NRC FORM 313 (8-1999) 10 CFR 30, 32, 33 34, 35, 36, 39 and 40 — U. S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB: NO. 3150-0120 EXPIRES:08/31/2002
APPLICATION FOR MATERIAL LICENSE	Estimated burden per response to comply with this mandatory information collection request: 7.4 hours. Submittal of the application is necessary to determine that the applicant is qualified and that adequate procedures exist to protect the public health and safety. Send comments regarding burden estimate to the Records Management Branch (T-6 E6), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to bjs1@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0120), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATION FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

DIVISION OF INDUSTRIAL AND MEDICAL NUCLEAR SAFETY
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS:

IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

LICENSING ASSISTANT SECTION
NUCLEAR MATERIALS SAFETY BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406-1415

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

SAM NUNN ATLANTA FEDERAL CENTER
U. S. NUCLEAR REGULATORY COMMISSION, REGION II
61 FORSYTH STREET, S.W., SUITE 23T85
ATLANTA, GEORGIA 30303-8931

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

MATERIALS LICENSING SECTION
U.S. NUCLEAR REGULATORY COMMISSION, REGION III
801 WARRENVILLE RD.
LISLE, IL 60532-4351

ALASKA, ARIZONA, ARKANSAS, CALIFORNIA, COLORADO, HAWAII, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEVADA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, OREGON, PACIFIC TRUST TERRITORIES, SOUTH DAKOTA, TEXAS, UTAH, WASHINGTON, OR WYOMING, SEND APPLICATIONS TO:

NUCLEAR MATERIALS LICENSING SECTION
U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TX 76011-8064

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S.NUCLEAR REGULATORY COMMISSION JURISDICTIONS.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER ______
- [X] C. RENEWAL OF LICENSE NUMBER SMB-920

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip code)*

Cabot Supermetals, Inc.
P.O. Box 1608, County Line Road
Boyertown, PA 19512-1608

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

Cabot Supermetals, Inc.
County Line Road
Boyertown, PA

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

Timothy Knapp, RSO

TELEPHONE NUMBER

(610) 369-8520

SUBMIT ITEMS 5 THROUGH 11 ON 8-1/2 X 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL.
   a. Element and mass number; b. chemical and/or physical form; and c. maximum amount which will be possessed at any one time.
6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.
7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING EXPERIENCE.
8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.
9. FACILITIES AND EQUIPMENT.
10. RADIATION SAFETY PROGRAM.
11. WASTE MANAGEMENT.
12. LICENSEE FEES *(See 10 CFR 170 and Section 170.31)*
    FEE CATEGORY | AMOUNT ENCLOSED $
13. CERTIFICATION. *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

    THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, 36, 39 AND 40, AND THAT ALL INFORMATION CONTAINED HEREIN IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

    WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

CERTIFYING OFFICER – TYPED/PRINTED NAME AND TITLE	SIGNATURE	DATE
T. H. Odle, Vice President, General Manager	[signature]	2-6-2004

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	AMOUNT RECEIVED	CHECK NUMBER	COMMENTS
			$		
APPROVED BY				DATE	

SUPPLEMENTAL INFORMATION FOR RENEWAL APPLICATION FOR LICENSE NUMBER SMB-920

Prepared for:

CABOT SUPERMETALS

BOYERTOWN, PA

Prepared by:

WESTON SOLUTIONS, INC.

MARCH 23, 2004

TABLE OF CONTENTS

SECTION **PAGE**

1. PURPOSE OF APPLICATION ... 1
2. NAME AND MAILING ADDRESS OF APPLICANT ... 1
3. ADDRESS WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED ... 1
4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION ... 1
5. RADIOACTIVE MATERIALS ... 1
6. PURPOSES FOR WHICH RADIOACTIVE MATERIAL WILL BE USED ... 1
7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING EXPERIENCE ... 2
8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS ... 3
9. FACILITIES AND EQUIPMENT ... 3
9.1 PLANT FACILITIES AND PROCESS DESCRIPTION ... 3
9.1.1 General Plant Information ... 3
9.1.2 Improvements to Control of Licensed Material ... 5
9.2 SITE ACCESS AND RESTRICTED AREAS ... 6
9.3 FACILITY OR SITE CHANGES ... 6
10. RADIATION SAFETY PROGRAM ... 7
10.1 COMMITMENT TO RADIATION SAFETY PROGRAM IMPLEMENTATION ... 7
10.2 ORGANIZATION AND PERSONNEL QUALIFICATIONS ... 7
10.3.1 Corporate Management ... 7
10.3.2 Site Management ... 9
10.4 ALARA COMMITTEE ... 10
10.5 WRITTEN PROCEDURES ... 11
10.6 TRAINING IN THE USE OF RADIOACTIVE MATERIAL ... 11
10.7 METHODS OF EXPOSURE CONTROL ... 13
10.7.1 Administrative Controls ... 13
10.7.2 Engineering Controls ... 13
10.7.3 Personal Protective Equipment ... 14
10.7.4 Hazard Monitoring Systems ... 14
10.8 RADIATION MONITORING INSTRUMENTS ... 15
10.9 RADIATION SURVEYS AND MONITORING PROGRAMS ... 15
10.9.1 Occupational Monitoring ... 15
10.9.2 Environmental Programs ... 17
11. WASTE MANAGEMENT ... 37
11.1 PAST PRACTICES AND DISPOSAL HISTORY ... 37
11.2 WASTE DISPOSAL PLANS FOR ONGOING OPERATIONS ... 37
11.3 DECOMMISSIONING FUNDING PLAN ... 38
12. LICENSE FEES ... 39

LIST OF APPENDICES

APPENDIX A Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant, June 9, 2003

APPENDIX B Review of the Bioassay Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant, June 9, 2003

APPENDIX C Species Impact Review Letters

APPENDIX D Letters Justifying Termination of Forage Crop Sampling

APPENDIX E Technical Basis for the Location and Screen Interval of Groundwater Monitor Wells at Cabot Performance Materials Corporation Boyertown, Pennsylvania Plant, August 9, 2002

APPENDIX F Hydrology Figures

APPENDIX G Dose Assessment for Disposal of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania, April 22 2003

APPENDIX H Cabot Supermetals, Inc. 2004 Decommissioning Cost Estimate for the Boyertown, Pennsylvania Site, March 11, 2004

FIGURES

Figure **Page**

Figure 9-1. Site Plan 4

Figure 10-1. Boyertown Facility Organizational Structure 8

Figure 10-2. Average Ambient Air Fluoride Concentrations. 25

Figure 10-3. Wind Direction as a percentage of total time with wind. 36

Figure 10-4. Wind Direction by groups. 36

TABLES

Table **Page**

Table 10-1. Summary Table of Environmental Monitoring Programs, 2004 License Renewal 22

Table 10-2. Summary of Background-Corrected Ambient Air Samples 23

Table 10-3. Annual Doses at Site Boundary Calculated from Air Effluent Data for Comparison to 10 mrem/year Constraint Limit (mrem/year) 24

Table 10-4. Results of Quarterly Radon Monitoring at the Plant Site Boundary (pCi/L) 25

Table 10-5. Gross alpha and beta results (pCi/g) for upstream, downstream, and outfall monitoring locations 27

Table 10-6. Gross alpha and beta results (pCi/g) for sediment in upstream and downstream monitoring locations 27

Table 10-7. Ground water monitoring results (pCi/L) for Facility wells 28

Table 10-8. Ground water monitoring results (pCi/L) for Bulk Storage Bin wells 29

Table 10-9. Groundwater Monitoring Well Construction Specifications Cabot Performance Materials Boyertown, Pennsylvania 30

Table 10-10. Mean and extremes of monthly average temperature (°F) 35

Table 10-11. Mean, maximum daily and monthly mean rainfall. 35

1. PURPOSE OF APPLICATION

Refer to Form 313 (submitted as separate document) for which this document provides supplemental information.

2. NAME AND MAILING ADDRESS OF APPLICANT

Refer to Form 313 (submitted as separate document) for which this document provides supplemental information.

3. ADDRESS WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

Refer to Form 313 (submitted as separate document) for which this document provides supplemental information.

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

Refer to Form 313 (submitted as separate document) for which this document provides supplemental information.

5. RADIOACTIVE MATERIALS

a. Element and mass number: Natural uranium and thorium.
b. Physical form: Any, but primarily solid feed materials for plant operations.
c. Maximum amount possessed at any time: 400 tons, as elemental uranium and thorium.

6. PURPOSES FOR WHICH RADIOACTIVE MATERIAL WILL BE USED

This application requests renewal of license number SMB-920 for Cabot Supermetals (CSM), formerly Cabot Performance Materials. The company changed its name in 2002, but made no changes in its location, operations, or corporate management personnel. CSM is a business unit of:

Cabot Corporation
75 State St.
Boston, MA 02109-1806

The parent corporation under which CSM operates is a $1.5 billion specialty chemical company. CSM is one of 14 business entities that compose Cabot Corporation. Each of those 14 businesses has responsibility for individual performance of operations. Neither CSM, nor Cabot Corporation is a foreign owned business.

The facility covered under this license and the headquarters for CSM are located at the following address:

Cabot Supermetals
County Line Road
Boyertown, PA 19512

Authorized uses include receipt, possession, and processing by CSM at the Boyertown, Pennsylvania facility in accordance with the statements, representations, and conditions specified in this application for license renewal and attached supplements. Statements, representations, and conditions specified in this application replace in whole and supersede all prior submittals.

This license allows the receipt and possession of feed material containing uranium and thorium to be processed for tantalum and niobium, two non-radioactive products that are used in the electronics industry. CSM expects these operations to remain economically viable for the foreseeable future and requests this license to be issued for the maximum period of time allowed by the regulations.

Although CSM is licensed to handle source material under the NRC category for uranium mills, CSM's Boyertown plant is not a uranium operation and is of a much smaller scale than most uranium mills. The majority of the Boyertown plant is dedicated to chemical processing, so radioactive materials are handled in a very limited number of buildings and work areas. The quantities of licensed material that are received as feed material and processed or stored at the site are minimal compared to the massive quantities that are handled at uranium mills. Incoming ores are contained in drums until they are fed into the process, not exposed to the elements in large quantities while stored on open pad sites. None of the radioactive constituents of the ore are concentrated, unlike uranium mills that concentrate uranium as an end product. CSM's tantalum and niobium products do not contain any of the licensed radionuclides. Virtually all of the radionuclides in the feed material are retained in the presscake that is transferred to the bulk storage bins until it is ultimately disposed off-site.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING EXPERIENCE

The individual responsible for the execution of the radiation safety program at the Boyertown facility is the Radiation Safety Officer (RSO). Duties and responsibilities of the Radiation Safety Officer are described in section 10 of this application. CSM requires that the RSO will have the following training and experience as a minimum:

- BS degree in biology or a physical science
- Completion of a basic radiation safety course
- At least two years experience in the safe use and handling of radioactive material

The Radiation Safety Officer also attends a professional society meeting, seminar, or radiation safety training session at least once every two years as part of CSM's professional development program. The RSO for this license is Timothy Knapp. CSM will notify the NRC in writing in the event that Mr. Knapp vacates the RSO position. CSM will ensure that the duties of the RSO are assigned to and carried out by a responsible, qualified individual at all times during plant operation, and will implement a system to provide back-up, on-call support for the RSO to ensure that lapses do not occur.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS

Training for individuals working with radioactive material is described in Section 10.5 as part of the Radiation Safety Program. Training for individuals working in or frequenting restricted areas will be commensurate with the individuals' duties and with the requirements of 10 CFR 19 and applicable sections of Regulatory Guide 8.31.

9. FACILITIES AND EQUIPMENT

The description of facilities and equipment provided herein is accurate and current as of the date of this application. CSM may change facilities and equipment as required to meet its business needs with the stipulation that any changes expected to impact the handling, control, or monitoring of licensed radioactive material will be made in accordance with the conditions of this license and all applicable federal, state, and local rules and regulations. The U.S. Nuclear Regulatory Commission (NRC) will be informed in writing of any significant changes in facilities and operations.

9.1 PLANT FACILITIES AND PROCESS DESCRIPTION

The Boyertown facility is sited on approximately 200 acres located along both sides of County Line Road about 1.5 miles (2.4 km) northeast of Boyertown, Pennsylvania. The population of Boyertown was determined to be 3759 during the 1990 census and has remained relatively constant since that time. The site resides in two counties, Berks and Montgomery, with County Line Road marking the boundary between the two. The topography is relatively flat with a slightly elevated knoll just northeast of the main plant area. There is a stream running along the western site boundary, and site drainage is generally south and west. There has been no significant change in the residential areas nearest to the site since the last license renewal. Figure 9-1 presents the layout of the operations, and includes a legend to identify pertinent features such as site buildings and structures, on-site roadways, points of vehicular and pedestrian access, and locations where licensed materials are present. The areas where radioactive materials are received, handled, stored, and processed represent a small fraction of the overall plant site. It is also important to note that ore is typically received and stored in containers such as drums, not in exposed bulk quantities as is common practice at uranium mills. The ore is emptied from the containers under controlled and monitored conditions in Building 73.

9.1.1 General Plant Information

The Boyertown Plant is operated by Cabot Supermetals, Inc (CSM) and receives and processes low-grade uranium ores to extract tantalum and niobium as product materials. The plant ore feed rate is approximately 4,350 kilograms per day (9,600 pounds per day), 5 days per week or 1,200 ton/yr. Based on analytical results from 207 samples collected throughout 2001, the ore averages 0.165% uranium and 0.057% thorium. Feed materials qualify as uranium and thorium ore, but those source materials are not processed by CSM with the intent of concentrating the source material. The uranium and thorium constituents of the ores would be contaminants in the product and remain in the residual ore materials stored on-site or transported and transferred to another source material licensee. Other significant differences that exist between typical uranium mills and the Boyertown plant operations include the following:

- Ores are generally received in drums, not in bulk shipments such as train cars or large capacity haul trucks.

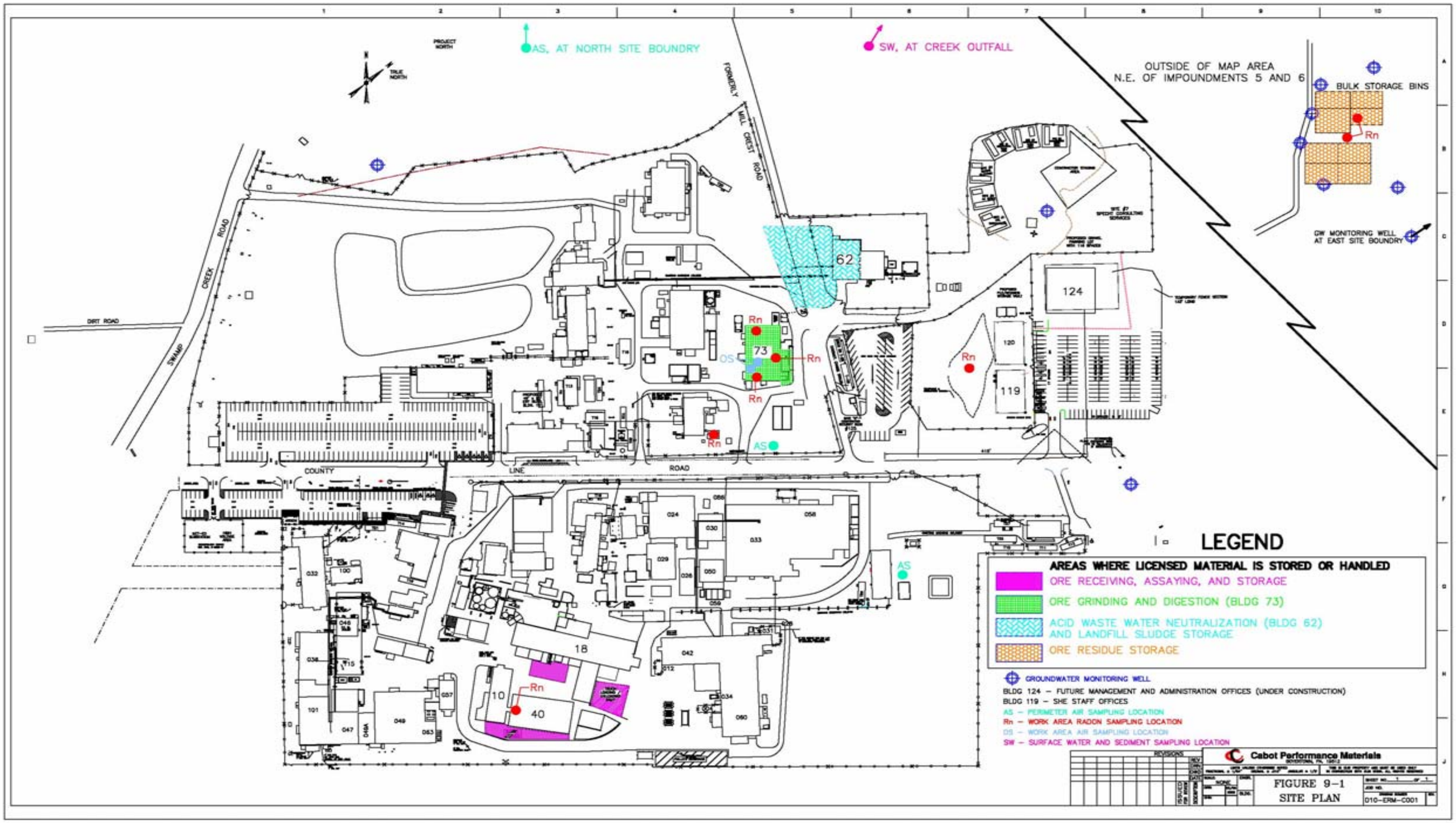

Figure 9-1. Site Plan

- The Boyertown facility processes much smaller quantities of material than a uranium mill.
- CSM does not stockpile its ore in exposed piles that are susceptible to wind and rain erosion. Rather the ores are retained in their shipping drums until they are placed inside a building and fed into the process.
- The ores received by CSM are typically sand-like and require far less grinding and crushing than most uranium ores.
- Uranium and thorium are not concentrated in the CSM process, and residual ore materials are stored temporarily inside buildings so they are not susceptible to wind erosion and do not require engineered cover materials.

Ore residues in the form of presscake are transported on-site to the bulk storage bins for temporary storage until they are shipped off-site. Virtually all the radioactivity present in the ore is transferred into these residues, except for the trace amounts that are passed into the wastewater filtercake that is described below. The plant produces about 1,000 tons/yr of the presscake. In 1997 and 1998, CSM shipped approximately 18,000 tons of presscake for reprocessing as alternate feed at a uranium recovery facility (mill) in Utah. The average concentration of the shipped material was 2,800 pCi/g for a total calculated uranium and thorium activity of 45 Ci.

Wastewater is treated with the addition of lime and filter pressing to adjust the pH and remove solids. The levels of radioactivity in the filtercake are marginally greater than background, and the largest contributor is the lime that is added to treat the water. Daily accumulations of the residue are transported to a landfill for final disposal after the content of uranium and thorium in the material is determined to be less than 10 pCi/g. From 1999 through September 2002, the uranium and thorium content averaged 4.2 and 1.0 parts per million (2.8 and 0.1 pCi/g), respectively. CSM produces about 19,000 tons/yr of this residue.

9.1.2 Improvements to Control of Licensed Material

The bulk storage bins are designed to contain the ore residues (presscake) in a secure manner that isolates them from the environment. In 2002 CSM initiated a project to maintain and improve the bins after noting that the roof to wall interface was no longer preventing precipitation from entering the bins. The improvements have effectively eliminated the potential for surface water and precipitation intrusion into the bins. All but one of the bins were empty because of the previous shipments of the presscake to sites licensed to accept alternate feed materials, facilitating the following improvements:

- Placing rubber liners across the concrete floors and up the walls to further ensure that potential freestanding liquids would be retained in the bins,
- Replacing concrete blocks that had loosened or fallen repaired upper sidewalls,
- Extending the upper sidewalls to meet with the roof to prevent windblown precipitation from entering the bins, and
- Repairing and improving rain gutters and grading around the bins to prevent runoff from entering the bins.

An additional structural improvement was made to Building 73, where the drums of ore are temporarily stored prior to emptying them into the circuit. A roof extension and sidewalls were added to the northwest end of the building to provide a more secure and weather-protected storage location for the small quantity of drums that are staged there. This structural shelter supplements the protection that was already provided by the containers that hold the ore until it is introduced into the circuit.

9.2 SITE ACCESS AND RESTRICTED AREAS

The perimeters of the Boyertown plant site are fenced into the two areas separated by County Line Road. The two primary access gates (pedestrian and vehicle access) are staffed with security guards to prevent inadvertent or unauthorized access. Secondary access gates are equipped with automatic identification card readers that release the magnetic locks when an authorized card is presented.

Controlled work areas include the buildings in which radioactive materials are handled and processed (Building 73), and where ore and ore residues (presscake)are stored temporarily in the Bulk Storage Bins on the northeast end of the site. Access to those areas is controlled administratively through general site access procedures, as described above, signs posted in accordance with regulations, and training provided to employees, visitors, and contractors.

The Bulk Storage Bins are constructed to prevent erosion, migration, or dispersal of the residues. Each bin is constructed with a concrete floor, block walls, and a metal roof to fully contain the presscake and ensure secure storage and prevent erosion and dispersion. They are located in an area surrounded by a chain-link security fence with a single point of access that is controlled by a locked gate. The key to the gate is retained at security, and authorized individuals must sign a logbook in order to receive a key. Plant security guards patrol the access road to the bulk storage bins periodically.

The flow of licensed material is as follows. Ores contained in closed drums are received on trucks at the receiving area. They are assayed and transported to the process staging area while still in their containers. Individual drums are moved into the ore feed area in Building 73, as needed. The ore is fed through a grinding circuit into the plant processing tanks where acid is used to separate the tantalum and niobium from the ore. Ore residues are separated from the process as sludge or moist solids and transported to the Bulk Storage Bins. Solid materials from an on-site acidic wastewater neutralization plant are analyzed to ensure they contain concentrations of uranium and thorium that are below the release limits established in this license, and shipped off-site for disposal at a nearby landfill.

9.3 FACILITY OR SITE CHANGES

CSM considered, but never commissioned, the “second stage digester” as described in the previous EA. In addition, under current business conditions CSM does not intend to reprocess ore residues onsite; however, CSM may contract this service to a third party that is licensed and permitted to perform such work. The only current project potentially affecting the plant process is the proposed new wastewater treatment system. This system will upgrade CPM’s current treatment technology and minimize operational costs. This change has been approved by the NRC on August 27, 2002 and is described below. CSM will incorporate applicable review and permitting procedures as required by other federal, state and municipal authorities.

CSM plans to modify its wastewater treatment process by segregating the “raffinate” wastewater from its composite wastewater stream. Currently CSM combines the raffinate wastewater stream with other wastewater streams to precipitate fluoride by adding lime. The segregated raffinate wastewater stream could be characterized as a mixed hazardous waste based on corrosivity (D002) and gross alpha concentrations in the range of 0.001 - 0.021 μCi/l.

Wastewater treatability studies have shown that the fluoride complexes contained in the raffinate wastewater stream, when combined with the other wastewater streams at the facility, reduce the effectiveness of precipitation by lime addition. These studies also showed that segregation of the raffinate wastewater stream and treatment with a combination of lime and de-watered wastewater treatment sludge allows for effective treatment of both the remaining combined stream and the segregated raffinate stream. The resulting stream would contain 40-50% solids.

In addition, the treatability studies have shown the resultant solids would not exhibit any hazardous waste characteristic, and the radiological constituents would be well below the filtercake release limit justified by the dose assessment provided referenced in Section 11 of this document, and the related license condition. Therefore, CSM believes that the solids generated by the proposed segregation and on-site treatment of this mixed hazardous waste stream would continue to qualify for ultimate disposal as a residual waste.

10. RADIATION SAFETY PROGRAM

CSM has conducted operations at the Boyertown facility under license SMB-920 for more than 20 years, and has successfully completed renewals and amendments to that license on several occasions. The processes and facilities have not significantly changed other than to add capacity or improve the efficiency of the plant operations. In addition, license inspections have been completed at the facility on several occasions and the most recent inspection was conducted in September / October 2001 and resulted in only minor (Severity Level IV) violations. This application for renewal of the license summarizes the current conditions and ongoing programs at the facility, including the latest improvements that have been designed to address input from the on-site inspection.

10.1 COMMITMENT TO RADIATION SAFETY PROGRAM IMPLEMENTATION

CSM is committed to establishing, implementing, and maintaining a Radiation Safety Program that meets or exceeds the regulatory requirements, including 10 CFR 20 Subpart B, and complies with accepted industry practices. It shall be the objective of the program to ensure that exposures to employees and members of the general public from radioactive materials used by CSM are kept as low as reasonably achievable (ALARA). The Radiation Safety Program is currently maintained by CSM at the Boyertown facility in accordance with the conditions defined in source material license SMB-920. It is worth noting that, beginning in calendar year 2000, CSM initiated changes in the organizational structure and management personnel in the Safety, Health, and Environment (SH&E) Department into which the RSO reports. The radiation safety programs have been improved under this revised structure and the following subsections describe the current programs. Changes from past programs are specifically identified throughout these subsections.

10.2 ORGANIZATION AND PERSONNEL QUALIFICATIONS

This section describes the organizational structure of the Boyertown facility and the roles and responsibilities of managers and staff that are relevant to the radiation safety programs at the site. An organizational chart showing the individuals whose responsibilities may directly impact the success of the radiation safety programs is presented in Figure 10-1. CSM may revise its management structure in order to address the changing needs of its operations and business sector. A license revision or notification to the NRC is required only for changes that negatively impact the independent reporting path for the RSO, the authorities of the RSO, or the involvement of the RSO in the operational management of the facility. Additional information regarding those individuals is provided in the following subparts of section 10.2.

10.3.1 Corporate Management

CSM corporate management is lead by the Vice President and General Manager (VP/GM) of the Boyertown facility. He has overall responsibility for the activities at the site, and profitability of the

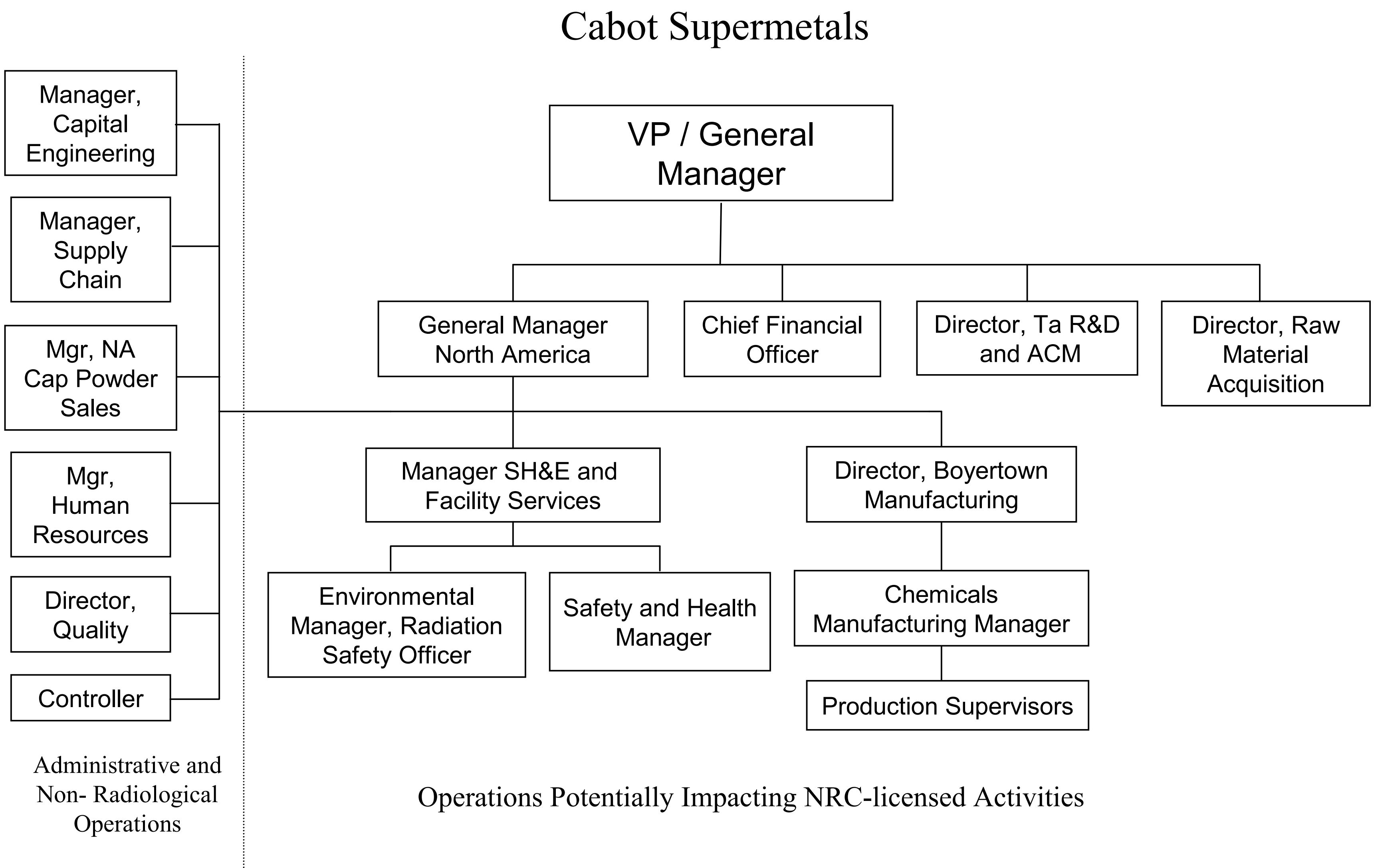

Figure 10-1. Boyertown Facility Organizational Structure

operations. He is ultimately responsible for the health and safety of the site employees, and protection of the environment and members of the general public.

Additional corporate managers include the directors and managers who report to the VP/GM. As represented in Figure 10-1, there are four individuals reporting to the VP/GM who have responsibilities that may directly impact the license or the implementation of the radiation safety programs. The managers responsible for SH&E functions and Manufacturing operations report to the General Manager, North America (GM/NA). Those managers have the authority to halt operations that appear to be unsafe, and may be called upon to approve the restart of operations after such a shutdown. The Manager, SH&E and Facility Services is responsible for the development and implementation of the SH&E programs and is the direct supervisor of the Radiation Safety Officer (RSO). The Manager, SH&E and Facility Services has overall responsibility for the technical quality and adequacy of the radiation safety program. He ensures that the RSO has the support and resources necessary to conduct his work activities. He also provides routine feedback to corporate management regarding the status of his programs and interacts with the other directors as necessary to ensure they understand and implement the radiation safety programs. The SH&E functions and operations functions report independently to the GM/NA to provide objective audit, review, and control activities for the SH&E programs. In this independent role, the SH&E staff and managers provide a mechanism by which any employee can report potentially unsafe conditions or safety concerns. The SH&E managers promptly assess and resolve any reported concerns.

The remaining three key individuals that report to the VP/GM are the Chief Financial Officer, the Director, Tantalum Research and Development and ACM, and the Director, Raw Material Acquisition. They are responsible for individual aspects of the day-to-day operations of various CSM facilities. They ensure that the plant operations comply with the company's policies and procedures.

10.3.2 Site Management

The Chemicals Manufacturing (CM) Manager reports to the Director, Boyertown Manufacturing and has responsibility on a day-to-day basis for ensuring that the Boyertown plant complies with the company's policies and procedures, including the site radiation safety programs. The CM Manager has the authority to immediately terminate any activity that is found to be an imminent threat to health, safety, or property and must approve startup of operations after any such shutdown.

The Radiation Safety Officer reports directly to CSM's Manager, SH&E and Facility Services and is responsible for monitoring compliance with the conditions of the radioactive materials license and relevant local, state and federal regulations. The RSO has access to all levels of operational management as necessary for the execution of his/her duties. The RSO has the authority to immediately terminate any activity that is found to be an imminent threat to health, safety, or property, or that is likely to violate the license conditions or radiation safety program requirements, and this authority cannot be revoked. A full-time employee fills the RSO position and the Manager, SH&E and Facility Services provide staff as necessary to support the position. Specific qualifications and training for the RSO are described above in ITEM 7 of this document.

Specific duties of the RSO include, but are not limited to the following:

- Membership on the ALARA committee
- Monitoring activities involving radioactive material, including conducting routine measurements and special surveys of areas where radioactive material is used.
- Determining compliance with rules and regulations and license conditions.

- Providing guidance on the proper shipping of all radioactive material from the CSM facility and ensuring compliance with applicable regulations of the U.S. Department of Transportation (DOT) and other appropriate agencies.
- Assuring that an accurate inventory of source material is maintained.
- Managing the radioactive waste program.
- Monitoring the storage of source material not in use.
- Performing and arranging for calibration of instruments.
- Assuring leak tests are performed on generally licensed gauging devices.
- Coordinating the radiation safety training of personnel before they are allowed to work independently in restricted areas, and ensuring that class information is current, correct, and appropriate.
- Training and supervising radiological technicians who conduct radiation monitoring program activities to ensure that procedures are followed and results are correct.
- Offering timely feedback on aspects of radiation safety to employees, management, and to the Director of Safety, Health, and Environment.
- Maintaining files of information relevant to future site decommissioning and managing radiological decontamination efforts.
- Maintaining files for records related to the Radiation Safety Program.
- Maintaining radiological contingency plans and overseeing and coordinating the response to any radiological emergency related to the Boyertown operations.

Detailed position descriptions for any of the positions listed above may be acquired from CSM upon request.

10.4 ALARA COMMITTEE

CSM maintains an ALARA Committee to ensure that its operations are conducted in a manner that meets the ALARA commitment. The primary responsibility for oversight and continuous improvement of the radiation safety program is assigned to the ALARA Committee. The objective of the committee is to ensure that exposures to, and releases of licensed radioactive materials are maintained at levels that are as low as reasonably achievable, that operations comply with license conditions, and that unexpected circumstances or changed conditions are appropriately considered and addressed. The members of the committee are selected according to their positions at the facility and are as follows:

- Chemicals Manufacturing Manager – Chairman
- Radiation Safety Officer – Senior Technical Support
- Maintenance Manager – Member
- Safety and Health Manager – Member
- Production Supervisor – alternating member, annually
- Manager, SH&E and Facility Services – invitee
- Director, Boyertown Manufacturing – invitee
- One representative from each of the union locals with workers at the plant

The committee membership and leadership have been modified to better develop interaction between operational management and radiation safety staff. Each year the committee will establish goals for the radiation safety program in support of the ALARA objectives.

The ALARA Committee shall meet at least quarterly to review the radiation monitoring results. Previously, the committee met only once each year. In addition, the Chairman shall call special meetings of the committee whenever a new process or procedure in production is initiated that he determines should be reviewed for ALARA considerations. Any employee at the site may submit to the Chairman a request for a special meeting to address processes, procedures, or program implementation that may impact compliance with the ALARA philosophy. The committee will conduct annual reviews of the radiation safety programs and monitoring results, and may commission independent third party reviews to meet this requirement. Written documentation of meetings and activities of the ALARA Committee are maintained by the Chairman.

Previous applications for license renewal have described additional safety-related committees, including the Preparedness, Prevention, and Contingency Plan Committee, the Health and Safety Committee, the Labor–Management Health and Safety Committee, the Safety Council, the Plant Safety Committee, and the Laboratory Safety Committee. Those committees will no longer have any direct role in the radiation safety programs. The members of the ALARA Committee will coordinate their actions with the other committees by contacting appropriate committee participants as necessary.

10.5 WRITTEN PROCEDURES

CSM establishes and maintains written procedures to address the routine activities of its radiation safety program. The current list of written procedures includes, but is not limited to, the following topics:

- Source material inventory
- Personal dosimetry
- Air sampling
- Sludge sampling and storage
- Filter cake sampling
- Ground water sampling
- Surface water sampling
- Sediment sampling
- Incoming ore surveys
- Contamination surveys using wipe samples
- Radiation surveys of roll mil thickness gauges
- Instrument calibration and use
- Radiation safety orientation.

Existing procedures are reviewed during the annual radiation safety program reviews and revised as necessary to keep them current and accurate. New procedures are developed, reviewed, authorized, and implemented as necessary to document new processes. Procedures are tracked and maintained in compliance with ISO-9000 requirements. Official copies of procedures are maintained in electronic format and the RSO keeps a current set of procedures for the radiation safety programs available for review during on-site inspections by the NRC.

10.6 TRAINING IN THE USE OF RADIOACTIVE MATERIAL

CSM has developed and implemented a radiation protection-training program for its employees and visitors to the facility. This program was designed to meet the requirements of Parts 19 and 20 of Title 10 of the Code of Federal Regulations. Training classes serve as part of the indoctrination for new workers and incorporate topics such as the following:

- Basic principles of radioactivity and characteristics of radioactive material
- Radiation hazards and potential health impacts from overexposure / prenatal exposure
- Proper methods for safely working with radioactive materials
- Methods for reducing radiation doses and controlling contamination
- Regulatory limits and ALARA philosophy
- Monitoring methods and instruments
- Employees' rights and access to records
- Personal protective equipment
- Cabot's radiation safety programs, roles and responsibilities

New workers complete a written test as part of their indoctrination. The information imparted during radiation safety training is reviewed and revised during the annual review of the radiation safety programs conducted by the ALARA Committee. Cabot includes reviews of radiation safety topics and training on new or revised radiation safety procedures and protocols on an on-going, as needed basis as part of its continuing safety training and employee meetings. In addition to this continuous retraining, restricted area workers are required to attend a refresher course at least once every three years. CSM retains written documentation of participation in all of these retraining sessions. Training requirements are established for three categories of individuals, as indicated below.

- Restricted Area Workers – All employees whose work activities are expected to require access to restricted areas will complete general radiation worker training prior to working without supervision in those areas. Class agendas and sign-up sheets are maintained as records of training. Agendas and materials used for this training are subject to minor changes in content without prior notification of the regulatory agencies. Topics that are typically covered in the class are listed below.
  - Fundamentals of radiation safety including--
    - Characteristics of radiation and contamination;
    - Units of radiation dose and quantity of radioactivity;
    - Hazards of exposure to radiation, including internal, external, and acute, and chronic exposures, and stochastic and non-stochastic effects;
    - Levels of radiation from licensed material;
    - Methods of controlling radiation dose (hygiene and administrative controls such as controlled area procedures, engineering controls such as ventilation, protective equipment such as respirators, and general concepts for reducing doses such as time, distance, and shielding); and
    - Reporting responsibilities and procedures, and proper responses to incidents, accidents, emergencies, and releases.
  - Locations and physical forms of licensed material;
  - Locations and markings of restricted areas and airborne radioactivity areas;
  - Radiation detection instruments including use of personnel monitoring equipment; and operation, and limitations of radiation survey instruments

  - Storage, control, and disposal of licensed material; and
  - The requirements of pertinent Federal regulations.

