in more detail in Section 3.1.2.3.

The Recreational Walker scenario involves limited occupancy of the railway ROW area for 17 hours per year. The Excavation Worker scenario involves limited exposure (40 h) during an excavation in the ROW area.

These scenarios are based on continued industrial use and limited occupancy of the land for the next 1000 years. STEP, Inc. bases future industrial land use assumptions on current and historical land use patterns, pointing out that the land has been used for industrial purposes for at least 96 years, that the property is currently zoned for heavy manufacturing, and that the site has been designated by the Reading Redevelopment Authority for industrial/commercial and related uses.

The NRC Standard Review Process, Chapter 4, [2000, draft] states that "...sites looking for unrestricted release, should not rely solely on [arguments regarding current land practices] as reason to remove pathways or change the scenario unless either the radionuclides have a relatively short half-life (approximately 10 years or less or the dose from long-lived radionuclides reaches its peak before 100 years." The radionuclides at this site are long-lived and concentrations will not decline significantly within the 1000-year period of consideration.

STEP, Inc. included a resident gardener scenario in their revised Radiological Assessment as part of their sensitivity analysis (STEP, Inc., 2000b), but did not include this scenario in the Decommissioning Plan. STEP, Inc. claims that future use of the site by a residential gardener in the next 1000 years is unlikely to occur. They argue further that use by a residential gardener would result in a TEDE of less than 25 mrem/y. The resident gardener scenario is discussed in more detail in Section 3.1.2.2 and 3.1.2.3 of this report.

SNL believes that the Decommissioning Plan should include a resident gardener scenario to be consistent with NRC's draft guidance. Alternately, the Decommissioning Plan would need to provide substantially more justification for exclusion of a resident gardener scenario. The additional justification should not rest on arguments that rely on:

- current land use patterns,
- zoning and community development plans, and
- the fact that slag is not soil.[1]

## 3.2 Time Period of Concern

The time period of concern here is the entire 1000 years. The radionuclides at this site are long-lived and will not decay significantly during this period. In addition, off-site transport via erosion or infiltration is not expected to significantly reduce radionuclide concentrations in the next 1000 years.

## 3.3 Definition of the Critical Group and the Average Member of the Critical Group

The dose limitations in Subpart E of 10 CFR Part 20 (NRC, 1997) refer to an "average member of the critical group." The critical group is defined in Section 20.1003 as "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

[1]Soil is not a necessary ingredient for plant growth.

In the supplemental information for the final rule, the concept of the average member of the critical group is explained further: "... if the site were released for unrestricted use, the critical group would be the group of individuals reasonably expected to be the most highly exposed considering all reasonable potential future uses of the site. ... The average member of the critical group is an individual who is assumed to represent the most likely exposure scenario based on prudently conservative exposure assumptions and parameter values within model calculations."

### 3.3.1 Groundwater Pathways: Irrigation, Aquatic, and Drinking Water

SNL disagrees with many of the arguments and conclusions that STEP, Inc. makes concerning the groundwater pathways. The specific points of contention are discussed in Section 7.1 of the SNL Assessment (SNL, 1999).

However, the Decommissioning Plan provides water table aquifer thickness data and it indicates that several hours are required to produce 2-L (.53 gal) water samples from existing wells at the base of the pile (STEP, Inc., 2000a). Based on this information, SNL agrees that the water table aquifer is not a practical source of groundwater for drinking, irrigation, or a fish pond.

### 3.3.2 Suburban Garden

The Radiological Assessment for the Reading Site (STEP, Inc., 2000b) includes dose estimates for a resident gardener. The approach that STEP, Inc. used to define the dose from this pathway is outlined in this section. First, STEP, Inc. assumed that a resident gardener would have a 40 $m^2$ (430 $ft^2$) garden. STEP, Inc. assumed a ratio of leafy vegetables to other vegetables of 1:5 based on NUREG/CR-5512, Volume 3 data. STEP, Inc. then used the default crop yield parameters in RESRAD 5.91 to compute garden yields for vegetables and leafy vegetables. STEP, Inc. assumed that the homegrown vegetables and leafy vegetables were ingested by two people.

