UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 13, 1997

Mr. Howard A. Pulsifer
Vice President, General Counsel & Secretary
AAR Corporation
1111 Nicholas Boulevard
Elk Grove Village, Illinois 60007

SUBJECT: NRC REVIEW OF THE AAR *Site Remediation Plan for the Former Brooks and Perkins, Inc. Site*, DATED APRIL 8, 1996

Dear Mr. Pulsifer:

On April 8, 1996, AAR Manufacturing Group, Inc. submitted the "Site Remediation Plan for the Former Brooks and Perkins, Inc. Site" to the Nuclear Regulatory Commission for review and approval. NRC conducted an administrative review of AAR's proposed plan, and determined that the Remediation Plan was sufficient to warrant a technical review. Based on our technical review, the NRC staff concludes that AAR's proposed remediation approach for outdoor areas is unacceptable as presented.

AAR's proposed approach consists of off-site disposal of surface soils and subsurface soils containing concentrations of thorium resulting in exposure rates of ≥10 μR/hr above background measured 1 meter above ground surface. In addition, AAR performed a radiological dose assessment that generally follows the guidance presented in Policy and Guidance Directive PG-8-08 entitled, "Scenarios for Assessing Potential Doses Associated with Residual Radioactivity."

Although the staff recognizes that 10 μR/hr is consistent with the NRC's exposure rate limit for outdoor areas, and the dose assessment indicates public exposures of less than 11 mRem/yr for a resident scenario, we have two concerns with the analysis presented in the remediation plan. First, the remediation plan does not include a comparison of the thorium soil concentration values with the NRC's 10 pCi/g guideline value presented in "Branch Technical Position for Disposal or On-site Storage of Thorium or Uranium from Past Operations." Further, the plan does not include analyses to compare surface and subsurface soil activity with the averaging criteria presented in the NRC guidance document "Manual for Conducting Radiological Surveys in Support of License Termination," (NUREG/CR-5849). Second, the radiological assessment assumes that thorium contamination is evenly distributed throughout the site even though site characterization data indicates that the contamination is not uniform, and that some areas are elevated. Our concerns over AAR's lack of consideration of 1) the 10 pCi/g soil concentration guideline, and 2) the nonuniform elevated areas, both subsurface and surface, are the basis for our conclusion that the remediation plan is unacceptable as presented.

In previous guidance involving subsurface soil contamination exceeding the unrestricted use criteria (10 pCi/g for thorium), NRC approved the application of the averaging criteria in NUREG/CR-5849 for each 1-3 foot subsurface plane. While this approach is conservative and provides adequate public health protection, there are alternative ways to assess the potential dose associated with subsurface contamination. One such method acceptable to the NRC staff is discussed in the attached document, "Method for Surveying and Averaging Concentration of Thorium in Contaminated Subsurface Soil." This attachment describes a set of decommissioning performance objectives for subsurface soil that the NRC would find acceptable for use at AAR's Livonia site, as well as guidance on designing final surveys to demonstrate compliance with the performance objectives. However, in order to demonstrate compliance with the performance objectives, it appears that additional sampling will be required.

AAR has the option of proceeding in one of the following four ways: (1) revise the sampling and remediation plan consistent with meeting the performance objectives identified in the attachment; (2) revise the remediation plan based on an alternative analysis, performed by AAR, evaluating potential doses to individuals due to the presence of nonuniform subsurface and surface contamination; (3) use NUREG/CR-5849 averaging criteria for each 3 foot planar level; or (4) provide additional justification for assuming uniform distribution of thorium contamination at the site.

The concerns identified above need to be resolved before the staff can complete its comprehensive technical review of the remediation plan. If you would like to discuss the issues identified in this letter or approaches for resolving these issues, please contact me at 301-415-6607.

