13

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

FEB 25 1993

Docket No. 40-8778
License No. SMB-1393

Molycorp, Inc.
ATTN: Ms. Barbara K. Dankmyer
Resident Manager
300 Caldwell Avenue
Washington, Pennsylvania 15301

Dear Ms. Dankmyer:

SUBJECT: NRC COMMENTS ON THE PLAN FOR SITE CHARACTERIZATION IN SUPPORT OF DECOMMISSIONING OF THE MOLYCORP INC. WASHINGTON, PA FACILITY

The Nuclear Regulatory Commission staff has completed its review of the report entitled "Plan for Site Characterization in Support of Decommissioning of the Molycorp Inc. Washington, Pa Facility." This document is herein referred to as Molycorp's Site Characterization Plan (SCP) or the SCP. In its review of Molycorp's SCP, the staff also considered a supporting report, submitted by Radiation Surveillance Associates, Inc. on January 4, 1993, entitled "Justification of the Calibration Factor used for Borehole Measurements of Underground Radiation Exposure Rates and Average ^{232}Th Concentration."

We commend Molycorp for developing the SCP in a format consistent with NRC's Draft Branch Technical Position (BTP) on Site Characterization for Decommissioning Sites, July 1992. This greatly facilitated our review of this document.

Our review was complicated by uncertainty in Molycorp's preferred approach for decommissioning the site. We recognize that Molycorp is now in the process of evaluating a range of decommissioning and disposal alternatives. We encourage Molycorp to conceptualize its preferred decommissioning approach as early as possible. This will help to clarify what information needs to be collected during site characterization, and thus better focus the characterization effort.

In the course of our review, we identified a number of general comments (Enclosure #1) on the SCP. If Molycorp addresses and resolves these comments now, a great deal of time and site characterization effort may be saved. Some of our major comments include:

1. The utility of the proposed gamma logging technique for deriving subsurface thorium concentrations has not been demonstrated. Therefore, directly measured concentration data (based on conventional sampling and radiochemical analysis) should be used rather than diluted and approximate concentrations derived from gamma logging for demonstrating compliance with NRC decommissioning criteria. The staff continues to accept the use of gamma logging for identifying the general zone (depth and lateral extent) of radioactive contamination.

2. The SCP and RSA's 1992 report suggest that Molycorp may propose a dose criterion in place of NRC's decommissioning criteria. Molycorp should not proceed with site characterization with the expectation that some alternate decommissioning criteria, based on dose or exposure rate, will be approved for release of this site for unrestricted use. If Molycorp wishes to pursue an alternate decommissioning criterion, Molycorp needs to propose the criterion and justify it by demonstrating that it will achieve residual concentration levels that are As Low As Reasonably Achievable (ALARA). The establishment of an alternate decommissioning criterion would require Commission review and approval.

3. A great deal of characterization information has already been collected for this site. Molycorp should review and analyze this information, and the SCP should discuss how the results of this analysis have been used in planning future site characterization activities. For example, the SCP presently lacks an adequate description of what is presently known about the hydrogeology, and how this information was used in planning future hydrological characterization. The SCP should review the results of past hydrogeologic work in discussing the rationale for future characterization work in this area.

The staff has also identified a number of specific technical comments (Enclosure #2) on the SCP. If you would like to meet with NRC staff to discuss these comments, we would be happy to arrange such a meeting. If you have any questions, please contact me at (301) 504-2546.

Sincerely,
[Original signed by]
Chad J. Glenn, Project Manager
Decommissioning and Regulatory Issues Branch
Division of Low-Level Waste Management and Decommissioning
Office of Nuclear Material Safety and Safeguards

Enclosures: As stated

cc:
G. Dawes, Molycorp
J. Yusko, PA-DER-RP
M. Landis, ORISE
B. Belanger, EPA Region III
J. Kinneman, Region I

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NRC Review and Comments On:
Plan For Site Characterization In Support Of Decommissioning
Of The Molycorp Inc. Washington, Pa Facility

GENERAL COMMENTS

1. Review and Analysis of the Previous Characterization Work:

The SCP does not discuss how the results of past site characterization efforts have been used in planning future characterization work. Previous characterization work performed by Applied Health Physics (AHA), Radiation Surveillance Associates, Inc., (RSA), and Oak Ridge Associated Universities (ORAU) have contributed significantly to the existing information base relevant to site characterization. Much of this characterization work is documented in three reports (AHA, 1971; ORAU, 1985; and RSA, 1990). These reports contain information on radiation surveys, core sampling, soil and slag concentrations based on laboratory analysis, and sub-surface gamma logging. The SCP should summarize the results of these previous characterization efforts. and explain how this information was used to guide future site characterization work. The NRC staff believes that this evaluation will assist in providing a sound basis for planning future site characterization work and potentially reduce the time and cost of site characterization by eliminating unnecessary site characterization efforts.

2. Location of Boreholes and Selection of Samples:

The SCP does not provide a clear rationale for selecting the number of boreholes and quantity of samples collected during site characterization. For example, Molycorp is planning to drill an additional 300 boreholes down to bedrock to measure the intensity of the subsurface gamma field (Section 5.2.2 page 39), analyze 200 soil samples from the cores for ^{232}Th by ICP (Section 5.2.3 page, 41), and analyze 20 well-water samples for $^{232,230,228}Th$, $^{238,234}U$, and $^{228,226}Ra$ (Section 5.5, page 45). The SCP should discuss the rationale for the number and selection of borehole locations, types and quantities of samples collected during site characterization, and clarify how these data will be used in planning site decommissioning or conducting a termination survey.

3. Decommissioning Criteria:

A dose criterion should not be used in place of NRC's existing decommissioning criteria. The SCP indicates that Molycorp is proposing to use a dose criterion as either the major or the sole criterion to demonstrate compliance with NRC cleanup and decontamination guidelines. Recent discussions with Molycorp consultants also indicate that Molycorp may propose a remediation guideline value based on a dose rate in place of NRC's existing soil concentration guidelines in the 1981 Branch Technical Position (BTP) entitled *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations*. It is important to note, that the decommissioning guidelines for residual soil concentrations that have been approved by the Commission for the release of sites for unrestricted use are the soil concentration limits in Options 1 and 2 of NRC's 1981 BTP. The ultimate decision to terminate a license and release a site for unrestricted use will be based on NRC's existing decommissioning guidelines. These remediation guidelines are applied on a site-specific basis with emphasis on residual contamination levels that are As Low As Reasonably Achievable (ALARA). Therefore, Molycorp should not proceed with site characterization with the expectation that some alternative decommissioning criterion, based on dose or exposure rate, will be approved for the release of this site for unrestricted use. If Molycorp wishes to pursue an alternate decommissioning guideline, Molycorp needs to propose the criterion and justify it by demonstrating that it will achieve residual contamination levels that are ALARA.