STEP, Inc. used RESRAD 5.91 to do their dose assessment, although they drew on data from NUREG/CR-5512, Volume 3. Because of model differences, STEP, Inc. had to derive comparable RESRAD 5.91 input parameters from the NUREG/CR-5512, Volume 3 data. RESRAD 5.91 uses one soil-to-plant transfer factor per radionuclide, while the NUREG/CR-5512 model uses separate factors for each radionuclide for leafy vegetables and other vegetables. In addition, RESRAD 5.91 soil-to-plant transfer factors are on a wet weight basis, while NUREG/CR-5512 and DandD 1.0 factors are given on a dry weight basis.

To develop soil-to-plant transfer coefficients for use in RESRAD 5.91, STEP, Inc. dealt with these differences by using:

- the default dry/wet ratios proposed by Kennedy and Strenge (Beyeler, 1999, Table 6-77),[2]
- the approximate 1:5 yield ratios for leafy to other vegetables proposed by Kennedy and Strenge (Beyeler, 1999, Table 6.20 and Kennedy, 1992), and
- the geometric means of soil-to-plant transfer coefficient data presented in NUREG/CR-5512, Volume 3 (Beyeler, 1999, Table 6-75).

***Discussion of the STEP, Inc. Approach to Garden Pathway Dose Estimates***

STEP, Inc. did not justify the parameters related to ingestion of soil adhering to homegrown vegetables and leafy vegetables. These unjustified factors include the RESRAD variables:

- Mass loading for foliar deposition,
- Translocation factor for leafy vegetables,
- Translocation factor for non-leafy vegetables,
- Dry foliar interception fraction for non-leafy vegetables,
- Dry foliar interception fraction for leafy vegetables,
- Weathering removal constant for vegetation,
- Growing season for leafy vegetables,
- Growing season for non-leafy vegetables.

[2]Leafy vegetables: 0.2, other vegetables: 0.25.

It may not be practical for STEP, Inc. to justify each of these factors. They may propose to select a set of values for these parameters that forces the mass of soil adhering to homegrown vegetables to be equal to the value that would be obtained using the soil adhesion factors tabulated in Table 5.7 of NCRP-129 (NCRP, 1999).

STEP, Inc. did not base the garden area on regional or national statistics. Thus, the garden size used in their assessment was not appropriate for the average member of the group. The area of the garden (40 $m^2$ [431 $ft^2$]) is less than 20 percent of the 223 $m^2$ (2400 $ft^2$) of slag material on the flat area on top of the pile.

The garden yield rates used by STEP, Inc. are roughly one half of the values identified in NUREG/CR-5512, Volume 3, Table 6-55. These values result in lower garden produce consumption rates and lower doses. In the absence of soil conditioners and fertilizers, the slag is not likely to exhibit a high degree of fertility. Consequently, SNL believes that the yield rates per square meter used by STEP, Inc. are acceptable for dose assessment when used with the full radionuclide concentrations.[3]

STEP, Inc. did not provide a rationale for their assumption that the garden produce should be divided among two people.

SNL finds that the method STEP, Inc. used to derive homegrown vegetable consumption rates is arbitrary and unnecessarily circuitous. SNL believes that the consumption rates should be based on national or regional consumption rates of homegrown vegetables by suburban gardeners. Such data is tabulated in the EPA's *Draft Exposure Factors Handbook* (EPA, 1996).

The method STEP, Inc. used to derive soil-to-plant transfer coefficients for use in RESRAD 5.91 is reasonable. However, the derived soil-to-plant transfer coefficients need to be based on adequately-defended homegrown leafy and non-leafy vegetable consumption rates. This is necessary because the ratio of these consumption rates affects the value of the resulting soil-to-plant transfer coefficients. The dry/wet ratios for produce used by STEP, Inc. resulted in higher transfer coefficients (and higher doses) than would have been obtained using data from Table 6-78 of NUREG/CR-5512, Volume 3. STEP, Inc. calculated soil-to-plant transfer coefficients for use with RESRAD 5.91 based on the geometric mean values. Given the insolubility of the slag, STEP, Inc.'s use of the geometric means instead of higher percentiles of the distributions is reasonable; the difference between the geometric means and the 90$^{th}$ percentiles of the distributions is only a factor of 3.25.[4]

### 3.3.3 Occupancy of Contaminated Areas

STEP, Inc.'s two Worker scenarios included in the original and the revised Decommissioning Plans include only limited occupancy of a 4.5 × 4.5 m (15 × 15 ft) structure (180 hours per year) and 20 hours per year of time outdoors on the top and sides of the pile.

