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April 7, 1993

Docket No. 40-7102

Mr. Gary Comfort
Mail Stop GH-3
United States Nuclear Regulatory Commission
Licensing Section One
Licensing Branch
Division of Fuel Cycle Safety and Safeguards, NMSS
Washington, DC 20555

RE: Conceptual Decommissioning Plan for Shieldalloy Metallurgical Corporation (SMC) Newfield, New Jersey, USNRC License SMB-743

Dear Mr. Comfort:

Please find enclosed three copies of the subject report for your review as part of SMC's license renewal application. On February 10, 1993, we submitted NRC Form 313 with attachments. This submittal is the second of the three components of SMC's entire license renewal application. As discussed during the NRC site visit to Newfield on February 19, 1993, SMC will submit a Decommissioning Funding Plan upon notification of NRC's acceptance of the subject report.

If there are any questions concerning the subject report, please contact me.

Sincerely,

Craig R. Rieman

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Conceptual Decommissioning Plan for the Newfield, New Jersey Facility

By:

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Report No. IT/NS-93-104
April 7, 1993

RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

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CONCEPTUAL DECOMMISSIONING PLAN FOR THE NEWFIELD, NEW JERSEY FACILITY

SHIELDALLOY METALLURGICAL CORPORATION
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April 7, 1993

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INTRODUCTION

Background Information

Shieldalloy Metallurgical Corporation (Shieldalloy) operates a manufacturing facility located in Newfield, New Jersey. This facility manufactures or has manufactured specialty steel and super alloy additives, primary aluminum master alloys, metal carbides, powdered metals, and optical surfacing products. Raw materials currently used at the facility include ores which contain oxides of columbium (niobium), vanadium, aluminum metal, titanium metal, strontium metal, zirconium metal, and fluoride (titanium and boron) salts. During the manufacturing process, the facility generates slag, dross, bag house dust, and waste waters, among other waste streams.

One of the materials received, used or stored by Shieldalloy contains radioactive material which is classified as "source material" pursuant to Title 10, Code of Federal Regulations, Part 40. It is pyrochlore, a concentrated ore containing columbium (niobium). The pyrochlore contains greater than 0.05% of natural uranium and natural thorium.

Shieldalloy currently holds U. S. Nuclear Regulatory Commission (USNRC) License No. SMB-743 which allows possession, use, and storage of source material. The most recent renewal of SMB-743 was issued in July, 1980. Prior to its expiration in July, 1985, Shieldalloy submitted an application for renewal, thus extending SMB-743 until the USNRC acts upon the renewal application. A revised renewal application was submitted on July 18, 1988, June 2, 1992, and again in February, 1993.

On December 15, 1992, the USNRC requested that Shieldalloy provide a conceptual decommissioning plan as part of the June, 1992 renewal application. This report, which supplements the renewal package, is intended to provide that information. It contains a description of the decommissioning objective, a conceptual plan for decommissioning the site, an assessment of the long-term risk associated with the decommissioning alternative, and estimated costs for achieving the decommissioning objective.

Statement of Purpose

The purpose of this document is to provide Shieldalloy's conceptual plan to decontaminate and decommission the Newfield plant in a timely fashion after licensed activities are terminated. The extent of decommissioning efforts will be sufficient to assure that long-term radiation exposures to members of the general population after license termination are within acceptable limits.

DECOMMISSIONING OBJECTIVE

Regulatory Basis

A critical step in the decommissioning process is determination of the objective of the action. The objective typically refers to the maximum acceptable dose limit that will be incurred by members of the general public after all action is complete, and the USNRC license is terminated.

There are a number of dose limits promulgated by standards groups and regulatory agencies that are considered to present negligible risk, any one of which would constitute an acceptable objective for decommissioning of the Newfield site. The following are a few examples.

- The National Council on Radiation Protection and Measurements (NCRP) recommends a dose limit of 100 millirem per year from manmade sources for individual members of the public (NCRP, 1987). While this limit is based on scientific recommendations developed through an impartial consensus process, it does not provide a regulatory basis upon which the release criteria for the Newfield facility may be derived.

- The USNRC, in a 1991 Final Rule (NRC, 1991), adopted the recommendations of the NCRP as its basic dose limit applicable to any licensed facility. However, this Final Rule is not scheduled for implementation until 1994. Moreover, once the USNRC license for Shieldalloy's Newfield facility is terminated, this limit may no longer be applicable.