4. Radiological Characterization of Site:

The primary objectives of Molycorp's radiological characterization efforts should be to assess the extent of contamination above background levels, and to identify locations and distributions of highly contaminated areas that may propose special handling concerns during decommissioning. This radiological characterization may require the use of a combination of techniques. For example, gamma logging may be quite useful during characterization in identifying the general zone of contamination (vertical and horizontal boundaries). However, for determination of thorium concentrations after the completion of remediation, the staff believes that an approach based on gamma screening coupled with direct measurement of thorium concentrations is more appropriate. The staff believes that this coupling is appropriate given: 1) the inherent limitations of the gamma logging technique in determining thorium concentrations (discussed below), and 2) due to the nature of the thorium contamination (e.g., occurs in patchy, or randomly distributed discrete hot spots). This should be addressed further in the Decommissioning Plan as a part of the sampling plan for the termination survey.

5. Characterization to Evaluate Volume Reduction Technologies:

Due to the nature and form of contamination at this site, NRC staff encourages Molycorp to consider an alternate approach of characterizing and remediating the site simultaneously. If the remediation of the site disturbs and redistributes contaminated material onsite, there would be limited value in conducting detailed characterization of the distribution of radionuclides as a part of site characterization. Under this alternate approach, Molycorp might excavate contaminated and potentially contaminated soil and process this material via physical screening or separation (e.g., sieving or heavy liquid separation). For example, one soil remediation process that has been commercially demonstrated excavates and places contaminated soils on a continuously moving conveyor belt. An array of radiation detectors monitors the soil on the belt and identifies and segregates highly contaminated soil from clean soil. This type of simultaneous characterization and remediation approach might effect sizable reductions in volumes of waste requiring disposal in a licensed facility and accelerate the decommissioning process at Molycorp's Washington site.

The SCP does not, however, discuss the collection of information needed to evaluate the feasibility of using volume reduction technologies for site remediation and decommissioning. Certain physical characteristics of the contamination at Molycorp's Washington, PA site may provide favorable characteristics for the physical separation of contaminants. For example, grain size distribution, density, solubility, metallic and magnetic properties, and apparent inhomogeneity of the contaminated material may be useful characteristics in separating contaminated slag from uncontaminated slag and soil. The NRC staff believes that a careful evaluation of these properties may provide insight into an effective approach for site remediation. Volume reduction technologies may significantly reduce decommissioning costs by decreasing the volume of contaminated material requiring off-site disposal. Many of these volume reduction methods are based on physical/mechanical technologies that are common to the coal and ore processing industries.

In order to evaluate potential applicability of volume reduction methods to Molycorp's Washington site, it is important to characterize the physical and mineralogical properties of the contaminated material (soil and slag). Section 4.4.2 of NRC's BTP on *Site Characterization for Decommissioning Sites* (July 1992) suggests that detailed information be obtained on the composition of surface and subsurface deposits, including mineralogy and other physical characteristics. Important physical properties of contaminated material in consideration of applicability of volume reduction technologies include: grain size distribution, relationship of radioactivity to particle size, magnetic properties, and mineralogical/chemical composition. NRC staff suggests that Molycorp consider the collection of this type of information during characterization to determine if volume reduction methods may be applicable to this site.

The U. S. Environmental Protection Agency has prepared a "Characterization Protocol for Radioactive Contaminated Soils" designed to evaluate the feasibility of applying one or more volume reduction technologies for remediation of contaminated soils. This protocol may provide some useful information on how to evaluate the potential applicability of volume reduction technologies. This protocol is attached (Attachment 1) for your consideration.

6. Surface/Subsurface Contamination and Affected/Unaffected Areas:

Surface gamma exposure rates should not be used as the sole indicator of potential subsurface contamination in determining "affected" and "unaffected" areas. The SCP indicates (Section 5.2.1, pp. 36-38) that surface gamma exposure data, below background levels, are indicative of uncontaminated subsurface soils and may be useful in dividing the site into affected and unaffected areas. NRC staff has examined the subsurface gamma log data in the 36 boreholes given in RSA 1990 report, and the gamma survey data of surface soils at locations corresponding to each borehole location. NRC staff observed a large number of subsurface locations in the boreholes that showed elevated gamma exposure rates, whereas the corresponding gamma survey of surface soil indicated approximately background levels (For example, see surface gamma survey and gamma logging data for boreholes: BH21, BH26, BH7, BH29, and BH6). This indicates that background gamma exposure rates at the surface should not be used as the sole indicator of subsurface contamination [illegible] should base its classification of affected and [illegible] on surface as well as subsurface sampling and analysis, and on the historical usage of source material at the site. NUREG/CR-5849 provides guidance on the classification of affected and unaffected areas.

Also, historical information on source material processing and radiological surveys at this site suggest that the boundary of the affected area outlined in Figure 5-2 should be extended in the "active plant area" north of Caldwell Avenue. The discussion in the SCP relating to this Figure supports this position. The SCP states (Section 5.2, page 37) that "due to the historical usage patterns, there is a potential for contamination under or adjacent to the & D offices and the process buildings west of Building 34, where the FeCb slag was produced". ORAU's previous survey of the site also identified elevated radiation levels under and adjacent to Building 34 and adjacent to Buildings 20, 25, 26, 28, 29 (R & D Bldg,), 30 and the Bag House east of Building 20. Also, based on a 1971 AHP report, Building 33 was a former radioactive material storage area for FeCb ore. According to the guidance provided in NUREG/CR-5849, affected areas are defined as areas that have potential radioactive contamination (based on plant history) or known radioactive contamination (based on surveys). Therefore, the areas described above, currently outside of the affected area shown in Figure 5-2, should be included as affected areas unless Molycorp can demonstrate that these areas are unaffected (i.e., no radioactive material above background concentrations). The SCP should also identify any affected areas outside the site boundary resulting from past operations at this facility. For example, areas adjacent to Chartiers Creek and outside the facility fenceline, that are either known or suspected to be contaminated, should be included as an affected area.