- Ancillary Personnel – Ancillary personnel such as clerical, security, and administrative staff whose routine work activities at the Boyertown plant do not require their presence in restricted areas will not normally have access to the areas where radioactive materials are stored and handled. However, they will be provided basic hazard recognition and emergency notification training that addresses the radiological hazards at the site. Topics that are typically covered in the class include hazard recognition, locations of radioactive materials, and procedures to follow in case a radiological release is encountered.
- Non-employees – Appropriately trained Cabot employees will accompany non-employees such as visitors and subcontracted workers who are expected to require access to restricted areas while on-site. The plant is enclosed by a security fence and staffed by full-time guards who ensure that visitors are logged in, provided safety equipment, and accompanied by a Cabot escort prior to accessing the plant site. The Cabot escort provides basic hazard recognition information, determines if the visitor will need to access restricted areas, and is responsible for the safety of the non-employee while on-site. If non- employees need to access restricted areas of the site without a Cabot escort they will first receive the Restricted Area Worker training required for Cabot employees.

10.7 METHODS OF EXPOSURE CONTROL

CSM has established routine work practices and procedures designed to minimize exposures to radioactive materials for employees and members of the general public. Detailed procedures are available for review as described in Section 10.4, and a general description of methods used at the site is provided in the following subsections.

10.7.1 Administrative Controls

CSM employs administrative controls such as designating restricted access areas, requiring training courses for workers, prohibiting undesirable activities in designated work areas, and displaying signs, postings, and labeling as required. Work areas in Building 73 where ore containers are opened and fed into the circuit, and the highest potential exists for airborne radioactive particulates are restricted from access by employees whose duties do not involve the grinding process. Workers are prohibited from eating, drinking, smoking, or chewing in the plant processing areas, and they are informed of these restrictions during training sessions and by signs in the work areas. Work areas are posted with signs and informational postings as required by the regulations and consistent with their conditions.

10.7.2 Engineering Controls

CSM incorporates engineering controls such as general and local ventilation in enclosed work areas to control radioactive contaminant levels at their sources and reduce the need for respirators in work areas where levels may approach or exceed occupational derived air concentrations specified in 10 CFR Part 20, Appendix B, Table 1. Ore grinding equipment is enclosed within rooms to isolate potential releases from the general work areas in Building 73. Ventilation systems are designed, installed and tested by a qualified engineer, and included in routine plant maintenance plans. Concentrations of contaminants in exhaust are controlled to ensure that occupational and environmental releases do not exceed regulatory limits. Atmospheric releases from the ore handling area are controlled with scrubbers and a baghouse. Particles collected in the baghouse are recycled into the process. The performance of these systems is monitored as described in the section titled “Environmental Monitoring”.

Liquid effluents are retained in on-site lagoons to control their release from the site. They are only discharged when stream flow conditions are adequate to ensure compliance with regulatory limits. No additional control of the effluent is required at this time; however, CSM monitors the effluent to detect conditions that might indicate a need for additional control. Alternate methods of disposal in compliance with regulatory requirements may be implemented in the event that stream flow is inadequate to keep up with site effluent requirements. CSM will ensure that liquid effluents are released from the site only in a manner that complies with regulatory release limits.

10.7.3 Personal Protective Equipment

Respirators are used in work areas where airborne concentrations are expected to exceed the occupational derived air concentration specified in 10 CFR Part 20, Appendix B, Table 1 for the radionuclides of concern. The SH&E Department maintains a respiratory protection program in compliance with OSHA and NRC requirements that incorporates the following components to ensure that respirators are properly fitted, used, and maintained to prevent excessive employee exposures:

- Employee training
- Medical evaluations, including pulmonary function tests prior to respirator use and annually for routine respirator users
- Fit-tests to ensure adequate face to facepiece seal
- Air monitoring to determine when conditions warrant respirator use and to ensure that respirator protection factors are not exceeded

Protective clothing, such as disposable or washable coveralls, gloves, and shoe covers may also be used to minimize the potential for surface contamination of clothing and skin surfaces where transferable contamination may be present.

10.7.4 Hazard Monitoring Systems

CSM has installed various controls on the process tanks in Building 73 since the last renewal application. These control devices are outlined below:

- **Level monitoring of the digester and reslurry tanks**. Each tank is continuously monitored using Krohne radar level gauges with local displays and connections to the Building 073 PLC system. The PLC logic includes programmed high level and high-high level alarms that trigger audible and visual alarms. These alarms are also interlocked through the logic to halt transfers of material into the vessels in the case of such alarm conditions. These devices were installed in 1999.
- **Scrubber monitoring**. The scrubber pressure drop and make-up water flows are continuously monitored to verify proper operation of the scrubber system that ventilates the operation. These devices have local displays and are connected to the building PLC system. The operators monitor these readings on a routine basis.
- **HF tank monitoring**. The HF bulk tank and weigh tank are each mounted on Weigh-Tronix load cells with local displays and connections to the PLC system. In addition, both tanks have Ametek Drexelbrook high-high level capacitance probes connected to the PLC system.

For all of these systems, extensive interlock logic halts transfers in the event of unexpected weight and/or level loss, overweight and/or high level, and high-high level conditions, as well as in the case of scrubber malfunction. This logic is also programmed to prevent certain concurrent transfers if such transfer would compromise the ability to detect fault conditions.

10.8 RADIATION MONITORING INSTRUMENTS

The RSO maintains various radiation-monitoring instruments for conducting surveys and measurements and analyzing samples. A qualified, licensed contractor calibrates the instruments on at least an annual frequency. The following types of instruments, or their functional equivalents, are maintained at the site, at a minimum.

TYPE	PURPOSE
Micro-R meter (NaI)	General area surveys
Geiger-Mueller tube	General area surveys
	Dose assessment, area monitoring
Geiger – Mueller pancake probe	Contamination surveys, fixed and removable
Dual scaler (alpha – beta)	Sample counting (air particulates, smears)
Alpha/beta surface probe	Contamination surveys (100 sq. cm.)

Instruments used to show compliance with applicable regulations are calibrated before first use and after repair. Each instrument that is available for use is calibrated at least annually thereafter. Calibration records are retained for each instrument for at least the two most recent periods to establish documentation that the annual frequency is being maintained.

Hand-held survey instruments used for the estimation of contamination will be calibrated by determining the detection efficiency of the system using a reference source appropriate to the use of the instrument. The efficiency and reference radionuclide will be noted on the calibration label.

The RSO maintains on-site offices and facilities to support the radiation safety programs. These facilities are used to maintain and source-check the radiation-monitoring instruments, count samples such as airborne particulate filters that are analyzed on-site, provide office space for the RSO and his staff, and maintain files for the records that document compliance with the conditions of the radioactive materials license.

The RSO's office is located in an area that is not significantly affected by elevated levels of radiation from site operations and is separate from other work areas associated with daily site operations. Records are kept in lockable file cabinets. The sample counting area is cleaned and monitored at least monthly to ensure that contaminated material does not accumulate and negatively impact the work environment or the sample counting statistics.

10.9 RADIATION SURVEYS AND MONITORING PROGRAMS

10.9.1 Occupational Monitoring

Occupational monitoring programs are designed in compliance with the requirements of 10 CFR 20 to measure concentrations of radioactive material and radiation levels in the work environment, and evaluate personnel dose equivalents when those concentrations or levels exceed administrative limits. The RSO is responsible for the technical oversight and implementation of the monitoring programs. He oversees activities performed by technicians, reviews the data, evaluates potential changes in the programs or procedures, determines if follow-up actions are required, and maintains files of the results.

The following subsections describe, in general, the types of measurements that are performed. Monitoring program details are provided in site-specific procedures and documents that are maintained by the RSO at the plant and have been reviewed by NRC personnel during past inspections.

10.9.1.1 Exposure to External Radiation

Personal or area dosimeters are used to track levels of radiation exposure in the work areas where ores and residues are handled. Area dosimeters are considered an acceptable alternative to personal dosimeters in some areas of the plant because of the low levels of radioactivity in the materials, the small quantities of materials that are handled, and the short periods of time that workers are close to the material. Area dosimeters are placed in locations where highest dose rates are found as determined by the RSO.

10.9.1.2 Monitoring Airborne Radionuclides

There are two primary airborne radiological contaminants of concern in the plant. They are radon gas, of concern inside buildings where the ores or residues are located, and ore dust, found wherever dry ores are ground or disturbed. Passive radon monitors are located at designated places selected by the RSO inside structures where large quantities of ore or residues are stored or handled. Locations for these monitors are selected indoors, at typical breathing zone heights in areas of the structures where ventilation is limited and concentrations of the heavier-than-air gas would be the greatest. Locations are adjusted as necessary by the RSO.

Work area air particulate samples or personal lapel samples are used to collect air particulate samples. Those samples are collected at a frequency that is determined by work activities that may generate airborne radioactive particulates, such as feeding ore into the grinding circuit. Filters are counted for alpha and beta activity to determine if workers are exposed to concentrations that exceed administrative limits. Air particulate sampling results are also used to determine if employees are likely to have inhaled or ingested quantities of radioactive material that would require further evaluation using bioassay methods. Bioassay measurements are not required unless air sample results indicate that an individual is likely to have received in one year an intake in excess of 10% of the applicable Annual Limit on Intake. CSM has developed a technical basis document, “Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant” (June 9, 2003), provided in Appendix A, that describes and justifies the air particulate program and the process for evaluating and implementing follow-up measurements. In addition, CSM reviewed the bioassay requirements and site conditions that could result in internal deposition of radioactive materials. The results are reported in a document titled “Review of the Bioassay Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant” (June 9, 2003) provided in Appendix B. CSM is committed to maintaining its air sampling and bioassay programs while incorporating all of the recommendations and program revisions contained in those two documents. The NRC reviewed draft versions of both documents and comments were addressed in these final versions.

10.9.1.3 Surface Contamination Surveys

Ores and residues are not handled in a manner or in quantities that are likely to result in significant surface contamination. However, wipe samples are routinely collected monthly from locations where surface contamination would be most likely to accumulate or would present the greatest potential for transfer to personnel. Samples are counted for alpha activity and corrective actions are implemented to clean surfaces if levels are increasing or above administrative limits.

10.9.1.4 Miscellaneous Radiological Surveys

Additional instrument surveys are performed as directed by the RSO to check incoming ore shipments or other site conditions to ensure that radiological conditions are not significantly changed. Ore shipments typically present external dose rates of less than 2 mR/hr. Any shipment that exceeds that dose rate will be segregated in a fenced or barricaded area and labeled as appropriate. Instrument surveys and leak tests are also performed as required for several sealed sources maintained at the site under general license.

10.9.1.5 HF Monitors

Each digester and reslurry tank and both filter presses in Building 073 have local Scott-Bacharach HF monitors (one at each tank, two at each press) that continuously monitor the air quality in the work areas. These devices have local displays and are connected to the building programmable logic control (PLC) system that provides audible and visual alarms at programmed "warning" and "high" HF concentrations. Two units were installed in 2001, and the remainder was installed in 2002.

10.9.2 Environmental Programs

The NRC issued an Environmental Assessment (EA) for the Boyertown site in September of 1996 as part of the last license renewal. The plant operations and facility conditions are generally unchanged from the descriptions in the 1996 document. The following description of the Environmental Monitoring Program at the site and conditions around the Boyertown plant is provided as an update to the information in that document, and to describe the monitoring program for the renewed license.

The need for the proposed action and the environmental consequences of the proposed license renewal are consistent with the information in the 1996 EA. The plant operations are as described in that document with minor exceptions as noted in this application for renewal of the license. This information and the lack of environmental impacts from ongoing operations demonstrated in the following data summaries continue to support a finding of no significant impact.

In addition to its NRC license, CSM acquires all necessary permits and licenses required by local, state, regional, and other federal agencies for its on-site activities. CSM maintains contact with those agencies and complies with the permit requirements, and with regulations that apply to the ongoing operations.

10.9.2.1 Climatic Conditions

Adverse climatic conditions that can be expected at the site include the types of events that are typical for the region and have been experienced during the decades that the plant has been in operation; severe thunderstorms, heavy precipitation and floods, severe winter storms with significant snow accumulations, and occasional strong winds. Extreme weather conditions are not typically experienced because the site is far enough inland to be spared the direct impact of coastal storms such as hurricanes, and because the surrounding topography minimizes the potential for tornadoes to affect the site, although tornadoes are occasionally reported in the region.

Adverse weather conditions were taken into account when the plant was designed, and are considered when changes are planned in the site grading, process buildings, or materials storage configurations on-site. Wind-loading, snow-loading, and precipitation run-off calculations are part of any design plans for structures and site configuration. There is minimal potential for adverse weather to impact the licensed material at the site in a manner that would disperse significant quantities of the material into the environment because of the small quantities of material that are present at the site, and because virtually all of the material contained throughout the process. The ore is received in a variety of containers such as individual drums or similar containers, and remains in those containers until they are emptied directly into the process circuit. Most of the drums are stored in protected areas around the process buildings until they are fed into the circuit; the ore is not stored outside in a dispersible form. Additional facility improvements that provide better control and protection of licensed material are described in Section 9.1.2 of this application.

After processing, all significant quantities of radioactive material are present in the ore residues (presscake) that are stored temporarily in small quantities in hoppers kept in a covered area. The presscake is then transported to the bulk storage bins for interim storage. The bulk storage bins are concrete brick buildings that are constructed to withstand severe weather conditions and have been maintained to ensure that the residues are protected from the weather. Details of the current condition of the bulk storage bins are provide in Section 9.1.2 of this application.

The site is graded to contain precipitation run-off from the immediate plant areas on the site, using the on-site settling ponds as retention areas. Water from the ponds is released to the nearby stream in accordance with the site NPDES permit after CSM ensures that effluent standards are met. Site areas that are not impacted by licensed materials or process chemicals are graded toward the natural drainages in the area, ultimately flowing into the nearby stream.

Updated summaries of meteorologic and climatic data are provided in Section 10.9.2.12.

10.9.2.2 Cultural and Historic Resources

CSM will administer a cultural resource inventory before engaging in any developmental activity in an area of the site not previously assessed for cultural and historic resources. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act (as amended) and its implementing regulations (36 CFR 800), and the Archaeological Resources Protection Act (as amended) and its implementing regulations (43 CFR 7).

In order to ensure that no unapproved disturbance of cultural resources occurs, CSM will halt any work that results in the discovery of previously unknown cultural artifacts. Exposed artifacts will be inventoried and evaluated in accordance with 36 CFR Part 800, and CSM will ensure that no further disturbance of the area occurs until a cultural and historic resource assessment is completed in compliance with the applicable regulations, as listed above, or CSM has received authorization from the NRC to proceed.

10.9.2.3 Land Use

Commercial and residential development around the Boyertown area has been marginal over the past 10 years, and a recent survey of the area within a 5-mile radius of the CPM facility indicates little change in the demographics of the Boyertown area. The primary land use is still farming to support dairy herds. A single, new residential subdivision has been identified in the vicinity of the plant. Located approximately two miles from the site boundary, the subdivision consists of about 30 homes, all connected to city water and sewer lines. There is no impact to plant operations expected from the subdivision, as there are no resources or infrastructure shared between them. The stagnant residential and commercial development in the area is expected to continue and CSM does not foresee problems with water accessibility or quality.

10.9.2.4 Floodplains and Wetlands

In order to assess site conditions associated with floodplains and wetlands a number of information sources were reviewed, including:

- Environmental Assessment for Renewal of Source Material License No. SMB-920, Docket 40-6940; Cabot Performance Materials; September 1996;
- Wetland Jurisdictional Determination Report – Cabot Performance Materials Corporation; Soil Services Company, Inc.; November 2002;
- National Wetlands Inventory; U.S. Fish and Wildlife Service; June 2003.

Information in this report is based solely on the surveys conducted in support of the above-mentioned reports and references, and the results documented in those reports. As reported in the September 1996 EA report, and confirmed through review of current (June 2003) National Wetlands Inventory (NWI) maps, the site does contain several wetland areas. Specifically, as mapped by the NWI, two (2) distinct wetland areas are noted along the southeast portion of the site. These wetland areas have been classified as “Inland Forested Wetlands”.

As noted in the September 1996 EA report portions of the site are located within the 100-year floodplain, including lagoons 1, 2, 3 and 4; the settling pond; and building 055. This report also noted that the base flood level within the area of these structures ranged from 95 to 96 meters above sea level. The ponds are diked to an elevation of approximately 1.8 meters above grade. Current site conditions and grade elevations have not changed significantly from conditions noted in the 1996 EA report to indicate an increased risk of site flooding.

A report prepared in November 2002 by Soil Services Company, Inc., titled, *“Wetland Jurisdictional Determination Report”* was also reviewed in preparation of this discussion of site conditions associated with wetlands. This report was prepared in support of a proposed office development at the subject site in accordance with the U. S. Army Corps of Engineers Wetlands Delineation Manual (Technical Report Y-87-1). This report summarizes wetland delineation activities completed for the area in the vicinity of this office expansion project, not the entire project site. As noted in this report, limits of delineated jurisdictional wetlands and waters of the Commonwealth of Pennsylvania and the United States of America appear to have been accurately defined and no impacts to these wetland areas have been identified from the recent office development project.

In summary, the proposed action, the renewal of the U.S. Nuclear Regulatory Commission source material license for the Boyertown, Pennsylvania facility is not associated with modifications or changes to manufacturing processes, facility structures or infrastructure. Therefore, impacts to floodplains and wetlands associated with site operations have not been identified.

No mitigative measures are required or proposed for floodplains or wetlands protection associated with the proposed action.

10.9.2.5 Biota

The following information source was reviewed in order to assess site conditions associated with biota:

- Environmental Assessment for Renewal of Source Material License No. SMB-920, Docket 40-6940; Cabot Performance Materials; September 1996.

No surveys of site flora and fauna were conducted in support of the current environmental assessment. It was assumed that, based on the lack of site development that has occurred from September 1996 to date, site conditions associated with flora and fauna have not changed significantly.

According to the former EA (September 1996), the natural climax vegetation in the region is classified as Appalachian oak forest. Dominant species include white and red oak. Other common species include red maple, sugar maple, swamp hickory, and several other species of oak and hickory. Farming and urbanization have significantly impacted regional native vegetation over the prior 200 years. Montgomery County woodlands consist primarily of second and third growth stands of red oak, ash maple elm, eastern red cedar, and sugar maple beech and yellow birch.

The 1996 EA estimated that 30% of the site has been developed with plant facilities. The remaining 70% consists of equal areas of woodlands and open fields. Common trees on and in the vicinity of the site include a number of species of oak, hickory, maple, elm and ash. Open fields consist of grasslands and agricultural lands, planted primarily with corn. As noted in the 1996 EA approximately 55 species of reptiles and amphibians, 42 species of mammals, and 176 birds range throughout the area.

Common field animals noted include the eastern cottontail rabbit and ring-necked pheasant. Based on assessment of site habitat it is anticipated that bobwhite quail, mourning dove, and red fox may also be present. Woodland habitats are expected to contain gray squirrel, red squirrel, raccoons, opossums, and striped skunks. Waterfowl have been identified present within the on-site lagoons, including Canada geese, mallards, green-winged teal and black ducks.

As noted in the 1996 EA flora and fauna was surveyed within West Swamp Creek during a May 1967 biological survey. Twelve species of fish were identified, including shiners, dace, suckers, chubsuckers, killifish and sunfish. Major plant species identified in West Swamp Creek include duckweed, waterweed, mud plantain, arrowhead, and pondweed.

In summary, the proposed action, the renewal of the U.S. Nuclear Regulatory Commission source material license for the Boyertown, Pennsylvania facility is not associated with modifications or changes to manufacturing processes, facility structures or infrastructure. Therefore, impacts to site biota associated with site operations have not been identified.

No mitigative measures are required or proposed for protection of site biota associated with the proposed action. Site-specific, updated information regarding the relevant endangered species is provided in the following section of this report.

10.9.2.6 Threatened and Endangered Species

In order to assess whether threatened and endangered species were known to exist within or adjacent to the site boundaries, a current site survey of candidate, threatened and endangered species was completed. The U.S. Nuclear Regulatory Commission (NRC) in a letter dated 10 January 2003 to Mr. Timothy Knapp of Cabot Supermetals recommended this approach. Written species impact review responses were requested from the following agencies:

- U.S. Fish & Wildlife;
- Pennsylvania Fish & Boat Commission;
- Pennsylvania Natural Diversity Inventory;
- Berks County Conservation District;
- Montgomery County Conservation District.

Outlined below are the results of the species impact reviews. Copies of the written responses received from each agency are provided in Appendix C.

<u>USF&W</u>:

As outlined in their February 3, 2003 response, no Federally listed, proposed or candidate species were identified within the site boundaries. However, the site lies within the known range of Bog turtle

(*Clemmys mulhlennbergii*). Provided that wetlands occurred within or near the project and if the proposed project activities would adversely affect the species, USF&W advised that a habitat assessment be performed. As the Boyertown facility has been in continuous operation since approximately 1950 and no modifications to the facility, associated processes and facility infrastructure are associated with the NRC license renewal, no impacts to this potential species have been identified associated with the proposed action.

Pennsylvania Fish & Boat Commission:

As outlined in their January 23, 2003 response, no fishes, amphibians or reptiles listed by the PAF&B as threatened or endangered were known to occur at or in the immediate vicinity of the project area.

Pennsylvania Natural Diversity Inventory:

As outlined in their January 17, 2003 response, the PNDI records indicated that no occurrences of species of special concern were known to exist within the project area; therefore, they do not anticipate any impact on endangered, threatened, or rare species at the project location.

Berks County Conservation District:

As outlined in their screening response dated January 2, 2003 on the Supplement No.1 Pennsylvania Natural Diversity Inventory Form; no potential conflicts with ecological resources of special concern were encountered during their review.

Montgomery County Conservation District:

As outlined in their response letter dated January 3, 2003 no potential conflicts with ecological resources of special concern were encountered during their review. The County initially interpreted the review request to be associated with anticipated earth disturbance and therefore their response letter requested a National Pollutant Discharge Elimination System General Permit plan (NPDES); however, as no earth disturbance is anticipated, there will be no need to formally submit a finalized plan.

In summary, the proposed action, the renewal of the U.S. Nuclear Regulatory Commission source material license for the Boyertown, Pennsylvania facility is not associated with modifications or changes to manufacturing processes, facility structures or infrastructure. Therefore, impacts to species and habitat associated with site operations have not been identified. Each of the five involved agencies contacted regarding the proposed action did not identify threatened or endangered species, or species of special concern, associated with the proposed action at the Cabot Boyertown facility.

Based on this site survey no threatened or endangered species have been identified at the Cabot Boyertown facility. Although the Bog turtle has been identified as a species that may exist at the facility no activities associated with the proposed action would result in an impact to the Bog turtle or it's associated habitat.

No mitigative measures are required or proposed for threatened and endangered species protection associated with the proposed action.

10.9.2.7 Environmental Monitoring

The Environmental Monitoring Program measures radiological conditions in air, water, and wastes at the Boyertown facility, along its site boundaries, or at effluent release points. Surface waters, sediments, ground water, and air samples are collected on a regular frequency not less than quarterly. Samples are analyzed for pertinent radionuclide concentrations and the results compared to administrative and regulatory limits, as well as past results to identify potential trends. Sampling locations have been selected to monitor background conditions near the facility and conditions along the site boundary at points of expected maximum potential releases to the environment, such as downwind, down gradient, and downstream from the plant. Other significant locations, such as the nearest occupied residence, may also be designated for sampling if there is potential impact from the site. Sampling frequency and analyses have been selected to determine if CSM is in compliance with license or permit conditions, and to identify trends that could eventually result in non-compliance if not corrected.

The individual components of the environmental monitoring program are described in the following text and summarized in Table 10-1, below. Monitoring locations are shown on the site drawing provided in Figure 9-1.

- Passive radon monitoring devices measure concentrations in air at the site boundaries.
- Air particulate samples collected at background and downwind site boundary locations.
- Surface water and sediment samples collected at upstream, and downstream locations.
- Ground water samples collected at locations that are up gradient from the site (background), and down gradient from site locations where the largest quantities of radioactive material are stored.

Table 10-1. Summary Table of Environmental Monitoring Programs, 2004 License Renewal

Sample Medium	No. of Stations	Analytical Frequency	Sample Type	Type of Analysis
Air	4	Semi-monthly	Continuous	Fluoride
Air	3	Quarterly	Continuous	Isotopic uranium/thorium
Air	4	Quarterly	Continuous	Radon (track-etch)
Sediment	2	Quarterly	Grab	Natural uranium, radium-226, and radium-228
Surface Water	2	Quarterly	Grab	Natural uranium, radium-226, and radium-228
Ground Water	7	Quarterly	Grab	Natural uranium, radium-226, and radium-228

The data in the summary table do not concur with information in the last license renewal application of the associated Environmental Assessment (EA, 1996) for two reasons. First, the EA for the last license renewal application (1996) erroneously included the outfall at West Swamp Creek as a surface water sampling location. That outfall is an effluent point for treated water released from the facility and is not an environmental surface water location. Thus, the outfall has been excluded from the current list of surface water locations and the number of locations is correctly identified in this table. The outfall will continue to be monitored as an effluent source.

Second, the analytical parameters represented in this table address only the requirements that apply to this license, and they include only the measurements that were recommended during the most recent annual ALARA Review of the site radiological programs. Gross alpha and gross beta measurements were included in the past for most of the sample media. However, those data provide only a general indication of the radiological conditions at the site and there are no NRC regulatory limits that can be applied to gross alpha and beta values. The isotopic analyses listed in Table 10-1 will allow direct comparison to

NRC limits and allow better differentiation between contributions from natural background sources and plant sources of radioactive material. CSM acquired tentative concurrence from the NRC that the types of analyses listed in the table are adequate to track and document license conditions at the site.

Text and tables provided in the following sections provide summaries of the environmental monitoring results from recent years. The data are compared to CSM administrative action levels or limits calculated by applying site-specific information to applicable. Compliance is evaluated for each type of data, and there have been no results that exceed regulatory limits, nor indications of significant releases of licensed radioactive material to the environment.

10.9.2.8 Ambient Air Monitoring

Ambient air is currently sampled around the site for gaseous and particulate effluents. The Walker Road location is in the predominantly upwind direction from the plant and serves as a background location. The others are downwind of plant operations and typically along the site boundary. Three locations are monitored weekly for gross alpha activity and quarterly for isotopic concentrations. Four locations are monitored semi-monthly for ambient fluoride. Four locations are monitored quarterly for radon.

Radiological contaminant concentrations at the downwind site boundary air sampling stations are summarized for the period from 1999 through 2003 in Table 10-2. These results are calculated from the isotopic analyses of air filters composited for each quarter of a year and are compared to a concentration limit calculated from the relevant values in 10 CFR 20, Appendix B, Table 2. Each quarterly value is compared to the annual average concentration limit and the resulting percentage is presented. The maximum value represents 27% of the concentration limit, and 33 of the remaining 41 values are at or below 10% of the concentration limit. These data, along with the fact that doses from external sources measured at the site boundary are less than 2 mrem/hour, demonstrate compliance with the annual dose limits in 10 CFR 20.1302(b)(2).

It is worth noting that the isotopic ratios found in these environmental air particulate samples represent typical weathered soils, not the ores or residues that are handled at the plant. Thus, the results probably are influenced more by resuspended soils than releases from the plant operations. Both of these downwind locations are near County Line Road, and public traffic on that paved road resuspends much of the dust that is collected by those samplers, resulting in higher dust levels than would be present from plant activities only.

Table 10-2. Summary of Background-Corrected Ambient Air Samples

Quarter	Effective AEC* for 10 mrem/ year:(µCi/ml)	County Line Road		Boiler House	
		Average effluent concentration (µCi/ml)	Fraction of Effective AEC (%)	Average effluent concentration (µCi/ml)	Fraction of Effective AEC (%)
1-99	6.45E-15	6.1E-16	9	3.1E-16	5
2-99	6.45E-15	7.6-16	12	3.2E-16	5
3-99	6.45E-15	4.3E-16	7	9.6E-17	1
4-99	6.45E-15	7.0E-17	1	2.9E-16	4
1-00	6.45E-15	6.7E-16	10	4.0E-16	6
2-00	6.45E-15	4.0E-16	6	4.7E-16	7
3-00	6.45E-15	6.0E-17	1	9.8E-17	2

Quarter	Effective AEC* for 10 mrem/ year:(µCi/ml)	County Line Road		Boiler House	
		Average effluent concentration (µCi/ml)	Fraction of Effective AEC (%)	Average effluent concentration (µCi/ml)	Fraction of Effective AEC (%)
4-00	6.45E-15	5.8E-16	9	2.7E-16	4
1-01	6.45E-15	6.3E-16	10	nd	0
2-01	6.45E-15	5.3E-16	8	8.0E-16	12
3-01	6.45E-15	2.9E-16	4	3.9E-17	1
4-01	6.45E-15	1.9E-17	0	nd	0
1-02	6.45E-15	4.9E-17	1	7.1E-17	1
2-02	6.45E-15	1.7E-16	3	3.2E-16	5
3-02	6.45E-15	4.2E-16	6	nd	0
4-02	6.45E-15	8.9E-16	14	5.6E-16	9
1-03	6.45E-15	1.4E-15	22	8.1E-16	13
2-03	6.45E-15	2.4E-17	0	3.1E-16	5
3-03	6.45E-15	9.7E-16	15	1.7E-15	27
4-03	6.45E-15	4.7E-16	7	5.9E-16	9

AEC = average effluent concentration.
nd = not detected; negative value after background correction.

Table 10-3 presents the worst-case doses to the general public calculated from the air effluent monitoring results collected at the downwind site boundary. The calculated doses are compared to the 10 mrem/year limit established by the "Constraint Rule" in 10 CFR 20.1101 and Regulatory Guide 4.20, *Constraint on Release of Airborne Radioactive Material to the Environment for Licensees Other Than Production Reactors*, December 1996. The results in Table 10-3 demonstrate that a worst-case scenario in which a member of the general public might be present at the downwind Boyertown site boundary on a full-time basis would result in a dose well below the limit.

Table 10-3. Annual Doses at Site Boundary Calculated from Air Effluent Data for Comparison to 10 mrem/year Constraint Limit (mrem/year)

Year	County Line Road	Boiler House
1999	0.72	1.78
2000	0.66	0.48
2001	0.57	0.32
2002	0.59	0.37
2003	1.12	1.32

The results of the environmental monitoring for fluoride are summarized in Figure 10-2 for the period 1999 through 2003. During this time period there have been no results that exceeded the Commonwealth of Pennsylvania fluoride standard of 5 µg/m^3. The legend indicates sampling location abbreviations that are as follows:

- SW – swamp at the south end of the site property,

- BH – Boiler House sampling location,
- EN – Engineering Building 119, and
- PT – the 69 pit at the far west end of the site property, near Swamp Creek Road.

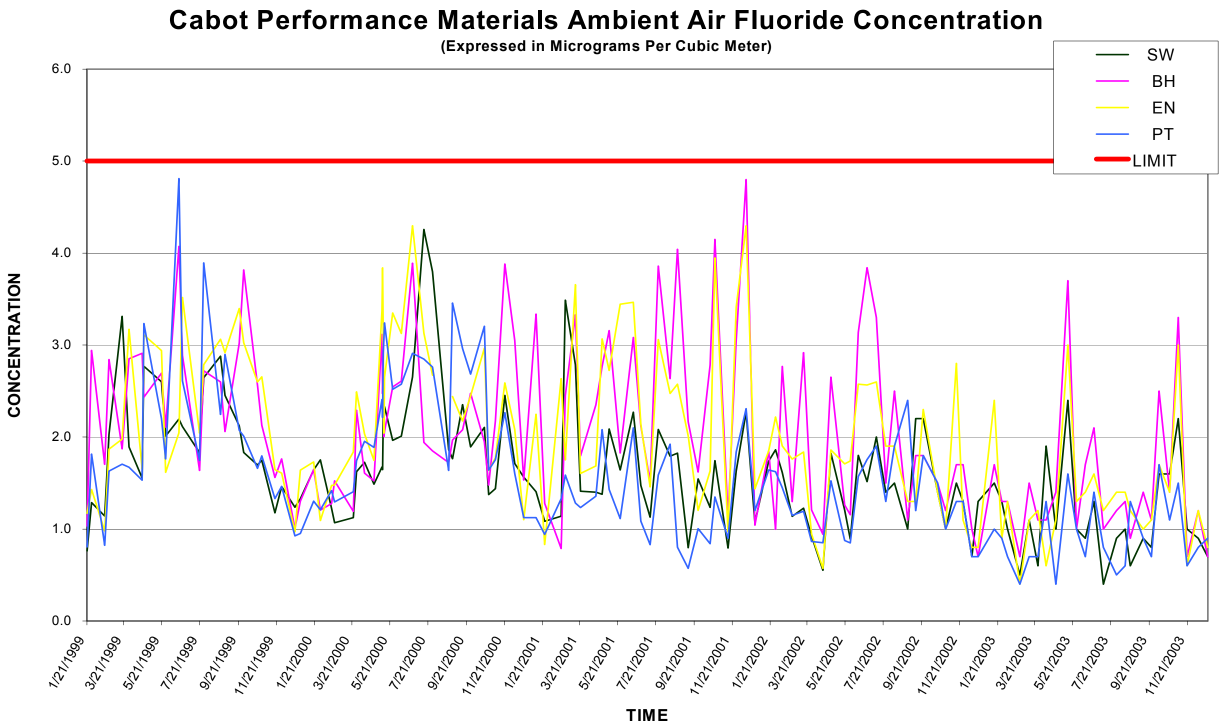

Figure 10-2. Average Ambient Air Fluoride Concentrations.

Results of track-etch monitoring of radon concentrations at site boundary locations are provided in Table 10-4, below. Results are in the range of background for the area and do not approach the limit of 10 pCi/L provided in 10 CFR 20, Appendix B, Table 2 for radon-222. The monitoring location abbreviations are explained below:

- County Line Road – at the site boundary along County Line Road,
- SE Fence –
- Bldg 16 Lab –
- EN – Engineering Building 119.

Table 10-4. Results of Quarterly Radon Monitoring at the Plant Site Boundary (pCi/L)

Quarter	County Line Road[a]	SE Fence[b]	Bldg 16 Lab[c]	EN
1-99	1.5		2.8	0.4
2-99**	0.6		1.4	0.2
3-99**	0.5		1.4	0.2
4-99	0.5		1.2	0.2
1-00	0.6		1.6	0.3
2-00	1.4		1.5	0.7
3-00	0.2		0.9	0.8
4-00	0.5		1.0	0.5

Quarter	County Line Road[a]	SE Fence[b]	Bldg 16 Lab[c]	EN
1-01	0.5		1.0	0.5
2-01	0.9		1.2	1
3-01	0.6		1.2	0.3
4-01	1.4		1.2	0.9
1-02	2.1		1.2	1.1
2-02	2.1		1.2	1.1
3-02	2.5		1.0	1.3
4-02	1.0		1.4	1.2
1-03	0.5		0.2	0.2
2-03	0.7	0.7	0.7	0.3
3-03	2.1	1.6	1.4	1.5

a The County Line Road location was positioned at Bldg 89 prior to the second quarter of 2003.
b The SE Fence location was established in the second quarter of 2003.
c The Bldg 16 location was positioned at Bldg 10 prior to the second quarter of 2003.

10.9.2.9 Forage Crop Sampling

Under a determination by the NRC in 1996 and as stipulated in the 1996 EA, CPM no longer performs forage crop sampling. Appendix D provides copies of letters documenting the 1996 determination by the NRC and notification from CSM to the NRC in 2002 verifying that forage crop sampling was terminated as a result. The chart referred to in the notification letter from CPM appears as Figure 10-2, above.

10.9.2.10 Surface Water and Sediment Sampling

The data for water and sediment analyses are summarized in Tables 10-4 and 10-5. Gross alpha and beta results are provided as general indicators of the conditions in surface waters under the assumption that a potential release of licensed radioactive material would be detectable in those analyses. Isotopic uranium and thorium analyses are performed on surface water samples, and those results are commonly below detection limits and always well below CSM administrative action levels, which supports using the gross alpha and beta results to represent the lack of surface water impacts in recent years.

The liquid waste treatment system generates liquid and solid streams that have a very limited potential to contain radioactive material. The liquid stream is routed to lagoon 5, then to lagoon 6 for final pH adjustment, and then released from Outfall 001 to West Swamp Creek. As indicated in the 1996 EA, the volume of water that flows in the creek is insufficient to be used as a drinking water source, but the constant flow is adequate to dilute contaminant concentrations far in excess of those that have been measured at Outfall 001. The water flow rate through the outfall is monitored continuously under the NPDES program.

Outfall 001 (which is an effluent source, not a surface water location) and locations upstream and downstream form the outfall have been monitored quarterly and analyzed for isotopic U and Th and gross beta activity. Action levels for uranium and thorium are 15 and 1.5 pCi, respectively, and isotopic results have been at or below detection limits and have not exceeded the action levels during this period. Actions in case limits are exceeded may include re-analysis, investigation and correction of cause, and verification of correction. Current minimum detection levels are reported as 1.0 pCi/l or better for isotopic U and Th.

The variability and range of radiological conditions in the effluent and in surface water upstream and downstream from the outfall are represented by the gross alpha and beta data in Table 10-5. Gross beta values at Outfall 001 and for the 3rd quarter of 2002 at the downstream location appear elevated due to potassium-40 that occurs naturally in the potassium chloride that is added during the tantalum salt conversion process, and does not indicate the presence of licensed material. This fact was verified by gamma spectroscopy analyses that identified levels of potassium-40 that compared closely with the gross beta values. Title 10 CFR Part 20 Appendix B, Table 2 does not include gross alpha and beta limits for water. However, the Tale 2 limits for uranium and thorium isotopes that are primarily alpha emitters are in the range of 100 pCi/l. Limits for the beta emitters are in the range of 1000 pCi/l. The maximum downstream surface water results do not exceed 50% of those limits.

The average alpha and beta emitter concentrations of the upstream sediment sampling for 1999 through 2003 are 7.6 and 21.7 pCi/g, respectively, allowing for no contribution from samples that were below detection limits. The average downstream concentrations of alpha and beta emitters for the same time period are 6.7 and 21.8 pCi/g, respectively. There is not much variability in the values for either parameter, and there is no significant distinction between the average concentrations at upstream and downstream monitoring locations. None of the recorded concentrations have approached CSM's 100-pCi/g action level for gross alpha in sediment samples.