- In 1990, the USNRC issued a Policy Statement which established the framework within which the USNRC would make licensing decisions to exempt some or all regulatory controls over certain practices involving radioactive material (NRC, 1990). This Statement set a "below regulatory concern" dose criterion of 10 millirem per year, which was based upon what the USNRC considered to be an acceptable hypothetical lifetime risk of 3.5×10^{-4} per rem. However, this Policy Statement has since been withdrawn.

- Guidance on acceptable release criteria were presented in a 1981 Branch Technical Position (BTP), wherein the USNRC identified four acceptable options for disposal or on-site storage of uranium- and/or thorium-contaminated materials (NRC, 1981). To release a site for unrestricted use, a licensee must assure that the residual radioactivity does not exceed the radionuclide concentrations contained in Options 1 or 2 of the BTP.[1] If it does, two additional Options are possible, however these require a petition for exemption from the unrestricted release requirement. Recognizing the limitations of the BTP and the lack of a clear regulatory basis, current USNRC thinking is directed toward establishment of risk-based release criteria as a demonstration of the codified ALARA (As Low As Reasonably Achievable) requirement (NRC, 1991).

- The U. S. Environmental Protection Agency (USEPA) imposes a limit of 25 millirem per year to any member of the public from nuclear fuel cycle facilities (EPA, 1991). This rule is not directly applicable to the Newfield plant since the plant is not a fuel cycle facility. However, there are similarities in certain radiological constituents (e.g., uranium and daughters).

- The USEPA sets a dose limit of 4 millirem total body or organ dose equivalent as the basis for controlling the concentrations of radioactivity in drinking water (EPA 1991b). This dose limit does have applicability in all states and for all operations involving radioactive materials.

In the absence of specific USNRC regulatory guidance, Shieldalloy has selected the USEPA requirement of 4 millirem per year (drinking water standard) as the decommissioning objective for closure of the Newfield site. The reasons for selecting this dose limit are three-fold: It is the lowest of the values listed above and thus is consistent with Shieldalloy's desire to implement defensible yet conservative radiological protection practices; it provides a regulatory basis for development of release criteria; and the intent is consistent with the USNRC's requirement that radioactive materials be disposed of in a manner that ensures that exposures to radiation or radioactive material are as low as is reasonably achievable (ALARA), with economic and social factors taken into account (NRC, 1991).

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1 These concentrations are based on limiting individual radiation doses to 170 millirem per year.

If the existing residual radioactive materials at the Newfield site can be disposed of in a fashion that assures the 4 millirem per year dose limit for members of the general public is not exceeded, that decommissioning alternative would present negligible risk, and is thus consistent with the USNRC's ALARA requirement. Therefore, the decommissioning objective for the Newfield site is that no member of the public in the vicinity of the site shall incur a total effective dose equivalent (TEDE) in excess of 4 millirem per year.

Decommissioning Alternative

The licensable radioactivity at the Newfield plant consist primarily of residual materials generated as a result of processing of ores containing thorium and uranium. These materials are primarily in the form of slag which contains residual quantities of thorium-232 and uranium-238, along with the radionuclides resulting from the decay of the isotopes in the series. Hazards to the general population could occur through several pathways, including:

- Inhalation of radon decay products, particularly where radon is concentrated within building structures;
- Inhalation of particulates or ingestion of materials containing radionuclides of the two series;
- Ingestion of radionuclides via drinking water and food; and
- External body exposure to gamma radiation.

While decommissioning a site is generally intended to result in unrestricted public use of land, and renewed use of amenities which had been denied during a facility's life, for the Newfield facility, that goal is thought to be unachievable within the constraints of public health impact, time, and cost. Consequently, this decommissioning plan is based on the assumption that the unrestricted release requirement is not reasonably achievable. Therefore, in-situ stabilization of all radioactive materials at the Newfield site is Shieldalloy's current concept for achieving the decommissioning objective.

For this alternative, in-situ stabilization will consist of on-site disposal by engineered containment and capping. Capping will consist of covering the contaminated slag with a thick layer of low-permeability material, which will be followed by re-vegetation of the area. The overall design of the engineered containment and the cap will be specified to attenuate the gamma radiation associated with the radionuclides present in the slag, to protect the ground water, minimize the risk of intrusion, and to provide assurance that release of radon from residual radioactive material to the atmosphere will not exceed acceptable limits.

