ENERCON SERVICES, INC.

Decommissioning Summary Report

Specialty Metals Plant
Westinghouse Electric Company
Blairsville
Pennsylvania

Project No. WESTBLV001

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EXECUTIVE SUMMARY

ENERCON Services Inc. (ENERCON) was retained by Westinghouse Electric Company (Westinghouse) to prepare a Decommissioning Summary Report for the Westinghouse Specialty Metals Plant (WSMP) located in Derry Township, Westmoreland County, Pennsylvania near the community of Blairsville (Cummings/Riter 1995a, Figure 1). The site is located on approximately 485 acres along Township Road 966, which terminates at WSMP. Major manufacturing buildings at the facility include the Main Building, Westro Building, Zircaloy Building, and the Die Shop. Areas of radiological interest on the site grounds include the Former Zircaloy Burn Area (FZBA), the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound and the Quarry Area.

This report compiles and summarizes the investigations, remedial actions, and final status survey activities that have been conducted since 1993 to address radiological concerns in the site buildings and on the site grounds. In doing so, this report demonstrates that WSMP now satisfies United States Nuclear Regulatory Commission (NRC) guidelines for release of formerly licensed sites to unrestricted use in accordance with the provisions of 10 CFR 20 Subpart E.

This report has been prepared for electronic submittal to the NRC. The body of the report includes five main sections. Section 1 is the report introduction, which provides historical background information, identifies the objectives and scope of the report, and outlines the report organization. Section 2 summarizes decommissioning activities conducted on the site grounds. Through incorporation of attached documents related to site grounds, Section 2 provides justification for release of the site grounds for unrestricted use. Section 3 summarizes decommissioning activities conducted on or inside the site buildings. Through incorporation of attached documents related to site buildings, Section 3 provides justification for release of the site buildings for unrestricted use. Section 4 summarizes waste shipment and disposal. Conclusions regarding the radiological status of the WSMP are summarized in Section 5. Appendices provide supporting documentation. Appendix A provides photographs of the Quarry Area for reference. Appendix B includes waste manifests that document proper disposal of waste material from areas of radiological concern. Appendix C provides photographs of the FZBA for reference. Appendices D, E, F and G provide information associated with the RESRAD dose analysis conducted for the FZBA, and Appendices H, I, and J provide information associated with the RESRAD-Build Dose Analysis conducted for the Main Building (Building 1). Finally, the attachments are electronic copies of various reports that document the radiological status of the WSMP.

BACKGROUND

The WSMP was founded in 1955 as a research and development (R&D) and manufacturing facility for Westinghouse. During the period from approximately 1955 to 1961, fuel manufacturing operations were conducted at the WSMP using enriched uranium in both metal and oxide forms. Atomic Energy Commission (AEC) Licenses SNM-37 and SUC-509 authorized commercial and naval fuel manufacturing and R&D utilizing low-enriched, high-enriched, and depleted uranium. These licenses were terminated on July 1, 1961 and December 31, 1964, respectively. The facility currently manufactures zircaloy tubing, and radioactive materials are no longer used.

As part of the NRC program to ensure that AEC and NRC licenses that have been terminated meet the NRC's criteria for release for unrestricted use, additional review of the site was required. The available license documentation did not provide sufficient information to define the radiological status of the site at the time of license termination. In addition, no records were found to document the radiological status of the buildings following termination of that work in the 1960s.

As a result of reviews of terminated license files conducted by the Oak Ridge National Laboratory, the WSMP site was identified as having inadequate documentation to define the radiological status of the site. In February 1994, Westinghouse voluntarily committed to the NRC to conduct a detailed radiological survey of the site and to conduct remediation as necessary in order to assure the site meets the applicable criteria for unrestricted use. This report summarizes decommissioning activities that have been conducted to fulfill this commitment.

SITE GROUNDS

Westinghouse conducted numerous decommissioning activities associated with site grounds since 1994 including site characterization, remediation and final status surveys. The focus of the early radiological investigations was broad so that the entire site was considered. Subsequent investigations were more narrowly focused to consider only the areas of radiological interest, and remediation activities were ultimately performed in limited areas of the site.

Early investigations identified the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound, the Quarry Area and the FZBA as areas of radiological interest. Each of these areas was systematically evaluated. The Northeast Fill Area, the Former Pond Area, and the Casting Sand Mound were eliminated as areas of radiological concern after it was demonstrated that radiation in these areas was within the normal variation of background for the type of material encountered. Only the Quarry Area and the FZBA were ultimately identified as requiring remediation of licensed material to meet unrestricted release criteria.

Quarry Area

According to long term Westinghouse employees, the Quarry Area was used in the 1950's and 1960's to burn zirconium fines. Based on this anecdotal information and visual evidence of discarded drums, Westinghouse conducted investigations and remediation activities in the area in the 1996/1997 timeframe. The initial scoping surveys confirmed that radiation levels in the Quarry Area exceeded background radiation levels. Elevated areas were associated with ash possibly from the FZBA.

Several options were considered for remediation of the Quarry Area, including the use of heavy excavation equipment (i.e. backhoes, loaders, etc.) However, soil cover was very thin (0-6 inches) rendering conventional excavation equipment ineffective. The combustible nature of the zirconium fines was also considered in the selection of an appropriate remediation option. Considering the environmental setting, Westinghouse elected to use a vacuum truck to remove the thin veneer of contaminated soil and zirconium fines from the area. The soil and zirconium fines that were vacuumed from the area were placed in 55-gallon drums or 1-cubic yard supersacks, and shipped to the Envirocare Facility in Clive, Utah.

A final gamma survey consisting of discrete measurements on a square grid was conducted in the Quarry Area to demonstrate that the release criteria had been achieved. Prior to conducting the final survey for the Quarry area, a reference grid system with 4-meter spacing was established to facilitate systematic selection of measurement locations. Sampling was not required since soil in the area had been completely removed and the remaining surface consisted of solid rock. These measurements were taken using a portable Exploranium GR-256 Spectrometer with a 3-inch NaI detector to identify locations of elevated activity.

Extensive remediation work was performed in the Quarry Area as demonstrated by photographs included in Attachment A. In addition, the PADEP performed confirmatory surveys and the NRC was apprised of remediation and survey activities as the work proceeded. Although Westinghouse has not retained data from the final gamma walkover, the area is considered suitable for unrestricted release based on the final condition of the area, which is basically devoid of all soil cover.

Former Zircaloy Burn Area

In conjunction with the fuel fabrication work in the Main Building, a separate building was used for various waste treatment and packaging operations. These operations consisted of an evaporator for liquids, an incinerator, and solid waste packaging and storage in preparation for shipment. This building was located south of the Main Building until its removal was completed in the 1990s. The area encompassing the location of this former building is now referred to as either the "Former Zircaloy Burn Area" (FZBA) or the "Cow Palace Area", related to activities that subsequently took place in this building and the surrounding area (manufacturing of cow magnets and burning of waste zirconium).

Preliminary radiological investigations were conducted in the FZBA from 1994 through 1996. In general, these efforts identified a few surface contamination areas but did not identify significant contamination. With this understanding, Westinghouse decided to perform a risk analysis to determine if remedial actions were necessary in the FZBA. As an outcome of this process, a decision was made to remove an underground terra-cotta line that was known to traverse the area. Excavation activities associated with removal of this terra-cotta line lead to identification of subsurface contamination.

Additional sampling and radiological surveying was conducted in 1998 to better delineate the extent of radiological contamination. During this investigation, it was determined that portions of the structure of the building that once occupied the FZBA had been buried in the FZBA. With a better understanding of the potential extent of the contamination, removal of the terra-cotta drain and associated sumps was completed along with removal of surrounding soil. Pipe remediation lead to discovery of a leach field, which was investigated and determined to be non-radiological. In the same timeframe, building rubble excavation was conducted.

During the building excavation activities, an ash layer was discovered. This layer was approximately 0.25 inch thick and was located approximately 2 to 2.5 feet below the ground surface. Investigation of the ash layer ensued. The ash layer led to the former lagoon that had been previously identified. It was also found that the ash contained various uranium enrichments. Additionally, a PVC line that led to the former lagoon was discovered during excavation activities. Subsequent investigation of the former lagoon identified isolated pockets of enriched uranium well above background amongst the debris that had been deposited in the former lagoon.

Other areas of potential radiological contamination were also identified at this time in the vicinity of the FZBA. Considering the uncertain extent and nature of the contamination, additional investigations were conducted to better understand these issues. The results of these additional investigations are summarized in Cummings/Riter, 1999. This report better defined the extent and area of the contamination and provided a volume estimate of contaminated soil.

With this information in hand, Westinghouse retained B. Koh and Associates, Inc. to conduct a Feasibility Analysis (B. Koh, 1999), and develop a site remediation plan (B. Koh, 2000). It was determined that the final release survey would be combined with remedial activities in a two step approach. Step one would involve establishing a 10 m x 10 m grid over the FZBA, and conducting final status survey activities. In step two, grids that exceeded NRC release criteria would be evaluated to determine compliance with weighted average limits as permitted by NUREG/CR-5849, or additional excavation would be conducted and the grid resurveyed. The results presented in the Final Status Survey Report (B. Koh, 2001b) demonstrate that the residual uranium concentration at the site is less than 30 pCi/g, and the site therefore is in compliance with the guidelines of the 1981 Branch Technical Position for unrestricted use of the site.

The finding that the area is suitable for unrestricted release has been substantiated by performing a dose analysis using the RESRAD computer code and comparing the results with NRC release criteria of 25 mrem per year. Two exposure scenarios were modeled. The residential gardener scenario results in a peak mean annual total effective dose equivalent (TEDE) of approximately 0.029 mrem/year, which is well below the 25 mrem/year unrestricted release criteria. The industrial worker scenario results in a TEDE of approximately of 0.0009 mrem/year, which is much lower than the dose resulting from the resident gardener scenario.

On the basis of the Final Status Survey (FSS) performed by B. Koh and Associates and the dose modeling performed by ENERCON, the FZBA is considered suitable for release for unrestricted use in accordance with the provisions of 10 CFR 20 Subpart E.

SITE BUILDINGS

Westinghouse conducted radiological investigations and decommissioning activities in certain WSMP Buildings from 1994 to 2000 to address legacy issues associated with past manufacturing processes. The multi-building complex includes four principle buildings. Those are the Main Building, the Westro Building, the Zircaloy Building, and the Die Shop, referred to as Buildings 1, 2, 3, and 4, respectively

Only Building 1 (Main Building) and a portion of Building 4 historically included operations that involved uranium. Buildings 2 and 3 were constructed after uranium operations ceased. However, a small area in Building 3 was used for storage of waste containers during the site remediation efforts. As such, Buildings 2 and 3 and portions of Building 4 are considered background areas. While Final Status Survey (FSS) activities were conducted in each of the buildings, remediation activities were only required in Building 1.

Pipe Removal and Subfloor Soil Remediation in Building 1

An investigation was conducted to locate all of the potentially contaminated underground piping and associated sumps within Building 1. Remediation of the underground piping and sumps occurred over an extended period due to the necessity to coordinate with the operational needs of the facility. As an area became available for remediation work, the piping and sumps were removed. Each excavation was then surveyed using instrumentation such as NaI detectors and soil samples were taken. Backfilling of the excavations usually occurred soon afterwards without waiting for analytical results, due to the need to return each area to operational use. In general, the gamma surveys were sufficient to identify potential problems. However in a few cases, the final analytical results exceeded the release criteria of 30 pCi/g of total uranium (or the operational equivalent of 1 pCi/g of U-235). Overall the surface area represented by excavations represented a small fraction of the total area beneath the plant floor.