Sincerely,

John T. Buckley

John T. Buckley
Low-Level Waste and Decommissioning
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket No: 040-00235
License No: STB-0362

Attachment: As stated

cc: B. Koh & Associates

METHOD FOR SURVEYING AND AVERAGING CONCENTRATIONS OF THORIUM IN CONTAMINATED SUBSURFACE SOIL

Prepared by NRC Staff in Connection
With the Review of the AAR "Site
Remediation Plan for the Former Brooks
and Perkins, Inc. Site," Docket #040-00235
NRC Contact: David Fauver, 301-415-6625

I. INTRODUCTION

Current NRC guidance for conducting final surveys at decommissioning facilities is contained in Draft NUREG/CR-5849, "Manual for Conducting Surveys in Support of License Termination." NUREG/CR-5849 primarily addresses the final surveys of surface contamination on both buildings and open land areas, including guidance on acceptable averaging methods for surface contamination that exceeds the unrestricted use criteria (i.e., elevated areas). However, methods for surveying and averaging subsurface contamination are not discussed. This document provides a method for averaging elevated areas of subsurface soil contamination. Note that the potential for exposure from subsurface contamination via the groundwater pathway is not addressed in this document. The groundwater pathway should be evaluated on a case-by-case basis.

The averaging method in NUREG/CR-5849 assumes that soil samples are collected from the ground surface (first 15 cm). This sampling and averaging method is acceptable for the majority of decommissioning sites since the surface samples are considered sufficiently representative to assess the potential dose using conventional pathway analysis. However, conventional pathway analysis, and the NUREG/CR-5849 averaging method, may not be appropriate if significant subsurface contamination is present.

Conventional pathway analysis concludes that the dose from subsurface contamination is essentially zero, except from the groundwater pathway (see discussion below for other exceptions). This conclusion assumes that the contamination will remain at depth for very long periods of time (the typical pathway analysis is run for a 1000 year period). Since it is not reasonable to assume that the subsurface soil will remain undisturbed for a 1000 year period, simple scenarios were developed to predict how subsurface soil would be excavated in the future, the volume of the excavated soil, and the dose consequences of the contaminated soil in the post-excavation geometry. Based on the predicted excavation volumes and the dose consequences, surveying and averaging protocol were developed for in-situ subsurface soil.

Two excavation scenarios were evaluated. The first scenario assumes the construction of a slab-on-grade house; the second a house with a basement. For each of the construction scenarios, the volume of excavated soil and the extent of surface spreading, as well as the depth of surfaces on which the foundations could be built, were estimated. The potential dose from the subsurface soil, after excavation, was estimated by: 1) calculating the dose

Attachment

from the contaminated soil spread on the ground surface and 2) calculating the dose from the in-situ contaminated surface that is exposed after excavation, assuming that the foundation of the house is built on the exposed surface.

It is recognized that subsurface contamination contained closer to the surface, say 0-1 meter, may deliver dose without being excavated. This exposure may occur from: 1) direct gamma radiation from in-situ soil closer to the surface, 2) the root uptake pathway down to about the first meter, and 3) the uncovering of contaminated surfaces through grading during construction, and surface erosion over time, which could then cause dose through surface exposure pathways. However, the average concentration allowed for the in-situ soil from 0-1 meter would be greater than that allowed under the excavation scenario due to the soil being spread over a larger area after excavation. Therefore, the excavation scenario is used to determine acceptable averaging limits for the 0-1 meter layer. This conservatism is appropriate because of the uncertainty as to potential exposure pathways for near surface contamination.

Finally, after the concentrations and averaging volumes were determined, a survey method was developed that would be acceptable to NRC for demonstrating that the averaging criteria are met. Section II describes the survey method. The technical basis for the averaging concentrations and survey method is presented in Section III.

II. SURVEY METHOD FOR SUBSURFACE THORIUM CONTAMINATION

The final survey method for subsurface contamination should ensure that the number and location of samples are sufficient to; 1) demonstrate, with reasonable confidence, that a significant volume of subsurface contamination is identified by one of the samples, and 2) demonstrate that the average contamination level in the identified volume would not result in a significant dose after excavation.

The survey method described below can be used to satisfy the above two objectives. The technical basis for this survey method is presented in Section III. The concentration values are based on the current unrestricted use limit of 10 pCi/g total thorium for widespread surface contamination. If the guideline value changes, the averaging criteria will change accordingly. Other survey methods may be acceptable if they are justified on a dose basis and provide sufficient confidence that significant volumes of soil are identified.