Table 10-5. Gross alpha and beta results (pCi/g) for upstream, downstream, and outfall monitoring locations

Year-Quarter	Upstream		Downstream		Outfall 001	
	Gross Alpha	Gross Beta*	Gross Alpha	Gross Beta*	Gross Alpha	Gross Beta*
1-99	nd	nd	nd	nd	210	nd
2-99**						
3-99**						
4-99	nd	nd	nd	nd	nd	15
1-00	nd	nd	3.4	nd	nd	nd
2-00	nd	nd	nd	74.6	nd	nd
3-00	nd	nd	nd	5.3	nd	4220
4-00	nd	nd	nd	39.7	nd	3970
1-01	nd	nd	nd	137	nd	3160
2-01	nd	61.8	nd	107	nd	793
3-01	nd	3.33	nd	88.2	nd	4090
4-01	1.02	1.98	3.59	77.3	nd	4470
1-02	nd	nd	nd	98.3	nd	4010
2-02	0.971	1.51	3.18	148	54.9	3370
3-02	nd	2.1	nd	422	nd	3350
4-02	nd	10.4	nd	12.5	nd	2260
1-03	nd	nd	nd	nd	nd	1700
2-03	nd	nd	nd	nd	13.8	1650
3-03	nd	nd	nd	93.2	nd	2640

*Gross Beta results include contribution from K-40.
**No data are available from these quarters due to the departure of the RSO and the difficulty in acquiring a replacement.

Table 10-6. Gross alpha and beta results (pCi/g) for sediment in upstream and downstream monitoring locations

Year-Quarter	Upstream		Downstream	
	Alpha	Beta[a]	Alpha	Beta[a]
1-99	5.4	1	6.4	0.91
2-99[b]				
3-99[b]				
4-99	19	0.85	6.2	0.86
1-00	8.4	1.2	10	0.99
2-00	5.04	27	5.99	25
3-00	nd	23.1	3.56	20.8
4-00	12.5	31	4.48	19.2

Year-Quarter	Upstream		Downstream	
	Alpha	Beta[a]	Alpha	Beta[a]
1-01	3.72	24.4	nd	25.7
2-01	7.63	28.6	4.59	27.8
3-01	3.67	26.1	3.7	22.6
4-01	6.47	29.4	10.1	34.8
1-02	2.85	22.9	6.02	21.2
2-02	8.29	28.6	8.04	34.1
3-02	7.5	26.3	6.9	22.8
4-02	5.53	27.3	5.59[c]	27.4[c]
1-03	10.6	21.8	6.92	29
2-03	8.65	25.9	10.8	23.1
3-03	6.89	23.3	8.06	33.9

[a] Gross Beta results include contribution from K-40 associated with process chemicals.
[b] No data are available from these quarters due to the departure of the RSO and the difficulty in acquiring a replacement.
[c] Results presented from reanalysis of samples on 3/6/03.

10.9.2.11 Groundwater Monitoring

Groundwater monitoring wells exist in two categories defined by the section of the site that they monitor; facility wells are associated with the general plant operations, and Bulk Storage Bin wells are associated with the storage area for the presscake. Gross alpha, gross beta, and isotopic analyses are performed on well samples. Groundwater-monitoring results for the past 5 years are summarized in Tables 10-7 and 10-8 using gross alpha and beta results from the past 5 years. As with the surface water samples, gross alpha and beta results are adequate indicators of the radiological condition of the groundwater, the isotopic data are frequently below detection limits, and none of the data approach an action limit of 100 pCi/l that compares to the 10 CFR 20, Appendix B, Table 2 value that would apply to for most of the uranium and thorium isotopes.

Table 10-7. Ground water monitoring results (pCi/L) for Facility wells

Year - Quarter	Gross Alpha				Gross Beta			
	MW-1a	MW-2	MW-3	MW-4	MW-1	MW-2	MW-3	MW-4
1-99	nd	5.8	nd	4.2	nd	nd	nd	nd
2-99*								
3-99*								
4-99	nd	nd	nd	nd	nd	nd	nd	21
1-00	3.7	7.6	nd	3	nd	nd	nd	nd
2-00	4.4	nd	nd	nd	nd	nd	nd	32.7
3-00	6.99	9.86	4.24	nd	6.01	nd	4.73	39.2
4-00	4.62	4.01	nd	1.99	nd	4.98	7.58	43.1
1-01	4.34	3.01	nd	nd	nd	nd	nd	36.2
2-01	7.52	nd	nd	nd	nd	nd	nd	45.5
3-01	5.04	7.12	1.12	nd	3.37	nd	nd	52.3
4-01	8.36	11.5	16.9	nd	6.52	nd	21.3	49.8
1-02	6.88	8.81	2.71	nd	nd	nd	nd	36.7
2-02	5.59	10.8	nd	nd	4.13	4.18	3.9	41
3-02	6.66	6.43	nd	nd	nd	nd	nd	46.1
4-02	nd	nd	nd	nd	nd	4.31	3.18	40.9
1-03	5.52	9.06	nd	nd	nd	nd	nd	36.1
2-03	4.77	7.3	nd	nd	2.41	5.61	nd	39
3-03	4.92	5.54	nd	nd	nd	nd	nd	44

* No data are available from these quarters due to the departure of the RSO and the difficulty in acquiring a replacement.

Table 10-8. Ground water monitoring results (pCi/L) for Bulk Storage Bin wells

Year - Quarter	Gross Alpha					Gross Beta				
	MMW-1	MMW-2	MMW-3	MMW-4	MMW-5	MMW-1	MMW-2	MMW-3	MMW-4	MMW-5
1-99	nd	nd	7.8	nd	7	nd	nd	nd	nd	nd
2-99*										
3-99*										
4-99	nd	nd	45	nd	nd	nd	8	63.00	nd	nd
1-00	2.1	3.2	6.5	nd	nd	nd	nd	nd	nd	nd
2-00	2.01	4.03	29.8	4.01	10.1	5	nd	11.50	nd	4.55
3-00	nd	2.95	9.55	6.84	4.68	nd	nd	nd	nd	nd
4-00	41.8	4.33	11.5	nd	6.04	nd	nd	nd	nd	nd
1-01	nd	3.99	20.6	nd	7.21	nd	nd	10.60	nd	4.28
2-01	nd	5.08	14.15	nd	10.2	nd	nd	10.46	nd	nd
3-01	2.55	5.26	14.8	2.13	7.12	2.99	nd	9.29	2.68	2.91
4-01	1.79	2.81	14.3	4.05	7.96	nd	5.08	6.22	nd	4.56
1-02	3.3	9.08	14.8	11.3	12.2	nd	nd	30.80	4.20	56.50
2-02	nd	5.02	13.1	nd	7.61	5.93	nd	5.36	nd	nd
3-02	nd	5.34	9.87	4.64	10.8	nd	nd	nd	nd	5.07
4-02	2.45	4.89	7.73	5.78	7.74	2.62	3.55	8.02	6.72	3.23
1-03	nd	3.65	12.1	4.87	6.56	nd	nd	4.42	nd	2.06
2-03	nd	nd	12.2	3.59	7.62	nd	nd	4.97	nd	3.64
3-03	nd	3.65	12.3	nd	9.76	nd	nd	5.46	nd	nd

* No data are available from these quarters due to the departure of the RSO and the difficulty in acquiring a replacement.

CSM re-developed the MMW-3 well, replaced the bladder inside the well, and replaced the wellhead in 2002. In the summer of 2002 CSM also completed a $250,000 project to redirect the sheet run off from around the Bulk Storage Bins. CSM consulted with a groundwater expert in 2002 to determine the optimum locations for all wells based on a refined (2000) groundwater flow conceptual model. The findings are presented in a report titled "Technical Basis for the Location and Screen Interval of Groundwater Monitor Wells at Cabot Performance Materials Corporation Boyertown, Pennsylvania Plant" (August 9, 2002) provided in Appendix E. Supplemental information is provided below regarding groundwater conditions and site wells.

Potentiometric Surface Map

Three figures provided in Appendix F (Figures 1, 2, and 3) illustrate groundwater flow elevations and interpreted groundwater flow directions for the Boyertown facility. These figures, which illustrate groundwater flow in September 2000, September 2001, and September 2002, show that groundwater consistently flows to the southwest towards a local discharge point at West Swamp Creek.

Environmental Standards, Inc. (Environmental Standards) evaluated groundwater elevation contour maps for more than 30 sampling events. Although absolute elevations fluctuate depending on water supply conditions (drought *vs.* normal or high groundwater events), the overall flow direction is consistently to the southwest as shown in the Appendix F figures.

Well Construction Information

Table 10-9 provides summary data for wells at the facility, as requested by the NRC. The wells proposed for inclusion in the NRC license renewal are highlighted.

Table 10-9. Groundwater Monitoring Well Construction Specifications
Cabot Performance Materials Boyertown, Pennsylvania

Well Identification	Date Constructed	Total Depth (ft bgs) (1)	Well Material	Screened/Open Interval (ft bgs)	Monitoring Well Purpose or Regulatory Program
MW 90-1D	06/01/1990	89.5	PVC	69.5-89.5	Plant Area Assessment Program
MW 90-1Sr	01/09/1999	31.0	PVC	10.0-30.0	Plant Area Assessment Program
MW 90-2D	06/01/1990	86.3	PVC	56.3-86.3	Plant Area Assessment Program
MW 90-2S	05/30/1990	31.9	PVC	21.9-31.9	Plant Area Assessment Program
MW 90-3D	06/01/1990	89.2	PVC	69.2-89.2	Plant Area Assessment Program
MW 90-3S	05/31/1990	36.8	PVC	16.8-36.8	Plant Area Assessment Program
MW 90-4S	05/30/1990	31.6	PVC	11.6-31.6	Plant Area Assessment Program
MW 90-5S	05/31/1990	30.8	PVC	20.8-30.8	Plant Area Assessment Program
MW 90-6S	09/25/1990	47	PVC	17-47	Plant Area Assessment Program
MW 90-7S	09/27/1990	54	PVC	29-54	Plant Area Assessment Program
MW 95-01	02/21/1995	60	PVC	30-60	PA DEP Residual Waste Program
MW 95-02	02/22/1995	57	PVC	37-57	PA DEP Residual Waste Program
MW 95-03	02/22/1995	38	PVC	28-38	PA DEP Residual Waste Program
MW 95-04	02/23/1995	60	PVC	40-60	PA DEP Residual Waste Program
MW 97-05	02/24/1998	34	PVC	14-34	PA DEP Residual Waste Program
MW 97-06	02/24/1998	94	PVC	74-94	PA DEP Residual Waste Program
MW 97-07	02/24/1998	64	PVC	44-64	PA DEP Residual Waste Program
MW 00-08	03/21/2000	56.8	PVC	40-55	Plant Area Assessment Program
MW 00-09	03/20/2000	36.5	PVC	25-35	Plant Area Assessment Program
MW 00-10	06/23/2000	56.8	PVC	35.5-55.5	Focused Impoundment Investigation
MW 02-11	06/17/2002	40.83	PVC	20.8-40.8	Plant Area Assessment Program
MMW-1	10/08/1985	101	PVC	43.3-73.3	NRC Permit Monitoring
MMW-2	10/09/1985	101	PVC	45-75	NRC Permit Monitoring
MMW-3	10/09/1985	101	PVC	44.3-74.3	NRC Permit Monitoring
MMW-4	10/07/1985	101	PVC	45-75	NRC Permit Monitoring
MMW-5	10/08/1985	101	PVC	40-70	NRC Permit Monitoring
Well 1A/ Production Well 8	06/28/1957	405	PVC	21-405	NRC Permit Monitoring
Well 2/ Production Well 2	11/10/1959	528	PVC	16-528	NRC Permit Monitoring
MW-3	ND	15.6	PVC	ND	NRC Permit Monitoring
MW-4	ND	14.5	PVC	ND	NRC Permit Monitoring

Notes: (1) All depths referenced to land surface and expressed in feet below ground surface (ft bgs).
ND Indicates no data were available on a given well specification.
Well 1A / Production Well 8 & Well 2 / Production Well 2 are completed as open borehole wells with no sand pack or bentonite seal.
Highlighted wells are proposed to be included in the new NRC permit.

Travel Time

In order to calculate potential groundwater travel times (seepage velocities) from the bulk storage area to the proposed new monitoring well locations, Environmental Standards reviewed CSM's hydrogeologic setting and the currently accepted site conceptual model as presented in the Environmental Standards document titled *Supplemental Assessment of March 2000 Water Sampling Program, Cabot Performance Materials, Boyertown, Pennsylvania Plant* (Environmental Standards, 2000).

As presented in the conceptual model, the Boyertown facility is located in the Triassic Basin of the Piedmont Physiographic Province. The shales of the Brunswick Formation, the youngest lithologic unit of the Late Triassic Stage Newark Group, underlie the area. The Newark Group is contained in a southwest trending basin that reaches from Rockland County, New York, through Adams County, Pennsylvania. The Newark Basin is the largest of three basins included in one of six major Triassic rift valleys that run in a sinuous belt for more than 1,000 miles from Nova Scotia to South Carolina. These rift valleys formed as a result of tensional stress along the Atlantic coast that caused downward normal faulting.

The Newark Group consists of 16,000 to 20,000 feet of non-marine sedimentary rocks (and associated intrusive and extrusive igneous rocks) deposited in the Triassic rift valley from Paleozoic source rocks to the northwest. The lowest member of the Newark Group is the Stockton Formation, which consists primarily of light yellowish gray to pale reddish brown well-sorted arkose and subordinate conglomerate and mudstone. In the vicinity of the project site, weathered arkosic and sand zones within the Stockton Formation are the sources for most of the potable water withdrawn from the Stockton Formation.

The Stockton Formation is conformably overlain by the Lockatong Formation, a large lacustrine lens that ranges from 3,750 feet thick in the center of the basin to 500 to 750 feet thick in the subsurface west of Staten Island. The Lockatong Formation, as an aquifer, is reportedly the poorest groundwater producing unit in the Newark Group (Hall, 1974). The Lockatong Formation grades conformably upward into the reddish brown shales of the Brunswick Formation.

The Brunswick Formation consists of a thick sequence of interbedded brown, reddish brown, and gray shale, sandy shale, sandstone, and some conglomerate. The thickness of the Brunswick Formation is estimated to range from greater than 16,000 feet in the southwest portion of the basin to several thousand feet in the vicinity of the Boyertown facility. Regional bedding generally strikes in a northeast direction, with the dip between 10° and 30° northwest, but this can vary significantly on a local scale.

Environmental Standards determined that the Brunswick Formation, over which the site is located, can be locally characterized by complicated hydrogeology, with groundwater flow controlled by a combination of local and regional topography, formation bedding, fracturing, and regional groundwater usage. Secondary permeability developed in discrete bedding planes and fractures normally control groundwater flow.

The number and width of secondary openings and, consequently, formation hydraulic conductivity controls (to some degree) the seepage velocity of the Brunswick Formation. Impermeable bedding surfaces in the Brunswick Formation often limit the potential degree of vertical compound migration, particularly in local areas where groundwater pumping is limited.

In the Brunswick Formation, local and regional topography significantly influences groundwater conditions. For example, in high ridgetop areas, a localized perched water zone in the upper bedrock (approximately 10-20 feet below ground surface [bgs]) overlies a deeper regional groundwater flow system. By contrast, in low-lying areas such as valleys and well-developed flood plains, the entire sequence may be saturated.

Locally, the Boyertown facility is located in a north-south trending drainage sub-basin that discharges groundwater and overland flow to West Swamp Creek. Drainage patterns and the conceptual flow model developed for the local area suggest that water flow in this sub-basin, as expected, is relatively separate and distinct from the surrounding sub-basins that also discharge to West Swamp Creek (Figure 4 in Appendix F).

The diabase dike intrusives, northeast of the facility, have caused additional fracturing of the Brunswick Formation in the area, and thus, secondary porosity is more abundant in the vicinity of these diabase dikes than when relatively distant from these igneous intrusive rocks.

An interpretation of historical groundwater elevation contour data indicates that groundwater beneath the Boyertown facility consistently flows in a south-southwest direction and discharges to West Swamp

Creek. The hydrogeologic flow model developed for the local groundwater system suggests that the area upgradient (north and northeast) of the facility property is an upland zone of relatively significant groundwater recharge and high groundwater gradients. This area is characterized by a strong downward vertical hydraulic gradient and a rapid groundwater seepage velocity to the south and southwest.

Environmental Standards performed a search of available hydrogeologic data and studies on the Brunswick Formation in order to calculate the potential travel time from the bulk storage area to the newly proposed monitoring well locations (these monitoring wells include wells MW 95-03, MW 95-04, and MW 97-06; see Figures 1, 2, and 3 in Appendix F). The review evaluated publicly available literature, Boyertown facility site-specific studies, and Environmental Standards hydrogeologic reports prepared for other client projects in the Brunswick Formation. The review specifically focused on projects located in the general vicinity of the Boyertown facility.

Based on its review, Environmental Standards elected to use both site-specific data and the results from a bromide tracer study conducted on the Brunswick Formation aquifer from another local industrial facility located in Perkasie, Pennsylvania (less than 19 miles east of the Boyertown facility). The Perkasie site which is located in the same relative geologic position in the Newark Basin, is in southeast Pennsylvania, is underlain by the Brunswick Formation, and is proximal to the same local diabase intrusive complex (Figure 5 in Appendix F).

The bromide tracer study results were used for this travel time estimation because Environmental Standards considered the results to more accurately reflect the influence of both primary and secondary porosity on groundwater seepage velocity rather than standard pump test or slug test results. For example, in the original Rogers, Golden and Halpern (RGH) groundwater engineering report completed on behalf of CSM in December 1985, slug test results suggested that formation hydraulic conductivities were very low (averaged 0.3 ft/day) (RGH, 1985). In addition, porosity values used in the RGH calculations reflected primary porosities and neglected to account for secondary porosities (a porosity value of 5 percent was assumed by RGH).

Much has been learned regarding fractured bedrock flow since the RGH report was prepared. Environmental Standards determined that calculating groundwater (and subsequently radionuclide) travel times using only primary porosity hydraulic conductivities in fractured bedrock may well lead to erroneous (perhaps even dangerous) assumptions regarding licensee response times to react to an inadvertent release of radionuclides into groundwater (if such a release were to occur). Environmental Standards' experience in the Brunswick Formation in this area suggests that the RGH-reported hydraulic conductivities are reflective of primary porosity conductivities but are not reflective of not secondary (fracture, weathered bedding plane) conductivities. Thus, a revision of the original RGH travel time calculation is appropriate.

Environmental Standards' hydrogeologists generally model the Brunswick Formation using a dual porosity-modeling paradigm. The dual porosity paradigm emerges from considering both primary porosity (matrix porosity) and secondary porosity (fracture and weathered bedding plane). While modeling is a simulative exercise, the bromide tracer study referenced above relied on direct empirical observation of groundwater transport behavior. Environmental Standards elected to use the groundwater seepage velocity developed from the nearby bromide tracer study because this velocity accounts for both primary and secondary porosity and relies on the results of direct observation. In addition, the extrapolation of these data seems appropriate given the previously enumerated similarities between the two sites.

In order to calculate travel times, Environmental Standards used the following equations in its analysis.

- Potential travel time = Seepage velocity in groundwater × distance from the bulk storage area to the potential new monitoring well.
- Seepage velocity in groundwater = Hydraulic gradient × ratio of hydraulic conductivity to effective porosity.

A groundwater seepage velocity of 27 feet per day was used in the calculations. This value was derived from the sodium bromide tracer study conducted in the Brunswick Formation at the manufacturing facility near Perkasie, Pennsylvania (Environmental Standards, 1999). The seepage velocity of 27 feet per day was determined at the Perkasie site when the hydraulic gradient was measured to be 0.026 at the site. Using these two input variables for the site near Perkasie, the ratio of hydraulic conductivity to effective porosity was calculated to be 1038.5 ft/day for the site.

The distance from the Bulk Storage Bins to the proposed new monitoring wells was measured using an Autocad map and the Pennsylvania-licensed surveyor data for each well. The distances from the bulk storage area to the proposed monitoring wells are as follows.

- MW 95-03 – 745 feet
- MW 95-04 – 700 feet
- MW 97-06 – 810 feet

Using the site-specific hydraulic gradient from the bulk storage area to the proposed new monitoring wells (0.025) and the ratio of hydraulic conductivity to effective porosity (1038.5 ft/day) derived from the sodium bromide tracer study, the travel time equations were solved for each monitoring well and the following results were obtained.

- MW 95-03 – 29 days
- MW 95-04 – 27 days
- MW 97-06 – 31 days

Further, the travel time from the Bulk Storage Bins to West Swamp Creek (the nearest surface water discharge point and radionuclide receptor, 1900 feet downgradient of the bulk storage area) is 268 days. This estimate is based on assuming a hydraulic gradient from the bulk storage area to the monitoring wells of 0.025 and a hydraulic gradient from these wells to the creek of 0.0048. As shown on the groundwater elevation contour maps in Appendix F, the gradient in the aquifer beneath the Boyertown facility is substantially reduced in the Swamp Creek flood plain.

It should be noted that the preceding values represent minimum radionuclide travel times from the bulk storage area to the proposed new monitoring wells and West Swamp Creek. Other physical-chemical processes that would inhibit travel of radiological contaminants accidentally released from the Bulk Storage Bins to the proposed new downgradient monitoring wells were not considered. Some of these processes include ion-exchange phenomenon (cation adsorption, for example), complex formation, anion adsorption and exclusion mechanisms, and equilibrium/kinetic adsorption considerations. Other processes that retard the radionuclide and elemental mobility in soils have also not been considered, thus, the travel times presented represent travel time minimums.

Water Use

Process water is taken from the stream that flows along the plant site boundary, treated to remove impurities, used in the plant process, sent to the wastewater treatment plant to adjust the pH, and returned to the stream in accordance with the site NPDES permit. The process wastewater is returned to the stream at a rate of 150,000 gal/day, along with an additional 120,000-gal/day contribution from site runoff, non-contact cooling water, and steam condensate. Surface water sampling locations in the stream are monitored to ensure that effluent does not exceed regulatory limits. The removal, use, treatment, and return of the surface water imparts no significant impact to the environment because the effluent is treated to ensure that its pH, temperature, and particulate content do not alter conditions in the stream.

Throughput, production rates, and process water requirements have been steady in recent years at the Boyertown Plant. There are currently no planned changes to operations that would impact the rate of water use or require alternate water supplies.

The current subdivision under construction as identified in the October 4, 2002 evaluation is supplied with potable water by a public water purveyor. The source of this water is several miles from the Boyertown facility and the plant is not considered to be a realistic source of impact to this system's supply.

Further, there have been no increases in water use adjacent to or downgradient of the plant. CSM purchased real estate downgradient of the plant to improve site-lines at the Swamp Creek Road/County Line Road intersection. Two residences were purchased as part of this transaction. Both residences relied on groundwater for potable supply. The residences have been razed, and these potential groundwater receptors no longer exist, further reducing the potential exposure of nearby properties to accidental plant releases (if such releases were to occur).

CSM is committed to maintaining its groundwater-monitoring program while incorporating the recommendations and revisions contained in the document in Appendix E. The minor changes in the selection of wells to be monitored will use wells that currently exist at the site and will be incorporated into the program upon renewal of this license.

10.9.2.12 Climatology and Meteorology

CSM collected weather data from September 1999 to June 2002 using a DAVIS - Weather Monitor II weather station unit. The meteorological data collected on site includes air temperature, relative humidity, wind speed, wind direction, and barometric pressure. Collected data was stored in hourly increments. Rainfall data for this time period were acquired from the National Climatic Data Center, a product and service information center provided by the United States National Oceanic and Atmospheric Administration (NOAA).

On June 28, 2002, CSM installed a WeatherLog™ Weather Monitoring System. This new system monitors air temperature, relative humidity, dew point, barometric pressure, wind direction, wind speed, and rainfall. Located in CSM's security and main communications center, this weather monitoring system is equipped with real-time weather condition monitoring to be used during emergency response in the event of a spill or release. The new system is also equipped with a 4 to 20-milliamp signal-output that is received by CSM's central environmental monitoring system. All weather station parameter data points are then stored for future use.

The mean monthly temperatures and extremes are shown in Table 10-10. The maximum-recorded temperature during the period of record was 100.2 degrees F and the minimum was 3.8 degrees F. The annual mean temperature for the period of record was 52.8 degrees F based on the data collected on site.

Table 10-10. Mean and extremes of monthly average temperature (°F)

Month	Monthly Mean	Monthly Maximum	Monthly Minimum
January	30.1	68.2	3.8
February	34.5	64	6.6
March	41.9	80.8	16.2
April	53.1	94.1	26.2
May	62.4	97.7	34
June	71.8	98.9	42.3
July	71.5	96.6	37.3
August	73.3	100.2	41.3
September	63.7	91.4	34.6
October	52.4	84	25.2
November	44.6	70.7	17.7
December	33.7	70.4	7.4

Precipitation data from September 1999 to June 2002 were acquired through NOAA at the neighboring town of Bechtelsville, Pennsylvania (40 degrees 23' N / 75 degrees 37' W). These data are summarized in Table 10-11. The annual mean precipitation was 45.53 inches. The maximum daily rainfall took place on September 17, 1999.

Table 10-11. Mean, maximum daily and monthly mean rainfall.

Month	Average Daily Rainfall	Maximum Daily Rainfall	Average Monthly Rainfall
January	0.1	1.04	3.02
February	0.1	0.92	1.7
March	0.2	3.07	4.93
April	0.1	1.73	3.63
May	0.2	3.92	5.79
June	0.1	1.8	3.92
July	0.1	1.41	3.72
August	0.2	2.83	5.18
September	0.2	5.21	5.97
October	0.1	1.41	1.92
November	0.1	1.29	2.2
December	0.1	2.05	3.55

Wind direction data were recorded in hourly increments. Calm wind speed (which resulted in a non-detectable wind direction) was observed approximately 30% of the total observed time. The remaining 70% of observed wind directions are shown as the total detectable wind direction observations, as shown in Figures 10-8 and 10-9. The predominant wind direction group was north to west-northwest, which was observed 45% of the observed time.

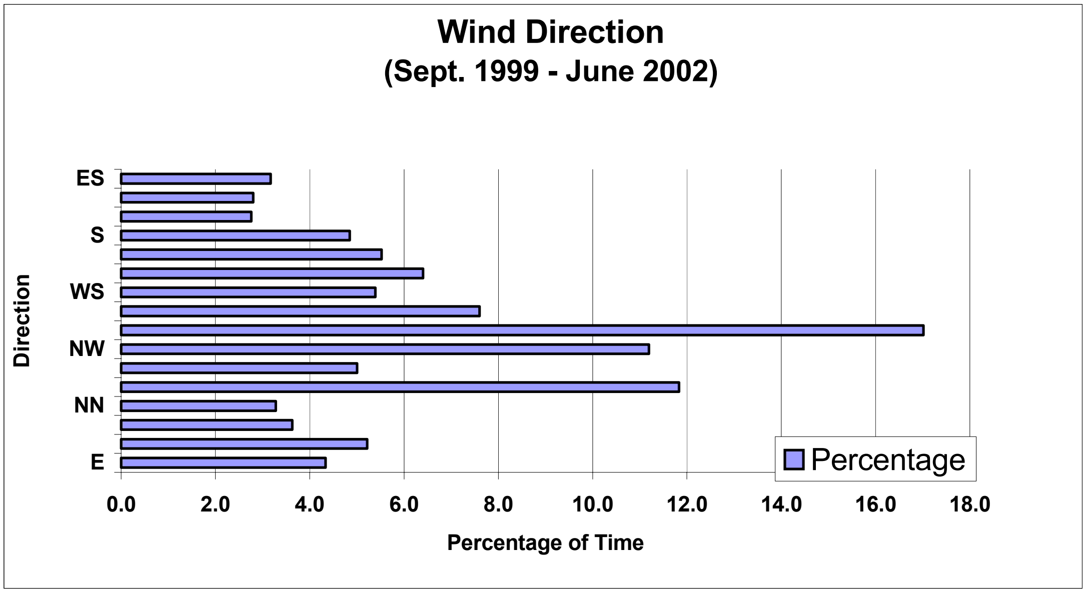

Figure 10-3. Wind Direction as a percentage of total time with wind.

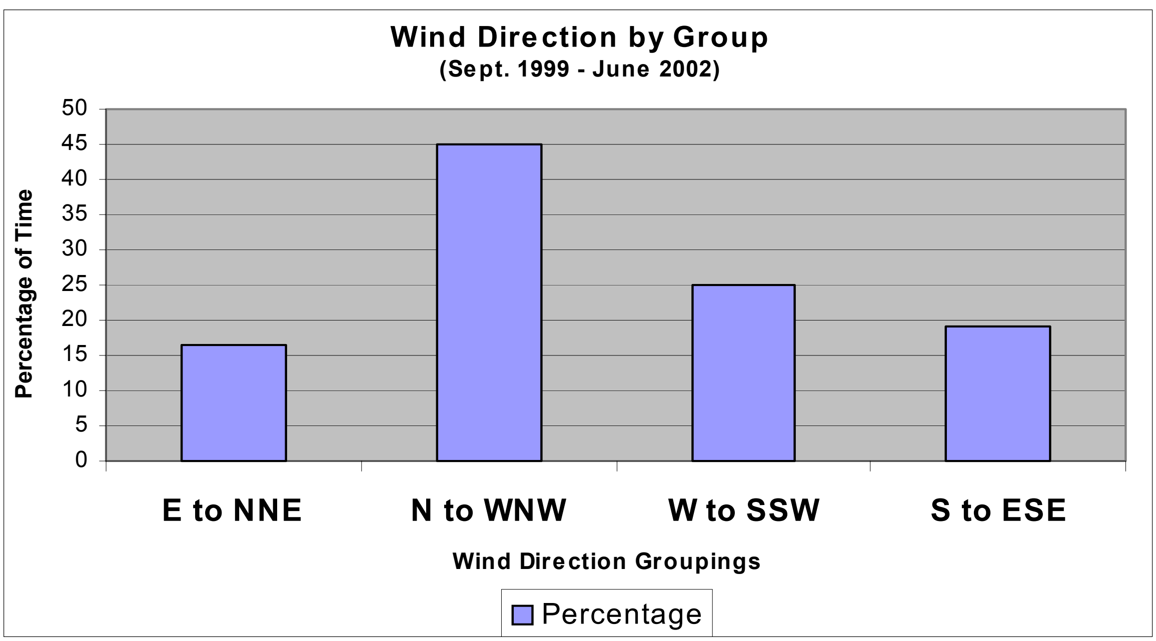

Figure 10-4. Wind Direction by groups.

10.9.2.13 Inventory Tracking and Documentation

A continuous inventory tracking system is currently in place using ore receipts, assay results, and calculations on spreadsheets to ensure the license limit of 400 tons of elemental uranium is not exceeded.

In addition, the sealed sources that are maintained under a general license are inventoried at the time of each required leak test.

10.9.2.14 Emergency Procedures

CSM maintains redundant power supply systems including on-site generators to ensure that the plant is never without the power necessary to continue operations. An emergency response vehicle is maintained to respond to site emergencies. Valves that control wastewater discharges are designed to close when power is interrupted to prevent uncontrolled releases of radioactive materials or chemicals in the event of an emergency. CSM also maintains a fire truck and trained staff to perform as a fire fighting and emergency response team.

11. WASTE MANAGEMENT

CSM manages one primary waste stream and one minor waste stream at the Boyertown plan as described in the following text.

11.1 PAST PRACTICES AND DISPOSAL HISTORY

The extraction process results in one principal radioactive waste stream, the presscake that remains after processing and contains virtually all the uranium and thorium that was in the ore, and a minor secondary waste stream, the wastewater filtercake. The presscake has not been considered as a waste because it contains economically recoverable quantities of CSM's product materials or other valuable minerals and metals. It has historically been accumulated in enclosed buildings (the Bulk Storage Bins) on-site with the intent of recovering those product materials. However, CSM may no longer accumulate that material and will handle it as described in Section 11.2, below.

The filtercake that is generated from the onsite treatment of acidic wastewaters has historically been released for disposal at nearby landfills as non-radioactive material. On an annual basis CSM produces approximately 19,000 tons of filtercake, which has been composite sampled at least quarterly and analyzed for U and Th to ensure that the total concentration remains below the release limit stated in CSM's license condition. In addition, CSM uses ore assay data to track uranium and thorium concentrations in individual ore batches and to isolate occasional batches that may contain higher concentrations than normal. Those batches are either rejected or are isolated during processing so that the related filtercake can be monitored closely to detect materials that exceed the landfill release limits.

Three shipments of low-level radioactive material have been sent off-site since the last license renewal. The first was shipped in 1997 and 1998. CSM emptied all eight Bulk Storage Bins on-site and shipped approximately 18,000 tons of ore digestion filtercake for reprocessing at a uranium recovery facility in Utah. The concentration of this material was calculated at 2,800 pCi/g for a total calculated U and Th activity of 45 Ci for the entire shipment. The second was shipped in September of 2000, with the NRC's approval. CPM shipped approximately 1,000 cubic yards of material to Waste Control Specialists (WCS) in Andrews, Texas, as "unimportant quantity" material as defined in 10 CFR Part 40.13. The third and most recent shipment of radioactive material was shipped in July of 2002 to RACE, LLC in Memphis, Tennessee, for consolidation and final disposition at WCS. This shipment, which was mostly old process equipment, was shipped as "Radioactive Material, Excepted Package-Limited Quantity of Material." The total volume of this shipment was 370 cubic yards, with a total calculated U and Th activity of 10.33 mCi.

11.2 WASTE DISPOSAL PLANS FOR ONGOING OPERATIONS

There are currently four feasible alternatives for handling the ore residues and any radiological wastes from the process. First, CSM could continue to store the material on-site until operations ceased, additional tantalum recovery processes were employed, storage capacity at the site was exceeded, or the possession limits of this license were approached. The plant could proceed for many years in this manner at the current rate of processing and if the quantity of stored material someday exceeded the values used in the Decommissioning Funding Plan Cost Estimate, CSM would revise the cost estimate and the financial assurance vehicle to adequately address the additional cost of disposal for the larger quantity. Second, the material could be disposed at a licensed disposal site for radioactive wastes. The material would be characterized, packaged, and transported to an acceptable disposal facility in accordance with applicable regulations of the U.S. Department of Transportation and the U.S. NRC.

Third, the material could be transferred to another operation that was licensed to receive uranium and thorium. For instance, the presscake could be packaged and transported in accordance with applicable regulations for transfer to another licensee as alternate feed material. The recipient would take ownership of the material to process and dispose of it as appropriate for their operation. The fourth alternative involves the possible qualification of all or part of the material as unimportant quantities of radioactive material under the exemptions given in 10 CFR 40.13. CSM may pursue any of these alternatives in the future. CSM has established a contract with a facility in Utah to accept the material as alternate feed, and this will be the preferred alternative for waste disposal. It is CSM's intent to package and dispose of the material in this manner on a frequent and routine basis to prevent significant accumulations in the Bulk Storage Bins.

The filtercake that represents the minor waste stream from the plant operations will continue to be disposed as non-radioactive material at nearby landfills. The average concentrations of Th and U in the filtercake and the isotopic composition of the material have been evaluated. In addition, doses were assessed for ongoing landfill disposal to establish a regulatory basis for a release limit that will be listed as a condition to the license upon renewal. Average uranium and thorium concentrations in the filtercake and results from dose calculations are described in a document titled "Dose Assessment for Disposal of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania", April 22 2003 provided in Appendix G. Revised sampling and analysis protocols have been developed that will require analysis of filtercake samples more frequently (monthly) than in the past, and will implement the new release limit. The ore assay data will continue to be used to identify and isolate any ore batches that contain higher than usual concentrations of uranium and thorium and may result in filtercake that exceeds the release limits. In the event that batches of filtercake someday exceed the annual average activity limit such that it cannot be released to the landfill, CSM will consider applying the presscake disposal alternatives described above.

CSM will employ other disposal options as may be approved in the future by the NRC. If at any point CSM generates mixed wastes they will be managed in accordance with the most recent regulatory guidance.

11.3 DECOMMISSIONING FUNDING PLAN

CSM continues to maintain a mechanism to provide assurances that funds will be available for decommissioning the Boyertown facility. CSM has adequate financial resources to continue operating and ultimately decommission the facilities covered by this license. Recent financial reports from the company were supplied to the NRC in support of this assertion. The supporting basis for the value of the current funding mechanism is the "Cabot Supermetals, Inc. 2004 Decommissioning Cost Estimate for the Boyertown, Pennsylvania Site", March 11, 2004, which is provided as Appendix H with this application. Upon acceptance by the NRC of the cost basis provided in Appendix H, CSM will establish an Irrevocable Standby Letter of Credit as directed by the NRC for a value that equals or exceeds the total of the cost estimate.

The estimated cost to close and remediate the plant and the value of the "Irrevocable Standby Letter of Credit" are reviewed by the RSO every two years in accordance with the requirements of 10 CFR 40.36. The expiration date of the letter of credit is extended annually for a term of one year unless CSM and the NRC are notified at least 90 days prior to the expiration date. The next biennial review will be performed within 24 months of the license renewal date, and the bond will be adjusted as appropriate at that time.

12. LICENSE FEES

- Fee category: 2.a.1
- Amount assessed: Full cost, payable upon notification from the NRC.

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX A

Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant

Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant

June 9, 2003

Prepared by:

Weston Solutions, Inc.