Survey Unit I-39 represented a substantially different situation than the reminder of the plant. This area apparently housed a hot rolling mill on which depleted uranium metal fuel elements were manufactured. Rather than underground piping, this area was found to be a series of trenches and pits associated with the hot rolling mill. No drawings were available to indicate the original construction so the remediation effort consisted of excavating down to the various surfaces. This resulted in essentially exposing the entire original structure, which was subsequently filled in and covered over.

Report #008 compiles interior soil data related to the removal of the underground pipes and sumps within Building 1. As indicated in Report #008, all known underground piping and structures that were associated with the original process operations have been removed. Based on the analytical results for the soil samples (taken as closeout samples prior to closure of the excavation), the subsurface soil meets the criteria for unrestricted release. Although a few sections show elevated results, these areas are small relative to the entire plant and are now covered by the restored concrete floor. The eventual demolition of the building would be expected to result in substantial mixing of the subsurface soil such that the small areas of elevated activity could not result in any substantial risk to individuals.

Buildings 1 and 4 Roofs

Report #004 compiles information on the roof surveys performed on Buildings 1 and 4 at the Blairsville site. Only the roofs of Buildings 1 and 4 were included in the roof survey because only Building 1 and Survey Unit 4-18-1 of Building 4 existed during the period of use of licensed materials. Included in Report #004 are the survey data sheets with the conversion of the results into units comparable with the acceptance criteria, statistical analysis of the survey data in order to determine if the radiological acceptance criteria have been met at the desired degree of confidence, a compiled statistics table, and data trend visualization plots. Based on the radiological surveys of the roofs for Buildings 1 and 4, these roofs meet all applicable criteria for release for unrestricted use.

Building Surfaces

Report #006 provides an overall summary of the building remediation project and final survey. Other Reports have been prepared that provide specific information in detail. References are made throughout Report #006 to provide a roadmap to all relevant information. Where appropriate, sufficient information is included in Report #006 to provide a document that presents a complete overview of the final status of the site buildings. The individual reports referenced in Report #006 provide the detailed documentation necessary to justify the information contained therein.

Report #006 provides the general information relative to the final radiological surveys of buildings. Refer to that report for the following information:

- Site Description
- Radiological Acceptance Criteria
- Survey Classification System
- Classification of Building Area
- Selection of Survey Instruments and Instrument Characterization
- System for Identification of Survey Point Locations
- Statistical Analysis of Survey Results
- Survey Protocol

Report #007 provides complete information on the results of the radiological surveys of the interior of the building surfaces, including a table of compiled statistics to demonstrate compliance with the acceptance criteria. In addition, Report #002 provides data on the floor scans conducted within the buildings, and Report #003 contains survey diagrams and the original survey data sheets containing the actual measured results.

The information presented in Report #006 and the accompanying reports demonstrates that the current condition of the buildings on the Blairsville site meet all of the radiological acceptance criteria at the desired degree of confidence and are therefore acceptable for unrestricted use.

The finding that the building surfaces are suitable for unrestricted release has been substantiated by performing a dose analysis using the RESRAD-Build computer code and comparing the results with NRC release criteria of 25mrem per year. Three exposure scenarios were modeled. The industrial worker scenario results in the highest estimated peak receptor dose**.** The peak receptor dose due to unit activity for the industrial worker scenario is approximately 0.00042 mrem at time 0. Considering a conservatively high estimate of average total uranium activity of 235 dpm/100 cm^2 for all surfaces in the room with the highest levels of residual radioactivity, the estimated peak receptor dose would be 0.1 mrem/year, which is well below the 25 mrem/year unrestricted release criteria.

On the basis of the Final Status Survey (FSS) activities described in Westinghouse Reports 001 through 008 and the dose modeling performed by ENERCON, the site buildings are considered suitable for release for unrestricted use in accordance with the provisions of 10 CFR 20 Subpart E.

CONCLUSIONS

In 1994, Westinghouse began a process of conducting detailed radiological surveys of the site and conducting remediation as necessary in order to assure the site meets the applicable criteria for unrestricted use. The focus of the early radiological investigations was broad so that the entire site was considered. Subsequent investigations were more narrowly focused to consider only the areas of radiological interest, and remediation activities were ultimately performed in limited areas of the site grounds and site buildings. Groundwater sampling indicated the presence of only naturally occurring radionuclides.

Early investigations of the site grounds identified the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound, the Quarry Area and the FZBA as areas of radiological interest. Each of these areas was systematically evaluated, and only the Quarry Area and the FZBA were ultimately identified as requiring remediation to meet unrestricted release criteria. The Quarry Area was thoroughly vacuumed leaving the area nearly devoid of soil material and zirconium fines. Final gamma walkovers confirmed that the Quarry Area achieved unrestricted release criteria. Extensive remediation activities were also conducted in the FZBA after it was determined that concentrations of uranium in soil exceeded unrestricted release criteria. In this case contaminated soil and demolition debris was excavated from the area and disposed off-site at appropriately licensed facilities. The final status survey documented in B. Koh, 2001b confirms that the FZBA met unrestricted release criteria. RESRAD modeling conducted by ENERCON confirmed that the annual dose expected for a member of the public is well below the release criteria of 25 mrem per year. On the basis of these findings, the site grounds at the WSMP are considered suitable for release for unrestricted use.

Investigation and remediation of the site buildings has also been thoroughly documented. Areas of radiological concern in the site buildings included piping and associated soils underneath Building 1, Roof areas on Buildings 1 and 4, and building surfaces in Building 1. Each of these areas was thoroughly investigated and the final radiological status of each has been well documented demonstrating that these areas meet the criteria for unrestricted release that had been established for the site. RESRAD modeling conducted by ENERCON confirmed that the annual dose expected for a member of the public is well below the release criteria of 25 mrem per year. On the basis of these findings the site buildings at the WSMP are also considered suitable for release for unrestricted use.

1.0 Introduction

ENERCON Services Inc. (ENERCON) was retained by Westinghouse Electric Company (Westinghouse) to prepare a Decommissioning Summary Report for the Westinghouse Specialty Metals Plant (WSMP) located in Derry Township, Westmoreland County, Pennsylvania near the community of Blairsville (Cummings/Riter 1995a, Figure 1). The site is located on approximately 485 acres along Township Road 966, which terminates at WSMP. Major manufacturing buildings at the facility include the Main Building, Westro Building, Zircaloy Building, and the Die Shop. Areas of radiological interest on the site grounds include the Former Zircaloy Burn Area (FZBA), the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound and the Quarry Area.

This report compiles and summarizes the investigations, remedial actions, and final status survey activities that have been conducted since 1993 to address radiological concerns in the site buildings and on the site grounds. In doing so, this report demonstrates that WSMP now satisfies United States Nuclear Regulatory Commission (NRC) guidelines for release of formerly licensed sites to unrestricted use.

1.1 Site History

The WSMP was founded in 1955 as a research and development (R&D) and manufacturing facility for Westinghouse. During the period from approximately 1955 to 1961, fuel manufacturing operations were conducted at the WSMP using enriched uranium in both metal and oxide forms. Atomic Energy Commission (AEC) Licenses SNM-37 and SUC-509 authorized commercial and naval fuel manufacturing and R&D utilizing low-enriched, high-enriched, and depleted uranium. These licenses were terminated on July 1, 1961 and December 31, 1964, respectively. The facility currently manufactures zircaloy tubing, and radioactive materials are no longer used.

As part of the NRC program to ensure that AEC and NRC licenses that have been terminated meet the NRC's criteria for release for unrestricted use, additional review of the site was required. The available license documentation did not provide sufficient information to define the radiological status at the site at the time of license termination. In addition, no records were found to document the radiological status of the buildings following termination of that work in the 1960s.

As a result of reviews of terminated license files conducted by the Oak Ridge National Laboratory, the WSMP site was identified as having inadequate documentation to define the radiological status of the site. In February 1994, Westinghouse voluntarily committed to the NRC to conduct a detailed radiological survey of the site and to conduct remediation as necessary in order to assure the site meets the applicable criteria for unrestricted use.

1.2 Current Manufacturing Operations

Westinghouse began manufacturing Zircaloy tubing at WSMP in 1967. The site historically manufactured two lines of nuclear grade tubing; stream generator tubing and fuel clad tubing. The plant currently manufactures only fuel clad tubing. The manufacturing process involves pilgering of tube reduced extrusions, pickling/annealing between each pilger pass, finishing of the pilgered tubes, product inspection, and laboratory testing.

1.3 Objectives and Scope of this Report

This report summarizes decommissioning activities that have been conducted to fulfill the commitment made in 1994 by Westinghouse to conduct a detailed radiological survey of the site and to conduct remediation as necessary in order to assure the site meets the applicable criteria for unrestricted use. The operational criteria for unrestricted use that governed site investigation and remediation activities are summarized in Table 1-1. These criteria are consistent with the Site Decommissioning Management Plan (SDMP) Action Plan criteria.

Table 1-1. Operational Unrestricted Release Criteria

	Levels	Measurement		Limit	Units
I	Acceptable Surface Contamination Levels[2]	Total Surface Contamination	Average Value	5,000	DPM/100 cm^2
			Maximum Value	15,000	DPM/100 cm^2
		Removable Surface Contamination		1,000	DPM/100 cm^2
II	Acceptable Soil Contamination Levels	All Uranium Isotopes[3]		30	pCi/g
		U-235 Isotope[1]		1	pCi/g
III	Gamma Dose Rate	Dose Rate measured at 1 meter above the surface		5	μR/hr above natural background

1. The working limit for U-235 is based on the ratio of uranium to U-235 being 30.
2. Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors", U.S. Nuclear Regulatory Commission, June 1974.
3. 1981 Branch Technical Position. "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations". U.S. Nuclear Regulatory Commission, October 23, 1981.

1.4 Organization of this Report

This report has been prepared for electronic submittal to the NRC. The body of the report includes five main sections. Section 1 is the report introduction, which provides historical background information, identifies the objectives and scope of the report, and outlines the report organization. Section 2 summarizes decommissioning activities conducted on the site grounds. Through incorporation of attached documents related to site grounds, Section 2 provides justification for release of the site grounds for unrestricted use. Section 3 summarizes decommissioning activities conducted on or inside the site buildings. Through incorporation of attached documents related to site buildings, Section 3 provides justification for release of the site buildings for unrestricted use. Section 4 summarizes waste transportation and disposal. Conclusions regarding the radiological status of the WSMP are summarized in Section 5. Appendices provide supporting documentation. Appendix A provides photographs of the Quarry Area for reference. Appendix B includes waste manifests that document proper disposal of waste material from areas of radiological concern. Appendix C provides photographs of the FZBA for reference. Appendices D, E, F and G provide information associated with the RESRAD dose analysis conducted for the FZBA, and Appendices H, I, and J provide information associated with the RESRAD-Build Dose Analysis conducted for the Main Building (Building 1). Finally, the attachments are electronic copies of various reports that document the radiological status of the WSMP. With the exception of Attachment No.7, these attachments were previously submitted to the NRC for information to document progress made.

2.0 Site Grounds

Westinghouse conducted numerous decommissioning activities associated with site grounds since 1994 including site characterization, remediation and final status surveys. The focus of the early radiological investigations was broad so that the entire site was considered. Subsequent investigations were more narrowly focused to consider only the areas of radiological interest, and remediation activities were ultimately performed in limited areas of the site.

Early investigations identified the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound, the Quarry Area and the FZBA as areas of radiological interest. Each of these areas was systematically evaluated, and only the Quarry Area and the FZBA were ultimately identified as requiring remediation of licensed material to meet unrestricted release criteria. The reports described in the following section document the radiological status of the site grounds since decommissioning activities were initiated in 1994. The reports are included as attachments and are referenced throughout this report.