In addition, Molycorp will also need to provide adequate administrative control procedures in its remediation plan to ensure that "unaffected" areas do not become contaminated during remediation. If adequate control procedures are not established, the unaffected area will need to be resurveyed as part of the termination survey after decommissioning.

7. <u>Use of NUREG/CR-5849 for Guidance on Sampling and Hot-Spot Characterization</u>:

NUREG/CR-5849 provides instructions for performing final radiological surveys along with guidance on sampling and hot-spot characterization to support a facility's license termination application. This guidance would not specifically apply to the collection of information during site characterization. However, if Molycorp plans to use site characterization data to support a final termination survey, then Molycorp needs to ensure that the information is collected under a rigorous QA/QC program and in accordance with the procedures discussed in NUREG/CR-5849.

8. <u>Use of the Gamma Logging Technique to Derive ^{232}Th concentrations</u>:

Molycorp's consultant (RSA) provided a report (RSA, December 1992) that attempted to justify the calibration factors used to derive ^{232}Th concentrations from subsurface gamma radiation data (count rates) in borehole [illegible] measurements. The NRC staff has reviewed the report [illegible] believes that data from this technique will not be adequate to demonstrate compliance with NRC's existing decommissioning guidelines for thorium and uranium contamination in soil (1981 BTP). These concerns were raised previously in NRC's October 1992 comments. In its earlier comments, the NRC staff indicated that it is important to establish how data from this technique would be used. RSA's report clarifies the intended use of these data. The report states (bottom of page 26) that "We believe it is appropriate that Molycorp use the quantitative determination of average ^{232}Th concentration underground determined with in situ gamma measurements as a basis to establish cleanup criteria, as a basis for the dose assessment, and to demonstrate compliance."

This report indicates that Molycorp intends to use a four-step approach to comply with NRC decommissioning criteria. These procedures include: i) collection of exposure data (count rate) from subsurface gamma logging measurements, ii) conversion of gamma data (count rate) to exposure data (μR/h) using a calibration factor derived from field exposure data of a Pressurized Ion Chamber (PIC) detector located 1 meter above the surface, iii) conversion of the derived exposure data from step "ii" to concentration using Spiers (1968) and Beck (1972) conversion factors, iv) calculation of exposure or dose to critically exposed individual using RESRAD code with the input data derived in step "iii" for thorium concentrations. The following observations and concerns were identified based on the staff review of RSA's report.

1. Figure 10 of the report indicates that <u>no</u> correlation exists between gamma exposure rates and conventionally measured thorium concentrations.

2. This method tends to average contaminated slag present in localized high-activity spots over larger volumes of non-contaminated soil.

3. The 2.82 (μR/hr)/(pCi/g) calibration factor is based on direct radiation emanating from an infinite (area > 100 m^2 and thickness > 1 meter) slab source containing uniformly distributed radionuclides of the ^{232}Th chain in secular equilibrium. At Molycorp's Washington facility, the subsurface contamination is not uniformly distributed, but rather occurs as discrete heterogeneous, and finite volumes of soil and slag.

Other concerns with the calibration for this technique exist. For example, Molycorp is calibrating NaI scintillometer count rate data (for subsurface samples, collected at depths 1-9 feet, which has an effective volume of soil with a mass of 0.5 metric ton) with PIC exposure rate data (for surface samples 0.66 meters thick with an effective volume of 100 metric tons) [See RSA 1992 report as amended on February 11, 1993, by letter from RSA to NRC]. These calibration procedures were presented on pages 20-23 and Graphs 2-6 (page 27) of the RSA 1990 report. The RSA calibration approach may also produce errors in the calibration due to the correlation of two different gamma distributions arising from two different volumes of samples representing different locations at the site. Thus, although RSA provided different correction factors for the two different geometries, NRC staff believes that the validity of this correlation is questionable.

In summary, the use of the proposed gamma logging technique for the purpose of deriving subsurface thorium concentrations has not been demonstrated. Therefore, the derived average thorium concentrations would not be adequate for demonstrating compliance with NRC's decommissioning criteria or for performing a rigorous dose assessment. If Molycorp could adequately demonstrate a correlation between thorium concentrations derived from radiochemical analysis of core samples and average thorium concentrations derived from gamma logging, then gamma logging concentrations may be appropriate for dose assessment. In addition to NRC's concentration based decommissioning criteria, a dose or exposure rate criterion of 10 μR/h at one meter above background may be used as a maximum penetration radiation limit for unrestricted use. An acceptable hot spot criterion of two times this value may be used as a supplemental remediation criterion. However, Molycorp has not established how the gamma logging technique could be used to show conformance with the hot spot criterion and the soil concentration criterion.

Oak Ridge Institute for Science and Education (ORISE) has also reviewed RSA's December 30, 1992 report. ORISE's comments on the proposed gamma logging approach for determining average thorium concentrations are included in Attachment 2.

9. Establishment of Less Restrictive Cleanup Criteria:

Section 3 of the SCP (page 11) states that due to the highly insoluble nature of the slag, the cleanup criteria required to keep potential doses to exposed populations within acceptable limits will probably be less restrictive than that which would apply to facilities where radioactive contaminants are more mobile. The solubility of contaminated material generally does not dictate the cleanup criteria for a particular site, particularly for radionuclides such as ^{232}Th where the dominant exposure pathway is direct gamma exposure. Also, NRC's existing decommissioning criteria for the unrestricted release of contaminated sites have been established by the Commission. Therefore, any decision concerning the establishment of less restrictive cleanup criteria may require Commission review and approval. Also, the low solubility of slag has not yet been demonstrated.