Approved by:

Robert P. Schoenfelder ______________________ June 12, 2003

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TABLE OF CONTENTS

SECTION **PAGE**

1. EXECUTIVE SUMMARY 4

2. DERIVATION OF GROSS ALPHA DAC VALUES 5

2.1 COMPOSITION OF THE ORE MATERIALS 5

2.2 DEGREE OF EQUILIBRIUM IN THE DECAY CHAINS...................................7

2.3 DAC VALUES FOR THE URANIUM-238 DECAY CHAIN (ORE PROCESSING)..9

2.4 DAC VALUES FOR THE THORIUM-232 DECAY CHAIN (ORE PROCESSING)..11

2.5 DAC VALUES FOR MIXTURES OF URANIUM-238 AND THORIUM-232 DECAY CHAIN ISOTOPES 13

2.6 COMPARISON WITH PREVIOUS DAC FOR ORE PROCESSING................14

2.7 COMPARISON OF PERSONAL AND AREA AIR SAMPLE DATA IN BUILDING 73 15

2.8 THORIUM DOPING ACTIVITIES...18

2.8.1 Derivation of Mixture and Gross Alpha DAC for Thorium Doping..21

2.8.2 Breathing Zone Air Sample Data during Thorium Doping Activities 22

3. RECOMMENDATIONS AND CONCLUSIONS CONCERNING THE AIR SAMPLING PROGRAM...23

4. REFERENCES...25

LIST OF FIGURES

FIGURE **PAGE**

Figure 1. Plot of the Activity Percent Uranium Versus the Rank by U-238 to Th-232 ratio 6

Figure 2. Counting Container Configuration 8

Figure 3. Net Count Rate Versus Time Since Sealing. 8

Figure 4. Uranium-238 Decay Chain (after NCRP 1988) 9

Figure 5. Thorium-232 Decay Chain (after NCRP 1988) 12

Figure 6. Thorium Doping Room Layout 19

Figure 7. Slot hood, steam table and drum into which thorium-doped powder is collected. 20

Figure 8. Canopy hood, weighing table and area sampler head (blue) 20

Figure 9. Dependence of thorium nitrate gross alpha DAC on the ratio of Ac-228 to Th-232. .. 22

LIST OF TABLES

TABLE **PAGE**

Table 1. Summary Statistics for Ore Shipments Received by CSM During 2001 7

Table 2. Uranium-238 Decay Chain and Equilibrium Assumptions 10

Table 3. U-238 Decay Chain Stochastic Derived Air Concentration Values 10

Table 4. Thorium-232 Decay Chain and Equilibrium Assumptions 12

Table 5. Thorium-232 Decay Chain Stochastic DAC Values. 13

Table 6. Comparison of the Proposed and Previous DAC Values for Ore Processing 14

Table 7. Comparison of Breathing Zone and Area Air samples for Ore Dumping and Grinding Activities. 15

Table 8. Air Sample Results for Ore Screening Activities. 18

Table 9. Stochastic DAC values for class W thorium isotopes. 21

Table 10. Breathing Zone Sample Results for Thorium Doping Operations. 22

1. EXECUTIVE SUMMARY

This report provides a review of the occupational air-sampling program at the Cabot Supermetals, Inc. (CSM) plant in Boyertown, Pennsylvania. The CSM plant receives and handles radioactive materials under license SMB-920, which was issued by the U.S. Nuclear Regulatory Commission (NRC). Tantalum and niobium are extracted from ore materials that contain low concentrations of natural uranium and thorium. The radioactive constituents are not extracted or concentrated from the ore during this process. A second operation involving radioactive materials at CSM is thorium doping. This process uses thorium nitrate and is described in section 2.9 of this report.

Historical air sample data have demonstrated that workers are exposed only to low concentrations of airborne uranium, thorium, and their radioactive progeny during routine ore processing operations and thorium doping activities. Data are not available to document airborne concentrations that occasionally may be present during non-routine operations such as maintenance activities. These non-routine exposures are limited in duration and so the dose consequences are usually not expected to be significant.

This report documents the results of an evaluation of the CSM occupational air-sampling program and it represents an update of a detailed evaluation of the air-sampling program that was performed during 1995 by Applied Radiological Control, Inc. (1995). The review documented in this report was initiated in response to item B of a Notice of Violation issued on October 23, 2001 by the NRC (Kinneman 2001).

This report touches on several topics that affect the current sampling program, including derived air concentration (DAC) values for the ore processing and thorium doping activities at the plant, and placement of samplers to obtain representative dust samples. In addition, this document provides current area and breathing zone sample data and makes recommendations for calculation of a gross alpha DAC, effective DAC, and continued air sampling.

This report is an update of a draft occupational air-sampling program evaluation that was submitted for review by the NRC in September 2002. It now incorporates revisions that address comments provided in a letter to CSM from the NRC dated 14 January 2003 titled "Request For

Additional Information On The License Renewal Application For The Cabot Boyertown Facility, SMB-920 (L52461)". John McGrath of the NRC, Region I reviewed that draft. This revision of the air sampling evaluation does not pursue a prior request for approval to use dust cyclones. Instead, it provides a rationale for why CSM should be permitted to use a DAC based on a 10-micron activity median aerodynamic diameter particle size distribution for ore processing activities. It then calculates mixture DAC values and gross alpha DAC values based on this particle size. All mixture DAC and gross alpha DAC values presented herein are strictly based on standard ICRP Publication 30 metabolic models and methodology, which form the basis of the system of dose limitation adopted by the NRC.

This document proposes DAC values based on an activity ratio in ores of 3 U-238: 1 Th-232 in place of the previous DAC, which was based on a ratio of 2 U-238: 3 Th-232. A technical description of how the earlier ratios were chosen has not been found, but the ratios presented herein are based on a rigorous statistical evaluation of analytical data from 207 ore samples collected throughout 2001, as presented in Section 2.1. In addition, this report concludes that respirators are not required for adequate protection of workers during routine operations and that specific work control plans, such as radiation work permits, should document appropriate worker protection and special monitoring requirements for non-routine operations.

2. DERIVATION OF GROSS ALPHA DAC VALUES

This section establishes a rationale for a gross alpha DAC that may be used to estimate a committed effective dose equivalent from inhalation of ore dust at the CSM Boyertown plant. The DAC is believed to be protective of workers and is reflective of the historical variability of the uranium-238 to thorium-232 ratio.

2.1 COMPOSITION OF THE ORE MATERIALS

This evaluation of the uranium and thorium content of ores processed by CSM is based on the ores received and sampled in 2001. During 2001, CSM received a total of 207 shipments. The uranium and thorium concentrations in each of those ore shipments are listed in Attachment A.

The data in Attachment A were sorted by the rank of the uranium-238 activity fraction, that is, by how much of the radioactivity in an ore batch was produced by uranium-238:

U-238 activity / (U-238 activity + Th-232 activity).

Figure 1 is a graph of the activity percent uranium-238 versus the rank of the uranium-238 activity fraction for the ore received in 2001. This is an important factor because the dose per picocurie (pCi) of intake increases as the ratio decreases.

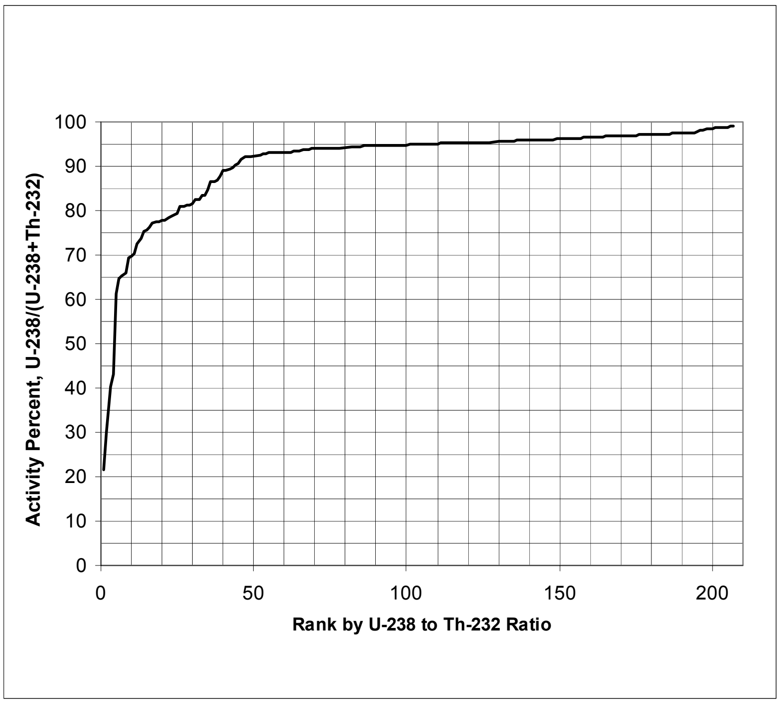

Figure 1. Plot of the Activity Percent Uranium Versus the Rank by U-238 to Th-232 ratio

Figure 1 illustrates that most of the ore materials processed by CSM during 2001 had high activity ratios of uranium-238 to thorium-232. To be conservative, the 95% lower confidence limit on the 0.1-quantile uranium-238 activity ratio for 2001 data is recommended for derivation of the gross alpha DAC.[1] This corresponds to 75% uranium-238 activity and 25% thorium-232

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[1] This is based on statistics of rank. The 0.1 quantile activity ratio is the activity ratio for the ore lot that has a rank of 21 out of 207. The 95% lower confidence limit on the 0.1 quantile value is the activity ratio that corresponds to the rank of: 21 – (1.645*$[207*0.1 * 0.9]^{0.5}$) or rank 14, which is 75% uranium-238: 25% thorium-232.

activity (or a ratio of 3:1). Ninety percent of the ore mixtures processed at the Boyertown site will have an activity ratio of uranium-238 to thorium-232 of 75% to 25% or greater. Summary statistics for ores received in 2001 are provided in Table 1.

Table 1. Summary Statistics for Ore Shipments Received by CSM During 2001

Average activity ratio: U-238 / U-238 + Th-232	0.91
Median activity ratio: U-238 / U-238 + Th-232	0.95
0.1 quantile activity ratio: U-238 / U-238 + Th-232	0.78 (Rank 21 of 207)
95% lower confidence limit on 0.1 quantile activity ratio	0.75 (Rank 14 of 207)

2.2 DEGREE OF EQUILIBRIUM IN THE DECAY CHAINS

The ore material processed by the Boyertown plant is expected to have uranium and thorium more or less uniformly distributed through its volume since the ore is composed of niobium/tantalum minerals in which uranium and thorium are randomly substituted for calcium and rare earth elements (Frondel 1958). Therefore, radon is formed throughout the matrix of these materials. Very little of the radon in the ore materials is produced at the surfaces of mineral grains, and so very little is expected to emanate from mineral grains. Since very little radon is expected to emanate from the ore, a high degree of equilibrium in the uranium-238 and thorium-232 decay chains is also expected.

Like the ore processed at CSM, oil field barite pipe scale contains radioactive materials (radium-226) that are distributed more or less uniformly throughout the matrix of the scale. As with niobium/tantalum minerals, very little of the radon is available for emanation. The EPA has assigned pipe scale materials a radon emanation fraction of 5% (EPA 1993).

To assess the equilibrium of the CSM ore materials, gross gamma was counted on a sample of feed material. A sample of ground ore material weighing 800 grams was placed into a 410-ml low-form polyethylene container that was allowed to sit open for 12 hours. The container was then sealed shut using black electrical tape. The sample was counted for a series of 10-minute counts in the configuration shown in Figure 2. The net count rate in counts per minute (cpm) was plotted versus time, as shown in Figure 3. The time scale on the graph represents the elapsed time in days since the sample was sealed.

Figure 2. Counting Container Configuration

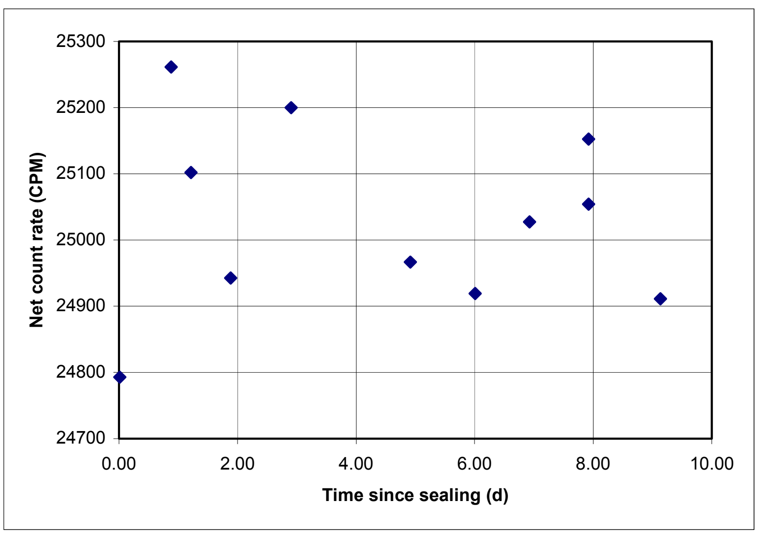

Figure 3. Net Count Rate Versus Time Since Sealing.

The gamma emitters in the uranium-238 and thorium-232 chains are largely progeny from radon-222 and radon-220. Therefore, a significant increase in the count rate with time since sealing would indicate that a significant amount of radon was lost when the container was open for the 12-hour period. Figure 3 indicates that the count rate remained essentially constant after sealing; therefore the material must maintain a high degree of equilibrium between radium and radon progeny during handling. It is concluded that the material would retain nearly all of its radon during handling and grinding, and the elements below radium-226 and radium-224 are assumed to be at 90% of their equilibrium activity. The 10% loss takes into account the 5% emanation loss described earlier and allows an additional 5% loss as a conservative factor.

2.3 DAC VALUES FOR THE URANIUM-238 DECAY CHAIN (ORE PROCESSING)

The uranium-238 decay chain is depicted in Figure 4. The degree of equilibrium and number of alpha emissions per uranium-238 decay are given in Table 2.

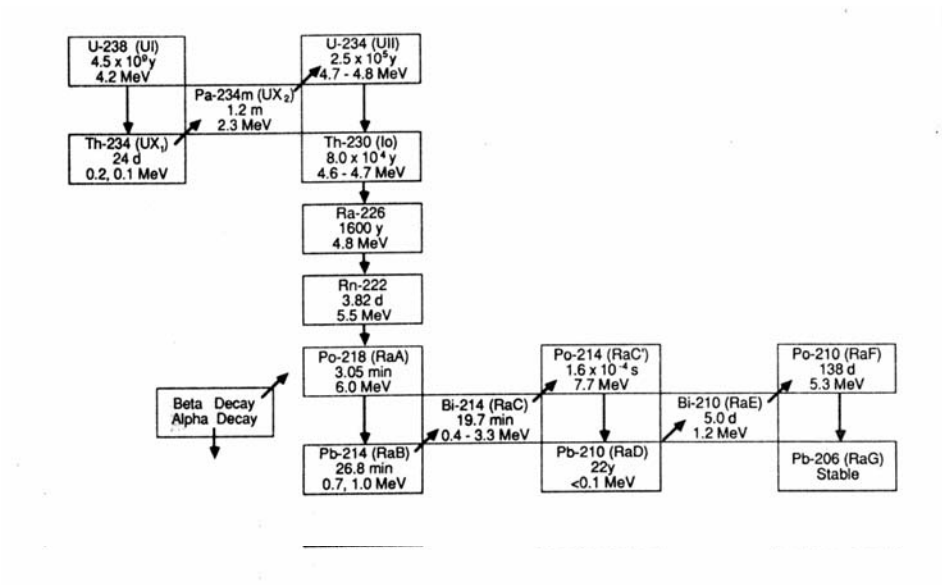

Figure 4. Uranium-238 Decay Chain (after NCRP 1988)

Table 3 provides stochastic derived air concentration (SDAC) values for the isotopes in the U-238 decay chain for 10-micron activity median aerodynamic diameter (AMAD) particle sizes. Title 10 CFR Part 20, Appendix B provides a DAC for the grinding and milling of natural uranium, which is based on a 10-micron AMAD. Tantalum ore grinding is a very similar process to grinding uranium ore, so the assumption of a 10-micron AMAD is reasonable for CSM's feed material grinding, too. The SDAC values were calculated for 10-micron AMAD aerosols using equations 5.8 and 2.1 of ICRP publication 30 along with data provided in the supplements to ICRP publication 30. Additional details on the calculations for the 10-micron values are provided in a technical calculation provided to CSM (Weston Solutions, 2003a).

Table 2. Uranium-238 Decay Chain and Equilibrium Assumptions

Isotope	Equilibrium pCi per pCi U-238	Number of Alphas per Decay	Minimum Fraction of Equilibrium expected	pCi Alpha Activity per pCi U-238	pCi activity per pCi of U-238
U-238	1.00E+00	1	1	1	1.00E+00
U-234	1.00E+00	1	1	1	1.00E+00
Th-234	1.00E+00	0	1	0	1.00E+00
Th-230	1.00E+00	1	1	1	1.00E+00
Rn-222	1.00E+00	1	0.9	0.9	9.00E-01
Ra-226	1.00E+00	1	1	1	1.00E+00
Po-218	1.00E+00	1	0.9	0.9	9.00E-01
Po-214	1.00E+00	1	0.9	0.9	9.00E-01
Po-210	1.00E+00	1	0.9	0.9	9.00E-01
Pb-214	1.00E+00	0	0.9	0	9.00E-01
Pb-210	1.00E+00	0	0.9	0	9.00E-01
Pa-234m	1.00E+00	0	1	0	1.00E+00
Pa-234	1.30E-03	0	1	0	1.30E-03
Bi-214	1.00E+00	0	0.9	0	9.00E-01
Bi-210	1.00E+00	0	0.9	0	9.00E-01
Total	1.40+01			7.6	13.2013

Table 3. U-238 Decay Chain Stochastic Derived Air Concentration Values

Isotope	SDAC, 10-Micron AMAD, µCi/ml
U238	8.7E-11
Th234	1.4E-07
Pa234	6.1E-06
U234	7.8E-11
Th230	2.8E-11
Ra226	8.0E-10
Pb210	1.3E-10
Bi210	5.5E-08
Po210	4.6E-10

The mixture DAC for the uranium-238 decay chain (UDAC) is calculated from the data in Tables 2 and 3 as follows:

(Equation 1)

$$UDAC = 1/(\frac{1}{U238} + \frac{1}{Pa234} + \frac{1}{Th234} + \frac{1}{U234} + \frac{1}{Th230} + \frac{1}{Ra226} + \frac{0.9}{Po210} + \frac{0.9}{Pb210} + \frac{0.9}{Bi210}))$$

In this equation, the concentrations of uranium-238, uranium-234, thorium-230, radium-226 and protactinium-234m are equal. The concentrations of polonium-210, bismuth-210 and lead-210 are equal to 0.9 times the concentration of uranium-238. The isotope values in the denominator are the DAC values for the respective isotopes and particle sizes given in Table 3.

When the values for 10-micron AMAD particles are substituted into Equation 1, a mixture DAC of 1.4 E-11 µCi/ml uranium-238 is obtained. From Table 2 the number of alpha decays per decay of uranium-238 is 7.6. The corresponding gross alpha DAC for the uranium-238 decay chain is 1.1 E-10 µCi/ml.

2.4 DAC VALUES FOR THE THORIUM-232 DECAY CHAIN (ORE PROCESSING)

The thorium-232 decay chain is shown in Figure 5. The mixture DAC for the thorium-232 decay chain is calculated from the data in Tables 4 and 5 as shown in Equation 2.

The second column of Table 5 provides SDAC values for the thorium-232 decay chain based on a 1-micron activity median aerodynamic diameter (AMAD). These values are calculated to 2 significant figures based on data provided in the supplements to ICRP 30 and are used in a later section of this report.

The third column of Table 5 provides the SDAC values for the thorium-232 decay chain based on a 10-micron AMAD. The DAC values for 10-micron aerosols were calculated using equations 5.8 and 2.1 of ICRP publication 30 along with data provided in the supplements to ICRP publication 30. Additional detail on the calculation for the 10-micron DAC values is provided in a technical calculation provided to CSM (Weston Solutions, 2003a).

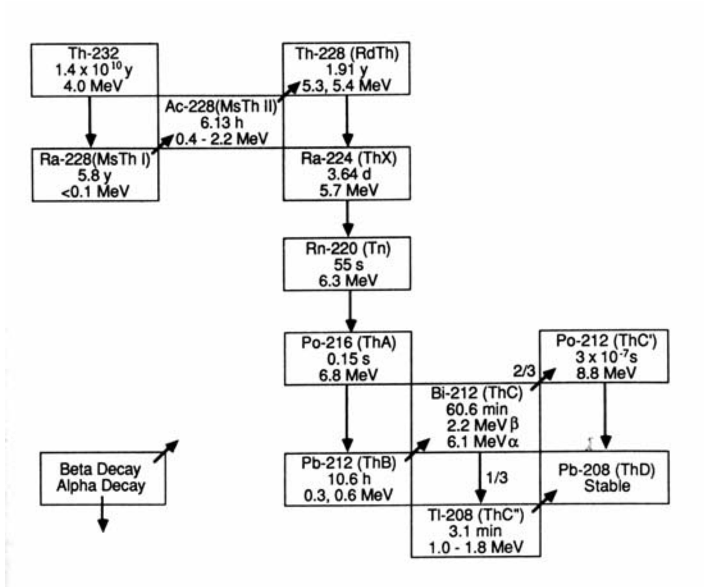

Figure 5. Thorium-232 Decay Chain (after NCRP 1988).

Table 4. Thorium-232 Decay Chain and Equilibrium Assumptions

Isotope	Equilibrium pCi per pCi Th-232	Number of Alphas per Decay	Fraction of Equilibrium Expected	pCi Alpha Activity per pCi Th-232	pCi Activity per pCi of Th-232
Tl-208	3.61E-01	0	0.9	0.00E+00	3.25E-01
Pb-212	1.00E+00	0	0.9	0.00E+00	9.00E-01
Bi-212	1.00E+00	0.36	0.9	3.24E-01	9.00E-01
Po-212	6.43E-01	1	0.9	5.79E-01	5.79E-01
Po-216	1.00E+00	1	0.9	9.00E-01	9.00E-01
Rn-220	1.00E+00	1	0.9	9.00E-01	9.00E-01
Ra-224	1.00E+00	1	1	1.00E+00	1.00E+00
Ra-228	1.00E+00	0	1	0.00E+00	1.00E+00
Ac-228	1.00E+00	0	1	0.00E+00	1.00E+00
Th-228	1.00E+00	1	1	1.00E+00	1.00E+00
Th-232	1.00E+00	1	1	1.00E+00	1.00E+00
Total	1.00E+01	---	---	5.70E+00	9.50E+00

Table 5. Thorium-232 Decay Chain Stochastic DAC Values.

Isotope	SDAC, 1-Micron AMAD, µCi/ml	SDAC, 10-Micron AMAD, µCi/ml
Th232	1.8E-12	5.8E-12
Ra228	4.9E-10	9.4E-10
Ac228	1.9E-08	9.4E-08
Th2228	6.8E-12	3.4E-11
Ra224	7.1E-10	3.4E-09
Pb212	1.3E-08	1.6E-08

(Equation 2)

$$ThDAC = \frac{1}{(\frac{1}{Th232} + \frac{1}{Th228} + \frac{1}{Ra228} + \frac{1}{Ra224} + \frac{1}{Ac228} + \frac{0.9}{Pb212})}$$

All isotopes above radon-220 in the decay chain are assumed to be in equilibrium in the thorium-232 chain. Radon-220 and progeny below it in the decay chain are assumed to be present at 90% of the equilibrium values. This leads to 5.7 alpha decays per thorium-232 decay, as given in Table 4. The isotope values in the denominator are the DAC values for the respective isotopes given in Table 5. When these values for 10-micron AMAD aerosols are substituted into Equation 2, one DAC for the thorium-232 chain corresponds to 4.9E-12 µCi/ml thorium-232 and the corresponding gross alpha DAC is 2.8E-11 µCi/ml.

2.5 DAC VALUES FOR MIXTURES OF URANIUM-238 AND THORIUM-232 DECAY CHAIN ISOTOPES

Equation 3 gives the DAC for mixtures of the two decay chains. The factor ThtoU is one-third for a mixture that has the activity ratio (ThtoU) of 1 thorium: 3 uranium, which is equivalent to the activity ratio of 25% thorium to 75% uranium, as explained in Section 2.1 of this report.

(Equation 3)

$$MixDAC = 1/\{ThtoU\{\frac{1}{Th232} + \frac{1}{Th228} + \frac{1}{Ra228} + \frac{1}{Ra224} + \frac{1}{Ac228} + \frac{0.9}{Pb212}\} + \{\frac{1}{U238} + \frac{1}{U234} + \frac{1}{Th230} + \frac{1}{Ra226} + \frac{1}{Pa234} + \frac{0.9}{Po210} + \frac{0.9}{Bi210} + \frac{0.9}{Pb210}\}\}$$

The same assumptions about degree of equilibrium from Tables 2 and 4 are made. This leads to 9.5 alpha decays per uranium-238 decay for this mixture. Substituting the DAC values from Tables 3 and 5 into Equation 3, one DAC (10-micron AMAD) corresponds to 7.2E-12 μCi/ml as uranium-238. One DAC of gross alpha activity (10-micron AMAD) corresponds to 6.9E-11 μCi/ml.

2.6 COMPARISON WITH PREVIOUS DAC FOR ORE PROCESSING

Table 6 provides a comparison of the proposed DAC and the DAC derived in 1995. The previous DAC was based on the assumption that only U-nat (uranium-238, thorium-234, protactinium-234m, uranium-234, thorium-234, and radium-226) and thorium-232 were present in the ore.

The DAC for U-nat given in Title 10 CFR Part 20, Appendix B was used to derive the 1995 DAC. It is based on the assumption that the AMAD of the material is 10 microns and that uranium-238 is in equilibrium with thorium-234, protactinium-234m, uranium-234, thorium-230, and radium-226. Other DAC values used in 1995 for other radionuclides were based on 1-micron AMAD aerosols despite a lack of justification for that value in the CSM operations. The proposed DAC values developed herein are entirely based on 10-micron AMAD aerosols in accordance with the Title 10 CFR Part 20, Appendix B values for grinding and milling of natural uranium ores. As explained in Section 2.1, the uranium to thorium activity ratio that is used in this report is based on a rigorous analysis of all ore materials received in 2001. It was chosen with the objective of having a gross alpha DAC that over-estimates dose 90 percent of the time.

Table 6. Comparison of the Proposed and Previous DAC Values for Ore Processing

Factor	Proposed DAC	DAC Derived in 1995
Isotopes considered	All isotopes in U-238 and Th-232 decay chains.	Unat (U-238, Th-234, Pa-234m, U-234, Th-230 and Ra-226) and Th-232.
Assumed Particle size	10-micron AMAD	Mixed: 1-micron AMAD Th-232 + 10-micron Unat
Number of Alphas in U-238 decay chain	7.6	4
Number of Alphas in Th-232 decay chain	5.7	3
Activity ratio	25 % Th-232: 75% U-238	60% Th-232: 40% U-238
Gross Alpha DAC	6.9 E-11 μCi/ml	5.4E-12 μCi/ml

2.7 COMPARISON OF PERSONAL AND AREA AIR SAMPLE DATA IN BUILDING 73

Personal breathing zone and area air samples have been collected simultaneously in Building 73 work areas at CSM. In general, each breathing zone sample was collected over a work shift. Area air samplers are usually allowed to operate continuously, and the air filter media are replaced once a week. All area air and breathing zone sample results to date have been collected as total dust samples.

Most breathing zone air samples were collected during ore dumping and grinding operations. These area and breathing zone sample results are provided in Table 7 for the time period of April 22, 2002 to June 10, 2002. The breathing zone and area air samples were collected as total dust samples. Based on Table 7, the breathing zone concentrations during ore dumping averaged 4.1% of the DAC (10-micron AMAD). The average airborne concentrations translate to a concentration of less than 10% of the SDAC for the mixture so it is not necessary to demonstrate that the air sampled by area samplers is representative of air in the breathing zones of workers, in accordance with guidance in Regulatory Guide 8.25.

Table 7. Comparison of Breathing Zone and Area Air samples for Ore Dumping and Grinding Activities.

SampleEndDate	Area Gross Alpha Concentration, uCi/ml	Date	Breathing Zone Gross Alpha Concentration, uCi/ml
8-Jan-02	7.7E-13		
14-Jan-02	1.6E-13		
21-Jan-02	1.9E-13		
28-Jan-02	5.5E-13		
4-Feb-02	1.8E-13		
11-Feb-02	2.6E-13		
18-Feb-02	2.4E-13		
25-Feb-02	1.3E-13		
6-Mar-02	1.8E-13		
12-Mar-02	1.2E-13		
19-Mar-02	9.8E-14		
25-Mar-02	1.9E-13		
2-Apr-02	1.8E-13		
8-Apr-02	2.8E-13		
		11-Apr-02	5.3E-12
12-Apr-02	2.9E-13	12-Apr-02	2.0E-12

SampleEndDate	Area Gross Alpha Concentration, uCi/ml	Date	Breathing Zone Gross Alpha Concentration, uCi/ml
		16-Apr-02	4.3E-12
		18-Apr-02	6.8E-13
		19-Apr-02	3.3E-12
22-Apr-02	2.0E-13	22-Apr-02	3.7E-13
29-Apr-02	2.3E-13	24-Apr-02	3.6E-13
		30-Apr-02	4.3E-13
		30-Apr-02	2.2E-12
		01-May-02	1.5E-12
		04-May-02	7.1E-13
6-May-02	2.3E-13	06-May-02	9.9E-13
		08-May-02	1.1E-12
		09-May-02	5.9E-13
		09-May-02	1.6E-12
		10-May-02	9.2E-13
		10-May-02	5.9E-14
13-May-02	1.1E-13	13-May-02	4.2E-12
		14-May-02	7.7E-13
		15-May-02	2.2E-12
		17-May-02	2.3E-12
20-May-02	6.3E-13	20-May-02	4.9E-14
		21-May-02	6.4E-12
		21-May-02	1.1E-12
		22-May-02	7.1E-13
		22-May-02	3.9E-13
28-May-02	3.2E-13	23-May-02	2.5E-12
		30-May-02	1.6E-12
		31-May-02	1.0E-11
3-Jun-02	2.2E-13	31-May-02	1.1E-12
		06-Jun-02	1.8E-13
		06-Jun-02	1.7E-12
		07-Jun-02	3.4E-14
		10-Jun-02	4.0E-12
10-Jun-02	6.1E-13	10-Jun-02	1.8E-12
		11-Jun-02	7.4E-13
		12-Jun-02	2.2E-12
		13-Jun-02	1.5E-12
17-Jun-02	1.0E-13	17-Jun-02	5.8E-13
24-Jun-02	1.4E-13		
1-Jul-02	2.1E-13		
8-Jul-02	2.2E-13	02-Jul-02	1.3E-12

SampleEndDate	Area Gross Alpha Concentration, uCi/ml	Date	Breathing Zone Gross Alpha Concentration, uCi/ml
		10-Jul-02	3.0E-12
		11-Jul-02	0.0E+00
		15-Jul-02	4.4E-13
15-Jul-02	3.5E-13	15-Jul-02	1.6E-12
		17-Jul-02	6.1E-13
		17-Jul-02	6.1E-13
		19-Jul-02	2.9E-12
22-Jul-02	2.7E-13	22-Jul-02	3.4E-12
		23-Jul-02	1.3E-12
		24-Jul-02	1.1E-12
		25-Jul-02	4.1E-12
		25-Jul-02	9.2E-12
29-Jul-02	5.5E-13	29-Jul-02	4.1E-13
		30-Jul-02	2.9E-12
		30-Jul-02	1.5E-12
		30-Jul-02	4.7E-13
		01-Aug-02	4.8E-13
		01-Aug-02	4.0E-13
		02-Aug-02	6.9E-13
		02-Aug-02	2.4E-12
5-Aug-02	7.1E-13	05-Aug-02	1.6E-12
		06-Aug-02	2.3E-12
		06-Aug-02	3.1E-13
		09-Aug-02	3.7E-12
		13-Aug-02	2.3E-12
		14-Aug-02	8.7E-13
		15-Aug-02	4.3E-13
		21-Aug-02	4.6E-13
		22-Aug-02	2.7E-13
		26-Aug-02	7.8E-13
		28-Aug-02	9.9E-14
		29-Aug-02	7.3E-13
		17-Sep-02	1.6E-12
		17-Sep-02	3.4E-12
		18-Sep-02	4.4E-13
		20-Sep-02	3.1E-13
		24-Sep-02	7.2E-12
		24-Sep-02	3.9E-13
		24-Sep-02	8.5E-13
		25-Sep-02	2.8E-12

SampleEndDate	Area Gross Alpha Concentration, uCi/ml	Date	Breathing Zone Gross Alpha Concentration, uCi/ml
		30-Sep-02	1.4E-12
		01-Oct-02	3.2E-13
		01-Oct-02	4.2E-13
		02-Oct-02	4.6E-12
		02-Oct-02	3.7E-13
		03-Oct-02	4.3E-13
		04-Oct-02	1.4E-13
		07-Oct-02	1.7E-11
		09-Oct-02	2.7E-12
		10-Oct-02	7.8E-11
		Breathing Zone Average	2.8E-12
		Breathing Zone Maximum	7.8E-11

Only two breathing zone sample results were obtained for ore screening activities; these results are presented in Table 8. The average breathing zone concentration during this activity was 3.2E-12 µCi/ml. This is 4.6% of the DAC (10-micron AMAD), which is generally consistent with the levels documented by the area air sample results. At these concentrations, it is not necessary to demonstrate under Regulatory Guide 8.25 that area air samples are representative of the air inhaled by workers.

Table 8. Air Sample Results for Ore Screening Activities.

Sample End Date	**Area Sample (µCi/ml)**	**Breathing Zone Sample Date**	**Breathing Zone Concentrations, (µCi/ml)**
13-May-02	1.1 E-13	10-May-02	1.2E-12
28-May-02	3.2E-13	16-May-02	5.3E-12
		Average	3.2E-12

2.8 THORIUM DOPING ACTIVITIES

Thorium is added to tantalum powder in the Thorium Doping Room located in building 29. This process involves a number of steps. First, thorium nitrate is weighed on a balance and dissolved in water. The thorium nitrate solution is poured onto a layer of tantalum powder that has been spread in a layer on a drying table. A steam heating system heats the tabletop to drive off the water. The material is then collected into a drum using a HEPA vacuum system. Finally it is mixed using a shaker.

The Thorium Doping Room is the size of a walk-in closet, about 7 feet wide by 10 feet long. The layout is provided in Figure 6. There are two local exhaust ventilation devices in the room. A slot hood is located adjacent to drying table, and a canopy exhaust hood is located on the opposite side of the room adjacent to the weighing table. Figure 7 provides a view of the end of the room where the steam table is located. The HEPA vacuum is located on the weighing table under the canopy hood. The air sampler head is located at breathing zone height near the HEPA vacuum, as shown in Figure 8. Makeup air comes into the room via the entrance, which has no door.

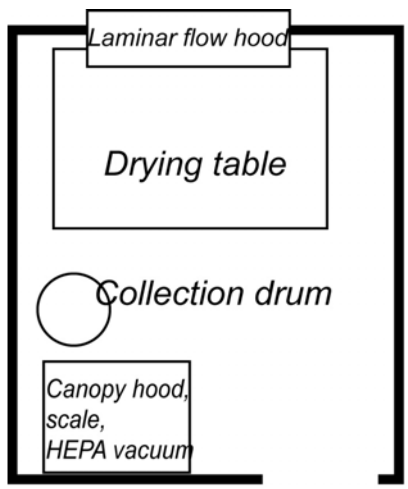

Figure 6. Thorium Doping Room Layout

Figure 7. Slot hood, steam table and drum into which thorium-doped powder is collected.

Figure 8. Canopy hood, weighing table and area sampler head (blue)

2.8.1 Derivation of Mixture and Gross Alpha DAC for Thorium Doping

The basis for a DAC for thorium doping activities is provided in this section. The detailed derivation is provided in a technical calculation provided to CSM (Weston Solutions, 2003a). The radioactive material is in the form of a thorium nitrate. Thorium nitrate has been assigned to lung clearance class W material under the ICRP Publication 30 system of dosimetry.

The Th-232 and Th-228 SDACs given in Table 9 were calculated from data in Federal Guidance Report 11. The remaining values used to calculate the mixture DAC were taken from column 2 of Table 5 of this document.

Table 9. Stochastic DAC values for class W thorium isotopes.

Isotope	SDAC, μCi/ml
Th-232	1.3E-12
Th-228	8.3E-12

Freshly prepared thorium nitrate is assumed to initially contain equal activities of thorium-232 and thorium-228. The progeny of thorium 232 and thorium-228 are not assumed to be present in the freshly produced thorium nitrate because the chemical separation used to generate the thorium would likely isolate these other metals or nuclides. The thorium nitrate reagent used by CSM is assumed to have aged for some time prior to use. This results in ingrowth and decay of radium-228 as well as thorium-228 and its progeny, which would result in a DAC that is less restrictive than the one that is used herein. The minimum possible activity ratio of thorium-228 to thorium-232 is 0.424 (Weston Solutions, 2003a). Based on this ratio the minimum number of alphas emitted per decay of thorium-232 is 3.52. The most restrictive possible stochastic gross alpha DAC for thorium nitrate occurs at an effective age of 4.5 years. The minimum gross alpha DAC for thorium doping is 4.2E-12 μCi/ml. This corresponds to a thorium-232 concentration of 1.2E-12 μCi/ml if no thorium-230 is present.

The gross alpha DAC for thorium nitrate varies by almost a factor of two with age. The most restrictive DAC values are used as long as the age is not known. If the actinium-228 to thorium-232 ratio has been determined by alpha and gamma spectroscopy, then the appropriate DAC value from Figure 9 can be used for dose calculations. Some thorium-230 may also be present in the thorium nitrate reagent. As the amount of thorium-230 increases, the minimum gross alpha DAC proposed for thorium doping (4.2E-12 μCi/ml) becomes increasingly conservative.

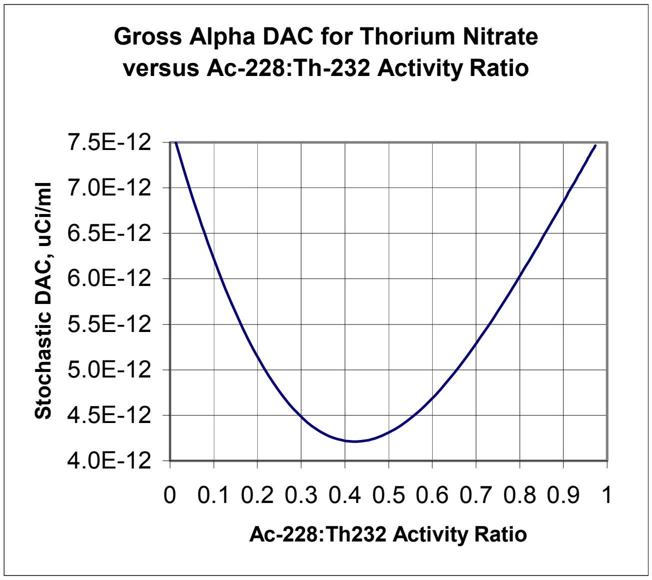

Figure 9. Dependence of thorium nitrate gross alpha DAC on the ratio of Ac-228 to Th-232.

2.8.2 Breathing Zone Air Sample Data during Thorium Doping Activities

Table 10 provides workshift breathing zone gross alpha concentrations during thorium doping operations. The reference time period was January through April 2003. Out of the 29 workshift breathing zone samples, the maximum gross alpha concentration was 6.3 E-13 μCi/ml, which was 9% of the thorium nitrate gross alpha SDAC of 4.2 E-12 μCi/ml. The average concentration was 2.3E-13 μCi/ml, or 5.5% of the SDAC. Since thorium doping only occurs 2 to 3 days per week, annual intakes of thorium nitrate by workers will be well below 10% of the stochastic ALI per year.