2.1 Documents Related to Site Grounds

2.1.1 Cummings/Riter Consultants, Inc., 1995a, "Data Summary Report, Site Investigation, Westinghouse Electric Corporation, Specialty Metals Plant, Blairsville, Pennsylvania"

This document (Cummings/Riter, 1995a) summarizes the results of a Phase I site investigation performed at the WSMP site. The investigation involved review of historical aerial photographs, field reconnaissance, review of published geologic literature, drilling soil/weathered bedrock borings, shallow monitoring well installation and a sampling and analysis program for soil, groundwater, surface water and sediment.

2.1.2 Cummings/Riter Consultants, Inc., 1995b "Data Summary Report, Phase II Investigation, Westinghouse Electric Corporation, Specialty Metals Plant, Blairsville, Pennsylvania"

This document (Cummings/Riter, 1995b) presents the results of a Phase II site investigation conducted at the WSMP. Specifically, the investigation involved review of published geologic literature, surficial and subsurface soil sampling, abandonment of former groundwater supply wells, monitoring well installation, shallow groundwater pump testing, borehole geophysical logging, a sampling and analysis program for soil and groundwater, and evaluation of the on-site pond levels and site groundwater levels.

This document presents the results of further radiological investigation activities conducted in the following areas:

- The FZBA
- Monitored waste line to evaporator
- Fill area northeast of facility
- Fill area (casting sand) north of visitors parking lot

2.1.3 Cummings/Riter Consultants, Inc., 1996, "Addendum, Data Summary Report, Phase II Investigation, Westinghouse Electric Corporation, Specialty Metals Plant, Blairsville, Pennsylvania"

This document (Cummings/Riter, 1996) summarizes the results of the Phase II groundwater assessment and the former lagoon area assessment performed at the WSMP Site.

2.1.4 Cummings/Riter Consultants, Inc., 1999, "Data Summary Report, Radiological Testing, Former Zircaloy Burn Area, Westinghouse Electric Company, Specialty Metals Plant, Blairsville, Pennsylvania"

This document (Cummings/Riter, 1999) presents the results of a soil sampling program conducted in November 1998 by Cummings/Riter at the WSMP Site. This document includes procedures for the collection and characterization of soil cores, handwritten copies of the soil sample description logs, chain-of-custody forms, a soil boring location map, and a fence diagram of the FZBA. A summary of the physical and radiological characteristics of the area based on the soil-coring program is also provided. In addition, the results of soil sampling and radiological testing performed by Westinghouse at the FZBA is included.

2.1.5 B. Koh & Associates, Inc., 1999, "Feasibility Analysis of Uranium Impacted Soil, Westinghouse Electric Company, Specialty Metals Plant, Blairsville, Pennsylvania"

This document (B. Koh, 1999) evaluates the feasible options for remediating uranium impacted soils at the WSMP. This feasibility analysis evaluated the following remedial options:

- In-Situ Characterization
- Ex-Situ Characterization
- Site Specific Dose Analysis
- Physical Separation – Soil Processing
- Onsite Disposal

This report recommended off-site disposal of contaminated soil.

2.1.6 B. Koh & Associates, Inc., 2000, "Site Remediation Plan for the Former Zircaloy Burn Area, Specialty Metals Plant, Westinghouse Electric Company, Blairsville, Pennsylvania"

This document (B. Koh, 2000) presents the remediation plan for the FZBA. The selected remediation alternative for the FZBA consisted of excavating soils containing concentrations of uranium that exceeded the performance objectives. Concrete and other construction debris type material associated with the FZBA were to be remediated to the levels specified in "Guidance for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for Byproduct, Source, or Special Nuclear Materials" (NRC, August 1987).

2.1.7 B. Koh & Associates, Inc., 2001a, "Addendum, Site Remediation Plan for the Former Zircaloy Burn Area, Westinghouse Specialty Metals Plant Site, Blairsville, Pennsylvania"

This document (B. Koh, 2001a) summarizes the results of soil sampling and analysis that was conducted in accordance with the "site remediation Plan for the Former Ziraloy Burn Area) (B. Koh, 2000). This addendum describes the sampling and analysis that were undertaken at the site and identifies the specific quadrants that exceeded the guideline value for residual uranium.

2.1.8 B. Koh & Associates, Inc., 2001b, "DRAFT Final Status Survey Report, Former Zircaloy Burn Area, Westinghouse Specialty Metals Plant, Blairsville, Pennsylvania"

This document (B. Koh, 2001b) is the Final Status Survey Report for the FZBA. This report describes potential contaminants and release guidelines, decommissioning activities, and the final status survey process. This document provides a demonstration that criteria for unrestricted release of the FZBA have been achieved. Although identified as a draft report, the technical content of the report accurately presents the results of the Final Status Survey for the FZBA.

2.2 General Site Grounds Investigations

Several site investigations were conducted to evaluate site grounds at the WSMP site. The focus of the early radiological investigations was broad so that the entire site was considered. Subsequent investigations were more narrowly focused to consider only the areas of radiological interest. This section describes the broadly focused investigations that were conducted to evaluate the site grounds. The following sections provide more detail regarding specific areas of radiological interest and provide a final status determinations for each.

2.2.1 Phase I Site Investigation, 1994

The comprehensive investigation of site grounds began in 1994 when Cummings/Riter conducted a site investigation to evaluate the nature and extent of compounds of interest in soil in the vicinity of potential source areas, shallow groundwater, surface water and sediment (Cummings/Riter, 1995a). The compounds of interest included radiological and non-radiological parameters. This investigation also included an evaluation of the shallow hydrogeologic regime at the WSMP Site. The investigative tasks performed during this investigation included the following:

- Sump/basin reconnaissance
- Historical aerial photograph review
- Field reconnaissance
- Shallow groundwater, soil, surface water and streambed sediment sampling and analysis

Along with gaining an understanding of the shallow hydrogeologic regime at the site, the following findings were notable with respect to radiological status of the site:

- Slightly elevated (20 percent above background) field radiological readings were reported in two areas north of the railroad tracks; one in a shallow depression or impoundment, the other along a path leading to a natural gas well location.

- Field radiological readings twice background were detected in a field to the west of the north end of the Westro Building, primarily 150 to 200 feet west of the building. This area is commonly referred to as the "Former Pond Area".

- Field radiological readings 10 to 15 times background were reported in a mound adjacent to the main guard station, north of the visitors parking lot. This area is commonly referred to as the "Sand Mound Area".

- Soil radiochemistry results for the surface and near-surface samples collected in the FZBA indicated that some soil exceeded the release criteria of 30 pCi/g for uranium in soil. This area was noted as requiring additional delineation.

- Soil radiochemistry results for the soil boring samples collected in the fill area northeast of the facility indicated radiological results that exceeded background. This area, commonly referred to as the "Northeast Fill Area", was also noted as requiring additional delineation.

- Groundwater sampled from shallow site monitoring wells exceeded the Pennsylvania Maximum Contaminant Levels (MCLs) for pH, total iron, total manganese and gross alpha for both the upgradient and downgradient monitoring wells, indicating these levels represent background groundwater quality.

Considering the findings of this investigation, Westinghouse narrowed the focus of future radiological investigations of the site grounds to the two slightly elevated areas north of the railroad tracks, the Former Pond Area, the Sand Mound Area, the FZBA, and the Northeast Fill Area.

2.2.2 Phase II Site Investigation, 1995

The radiological evaluation of the site grounds continued in 1995 with a Phase II Site investigation conducted by Cummings/Riter (Cummings/Riter, 1995b). This investigation was designed to further evaluate the nature and extent of the contaminants of interest in shallow and deep groundwater and to further investigate the compounds of interest (COI) in soils in the two slightly elevated areas north of the railroad tracks; the Former Pond Area; the Sand Mound Area; the FZBA; and the Northeast Fill Area. In addition, the shallow and deep hydrogeologic regime and the surface water/groundwater relationship at the site were investigated.

The following findings of the Phase II investigation were notable with respect to the radiological status of the site:

- Radiological surveys of the two slightly elevated areas north of the railroad tracks established that the above background radiation readings were due to variations in naturally occurring radioactive materials.

- Radiological surveys of the Former Pond Area established that the above background radiation readings were due to variations in naturally occurring radioactive materials.

- Various surveys (radiological, trenching, and magnetometer) of the FZBA identified subsurface anomalies. Near surface deposits of various rubble were found, some of which exhibited above background radiological readings. There were indications of the possible presence of subsurface metals unrelated to known site features.

- Radiological analysis of soil samples taken from the Northeast Fill Area combined with borehole logging results and downhole NaI Spectral results, indicated variations in radiation levels due to naturally occurring radioactive materials. Soil sample S-5 from Borehole B-48 and the associated borehole logging at a depth of about 8 to 11 feet below ground surface identified the presence of a deposit of sand which exhibited radiation levels that indicate the probable presence of naturally occurring uranium and thorium.

Based upon the findings of the Phase II Investigation, subsequent radiological investigations of the site grounds were intended to focus on the FZBA. However, another area of radiological interest became apparent some time in 1996 through observations of discarded 55–gallon drums and subsequent discussions with former and current employees. This area is located adjacent to the south side of the Northeast Fill Area. This area is commonly referred to as the Quarry Area based upon its historic use as a sandstone quarry for a local bridge project. All other land areas at the site were eliminated as areas of radiological concern, and subsequent radiological investigations and remediation activities were focused on the FZBA and the Quarry Area.

2.3 Northeast Fill Area

2.3.1 Phase I Site Investigation

Cummings/Riter performed a Phase I Site Investigation of soils, sediments, groundwater, and surface water at the site in October and November 1994 (Cummings/Riter, 1995a). During this investigation, a fill area was identified northeast of the WSMP and adjacent to Township Road 966. This area is known as the Northeast Fill Area. The fill area was created by disposal along a steep slope adjacent to the Conemaugh River. For this investigation, three soil borings identified as B-39, B-40, and B-41 were advanced through the fill material and into the underlying soil. A fourth boring was also advanced in the vicinity for installation of Monitoring Well MW-5A. However, the soil and upper weathered bedrock in the vicinity of the fill area were dry, and the shallow monitoring well was not installed.

Seven soil samples were collected from these borings and tested for radiological parameters. In addition, two samples were subject to more detailed radiological analysis. These additional samples were selected based on screening results conducted by Westinghouse for samples collected from the soil borings. Radiochemistry results for the selected subsurface soil samples indicated the presence of total uranium exceeding background concentrations.

2.3.2 Phase II Site Investigation

Cummings/Riter performed a Phase II Site Investigation of soils and groundwater at the site from August through October 1995 (Cummings/Riter, 1995b). One objective of the Phase II investigation was to further evaluate soils in the Northeast Fill Area. The investigative tasks included subsurface soil (fill) sampling and analysis and borehole geophysics.

Five soil borings identified as B-45 through B-49 were advanced in the former disposal area. Ten soil samples were collected from these borings and tested for radiological parameters. Additional samples were subject to more detailed radiological analysis. These additional samples were selected based on screening results conducted by Westinghouse for samples collected from the soil borings. Radiochemistry results for the selected subsurface soil samples exhibited normal variations in background levels of naturally occurring radioactive materials with one exception. Sample S-5 in Boring B-48 shows evidence of elevated radiation readings due to the presence of sands containing higher levels of natural uranium and thorium. This is consistent with the findings observed for such sandy material in the Sand Mound area. This material is apparently discarded casting sand from casting operations previously conducted at the facility.

In addition, a borehole geophysical survey was performed during the investigation in boreholes B-45 through B-49. This survey also indicated normally expected variations in radiation levels. The most significant anomaly in the borehole logging results also corresponds to the level at which Sample S-5 was taken in Boring B-48.

2.3.3 Final Status Determination for the Northeast Fill Area

Radiological analysis of soil samples taken from the Northeast Fill Area combined with borehole logging results and downhole NaI Spectral results, indicate variations in radiation levels were due to naturally occurring radioactive materials. No further investigative work was conducted in the Northeast Fill Area. This area is considered suitable for unrestricted release.