10. Insufficient Information in the Hydrogeology Section:

The hydrogeology section of the SCP lacked significant characterization information. Specifically, the SCP needs to be revised to describe Molycorp's plans and rationale for characterizing: mass transport properties (e.g., K_d, effective porosity); groundwater flow direction and rates; recharge/discharge locations and rates; locations, number, and design of wells; radiological and nonradiological groundwater constituents; relationship between count rates measured in wells vs groundwater radionuclide concentrations; and leachate derived from surface and subsurface soil.

In a January 14, 1993, conference call with Molycorp and its contractors, NRC staff discussed its preliminary comments on sections of the SCP concerning the hydrogeologic characteristics of the site. The NRC staff's comments are summarized below.

The staff noted that the SCP presently lacks an adequate description of what is presently known about the site hydrogeology, and what future tasks are necessary to characterize the hydrogeology of the site. The SCP should also analyze previous site characterization work to provide the rationale and justification for the proposed site characterization activities outlined in the SCP. In its comments, the staff indicated that the SCP should include:

(a) An analysis and summary of information on the site background and physical setting;

(b) Analysis and summary of previous site characterization work relating to hydrogeology (e.g., flow direction, location of previous wells, leaching and mass transport properties, etc.);

(c) Analysis and summary of radiologic characteristics of surface water and groundwater; and

(d) A presentation of the conceptual site model, including an analysis and summary of the nature and extent of contamination; preliminary assessment of human and environmental impact; and the additional data needed to conduct a dose assessment.

The staff also noted other specific elements in the SCP that should be described in more detail, including the quality assurance plan, field sampling plan, types of tests that will be conducted to characterize the site hydrogeology, location and rationale for the selection of sites for new water wells, methods used to drill water wells, design and completion of water wells, type and frequency of water sampling and analysis performed on samples, and the identity of any computer codes under consideration for groundwater flow and transport modelling if known at this time.

11. <u>Evaluation of Mixed Waste Contamination</u>:

Molycorp should contact the Pennsylvania Department of Environmental Resources to determine the extent to which the potential presence of hazardous materials should be evaluated and characterized. The NRC believes that any characterization for hazardous chemicals should be comparable to characterization for radiological contamination. The NRC favors a single characterization plan dealing with both radiological and hazardous chemical wastes if possible.

12. <u>Hot Spot Definition and Guideline Limits</u>:

The SCP states (Section 1.2, p. 3) that "based on a limited underground survey (RSA, 1990) (32 boreholes) the thorium waste buried under and adjacent to the eight holding ponds on the west side of the site meets the Option 4 limits at all locations surveyed and on average, meets options 2 limits. Local hot spots underground generally do not exceed the Option 2 limits by more than a factor of 10." In accord with NUREG/CR-5849, contamination levels above 3 times NRC guideline levels are considered hot spots. Therefore, the contamination levels noted in these areas exceed NRC's current cleanup [illegible] Option 4 of the 1981 BTP is no longer [illegible] reliance on institutional controls is inconsistent with NRC's definition of decommissioning. NRC's guideline value for total thorium under Option 2 of the BTP is 50 pCi/g. The SCP indicates that local hot spots generally do not exceed Option 2 limits by more than a factor of 10 (e.g., 500 pCi/g). As indicated above, NRC guidance states that the activity at any location should not exceed 3 times the guideline value, or 150 pCi/g total thorium in the case of Option 2. Further, the specific activity of ^{232}Th in slag has been measured at 1250 pCi/g. Therefore, the concentration of thorium slag (^{232}Th and ^{228}Th) where all daughters are present and in secular equilibrium could exceed 2000 pCi/g. Molycorp should use NRC's guidance in NUREG/CR-5849 for identifying hot spots in the termination survey or justify an alternative hot spot criterion.

13. Information on Regional Characteristics of Site:

The SCP indicates that the site characterization report will include a discussion of regional geology, if this information is obtainable without prohibitively costly studies. One available source of regional information for this area is the U.S. Department of Energy's (DOE's) 1983 Final Environmental Impact Statement (FEIS) on the Cannonsburg uranium mill tailings site. This FEIS (DOE/EIS-0096-F) is entitled *Remedial Actions at the Former Vitro Rare Metals Plant Site, Cannonsburg, Washington, Pennsylvania*. The Cannonsburg site is located less than 10 miles north of Molycorp's site in Washington, Pennsylvania. Given the proximity of these two sites and the fact that both sites are situated on Chartiers Creek, the FEIS may provide a valuable source of information for characterization with respect to regional geologic, hydrologic, meteorologic and other features relating to Molycorp's Washington site.

14. Determination of Background Soil Concentrations:

The determination of surface and subsurface background soil concentrations should be based on measurement of both direct radiation levels (gamma exposure rates) and laboratory analysis of soil samples. The SCP indicates (Section 5.4, p. 45) that 9 boreholes will be logged using a NaI probe in order to establish the background count rate due to gamma exposure from naturally occurring radionuclides in native soils and in other fill material. Soil samples should also be collected at regular intervals and analyzed to determine background soil concentrations. The SCP should also describe the methodology that will be used to select representative areas for determining background concentrations of ^{232}Th and other radionuclides in subsurface media. NUREG/CR-5849 should also be consulted for guidance on conducting background surveys.

Enclosures:
1. EPA Characterization Protocol
   for Radioactive Contaminated Soils
2. ORISE Comments on Gamma
   Logging Technique

13B 1

United States Environmental Protection Agency | Office of Solid Waste and Emergency Response | Publication 9380.1-10FS May 1992

EPA

Characterization Protocol for Radioactive Contaminated Soils

Office of Emergency and Remedial Response
Office of Radiation Programs, ANR-458

Quick Reference Fact Sheet

The Superfund Amendments and Reauthorization Act of 1986 (SARA) mandates that remediation at Superfund sites must utilize a permanent solution and alternative treatment technologies or resource recovery options to the maximum extent practicable. Treatment technologies that permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances are preferred in this requirement. However, in most remedial actions conducted to date at radioactive sites, the radioactive soil has been excavated and stored in temporary above ground containment facilities. To alleviate this storage situation the Office of Radiation Programs has developed an innovative soil characterization process applicable in the RI/FS stages of the Superfund process to support the development of technologies for on-site volume reduction of radioactive soils by physical separation[1,2] technologies.