Engineered containment and capping was selected as the remedial alternative for Newfield due to its cost, ease of application, and its use for remediation of other radiologically contaminated sites. The primary drawbacks to this remedial alternative are that it does not eliminate the source of radioactivity, and the cap must be maintained as long as the contaminants exist at the site. As a result, it is expected that land use restrictions and perpetual care in the form of a long-term environmental surveillance and cap maintenance program, may be imposed at the termination of decommissioning activities at the Newfield site. If this is the case, Shieldalloy intends to apply for exemption from the unrestricted release requirement of 10 CFR 40.42 (NRC, 1992), using a site-specific demonstration of "negligible risk" as the basis.

CONCEPTUAL DECOMMISSIONING PLAN

General Site Characteristics

The Shieldalloy plant is built on approximately 60 acres in the Borough of Newfield (Gloucester County), New Jersey.[2] The topography of the Newfield area is relatively flat, and the Shieldalloy property is located on a slight topographic high, with the ground surface generally sloping to the west-southwest, towards the Hudson's Branch. The Hudson's Branch, a tributary of Burnt Mill Branch, in the Maurice River Basin, is the predominant surface water body in the vicinity of the plant. It borders the southern boundary of the property, where it flows from east to west.[3]

The plant area is surrounded by a seven-foot tall chain link fence, topped with barbed wire. There are 27 buildings on the property, and their construction is either steel frame or concrete block. The plant is divided into four functional areas, described as follows:

- Manufacturing area - This area contains a number of operations facilities, offices, and loading docks. For the most part, the area is covered with buildings and asphalt or concrete pavement. Included are the Railroad Siding Area, Department 111 (ferrocolumbium operation), Department 107 (induction melting), Department 102 (aluminothermic reduction operation), Department 101 (metal grinding operations), Department 115 (aluminum master alloys), Department 116/118 (metal powder compaction operations), and Department 204 (maintenance operations).

- Storage Yard - This area is located on the eastern portion of the property, and is used to store materials generated during manufacturing operations.

- Lagoon area - This area consists of nine lagoons located in the central portion of the property.

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2 A small portion of the property lies in Cumberland County, New Jersey.

3 The Hudson's Branch flows from northeast to southwest after it leaves the Shieldalloy property.

- Undeveloped plant property - This area is located along the southern plant property boundary, and includes all undeveloped and unused areas of the plant.

Items to be Decommissioned[4]

The licensed radioactive material inventory at the plant currently consists of the operating inventory of pyrochlore, the slag from the D111 and D102 production departments, and the dust from the D111 bag house.[5] Greater than 99% of the radioactive species in the feed material for the smelting operation remain in the slag and in the baghouse dust (IT, 1992). As of October 31, 1991, the total inventory of source material on site is 235,000 kg. of ^{232}Th, and 29,400 kg of ^{238}U (Rieman, 1992). Table 1 shows the physical quantities of these materials. At the current production schedule, the inventory is expected to increase at a nominal rate of approximately 1,000 kg of ^{232}Th and 100 kg of ^{238}U per month (Smith, 1992).

Ferrocolumbium standard slag, ferrocolumbium high-ratio slag, and columbium nickel slag generated from the smelting operation consist of solid, non-combustible material with the consistency of vitrified rock. All three slag types are maintained separately from the others at their respective points of generation, and are transported in trucks from D111 to the Storage Yard. Currently, there are approximately 18,000 cubic meters of ferrocolumbium slag and approximately 15,000 cubic meters of baghouse dust in the Storage Yard.[6] Table 2 is a summary of radioactive residual materials streams generated at Shieldalloy.

In the past, ferrocolumbium slag may have been used on-site as fill material for certain construction projects within the plant site. Possible placement locations include the

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[4] The items listed herein are intended for planning purposes only. At the actual time of license termination, the list of items to be decommissioned will be determined from the results of the site-wide characterization.

[5] Over 95% of the licensed material at the Newfield plant is in the form of slag.

[6] Historically, dusts generated from both ferrocolumbium production and un-recycled dusts from ferrovanadium production were not segregated. Currently, however, the ferrovanadium contribution to the collected dusts is negligible.

southwest fence line and in the vicinity of the T12 Tank Area. The ambient exposure rates in these areas currently range from background to a few tens of microR per hour (IT, 1992).