2.4 Former Pond Area

2.4.1 Phase I Site Investigation

The Former Pond Area was identified as an area of interest during a review of historical aerial photographs conducted as part of the Phase I Site Investigation (Cummings/Riter, 1995a). In this Phase I Report, the former pond area was described as a field to the west of the north end of the Westro Building approximately 150 to 200 feet west of the building. Radiological field monitoring conducted at ground level identified radiological levels that were twice background. This area was further investigated in the Phase II Investigation.

2.4.2 Phase II Site Investigation

One objective of the Phase II investigation (Cummings/Riter, 1995b) was to further evaluate the nature and extent of COI in the Former Pond Area. Surface soil samples were collected from a section of the field west of the Westro Building by Cummings/Riter personnel for radiological testing by Westinghouse. The sample locations were identified in the field based on the results of radiological field screening during Phase I by Westinghouse. Samples were then collected from each location on an 8-meter grid system.

The surficial soil samples were radiologically screened by counting the sample in a shielded cave using the Model GR-256 NaI gamma spectrum counting instrument. Based on these screening data, representative samples were taken for further radiochemistry analysis by the Radiochemistry Laboratory at the Westinghouse Waltz Mill Facility. These results indicate that for the Former Pond Area, the samples analyzed exhibit normal variations in background levels of naturally occurring radioactive materials. The ground surveys using the Model GR-256 NaI gamma spectrum instrument did not show any anomalous results in the Former Pond Area.

2.4.3 Final Status Determination for the Former Pond Area

Based on survey activities conducted during the Phase II investigation, no further investigative work was conducted in the Former Pond Area. This area is considered suitable for unrestricted release.

2.5 Casting Sand Mound

2.5.1 Phase I Site Investigation

The Sand Mound Area was identified from aerial photographs during the Phase I Site Investigation (Cummings/Riter, 1995a). The sand mound is a linear fill area (sand mound) that was identified northeast of the Main Building Shop Area and immediately north of an asphalt parking lot. This area consists of a slight mound with evidence of stressed vegetation. During initial field screening, radiological readings were 10 to 15 times background within the established grid area

In the Phase I Investigation, a 25-foot sampling grid was established over the fill area. Surficial soil samples were collected from 22 locations established by the grid. Two soil borings (B-42 and B-43) were also advanced in this area during the investigation. In addition, a more detailed gamma spectrum survey was conducted on two-meter grid spacing. This survey was conducted using the model GR-256 gamma spectrometer with an NaI detector. The area covered by this survey was larger than that covered by the 25-foot grid soil sampling.

2.5.2 Final Status Determination for the Casting Sand Mound

No further investigative work was conducted in the Former Pond Area. The sandy material was determined to be non-licensed material. This area is considered suitable for unrestricted release.

2.6 Quarry Area

2.6.1 Description of Decommissioning Activities

Information concerning past activities in the Quarry Area was obtained through interviews with long term Westinghouse employees. According to these sources, the Quarry Area was used in the 1950's/1960's to burn zirconium fines. Based on this anecdotal information and visual evidence of discarded drums, Westinghouse conducted investigation and remediation activities in the area in the 1996/1997 timeframe. Photographs of the Quarry Area are presented in Appendix A for reference.

At the time of the initial investigation, the area was overgrown with trees and shrubs and littered with remnants of several 55-gallon drums and other debris (See Photographs 1 through 12). The initial scoping surveys confirmed that radiation levels in small areas within the quarry area exceeded background radiation levels (See Photograph 13). Elevated areas were apparently associated with ash that might have come from the FZBA.

Several options were considered for remediation of the Quarry Area, including the use of heavy excavation equipment (i.e. backhoes, loaders, etc.) However, soil cover was very thin in the Quarry Area (0-6 inches) rendering conventional excavation equipment ineffective. In addition, zirconium, when finely divided, can ignite with minimal friction. The combustible nature of the zirconium fines was also considered in the selection of an appropriate remediation option.

Considering the environmental setting, Westinghouse elected to use a vacuum truck to remove the thin veneer of contaminated soil and zirconium fines from the area. To mitigate the potential for auto-ignition during remediation activities, care was taken to remove a mixture of soil and zirconium fines during the vacuuming process rather than pure zirconium. Vacuumed material was taken to an asphalt-lined stockpile area for staging. A tarp was placed on stockpiled material to mitigate drying and dusting. (See Photographs 14 through 33.)

Staged material was then taken into a temporary building for packaging (See Photograph 14). In the temporary building, waste material was mixed in a batch mixer to meet "fissile exempt" homogeneity requirements. Soil Moist® was then added to the soil in the batch mixer to reduce the potential for drying and potential combustion during shipment. Soil Moist® is an environmentally safe synthetic super-absorbent copolymer. When mixed in soil, the granules soften and swell as water is absorbed. When the soil dries, the stored water is released back to the soil. After mixing, the homogenized mixture was placed in 55-gallon drums or 1-cubic yard supersacks. Drums/supersacks were stored temporarily in an on site building prior to shipment to the Envirocare Facility in Clive, Utah. Waste manifests that include shipments from the Quarry Area are included in Appendix B.

2.6.2 Final Status Determination for the Quarry Area

A final gamma survey was conducted in the Quarry Area to demonstrate that the release criteria had been achieved. Prior to conducting the final survey for the Quarry area, a reference grid system with 4-meter spacing was established to facilitate systematic selection of measurement locations. Gamma measurements were then taken using a portable Exploranium GR-256 Spectrometer with a 3-inch NaI detector to identify locations of elevated activity. Soil sampling was not required since soil in the area had been completely removed and the remaining surface consisted of solid rock.

Extensive remediation work was performed in the Quarry Area as demonstrated by the attached photographs (See Photographs 34 through 43). In addition, the PADEP performed confirmatory surveys and the NRC was apprised of remediation and survey activities as the work proceeded. Although Westinghouse has not retained data from the final gamma walkover, the Quarry Area is considered suitable for unrestricted release.

2.7 Former Zircaloy Burn Area

2.7.1 Overview

In conjunction with the fuel fabrication work in the Main Building, a separate building was used for various waste treatment and packaging operations. These operations consisted of an evaporator for liquids, an incinerator, and solid waste packaging and storage in preparation for shipment. This building was located south of the Main Building until its removal was completed in the 1990s. The area encompassing the location of this former building is now referred to as either the "Former Zircaloy Burn Area" (FZBA) or the "Cow Palace Area", related to activities that subsequently took place in this building and the surrounding area (manufacturing of cow magnets and burning of waste zirconium).

Preliminary radiological investigations were conducted in the FZBA from 1994 through 1996 (Cummings/Riter, 1995a, Cummings/Riter, 1995b, and Cummings/Riter, 1996). In general, these efforts identified a few surface contamination areas but did not identify significant contamination. With this understanding, Westinghouse decided to perform a risk analysis to determine if remedial actions were necessary in the FZBA. As an outcome of this process, a decision was made to relocate an underground terra-cotta line that was known to traverse the area. Excavation activities associated with relocation of this terra-cotta line lead to identification of subsurface contamination.

Additional sampling and radiological surveying was conducted in 1998 to better delineate the extent of radiological contamination. During this investigation, it was determined that portions of the structure of the building that once occupied the FZBA had been buried in the FZBA. With a better understanding of the potential extent of the contamination, removal of the terra-cotta drain and associated sumps was completed along with removal of surrounding soil. Pipe remediation lead to discovery of a leach field, which was investigated and determined to be non-radiological. In the same timeframe, building rubble excavation was conducted.

During the building excavation activities, an ash layer was discovered. This layer was approximately 0.25 inch thick and was located approximately 2 to 2.5 feet below the ground surface. Investigation of the ash layer ensued. The ash layer led to the previously identified former lagoon. It was also found that the ash contained various uranium enrichments. Additionally, a PVC line that led to the former lagoon was discovered during excavation activities. Subsequent investigation of the former lagoon identified isolated pockets of enriched uranium well above background amongst the debris that had been deposited in the former lagoon.

Other areas of potential radiological concern were also identified at this time. These included a former treeline area north of the FZBA and an area west of the former building that had not been thoroughly investigated. Considering the uncertain extent and nature of the contamination, additional investigations were conducted to better understand these issues. The results of these additional investigations are summarized in Cummings/Riter, 1999. This report better defined the extent and area of the contamination and provided a volume estimate of contaminated soil.

With this information in hand, Westinghouse retained B. Koh and Associates, Inc. to conduct a Feasibility Analysis (B. Koh, 1999), and develop a site remediation plan (B. Koh, 2000). It was determined that the final release survey would be combined with remedial activities in a streamlined, two step approach. Step one would involve establishing a 10 m x 10 m grid over the FZBA and conducting final status survey activities. In step two, grids that exceeded NRC release criteria would be evaluated to determine compliance with weighted average limits as permitted by NUREG/CR-5849, or additional excavation would be conducted and the grid resurveyed. The results presented in the Final Status Survey Report (B. Koh, 2001b) demonstrate that the residual uranium concentration at the site is less than 30 pCi/g, and the site therefore is in compliance with the guidelines of the 1981 Branch Technical Position for unrestricted use of the site.

Details regarding the investigations, remediation activities, and final status surveys that took place in the FZBA are presented in the following sections, and photographs of the FZBA are provided in Appendix C for reference. In addition, the finding that the area is suitable for unrestricted release has been substantiated by performing a dose analysis using the RESRAD computer code and comparing the results with the NRC release criteria of 25 mrem per year. The FZBA dose assessment is detailed in Section 2.8.

2.7.2 Preliminary Investigations

2.7.2.1 Phase I Site Investigation, 1994

Cummings/Riter Consultants, Inc. performed a Phase I site investigation of soils, sediments, groundwater, and surface water at the site in October and November 1994 (Cummings/Riter, 1995a). Included in this investigation were ten subsurface borings in the vicinity of the FZBA, with twelve soil samples from these borings analyzed for radiological parameters. In addition, 234 discrete surface soil samples were collected from a 25-foot grid established in the same area for initial screening using a gamma survey instrument. Seventeen of these surface soil samples were then submitted for analysis of specific radioisotopes. Radiochemistry results for selected surface and subsurface soil samples indicated the presence of total uranium at concentrations in excess of 30 picoCuries per gram (pCi/g). Such results were indicative of uranium in excess of natural background.

2.7.2.2 Phase II Investigation, 1995

Cummings/Riter performed a Phase II investigation of soils and groundwater at the site from August through October 1995 (Cummings/Riter, 1995b). As part of this investigation, 28 surface soil samples were collected from a 25-foot grid established immediately east of the Phase I sampling grid at the FZBA. Samples were screened using a gamma survey instrument. A magnetometer survey was also performed in these areas, as well as additional surface scanning using a gamma survey instrument in areas that had been identified as exhibiting radiological activity above background. After an initial surface remediation effort established that impacts were present at greater depths, a series of test trenches were excavated in the area to a depth of up to two meters. Upon completion of each trench, the exposed soils were scanned using a gamma survey instrument, and samples were collected from the trenches at five meter intervals for subsequent radiological analysis. The results of the various surveys performed as part of the Phase II investigation (radiological, trenching, and magnetometer) indicated the presence of uranium in excess of natural background in the FZBA, with total localized uranium concentrations exceeding 30 pCi/g in surface and subsurface materials.

2.7.2.3 Addendum – Phase II Investigation, 1996

Cummings/Riter performed an additional Phase II characterization of site soils and groundwater in April, September, and October 1996 (Cummings/Riter, 1996). The additional work included an assessment of a former lagoon reported to be adjacent to the existing sludge drying beds. As part of this work, electromagnetic geophysical surveys and trenching were performed in order to locate and characterize the former lagoon, and two soil samples were collected from the trenches for radiological analysis. Small quantities of processed uranium were identified with some of the debris encountered in the former lagoon, but general levels of radioactivity were consistent with normal background.