Table 10. Breathing Zone Sample Results for Thorium Doping Operations.

Date	Gross Alpha Concentration, μCi/ml
1/24/2003	7.2E-14
2/6/2003	1.2E-13
2/7/2003	7.2E-14
2/8/2003	2.7E-13
2/19/2003	4.6E-13

Date	Gross Alpha Concentration, µCi/ml
2/21/2003	2.3E-13
2/22/2003	1.7E-13
2/24/2003	1.2E-13
2/25/2003	1.2E-13
2/26/2003	1.6E-13
2/27/2003	2.3E-13
2/28/2003	1.2E-13
3/1/2003	1.4E-13
3/3/2003	9.9E-14
3/4/2003	3.1E-13
3/5/2003	1.3E-13
3/6/2003	2.1E-13
3/7/2003	3.0E-13
3/17/2003	4.6E-14
3/18/2003	4.7E-13
3/19/2003	4.3E-13
3/20/2003	4.1E-13
3/21/2003	6.3E-13
3/25/2003	1.5E-13
3/26/2003	1.8E-13
4/2/2003	2.4E-13
4/3/2003	1.8E-13
4/4/2003	3.5E-13
4/5/2003	3.4E-13

3. RECOMMENDATIONS AND CONCLUSIONS CONCERNING THE AIR SAMPLING PROGRAM

The following recommendations are based on observations from the air sampling program review.

3.1 ORE PROCESSING OPERATIONS AND GENERAL RECOMMENDATIONS

1. The gross alpha SDAC values for ore materials and thorium doping presented herein are suitable for calculating the committed effective dose equivalent (CEDE) from inhalation. If the CEDE exceeds 1 rem in a year, then the committed dose equivalent to the bone surface will also need to be calculated and reported.

2. Respirator use during routine ore-processing activities should not be necessary to maintain doses as low as reasonably achievable.

3. Use an activity ratio of 3 uranium-238 : 1 thorium-232. The 3:1 activity is expected to overestimate inhalation doses from airborne material 90% of the time. This ratio is based on a rigorous statistical evaluation of data from 207 lots of ore material processed during 2001.

4. Use the 10-micron AMAD gross alpha DAC of 6.9E-11 μCi/ml to obtain an initial estimate of the inhalation exposures from airborne ore dust at CSM.[2] All area sample filters should be saved after gross activity has been counted and they should be submitted as 3-month composite samples for each location and analyzed for isotopic uranium and isotopic thorium. The gross alpha DAC that is calculated from the actual thorium to uranium isotopic ratio for the quarter should be used to determine the DAC hours that are recorded on a person's official exposure record. On average, it is expected that the quarterly gross alpha isotopic data will reduce the initial DAC-hour estimate by 30%.

5. Enough data have been collected to demonstrate that gross alpha air concentrations during routine ore-processing activities will, on average, be well below 10% of the DAC (10-micron AMAD). Area air samplers are located at the ore dumping stations and should be representative of the dustier routine operations. However, Regulatory Guide 8.25 does not require that area samples be representative of the air inhaled by workers for such low concentrations.

6. Breathing zone air sampling during routine ore-processing activities can be curtailed. Archive past breathing zone filters and maintain the chain of custody once gross counting has occurred. The radiation safety officer should decide when the filters are no longer useful and can be discarded.

3.2 THORIUM DOPNG AND NON-ROUTINE OPERATIONS

1. Data have been collected from enough breathing zone samples in the thorium doping room to demonstrate that gross alpha air concentrations during routine thorium doping activities will, on average, be well below 10% of the SDAC. The thorium doping room is small and an area air sampler is used to monitor conditions in the work area. In accordance with Regulatory

[2] Unless NRC has an objection to the 10-micron AMAD assumption.

Guide 8.25, area samples are not required to be representative of the air inhaled by worker for such low concentrations.

2. Non-routine operations that create dusty conditions can produce elevated airborne radionuclide concentrations. Fixed location area air samplers probably cannot give results that are representative of non-routine activities that involve contact with licensed materials. Workers should wear breathing zone air samplers whenever these non-routine activities occur. Non-routine activities, which involve the use of temporary engineering controls or respiratory protection, should be managed under activity-specific work control document, such as radiation work permits.

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ATTACHMENT A

URANIUM AND THORIUM CONTENT OF FEED MATERIALS PROCESSED BY CSM IN 2001

Cabot Lot No	% Th	% U	Activity % U-238	Rank by %U-238 Activity
4987	0.015	0.522	99	207
4985	0.015	0.446	99	206
4954	0.015	0.420	99	205
228628004	0.015	0.416	99	204
4969	0.015	0.395	99	203
4995	0.015	0.380	99	202
4933	0.015	0.369	99	201
1008	0.015	0.318	98	200
4967	0.015	0.299	98	199
4955	0.015	0.287	98	198
1006	0.015	0.264	98	197
228624003	0.015	0.237	98	196
4986	0.015	0.206	98	195
4921	0.015	0.198	98	194
4932	0.015	0.194	98	193
5027	0.015	0.192	98	192
4945	0.015	0.191	98	191
224035003	0.015	0.191	98	191
4988	0.015	0.189	97	189
4992	0.015	0.188	97	188
4907	0.015	0.182	97	187
224035005	0.015	0.178	97	186
	0.015	0.177	97	185
5019	0.015	0.175	97	184
4976	0.015	0.172	97	183
5127	0.015	0.172	97	183
5127a	0.015	0.172	97	183
1012	0.015	0.171	97	180
4993	0.015	0.170	97	179
4943	0.015	0.166	97	178
5204	0.015	0.163	97	177
224035006	0.016	0.171	97	176
228623001	0.015	0.159	97	175
228623002	0.015	0.158	97	174
228623004	0.015	0.156	97	173
5129	0.015	0.151	97	172
5154	0.015	0.151	97	172
5154A	0.015	0.151	97	172
228624002	0.015	0.149	97	169
4904	0.015	0.148	97	168
5063	0.015	0.148	97	167
5074	0.015	0.148	97	167
4946	0.015	0.145	97	165
224035007	0.015	0.144	97	164
5098	0.015	0.143	97	163
1005	0.015	0.140	97	162
5064	0.015	0.138	97	161

Cabot Lot No	% Th	% U	Activity % U-238	Rank by %U-238 Activity
5219	0.022	0.200	97	160
4944	0.015	0.134	96	159
4968	0.015	0.131	96	158
228623003	0.015	0.131	96	157
4960	0.015	0.130	96	156
5025	0.015	0.129	96	155
4903	0.015	0.128	96	154
228618001	0.031	0.262	96	153
5048	0.015	0.126	96	152
4949	0.015	0.125	96	151
228623005	0.015	0.123	96	150
228624008	0.018	0.144	96	149
4916	0.015	0.120	96	148
228624007	0.015	0.119	96	147
228624011	0.015	0.119	96	147
4913	0.015	0.118	96	145
5107	0.017	0.131	96	144
4964	0.015	0.116	96	143
5128	0.015	0.114	96	142
4953	0.015	0.114	96	141
4991	0.015	0.113	96	140
4994	0.015	0.112	96	139
5061	0.015	0.112	96	139
228625004	0.015	0.112	96	139
228623009	0.015	0.111	96	136
4947	0.015	0.109	96	135
5184	0.021	0.153	96	134
5014A	0.015	0.108	96	133
5046	0.015	0.108	96	133
4905	0.015	0.106	96	131
4958	0.015	0.104	96	130
4959	0.015	0.104	96	130
228623008	0.015	0.104	96	130
228623010	0.015	0.103	95	127
228608002	0.026	0.180	95	126
4931	0.015	0.102	95	125
228623015	0.015	0.102	95	125
228626003	0.062	0.416	95	123
228625007	0.018	0.119	95	122
1009	0.015	0.100	95	121
228623011	0.015	0.100	95	121
228627001	0.097	0.647	95	119
5055	0.021	0.141	95	118
5011	0.015	0.099	95	117
228623006	0.015	0.099	95	117
1007	0.015	0.098	95	115
4984	0.015	0.098	95	115

Cabot Lot No	% Th	% U	Activity % U-238	Rank by %U-238 Activity
228620002	0.015	0.098	95	115
5024	0.015	0.097	95	112
228627002	0.088	0.568	95	111
228625002	0.018	0.117	95	110
4971	0.015	0.094	95	109
228623007	0.015	0.094	95	109
4952	0.021	0.132	95	107
228625006	0.015	0.093	95	106
228624006	0.015	0.093	95	106
228628001	0.056	0.349	95	104
4972	0.015	0.092	95	103
228628003	0.088	0.534	95	102
228626002	0.070	0.424	95	101
4961	0.015	0.090	95	100
4996	0.015	0.090	95	100
4948	0.015	0.089	95	98
5177	0.023	0.135	95	97
4906	0.059	0.346	95	96
228626001	0.068	0.397	95	95
224035004	0.031	0.179	95	94
4983	0.015	0.086	95	93
228625008	0.018	0.102	95	92
4930	0.015	0.086	95	91
5049	0.015	0.086	95	91
228628002	0.084	0.481	95	89
228628002	0.084	0.481	95	89
5108	0.069	0.390	95	87
231006002	0.015	0.085	95	86
228625003	0.015	0.083	94	85
5056	0.020	0.112	94	84
	0.015	0.081	94	83
4918	0.015	0.080	94	82
4920	0.015	0.080	94	82
4970	0.015	0.080	94	82
5051	0.015	0.080	94	82
4915	0.015	0.079	94	78
5013	0.015	0.079	94	78
5186	0.018	0.092	94	76
5149	0.018	0.092	94	75
228623014	0.015	0.076	94	74
228625001	0.018	0.094	94	73
228618003	0.016	0.081	94	72
228608001	0.035	0.178	94	71
5218	0.018	0.093	94	70
4902	0.015	0.075	94	69
5053	0.112	0.549	94	68
4919	0.015	0.073	94	67

Cabot Lot No	% Th	% U	Activity % U-238	Rank by %U-238 Activity
5054	0.035	0.170	94	66
228618002	0.038	0.176	93	65
228619001	0.015	0.070	93	64
228623012	0.015	0.069	93	63
226594001	0.015	0.068	93	62
228623018	0.015	0.068	93	62
226599001	0.015	0.068	93	62
226600001	0.015	0.068	93	62
228625005	0.018	0.083	93	58
	0.015	0.067	93	57
228614004	0.015	0.066	93	56
5007	0.046	0.199	93	55
5012A	0.015	0.063	93	54
4957	0.015	0.062	93	53
228623013	0.015	0.059	92	52
228623016	0.015	0.059	92	52
228623017	0.015	0.059	92	52
228646001	0.097	0.382	92	49
4914	0.015	0.059	92	48
4917	0.015	0.058	92	47
5073	0.015	0.053	92	46
5050	0.024	0.075	91	45
228615005	0.149	0.458	90	44
5020	0.015	0.042	90	43
228646003	0.016	0.044	89	42
5028	0.062	0.168	89	41
228621001	0.098	0.257	89	40
1011	0.015	0.035	88	39
5176	0.030	0.065	87	38
228614005	0.161	0.338	87	37
5047	0.027	0.057	86	36
4963	0.015	0.027	85	35
228614003	0.225	0.375	84	34
4965	0.118	0.193	83	33
5052	0.157	0.243	82	32
5058	0.082	0.126	82	31
5057	0.233	0.336	81	30
4962	0.015	0.021	81	29
228614001	0.263	0.370	81	28
228622001	0.158	0.220	81	27
228621003	0.156	0.215	81	26
5060	0.112	0.140	79	25
228615004	0.185	0.229	79	24
5125	0.120	0.146	79	23
5185	0.015	0.018	78	22
5178	0.032	0.036	**78**	**21**
226589001	0.103	0.118	78	20

Cabot Lot No	% Th	% U	Activity % U-238	Rank by %U-238 Activity
5006	0.129	0.147	78	19
5023	0.483	0.543	77	18
228621002	0.172	0.192	77	17
5005	0.120	0.126	76	16
231006001	0.193	0.195	75	15
5059	0.158	0.157	75	14
1010	0.054	0.050	74	13
228615003	0.176	0.153	73	12
228646002	0.176	0.136	70	11
4966	0.160	0.120	70	10
1013	0.172	0.128	69	9
5021	0.129	0.081	66	8
5022	0.049	0.031	65	7
228615001	0.253	0.153	65	6
5124	0.319	0.165	61	5
1004	0.232	0.058	43	4
4956	1.128	0.251	40	3
4922	0.607	0.086	30	2
5192-ORE	0.962	0.086	22	1
Total				

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX B

Review of the Bioassay Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant

Review of the Bioassay Program at the Cabot Supermetals, Incorporated Boyertown, Pennsylvania Plant June 9, 2003

Prepared by:

Weston Solutions, Inc.

Approved by:

Robert P. Schoenfelder ______________________ June 12, 2003

Robert Schoenfelder
Project Manager

Date

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 1

2. EXPOSURE SCENARIOS AT THE BOYERTOWN PLANT 2

2.1 ORE PROCESSING ACTIVITIES 2

2.2 THORIUM DOPING ACTIVITIES 2

3. BIOASSAY PERFORMANCE REQUIREMENTS 3

4. DERIVATION OF INTAKES OF ORE MATERIAL THAT WOULD CORRESPOND TO 40 DAC HOURS AND 200 DAC HOURS 3

4.1 ASSUMPTIONS 3

4.2 COMPOSITION OF THE ORE MATERIALS 4

4.3 DECAY CHAINS FOR PRINCIPAL ISOTOPES 5

4.4 ANNUAL LIMITS OF INTAKE AND RELATED FACTORS FOR ORE MATERIAL 6

5. ORE MATERIALS: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY 7

5.1 IMPLICATIONS FOR URINE BIOASSAY 13

5.2 IMPLICATIONS FOR FECAL BIOASSAY 15

5.3 IMPLICATIONS FOR WHOLE BODY COUNTING 15

6. THORIUM DOPING: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY 16

6.1 DERIVATION OF INTAKES OF THORIUM NITRATE THAT WOULD CORRESPOND TO 40 DAC HOURS AND 200 DAC HOURS 16

6.2 ASSUMPTIONS 17

6.3 ANNUAL LIMITS OF INTAKE AND RELATED FACTORS FOR THORIUM DOPING 18

7. THORIUM DOPING: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY 19

7.1 IMPLICATIONS FOR URINE BIOASSAY 22

7.2 IMPLICATIONS FOR FECAL BIOASSAY 22

7.3 IMPLICATIONS FOR WHOLE BODY COUNTING 23

8. CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE BIOASSAY PROGRAM 23

8.1 ORE MATERIALS 24

8.2 THORIUM DOPING 25

9. REFERENCES 26

LIST OF FIGURES

FIGURE **PAGE**

Figure 1. Plot of the Activity % Uranium Versus the Rank by U-238 to Th-232 Ratio................ 4

Figure 2. Uranium-238 Decay Chain (after NCRP 1988) 5

Figure 3. Thorium-232 Decay Chain (after NCRP 1988)... 6

Figure 4. Daily Thorium-230 or Thorium-232 Excretion Rate Versus Time................................ 9

Figure 5. Daily Thorium-228 Excretion Rate Versus Time. 9

Figure 6. Daily Uranium Excretion Rate Versus Time.. 10

Figure 7. Daily Radium-226 Excretion Rate Versus Time.. 10

Figure 8. Daily Thorium-232 (or Thorium-230) Excretion Rate Versus Time 20

Figure 9. Daily Thorium-228 Excretion Rate Versus Time. 20

LIST OF TABLES

TABLE **PAGE**

Table 1. Summary Statistics for Ore Shipments Received by CSM During 2001 5

Table 2. Stochastic Annual Limit of Intake and Related Factors for 10-micron AMAD Ore Having an Activity Ratio of 75% U-238 : 25% Th-232 6

Table 3. Airborne Concentrations That Correspond to 1 SDAC for a Radionuclide Mixture of 3 U-238: 1 Th-232 7

Table 4. Thorium-232, Thorium-228 Daily Excretion Rates (Class Y, 10-micron AMAD) 11

Table 5. Uranium Daily Excretion Rates (Class Y, 10-micron AMAD)..................................... 12

Table 6. Radium-226 Daily Excretion Rates (Class W, 10-micron AMAD) 13

Table 7. MDC Values for Urine Sample Analyses by Alpha Spectroscopy 14

Table 8. Maximum Time Following an Intake of Ore Material That Urine Bioassay Would Be Useful[a] 14

Table 9. MDA Values for Fecal Sample Analyses by Alpha Spectroscopy................................ 15

LIST OF TABLES (CONTINUED)

TABLE **PAGE**

Table 10. Maximum Time Following an Intake of Ore Material That Fecal Bioassay Would Be Useful[a] (days) 15

Table 11. Whole Body Counting MDA Values Provided by Canberra Special Services Division 16

Table 12. Thorium-232 intakes corresponding to the SDAC, the SALI, and 0.02 SALI for the mixture of Radionuclides 18

Table 13. Thorium-232 Daily Excretion Rates (Class W, 1 micron AMAD) 21

Table 14. Frequency of Urine or Fecal Bioassays for Thorium Nitrate, Class W Mixtures[a] 22

1. EXECUTIVE SUMMARY

This report provides a review of the bioassay program that is in place at the Cabot Supermetals, Inc. (CSM) Boyertown plant. The Boyertown plant receives and handles radioactive materials under license SMB-920 issued by the U.S. Nuclear Regulatory Commission (NRC). Several recommendations are provided based on this technical evaluation.

The Canberra Special Services Division performed a previous evaluation of the bioassay program in 1995 under contract to CSM (Canberra 1995) that is superseded by this document. This report was prepared in response to item A of a Notice of Violation issued on October 23, 2001 by the NRC (Kinneman 2001). It is an update of a draft report that was submitted to the NRC for review in September 2002 and now incorporates revisions to address comments provided in a letter to CSM from the NRC dated 14 January 2003 titled "Request For Additional Information On The License Renewal Application For The Cabot Boyertown Facility, SMB-920 (L52461)". Mr. John McGrath of the NRC, Region I reviewed and commented on that draft. This revision now evaluates the excretion and retention of both ore dust radionuclides (10-micron AMAD) and thorium nitrate.

This document is a companion report to the *Review of the Occupational Air Sampling Program at Cabot Performance Materials Corporation Boyertown, Pennsylvania Plant*, which was prepared for CSM by Weston Solutions, Inc. in June 2003 (Weston Solutions, Inc. 2003). The air sampling program review develops the basis for the mixture derived air concentration (DAC) and gross alpha DAC used in this report. The whole body retention and excretion characteristics of the radioactive materials of concern are described in the present report.

A purely technical memo (Weston Solutions 2003a) provides the actual Berkeley Madonna (a commercially distributed dynamic simulation software package) simulation input files, calculation of stochastic DACs, and other supporting documentation related to the air sampling and bioassay program evaluations.

CSM's current annual whole body counting program was found to be inadequate in a Notice of Violation issued on October 23, 2001 (Kinneman 2001). An independent review of the program has been conducted and deficiencies in the program evaluated. The following sections are intended to provide the basis for an acceptable bioassay program. Conclusions and recommendations are provided at the end of the document.

2. EXPOSURE SCENARIOS AT THE BOYERTOWN PLANT

2.1 ORE PROCESSING ACTIVITIES

The CSM plant in Boyertown, Pennsylvania, extracts tantalum and niobium from ore materials that contain low concentrations of natural uranium and thorium. Almost all of the ores contain less than 1 percent uranium plus thorium (U + Th) by weight. The radioactive constituents are not extracted or concentrated from ore material during this process. Consequently, workers may be exposed to low concentrations of airborne uranium and thorium plus their radioactive progeny during routine plant operations.

During non-routine operations such as maintenance of scrubbers and grinders, however, air concentrations may occasionally exceed the DAC. Respirators may be worn during particularly dusty operations, in concurrence with requirements of a task-specific radiation work permit (RWP) to ensure that doses are as low as reasonably achievable (ALARA).

The average airborne concentrations in building 73 were demonstrated to be below 10 percent of the proposed 10-micron activity median aerodynamic diameter (AMAD) DAC (Weston Solutions, 2003). Consequently CSM will rely primarily on area air sampling to assign doses from ore processing activities in the future. The occasional use of respirators for non-routine tasks will trigger the need for bioassay of workers performing those tasks as required by Title 10 Code of Federal Regulations, Section 20.1703(C)2 (10 CFR 20.1703(c)2).

2.2 THORIUM DOPING ACTIVITIES

Thorium doping activities occur in a room in building 29. This activity is described in section 2.9 of the air sampling review mentioned previously (Weston Solutions 2003). The potential of this activity to result in inhalation exposures to radioactive material is still being evaluated. CSM would like to assign doses from this activity based on area air sampling. The detection limit that would be required to demonstrate that air concentrations are less than 10% of the DAC is difficult to achieve through lapel sampling unless filters are bulked and submitted as a composite.

Respirators are currently used during thorium doping activities, and this triggers the need for bioassay under 10 CFR 20.1703(C)2.

3. BIOASSAY PERFORMANCE REQUIREMENTS

NRC Regulatory Guide 8.9 (NRC 1993) provides the technical performance requirements for a bioassay program. Under Regulatory Guide 8.9, the bioassay program must be designed to detect acute intakes of radioactive materials that correspond to no more than 40 DAC hours of exposure from the mixture. The bioassay program applies to all workers who wear respirators for protection against radioactive materials.

4. DERIVATION OF INTAKES OF ORE MATERIAL THAT WOULD CORRESPOND TO 40 DAC HOURS AND 200 DAC HOURS

A referenced document (Weston Solutions 2003) provides the basis for the gross alpha stochastic derived air concentration (SDAC). This section summarizes the basis, provides the individual SDAC values, and derives intakes that represent 40 SDAC hours and 200 SDAC hours. The gross alpha SDAC is believed to be protective of workers and is reflective of the historical variability of the uranium-238 to thorium-232 ratio.

4.1 ASSUMPTIONS

The DAC values for ore material that were derived in the air sampling review (Weston Solutions 2003) are based on the following assumptions:

- 10-micron activity median aerodynamic diameter (AMAD),
- ICRP 30 Lung Model, as provided in ICRP 30 Figures 5.1 and 5.2, and the equations provided in section 5.2 of that document,
- ICRP 30 GI Tract Model, as provided in ICRP 30, Equations 6.1a through 6.1d and 6.3 and data in in Figure 6.1,
- 100% deposition efficiency in the respiratory tract,
- Regional deposition fractions for 10-micron AMAD aerosols, per ICRP 30 Figure 5-1. D_{NP} = 0.87, D_{TB} = 0.08 and D_P=0.05.
- ICRP 30 metabolic data for gastrointestinal uptake fraction, F_1, and systemic fraction excreted in urine, F_U, as follows:

- Uranium, Class Y lung clearance: $F_1 = 0.002$, $F_U = 1.0$
- Thorium, Class Y lung clearance: $F_1 = 0.002$, $F_U = 1.0$
- Radium, Class W lung clearance: $F_1 = 0.2$, $F_U = 0.05$ (given in ICRP 54, page 183).

- Equilibrium in decay chains from parent to radium,
- 90% degree of equilibrium between radium and radon or thoron,
- Equilibrium between (1) radon and its progeny and (2) thoron and its progeny,
- Respiration rate of 0.02 m^3/minute

4.2 COMPOSITION OF THE ORE MATERIALS

A conservative composition of ore materials was developed in the air sampling review (Weston Solutions 2003). That evaluation of the uranium and thorium content of ores processed by CSM was based on 2001 as the reference year and used a rigorous statistical evaluation to establish the composition of the ore. Figure 1 is a graph of the activity percent uranium-238 versus the rank of the activity ratio for the ore received in 2001. Summary statistics for ores received in 2001 are provided in Table 1.

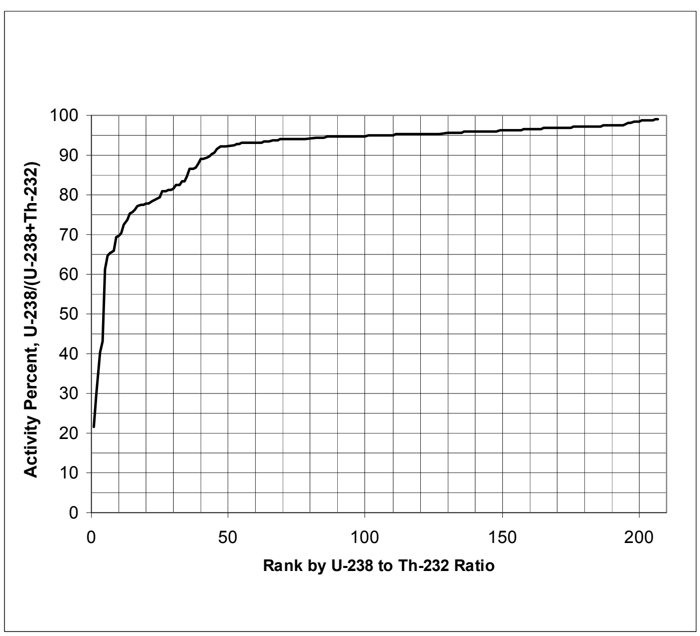

Figure 1. Plot of the Activity % Uranium Versus the Rank by U-238 to Th-232 Ratio

As the ratio U-238/[U-238 + Th-232] gets smaller, the dose per picocurie (pCi) of intake increases. The assessment presented in this document is based on the ratio of 0.75 U-238 : 0.25 Th-232, which corresponds to the 95% lower confidence limit on the 0.1 quantile of the ratio distribution during 2001. Therefore, at least 90% of the time the ore composition proposed in the air sampling review (Weston Solutions 2003) is expected to overestimate the dose (i.e. it is prudently conservative).

The basis for the old isotopic ratio, 0.4 U-238: 0.6 Th-232, that formed the basis for the old gross alpha DAC is not known, however it appears to have been based on a worst case evaluation. It is believed to overestimate dose to a significant degree and is reasonably replaced by the ration of 0.75 : 0.25.

Table 1. Summary Statistics for Ore Shipments Received by CSM During 2001

Average activity ratio: U-238/[U-238 + Th-232]	0.91
Median activity ratio: U-238/[U-238 + Th-232]	0.95
0.1 quantile activity ratio: U-238/[U-238 + Th-232]	0.78
95% lower confidence limit on 0.1 quantile activity ratio	0.75

4.3 DECAY CHAINS FOR PRINCIPAL ISOTOPES

The U-238 decay chain is depicted in Figure 2. An equilibrium value of 90% is assumed for the nuclides below Ra-226 in the decay chain due to the 10% emanation of Rn-222.

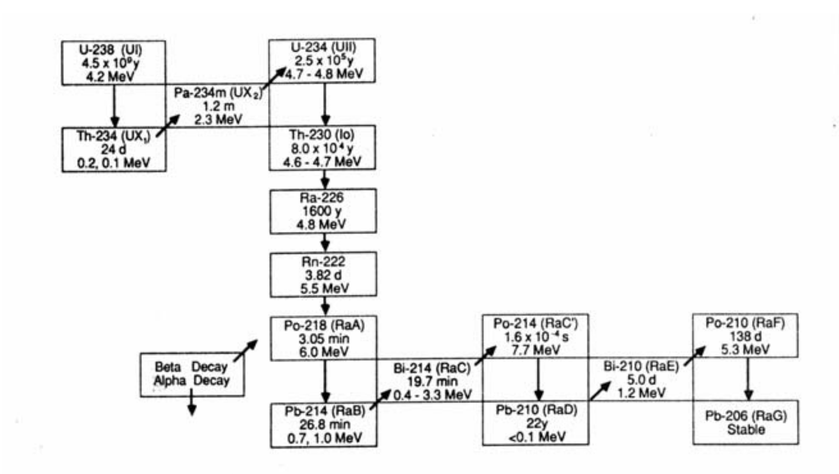

Figure 2. Uranium-238 Decay Chain (after NCRP 1988)

The Th-232 decay chain is depicted in Figure 3. The nuclides below Ra-224 in this decay chain are assumed to be present at 90% of their equilibrium values due to 10% emanation of Rn-220.

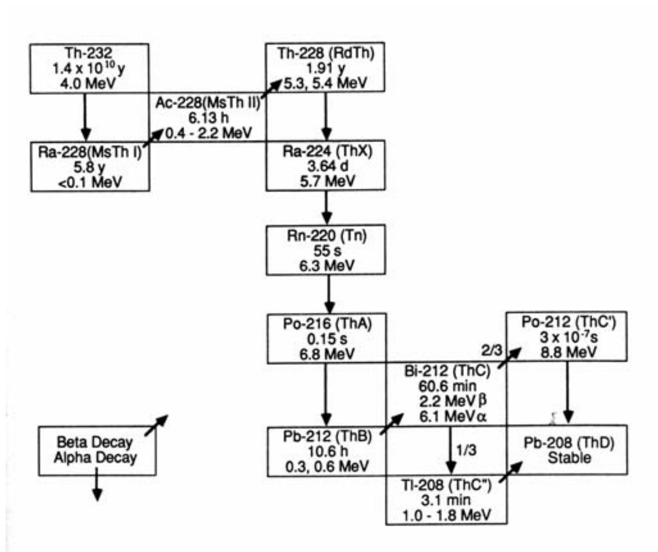

Figure 3. Thorium-232 Decay Chain (after NCRP 1988)

4.4 ANNUAL LIMITS OF INTAKE AND RELATED FACTORS FOR ORE MATERIAL

Tables 2 and 3 provide the stochastic annual limits of intake (SALIs) and related factors that were considered in developing a bioassay program. The detection limits for beta emitters are generally much higher than those for alpha emitters; thus beta emitters such as radium-228 (Ra-228) and lead-210 (Pb-210) were not considered suitable for bioassay analysis.

Table 2. Stochastic Annual Limit of Intake and Related Factors for 10-micron AMAD Ore Having an Activity Ratio of 75% U-238 : 25% Th-232

Isotope	ICRP 30 Lung Clearance	SDAC 10-micron AMAD (µCi/ml)	SALI 10-micron AMAD (µCi)	0.02 SALI Intake for Mixture (pCi)
U-238	Y	8.7 E-11	0.209	348
Th-234	Y	1.4 E-7	342	348
Pa-234	Y	6.1 E-6	14634	348
U-234	Y	7.8 E-11	0.188	348
Th-230	Y	2.8 E-11	0.0668	348
Ra-226	W	8.0 E-10	1.92	348
Pb-210	D	1.3 E-10	0.305	313

Isotope	ICRP 30 Lung Clearance	SDAC 10-micron AMAD (µCi/ml)	SALI 10-micron AMAD (µCi)	0.02 SALI Intake for Mixture (pCi)
Bi-210	W	5.5 E-8	131	313
Po-210	W	4.6 E-10	1.11	313
Th-232	Y	5.8 E-12	0.0139	116
Ra-228	W	9.4 E-10	2.27	116
Ac-228	Y	9.4 E-8	225	116
Th-228	Y	3.4 E-11	0.0816	116
Ra-224	W	3.4 E-9	8.20	116
Pb-212	D[a]	1.6 E-8	37.7	104

[a] Degree of equilibrium assumed to be as stated in section 4.1

Table 3. Airborne Concentrations That Correspond to 1 SDAC for a Radionuclide Mixture of 3 U-238: 1 Th-232

Isotope	Concentration (µCi/ml) When the Mixture is Equal to One SDAC.
U-238, Th-234, Pa-234, U-234, Th-230, Ra-226 (each)	7.2 E-12
Rn-222 and Progeny (each) [a]	6.5 E-12
Th-232, Ra-228, Ac-228, Th-228, Ra-224 (each)	2.4 E-12
Rn-220 and Progeny (each) [a]	2.2 E-12
Gross Alpha	6.8 E-11

[a] Degree of equilibrium assumed to be as stated in section 4.1

5. ORE MATERIALS: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY

Consistent with Regulatory Guide 8.9 requirements (NRC 1993), this section provides retention and elimination models that conform to the models provided in ICRP 30 (ICRP 1977) and ICRP 54 (ICRP 1988). The retention and excretion models for thorium-class Y, uranium-class Y, and radium-class W were implemented in Berkeley Madonna version 8.0.1, a commercially distributed dynamic simulation software package.[1] The models were validated by comparison with retention and excretion curves that were published in ICRP 54 and by mass balance considerations.

The excretion rate curves provided in Figures 4, 5, 6 and 7 do not differ perceptibly from ICRP 54 excretion rate curves. These figures present the excretion rate averaged over one day. The timing convention used is that day 1 starts at the time of exposure and ends 24 hours later.

Daily excretion rate data are provided in Tables 4, 5, and 6; these values were obtained by subtracting the cumulative amount excreted for each day from the cumulative amount excreted as of the previous day. These tables also provide the amount of thorium-232, uranium-238, and radium-226 that are expected to be excreted per day following an acute intake of uranium-238 and thorium-232 (both with progeny) that is equivalent to 40 DAC hours. Chronic intakes are not addressed because the average airborne concentration from routine work activities is less than 10% of the applicable DAC (Weston Solutions, 2003), and chronic overexposures are not considered credible as long as air sample data continue to indicate low values. Ongoing occupational air sampling results will indicate a need for corrective actions long before chronic exposure problems can develop, and at lower levels of intakes than can be detected by bioassay.

These estimates are based on an activity ratio of 3 uranium-238 : 1 thorium-232 and the degree of equilibrium stated in section 4.1. Based on this activity ratio, the activity of thorium-230 excreted per day would be three times the amount of thorium-232 excreted per day; a separate table is not provided for thorium-230.

[1] A freeware version of Berkeley Madonna is available at www.berkeleymadonna.com. Copies of the model definition files are available on request.

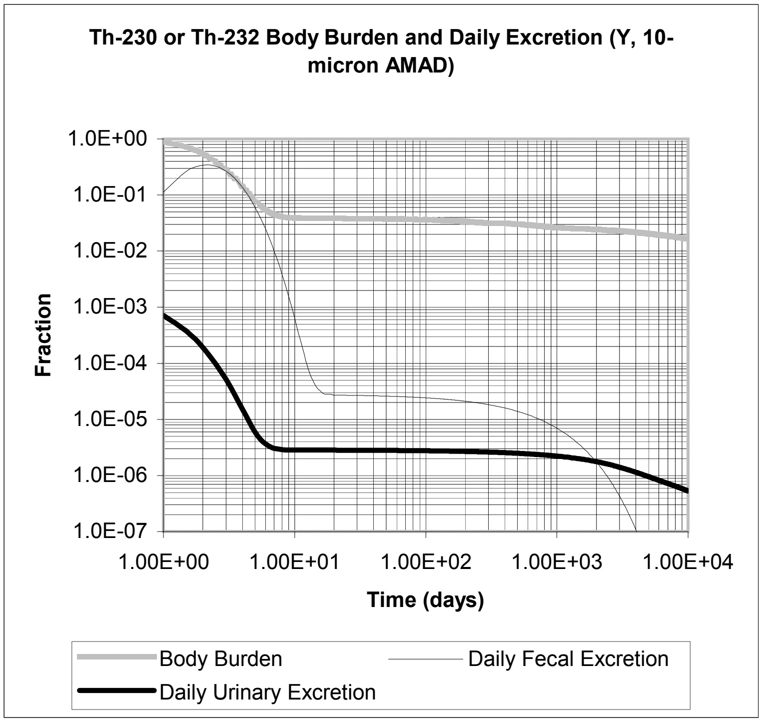

Figure 4. Daily Thorium-230 or Thorium-232 Excretion Rate Versus Time

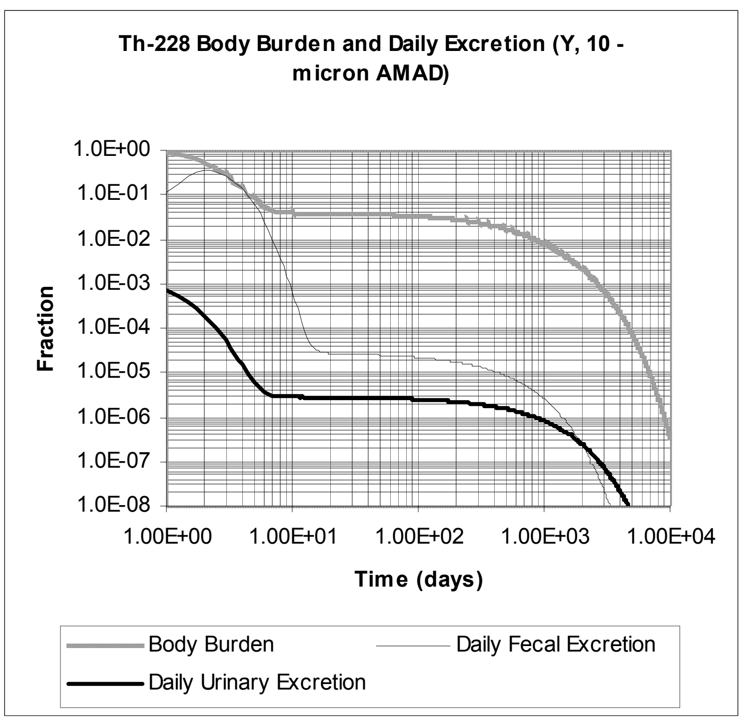

Figure 5. Daily Thorium-228 Excretion Rate Versus Time.

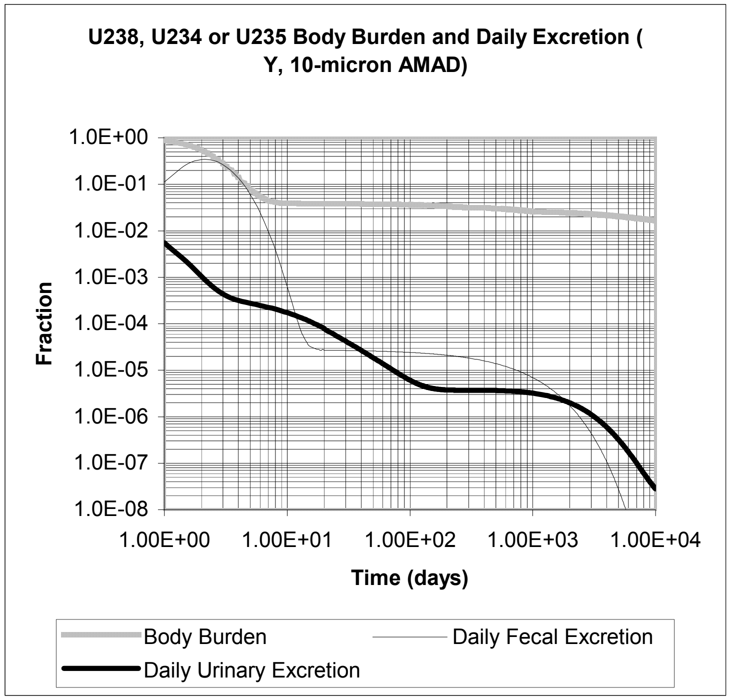

Figure 6. Daily Uranium Excretion Rate Versus Time.