Radiological surveys of the Newfield facility were conducted in 1988 and 1991 in order to characterize certain radiological constituents that were present both on the property, and in designated off-site locations (ORAU,1988 and IT, 1992). In those surveys, elevated surface count rates were identified due south of the D111 baghouse.[7] Also, thorium and uranium concentrations in soil/sediment that are slightly in excess of background were noted outside of the Shieldalloy property boundary in the Hudson's Branch Watershed. The most likely mechanism for transport of these radioactive materials outside of the property boundaries is believed to be physical migration due to stormwater runoff, rather than movement through the groundwater (ORAU, 1988 and IT, 1992). The D111 baghouse (as a result of silo-emptying operations) and the lime pile in the storage yard were considered to be possible sources of radioactive materials in the Hudson's Branch.[8]

The items to be addressed during decommissioning of the Newfield facility prior to license termination are:

- Slag piles in the Storage Yard
- Bag house dust in the Storage Yard
- Building D111

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[7] The D111 baghouse contains low-concentration radioactive materials. The baghouse silo is emptied periodically, and its contents are transported by vehicle to the "lime pile", which is located in the southwestern corner of the storage yard.

[8] Prior to evaluating the feasibility of various remedial actions for the radioactive materials contained in the Hudson's Branch, a baseline assessment of their radiological impact was performed (IT, 1992b). The results of this assessment indicated that the maximum radiation dose rate to a hypothetical farm family residing within the immediate area of the Hudson's Branch, with uranium and thorium concentrations evenly-distributed throughout, is 14.18 millirem for the first year after deposition. The maximum risk of fatal cancer for this same time period is 1.77×10^{-6}. However, the assumptions used in the baseline radiological risk assessment were extremely conservative, and the true risk is significantly less than the value reported.

- Building D102
- Mislocated slag within the plant property
- Hudson's Branch Watershed

It is assumed, for this conceptual decommissioning plan, that the total inventory of radioactive materials to be disposed of on site will be equal to the total volume of materials currently present, plus the projected inventory increase over the five year duration of the USNRC license. Based upon current rates of inventory increase, the five year increase of ^{232}Th and ^{238}U is projected to be 62,500 kg and 5,000 kg, respectively.

The mass of mislocated slag is not known at this time, but, for the purposes of this report, is assumed to consist of an additional 62,500 kg and 5,000 kg of thorium and uranium. It is estimated that an additional 500 m^3 of radioactive material will be accumulated during the decommissioning of buildings D111 and D102, which will also be disposed of in the Storage Yard. These result in a total mass of approximately 400,000 kg of source material and a total volume of approximately 52,500 m^3 to be disposed of on site.[9]

Procedure

Once licensed activities cease at the Newfield facility, the decommissioning process will involve a number of steps, each of which entails some cost and effort. The following is a brief summary of those steps:

- Review existing site characterization data and perform additional site characterization, as required.
- Evaluate decommissioning options and generate a technical basis document in support of the decommissioning objective based upon available data/information. The technical basis document

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[9] It is Shieldalloy's intent to produce ferrocolumbium alloys at the Newfield site for a number of years into the future. Therefore, a revision to this Conceptual Decommissioning Plan, to account for possible increase in inventory beyond that which is assumed here, will accompany future license renewal applications.

will include a risk assessment for in-situ stabilization of radioactive materials, as well as a comparison of the risks, costs, and implementability of the alternative decommissioning methods.[10]

- Develop a site-wide Decommissioning Plan/Schedule.
- Implement the site-wide Decommissioning Plan.
- Perform a release survey and generate a Decommissioning Report.
- Request termination of USNRC license to permit closure of the site.[11]
- Implement long-term surveillance, reporting, and cap maintenance/inspection programs as required by provisions of the land use restrictions.

Table 3 contains a listing of the procedures that will be followed for completion of these steps.

Final Report to the USNRC

A final release survey will be performed upon completion of remedial actions, and prior to any work area restoration. In general, the survey methodology will be designed in accordance with the recommendations of (draft) NUREG/CR-5849 (Berger, 1992). The objective of the survey will be to demonstrate that the radiological conditions at the Newfield site meet the decommissioning objectives, that surface radioactivity in buildings and structures are less than the site-specific release criteria, and that radiation doses to members of the general population will not exceed 4 millirem per year. These conditions will be

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[10] Decommissioning options to be addressed are likely to include on-site disposal with capping and/or vertical barriers; on-site land encapsulation; off-site land disposal, and various segregation/disposal options.

[11] As necessary, application for exemption from the unrestricted release requirement of 10 CFR 40.42 will be included.

demonstrated at a 95% confidence level. The survey data will be used to calculate the total inventory of residual uranium and thorium at the Newfield site.

CONCEPTUAL RISK ASSESSMENT

To demonstrate the feasibility of in-situ disposal as the conceptual decommissioning alternative of choice for the Newfield facility, a conceptual dose/risk assessment was performed. For this effort, the methodologies contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (ANL, 1989) were used to provide radiation dose estimates from radionuclides contained in soil and groundwater.