2.7.2.4 Discussion of 1994-1996 Characterization Activities

Extensive surface and subsurface investigations were conducted in the FZBA prior to initiating remediation activities (Cummings/Riter, 1995a, Cummings/Riter, 1995b, Cummings/Riter, 1996). A few surface contamination areas were identified and remediated as a result of those investigations. Also exploratory trenches were dug to investigate the subsurface features. In general, those investigations did not identify significant contamination. However, one item of interest in the FZBA was a buried terra-cotta pipeline, which is identified on the diagram "Area 4 Test Trenches" in Appendix B of Cummings/Riter, 1995b. A decision was made to relocate the terra-cotta line and remove it during the summer of 1998, coincident with the removal of a remaining underground line in the Finishing Area of the Main Building. The relocation and removal of the terra-cotta line led to the identification of additional contamination.

A complicating factor in early characterization efforts was the lack of understanding that the FZBA had been covered some time in the past with a layer of fill soil. It was hypothesized that the fill layer may have been constructed with material excavated from the on-site pond located to the southwest of the FZBA. These cut and fill activities could have occurred during several pond expansion projects that occurred over the years. The fill layer covered the original topography of the FZBA and was estimated to be a minimum of 2 feet thick.

2.7.3 Initial Findings Beneath Building Footprint

During the site characterization and investigation that occurred in the 1995/1996 time frame, a buried pipe segment, of what has since been found to be a 70 foot section of terra-cotta piping, was located under the surface of the FZBA. The pipe is now believed to have been connected to the floor drain system of the former building structure. At the time of the pipe's discovery, it was confirmed that the pipe contents were contaminated with materials characteristic of enriched uranium. It was determined that the line would need to be removed in the future. No other information or evidence of other materials buried beneath the surface was evident at the time of the initial investigation. Furthermore, site history and knowledge of the former process and use of the drain line as well as the disposition of the former building structure was never fully detailed.

Remediation of the drain line began in early June 1998 with the relocation of the pipe segment. At the time, the drain line was the only identified subsurface feature. However, prior to the excavation activity, drawings were identified that showed the presence of two sumps that had been connected to the drain line. The approximate locations of the sumps were identified and a search for the sumps was performed coincident with the removal of the terra cotta line. When the line was uncovered only about half of the line remained intact with the other half having been dispersed throughout the immediate area as evidenced by broken sections of terra cotta piping and pipe contents (sludge).

There were also indications that leakage had occurred from the pipe joints, and radiological contamination had leached into the soil. Excavation and removal of the affected soil was required. During this phase of the remediation, large sections of concrete were uncovered suggesting that much of the former building structure had been buried within the footprint of the former building and in the area immediately east of the former building.

As pipe removal activities proceeded, radiological contamination was found to be more wide spread than originally believed. During the initial site investigation in 1995, both shallow and deep samples were collected from the FZBA, without any indication of contamination. The shallow soil samples were collected from a depth of 0 to 6 inches and 6 to 12 inches and the deep soil samples collected down to bedrock. It was discovered in June 1998 that the shallow soil that had been collected represented clean fill material placed on top of the original soil following the final excavation and burial of the former building structure. It was estimated that a clean fill layer 18 to 24 inches thick was placed over the original surface.

The sumps were located and excavated. Upon access to the sump interiors, it was noted that equipment and other related debris had been placed inside of the sumps prior to closure. Many of these materials were radiologically contaminated. In addition, significant volumes of soil and concrete were found inside the sumps. All contaminated equipment was removed and packaged accordingly for ultimate disposal as radiological waste.

Based on observations during sump excavation and radiological screening of debris, concrete and other assorted materials contained within the sump, it was determined that the footprint of the former building should be investigated in greater detail. During this investigation, it was confirmed that the primary building structures, such as the floor and portions of the wall, had been buried in the area.

2.7.4 Remediation Actions in Building Area

Remediation activities conducted in specific areas of the FZBA are described separately below. The locations of these features are provided in Cummings/Riter, 1999, Appendix A, Figure A-1.

2.7.4.1 Drain Pipe Excavation

The entire length of the remaining terra-cotta pipeline was exposed for excavation. Approximately half of the line was found in place. The other half (the shallow end) had apparently been dispersed during the removal of the building foundation since fragments of the terra-cotta pipe material were found throughout the area as the excavation proceeded. The portion of the line that remained in place was severely fractured and was essentially plugged with contaminated sediment. There were also indications of soil contamination beneath the pipeline. Since a red dye had been used in the ceramic magnet manufacturing process housed in the building during its later use, the red coloring of the soil also provided a visual indication of leakage from the pipe. The terra-cotta pipeline and all surrounding contaminated material was removed based on visual indications and radiological field measurements. Soil samples were taken along the length of the pipeline for analysis by gamma spectrometry. Additional soil was removed until the samples indicated that the remaining surface area would meet the release criteria for uranium contamination.

2.7.4.2 Removal of Sumps

Two buried sumps were located at the northern end of the terra-cotta pipeline. The terra-cotta pipeline apparently ended in one sump. The other sump had a line leading to it but the feed and use of this sump is not clear. Both sumps had been demolished to a level below grade and then backfilled with debris. Some of the sump contents included contaminated fragments of process equipment. The sumps were emptied of their contents and the remaining concrete sumps were removed from the ground. The contamination in the vicinity of the sumps was removed from the ground. The contamination in the vicinity of the sumps was removed based on both visual indications and radiological field measurements. Soil samples were taken in the sump excavations for analysis by gamma spectrometry. Additional soil was removed until the samples indicated that the sump excavation surface would meet the release criteria for uranium contamination.

2.7.4.3 Identification of Leach Field System

During the remediation of the pipeline and sumps, a piece of heavy equipment broke through into a buried concrete pit covered with a concrete lid. Subsequent excavation of the area identified the initial pit, a concrete distribution box, and a system of three parallel pipelines. These components were identified as a leach field system that was not identified on the available WSMP drawings. The piping system consisted of short lengths of terra-cotta pipe that were laid end-to-end in a gravel layer. There was no connection between the pipe ends so leakage would occur at each location where the pipes were butted together.

There was no odor associated with the system and no sludge in the concrete pit, both of which indicate that the system had not been used for sanitary waste disposal. Samples taken along the three pipelines did not indicate the presence of radiological contamination. Based on the sampling information, the location of the ends of the pipelines and the concrete pit were documented and the area was backfilled using the excavated soil. This action was taken to provide additional area in which to maneuver equipment and stockpile soil.

2.7.4.4 Separation of Building Rubble

Along with the excavations discussed above for the terra-cotta pipelines and the sumps, the entire area beneath and immediately east of the former building was excavated to remove building rubble. It appeared that the plant floor and subsurface foundation were disposed of in an excavation in front of the former building. In order to assess the condition of the building rubble, all such material was segregated in a separate pile. Smaller items found to be contaminated were immediately packaged for disposal. The resulting pile of building rubble was then surveyed for radiological contamination and the small fraction of pieces that exceeded the release criteria for surface contamination were set aside for eventual disposal in a licensed burial facility. Most of rubble met the free release criteria, and was transported to a permitted landfill for disposal as industrial waste.

2.7.4.5 Formation and Evaluation of "Clean" Soil Pile

After separation of the building rubble, the remaining material excavated from the footprint of the former building and surrounding area consisted of about 43,000 cubic feet of soil. In order to evaluate the radiological condition of this soil in a meaningful manner, it was spread into a layer about 4 feet thick.

As an initial evaluation of the spread material, a gamma survey was conducted on an established grid pattern. This data was compiled and entered into a computer graphics program (Surfer) to plot the data in both 3-D and contour plots to help visualize the information. The data and the computer-generated plots are included in Cummings/Riter, 1999, Attachment A-1. The conclusion from that evaluation was that the soil appeared to be relatively uniform in radiation level. Soil samples from the spread material were then collected on a predetermined pattern. The evaluation (sampling, analysis and conclusions) of this "clean" soil pile is found in Cummings/Riter, 1999, Attachment A-2.

2.7.5 Identification of Ash Layer

During excavation to remove building debris and rubble from the vicinity of the former building, a well defined layer of dark ash-like material was observed that also contained materials similar to zirconium turnings and chips. Upon further observation many of the zirconium pieces appeared to be heat affected, as if they were residual materials from an incomplete burning process. A radiological field survey of the ash layer indicated the likely presence of radiological contamination. The layer was found at a depth of approximately 2 to 2.5 feet below the ground surface and was approximately 0.25 inch thick. The layer was first located along the southeast end of the former building footprint excavation and bordering the roadway leading to the pond. Investigation indicated that the layer was present, parallel to the roadway and it appeared to continue east below the surface of the existing access road. Discovery of this ash layer indicated a need for further investigation, including radiological surveys and collection of samples for gamma spectrometry analysis to identify the extent and nature of the radiological contamination.

Further investigation of the extent of the ash layer entailed excavation of shallow, narrow trenches. The depths of these trenches were limited such that once the potentially contaminated layer of ash was identified, either visually or via field survey instrumentation, no further vertical investigation was conducted. This series of trenches provided evidence of the ash layer under the roadway as well as on the eastern side of the road leading toward a former lagoon. The ash layer in this area varied from 0.5 to 1 inches thick and was located at a depth of approximately 8 to 12 inches. In general, whenever ash material was encountered it also contained the zirconium turnings/chips. The locations of the excavated trenches dug for this portion of the investigation are indicated in Cummings Riter, 1999, Appendix A, Figure A-1.

During the trenching operation along the eastern side of the roadway, field instrumentation indicated what appeared to be an area of elevated radiological contamination. Further investigation identified what appeared to be a fuel pellet of a size consistent with commercial product. This was uncovered approximately 6 to 12 inches below the surface. The soil in the immediate area also indicated elevated radiological levels above background. The pellet and soil samples from the vicinity of its discovery were taken to the Antech Laboratory, in Madison, PA for gamma spectrometry analysis.

Gamma spectrometry analysis of ash material, soil and the pellet indicated the presence of a variety of uranium enrichments. Ash and soil samples showed contamination due to depleted uranium, low, and moderately enriched uranium. The pellet discovered to the east of the road was depleted uranium.

Based on analytical and field survey data, and visual observations from the shallow trenching investigations, it was determined that the ash layer was not uniformly dispersed throughout the area, rather it appears to be distributed in a spotty, haphazard manner. Additional subsurface investigations were needed to delineate the vertical and horizontal extent of contamination. At this time Cummings/Riter was retained to provide assistance in the development of the protocol and methodologies for a detailed evaluation of the area.

2.7.6 Identification of Former Lagoon

A former lagoon had been previously identified and evaluated in Section 5.4 of Cummings/Riter, 1996. During that investigation three trenches were excavated in the area of the approximate location of the lagoon, as based on review of historical aerial photographs. Two samples were taken of soil material associated with some metal debris found during the trenching. The isotopic composition of these samples was consistent with the processed uranium that would have been used in the fuel fabrication work. The amount of contaminated material was very small and unlikely to be representative of the average concentration in the soil. Based on these results, it did not appear that further investigation was warranted.

During the excavation of the area under the footprint of the former building, a black PVC line was uncovered that led from the building towards the area of the former lagoon. This line was investigated by excavating a trench along its length until the line terminated at the apparent southwest corner of the former lagoon. Based on the physical information, a portion of the former lagoon was found to be located further north than had been originally thought.

To further evaluate the lagoon area, excavation was initiated at the southwest corner where the PVC line terminated. More detailed review of the historical aerial photograph indicated that this corner was indeed where the water effluent entered the lagoon. The initial excavation did not indicate the presence of radiological contamination, but it did indicate that the lagoon had been filled with rubble. When some of the concrete slabs were overturned for removal, several isolated pockets of radioactivity well above background were identified. These locations were gray in color and included some zirconium metal turnings and chips. A sample of this material was collected and sent to the laboratory for gamma spectrometry analysis.