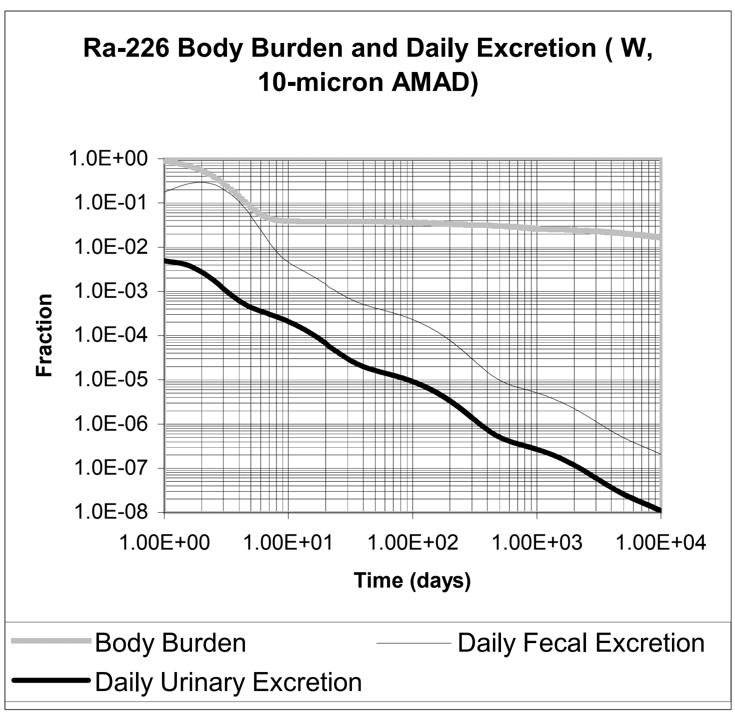

Figure 7. Daily Radium-226 Excretion Rate Versus Time.

Table 4. Thorium-232, Thorium-228 Daily Excretion Rates (Class Y, 10-micron AMAD)

Day	Body Burden	Fractional (day^{-1})		40-DAC hour mixture (pCi/day)	
		Fecal	Urine	Fecal	Urine
1.0	8.87E-01	1.1E-01	7.2E-04	1.3E+01	8.3E-02
1.5	7.21E-01	2.6E-01	3.8E-04	3.1E+01	4.4E-02
2.0	5.45E-01	3.4E-01	1.9E-04	4.0E+01	2.2E-02
2.5	3.94E-01	3.3E-01	9.9E-05	3.8E+01	1.1E-02
3.0	2.79E-01	2.7E-01	5.1E-05	3.1E+01	6.0E-03
3.5	1.97E-01	2.0E-01	2.7E-05	2.3E+01	3.2E-03
4.0	1.41E-01	1.4E-01	1.5E-05	1.6E+01	1.8E-03
4.5	1.04E-01	9.3E-02	9.1E-06	1.1E+01	1.1E-03
5.0	8.00E-02	6.1E-02	6.0E-06	7.1E+00	7.0E-04
5.5	6.47E-02	3.9E-02	4.4E-06	4.6E+00	5.1E-04
6.0	5.50E-02	2.5E-02	3.7E-06	2.9E+00	4.2E-04
6.5	4.89E-02	1.6E-02	3.3E-06	1.8E+00	3.8E-04
7.0	4.50E-02	1.0E-02	3.1E-06	1.2E+00	3.5E-04
7.5	4.26E-02	6.3E-03	3.0E-06	7.3E-01	3.4E-04
8.0	4.11E-02	3.9E-03	2.9E-06	4.6E-01	3.4E-04
8.5	4.01E-02	2.5E-03	2.9E-06	2.9E-01	3.3E-04
9.0	3.95E-02	1.6E-03	2.9E-06	1.8E-01	3.3E-04
9.5	3.91E-02	9.9E-04	2.9E-06	1.1E-01	3.3E-04
10.0	3.89E-02	6.3E-04	2.8E-06	7.3E-02	3.3E-04
10.5	3.87E-02	4.1E-04	2.8E-06	4.8E-02	3.3E-04
11.0	3.86E-02	2.7E-04	2.8E-06	3.1E-02	3.3E-04
11.5	3.85E-02	1.8E-04	2.8E-06	2.1E-02	3.3E-04
12.0	3.85E-02	1.3E-04	2.8E-06	1.5E-02	3.3E-04
12.5	3.85E-02	9.2E-05	2.8E-06	1.1E-02	3.3E-04
13.0	3.84E-02	6.9E-05	2.8E-06	8.0E-03	3.3E-04
13.5	3.84E-02	5.4E-05	2.8E-06	6.3E-03	3.3E-04
14.0	3.84E-02	4.5E-05	2.8E-06	5.2E-03	3.3E-04

Table 5. Uranium Daily Excretion Rates (Class Y, 10-micron AMAD)

Day	Body Burden	Fractional (day^{-1})		40-DAC hour mixture (pCi/day)	
		Fecal	Urine	Fecal	Urine
1.00E+00	8.82E-01	1.1E-01	5.5E-03	3.9E+01	1.9E+00
1.50E+00	7.16E-01	2.6E-01	2.2E-03	9.2E+01	7.6E-01
2.00E+00	5.40E-01	3.4E-01	1.0E-03	1.2E+02	3.6E-01
2.50E+00	3.90E-01	3.3E-01	6.1E-04	1.1E+02	2.1E-01
3.00E+00	2.74E-01	2.7E-01	4.4E-04	9.2E+01	1.5E-01
3.50E+00	1.92E-01	2.0E-01	3.6E-04	6.9E+01	1.2E-01
4.00E+00	1.36E-01	1.4E-01	3.2E-04	4.8E+01	1.1E-01
4.50E+00	9.92E-02	9.3E-02	2.9E-04	3.2E+01	1.0E-01
5.00E+00	7.51E-02	6.1E-02	2.8E-04	2.1E+01	9.6E-02
5.50E+00	5.97E-02	3.9E-02	2.6E-04	1.4E+01	9.1E-02
6.00E+00	4.98E-02	2.5E-02	2.5E-04	8.7E+00	8.6E-02
6.50E+00	4.36E-02	1.6E-02	2.4E-04	5.5E+00	8.2E-02
7.00E+00	3.97E-02	9.9E-03	2.3E-04	3.5E+00	7.9E-02
7.50E+00	3.72E-02	6.2E-03	2.2E-04	2.2E+00	7.5E-02
8.00E+00	3.56E-02	3.9E-03	2.1E-04	1.4E+00	7.2E-02
8.50E+00	3.45E-02	2.5E-03	2.0E-04	8.6E-01	6.9E-02
9.00E+00	3.38E-02	1.6E-03	1.9E-04	5.4E-01	6.6E-02
9.50E+00	3.33E-02	9.9E-04	1.8E-04	3.4E-01	6.3E-02
1.00E+01	3.30E-02	6.3E-04	1.7E-04	2.2E-01	6.0E-02
1.05E+01	3.28E-02	4.1E-04	1.7E-04	1.4E-01	5.8E-02
1.10E+01	3.26E-02	2.7E-04	1.6E-04	9.4E-02	5.5E-02
1.15E+01	3.24E-02	1.8E-04	1.5E-04	6.3E-02	5.3E-02
1.20E+01	3.23E-02	1.3E-04	1.5E-04	4.4E-02	5.1E-02
1.25E+01	3.22E-02	9.1E-05	1.4E-04	3.2E-02	4.9E-02
1.30E+01	3.21E-02	6.9E-05	1.3E-04	2.4E-02	4.7E-02
1.35E+01	3.20E-02	5.5E-05	1.3E-04	1.9E-02	4.5E-02
1.40E+01	3.19E-02	4.5E-05	1.2E-04	1.6E-02	4.3E-02
1.50E+01	3.18E-02	3.4E-05	1.1E-04	1.2E-02	4.0E-02
1.60E+01	3.16E-02	3.1E-05	1.1E-04	1.1E-02	3.7E-02
1.70E+01	3.15E-02	2.9E-05	9.8E-05	1.0E-02	3.4E-02
1.80E+01	3.14E-02	2.8E-05	9.2E-05	9.7E-03	3.2E-02
1.90E+01	3.13E-02	2.7E-05	8.5E-05	9.4E-03	3.0E-02
2.00E+01	3.12E-02	2.7E-05	7.9E-05	9.4E-03	2.8E-02
2.10E+01	3.11E-02	2.7E-05	7.2E-05	9.4E-03	2.5E-02
2.20E+01	3.10E-02	2.7E-05	6.7E-05	9.4E-03	2.3E-02
2.30E+01	3.09E-02	2.7E-05	6.3E-05	9.4E-03	2.2E-02
2.40E+01	3.08E-02	2.7E-05	5.9E-05	9.3E-03	2.1E-02

Table 6. Radium-226 Daily Excretion Rates (Class W, 10-micron AMAD)

Day	Body Burden	Fractional (day^{-1})		40-DAC hour mixture (pCi/day)	
		Fecal	Urine	Fecal	Urine
1.0	8.19E-01	1.8E-01	4.9E-03	6.1E+01	1.7E+00
1.5	6.68E-01	2.7E-01	4.0E-03	9.3E+01	1.4E+00
2.0	5.23E-01	2.9E-01	2.8E-03	1.0E+02	9.6E-01
2.5	4.04E-01	2.6E-01	1.8E-03	9.1E+01	6.2E-01
3.0	3.15E-01	2.1E-01	1.2E-03	7.2E+01	4.1E-01
3.5	2.52E-01	1.5E-01	8.2E-04	5.3E+01	2.8E-01
4.0	2.07E-01	1.1E-01	6.2E-04	3.7E+01	2.1E-01
4.5	1.77E-01	7.4E-02	5.0E-04	2.6E+01	1.8E-01
5.0	1.56E-01	5.1E-02	4.4E-04	1.8E+01	1.5E-01
5.5	1.42E-01	3.5E-02	3.9E-04	1.2E+01	1.4E-01
6.0	1.32E-01	2.4E-02	3.6E-04	8.4E+00	1.2E-01
6.5	1.24E-01	1.7E-02	3.3E-04	6.1E+00	1.1E-01
7.0	1.19E-01	1.3E-02	3.1E-04	4.5E+00	1.1E-01
7.5	1.14E-01	1.0E-02	2.9E-04	3.5E+00	1.0E-01
8.0	1.10E-01	8.0E-03	2.7E-04	2.8E+00	9.3E-02
8.5	1.07E-01	6.7E-03	2.5E-04	2.3E+00	8.8E-02
9.0	1.04E-01	5.8E-03	2.4E-04	2.0E+00	8.2E-02
9.5	1.02E-01	5.1E-03	2.2E-04	1.8E+00	7.7E-02
10.0	9.95E-02	4.6E-03	2.1E-04	1.6E+00	7.2E-02
10.5	9.74E-02	4.2E-03	2.0E-04	1.5E+00	6.8E-02
11.0	9.54E-02	3.9E-03	1.8E-04	1.3E+00	6.4E-02
11.5	9.36E-02	3.6E-03	1.7E-04	1.3E+00	6.0E-02
12.0	9.19E-02	3.4E-03	1.6E-04	1.2E+00	5.7E-02
12.5	9.03E-02	3.2E-03	1.5E-04	1.1E+00	5.3E-02
13.0	8.88E-02	3.0E-03	1.4E-04	1.0E+00	5.0E-02
13.5	8.74E-02	2.8E-03	1.4E-04	9.8E-01	4.8E-02
14.0	8.60E-02	2.6E-03	1.3E-04	9.2E-01	4.5E-02
15.0	8.35E-02	2.4E-03	1.1E-04	8.3E-01	4.0E-02
16.0	8.13E-02	2.1E-03	1.0E-04	7.4E-01	3.6E-02
17.0	7.93E-02	1.9E-03	9.2E-05	6.7E-01	3.2E-02
18.0	7.74E-02	1.8E-03	8.3E-05	6.1E-01	2.9E-02
19.0	7.58E-02	1.6E-03	7.5E-05	5.6E-01	2.6E-02
20.0	7.42E-02	1.5E-03	6.8E-05	5.1E-01	2.4E-02
21.0	7.28E-02	1.3E-03	5.9E-05	4.5E-01	2.0E-02

5.1 IMPLICATIONS FOR URINE BIOASSAY

The urine excretion rates following a 40-DAC hour exposure to the anticipated mixture of radionuclides at CSM's Boyertown Plant are provided in the extreme right columns of Tables 4, 5, and 6. On average, a person excretes about 2 liters (L) of urine per day, so the typical concentrations in pCi/L of the radionuclides in urine would be about one-half of the values given in the last column of Tables 4, 5, and 6. Appendix C of ANSI/HPS N13.30-1996 (HPS 1996) provides reasonably achievable minimum detectable concentrations (MDC) for urine bioassay samples, which are summarized in Table 7.

Table 7. MDC Values for Urine Sample Analyses by Alpha Spectroscopy

Thorium-232, Thorium-230	0.1 pCi/L
Uranium-234, Uranium-238	0.1 pCi/L
Radium-226	0.1 pCi/L

Alpha spectroscopy is the current best commercially available technology for urine sample analysis. Thermal ionization mass spectroscopy (TIMS) is a new technology that would markedly improve the detection limits for urine bioassay if it becomes commercially available, and urine bioassay may be re-evaluated in that event. Based on the excretion rates given in Tables 4, 5, and 6 and the MDC values in Table 7, routine urine bioassay samples collected less frequently than weekly would be of very limited value in detecting a 40-SDAC hour exposure because the quantities of radionuclides excreted after one week would not meet the MDC, as shown in Table 8. The third column presents the maximum time that bioassay could be useful in detecting a 200-SDAC hour intake, which represents an extreme exposure in comparison to the extremely low routine exposures documented via air sampling at the CSM site.

Table 8. Maximum Time Following an Intake of Ore Material That Urine Bioassay Would Be Useful[a]

Isotope Detected and Clearance Class	40-DAC hour intake (days)	200-DAC hour intake (days)
Thorium-232, Class Y	Not recommended	2
Thorium-230, Class Y	1	3
Uranium-234, Uranium-238, Class Y	4	24
Radium-226, Class W	7	21
[a]Assuming that the intake is instantaneous, the urine sample is collected over the 24 hours following the exposure, and that the laboratory ensures that they can achieve an MDC of 0.05 pCi/L. ANSI/HPS N13.22-1995, *Bioassay Programs for Uranium*, (HPS 1995) does not recommend urine bioassay for Class Y uranium.		

5.2 IMPLICATIONS FOR FECAL BIOASSAY

The fecal excretion rates following a 40-SDAC hour exposure to the anticipated mixture of radionuclides at CSM's Boyertown Plant are provided in the fifth columns of Tables 4, 5 and 6. Appendix C of ANSI/HPS N13.30-1996 (HPS 1996) provides reasonably achievable minimum detectable activities (MDAs) for fecal samples that are restated in Table 9.

Table 9. MDA Values for Fecal Sample Analyses by Alpha Spectroscopy

Thorium-232, Thorium-230	1 pCi/sample aliquot, from ANSI/HPS N13.30-1996 (HPS 1996)
Uranium-234, Uranium-238	1 pCi/sample aliquot, from ANSI/HPS N13.30-1996 (HPS 1996)
Radium-226	0.5 pCi/sample aliquot.[2]

Based on the excretion rates given in Tables 4, 5, and 6 and the MDA values in Table 9, fecal bioassay samples would be useful for quantifying acute intakes for a few days following the event, as shown in Table 10.

Table 10. Maximum Time Following an Intake of Ore Material That Fecal Bioassay Would Be Useful[a] (days)

Isotope and Clearance Class	40-DAC hour intake	200-DAC hour intake
Thorium-232, Class Y	6	8
Thorium-230, Class Y	7	9
Uranium-234, Uranium-238, Class Y	7	9
Radium-226, Class W	9	21
[a]Each fecal sample will be split into two parts at the lab for quality assurance purposes, effectively cutting the sample volume and detectable activity by one-half, and reducing the time-after-intake for which the MDC would be excreted.		

5.3 IMPLICATIONS FOR WHOLE BODY COUNTING

The Canberra Special Services Division performed whole body counting for CSM during 1995 (Canberra 1995). Canberra reported the MDAs provided in Table 11 for that work.

[2] Conversation with Eberline Services, Inc. Laboratory Manager, Karen Schoendaller, August 28, 2002.

Table 11. Whole Body Counting MDA Values
Provided by Canberra Special Services Division

Isotope	Minimum Detectable Activity
Thorium-232 (based on Thallium-208)	1,000 pCi
Radium-226 (based on Bismuth-214)	1,300 pCi

Thorium-232. Based on the data in Table 2, the amount of thorium-232 that represents a 2,000-SDAC hour exposure to an ore dust mixture is 5800 pCi [= 116 pCi/0.02 SALI from Table 2]. At a deposition efficiency of 100%,[3] a 5800-pCi intake of thorium-232 corresponds to a deposition of 5800 pCi of thorium-232. This is 5.8 times the MDA of the whole body counter and would be detectable for 3.5 days. Annual whole body counting lacks the sensitivity to detect intakes that correspond to 40 SDAC hours or 200 SDAC hours.

Uranium-238. Uranium-238 cannot easily be directly detected by whole body counting. A uranium-238 intake can be inferred from the gamma emissions of bismuth-214. A 2000-DAC hour exposure to the ore dust mixture would result in an intake and deposition of 17,400 pCi of bismuth-214. Because this exceeds the 1,300-pCi MDA for the system, the uranium-238 and daughters could be detected for only about 4.5 days, assuming Class Y lung clearance behavior.

6. THORIUM DOPING: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY

6.1 DERIVATION OF INTAKES OF THORIUM NITRATE THAT WOULD CORRESPOND TO 40 DAC HOURS AND 200 DAC HOURS

The air sampling review (Weston Solutions 2003) provides the basis for the gross alpha SDAC for thorium nitrate. This section summarizes the basis, provides the individual SDAC values, and derives intakes that represent 40 SDAC hours and 200 SDAC hours. The gross alpha SDAC is protective of workers.

[3] According to the ICRP 30 lung model (ICRP 1977), inhalation of radioactive particulate having a 10-micron AMAD results in a deposition of 100% in the respiratory tract. Virtually nothing is exhaled.

It is CSM's intention to assign inhalation doses from thorium doping activities on the basis of air sampling. Bioassay would serve primarily as an independent means of confirmation that significant intakes of radioactive materials did not occur during respirator use.

6.2 ASSUMPTIONS

The gross alpha SDAC values for ore material that were derived in the air sampling review (Weston Solutions 2003) are based on the following assumptions:

- ICRP 30 Lung Model, as provided in ICRP 30 Figures 5.1 and 5.2, and the equations provided in section 5.2 of that document,
- 1 -micron activity median aerodynamic diameter (AMAD) is used to be consistent with ICRP 30 standard assumptions as explained in the air sampling review (Weston Solutions 2003),
- 63% deposition in respiratory tract,
- Regional deposition fractions for 1 micron AMAD per ICRP 30 Figure 5-2,
- ICRP 30 GI Tract Model, as provided in ICRP 30, Equations 6.1a through 6.1d and 6.3 and data in in Figure 6.1,
- ICRP 30 metabolic data for radionuclides,
- Lung clearance class W for thorium and radium,
- Equilibrium in decay chains from parent to radium,
- Decay products following radium in the decay series are omitted from consideration for in vitro bioassay because they are short-lived,
- The absolute minimum activity ratio that is physically possible is $\frac{42.4\ pCi\ Th228}{100\ pCi\ Th232}$ as explained in the air sampling review (Weston Solutions, 2003),
- ICRP 30 metabolic data for thorium and values in ICRP 54 (page 183) are used including lung clearance class W, GI uptake fraction, F_1, of 0.0002, and Systemic fraction excreted in urine, F_U, of 1.0,
- Equilibrium is assumed throughout the Th-232 decay chain, and
- Respiration rate of 0.02 m^3/minute.

6.3 ANNUAL LIMITS OF INTAKE AND RELATED FACTORS FOR THORIUM DOPING

The degree of equilibrium of the thorium nitrate used in thorium doping is not known, but as indicated in the air sampling review (Weston Solutions, 2003) it is incapable of having an activity ratio of less than

$$\frac{42.4\ pCi\ Th228}{100\ pCi\ Th232}.$$

In addition, the amount of thorium-230 that is present in thorium nitrate as an impurity is not known at this time, but can be significant. Table 12 shows how the ratios of thorium-228:thorium-232 and thorium-230:thorium-232 affect the amount of thorium-232 that corresponds to 1 SDAC for the mixture. Fortunately, thorium-232 is the isotope that dominates the dose in thorium nitrate, and this allows useful and bounding recommendations to be provided in this report concerning bioassay even though the ratios of thorium isotopes are unknown. All bioassay recommendations in this report are based on an assumed isotopic activity ratio of: 1 pCi Th-232: 1 pCi Th-228: 1 pCi Th-230, which is conservative compared to the ratio given at the start of this section. Table 12 can be consulted to adjust these recommendations for other activity ratios, if isotopic ratios are later determined.

Table 12. Thorium-232 intakes corresponding to the SDAC, the SALI, and 0.02 SALI for the mixture of Radionuclides

Th-228:Th232 Activity Ratio	Th-230:Th-232 Activity Ratio	Th-232 Concentration at 1 SDAC for Mixture, µCi/ml	Th-232 Activity at 1 Mixture SALI, pCi	Th232 activity, 0.02 Mixture SALI, pCi
0.4	0	1.20E-12	2870	57.4
0.4	0.5	1.09E-12	2625	52.5
0.4	1	1.01E-12	2418	48.4
0.4	1.5	9.34E-13	2242	44.8
0.6	0	1.16E-12	2788	55.8
0.6	0.5	1.07E-12	2556	51.1
0.6	1	9.83E-13	2360	47.2
0.6	1.5	9.13E-13	2191	43.8
0.8	0	1.13E-12	2710	54.2
0.8	0.5	1.04E-12	2491	49.8
0.8	1	9.60E-13	2304	46.1
0.8	1.5	8.93E-13	2143	42.9

Th-228:Th232 Activity Ratio	Th-230:Th-232 Activity Ratio	Th-232 Concentration at 1 SDAC for Mixture, µCi/ml	Th-232 Activity at 1 Mixture SALI, pCi	Th232 activity, 0.02 Mixture SALI, pCi
1	0	1.10E-12	2637	52.7
1	0.5	1.01E-12	2428	48.6
1	1	9.38E-13	2250	45.0
1	1.5	8.74E-13	2097	41.9

7. THORIUM DOPING: RETENTION AND ELIMINATION OF RADIONUCLIDES FROM THE BODY

Consistent with Regulatory Guide 8.9 requirements (NRC 1993), this section provides retention and elimination models that conform to the models provided in ICRP 30 (ICRP 1977) and ICRP 54 (ICRP 1988). The retention and excretion models for thorium-class W were implemented in Berkeley Madonna version 8.0.1.[4] Excretion and retention data are not presented for radium-228 because it has rather high detection limits and would not be readily measured. The models were validated by comparison with retention and excretion curves that were published in ICRP 54 and by mass balance considerations.

The excretion rate curves provided in Figures 8 and 9 apply to acute intakes. They do not differ perceptibly from ICRP 54 excretion rate curves. These Figures present the excretion rate averaged over each day. The timing convention used is that day 1 starts at the time of exposure and ends 24 hours later, and so on.

Daily excretion rate data are provided in Table 13; these values were obtained by subtracting the cumulative amount excreted for each day from the cumulative amount of thorium isotope excreted as of the previous day following an acute intake of thorium-232 (with progeny) that is equivalent to more than 40 SDAC hours for the mixture. These estimates are based on the conservative assumptions of equilibrium in the Th-232 decay chain and a Th-230: Th-232 activity ratio of 1:1.

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[4] A freeware version of Berkeley Madonna is available at www.berkeleymadonna.com. Copies of the model definition files are available on request.

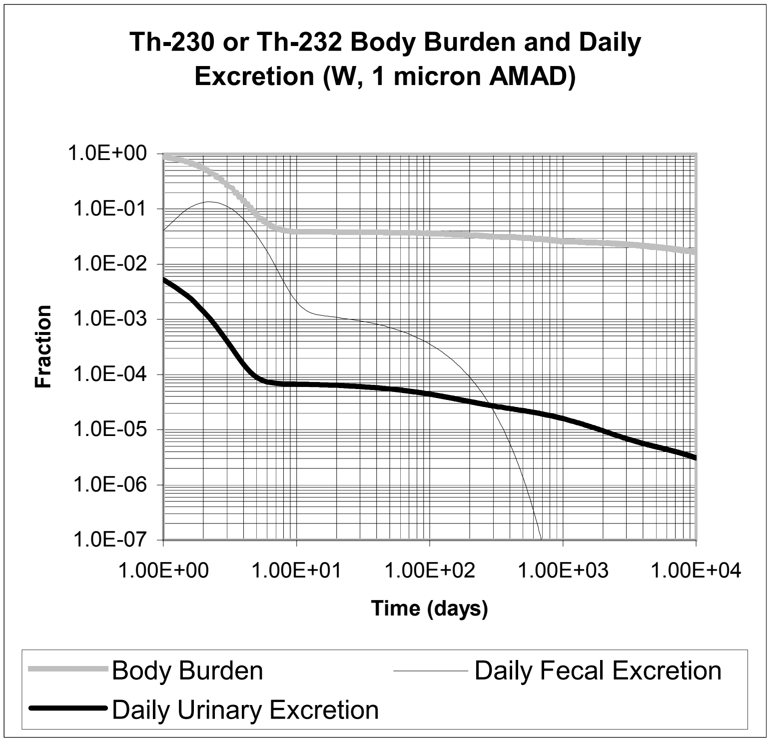

Figure 8. Daily Thorium-232 (or Thorium-230) Excretion Rate Versus Time

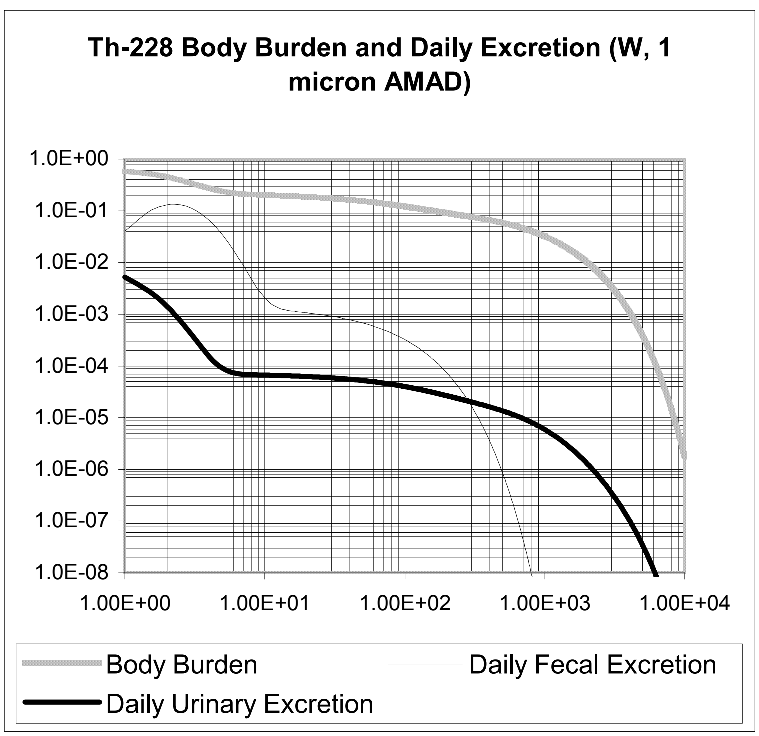

Figure 9. Daily Thorium-228 Excretion Rate Versus Time.

Table 13. Thorium-232 Daily Excretion Rates (Class W, 1 micron AMAD)

Day	Body Burden	Fractional (day^{-1})		40-DAC hour of mixture (pCi/d) [a]	
		Daily Fecal	Daily Urine	Daily Fecal	Daily Urine
1.00E+00	5.8E-01	4.0E-02	5.2E-03	1.8E+00	2.4E-01
1.50E+00	5.2E-01	9.8E-02	2.7E-03	4.4E+00	1.2E-01
2.00E+00	4.5E-01	1.3E-01	1.4E-03	5.9E+00	6.3E-02
2.50E+00	3.9E-01	1.3E-01	7.4E-04	5.9E+00	3.3E-02
3.00E+00	3.4E-01	1.1E-01	4.0E-04	5.0E+00	1.8E-02
3.50E+00	3.0E-01	8.8E-02	2.4E-04	4.0E+00	1.1E-02
4.00E+00	2.7E-01	6.6E-02	1.5E-04	3.0E+00	6.9E-03
4.50E+00	2.5E-01	4.8E-02	1.1E-04	2.1E+00	5.0E-03
5.00E+00	2.4E-01	3.4E-02	9.0E-05	1.5E+00	4.0E-03
5.50E+00	2.3E-01	2.4E-02	7.9E-05	1.1E+00	3.6E-03
6.00E+00	2.2E-01	1.7E-02	7.4E-05	7.7E-01	3.3E-03
6.50E+00	2.2E-01	1.2E-02	7.1E-05	5.5E-01	3.2E-03
7.00E+00	2.1E-01	8.8E-03	6.9E-05	4.0E-01	3.1E-03
7.50E+00	2.1E-01	6.5E-03	6.9E-05	2.9E-01	3.1E-03
8.00E+00	2.1E-01	4.9E-03	6.8E-05	2.2E-01	3.1E-03
8.50E+00	2.1E-01	3.8E-03	6.8E-05	1.7E-01	3.0E-03
9.00E+00	2.0E-01	3.0E-03	6.7E-05	1.3E-01	3.0E-03
9.50E+00	2.0E-01	2.5E-03	6.7E-05	1.1E-01	3.0E-03
1.00E+01	2.0E-01	2.1E-03	6.7E-05	9.4E-02	3.0E-03
1.05E+01	2.0E-01	1.8E-03	6.7E-05	8.2E-02	3.0E-03
1.10E+01	2.0E-01	1.6E-03	6.7E-05	7.4E-02	3.0E-03
1.15E+01	2.0E-01	1.5E-03	6.7E-05	6.8E-02	3.0E-03
1.20E+01	2.0E-01	1.4E-03	6.6E-05	6.4E-02	3.0E-03
1.25E+01	2.0E-01	1.3E-03	6.6E-05	6.1E-02	3.0E-03
1.30E+01	2.0E-01	1.3E-03	6.6E-05	5.8E-02	3.0E-03
1.35E+01	2.0E-01	1.3E-03	6.6E-05	5.7E-02	3.0E-03
1.40E+01	2.0E-01	1.2E-03	6.6E-05	5.5E-02	3.0E-03
1.45E+01	2.0E-01	1.2E-03	6.6E-05	5.4E-02	2.9E-03
1.50E+01	2.0E-01	1.2E-03	6.5E-05	5.4E-02	2.9E-03
1.55E+01	2.0E-01	1.2E-03	6.5E-05	5.3E-02	2.9E-03
1.60E+01	1.9E-01	1.2E-03	6.5E-05	5.2E-02	2.9E-03
1.65E+01	1.9E-01	1.2E-03	6.5E-05	5.2E-02	2.9E-03
1.70E+01	1.9E-01	1.1E-03	6.5E-05	5.1E-02	2.9E-03
1.75E+01	1.9E-01	1.1E-03	6.5E-05	5.1E-02	2.9E-03
1.80E+01	1.9E-01	1.1E-03	6.4E-05	5.0E-02	2.9E-03
1.85E+01	1.9E-01	1.1E-03	6.4E-05	5.0E-02	2.9E-03
1.90E+01	1.9E-01	1.1E-03	6.4E-05	5.0E-02	2.9E-03
1.95E+01	1.9E-01	1.1E-03	6.4E-05	4.9E-02	2.9E-03
2.00E+01	1.9E-01	1.1E-03	6.4E-05	4.9E-02	2.9E-03

[a] For a Th-228: Th230: Th-232 activity ratio of 1:1:1.

7.1 IMPLICATIONS FOR URINE BIOASSAY

The urine excretion rates following a 40-SDAC hour exposure to the anticipated mixture of radionuclides in the thorium doping operation are provided in the extreme right column of Table 13. On average a person excretes about 2 L of urine per day, so the typical concentrations in pCi/L of the radionuclides in urine would be about one-half of the values given in the last column of Tables 13. Appendix C of ANSI/HPS N13.30-1996 (HPS 1996) provides reasonably achievable minimum detectable concentrations (MDC) for urine bioassay samples, which are summarized in Table 7.

Based on the excretion rates given in Table 13 and the MDC values in Table 7, routine urine bioassay samples collected less frequently than daily would be of very limited value in detecting a 40-SDAC hour exposure, as shown in Table 14. Table 14 also presents the maximum time that bioassay could be useful in detecting a 200-SDAC hour intake (2 days), which further demonstrates the very limited value of urine bioassay in detecting even a higher level exposure.

Table 14. Frequency of Urine or Fecal Bioassays for Thorium Nitrate, Class W Mixtures[a]

Intake Level	Days Post-Exposure To Collect Samples	
	Urine Samples	Fecal Samples
40 DAC hours	1	4
200 DAC hours	2	7

[a] Assuming that the exposure was instantaneous, the urine sample is collected over the 24 hours following the exposure, and that the laboratory ensures that they can achieve an MDC of 0.05 pCi/L.

7.2 IMPLICATIONS FOR FECAL BIOASSAY

The fecal excretion rates following a 40-SDAC hour exposure to the anticipated mixture of radionuclides at the thorium doping operation are provided in the fifth column of Table 13. Appendix C of ANSI/HPS N13.30-1996 (HPS 1996) provides reasonably achievable minimum detectable activity (MDA) for fecal samples; these are restated in Table 9.

Based on the excretion rates given in Table 13 and the MDA values in Table 9, fecal bioassay samples would be slightly more useful than urine bioassay by quantifying acute intakes for a few days following the event, as shown in Table 14. Nonetheless, neither urine bioassay, nor fecal bioassay would be effective as routine methods of detecting worker exposures due to the extremely short period after exposure that detectable concentrations of the radionuclides that contribute the greatest dose are excreted.

7.3 IMPLICATIONS FOR WHOLE BODY COUNTING

The Canberra Special Services Division performed whole body counting for CSM during 1995 (Canberra 1995). Canberra reported the MDAs provided in Table 11 for that work.

Thorium-232. Based on the data in Table 12, the amount of thorium-232 that represents a 2,000-SDAC hour exposure to a thorium nitrate mixture is about 2,870 pCi. At a deposition efficiency of 63%,[5] a 2870-pCi intake of thorium-232 corresponds to a deposition of 1,808 pCi of thorium-232. This is 1.8 times greater than the MDA of a whole body counter and would be detectable via that detection method, but only for a period of 3 days following the intake. Whole body counting lacks the sensitivity to detect significant intakes of thorium nitrate over a reasonable period following the time of exposure, making it impractical as a tool for routine verification that worker intakes have not occurred.

8. CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE BIOASSAY PROGRAM

The licensed material used at the Boyertown plant includes all of the radionuclides of the uranium and thorium decay chains. This report, using conservative assumptions where specific conditions are unknown, has evaluated the effectiveness and analytical sensitivities of three bioassay methods for the individual isotopes that would present the greatest contribution to dose upon intake. Thus, this evaluation focuses on thorium and uranium. If there were a significant amount of lung clearance class W or D uranium in the ore material, then intakes would be overestimated by uranium bioassay since clearance estimates in the report are based on class Y material.

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[5] According to the ICRP 30 lung model (ICRP 1977), inhalation of radioactive particulate having a 1 micron AMAD results in a deposition of 63% in the respiratory tract.

Estimating intakes of uranium and thorium based on the assumption of class W behavior of radium-226 is technically compliant with requirements, but the radium-226 in ore material is expected to exhibit Class Y lung clearance behavior. This means that intakes of U and Th would be underestimated from radium-226 bioassay using the existing radium-226 class W charts and tables in the report.

Alpha spectroscopy is the current best commercially available technology for urine and fecal sample analysis. Thermal ionization mass spectroscopy (TIMS) is a new technology that would improve the detection limits for bioassay, if it becomes commercially available. The feasibility of bioassay for the CSM operations should be re-evaluated if TIMS is commercially offered and cost-effective.

The need for bioassay is triggered by the use of respirators to maintain doses as low as reasonably achievable. Occupational air samples have shown that concentrations average less than 10% of the applicable DAC, making respirators unnecessary. The bioassay program would not require routine testing if CSM relied on engineering controls, air sample results, and planning of radiological work via the radiation work permit system so that respiratory protection was necessary only for planned non-routine activities such as maintenance tasks.

Conclusions related to the two categories of materials used at the site, ore materials and thorium nitrate, are provided below, followed by recommendations for improving the site bioassay program. They are based on assumptions and models that are consistent with those in the air sampling review (Weston Solutions, 2003).

8.1 ORE MATERIALS

The following conclusions and suggestions resulted from this review of the ore materials used by CSM.

- Whole body counting is not sensitive enough to detect an acute deposition of the thorium-232 in ore dust that corresponds to a 2,000-SDAC hour intake of ore material for more than about 3 days after exposure.

- Whole body counting is not sensitive enough to detect an acute deposition of the uranium-238 in ore dust that corresponds to a 2,000-SDAC hour intake of ore material for more than about 4 days.

- Urine bioassay is not sensitive enough to reliably detect the Th-232 component that is present in intakes of ore material mixtures corresponding to 40 SDAC hours or a dose of 100 mrem, even if samples are collected during the 24 hours that follow an acute exposure.

- As indicated in Tables 8 and 10, U-234 should be detectable in urine samples for 4 days and Th-232 should be detectable in fecal samples for 6 days following a 40-SDAC hour intake of ore material. Samples should be collected that represent the fecal elimination over a 24-hour interval beginning 24 to 48 hours after the acute exposure. Employee acceptance is typically low for fecal sampling.

8.2 THORIUM DOPING

The following conclusions and suggestions are offered concerning the CSM bioassay program for thorium doping activities:

- Whole body counting is not sensitive enough to detect an acute deposition of the thorium-232 that corresponds to a 2,000-SDAC hour intake of thorium nitrate material.

- Urine bioassay is sensitive enough to reliably detect the Th-232 component that is present in intakes of thorium nitrate corresponding to 40 SDAC hours or a CEDE of 100 mrem only if samples are collected during the 24 hours that follow an acute exposure.

- As indicated in Table 14, Th-232 should be detectable in fecal samples for 4 days following a 40-SDAC hour intake of thorium nitrate material. Samples should be collected that represent the fecal elimination over a 24-hour interval beginning 24 to 48 hours after the acute exposure.