To estimate the potential risks to humans from the calculated doses, the methods promulgated by the National Academy of Science in the BEIR-V report (NAS, 1990) For this report, risk is defined as the annual or lifetime probability of the development of fatal cancer from exposure to ionizing radiation, and is estimated by:

$$Risk = (D)\ (CF)$$

where D = the dose received by the maximally-exposed individual, and CF = a conversion factor based upon the linear, no-threshold hypothesis. The conversion factor that was used for this assessment is 1.50×10^{-4} fatal cancers per rem of radiation dose equivalent (NAS, 1990).

To determine the radiation dose to members of a hypothetical farm family which might reside on the Shieldalloy property after licensed activities cease, a number of assumptions were made as input to the computer code entitled RESRAD (ANL 1989). This code was used to model radionuclide fate and transport, and to assess the committed dose equivalent from the residual contaminants. The following is a listing of those assumptions, which were intentionally selected to result in conservative, or over-estimates of dose.

- The total mass of source material to be decommissioned in place at the Newfield site is 400,000 kg. This was derived from the current inventory of ^{232}Th and ^{238}U (SMC, 1992); the projected five year inventory increase of ^{232}Th and ^{238}U; the estimated mass of mislocated slag, and the estimated mass of residual material from building D111 and D102 decontamination.

- Dose calculations were performed for a period of time starting at initial placement of the material (t=0 years) and ending 1000 years later (ANL, 1989).

- The materials left on site are confined to a total area of 9560 m^2. This is based upon a disposal area that is equal in size to the Newfield Storage Yard.

- The thickness of the materials left on site is 5.5 meters. This was derived from distributing the total volume of material (52,500 m^3) over a total surface area of 9560 m^2.

- The density of all residual radioactive materials is 2.23 g/cm^3 (SMC, 1992).

- The radionuclides in the residual materials are evenly distributed throughout, at an average concentration of 516 pCi/g of ^{232}Th (plus daughters), and 202 pCi/g of ^{238}U (plus daughters). These values are the average concentrations reported for the Standard Slag Pile (Berger, 1988).[12]

- The stabilized materials are covered with a low-permeability earthen cover, at a thickness of no less than four feet (1.22 meters), and a cover density (compacted clay) of 1.73 g/cm^3.

- The cover is designed to ensure an erosion rate of no greater than 2.79 x 10^{-4} meters per year.

- The annual precipitation rate at the Newfield plant is 1.12 meters per year (TRC, 1992).

- Hydraulic conductivity of the saturated zone beneath the material is 222.5 meters per year, the saturated zone porosity is 0.3, and the hydrological gradient is 0.004 (TRC, 1992).

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[12] The actual measured values in the Standard Slag Pile varied widely from background to over 1000 pCi/g. Also, the average concentrations of thorium and uranium reported for the Hi-ratio Slag Pile was 366 and 105 pCi/g, respectively (Berger, 1988). Therefore, the values used as input to this assessment are considered to be conservative in nature.

In general, the input parameters to the RESRAD code, including Dose Conversion Factors, were selected from the RESRAD default values. Table 5 contains a listing of all parameters used for this conceptual dose assessment.

Figure 1 shows the total dose to a member of the farm family residing on the Shieldalloy property for all radionuclides contained in the residual radioactive materials after decommissioning. The maximum dose of 0.86 millirem per year occurs at year 1000 after initial placement of materials and closure of the site.

The individual cancer risk to a member of the farm family attributed to exposure to the decommissioned Newfield plant is estimated by multiplying the maximum total dose for all radionuclides by the risk factor for fatal cancer of 5×10^{-4} per rem (NAS, 1990). The risk from all pathways, based upon the maximum total dose value of 0.86 millirem per year is:

$$Risk = 0.86 \frac{mrem}{year} x \frac{1\ rem}{1000\ mrem} x\ 5.00x10^{-4} \frac{fatal\ cancers}{rem} = 4.30x10^{-7} \frac{fatal\ cancers}{year}$$

For comparison, the following is the risk estimate to an average member of the United States population from annual background radiation exposure:

$$Risk = 380 \frac{mrem}{year} x \frac{1\ rem}{1000\ mrem} x\ 5.00x10^{-4} \frac{fatal\ cancers}{rem} = 1.90x10^{-4} \frac{fatal\ cancers}{year}$$

Thus the hypothetical farm family's risk of fatal cancer associated living on the decommissioned Newfield property containing the residual radioactive materials is 0.00019043, as compared to a risk of 0.00019000 associated with living elsewhere.