The analytical results indicated that the soil was contaminated with uranium and that the isotopic composition was highly enriched uranium consistent with material that would have been used in the fabrication of Navy fuel design.

2.7.7 Other Areas

2.7.7.1 Tree Line Along Parking Lot

Two parallel rows of pine trees that border the paved parking lot are located directly north of the FZBA. Since several of the trees were located such that they would interfere with additional trench investigations, these trees were removed. Tree ring counting of the trunks indicated that the trees were about 25 years old, which would mean that they were planted around 1973. Zircaloy turnings and chips were found under the root ball of the overturned tree stumps indicating that such materials had been scattered in this area prior to the planting of the trees. Gamma surveys conducted beneath the tree stumps did not indicate readings above expected background levels. As part of the erosion control measures associated with the excavation activities, a shallow trench was excavated around the entire excavation for the installation of a cloth mesh erosion control fence. In the area adjacent to the parking lot, the soil overturned during the shallow trenching indicated radiation levels above normal background levels. This indicated the probable presence of uranium contamination in this area that had not been fully characterized.

2.7.7.2 Areas Not Investigated

The excavated area around the former building focused primarily on the area beneath and east of the original building footprint. The area west of the building had not been thoroughly investigated because of the presence of soil piles in the area when the soil coring program was conducted. Prior to the final remediation and FSS activities, essentially no investigation had been conducted of the original ground surface beneath the soil piles.

2.7.8 Preliminary Conclusions

Based on the extent and nature of the contamination identified in the above described activities, it was decided to conduct a more extensive subsurface investigation of the area in order to quantify the extent of the contamination in terms of both area and depth. Cummings/Riter was retained to assist the investigation and prepare a report documenting the findings. Based on the coring, test trenching and other excavation activities, the following conclusions/information had been noted:

- Radiological contamination was not uniformly distributed throughout the FZBA, rather the materials were found at varying depths and areal extents.

- There were multiple sources of contamination with regard to the origin of the contamination including processed natural uranium, depleted uranium, low enriched uranium materials consistent with commercial fuel, and high enriched uranium consistent with Navy fuel. Attachments C and D of Cummings/Riter, 1999 include the log and analysis of all samples collected during the investigation/remediation and submitted for gamma spectrometry.

- In the FZBA there were other subareas that required additional characterization (surface and subsurface). These included the lay down area for the former "Clean Soil Pile", the lay down area for the former contaminated soil pile, the area to the north along the tree line adjacent to the parking lot, and possibly subsurface areas beneath the former leach bed.

2.7.9 Final Remediation Activities and FSS

Details regarding the final remediation activities and final status survey for the FZBA are presented in B. Koh, 2001b. The area was decommissioned because licensed activities ceased and company management endeavored to use the property without restrictions.

The selected remediation of the FZBA consisted of in-situ characterization/final survey in combination with excavation of soils. Soils containing concentrations of uranium that exceeded the performance objectives identified in the Branch Technical Position, "Disposal or Onsite Storage of Residual Thorium or Uranium Waste From Past Operations" SECY-81-576 ("1981 BTP") were excavated and disposed of at a licensed low-level radioactive waste facility. The final status survey was conducted in accordance with NUREG/CR-5849 "Manual for Conducting Radiological Surveys in Support of License Termination" (NUREG/CR-5849). Concrete and other construction debris type material associated with the FZBA was surveyed and evaluated to the levels specified in "Guidance for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use of Termination of License for Byproduct, Source, or Special Nuclear Materials". Site remediation activities were conducted in August 2000 and November 2001.

2.7.9.1 Site Description at the time of FSS

The remediation site occupied approximately 3 acres, south of the main manufacturing plant. It was a grass-covered field, sloping slightly from west to east. As shown in B. Koh, 2001b, Figure 1, the site had several prominent features. Excavations remained from the demolition of the FZB building and the removal of underground pipes and sumps. In addition, trenches were excavated as part of the early site characterization. There were two piles of excavated soil; one clean and the other contaminated. Also, an abandoned lagoon that contained concrete construction debris was located during the earlier site activities.

2.7.9.2 Potential Contaminants and Release Guidelines

Based on the operating history of the facility, the potential contaminant was processed uranium. Because of the variety of fuels that were processed, the enrichment of the uranium varied from depleted to fully enriched. As described in a later section, a systematic investigation of the isotopic ratios was conducted to determine actual and average enrichments.

Referring to the Branch Technical Position, several guidelines are applicable to uranium contaminants. Since only processed uranium was used at the Blairsville facility, the guideline for natural uranium was not appropriate. Since the guideline for enriched uranium is a lower concentration than that for depleted uranium, it was selected as the release criteria for the FZBA. In addition, the 1981 BTP limits the exposure an individual may receive from any residual contamination. Hence, the guidelines for unrestricted release of the FZBA were determined to be the following:

- An average soil contamination concentration of less than 30 pCi/g for total uranium,
- Soil concentration should be sufficiently low so that no individual may receive an external exposure in excess of 10 μR/hr.

At this concentration and exposure rate level, no further restrictions on land use are needed according to 1981 BTP.

2.7.9.3 Decommissioning Activities

Using an "in-situ characterization" methodology, the final release survey was combined with remedial activities in a streamlined, two-step approach. This approach was intended to ensure a timely and cost effective remediation strategy.

The following activities were conducted in Step One:

- A 10 m x 10 m grid was established on the impacted area (FZBA and surroundings) (B. Koh, 2001b, Figure 1). The affected area was divided into three sub areas as follows:
  - Sub Area A (E20 to E70) x (N0 to N80)
  - Sub Area B (E70 to E110) x (N30 to N80)

- Sub Area C (E110 to E130) x (N30 to N80)

The areas of A, B, and C were 4,000 m^2, 2,000 m^2 and 1,000 m^2, respectively, for a total of 7,000 m^2. The remainder of the site was classified as unaffected, its area being 5,100 m^2.

- A 100% walkover gamma scan utilizing a Ludlum Model 2221 coupled with a Ludlum 44-10 (2"x2" NaI) detector was conducted to identify elevated areas. The high and low readings were recorded for each 10m x 10m grid. Elevated readings were marked for further investigation.

- Consistent with NUREG/CR-5849 guidance, soil samples were obtained within each 5m x 5m quadrant of each grid of the affected area (i.e. four samples per 100m^2 grid). Samples were collected using a Geoprobe® sampler at intervals of four feet until native till was reached. Soil cores were scanned with a Ludlum Model 2221 coupled with a Ludlum Model 44-9 detector for field screening and handling purposes. The cores were divided into 2.0 to 2.5 foot sections, depending on the total depth of fill, and submitted for uranium analysis.

  Because an underground 8 inch high pressure gas pipeline was located along the western edge of the site, no samples were removed from the unaffected area designated by Grids A through J and 1 through 2.

  All soil samples were analyzed for U-238 by gamma spectroscopy. The total uranium concentration was calculated using a U-238 to total uranium conversion factor. As will be described in a later section, the conversion factor was derived from results of isotopic uranium analysis of soil containing measurable concentrations of uranium.

- Exposure rate measurements were obtained using a Ludlum Model 19 exposure rate survey meter at each soil sampling location.

  Evaluation of the surface and subsurface soil samples and exposure rate measurements were consistent with NUREG/CR-5849 methodology and the results presented in an "Addendum to the Site Remediation Plan, August 2001" (B. Koh, 2001a). Grids whose surface and subsurface uranium concentrations and exposure rate measurements were less than the cleanup criteria were deemed as meeting the NRC guidelines for unrestricted release. No additional final survey/sampling or remediation efforts were conducted at these locations.

Step Two was undertaken at those grids that exceeded the NRC release criteria as follows:

- The grid/area was excavated and the contaminated material stockpiled for disposal offsite. Soil samples were extracted from the base of the excavation and analyzed by gamma spectroscopy of U-238. The conversion to total uranium concentration was based on the factors developed during Step One, and described in a later section.

- Exposure rate measurements were made with a Ludlum Model 19 detector.

This in-situ characterization/final survey approach was used for all of the soil encompassing the FZBA, with the exception of the filled-in former lagoon, located to the east (B. Koh, 2001b, Figure 1). Since it was known that construction debris material was placed in the former lagoon as backfill, it was not possible to utilize the in-situ characterization/final survey approach completely. To supplement the in-situ characterization/final survey, an ex-situ characterization/final survey methodology was undertaken.

The soil and construction debris material was excavated from the lagoon, segregating the construction debris material and stockpiling the soil. The construction debris material was surveyed and found to be in compliance with the NRC release criteria contained in Regulatory Guide 1.86 (RG 1.86). Contaminated soil was stockpiled with the contaminated soil from the excavations. Soils with contamination less than 30 pCi/g were used as onsite backfill.

The excavated lagoon was subjected to a 100% walkover gamma scan, soil sampling consistent with NUREG/CR-5849 (i.e., four samples per 100 m^2) and exposure rate measurements obtained at each soil sample location.

In addition, one surface/subsurface sample per each 10 m x 10 m grid of the unaffected area was collected via a Geoprobe® sampler. The soil samples were collected at four foot intervals until native till was reached. The cores were scanned, handled and analyzed in a manner identical to the affected area samples. An exposure rate measurement was obtained at each soil sample location.

2.7.9.4 FZBA Final Status Survey

A final radiological survey was conducted to demonstrate that the remedial objectives for the FZBA had been achieved. The initial final radiological survey was conducted as part of the characterization to identify grids requiring excavation. Contaminated soil was excavated from the identified grids, and follow up final radiological surveys were performed of the excavated grids.

2.7.9.4.1 Surface Activity of Construction Debris Material

The specific objectives of the radiological survey of construction debris material were to demonstrate that:

1. Average surface contamination levels for each survey unit were within the acceptable release limits (RG 1.86). Averaging was based on 1 m^2 grid area direct measurements, and indirect measurements (wipes) were obtained at each grid intersection.

2. Small areas of residual activity known as "hotspots" did not exceed three times the average value. NUREG/CR-5849 allows averaging of elevated areas if the contamination levels are between one and three times the average limit and the weighted average over any contiguous 1 m^2 area is less than the average limit.

3. Reasonable efforts were made to clean up removable activity, and removable activity did not exceed 20% of the average surface activity guidelines.

2.7.9.4.2 Soil Activity

The specific objectives of the radiological survey and analysis of potentially contaminated soil were to demonstrate that:

1. Average uranium concentrations were within the release criteria. Averaging was based on 100 m^2 grid area and approximately 1 m depth (i.e., 100 m^3).

2. Small areas of residual activity known as "hotspots" did not exceed three times the average value.

3. Reasonable efforts were made to identify and remove hotspots that may have exceeded the average guideline by greater than a factor of $(100/A)^{1/2}$, where A is the area (m^2) of the hotspot.

4. Exposure rates did not exceed 10 μR/hr above background at an elevation 1m above the surface. Exposure rates may be averaged over a 100 m^2 grid area. Maximum exposure rates over any discrete area of <100 m^2 may not exceed 20 μR/hr above background.

The above conditions were to be demonstrated at the 95% confidence level for each survey unit as a whole.

The survey data was used to calculate the total inventory of residual activity from site operations.

2.7.9.4.3 Release Criteria

On the basis of the site contaminants, the release criteria were established as follows:

- The soil cleanup criterion for enriched uranium is 30 pCi/g total uranium (1981 BTP).

- The surface contamination guidelines for uranium are (RG 1.86):

  1,000 dpm alpha, beta-gamma/100cm^2, average over 1 m^2
  3,000 dpm alpha, beta-gamma/100cm^2, maximum over 100 cm^2
  200 dpm alpha, beta-gamma/100cm^2, removable

- The exposure rate guideline is:

  10 µRem/hr above background (average) at one meter from soil surfaces (if the weighted average over surrounding 100 m^2 is less than the average limit).
  20 µRem/hr above background (maximum) at one meter from soil surfaces.