Survey Assumptions:

1. Samples are collected on a 5 meter square grid.

2. Samples are composited over each 1 meter layer of soil.

3. Each sample is assumed to represent 25 m^3.

4. 100 m^3 averages are represented by the average of four samples collected from each 1 meter layer of soil.

5. Volumetric averages greater than 100 m^3 are calculated assuming each sample represents 25 m^3.

Averaging Criteria for Total Thorium (Th-232 + Th-228):

0-1 meter depth	Maximum Individual Sample < 50 pCi/g 10 m^3 average < 20 pCi/g 100 m^3 average < 13 pCi/g
1-2 meter depth	Maximum < 50 pCi/g 200 m^3 (0-2 m depth) < 10 pCi/g
2-3 meter depth	Maximum < 50 pCi/g 300 m^3 (0-3 m depth) < 10 pCi/g
3-4 meter depth	Maximum < 50 pCi/g 100 m^3 < 13 pCi/g 400 m^3 (0-4 m depth) < 10 pCi/g
> 4 meter depth	maximum < 50 pCi/g volume from surface to depth "x" < 10 pCi/g
survey unit	The volumetric average over the entire survey unit < the unrestricted use limit (10 pCi/g for total thorium)

The averaging criteria apply to any contiguous volume defined by the given number of 5 m grid samples, where each sample represents 25 m^3. For averaging over a 100 m^3 volume, each combination of four samples in a given 1 m layer should be evaluated. This would only be necessary if an individual sample exceeds 10 pCi/g. To calculate the average for volumes greater than 100 m^3, consider the samples in a given 10 m X 10 m area projected to the depth of interest. For example, the 300 m^3 volume average is calculated by averaging 12 samples represented by the four samples in the 0-1 m layer of a given 10 X 10 m area (assuming 5 m grid), and the 4 samples each in the 1-2 m and 2-3 m layers directly below the given 10 X 10 area. The samples at the respective depths would likely be from the same borehole.

In addition to the above, a vertical averaging criteria is also defined. This averaging criteria is intended to identify significant volumes of contiguous contamination in the vertical, as opposed to the horizontal, direction. The sampling and averaging described below also assumes a 5 m grid size.

- The average of the two samples from 0-2 meters in same borehole (50 m^3) < 14 pCi/g total thorium

- The average of the three samples from 0-3 meters in same borehole (75 m^3) < 13 pCi/g total thorium

III. TECHNICAL BASIS FOR SUBSURFACE SURVEYING AND AVERAGING METHOD

Discussion

After the contaminated soil is excavated and brought to the surface, the surface exposure pathways, and the surface averaging methods apply. The surface averaging method used for excavated subsurface soil is consistent with that used in NUREG/CR-5849. However, the NUREG/CR-5849 procedure was modified to reduce the conservatism. A discussion of how the NUREG/CR-5849 averaging method for surface contamination was modified is presented in the following section. How the modified averaging method was applied to excavated subsurface soil is presented in subsequent sections.

The averaging method in NUREG/CR-5849 was based on a combination of past practice and dose assessments. The averaging method has three steps:

1) elevated areas should be less than 3 times the release criteria,

2) the concentration in the elevated area should not be greater than $(100/A)^{1/2}$ times the release criteria, where "A" is the size of the elevated area in m^2, and

3) the average over any 100 m^2 area should be less than the release criteria.

The maximum criterion of 3 times the average limit in NUREG/CR-5849 (step #1 above) was based on a qualitative ALARA judgement and a comparison with the maximum criteria in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," which also uses 3 times the average value as the maximum. Since radionuclide specific evaluations will be performed (as described below), the 3 times maximum criterion was not used in the volumetric averaging method for subsurface contamination. The maximum criterion was determined by estimating the minimum volume of soil that could be excavated without mixing with surrounding soil and assessing the relative dose from this volume of soil compared to uniform, widespread contamination.