BACKGROUND

The volume reduction methods employed are based on physical/mechanical technologies that are common to the coal and ore processing industries. These common technologies have been adapted, modified, and directed toward the task of soil restoration. This soil characterization protocol is designed to demonstrate the suitabilitiy (or lack thereof) of various radioactivity contaminated soils for physical or chemical separation processes. These could potentially remove the radioactive fraction from the soil, thus producing a smaller volume requiring disposal. The protocol combines radiochemical and petrographic analysis of soil fractions, focusing on the contaminant waste and its particle size distribution in the host media. Soil remediation by volume reduction takes advantage of the fact that radionuclide contaminants concentrate generally in the smaller soil size fractions, and tend to selectively associate with materials that possess unique physical and/or chemical properties. The data obtained by following this protocol are used as the first phase of remediation assessment to determine if volume reduction is feasible.

CHARACTERIZATION DESCRIPTION

This soil characterization protocol examines the various size fractions of a representative sample of radioactive soil from a Superfund site, to provide the following information:

- Grain size distribution curve which relates weight percent versus particle size.
- Relationship of radioactivity to particle size
- Identification of the mineral/material composition and physical properties of the radioactive contaminants for the various size fractions.
- Identification of the mineral composition and physical properties of the host material for the various size fractions.
- Addtional information on contaminant and host material mineralogical and physical properties in support of feasible volume reduction techniques, e.g., magnetic properties.

These data are used to conceptualize a site-specific volume reduction process based on one or more of the following technologies:

- screening,
- classification,
- gravity separation,
- magnetic separation,
- flotation,
- chemical extraction,
- washing,
- scrubbing,
- surface de-bonding, and
- attrition.

The two-tiered soil characterization protocol, as shown in Figure 1, consists of feasibility analyses (Tier I), and optimization analyses (Tier II), as necessary, to cost-effectively maximize the volume reduction.

Pre-Tier I

Prior to Tier I laboratory tests, the representative contaminated soil samples obtained in compliance with EPA and DOE directives from a site[3,4,5] are radiologically screened to assure that the activity levels are within laboratory license requirements and that proper safety practices will be applied. Additional chemical analyses should be performed on a portion of each soil sample for the presence of organic and heavy-metal constituents if that information has not been previously collected. This information not only identifies hazardous constitutents (e.g., cyanide, heavy metals, chlorinated hydrocarbons), but also contributes to the mineralogical determination of the soil.

The remaining portions of each soil sample are oven dried at 60°C prior to weighing. The upper limit of 60°C is specified in order to maintain the mineral integrity of the soil by preventing the loss of water of hydration associated with the mineral structures which occur in some clays and other minerals at low temperatures.

Tier I

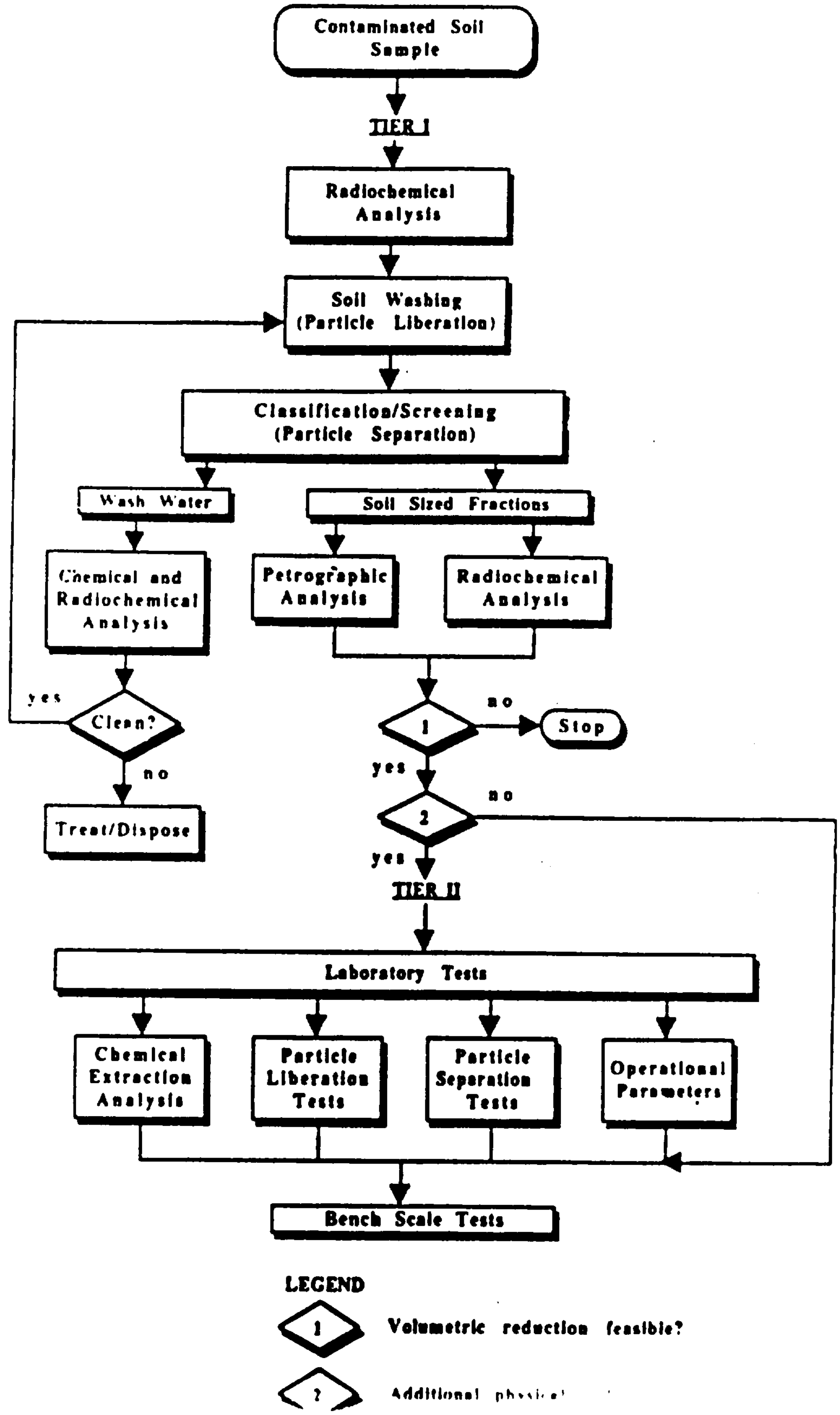
Tier I begins with radioanalysis of the dry soil samples by high-resolution gamma spectroscopy, and if necessary, alpha and beta spectroscopy analysis (using standard leaching/digestion and chemical methods[6]) to determine the level and type of activity present in each sample.