The resident gardener scenario provided in Appendix B of the revised Radiological Assessment included no indoor occupancy time and 70 h/y of exposure in the contaminated area.

STEP, Inc. argues that since the slag is limited to within 4.6 m (15 ft) of the edge of the embankment, the construction of a structure with or without a basement would not be likely. STEP, Inc. argues that "structures are not typically sited closer than 15 feet from a 30° to 35° slope."

***Discussion of the STEP, Inc. Approach***

**Worker Scenarios**

The concentration increases with depth on the site. The Worker scenario under current conditions implicitly takes credit for the presence of the current depth profile.

STEP, Inc.'s Worker scenario under eroded conditions passes because of the parameters chosen. In particular, the scenario would result in a TEDE greater than 25 mrem/y if two parameter changes are made:

[3]Leafy vegetables: 1.5 $kg/m^2/y$, other vegetables: 0.7 $kg/m^2/y$.

[4]It appears that STEP, Inc. is implicitly taking credit for the Total Available Uranium test results presented in Appendix A of the Radiological Assessment (STEP, Inc., 2000b) by proposing to base transfer coefficients on geometric mean values.

- pier and beam construction or a 8.9 cm (3.5 in.) thick concrete slab is assumed in place of a 15.3 cm (6 in.) slab[5], and

- the structure occupancy time is set to a value of 97.46 days per year, the default value for building occupancy of a non-residential structure.

In effect, STEP, Inc. has concluded that some limited occupancy of a structure, such as a tool shed, in the contaminated area is possible. At the same time, they are not considering the possibility of a similar structure that might be substantially occupied, such as a night watchman's shack or a parking attendant's booth.

SNL believes that substantial additional justification for both the occupancy time and the choice of a 15.3 cm (6 in.) thick slab is needed.

**Resident Gardener Scenario**

One major reason that the Resident Gardener scenario passes is that no occupancy of a structure in the contaminated area is assumed. A mobile home could easily be placed in the contaminated area on top of the pile. Because of the aspect ratio offered by a mobile home, the structure could fit into the contaminated area and still leave room for a garden. Because of this concern, substantially more justification of the assumption that no structure is present in the contaminated area is needed.

**Worker and Resident Gardener Scenarios**

In the draft of the Standard Review Process, Chapter 4, NRC states that "...sites looking for unrestricted release, should not rely solely on these arguments [regarding current land practices] as reason to remove pathways or change the scenario unless either the radionuclides have a relatively short half-life (approximately ten years or less or the dose from long-lived radionuclides reaches its peak before 100 years." Since the radionuclides at this site are long-lived and will not have decayed significantly within the 1000-year period of consideration, significant justification would be needed to preclude specific human activities at this site.

SNL did not find adequate justification for precluding the placement of either an on-grade or subgrade structure on this site. In the SNL analysis of the initial decommissioning report, a scenario was considered where a subgrade residential or industrial structure is placed on the edge of the slope with the structure partially penetrating the slag. This scenario exposes the average member of the critical group to TEDE that is significantly larger than the 25 mrem/yr criteria (SNL, 1999).

NRC did not include the possibility of a subgrade structure on the site in either their letter to Cabot Corporation (NRC, 1999) or in the meeting between NRC and Cabot Corporation that was held on December 15, 1999.

[5]Current building codes require a minimum slab thickness of 8.9 cm (3.4 in.) for slab on-grade structures.

# 4 LICENSEE'S ALARA ANALYSIS

Under regulations defined in 10 CFR 20.1404, Radiological Criteria for Unrestricted Use:

> "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem per year, including that from groundwater sources of drinking water, *and* the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal".

The draft regulatory guide, DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*, dated August 31, 1999, defines specific procedures for assessing ALARA. The methodology is based on a combination of remediation costs and the impact to workers, members of the public, and the environment [NRC, 1997a, NRC, 1995].