The area averaging criterion in NUREG/CR-5849 (step #2 above) was based on a dose assessment made in 1985 for the Department of Energy using the DOE "Manual for Implementing Residual Radioactivity Guidelines." This manual was eventually updated and codified in 1989 as DOE's RESRAD pathway analysis/dose assessment code. The dose from elevated areas of various sizes was estimated using default input parameters for the code. The conclusion from these dose estimations was that the dose is reduced as the area of contamination is reduced, assuming the same concentration. The extent of the reduction in dose as a function of area depends on whether the predominant dose pathway is from direct exposure, or from one or more of the other pathways such as inhalation and ingestion. In general, there is a greater dose reduction for elevated areas containing radionuclides that deliver a significant fraction of the dose through the inhalation and ingestion pathway than for radionuclides that deliver a higher fraction of dose via the direct exposure pathway. The formula in NUREG/CR-5849 (restated below) was derived from the 1985 DOE study of the dose consequences of elevated areas of various sizes.

$$\text{Allowable Concentration in Elevated Area} < C(100/A)^{1/2}$$

where: C = unrestricted use criteria
A = area of elevated area, m^2

The above formula represents the lower bound of acceptable concentrations in an elevated area of size "A" for all of the radionuclides evaluated. A similar dose assessment for a specific radionuclide will very likely result in an allowable concentration exceeding that calculated using the above formula. This is evidenced by Enclosure 1, which shows the nuclide specific dose consequences of elevated areas (represented by the multiple of the authorized limit on the Y axis) ranging in size from 1 m^2 to 100 m^2. Enclosure 1 also includes a line defined by the $(100/A)^{1/2}$ formula. Note that the $(100/A)^{1/2}$ line is below all of the nuclide specific curves, and represents the most conservative result.

Enclosure 1 was generated in 1985 and summarizes the results of the dose assessments used to select the $(100/A)^{1/2}$ formula for determining acceptable concentrations of contamination in elevated areas. To ensure that the current version of RESRAD is consistent with the 1985 dose assessments, a similar series of dose assessments were conducted using a recent version of RESRAD. As shown in Enclosure 2, the results are very similar. This demonstrates that RESRAD is appropriate, and will provide averaging criteria that is consistent with, albeit less conservative than, the $(100/A)^{1/2}$ criteria. Therefore, in order to provide more realistic criteria, the volumetric averaging method described below relies on radionuclide specific dose assessments, using the DOE RESRAD code, to determine the acceptable concentration in subsurface soil containing elevated contamination levels.

The third part of the averaging method in NUREG/CR-5849 (step #3 above) is that the average over any 100 m^2 should be less than the release criteria. The 100 m^2 average limitation was intended to address the potential for a 10 m x 10 m house being built on the 100 m^2 parcel of land. The 10 m x 10 m averaging criteria is essentially maintained in the subsurface volumetric averaging method.

The following sections describe the assumptions and calculations used to develop the volumetric averaging criteria for subsurface soil.

Excavation Assumptions

- Excavation scenarios for both a house w/basement and a house w/out basement

- House Size: 10 m x 10 m

- Dimensions of footers for house w/no basement:
  1 m deep x 1 m wide x 10 m long

- Basement Depth: 3 m

- Excavation Equipment Bucket Size: 1 m^3

- Five excavation scenarios evaluated:

  1) each of four 1 m deep x 1 m wide x 10 m long footer excavation for a house w/out basement is placed in separate pile

  2) the 1 m deep x 10 m wide x 10 m long portion of soil from the surface to a depth of 1 m is excavated for a house with no basement and placed in separate pile

  3) each 3 m deep x 2.5 m wide x 10 m long portion of soil for basement excavation placed in separate pile

  4) entire 3 m deep x 10 m wide x 10 m long excavation for house w/basement placed in one pile

  5) one bucket (1 m x 1 m x 1 m) of excavated soil placed in separate pile

- Each excavated pile uniformly blended

- Each pile spread over a 1 foot depth

Method for Calculating Acceptable Averaging Volumes and Concentrations for Subsurface Contamination

To determine the averaging volume for subsurface contamination, and the acceptable concentration as a function of volume, the first step was to calculate the volume of soil excavated in each of the above five scenarios. The dose from the excavated soil was then estimated and compared to the dose from widespread, uniform contamination.