8.3 SUGGESTED REVISIONS TO THE BIOASSAY PROGRAM:

- CSM should continue their use of engineering controls to maintain airborne thorium levels at less than 10% of the applicable DAC and cease using respirators unless there is reasonable expectation that airborne concentrations will exceed administrative limits.

- CSM should ensure that the occupational air-monitoring program is meticulously implemented and should explore completely opportunities to use or improve engineering controls.

- CSM should continue to assign doses from inhalation of thorium nitrate material on the basis of air samples.

- Since airborne concentrations of ore dust and thorium nitrate are well below 10% of the stochastic DAC, respirators are not required for routine work activities. If respirators are used continuously, or air sample results indicate a significant intake may have occurred, either urine or fecal samples should be used, as appropriate, to confirm that an overexposure to uranium or thorium has not occurred. The preferred 24-hour sample intervals should begin between 12 hours and 48 hours after the intake period ends.

- CSM should implement feasible engineering controls and plan radiological work so that airborne radionuclide concentrations are minimized during dusty, non-routine activities. This change will minimize or eliminate respirator use and limit the impact of the bioassay program on operations.

9. REFERENCES

Canberra, 1995. *Report of Whole Body Counting for* Cabot *Performance Materials from June 21, 1995 to June 22, 1995*. CAB001. Canberra Special Services Division. Meriden, CT.

Health Physics Society (HPS), 1996. *Performance Criteria for Radiobioassay*. An American National Standard, ANSI/HPS N13.30-1996. McLean, VA.

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International Commission on Radiological Protection (ICRP), 1988. *Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation*, ICRP Publication 54, Annals of the ICRP, Pergamon Press, New York.

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Kinneman, 2001. Letter from John D. Kinneman (U.S. Nuclear Regulatory Commission) from Martin O'Neill (Cabot Corporation). Inspection 04006940/2001001, Cabot Corporation, Boyerstown site and Notice of Violation, Docket 04006940, October 23, 2001.

National Council on Radiation Protection and Measurements (NCRP), 1988. *Measurement of Radon and Radon Daughters in Air*, NCRP Report 97. Bethesda, MD.

U.S. Nuclear Regulatory Commission (NRC), 1993. *Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program*, Regulatory Guide 8.9, Rockport, MD.

Weston Solutions 2003. *Review of the Occupational Air Sampling Program at the Cabot Performance Materials Corporation Boyerstown, Pennsylvania Plant.* Albuquerque, NM.

Weston Solutions 2003a. Supporting documentation for the review of the Cabot Super Metals' Boyertown Air Sampling and Bioassay Programs. Memo from Rick Haaker to Robert Schoenfelder.

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX C

Species Impact Letters

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, Pennsylvania 16801-4850

February 3, 2003

Jacob Dunnell II
Project Manager
Shaw Environmental & Infrastructure, Inc.
88C Elm Street
Hopkinton, MA 01748-1656

Dear Mr. Dunnell:

This responds to your letter of December 23, 2002, requesting information about federally listed and proposed endangered and threatened species within the vicinity of a manufacturing facility (Cabot Performance Materials) located in Boyertown Township, Berks County, Pennsylvania. The following comments are provided pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of endangered and threatened species.

The proposed project is within the known range of the bog turtle (*Clemmys muhlenbergii*), a species that is federally listed as threatened. The northern population of the bog turtle occurs in the States of Connecticut, New York, Pennsylvania, Maryland, New Jersey, Delaware and Massachusetts. Bog turtles inhabit shallow, spring-fed fens, sphagnum bogs, swamps, marshy meadows, and pastures characterized by soft, muddy bottoms; clear, cool, slow-flowing water, often forming a network of rivulets; high humidity; and an open canopy. Bog turtles usually occur in small, discrete populations occupying suitable wetland habitat dispersed along a watershed. The occupied "intermediate successional stage" wetland habitat is usually a mosaic of micro-habitats ranging from dry pockets, to areas that are saturated with water, to areas that are periodically flooded. Some wetlands occupied by bog turtles are located in agricultural areas and are subject to grazing by livestock.

If any wetlands occur within or near the project area, their potential suitability as bog turtle habitat should be assessed, as described under "*Bog Turtle Habitat Survey*" (Phase 1 survey) of the enclosed *Guidelines for Bog Turtle Surveys*. This habitat survey could easily be conducted by a wetland biologist concurrent with a routine wetland identification and delineation. If any wetlands are identified as potential bog turtle habitat, efforts should be made to avoid any direct or indirect impacts to those wetlands. If adverse effects to these wetlands cannot be avoided, a more detailed and thorough survey will be necessary, as described under "*Bog Turtle Survey*" (Phase 2 survey) of the *Guidelines for Bog Turtle Surveys*. The Phase 2 survey should be conducted by a qualified biologist with bog turtle field survey experience (see enclosed list of qualified surveyors). Survey results should be submitted to the Fish and Wildlife Service for review and concurrence. If project activities might adversely affect bog turtles, additional consultation with the Service will be required, pursuant to the Endangered Species Act.

This response relates only to endangered and threatened species under our jurisdiction based on an office review of the proposed project's location. No field inspection of the project area has been conducted by this office. Consequently, this letter is not to be construed as addressing potential Service concerns under the Fish and Wildlife Coordination Act or other authorities. A compilation of certain federal status species in Pennsylvania is enclosed for your information.

Please contact Bonnie Dershem of my staff at 814-234-4090 if you have any questions or require further assistance regarding this matter.

Sincerely,

David Densmore
Supervisor

Enclosures

Commonwealth of Pennsylvania
Pennsylvania Fish and Boat Commission
Division of Environmental Services
450 Robinson Lane
Bellefonte, PA 16823
814-359-5117

January 23, 2003

IN REPLY REFER TO
SIR# 11056

Shaw Environmental & Infrastructure, Inc.
Jacob Dunnell, II
88C Elm Street
Hopkinton, MA 01748-1656

RE: Species Impact Review (SIR) – Rare, Candidate, Threatened and Endangered Species
PNDI Potential Conflict Number: N112777
NRC Source Material License Renewal, Cabot Performance Materials
Boyertown Township, Berks County, Pennsylvania

Dear Mr. Dunnell:

I have examined the map accompanying your recent correspondence which shows the location for the proposed above referenced project.

Presently, none of the fishes, amphibians or reptiles we list as endangered or threatened are known to occur at or in the immediate vicinity of this study area.

To allow faster processing of Species Impact Reviews (SIRs) in the future, we are requesting that the enclosed, revised "SIR Request Form" be completed and returned to this office together with other relevant project information. Please make copies of the enclosed form and use with all future project reviews. If you have received, and in fact are using the new form, disregard the above request. Please note that the Pennsylvania Fish & Boat Commission conducts Species Impact Reviews **only for reptiles, amphibians, fishes, and aquatic invertebrates**. Reviews concerning other natural resources must be submitted to other appropriate agencies. In any future correspondence with us regarding this specific project, please refer to the SIR number above.

Thank you in advance for your cooperation.

Sincerely,

Steven R. Kepler

Steven R. Kepler, Fisheries Biologist
Division of Environmental Services

SRK:dmc

Enclosure

PFBC-NESU-1 (5/14/01)

COMMONWEALTH OF PENNSYLVANIA

FISH AND BOAT COMMISSION

NONGAME AND ENDANGERED SPECIES UNIT (NESU)

SPECIES IMPACT REVIEW (SIR) REQUEST FORM

A. This form provides the site information necessary to perform a computer database search for species of special concern listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Pennsylvania Fish and Boat Code or the Wildlife Code.

B. Use only *one form* for each proposed project or location. Complete the information below and <u>mail</u> form to:

Nongame and Endangered Species Unit
PA Fish and Boat Commission
450 Robinson Lane
Bellefonte, PA 16823
Fax: (814) 359-5175

C. This form, a cover letter including a project narrative, and accompanying maps should be sent to the above address for environmental reviews that *only* concern ***reptiles, amphibians, fishes and aquatic invertebrates.*** Reviews for other natural resources must be submitted to other appropriate agencies.

D. The absence of recorded information from our databases and files does not necessarily imply actual conditions on site. Future field investigations could alter this determination. The information contained in our files is routinely updated. A review is valid for one year.

E. ***Please send us only one (1) copy of your request*** – either by fax or by mail – not both. Mail is preferred to improve legibility of maps. Facsimile submission will not improve our response turn-around time.

F. ***Allow 30 days for completion of the review from the date of PFBC-NESU receipt.*** Large projects and workload may extend this review timeframe.

G. ***In any future correspondence with us following your receipt of the SIR response, please refer to the assigned SIR number at the top left of our cover letter.***

H. **FORMS THAT ARE NOT COMPLETED IN FULL, WILL NOT BE REVIEWED.**

PLEASE PRINT OR TYPE: **If available, provide the potential conflict PNDI Search Number:**__________

PFBC-NESU response should be sent to:

Company/Agency:____________________ **Form Preparer:**____________________

Address:____

Phone (8:00 AM to 4:00 PM):____________________

Project Description:____

Indicate if the project is: **Transportation** ☐ **or** **Non-transportation** ☐ **(check one)**

Will the proposed project encroach directly or indirectly (e.g., runoff) upon wetlands or waterways? Circle one for each:

<u>Wetlands</u>: **Yes** **No** **Unknown** **<u>Waterways</u>:** **Yes** **No** **Unknown**

County:____________________ **Township/Municipality:**____________________

Name of the United States Geological Survey (U.S.G.S.) 7.5 Minute Quadrangle Map where project is located:

Project size (in acres):__________

Attach an 8.5" by 11" photocopy (DO NOT REDUCE) of the section of the U.S.G.S. Quadrangle Map which identifies the project location. On this map, indicate the location of the project center (if linear, depict both ends) and outline the approximate boundaries of the project area.

Specify latitude/longitude of the project center. **Latitude:** _____° / _____' / _____" N

Indicate latitude/longitude in degrees-minutes-seconds format only. **Longitude:** _____° / _____' / _____" W

Three steps are needed to convert from decimal degrees to degrees-minutes-seconds: (1) Degrees will be the whole number. (2) To get minutes, multiply the decimal degree portion by 60. (3) Multiply the decimal minute portion by 60 to get seconds.
Example: (Latitude) 40.93748 = 40°; 0.93748 x 60 = 56.2488' = 56'; 0.2488 x 60 = 14.928 = 15" = 40°56'15" N
(Longitude) 75.94740 = 75°; 0.94740 x 60 = 56.844' = 56'; 0.844 x 60 = 50.64 = 51" = 75°56'51" W

FOR PFBC-NESU USE ONLY

SIR#	Quad Name	Data Source	Search Result-Potential Species Conflict	Action

January 17, 2003

Fax 717-772-0271
717-772-0258

Bureau of Forestry

Jacob Dunnell
The Shaw Group, Inc.
88C Elm Street
Hopkinton, MA 01748-1656

Re: Pennsylvania Natural Diversity Inventory Review for the Proposed USNRC Source Material License Renewal, Boyertown Township **PER NO: 13950**

Dear Mr. Dunnell:

In response to your request December 23, 2003 to review the above mentioned project, we have reviewed the area using the Pennsylvania Natural Diversity Inventory (PNDI) information system. PNDI records indicate that no occurrences of species of special concern are known to exist within the project area, therefore we do not anticipate any impact on endangered, threatened, or rare species at this location. PNDI attempts to be a complete information resource on species of special concern within the Commonwealth. However, it may not contain all location information for species within the jurisdiction of other agencies. Please contact the Fish and Boat Commission and US Fish and Wildlife Service for information on species within their purview.

PNDI is a site specific information system that describes significant natural resources of Pennsylvania. This system includes data descriptive of plant and animal species of special concern, exemplary natural communities and unique geological features. PNDI is a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy and the Western Pennsylvania Conservancy. This response represents the most up-to-date summary of the PNDI data files and is **good for one year**. An absence of recorded information does not necessarily imply actual conditions on-site. A field survey of any site may reveal previously unreported populations.

Feel free to phone our office if you have questions concerning this response or the PNDI system, and please refer to the P.E.R. Reference Number at the top of the letter in future correspondence concerning this project.

Sincerely,

Justin P. Newell
Environmental Review Specialist

MONTGOMERY COUNTY
CONSERVATION DISTRICT

143 Level Road • Collegeville, PA 19426-3313 • 610-489-4506 • Fax: 610-489-9795
www.montgomeryconservation.org

January 3, 2003

Shaw Environmental & Infrastructure, Inc.
ATTN: Jacob Dunnell
88C Elm Street
Hopkinton, MA 01740

Re: U.S. Nuclear Regulatory Commission (NRC) Source Material License Renewal
Boyertown Township, Montgomery County

Dear Applicant:

As required for a NPDES General Permit, we have researched the Pennsylvania Natural Diversity Inventory for any species of special concern listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the PA Fish & Boat or the Game Code.

Enclosed are the results of the search. This PNDI search request has been submitted **without** a plan. Please **resubmit** the PNDI results and information when submitting the finalized plan.

Sincerely,

Jeanette Jansen
Montgomery County Conversation District

3930-PM-WM0041 Rev. 11/2001

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
BUREAU OF WATERWAYS ENGINEERING

FOR OFFICIAL USE ONLY

PNDI Screening
Reviewer Jansen
Date 1/3/02
Phone No. 6104894506

SUPPLEMENT NO. 1
PENNSYLVANIA NATURAL DIVERSITY INVENTORY SEARCH FORM

This form provides site information necessary to perform a computer screening for species of special concern listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Pennsylvania Fish and Boat Code or the PA Game and Wildlife Code. Records regarding species of special concern are maintained by PA DCNR in a computer data base called the "Pennsylvania Natural Diversity Inventory" (PNDI). Results from this search are not intended to be a conclusive compilation of all potential special concern resources located within a proposed project site. On-site biological surveys may be recommended to provide a definitive statement on the presence or absence, or degree of natural integrity of any project site. Results of this PNDI search are valid for one year.

Please complete the information below, attach an 8½" x 11" photocopy (DO NOT REDUCE) of the portion of the U.S.G.S. Quadrangle Map that identifies the project location and outlines the approximate boundaries of the project and mail to the appropriate DEP regional office or delegated County Conservation District prior to completing a Chapter 105 environmental assessment or any other DEP permit application. (SEE REVERSE SIDE FOR LIST OF OFFICES AND ADDRESSES).

NAME: Jacob Dunnell II

ADDRESS: Shaw Environmental
88C Elm Street
Hopkinton, MA 01748

PHONE: (508) 497 6173

COUNTY: Berks / Montgomery

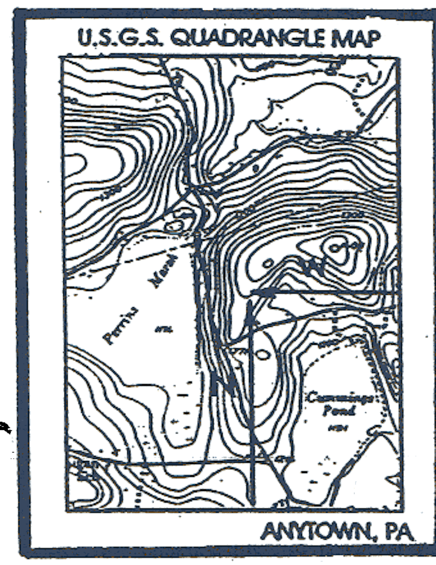
TWP./MUNICIPALITY: Boyertown

U.S.G.S. 7½ Minute Quadrangle
Sassamansville

M.C.C.D.
DEC 2 6 2002
RECEIVED

PROJECT DESCRIPTION AND SIZE (Briefly describe entire area relevant to your project, including acreage.)

- Existing Industrial Facility w/ paved parking, grass areas and small Forested Areas
- Approximately 165 acres



North (Up) 16.6 inches

West (to the left) 15 inches

INDICATE PROJECT LOCATION TO THE NEAREST ONE TENTH INCH MEASURING FROM THE EDGE OF THE MAP IMAGE FROM THE LOWER RIGHT CORNER.

FOR OFFICIAL USE ONLY

SCREENING RESULTS - Follow the directions of the checked block.

☒ No potential conflicts were encountered during the PNDI inquiry. Include this form and the PNDI receipt with your Chapter 105 environmental assessment or other DEP permit application submissions.

☐ Potential conflicts must be resolved by contacting the natural resource agencies listed on the PNDI receipt. Please provide a copy of this form and the PNDI receipt along with a brief description of your project to the listed agency for consultation and recommendations. Include this form, the printed PNDI search results and the natural resource agency's written recommendation with your Chapter 105 environmental assessment or other DEP permit application submissions.

PNDI Internet Database Search Results

PNDI Search Number: N111783
Search Results For Montgomery.County@dep.state.pa.us
Search Performed By: Richard Kadwill On 1/3/03 9:25:25 AM
Agency/Organization: Montgomery County Conservation District
Phone Number: 610-489-4506
Search Parameters: Quad - 407535; North Offset - 16; West Offset - 17; Acres - 250
Project location center (Latitude): 40.33784
Project location center (Longitude): 75.62189
Project Type: DEP Permits/Erosion/Sediment Control

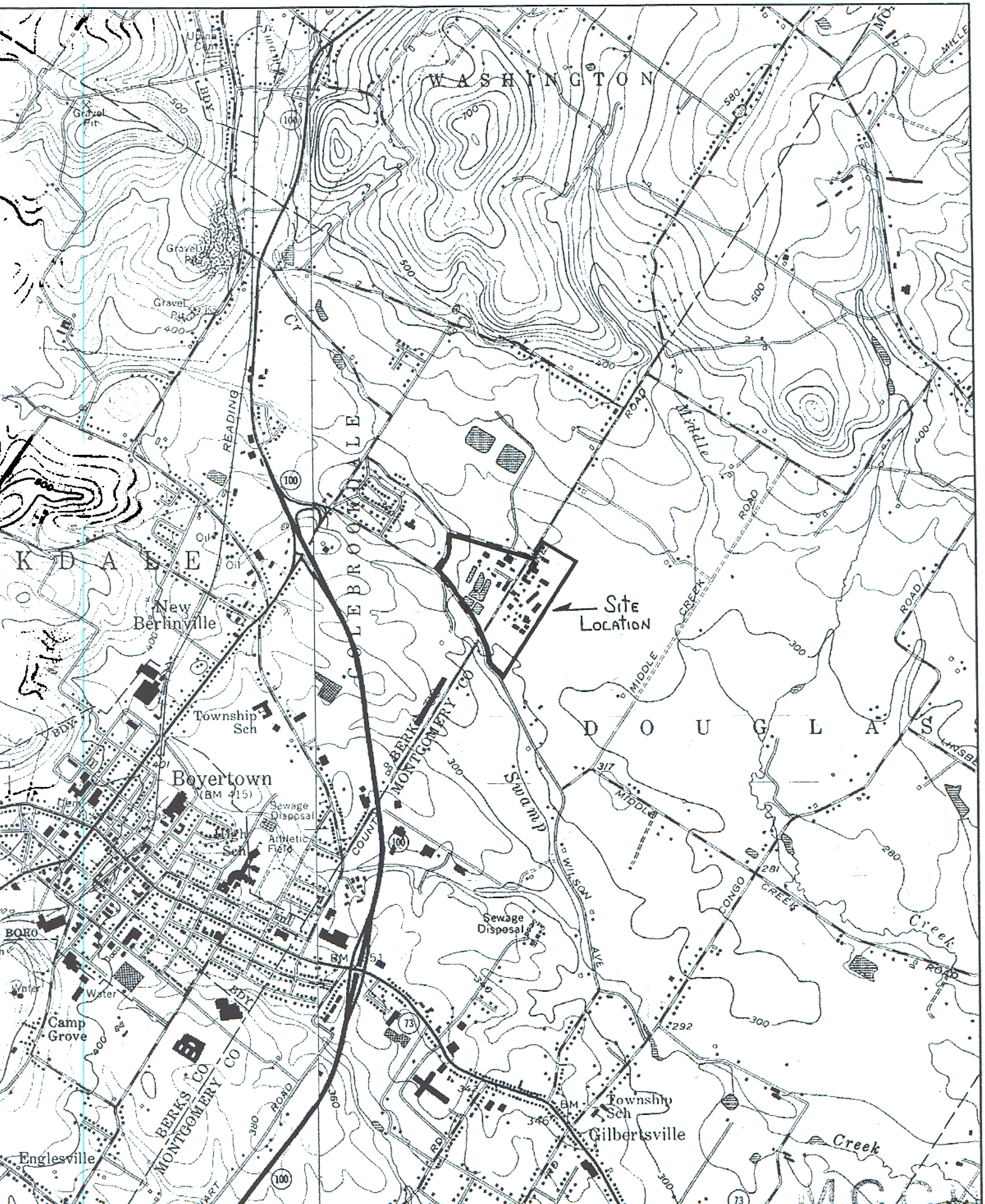
Print this page using your Internet browser's print function and keep it as a record of your search.

No conflicts with ecological resources of special concern are known to exist within the specified search area.

PNDI is a site specific information system, which describes significant natural resources of Pennsylvania. This system includes data descriptive of plant and animal species of special concern, exemplary natural communities and unique geological features. PNDI is a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy and the Western Pennsylvania Conservancy. This response represents the most up-to-date summary of the PNDI data files and is valid for 1 year. An absence of recorded information does not necessarily imply actual conditions on-site. A field site survey may reveal previously unreported populations.

Legal authority for Pennsylvania's biological resources resides with three administrative agencies. The handout entitled Pennsylvania Biological Resource Management Agencies, outlines which species groups are managed by these agencies. Feel free to contact our office if you have questions concerning this response or the PNDI system, and please refer to the PNDI Search Number at the top of this page in future correspondence concerning this project.

New Search using inches on a Quad
New Search using Latitude and Longitude | PNDI Search Home
PNDI Search Welcome



Name: SASSAMANSVILLE
Date: 12/24/2002
Scale: 1 inch equals 2000 feet

Location: 040° 20' 36.0" N 075° 36' 55.8" W

DEC 2 6 2002
RECEIVED

3930-PM-WM0041 Rev. 11/2001

RECEIVED
DEC 2 6 2002
Berks County
Conservation
District

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
BUREAU OF WATERWAYS ENGINEERING

FOR OFFICIAL USE ONLY
PNDI Screening
Reviewer B. Ruhl
Date 1/2/03
Phone No. 610-372-4657

SUPPLEMENT NO. 1
PENNSYLVANIA NATURAL DIVERSITY INVENTORY SEARCH FORM

This form provides site information necessary to perform a computer screening for species of special concern listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, the Pennsylvania Fish and Boat Code or the PA Game and Wildlife Code. Records regarding species of special concern are maintained by PA DCNR in a computer data base called the "Pennsylvania Natural Diversity Inventory" (PNDI). Results from this search are not intended to be a conclusive compilation of all potential special concern resources located within a proposed project site. On-site biological surveys may be recommended to provide a definitive statement on the presence or absence, or degree of natural integrity of any project site. Results of this PNDI search are valid for one year.

Please complete the information below, attach an 8½" x 11" photocopy (DO NOT REDUCE) of the portion of the U.S.G.S. Quadrangle Map that identifies the project location and outlines the approximate boundaries of the project and mail to the appropriate DEP regional office or delegated County Conservation District prior to completing a Chapter 105 environmental assessment or any other DEP permit application. (SEE REVERSE SIDE FOR LIST OF OFFICES AND ADDRESSES).

NAME: Jacob Donnell II

ADDRESS: Shaw Environmental
88C Elm Street
Hopkinton, MA 01748

PHONE: (508) 497 6173

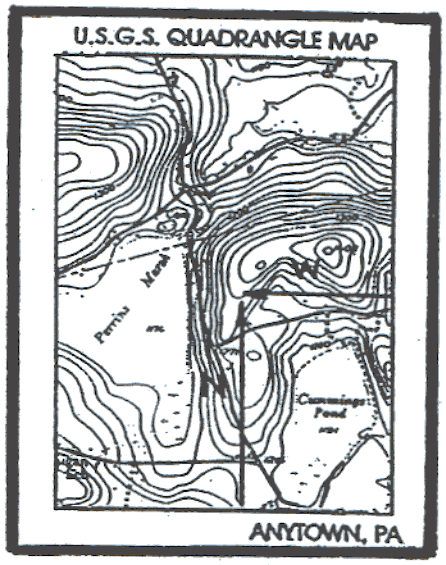
COUNTY: Berks / Montgomery

TWP./MUNICIPALITY: Boyertown

U.S.G.S. 7½ Minute Quadrangle
Sassamansville

PROJECT DESCRIPTION AND SIZE (Briefly describe entire area relevant to your project, including acreage.)

- Existing Industrial Facility w/ paved parking, grass areas and small forested areas
- Approximately 165 acres



North (Up) 16.6 inches

West (to the left) 15 inches

INDICATE PROJECT LOCATION TO THE NEAREST ONE TENTH INCH MEASURING FROM THE EDGE OF THE MAP IMAGE FROM THE LOWER RIGHT CORNER.

FOR OFFICIAL USE ONLY

SCREENING RESULTS - Follow the directions of the checked block

☒ No potential conflicts were encountered during the PNDI inquiry. Include this form and the PNDI receipt with your Chapter 105 environmental assessment or other DEP permit application submissions.

☐ Potential conflicts must be resolved by contacting the natural resource agencies listed on the PNDI receipt. Please provide a copy of this form and the PNDI receipt along with a brief description of your project to the listed agency for consultation and recommendations. Include this form, the printed PNDI search results and the natural resource agency's written recommendation with your Chapter 105 environmental assessment or other DEP permit application submissions.

PNDI Internet Database Search Results

PNDI Search Number: N111764
Search Results For BRuhl@bccd.org
Search Performed By: Bryon Ruhl On 1/2/03 2:35:12 PM
Agency/Organization: Berks County Conservation District
Phone Number: 610-372-4657
Search Parameters: Quad - 407536; North Offset - 16.6; West Offset - 15; Acres - 200
Project location center (Latitude): 40.34113
Project location center (Longitude): 75.73255
Project Type: Other\NRC Source Material License Renewal

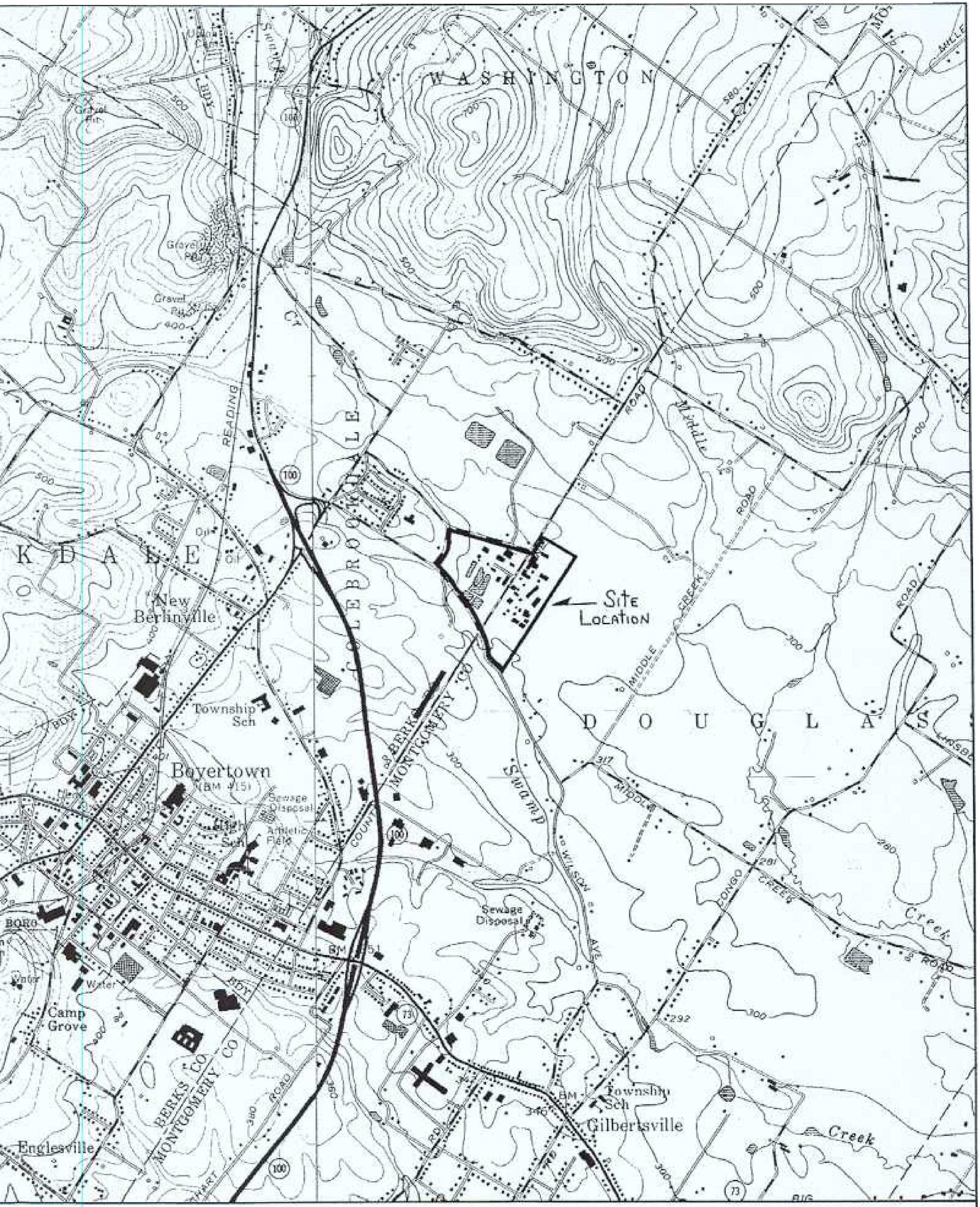
Print this page using your Internet browser's print function and keep it as a record of your search.

No conflicts with ecological resources of special concern are known to exist within the specified search area.

PNDI is a site specific information system, which describes significant natural resources of Pennsylvania. This system includes data descriptive of plant and animal species of special concern, exemplary natural communities and unique geological features. PNDI is a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy and the Western Pennsylvania Conservancy. This response represents the most up-to-date summary of the PNDI data files and is valid for 1 year. An absence of recorded information does not necessarily imply actual conditions on-site. A field site survey may reveal previously unreported populations.

Legal authority for Pennsylvania's biological resources resides with three administrative agencies. The handout entitled Pennsylvania Biological Resource Management Agencies, outlines which species groups are managed by these agencies. Feel free to contact our office if you have questions concerning this response or the PNDI system, and please refer to the PNDI Search Number at the top of this page in future correspondence concerning this project.

New Search using inches on a Quad
New Search using Latitude and Longitude | PNDI Search Home
PNDI Search Welcome



Name: SASSAMANSVILLE
Date: 12/24/2002
Scale: 1 inch equals 2000 feet

Location: 040° 20' 36.0" N 075° 36' 55.8" W

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX D

Forage Crop Letters

September 27, 2002

CABOT

Performance Materials

U. S. Nuclear Regulatory Commission
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards

Docket No. 40-6940
License No. SMB-920

RE: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Dear Ms. Brummett:

Cabot Performance Materials (CPM) received by letter dated June 25, 2002 a request for additional information for the renewal of CPM's Source Material License SMB-920. In section 3 "Environmental Monitoring Program" of this letter the NRC requested updated information on Forage Crop Sampling. This sampling requirement was removed as a license requirement by the Commission in 1996. Specifically by letter dated August 29, 1996 the NRC notified the Regional Manager of PADEP Air Quality Program of its intent to remove this requirement based on the fact that:

> "neither the federal nor state government has determined that fluoride in forage crops is a sufficiently important health issue to establish health-based regulations or other standards limiting its concentration in cattle feed."

Although Forage Crop Sampling is not performed at the facility CPM is required to perform perimeter monitoring for ambient air fluorides per Pennsylvania Code Title 25 Section 131.3. The limit set forth in this requirement is five micrograms per cubic meter. The attached chart is a summary of this data for the time period January, 1999 through June, 2002. During this period CPM has been operating within the regulatory limits and intends to continually improve processes and technologies to maintain this trend.

Given this information it is CPM's intent not to include Forage Crop Sampling in the response to the RAI. I am available to discuss this further at your convenience.

Best Regards,
Cabot Performance Materials

Timothy M. Knapp
Radiation Safety Officer

encl.

cc: Brad Okoniewski, Cabot
R. Schoenfelder, Weston

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

August 29, 1996

Ms. Francine Carlini, Manager
Air Quality Program
Pennsylvania Department of Environmental Protection
Southeast Regional Office
Lee Park Suite 6010
55 North Lane
Conshohocken, PA 19428

SUBJECT: FLUORIDE IN VEGETATION NEAR CABOT PERFORMANCE MATERIALS, BOYERTOWN, PENNSYLVANIA (TAC NO. L10014)

Dear Ms. Carlini:

This letter is to inform the Department of Envionmental Protection of the U. S. Nuclear Regulatory Commission's evaluation and conclusions concerning the renewal of an NRC source material license for Cabot Performance Materials (CPM) in Boyertown, Pennsylvania. As discussed by telephone with Mr. Jim Rebarchak of your staff, NRC has prepared an Environmental Assessment (EA) of the license renewal, in accordance with NRC's regulations in 10 CFR Part 51 implementing Section 102(2) of the National Environmental Policy Act, and plans to publish a finding of no significant impact (FONSI) for the license renewal.

During the environmental review in preparation for the EA and FONSI, it was noted that CPM monitors fluoride content in forage crops adjacent to the Boyertown facility, and that the fluoride content in the grass and corn crops has exceeded a reporting action level of 40 parts per million established in their current license. This action level was selected based upon research performed in the 1960s that reported observable effects in the bones and teeth of dairy cattle from forage having 40 ppm or higher seasonal average of fluoride. Data from CPM's forage monitoring program indicates that fluoride concentrations have exceeded this reporting action level in grass in 1988, 1991, 1992, and 1993, and in corn in all years 1988 through 1993. Because exceedences of the reporting action level are, by license condition, required to be reported by CPM to PADEP and to the NRC, we understand that these data have been reported to PADEP periodically.

As stated above, NRC plans to renew CPM's license to possess and use source material and to issue a FONSI for this action. The basis for this finding with respect to fluoride is that neither the federal nor state government has determined that fluoride in forage crops is a sufficiently important health issue to establish health-based regulations or other standards limiting its concentration in cattle feed. Accordingly, our intent is to delete the requirement in CPM's license to monitor for fluoride in forage crops.

If you need further information concerning this matter, please call Mary Adams of my staff at 301-415-8111.

Sincerely,

Robert C. Pierson, Chief
Licensing Branch
Division of Fuel Cycle Safety
and Safeguards, NMSS

Docket 40-6940
License SMB-920

cc: Mr. Kevin L. Holsopple
Radiation Safety Officer
Cabot Corporation
County Line Road
Boyertown, Pennsylvania 19512-1608

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX E

Technical Basis for the Location and Screen Interval of Groundwater Monitor Wells at Cabot Performance Materials Corporation Boyertown, Pennsylvania Plant

Technical Basis for the Location and Screen Interval of Groundwater Monitor Wells at Cabot Performance Materials Corporation Boyertown, Pennsylvania Plant

Prepared by:

Weston Solutions, Inc.
Albuquerque, New Mexico
and
Environmental Standards, Inc.
Valley Forge, Pennsylvania

Approved by:

____________________________________ ________________________
Robert Schoenfelder Date
Project Manager

Prepared for
Cabot Performance Materials Corporation
County Line Road
Boyertown, PA 19512

August 9, 2002

1. INTRODUCTION

This evaluation of the groundwater monitoring wells at the Cabot Performance Materials Corporation (CPM), Boyertown, Pennsylvania, Plant is provided in response to the Nuclear Regulatory Commission's (NRC) Request for Additional Information concerning renewal of NRC Source Material License SM-920 for the plant. In particular, this evaluation responds to item 6 of the Request for Additional Information, which is entitled "Groundwater Monitoring Well Locations."

The adequacy of the location and screen intervals of the groundwater monitoring well network can be justified when placed in the context of the local groundwater system. This evaluation includes a brief discussion of groundwater flow near the bulk storage bins (based on a conceptual groundwater flow model refined during 2000) and a suggested monitoring well network for future compliance monitoring.

2. GROUNDWATER CONCEPTUAL MODEL

Groundwater flow near the bulk storage bins is influenced by an igneous intrusive diabase system north of the plant property that is resistant to weathering and that is responsible for creating the upland hills northeast of Township Line Road, as shown in Figure 1. Soils overlying the diabase are of very limited thickness, and the diabase has few, if any, significant fractures for the vertical transmission of groundwater. In fact, water wells drilled in Triassic diabase intrusive systems in southeast Pennsylvania produce little, if any, water. Groundwater produced in the diabase is typically from very few sparsely distributed fractures.

The few fractures and limited soil cover of the diabase result in a relatively significant shallow/surface water run-off system during precipitation events. This precipitation develops into a naturally occurring near-surface stormwater run-off system that is interpreted to result in the rapid and forceful recharge (infiltration) of water at the nearest "more permeable" geologic formation. In the northern plant area near the bulk storage bins, this recharge area is in the immediate vicinity of Township Line Road at the Brunswick Formation-Triassic diabase contact. This rapid infiltration at the Brunswick Formation contact is interpreted to create a significant vertical pressure head and an equally significant pressure head in the lateral downgradient direction (south-southwest).