2.7.9.4.4 Survey Plan and Procedures

The survey plan and procedures were as described in B. Koh, 2000, Section 4. The instruments used during the surveys are described in Table C of B. Koh, 2001b.

2.7.9.5 Survey Results and Evaluations

2.7.9.5.1 Step One Results

The soil samples were removed during August 2000. The previously used 10 m x 10 m grid, consisting of 102 grids, was reestablished on the site (B. Koh, 2001b, Figure 1). A 100% walkover survey was conducted, recording the highest and lowest reading for each grid, and marking any hotspots exceeding twice background. Sampling occurred at one location within each grid in the unaffected area and at four locations within each grid in the affected area. In the affected area, each sample location is identified as a quadrant, i.e., 5 m x 5 m. In most instances, two 2 foot samples were removed at each location. However, there were some grids where physical constraints prevented complete sample removal. Exposure rate measurements were made at each sampling location. As shown in B. Koh, 2001b, Table B, the exposure rates varied from background to a maximum of 5µR/hr above background.

A Geoprobe® was used to extract the soil samples, which were scanned and packaged as required by the remediation plan. Outreach Laboratory, Broken Arrow, Oklahoma initially analyzed all samples by gamma spectrometry to determine the U^{238} concentration. As reported Cummings/Riter, 1999 (Data Summary) previous tests on soil samples from the site revealed a wide variation in the amount of enrichment among the samples. The conservative ratio, U^{Total}/U^{238}, of 10 was used to screen the initial results for total uranium concentration in excess of the guideline value, 30 pCi/g. In this manner 39 quadrants were identified for potential excavation.

One sample from each of the 39 quadrants that exceeded the guideline was then analyzed by alpha spectrometry to determine the concentrations of U^{234} and U^{235}. These results, plus the results of 22 other samples, were used to develop U^{234}/U^{238} and U^{235}/U^{238} ratios, which were applied to the gamma spectrometry results, as follows:

- The ratios determined for a particular sample were applied to the sample and the other samples from the same grid,
- The alpha spectrometry results were used to calculate average ratios for each of the four site areas; A, B, C and unaffected, and were applied to all other samples in the area.

The calculated average ratios for each area can be found in B. Koh, 2001b,Table D.

After recalculating the total uranium concentration of all samples using the U^{234}/U^{238} and U^{235}/U^{238} ratios as described above, an average total uranium concentration was calculated for each quadrant or grid as specified in B. Koh, 2000, Section 2.1.2.2. The average total uranium concentration of 14 quadrants exceeded the guideline value. The maximum and average concentration, as well as, the uranium ratios for each of these quadrants are presented in B. Koh, 2001b,Table D.

In addition, samples from the following quadrants failed to meet the hotspot criterion for soil activity (Criterion 3): H5-5, H6-2, G4-4, and A7.

2.7.9.5.2 Step Two Results

Excavation of contaminated soils began on October 29, 2001 and was completed by November 20, 2001. The excavations were characterized by three separate activities. The first was the removal of contaminated soils from the 14 grid locations identified in B. Koh, 2001b,Table D. The second was the removal and analysis of additional soil samples from the grids that did meet the hotspot criterion. Based on the results of the additional analyses, two grids, H5-5 and H6-2 were excavated. The third activity was removal of contaminated soils from the former lagoon area. All concrete debris removed from the lagoon was scanned and found to be uncontaminated.

After soil removal, the open excavations were scanned to confirm that no hotspots remained. Soil samples were removed for analysis and exposure rate measurements were made at the sample location. The exposure rates measured after excavation are presented in B. Koh, 2001b, Table B.

The results of 543 soil samples are presented in B. Koh, 2001b, Table A. The conversion of the U^{238} to U^{Total} is based on ratios as described above. The table shows that after soil removal, the average U^{Total}

concentration within all grids is within the guideline value, 30 pCi/g. A statistical analysis of the data, presented at the conclusion of Table A, confirmed that the average concentration of U^{Total} , at the 95% confidence level, was less than 30 pCi/g.

Results of eighteen individual samples from thirteen separate grids exceeded 30 pCi/g. The guidance of NUREG/CR-5849 states that when the concentration exceeds the guideline value, but is less that three times the guideline value, the area weighted average of elevated activity must be considered when calculating the grid average concentration. The statistical analyses for each grid, included as B. Koh, 2001b, Appendix A, demonstrate compliance with the guideline value, 30 pCi/g.

In addition to excavating sixteen grids and the former lagoon, the "contaminated soil pile" shown on B. Koh, 2001b, Figure 1, was removed. Soil samples extracted from beneath the pile and surface scans after the pile was removed confirmed removal of the "contaminated soil pile".

2.7.9.6 Radioactive Waste Disposal

Approximately 760 cubic yards of contaminated soil from the excavations and the "contaminated soil pile" were disposed of offsite at Envirocare of Utah. The total weight of the soil, as measured during loading for transportation, was 1,586,390 pounds. Based on the average concentration of U^{Total} of the excavated grids, as shown in Table D, the disposed material contained 62.6 milliCuries of uranium. Waste manifests are included in Appendix B.

2.7.9.7 Residual Uranium

The following assumptions were used to calculate the residual uranium at the site:

- The volume is 102 grids (10,200 m^2) at an average depth of 2 feet,
- The soil density is the same as the material shipped offsite,
- The uranium concentration is the average concentration of the sample results presented in B. Koh, 2001b, Table A, i.e., 13 pCi/g.

Based on these assumptions, the residual uranium at the site is approximately 101 milliCuries.

2.7.9.8 Final Status Determination for the FZBA

The results presented in this Final Status Survey Report demonstrate that residual uranium concentration at the FZBA is less 30 pCi/g, and is therefore in compliance with the guidelines of 1981 Branch Technical Position for unrestricted use of the site.

2.8 FZBA Radiological Dose Assessment

The RESRAD computer code was used to perform a dose analysis for the FZBA to demonstrate that residual radiation that may be present is well below the dose based release criterion of 25 mrem per year as required by the Code of Federal Regulations, Chapter 10, Subpart E. This analysis includes a model description, a discussion of model inputs, a brief summary of results, and a sensitivity analysis.

2.8.1 Model Description

The RESRAD Model was developed to assist in developing cleanup criteria and assessing the dose or risk associated with residual radioactive material (Yu, C. and others, 1993). Radiation dose computed in RESRAD is referred to as the total effective dose equivalent (TEDE). TEDE is the sum of the effective dose equivalent (EDE) from external radiation and the committed effective dose equivalent (CEDE) from internal radiation. The TEDE can be compared directly with dose limit for site decontamination of 25 mrem per year. For this project, the model was used to compute potential annual doses to workers or members of the public resulting from exposures to residual radioactive material in soil in the FZBA.

RESRAD dose assessment is based on a pathway analysis method known as the concentration factor method. With this method, the relationship between radionuclide concentrations in soil and the dose to a member of the critical population group is expressed as a sum of the products of "pathway factors" (Yu, C. and others, 1993). Pathway analysis for deriving dose estimates includes source analysis, environmental transport analysis, dose/exposure analysis, and scenario analysis. Each of these elements is discussed below with respect to the RESRAD modeling performed for the FZBA

2.8.1.1 Source Analysis

Source analysis involves deriving the source terms that determine the rate at which residual radioactivity is released into the environment. This rate is determined by the geometry of the contaminated zone, the concentration of the radionuclides present, the ingrowth and decay rates of the radionuclides, and the removal rate by erosion and leaching.

2.8.1.1.1 Contaminated Zone Geometry

The geometry of the FZBA contaminated zone is described by several parameters including the area of the contaminated zone and the thickness of the contaminated zone. The area of the contaminated zone is presented in B. Koh, 2001b, Figure 1. As shown in Figure 1, the FZBA was divided into 121 ten square meter grids for the final status survey. Based on Figure 1, and assuming that the thickness of the contaminated zone has been significantly reduced due to soil excavation activities, the contaminated zone was modeled as a 6-inch deep, 12,100 m^2 contaminated zone overlain by 1 foot of clean cover material. It is assumed that the radionuclides of interest are uniformly distributed within this contaminated zone.

2.8.1.1.2 Contaminant Concentration

The dose producing radionuclides in the contaminated zone are U-234, U-235, and U-238 and associated decay progeny. As indicated in B. Koh, 2001b, U-235 enrichment varies throughout the contaminated zone according to isotopic uranium analyses performed in support of the FSS. For modeling purposes, a U-234: U-235: U-238 activity ratio of 75%: 4%: 21% was selected. This ratio is representative of 3% U-235 enrichment. The use of an activity ratio characteristic of 3% U-235 enrichment was based on an analysis of information presented in Table A of B. Koh, 2001b. This analysis is presented Appendix D.

A total uranium concentration of 1 pCi/g was assumed for the RESRAD simulations. Corresponding U-234, U-235, and U-238 concentrations were 0.75 pCi/g, 0.04 pCi/g, and 0.21 pCi/g, respectively. Assumption of a total uranium concentration of 1 pCi/g allows the flexibility of using the results for simple derivation of a guideline value for total uranium, or calculation of a site TEDE for direct comparison with the 25 mrem/year guideline value. Derivation of a guideline value for total uranium would be accomplished by dividing the 25 mrem/year guideline value by the dose resulting from 1 pCi/g total uranium. Alternatively, the site TEDE can be estimated from the 1 pCi/g total uranium RESRAD simulation by multiplying the RESRAD result by the average total uranium concentration for the site. The average total uranium concentration for the FZBA is 13.0 pCi/g as presented in B. Koh, 2001b.

2.8.1.1.3 Other Source Analysis Factors

Time dependence of the annual dose received by a member of the critical population is controlled by the rate at which radionuclides are leached from the contaminated zone, the rate of ingrowth and decay of the radionuclides, erosion of cover and contaminated soil, and contaminant transport. Default values were used for the input parameters related to time dependence in most cases. However, site specific information was provided for cover depth, precipitation, watershed area, density of the saturated zone, and the thickness of the unsaturated zone.

2.8.1.2 Environmental Transport Analysis

Environmental transport analysis addresses identifying environmental pathways by which radionuclides can migrate from the source to a human exposure location and determining the migration rate along these pathways. RESRAD considers all significant exposure pathways for the critical population group when computing the TEDE. These potential pathways include the following:

1. Direct exposure to external radiation from the contaminated soil material;
2. Internal dose from inhalation of airborne radionuclides; including radon progeny (if applicable); and
3. Internal dose from ingestion of
    - Plant foods grown in the contaminated soil and irrigated with contaminated water,
    - Meat and milk from livestock fed with contaminated fodder and water
    - Drinking water from a contaminated well or pond;
    - Fish from a contaminated pond, and
    - Contaminated soil

Actual pathways used in the model are dependent on the exposure scenario selected. Applicable pathways are discussed below.

2.8.1.3 Dose/Exposure Analysis

Dose/exposure analysis addresses the problem of the derivation of dose conversion factors (DCFs) for the radiation dose that will be incurred by exposure to ionizing radiation. DCFs are dose/exposure relationships. The three exposure pathways identified above (external radiation, inhalation, and ingestion) correspond to three kinds of dose conversion factors. Default values were used for the FZBA dose assessment.

2.8.1.4 Exposure Scenario Analysis

The parameters that control the rate of radionuclide release into the environment and the severity and duration of human exposure at a given location are determined by patterns of human activity referred to as exposure scenarios. Several credible scenarios may be modeled in RESRAD such as the subsistence farmer and the industrial worker scenario. The actual scenario for a site depends on a number of factors, including the location of the site, zoning of the land, and physical characteristics of the site.

Soil guidelines are usually based on the resident farmer scenario. This scenario involves all environmental pathways for on-site or near site exposure and is expected to result in the highest predicted lifetime dose. Other scenarios, such as the resident gardener, industrial worker, and recreationist are taken into account by adjusting the scenario parameters in formulas for calculating the transport of radionuclides through the pathways.