Physical separation of the soil particles is accomplished by mixing at least 250 grams of each soil sample with water to produce a liquid-to-solid (L/S) ratio of 5/1, agitating the mixture with a vigorous motion for 30 minutes at ambient temperature, and wet screening[7] through a set of nested sieves. In some site specific cases it may be advantageous to perform a less vigorous wash because of the nature of the constituents. The standard sieves include at least mesh sizes 4 (4.75 mm), 50 (0.30 mm), 100 (0.15 mm), and 200 (0.075 mm). Each soil fraction is dried at 60°C, weighed, and analyzed for radionuclide activity. From this procedure the weight and radionuclide distribution by particle size is determined. A similar separation is also performed using hydroclassification methods. The results of these tests indicate the compatability of the soil to remediation by particle-size hydroseparation techniques.

[NOTE: All water used must be collected and analyzed since it may contain transferred radioactive contaminants, Target Analyte List metals, volatile organic solvents, and/or pesticides. The analytical results will determine if the water can be recycled, safely disposed down a drain, or if it must be treated as a hazardous waste.]

Petrographic analysis is conducted on each of the size fractions to identify the mineral/material composition and physical properties of the radioactive contaminants and host materials. Petrographic procedures[8,9,10] include the use of binocular and petrographic microscopes to provide a statistical point count of all materials larger than silt-size to 0.038 mm (400 mesh size), and x-ray diffraction analysis of fines less than 0.038 mm size. Density separations are made on sand and silt size fractions (0.30 to 0.045 mm) to concentrate heavy particles greater than 3.0 specific gravity using sodium polytungstate as the separating liquid. The heavy fractions, in many cases, provide focus on radioactive particles which tend to concentrate in minerals or anthropogenic radioactive materials of the heavy fractions. The degree of weathering, presence of coatings ...

Figure 1: Soil Characterization Flow Chart



hardness, magnetism, and degree of aggregation or homogeneous nature are also physical properties examined for interpretations that relate to adsorption, waste form, and potential physical separation methods.

Tier I Report

Tier I tests results are gained from the petrographic and radiochemical analysis of the size fractions, as depicted in Figure I, to assess the feasibility of using volume reduction as a remediation technology. The test results include a grain size distribution curve of weight percent versus particle size, graphic data on activity level versus particle size, and tables and graphs on complete physical and mineralogic descriptions. This data is instrumental to the interpretation of the radioactive contaminants concentration in specific size ranges and the physical similarity and difference of the contaminants in relation to host materials.

It is assumed that the petrography and radiochemistry will be performed by personnel who are qualified by education and experience to employ the methodology specified and that recommendations for additional tests to validate key parameters for future tests will be incorporated in the report, e.g., recommend analysis of diagnostic elements that constitute chemical signatures to radioactive compounds. Radiochemical data should also be correlated with mineralogic data for interpretations, e.g., secular equilibrium of radionuclides to validate natural radioactive mineral assemblages reported or in the event of non-secular equilibrium of radionuclides, to reflect on anthropogenically enhanced radioactive waste forms in the radioactive soil. Any historic data on the ore minerals used and chemical processes used to convert the radionuclides to anthropogenic compounds should also be reported for the forensic data it might provide to support the list of radioactive compounds reported in the Tier I testing.

The Tier I report will provide an assessment of the technical feasibility of using one or more of the volume reduction technologies. Based on the feasibility of the most promising alternative, the Tier I report will also provide recommendations on further testing (Tier II) focusing on the validation of key factors that affect volume reduction. On the other hand, an evaluation of the test data could lead to the preliminary conclusion that volume reduction is not technically feasible.

Tier II

If the Tier I test data indicates the soil is satisfactory for remediation consideration Tier II testing is conducted. Tier II tests are designed to collect additional data for further characterization of contaminated soils. For example, additional soil fractions may be tested to focus on the mineral phase of opaque constituents, particle coatings, or special materials requiring more precise instrumentation for validation of particles than was made available for Tier I tests. Additional tests may also be necessary to provide optimum soil separation sizes. These tests can be performed with small soil volumes. The results are to be used to plan bench-scale tests that are designed to take advantage of unique physical and chemical characteristics of radioactive contaminants and host soil constituents. Tier II tests to be considered are in support of one of the following general categories of treatment technologies:

- Particle separation,
- Particle liberation, and
- Chemical extraction.

Particle separation is the separation of a mixture of various particles into two or more portions. For example, magnetic separation separates a mixture of soil particles based on the difference in magnetic susceptibilities.

Particle liberation is the physical de-bonding of contaminated particles or coatings from clean particles. For example, attrition removes friable coatings from soil particles.

When performing chemical extraction, the soil is immersed in a solvent that has been carefully chosen to preferentially extract the contaminant.

Selected chemical extraction tests may be performed in Tier II (as shown in Figure 1) to determine the potential for remediation by simple chemical extraction. Chemical extraction tests are designed to remove contaminants from selected particle-size fractions or from whole soil if it proves to be unsuitable for remediation by physical separation techniques. For example, the latter possibility exists for soils with uniform radionuclide distribution among the various particle sizes.

The chemical extraction tests are conducted on 100 gram samples of selected soil fractions or whole soil. On a sample in which the nature of the contaminant is poorly known, extractions are performed at 90°C with water and each of four extracting reagents known to be effective in removing various radionuclides from contaminated soils. These reagents include dilute solutions of hydrochloric acid, nitric acid, sodium chloride with hydrochloric acid, and sodium hexametaphosphate. With foreknowledge of the presence of a contaminant in a particular mineral form, one or two other select extracting reagents specific for the mineral are also included in these preliminary tests. The results of these tests provide information about the potential of chemical extraction as a complement or alternative to remediation.