ESTIMATED COST OF DECOMMISSIONING

Cost estimates for implementing the steps shown in Table 3 are based on a variety of cost-estimating data, including curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates as modified by site-specific information. Prior estimates, site-cost experience, and good engineering judgements were used to identify those items that will control the estimates. The following is a listing of assumptions used:

- Site characterization: Eight week duration for a five man crew (labor - $98,000, travel and living - $28,000, analytical - $32,000, equipment - $4,000, miscellaneous supplies - $4,000)
- Stormwater and surface water control: Approximately 4,000 linear feet of piping, installation of small settling basin
- Building D111 Decontamination: Three month duration for 15 man crew (labor - $395,000, travel/living/equipment/analytical/misc - $215,000)
- Building D102 Decontamination: Two month duration for 15 man crew (labor - $266,000, travel/living/equipment/analytical/misc - $150,000)
- Mislocated slag: Approximately 8,000 yd^3 of slag is excavated and relocated to the Storage Yard.
- Hudson's Branch Water Shed: Approximately 2,400 yd^3 of soil is excavated and relocated to the Storage Yard
- Storage Yard: Approximately 300 ft x 300 ft area is capped with clay and covered with a geotex cover.
- Final Status Survey: Survey duration is seven weeks for a four-man crew. (Labor - $75,000, travel and living - $18,000, Analytical - $23,000, equipment - $4,000, and miscellaneous - $3,000)
- Long-term Surveillance: Assumes installation of 6 monitoring wells, 30-year monitoring period (6 wells at $5,000 per well, well sampling

four times per year for 30 years at $200 per sample is $144,000, allowance for repair of cap and wells of $26,000)

- Decommissioning Plan: Level of effort is based on conduct of similar projects, and includes time for re-writes, regulatory negotiation, and other ancillary items.

Both capital and operation and maintenance (O & M) costs were considered, where appropriate, along with O & M costs that may continue beyond implementation of the decommissioning action. Present-worth analysis was used for expenditures that occur over different time periods.

The estimated cost of decommissioning the Newfield site pursuant to this conceptual decommissioning plan is $2,367,600. Table 4 contains a break down of costs with respect to the individual procedures.

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TABLES

TABLE 1

Approximate Source Material Inventory as of October, 1991

Location	Volume (m^3)	Apparent Density (kg/m^3)	Total Mass (kg)	Mass of ^{232}Th (kg)	Mass of ^{238}U (kg)
FeCb Slag Pile, Standard	$1.68X10^4$	$2.74X10^3$	$4.61X10^7$	$2.17X10^5$	$2.77X10^4$
FeCb Slag Pile, High Radio	$1.04X10^3$	$3.06X10^3$	$3.19X10^6$	$1.09X10^4$	$9.57X10^2$
Lime Pile	$1.51X10^4$	$8.87X10^2$	$1.34X10^7$	$6.16X10^3$	$6.69X10^2$
Pyrochlore (Active Inventory)	--	--	--	$9.07X10^2$	$7.30X10^1$
TOTAL	--	--	--	$2.35X10^5$	$2.94X10^4$

TABLE 2:

Radioactive Residual Materials Generated at Shieldalloy

Definition	Description
Baghouse dusts	Dry solids which may contain licensable quantities of radioactive materials
Baghouse Bags	Combustible dry solids which may be contaminated with licensable quantities of radioactive materials
Pyrochlore supersacks	Combustible dry solids used to contain pyrochlore ores which may be contaminated with licensable quantities of radioactive materials
Ferrocolumbium slag	Dry solids known to contain licensable quantities of radioactive materials
Radioactive dry combustible material	Combustible, dry solids including plastic bags, absorbent paper and protective equipment used to prevent the spread of contamination.

TABLE 3

Summary of Decommissioning Procedure

Item to be Decommissioned	Procedural Step	General Description
Site-Wide	Site characterization	Evaluate adequacy of existing characterization data; develop a characterization plan; perform additional characterization, as required.
Site-Wide	Generation of Technical Basis Document	Develop the technical basis and justification for the decommissioning alternative, and generate site-specific release criteria.
Site-Wide	Stormwater and surface water control	Ditch and install drain grates/piping; excavate and install small settling basin.
Site-Wide	Generate Decommissioning Plan	Develop the site decommissioning plan including detailed work plan addressing activities to be performed, health and safety plan, quality assurance plan, and final status survey plan.
D111	Decontaminate building	Perform decontamination of equipment, building surfaces, and surrounding area; dispose of materials exceeding release criteria in Storage Yard; release others for unrestricted use.
D102	Decontaminate building	Perform decontamination of equipment, building surfaces, and surrounding area; dispose of materials exceeding release criteria in Storage Yard; release others for unrestricted use.