The standard exposure scenarios for the RESRAD model are summarized in Table 2-1.

Table 2-1: Typical exposure scenarios

Exposure Scenario	Description
Resident Farmer	A family is assumed to move onto the site after it has been released for use without radiological restrictions, build a home, and raise crops or livestock for family consumption.
Suburban Resident (Resident Gardener)	A family is assumed to move onto the site after it has been released for use without radiological restrictions and build a home. It is assumed that some plant food is raised on site. All other food and water is obtained from off-site sources.
Industrial Worker	Worker who spends 8 hours per day on site. It is assumed that no water or food obtained from the site is consumed.
Recreationist	Person spends a limited amount of time on site (i.e. 2 hours per day three days per week) while playing, fishing, hunting, hiking, or engaging in other outdoor activities.

Pathways considered in each scenario are summarized in Table 2-2.

Table 2-2: Pathways to be considered for the various exposure scenarios

Pathway	Resident Farmer	Suburban Resident (Resident Gardener)	Industrial Worker	Recreationist
External gamma exposure	Yes	Yes	Yes	Yes
Inhalation of dust	Yes	Yes	Yes	Yes
Radon inhalation(1)	Yes	Yes	Yes	Yes
Ingestion of plant foods	Yes	Yes	No	No
Ingestion of meat	Yes	No	No	Yes
Ingestion of milk	Yes	No	No	No
Ingestion of fish	Yes	No	No	Yes
Ingestion of soil	Yes	Yes	Yes	Yes
Ingestion of water	Yes	No	No	No

(1)Radon inhalation was disregarded for the FZBA dose assessment since radon is excluded from the 25 mrem/year dose limit. Furthermore, since the uranium contamination present is associated with licensed material that has been chemically purified, all progeny after U-234 have been removed and will not return to near secular equilibrium for >25,000 years. Therefore radon is not a consideration for exposure calculations.

Each of the exposure scenarios included in Table 2-2 was considered for dose assessment, and two were selected for evaluation. The resident farmer scenario was not evaluated due to the limited size of the area and issues associated with past industrial use of the site which make farming an unlikely future use. The resident gardener scenario was selected for assessment since it represents a feasible, though unlikely, future use for the site. The industrial worker scenario was selected for evaluation because it matches well with the current and likely future use of the site. The recreationist scenario was considered for evaluation, because the site abuts United States Army Corps of Engineers property that is currently used for recreational purposes. However, this scenario was not assessed at this time because it is unlikely to result in the highest dose to a member of the public due to the short exposure duration associated with most recreational activities.

2.8.2 Input Parameter Summary

The input values used in the RESRAD code for the FZBA resident gardener and industrial worker scenarios are summarized in Appendix E, Table E-1. This table lists the values used in each dose assessment, and provides justification for their use.

2.8.3 Results

Appendix F presents the RESRAD reports generated for both the resident gardener and industrial worker scenarios. The assumption 1 pCi/g total uranium in the residential gardener scenario results in a peak mean annual TEDE of approximately 0.0023 mrem at time 0. Considering that the estimated average total uranium concentration is 13.0 pCi/g for the FZBA, this equates to an actual estimated TEDE of 0.029 mrem/year, which is well below the 25 mrem/year unrestricted release criteria.

The assumption 1 pCi/g total uranium in the industrial worker scenario results in a peak mean annual TEDE of approximately 0.000073 mrem at time 0. Considering that the estimated average total uranium concentration is 13.0 pCi/g for the FZBA, this equates to an actual estimated TEDE of 0.0009 mrem/year, which is well below the 25 mrem/year unrestricted release criteria.

2.8.4 Sensitivity Analysis

The built-in sensitivity analysis capability of RESRAD was used to study the sensitivity of input parameters used to calculate the dose. The sensitivity information on input parameters identified those parameters with the greatest impact on the dose calculation. This information was then used to review the important input parameters and provide more detailed justification for their use.

The sensitivity analysis was a single-parameter analysis, where a range of values was evaluated for one parameter at a time. The results of the sensitivity analysis are summarized in Appendix G. Tables G-1 and G-2 summarize sensitivity factors, resulting doses, and percent increase for each parameter subject to sensitivity analysis for the resident gardener and industrial worker scenarios, respectively. Associated sensitivity analysis graphics are also included in Appendix G for each scenario.

2.8.4.1 Resident Gardener Sensitivity Analysis

Of 69 parameters assessed for their influence on the final result, eight parameters were found to have the greatest impact (> 10% dose increase). See Table 2-3.

Table 2-3: Most Sensitive Resident Gardener Scenario Parameters

Rank	Parameter	Sensitivity Factor	Dose Increase
1	Thickness of contaminated zone	2	88.14%
2	Cover depth	2	81.50%
3	U-238 contaminated zone distribution coefficient	10	81.50%
4	Depth of roots	2	74.86%
5	U-234 contaminated zone distribution coefficient	10	66.00%
6	U-235 contaminated zone distribution coefficient	10	54.94%
7	Fruits, vegetables, and grain consumption	1.5	32.80%
8	Cover erosion rate	5	10.67%

The *thickness of the contaminated zone* was important in the dose assessment because it defines the distance between the shallowest and the deepest depth of contamination. The thickness of the contaminated zone was estimated to be 6 inches. This value is considered reasonable because extensive soil excavation was conducted in the FZBA removing deeper pockets of contamination that may have been present.

The *cover depth* is a parameter required in the RESRAD code that defines the distance from the ground surface to the location of the uppermost soil sample with radionuclide concentrations that are clearly above background. The cover depth of 1 foot was used since the area was regraded, covered with topsoil, and revegetated after soil remediation activities were completed.

A *distribution coefficient, K_d* is a ratio of the mass of solute adsorbed or precipitated on the soil (per unit of dry mass) to the solute concentration in the liquid. The RESRAD default K_d value (50 cm^3/g) was used for each contaminated zone radionuclide in the FZBA dose assessment. For the sensitivity analysis, K_d was adjusted by a factor of 10. Increasing the contaminated zone K_d for each radionuclide to 500 cm^3/g resulted in a sharp increase in the dose approximately 300 years in the future. The spike in dose is associated with the external, inhalation and soil ingestion pathways. The spike is likely associated with the time when erosion of the cover soil is expected to be complete, and the contaminated zone is exposed.

At this time, the contaminants, which would have been tightly held in the high K_d soil matrix, would be exposed resulting in increased dose through the external, inhalation, and soil ingestion pathways.

Considering that the contaminated zone soils are somewhat sandy (Cummings/Riter, 1995a, Figures 3 and 8), the appropriate value for K_d would likely lie closer to 35 cm^3/g according to Table E.3 of the RESRAD User's Manual (Yu, C. and others, 2001) rather than 500 cm^3/g. An increase in dose above the base case is not apparent at the K_d values lower than the default value (50 cm^3/g). Therefore, use of the RESRAD default value (50 cm^3/g) is considered conservative.

The value used for the *depth of roots* is a default value. Use of this value is supported by "Data Collection Handbook to Support Modeling Impacts of Radioactive Material In Soil", (Yu, C. and others 1993). This reference indicates that most of the plant roots from which nutrients are obtained usually extend to less than 1m below the surface. Therefore, the RESRAD default value of 0.9 m is appropriate.

The value used for *fruits, vegetables, and grain consumption* was a default value. This is a national average, which is usually site independent. Further evaluation of this parameter is unnecessary.

The *cover erosion rate* is the rate at which soil is removed by erosion. The default value of 0.001 m/year was used as the cover erosion rate. Based on the discussion in Section A.2.1 of the RESRAD User's Manual (Yu, C. and others, 2001), the default value is conservative for the FZBA under both the resident gardener scenario and the industrial worker scenario. The User's Manual suggests typical ranges of erosion rates for different land uses and varying slopes. Considering that the FZBA is sloped at approximately 3.33%, and assuming the final vegetative cover would be similar to a permanent pasture under the resident gardener and industrial worker scenarios, a better estimate of the cover erosion rate might be 0.0001 m/year rather than 0.001 m/year. This would result in a lower dose estimate. Based on this assessment, the default value used in the RESRAD runs for the FZBA is considered to be conservative.

2.8.4.2 Industrial Worker Sensitivity Analysis

Of 32 parameters assessed for their influence on the final result, eleven parameters were found to have the greatest impact (> 10% dose increase). See Table 2-4.

Table 2-4: Most Sensitive Industrial Worker Scenario Parameters

Rank	Parameter	Sensitivity Factor	Dose Increase
1	U-238 contaminated zone distribution coefficient	10	1,539.79 %
2	U-235 contaminated zone distribution coefficient	10	1,403.14 %
3	U-234 contaminated zone distribution coefficient	10	1,266.49 %
4	Cover erosion rate	5	856.55 %
5	Cover depth	2	801.89 %
6	Density of cover material	1.2	98.14 %
7	Depth of soil mixing layer	2	94.04 %
8	Shielding Factor External Gamma	1.5	25.72 %
9	Fraction of time spent indoors	1.5	25.72 %
10	Fraction of time spent outdoors	1.5	16.15 %
11	Thickness of contaminated zone	2	12.05 %

The values used in the industrial scenario for *thickness of the contaminated zone*, *cover depth, cover erosion rate, and distribution coefficients* are justifiable as discussed above for the resident gardener scenario. The high apparent sensitivity of some of these values is somewhat misleading considering the very low dose estimated for the base case.

The value used for the *density of cover material* is 1.44 g/cm^3. This value was selected from Table 2.1 of Yu, C. and others, 1993 for a sandy loam based on soil descriptions contained in Cummings/Riter, 1995a, Figures 3, and 8. This value is more conservative than the default value and is well supported by site specific information. Therefore, further evaluation of this parameter is unnecessary.

The default value of 0.15 m was used for the *depth of the soil mixing layer*. This is a reasonable approximation for this site. No further evaluation is warranted considering the low dose estimated for the base case.

The value used for the *external gamma shielding factor* is 0.5512. This value was selected from "Preliminary Guidelines for Evaluating Dose Assessments in Support of Decommissioning", Table 2. This is more conservative than the value indicated in comparable references (i.e. NUREG/CR-5512 VOL.1 and NUREG/CR-5512 VOL.3). Therefore, this value will not be modified.

The values used for *fraction of time indoors* and the *fraction time outdoors* were both obtained from the RESRAD User's Manual, Table 2.3 (Yu, C and others. 2001). Therefore, modification of these parameters is unnecessary.

Finally, the *thickness of the contaminated zone* is a site-specific value, which is fairly insensitive. At the low dose rates estimated for the industrial scenario, no further evaluation of this parameter is necessary.

2.9 Conclusions Regarding Site Grounds

Early investigations of the site grounds identified the Northeast Fill Area, the Former Pond Area, the Casting Sand Mound, the Quarry Area and the FZBA as areas of radiological interest. Each of these areas was systematically evaluated, and only the Quarry Area and the FZBA were ultimately identified as requiring remediation to meet unrestricted release criteria. The Quarry Area was thoroughly vacuumed leaving the area nearly devoid of soil material and zirconium fines. Final gamma walkovers confirmed that the Quarry Area achieved unrestricted release criteria. Extensive remediation activities were also conducted in the FZBA after it was determined that concentrations of uranium in soil exceeded unrestricted release criteria. In this case contaminated soil and demolition debris were excavated from the area and disposed off-site at appropriately licensed facilities. The final status survey documented in B. Koh, 2001b confirms that the FZBA meets unrestricted release criteria. RESRAD modeling conducted by ENERCON confirmed that the annual dose expected for a member of the public is well below the release criteria of 25 mrem per year. On the basis of these findings the site grounds at the WSMP are considered suitable for release for unrestricted use in accordance with the provisions of 10 CFR 20 Subpart E.