Along with Tier I results, data from the Tier II tests can be used to select bench-scale test equipment for conducting remediation tests of contaminated soils. The initiation of bench-scale testing is based on the preliminary information provided by soil characterization which assesses the differences in physical properties between the waste form and host materials. For example, for physical volume reduction the applicable information relating to the differences in the waste form from the host material may be classified as follows:

- Relationship of radioactivity to particle sizes.
- Relationship of radioactivity to particle densities.
- Relationship of radioactivity to particle wettabilities.
- Relationship of radioactivity to particle shapes.
- Relationship of radioactivity to particle magnetic properties.
- Relationship of radioactivity to friability of particles or of particle coatings.
- Solubility of contaminants.

The most important information is the relationship of radioactivity to particle sizes. The information on the other physical properties such as density is obtained by identifying the waste form and host matrix using petrographic techniques. It is important to develop this petrographic information for various ranges of particle size. And, based on a careful analysis of this information, a preliminary bench-scale test can be designed using batch applications of physical methods if a difference in the physical properties stated exists between the radioactive contamination and the host materials.

Tier II Report

The Tier II report consists of the test data generated in the categories depicted in Figure I. In most cases, except for the chemical extraction tests, the Tier I recommendations provided focus on amplification of specific objectives that appear in tables and graphs in the report. Tier II tests results, just like Tier I tests results, are evaluated to assess the feasibility of using volume reduction, and if so, to what degree. The evaluation has focus on the physical differences previously cited between the waste form and host materials for design of bench-scale tests that will provide more realistic quantification of degree of separation possible by volume reduction equipment. The nature of the site specific soil drives the testing performed so that, while no standard format is presented, it is assumed that the test objectives will be governed by qualified personnel skilled in the state of the art of quality benefication testing. The report data can thus generate preliminary cost and time assessments that relate to the feasibility of volume reduction for the particular site.

SUMMARY

The characterization protocol described above for radioactive contaminated soils depends mainly upon the physical, chemical, and mineralogical characteristics of the soil and radioactive particles with respect to grain size. The intent is to return the "clean" soil fractions, which can be a major portion of the soil (by volume), to the ground, preferrably on-site.

Supplemental information concerning this protocol may be obtained from James Neiheisel or Mike Eagle at (202) 260-9630, ANR 461, U.S. Environmental Protection Agency, 401 M Street SW, Washington, D.C. 20460.

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13C 1

ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

January 27, 1993

Mr. Chad Glen, Project Manager
U.S. Nuclear Regulatory Commission
Decommissioning and Regulatory Issues Branch
Division of Low-Level Waste Management and Decommissioning
11555 Rockville Pike
Rockville, MD 20852

SUBJECT: JUSTIFICATION OF THE CALIBRATION FACTOR USED FOR BOREHOLE MEASUREMENTS OF UNDERGROUND RADIATION EXPOSURE RATES AND AVERAGE ^{232}TH CONCENTRATION AND RESPONSE TO NRC COMMENTS DATED OCTOBER 29, 1992, RADIATION SURVEILLANCE ASSOCIATES, INC. DECEMBER 30, 1992.

Dear Mr. Glen:

ESSAP has reviewed the subject document and offers the attached comments for your consideration. Contact me at (615) 576-2908 if you have any questions regarding this information.

Sincerely,

Michele R. Landis
Project Manager
Environmental Survey and
Site Assessment Program

MRL:kew

Attachment

cc: D. Tiktinsky, NRC/6E6
T. Mo, NRC/6H3
J. Hickey, NRC/6H3
J Swift/F. Brown, NRC/6H3
NRC/PMDA, 6E6
J. Berger, ORISE/ESSAP
File/212

Major Concerns

In general, the subject document was difficult to review in the absence of specific guidelines, their application and the objective for collecting this data.

Essentially, Figure 10 on Page 23 indicates that no correlation exists between measured concentrations of Th-233 (pCi/g) and downhole gamma exposure rate (μR/hr) for concentrations of Th-232 less than 50 pCi/g. This lack of correlation is attributed by the authors to the fact that "the soil volume sampled was very small compared to the volume of the region sampled by the NaI gamma probe." Given this information, an alternative method should have been utilized for validation of this methodology. Some techniques, which could be utilized, might include probe collimation, larger sample volumes, sample homogenization, and analysis by gamma spectrometry, rather than alpha spectroscopy.

Additional Concerns

Use of the factor given by Beck (1972) for converting gamma exposure rate at 1 meter to the average concentration in surrounding surface soil, which is applicable to distributed sources (page 2, paragraph 2), may not be appropriate for determining subsurface concentrations, especially "...since pieces of slag are probably not uniformly distributed." How then is the in-situ measurement procedure going to account for varying distances between the slag and detector; is an average or worst case distance going to be assumed? The correction factor was adjusted for 4π geometry, but this conversion, when going from a measurement in air at 1 meter from a slab geometry, to a measurement at contact in a borehole is questionable.

The more typical approach has been to "calibrate" probes at facilities with sources designed for this purpose. These facilities have concrete cylinders which contain known concentrations of radioactive material. Conversion factors are generated in units of cpm/pCi/g. An alternative would be to "calibrate" on-site by comparing total thorium concentrations and the associated gamma radiation levels measured at the points of sampling. This approach, if utilized, should account for the fact that the density (over 7 gm/cm³) and elemental composition of the slag is quite different from that of air or soil. The effects of these parameters on photon transmission and spectral changes should be considered. These would appear to be very critical issues because of the energy dependent response of NaI detectors. Also, would the detectors's effective "viewing distance" be a 1 foot radius in media with a significantly higher density than soil?

The evaluation of background is very unique. Background exposure rates are not usually corrected for the contribution from cosmic radiation. Incidentally, the June 1985 ORAU background data referred to were obtained with a Pressurized Ionization Chamber (PIC) and the on-site measurements were performed with a NaI instrument, cross-calibrated at the site against a PIC; cosmic radiation contributions should, therefore, be accounted for in the earlier ORAU data. However, for concentrations of Th-232 at which procedures of this type are useful, background is negligible. Additional information which should be included is a description of the instrumentation and the procedures describing its use and an estimate of the sensitivity.