Item to be Decommissioned	Procedural Step	General Description
Mislocated slag	Extract and transfer to Storage Yard	Locate slag areas through surveys, sampling, and/or review of historical data; extract areas exceeding release criteria and transport to Storage Yard for disposal.
Hudson's Branch Watershed	Extract and transfer materials in excess of release criteria.	Locate areas exceeding release criteria through surveys, sampling and/or historical data; extract contaminated areas and transport to Storage Yard for disposal.
Storage Yard	Cap	Stabilize baghouse dust; place all site radioactive materials in Storage Yard; grade; in-place compaction; install 4-foot clay cap and geotex cover.
Site-wide	Area restoration	Backfill excavations with clean fill after completion of verification survey; sow new grass
Site-wide	Final status survey	Pursuant to (draft) NUREG/CR-5849, conduct site-wide radiation and contamination surveys; perform sampling and analysis of site media.
Site-wide	Long-term surveillance and perpetual care program	Well installation; planned and periodic well sampling and reporting; visual inspections of cap integrity; cap maintenance; planned and periodic reports to appropriate agencies

TABLE 4

Estimated Cost of Decommissioning

Item to be Decommissioned	Procedural Step	Cost Estimate
Site-Wide	Site characterization	168,000
Site-Wide	Generation of Technical Basis Document	77,000
Site-Wide	Stormwater and surface water control	40,000
Site-Wide	Generate Decommissioning Plan	30,000
D111	Decontaminate building	614,000
D102	Decontaminate building	416,000
Mislocated slag	Extract and transfer to Storage Yard	190,000
Hudson's Branch Watershed	Extract and transfer materials in excess of release criteria.	30,000
Storage Yard	Grade and cap	605,000
Site-wide	Area restoration	14,600
Site-wide	Final status survey	123,000
Site-wide	Long-term surveillance and perpetual care program	200,000
TOTAL		$2,517,600

TABLE 5

RESRAD Input Parameter Values

Parameter	Input Value
Area of contaminated zone (m^2)	9.560E+03
Thickness of contaminated zone (m)	5.500E+00
Length parallel to aquifer flow (m)	1.330E+02
Basic radiation dose limit (mrem/yr)	1.000E+01
Time since placement of material (yr)	0.000E+00
Initial principal radionuclide (pCi/g ^{232}Th)	5.160E+02
Initial principal radionuclide (pCi/g ^{238}U)	2.020E+02
Cover depth (m)	1.220E+00
Density of contaminated zone (g/cm^3)	1.730E+00
Contaminated zone erosion rate (m/yr)	2.790E-04
Contaminated zone total porosity	4.000E-01
Contaminated zone effective porosity	2.000E-01
Contaminated zone hydraulic conductivity (m/yr)	1.000E+01
Contaminated zone b parameter	5.300E+00
Evapotranspiration coefficient	6.000E-01
Precipitation (m/yr)	1.000E+00
Irrigation (m/yr)	2.000E-01
Irrigation mode	Overhead
Runoff coefficient	2.000E-01
Watershed area for nearby stream or pond (m^2)	1.000E+06
Density of saturated zone (g/cm^3)	1.600E+00
Saturated zone total porosity	3.000E-01
Saturated zone effective porosity	2.000E-01
Saturated zone hydraulic conductivity (m/yr)	2.225E+02
Saturated zone hydraulic gradient	4.000E-03

Parameter	Input Value
Saturated zone b parameter	5.300E+00
Water table drop rate (m/yr)	6.100E-01
Well pump intake depth (m below water table)	1.000E+01
Model: Nondispersion (ND) or Mass Balance (MB)	ND
Individual's use of groundwater (m^3/yr)	1.500E+02
Number of unsaturated zone strata	1
Unsaturated zone 1, thickness (m)	4.000E+00
Unsaturated zone 1, soil density (g/cm^3)	1.600E+00
Unsaturated zone 1, total porosity	4.000E-01
Unsaturated zone 1, effective porosity	2.000E-01
Unsaturated zone 1, soil-specific b parameter	5.300E+00
Unsaturated zone 1, hydraulic conductivity (m/yr)	1.000E+02
Distribution coefficients for Ra-226:	
Contaminated zone (cm^3/g)	7.000E+01
Unsaturated zone 1 (cm^3/g)	7.000E+01
Saturated zone (cm^3/g)	7.000E+01
Leach rate (per year)	0.000E+00
Distribution coefficients for Th-232:	
Contaminated zone (cm^3/g)	6.000E+04
Unsaturated zone 1 (cm^3/g)	6.000E+04
Saturated zone (cm^3/g)	6.000E+04
Leach rate (per year)	0.000E+00
Distribution coefficients for U-238:	
Contaminated zone (cm^3/g)	5.000E+01
Unsaturated zone 1 (cm^3/g)	5.000E+01
Saturated zone (cm^3/g)	5.000E+01