To estimate the dose, the soil volumes defined by the five excavation scenarios were assumed to be brought to the surface and spread over a 1 foot depth. Using the resulting calculated surface area as input to the RESRAD code, the dose from the excavated soil was estimated using the resident farmer scenario and the input parameters from Policy and Guidance Directive PG-8-08 "Scenarios for Assessing Potential Doses Associated with Residual Radioactivity," May 1994. A second RESRAD run was then made, using the same concentration, and assuming the default area of 10,000 m^2. The ratio of the dose from the 10,000 m^2 area to the dose from the calculated area was then multiplied by the unrestricted use criteria to determine the acceptable concentration in the elevated area, and hence the corresponding subsurface volume. This concentration is considered acceptable since the dose from the elevated area containing this concentration will deliver the same dose as a large area contaminated at the unrestricted use level. To determine compliance with the volumetric averaging criteria, the average concentration over the in-situ volume of soil defined in the scenario must be less than the above ratio times the guideline.

For example, the following calculation provides the averaging volume and concentration for excavation Scenario #1, assuming that the contamination is total thorium (Th-232 + Th-228):

1. Volume of 1 m deep x 1 m wide x 10 m long footer is 10 m^3.
2. Assuming the 10 m^3 volume is excavated and spread over a 1 foot depth, the area of contamination on the surface would be 30 m^2.
3. Run RESRAD to estimate dose assuming 10 pCi/g total thorium and assuming that the contaminated area is 30 m^2 (Enclosure 3).
4. Run RESRAD to estimate dose, also assuming 10 pCi/g total thorium, but using the RESRAD default area of 10,000 m^2 (Enclosure 4).
5. Calculate the ratio of the dose from Step 4 to the dose from Step 3. For total thorium, the ratio is 2.0.
6. Multiply the ratio, i.e., 2.0, by the unrestricted use limit for total thorium, i.e., 10 pCi/g. The resulting concentration is 20 pCi/g, which represents the acceptable average concentration in a 10 m^3 volume of soil.

Note that Scenario #1 applies only to volumes of soil starting on the surface and ending at the first meter since the excavation is assumed to be for a footer, and would not go below 1 m.

The same calculations were performed for the other four excavation scenarios. The resulting five volumetric averaging guidelines for subsurface thorium contamination are listed below. The criteria for other radionuclides should be developed on a case-by-case basis. The excavation scenarios described above for housing construction are assumed to result in conservative averaging criteria since excavations for larger structures should result in larger excavated volumes, and a greater degree of mixing with surrounding soil.

Volumetric Averaging Guidelines For Subsurface Thorium Contamination

The five excavation scenarios were evaluated to determine acceptable averaging volumes and concentrations for subsurface thorium contamination. Enclosure 5 contains the RESRAD output for each of the five evaluations.

1) The average concentration of total thorium in a 10 m^3 volume should be less than 20 pCi/g.

2) The average concentration of total thorium in a 100 m^3 volume of soil should be less than 13 pCi/g.

3) The average concentration of thorium in a 75 m^3 volume of soil should be less than 13 pCi/g.

4) The average concentration of thorium in a 300 m^3 volume of soil should be less than 10 pCi/g.

5) The average concentration of thorium in a 1 m^3 volume of soil should be less than 50 pCi/g. This concentration is considered the maximum value for an individual sample composited over a 1 meter depth.

The above averaging guidelines were developed assuming that the soil is excavated and placed on the ground surface. The final step is to ensure that the volumetric averaging does not result in a layer of exposed soil with excessive concentrations. The soil layers of concern are the layer from 0-1 m and 3-4 m, which are the layers upon which the foundations for the slab-on-grade house and a house with a basement, respectively, are assumed to be built. To control these scenarios, the average over the 100 m^3 defined for these layers will be limited to the 100 m^3 averaging criteria.