The advantage stated on page 22, fifth paragraph, of integrating over a larger volume is not true, if a more precise correlation between gamma level and average thorium content cannot be developed. Also, the usefulness of results "directly interpretable in terms of ability to produce external exposure," is dependent on the application for which the data are developed. For example, if the data are collected to perform an analysis of multiple exposure pathways, the more useful unit is pCi/g.

With regard to the applicability of this procedure and its consistency with NUREG/CR 5849, it is our understanding that this logging procedure has been designed with site characterization in mind. NUREG/CR 5849 is intended specifically for final status surveys; the needs for these two types of surveys and ultimate data uses are different and consistency with NUREG/CR 5849 is thus not actually an issue at this point. If there is any intent to use the borehole logging data for final status evaluation, however, it should be noted that the proposed borehole spacing of 6.5 m on a square grid does not satisfy the recommendations of systematic soil sampling (5 m [illegible] on a square grid) or identification of "hot-spots" (5 m triangular grid) [illegible] to the capabilities of the instrumentation and technique, there is not adequate information provided to evaluate the detection sensitivity under the various situations anticipated, and thus review the use of the in-situ measurements to complement or replace sampling.

13D

Enclosure #2

SPECIFIC TECHNICAL COMMENTS

Page No.	Paragraph	Line	Issue
6	2nd	1	The SCP should include a "Legal Land Description" of the site.
13	2nd	1	In using the MILDOS code to evaluate dose from airborne exposure, the SCP should indicate what values will be used for the "Dust Mass Loading Factor" and should present or describe plans to collect adequate wind and population data.
13	1st	12	Molycorp should use the sensitivity analysis the RESRAD code to assess effects of uncertainties estimates of certain parameters on projected doses.
14	4th	12	The SCP should also include soil ingestion as one of the potential exposure pathways, or justify why exposure from this pathway is highly unlikely.
18	3rd	8	If Molycorp is considering onsite stabilization/disposal of large volumes of contaminated material, above the 1981 BTP Option 1 levels, the SCP should describe what additional characterization will be performed to evaluate suitability of the site if such an alternative is selected.
21	3rd	4	The SCP indicated that various other materials are present in layers between 0 and 10-12 feet thick. The SCP should elaborate on the characteristics of these materials or describe plans to characterize them.
25	1st	7	The SCP indicates that the cinder and slag deposit will have a major influence on the overall conductivity of the aquifer. Molycorp should explain how this observation or phenomenon will affect selection of groundwater modeling codes and input parameters for such codes.

26	1st & 2nd	2 & 5	The soil and vadose zone characterizations did not include determinations of the distribution coefficients (K_d's) for each radionuclide using non-contaminated local soil. These parameters may be needed to assess transport properties of local soil if significant quantities of radionuclides, above the 1981 BTP Option 1 levels, will remain after remediation.
27	1st	4	The SCP should indicate whether fracture-flow codes are necessary for simulation of groundwater flow conditions, and if so, which codes will be used.
32	1st	2	The SCP should provide data on the mineralogical, chemical and radiological characteristics of the ore imported from Araxa, Brazil.
2	4th	2	The SCP indicates that chemical analysis will be performed on a sample of FeCb slag. Will this sample represent the chemical composition of the bulk slag? Is the slag chemically, physically and radiologically homogeneous? Molycorp will need to justify the number of samples and frequency of sampling considering the NRC guidance document NUREG/CR-5849.
3	5th	2 & 3	The SCP indicates that slag sampling will comprise six samples: three samples to be collected from the slag pile, two samples from the crushed slag which was pumped to a settling basin, and one slag sample from an undefined area at the site. The issue of sampling representation needs to be addressed in this regard. As a minimum, approximately 30 samples from each type of slag should be collected and analyzed.
5	3rd	1-15	The licensee indicated that leachability studies will be conducted on slag samples. The number of samples was not identified. The applicant stated that one of the methods to be adopted for determination of leachability is EPA's Toxicity Characteristics Leaching Procedure (TCLP) test. Molycorp did not indicate in the SCP any plans to determine the host soil distribution coefficient for thorium. Molycorp should provide the specific number of leachability tests to be conducted and the basis for selecting such a number. The applicant should use ANSI ANS [illegible]

			leachability test in addition to EPA's TCLP test. Molycorp should also determine the distribution coefficient of the host soil for thorium and decay products, and other possible radionuclides that may be present in the soil (e.g., ^{238}U and decay products).
18	2nd	1-9	The SCP indicates that the external gamma survey will be useful in quantifying concentrations of thorium within a radius of 10 meters of the measurements. This has not been demonstrated. The applicant needs to consider all comments discussed above associated with this issue.
8	2	4-9	Based on the 1981 BTP, Option 1 soil concentrations are sufficiently low so that no individual will receive a direct exposure rate in excess of 10 μR/h above background. Therefore, 10 μR/h should be used in place of 14 μR/h for 5pCi/g of ^{232}Th (in equilibrium with its daughters). Also, the NRC meaning of background radiation includes radiation from cosmic sources and naturally occurring radioactive materials.
3	4	1-4	In conducting the surface survey in unaffected areas, it is not clear why readings will not be recorded below 20 μR/h. Readings should be documented in all areas surveyed.
	2nd	1-4	Molycorp is planning to collect 200 soil samples from the cores and is planning to conduct ^{232}Th analysis by ICP. Molycorp should describe its sampling procedures to ensure that samples are representative and collected using appropriate methods.
	3rd	1-10	The SCP states that 21 wells have been drilled from which groundwater samples can be and have been taken. The licensee needs to explain and illustrate the following: i) locations of these wells, ii) hydraulic gradient based on water level measurements, iii) construction of the wells and their ability to yield water levels and samples that are representative of in-situ conditions, and iv) techniques used to analyze water samples and results of such analyses.

57	2nd	1-10	Appendix A of the SCP describes an approach for selecting input data for leach rate and distribution coefficients. This approach is not acceptable because it relies on the leach rate of the slag in a bulk form. If significant quantities of radionuclides above the 1981 BTP Option 1 levels will remain after remediation, the licensee needs to also assess the leach rate for the finely ground slag which would have a much larger surface area and could be expected to exhibit increased leachability.
57	3rd	1-3	The applicant stated that default values are presented in Appendix E. There is no such appendix attached to the SCP document. The default values should be incorporated in the SCP.
igure 5-2			Add building numbers to figure.