Parameter	Input Value
Leach rate (per year)	0.000E+00
Distribution coefficients for daughter Pb-210:	
Contaminated zone (cm^3/g)	1.000E+02
Unsaturated zone 1 (cm^3/g)	1.000E+02
Saturated zone (cm^3/g)	1.000E+02
Leach rate (per year)	0.000E+00
Distribution coefficients for daughter Ra-228:	
Contaminated zone (cm^3/g)	7.000E+01
Unsaturated zone 1 (cm^3/g)	7.000E+01
Saturated zone (cm^3/g)	7.000E+01
Leach rate (per year)	0.000E+00
Distribution coefficients for daughter Th-228:	
Contaminated zone (cm^3/g)	6.000E+04
Unsaturated zone 1 (cm^3/g)	6.000E+04
Saturated zone (cm^3/g)	6.000E+04
Leach rate (per year)	0.000E+00
Distribution coefficients for daughter Th-230:	
Contaminated zone (cm^3/g)	6.000E+04
Unsaturated zone 1 (cm^3/g)	6.000E+04
Saturated zone (cm^3/g)	6.000E+04
Leach rate (per year)	0.000E+00
Distribution coefficients for daughter U-234:	
Contaminated zone (cm^3/g)	5.000E+01
Unsaturated zone 1 (cm^3/g)	5.000E+01
Saturated zone (cm^3/g)	5.000E+01
Leach rate (per year)	6.504E-04

Parameter	Input Value
Inhalation rate (m^3/yr)	8.400E+03
Mass loading for inhalation (g/m^3)	2.000E-04
Dilution length for airborne dust, inhalation (m)	3.000E+00
Occupancy factor, inhalation	4.500E-01
Occupancy and shielding factor, external gamma	6.000E-01
Shape factor, external gamma	1.000E+00
Fruits, vegetables and grain consumption (kg/yr)	1.600E+02
Leafy vegetable consumption (kg/yr)	1.400E+01
Milk consumption (l/yr)	9.200E+01
Meat and poultry consumption (kg/yr)	6.300E+01
Fish consumption (kg/yr)	5.400E+00
Other seafood consumption (kg/yr)	9.000E-01
Soil ingestion rate (g/yr)	3.650E+01
Drinking water intake (l/yr)	4.100E+02
Fraction of drinking water from site	1.000E+00
Fraction of aquatic food from site	5.000E-01
Livestock fodder intake for meat (kg/day)	6.800E+01
Livestock fodder intake for milk (kg/day)	5.500E+01
Livestock water intake for meat (l/day)	5.000E+01
Livestock water intake for milk (l/day)	1.600E+02
Mass loading for foliar deposition (g/m^3)	1.000E-04
Depth of soil mixing layer (m)	1.500E-01
Depth of roots (m)	9.000E-01
Drinking water fraction from ground water	1.000E+00
Livestock water fraction from ground water	1.000E+00
Irrigation fraction from ground water	1.000E+01

Parameter	Input Value
Total porosity of the cover material	4.000E-01
Total porosity of the building foundation	1.000E-01
Volumetric water content of the cover material	5.000E-02
Volumetric water content of the foundation	1.000E-02
Diffusion coefficient for radon gas (m/sec):	
In cover material	2.000E-06
In foundation material	2.000E-08
In contaminated zone soil	2.000E-06
Radon vertical dimension of mixing (m)	2.000E+00
Average annual wind speed (m/sec)	2.000E+00
Average building air exchange rate (l/hr)	1.000E+00
Height of the building (room) (m)	2.500E+00
Building interior area factor	1.000E+00
Bulk density of building foundation (g/cm^3)	2.400E+00
Thickness of building foundation (m)	1.500E-01
Building depth below ground surface (m)	1.000E+00
Fraction of time spent indoors	5.000E-01
Fraction of time spent outdoors (on site)	2.000E-01
Emanating power of Rn-222 gas	2.000E-01
Emanating power of Rn-220 gas	1.000E-01

FIGURES

FIGURE 1

Dose to Farm Family from Radionuclides in Residual Materials