The STEP, Inc. report determined the benefit of dose saved (dollars/m$^2$ remediated) based on exposure to five trespassers (4.4 mrem/y TEDE) and five workers (2.0 mrem/y TEDE). Using a discount rate of 3 percent per year over a 1000-year period, the calculated maximum benefit for any remedial action was \$2,200/m$^2$. They concluded that "no remedial action could result in a significant dose reduction for a cost as little as \$2,200."

The ALARA analysis and conclusions presented in *Radiological Assessment for Reading Slag Pile Site* do not conform to the recommended approach defined in the draft regulatory guide. In their assessment of ALARA, STEP, Inc did not consider: 1) the estimated total cost for remediation; and 2) the effectiveness of any remediation action.

The residual radioactivity that is ALARA is the concentration, *Conc*, at which the benefit from removal equals the cost of removal. The present worth of future collective averted dose, $PW(AD_{collective})$, can be estimated from the following [NRC, 1998]:

$$PW(AD) = P_D \times A \times 0.025 \times F \times Conc/DCGL \times Dsct$$

where *Dsct* allows credit for present worth of future benefits using a monetary discount rate of 0.03/yr. The decay rate, $\lambda$, is several orders of magnitude lower than the discount rate, $r$, and can be ignored in the calculations. With $F = 1$, $P_D = 0.0004$ persons/m$^2$, $A = 1859$ m$^2$, and $Conc/DCGL = 4.4/25 = 0.176$, the future collective averted dose (in monetary units) equals \$218. This means that any remediation effort that removes the entire inventory of radionuclides from the site ($F$=1) would result in a monetary benefit of \$218. Since there is no remediation process that could be completed for as little as \$218, the residual radioactivity is ALARA, and SNL concurs that the proposed decommissioning plan is ALARA.

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# 5 CONCLUSIONS

## 5.1 Resident Gardener

In general, STEP, Inc. used a circuitous approach to calculate dose from consumption of homegrown vegetables. With respect to homegrown vegetable consumption, SNL does not believe that adequate justification has been given to:

- the factors related to plant mass loading with contaminated soil,
- the area of the garden,
- the consumption rates for homegrown produce, and
- the factor of two occupants, which reduces the consumption rates.

SNL does not believe that STEP, Inc. has adequately justified the absence of a residential structure in the contaminated zone.

## 5.2 Worker Scenarios

SNL believes that additional justification is needed with regard to several aspects of the scenario structure: the limited occupancy time in the structure, the thickness of the slab, and the possibility of a subgrade structure.

### 5.2.1 Limited Occupancy Time

STEP, Inc. has assumed a structure to be present in the contaminated area. STEP, Inc. needs to address why a structure could not be substantially occupied by a worker, such as a night guard or a parking attendant.

### 5.2.2 Thickness of the Slab

The type of structure assumed by STEP, Inc. needs additional justification. In particular, STEP, Inc.'s choice of a 15.3 cm (6 in.) thick slab in the scenario needs to be justified when slabs as thin as 8.9 cm (3.5 in.) thick can currently be used. Also, the choice of a structure with a 15.3 cm (6 in.) slab needs to be justified when pier and beam construction could be employed.

### 5.2.3 Subgrade Structure

SNL believes that additional justification is needed to rule out the possibility of a subgrade structure being built into the slag sometime during the 1000-year period. NRC guidelines do not allow current land use to be used for justification where the radionuclides involved persist beyond 100 years. The radionuclides at this site will persist well beyond 1000 years.

## 5.3 Groundwater Pathway

Additional aquifer characterization presented in the revised Decommissioning Plan indicates the aquifer is not a practical source for drinking, irrigation, or a fish pond. SNL agrees with STEP, Inc. that the groundwater pathway can be ruled out.

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# 6 RECOMMENDATIONS

Homegrown vegetable consumption rates should be obtained directly from national or regional statistics for residential gardeners.

The Residential Gardener scenario should include a structure in the contaminated area. If this is not done, then a better justification for the absence of a structure should be provided.

The Worker scenarios should be revised to reflect possible effects of alternate construction methods other than a 15.3 cm (6 in.) thick slab. It also needs to address the rationale for why the structure could not be substantially occupied and the rationale for excluding the possibility of a subgrade structure.

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