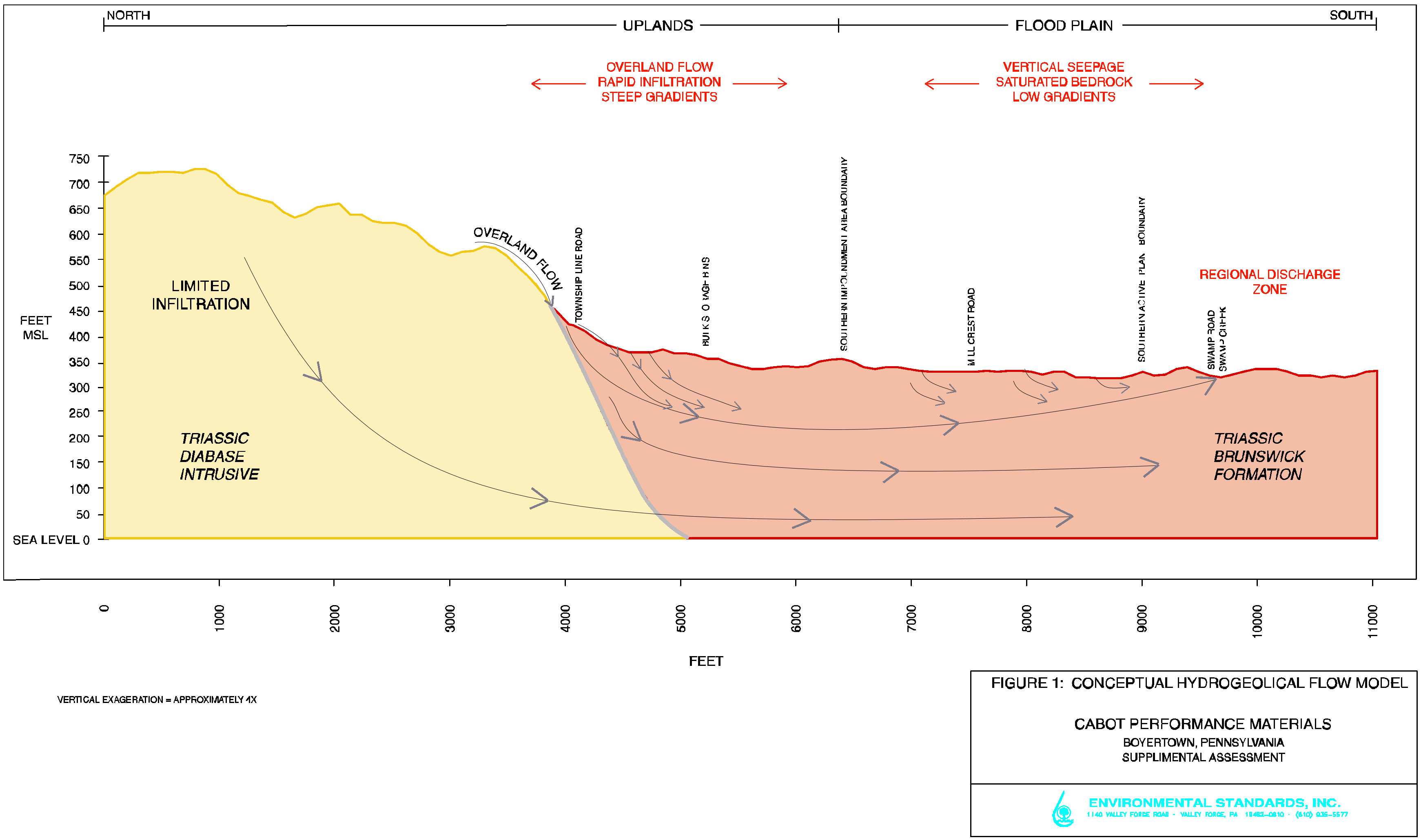


Figure 1: Conceptual Hydrogeological Flow Model

Once surface water run-off from the diabase uplands penetrates the Brunswick Formation underlying the bulk storage bins, fractures influence and control groundwater flow. As shown in Figure 1, recharge from the diabase uplands underflows the bulk storage bins, ultimately continuing to move in a south-southwesterly direction to West Swamp Creek (the regional groundwater discharge boundary to the west of the plant).

3. PROPOSED GROUNDWATER MONITORING WELL NETWORK

Using the recently refined conceptual groundwater flow model, CPM proposes to modify the existing groundwater monitoring well compliance network, as detailed in Table 1. The proposed and existing monitoring well network is shown in Figure 2. CPM proposes to monitor groundwater at seven locations; six existing groundwater monitoring wells (MMW-1, MMW-2, MMW-3, MMW-4, MMW-5, and Well 1A) will no longer be used for monitoring purposes. The MMW wells are installed immediately adjacent to the bulk storage bins, and may not be optimally placed to detect potential material storage effects on groundwater quality in the vicinity of the bulk storage bins (based on the revised conceptual model). The wells may be too close to account for dispersive effects and fracture flow characteristics. Similarly, Well 1A may be positioned hydraulically cross-gradient of the primary groundwater flow path for optimum use.

The six wells cited above will be replaced by four existing groundwater monitoring wells (MW 95-01, MW 95-03, MW 95-04, and MW 97-06) that were originally installed as part of a voluntary Pennsylvania Residual Waste program compliance monitoring program (administered by the Pennsylvania Department of Environmental Protection [PA DEP]). Each of the four wells is fitted with dedicated sampling systems that are identical to those found in the currently used wells (e.g., "Well Wizards").

Groundwater monitoring well MW 95-01 (which has not been used for compliance monitoring in the past) occupies the most upgradient position of any monitoring well at the plant. This well intercepts a regional water-producing fracture from 40 to 60 feet below grade. Data from this well will be used to characterize "background water quality" with respect to this monitoring program.

Table 1. Groundwater Monitoring Well Construction Specifications for Cabot Performance Materials Boyertown, Pennsylvania Plant

Well Identification	Top of Casing (1)	Total Depth (2)	Surface Casing (2)	Screened/ Open Interval (2)	Top Sand Pack (2)	Bentonite Seal Interval (2)	Top Bedrock (2)	Observed Water Producing Zones (2)	Current Monitoring Well Purpose or Regulatory Program	Proposed Monitoring Well Purpose or Regulatory Program
MW 95-01	360.07	60	7	60-30	26.5	26.5-24	2	26, 40-60	PA DEP Residual Waste Program	NRC License Monitoring
MW 95-03	333.01	38	13	28-38	26	26-24	7	24, 37	PA DEP Residual Waste Program	NRC License Monitoring
MW 95-04	329.99	60	9	60-40	37	37-34	4	22, 45	PA DEP Residual Waste Program	NRC License Monitoring
MW 97-06	327.21	94	11	94-74	69	69-63	6	ND	PA DEP Residual Waste Program	NRC License Monitoring
MMW-1	354.43	101	20	73.3-43.3	19.7	19.7-16.5	3	26, 74, 85	NRC Permit Monitoring	None
MMW-2	348.45	101	20	45-75	23	18-23	3	26, 56, 77	NRC Permit Monitoring	None
MMW-3	346.17 (3)	101	20	44.3-74.3	21.7	16.9-21.7	3	34	NRC Permit Monitoring	None
MMW-4	343.50 (3)	101	20	45-75	25.4	18.8-25.4	3	19, 51, 57, 96	NRC Permit Monitoring	None
MMW-5	342.67 (3)	101	20	40-70	20.6	13.6-20.6	2	35, 77	NRC Permit Monitoring	None
Well 1A	ND	405	21	21-405	NA	NA	ND	ND	NRC Permit Monitoring	None
Well 2	ND	528	16	16-528	NA	NA	ND	80, 340, 410, 483, 515	NRC Permit Monitoring	NRC License Monitoring
MW-3	ND	15.6	None	ND	ND	ND	ND	ND	NRC Permit Monitoring	NRC License Monitoring
MW-4	ND	14.5	None	ND	ND	ND	ND	ND	NRC Permit Monitoring	NRC License Monitoring

Notes:
(1) ft MSL - indicates the elevation is measured relative to mean sea level.
(2) All depths referenced to land surface and expressed in feet below ground surface (ft bgs).
(3) The top of casing elevation for this well was measured in 1985 and has not been resurveyed.
NA - Not Applicable; well is completed as an open borehole well and has no sand pack or bentonite seal.
ND - Indicates no data were available on a given well specification.

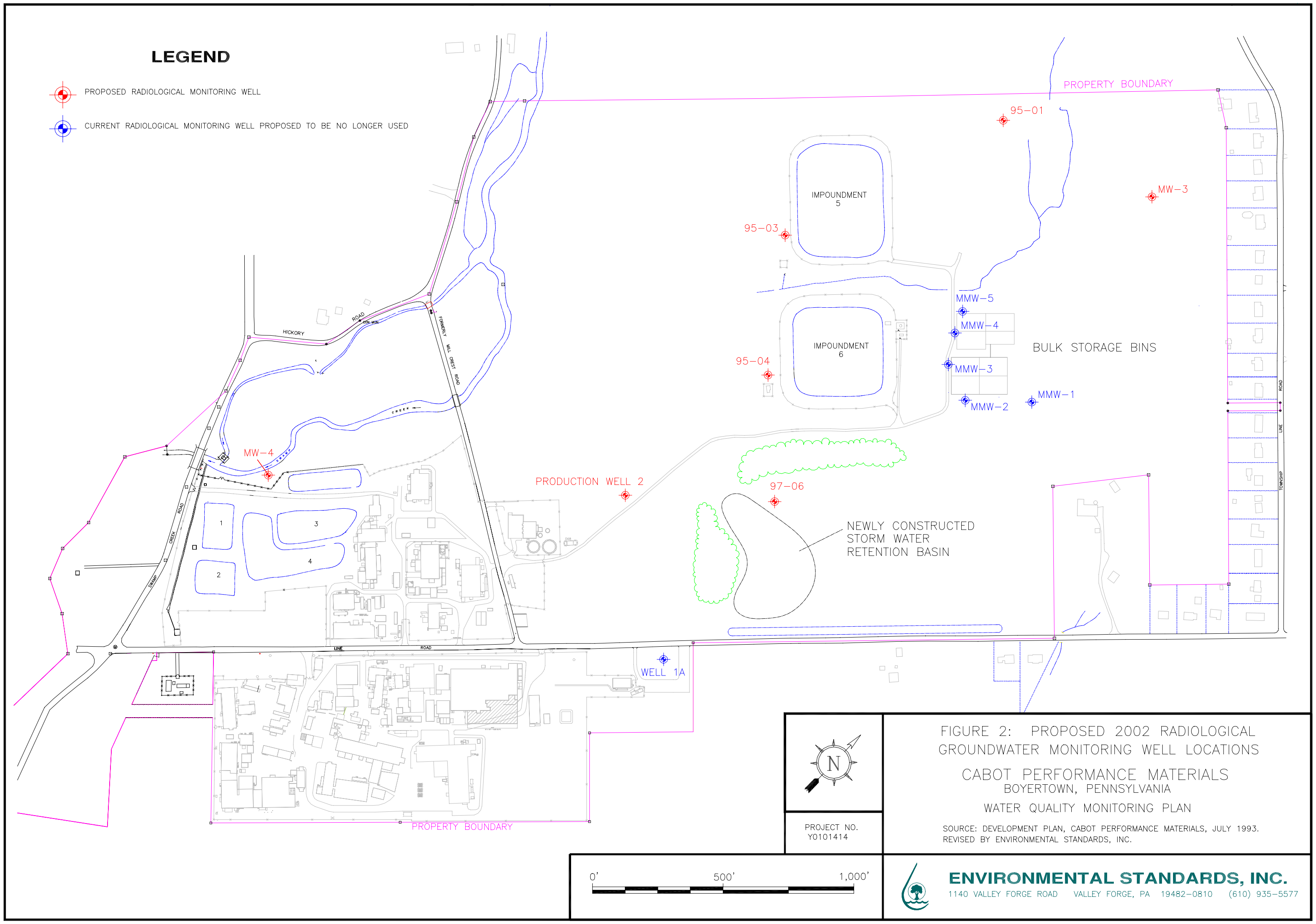


Figure 2: Proposed 2002 Radiological Groundwater Monitoring Well Locations

Groundwater monitoring wells MW 95-03, MW 95-04, and MW 97-06 intercept major groundwater producing fractures in the Brunswick Formation and lie immediately downgradient of the bulk storage bins. These wells, which have not been used for NRC compliance monitoring in the past, are properly positioned to intercept groundwater flowing beneath the bulk storage bins and to evaluate the potential for material storage to have affected groundwater quality.

MW 95-03 lies slightly north of the primary flow path of the bulk storage bins and just north of an interpreted east-west fracture (mimicked to some degree by an ephemeral stream between Impoundments 5 and 6) that controls groundwater flow slightly north of the bulk storage bins. During installation, water-producing fractures were identified in this well at 24 and 37 feet below grade. Samples from this well will provide information regarding the possible movement of bulk storage bin material north of the fracture. While it is currently believed that this fracture acts as an hydraulic barrier to meaningful flow to the north, it will be monitored to verify this belief.

MW 95-04, positioned immediately downgradient of the bulk storage bins, intercepts water-producing fractures at 22 and 45 feet below grade. This well is optimally positioned both vertically and horizontally to evaluate the potential for movement of bulk storage bin material in groundwater downgradient of the bins.

MW 97-06 is positioned downgradient of the bulk storage bins, and no specific water-producing fractures were identified during installation. This well is effectively positioned both vertically and horizontally to evaluate the potential for movement of bulk storage bin material in groundwater downgradient of the bins in a southerly direction. This well was included in the monitoring system because groundwater flow directions have varied slightly over time (10 years of data suggest the horizontal component of flow may be directed more towards MW 97-06 rather than MW 95-04). This well will be used to replace Well 1A, which is not as well positioned for groundwater monitoring.

Certain groundwater wells already in use are proposed for continued monitoring. These wells include Well 2 (a deep production well), monitoring well MW-3, and monitoring well MW-4.

Well 2 is proposed for monitoring because it is the sole plant production well currently in use (fire system water supply) and because of its construction characteristics (an open hole interval of more than 380 feet). This well represents the nearest point of use for groundwater downgradient of the bulk storage bins. In addition, the extended length of the open interval provides an assessment of “overall” groundwater condition in the aquifer downgradient of the bulk storage bin area.

Groundwater monitoring well MW-3 will continue to be used because it is the closest well to any residential properties (albeit the well is hydraulically upgradient of the bulk storage bins). Data from this shallow well will be used as “sentinel” (early warning point) data for the upgradient residents of Township Line Road in the unlikely event that bulk storage bin activities have affected upgradient water quality.

Groundwater monitoring well MW-4 will continue to be used for compliance monitoring because the well reflects downgradient water quality immediately adjacent to groundwater discharge to West Swamp Creek. Data from this shallow well will be used to evaluate water quality prior to discharge into West Swamp Creek.

Upon approval by the NRC of this proposed groundwater monitoring network, Wells 1A, MMW-1, MMW-2, MMW-3, MMW-4, and MMW-5 will be properly abandoned pursuant to PA DEP recommendations and guidelines.

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX F

Hydrological Figures

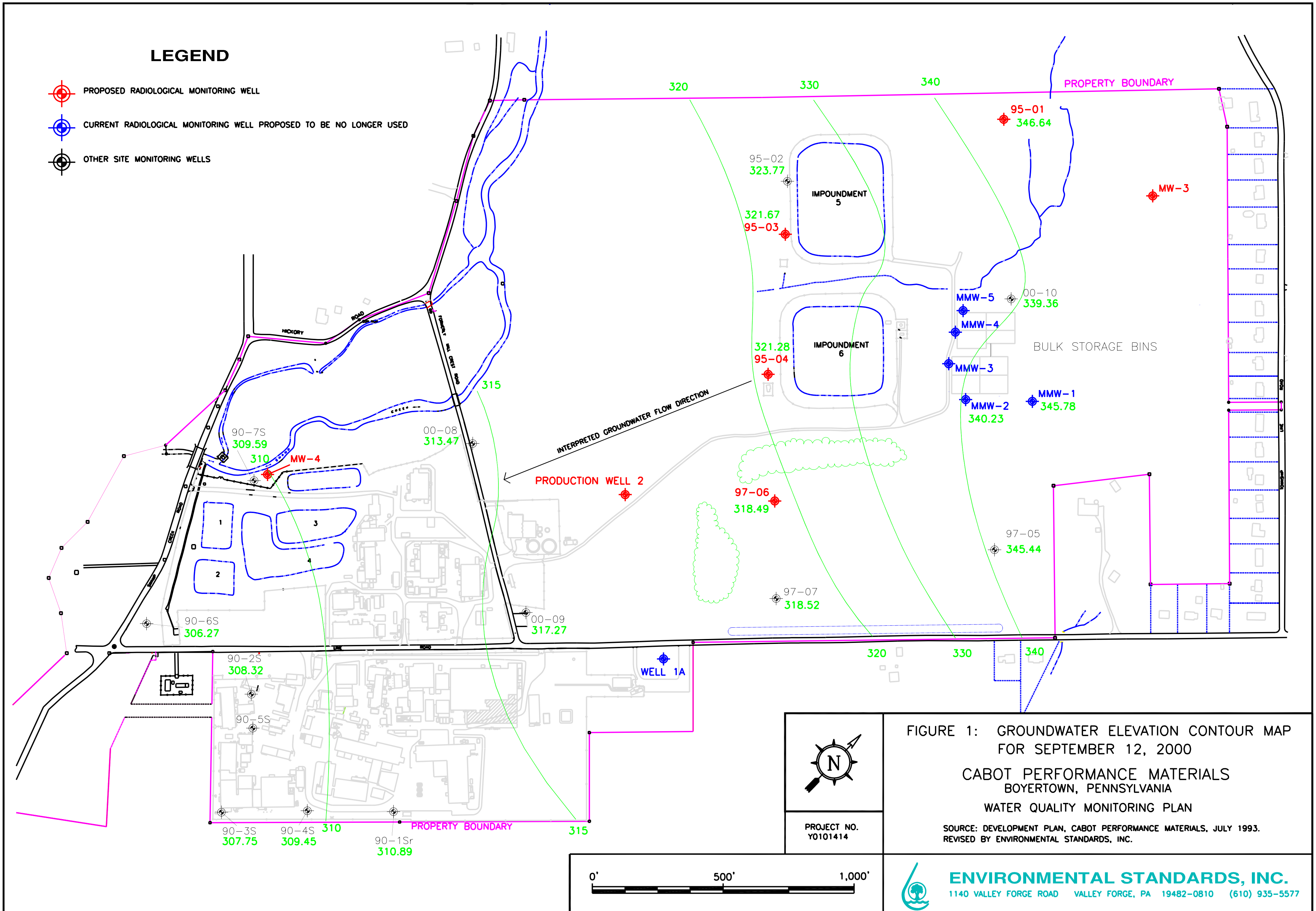


FIGURE 1: GROUNDWATER ELEVATION CONTOUR MAP FOR SEPTEMBER 12, 2000

CABOT PERFORMANCE MATERIALS
BOYERTOWN, PENNSYLVANIA

WATER QUALITY MONITORING PLAN

SOURCE: DEVELOPMENT PLAN, CABOT PERFORMANCE MATERIALS, JULY 1993.
REVISED BY ENVIRONMENTAL STANDARDS, INC.

PROJECT NO.
Y0101414

ENVIRONMENTAL STANDARDS, INC.
1140 VALLEY FORGE ROAD VALLEY FORGE, PA 19482-0810 (610) 935-5577

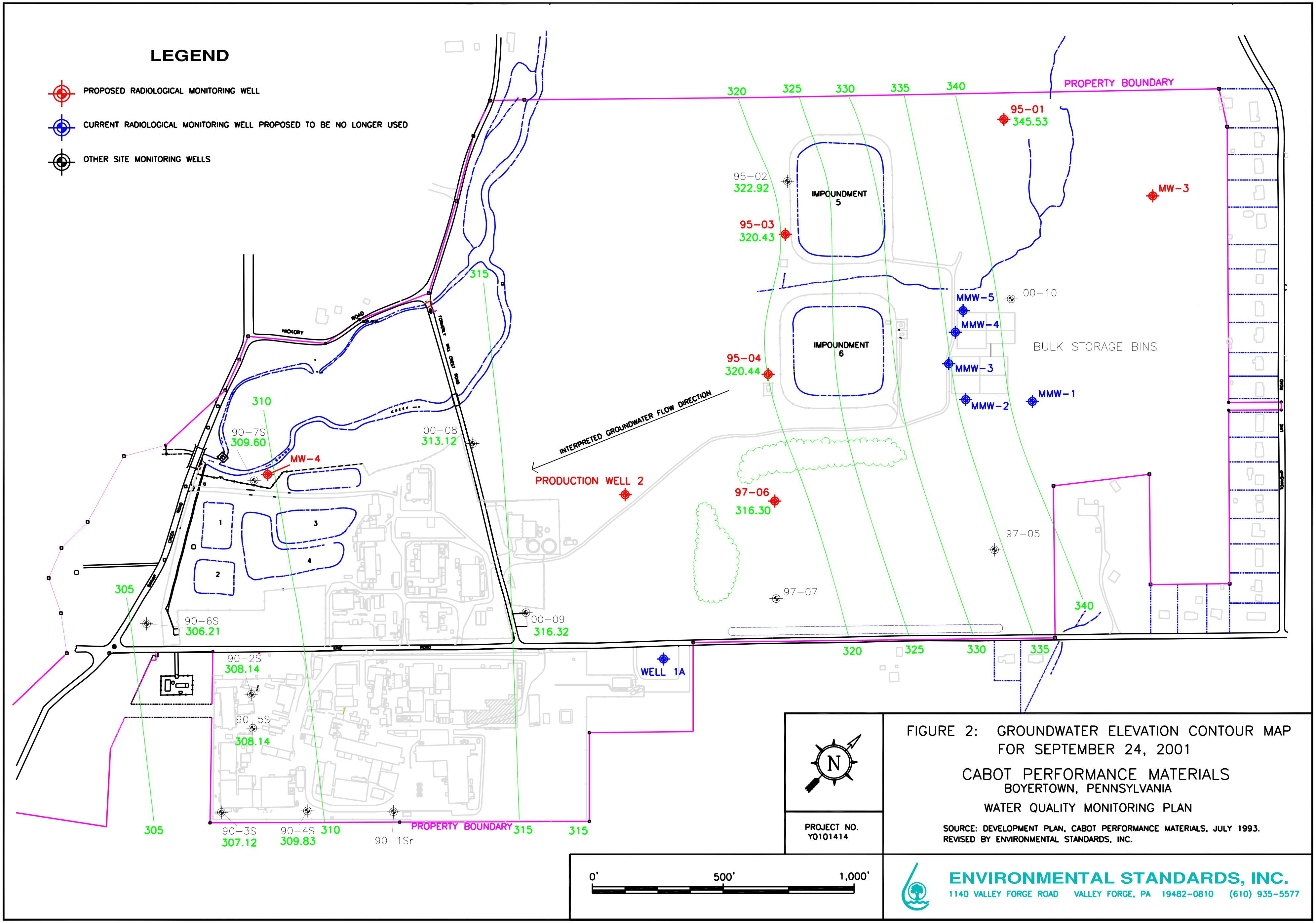


FIGURE 2: GROUNDWATER ELEVATION CONTOUR MAP FOR SEPTEMBER 24, 2001

CABOT PERFORMANCE MATERIALS
BOYERTOWN, PENNSYLVANIA
WATER QUALITY MONITORING PLAN

SOURCE: DEVELOPMENT PLAN, CABOT PERFORMANCE MATERIALS, JULY 1993.
REVISED BY ENVIRONMENTAL STANDARDS, INC.

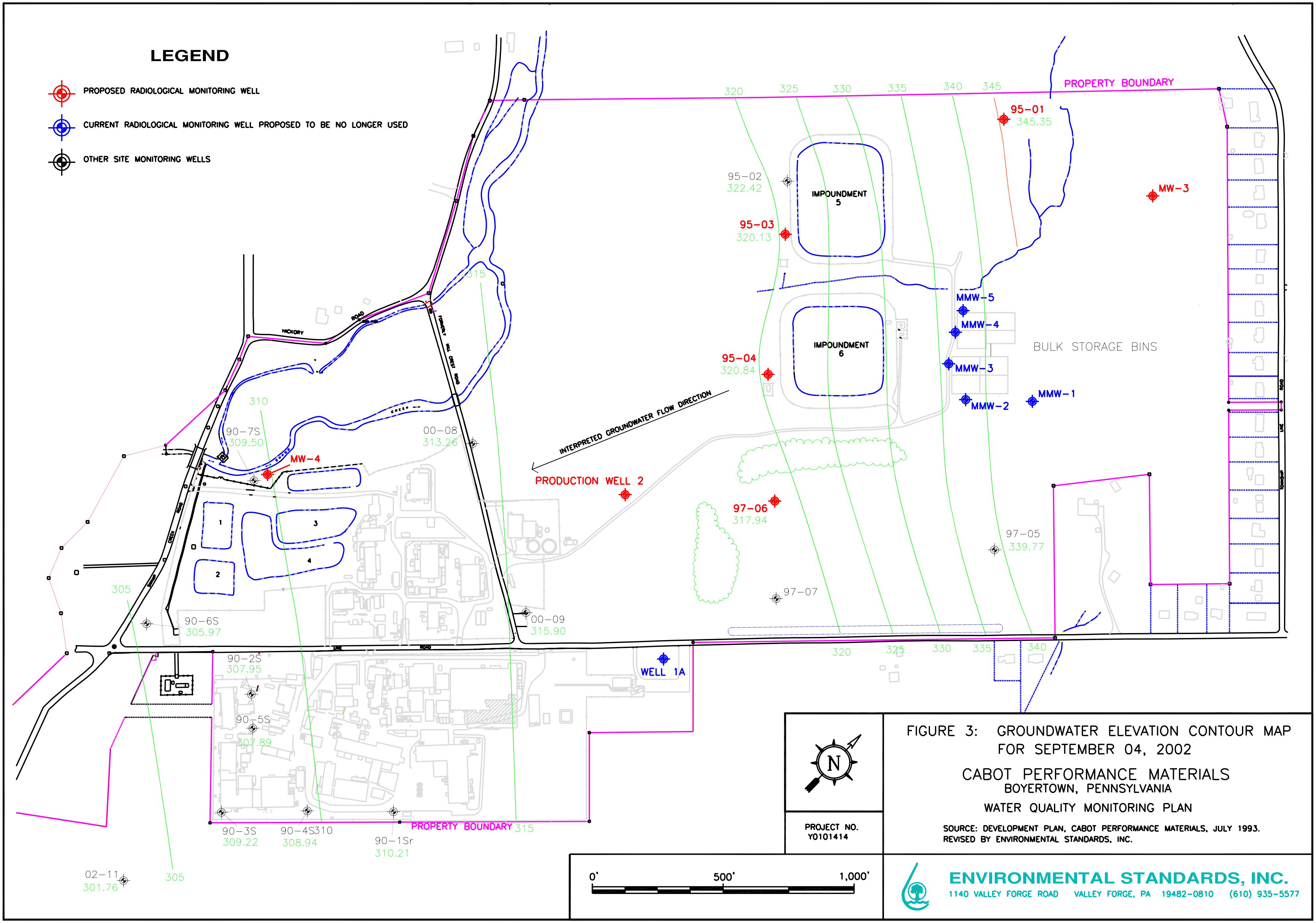

LEGEND
PROPOSED RADIOLOGICAL MONITORING WELL
CURRENT RADIOLOGICAL MONITORING WELL PROPOSED TO BE NO LONGER USED
OTHER SITE MONITORING WELLS
PROPERTY BOUNDARY
95-01
345.35
MW-3
95-02
322.42
IMPOUNDMENT 5
95-03
320.13
MMW-5
MMW-4
IMPOUNDMENT 6
BULK STORAGE BINS
95-04
320.84
MMW-3
MMW-1
MMW-2
INTERPRETED GROUNDWATER FLOW DIRECTION
PRODUCTION WELL 2
97-06
317.94
97-05
339.77
97-07
90-7S
309.50
00-08
313.26
MW-4
90-6S
305.97
00-09
315.90
WELL 1A
90-2S
307.95
90-5S
307.89
90-3S
309.22
90-4S
308.94
90-1Sr
310.21
02-11
301.76
320
325
330
335
340
345
315
310
305
0'
500'
1,000'
N
PROJECT NO.
Y0101414
FIGURE 3: GROUNDWATER ELEVATION CONTOUR MAP
FOR SEPTEMBER 04, 2002
CABOT PERFORMANCE MATERIALS
BOYERTOWN, PENNSYLVANIA
WATER QUALITY MONITORING PLAN
SOURCE: DEVELOPMENT PLAN, CABOT PERFORMANCE MATERIALS, JULY 1993.
REVISED BY ENVIRONMENTAL STANDARDS, INC.
ENVIRONMENTAL STANDARDS, INC.
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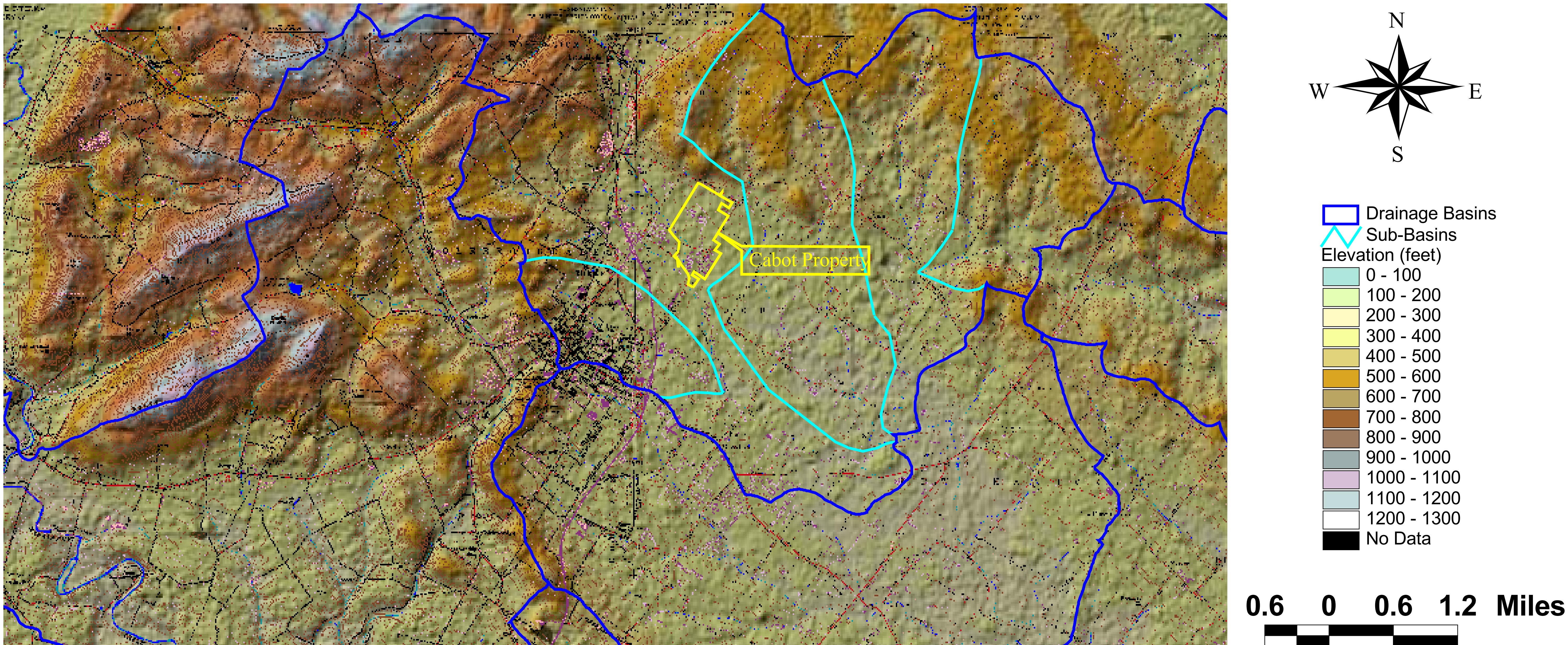
Figure 4: Major Drainage Basins in the Cabot Supermetals Boyertown Plant Area



SOURCE: U.S.G.S. 7.5' TOPOGRAPHIC QUADRANGLE, SASSAMANSVILLE, PA. 1957 (PHOTOREVISED 1990)
U.S.G.S 7.5' TOPOGRAPHIC QUADRANGLE, BOYERTOWN, PA. 1957 (PHOTOREVISED 1990)

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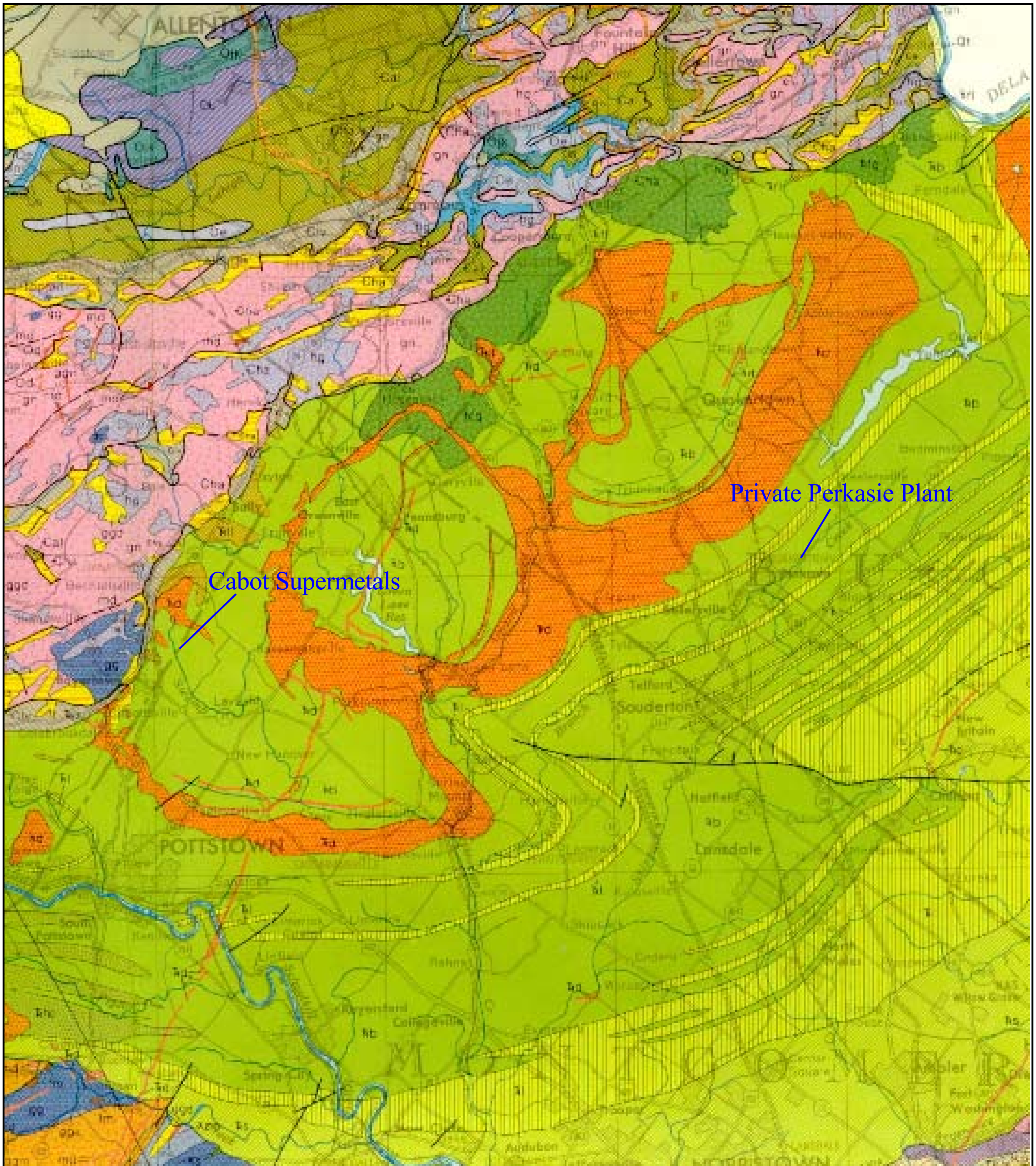

FIGURE 5: REGIONAL GEOLOGY

CABOT SUPERMETALS
BOYERTOWN, PENNSYLVANIA

FROM HALL, 1934, GROUNDWATER IN SOUTHEASTERN PENNSYLVANIA (THIRD PRINTING)

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Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX G

Dose Assessment for Disposal of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania

Dose Assessment for Disposal of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania

Prepared for

Cabot Supermetals
Boyertown, Pennsylvania

Prepared By

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April 22, 2003

TABLE OF CONTENTS

SECTION **PAGE**

1. INTRODUCTION ... 3
1.1 GENERAL ... 3
1.2 ABOUT THE AUTHORS ... 4
2. TECHNICAL APPROACH ... 4
3. SOURCE TERM ABSTRACTION ... 5
3.1 RADIONUCLIDES OF CONCERN ... 5
3.2 COMPARISON OF AVERAGE CONCENTRATIONS IN LANDFILL SLUDGE AND AVERAGE LANDFILL WASTE ... 6
3.3 PHYSICAL / CHEMICAL FORM ... 6
3.4 SPATIAL EXTENT OF THE MATERIAL ... 6
3.5 DISTRIBUTION OF RADIONUCLIDES THROUGHOUT THE SOURCE VOLUMES ... 8
3.6 SOURCES OF GROUNDWATER OR SURFACE WATER ... 8
3.7 SCENARIOS, PATHWAYS AND CRITICAL GROUPS ... 8
4. ADEQUACY OF DANDD 2.1.0 FOR THESE ASSESSMENTS ... 8
5. RESIDENT FARMER DOSE ESTIMATES ... 8
5.1 DOSE ESTIMATES BASED ON A DILUTION FACTOR OF 316 ... 8
5.2 LIMITS BASED ON OTHER DILUTION FACTORS. ... 9
6. SENSITIVE PARAMETERS ... 10
7. ALARA CONSIDERATION ... 10
8. REFERENCES ... 10
ATTACHMENT A: THE AUTHORS ... 1
ATTACHMENT B: 2002 LANDFILL SLUDGE STUDY ... 1

LIST OF TABLES

TABLE **PAGE**

Table 1 Landfill Information Obtained by Rick Haaker. 5

Table 2 Comparison of Mean and Maximum Concentrations for Freshly Generated Landfill Sludge, Average Landfill Waste Concentration, and Range of Background. 7

Table 4 Effect of the dilution factor on landfill capacity and on values in the denominator of factors in Equation 3. 9

Table B-1 Detected Radionuclide Concentrations in pCi/g on a dry weight basis. B-1

LIST OF FIGURES

FIGURE **PAGE**

Figure B-1 Plot of thorium-232 and uranium-238 activity for landfill sludge samples. B-2

Figure B-2 Plot of lead-210 and uranium-238 activity for landfill sludge samples. B-3

Figure B-3 Plot of polonium-210 and uranium-238 activity for landfill sludge samples. B-3

Figure B-4 Plot of lead-214 and uranium-238 activity for landfill sludge samples. B-4

Figure B-5 Plot of thorium-230 and uranium-238 activity for landfill sludge samples. B-4

Figure B-6 Plot of uranium-234 and uranium-238 activity for landfill sludge samples. B-5

Figure B-7 Plot of lead-214 and thorium-230 activity for landfill sludge samples. B-5

1. INTRODUCTION

1.1 GENERAL

The Cabot Supermetals (CSM) Facility at Boyertown, Pennsylvania processes tantalum ore that contains uranium (U) and thorium (Th) under Nuclear Regulatory Commission source material license number SMB-920. This process generates a high fluoride, acidic, liquid waste stream. This liquid waste stream contains small amounts of licensed radioactive material. It is neutralized with lime at CSM's onsite wastewater treatment plant. The resulting sludge, which is called landfill sludge, contains a mixture of unlicensed naturally occurring radioactive material (NORM), which is present in the lime, and licensed radioactive material that comes from the tantalum extraction process. The levels of U and Th in the sludge have historically been on the order of a few pCi/g, which is very near background levels in soils at the Boyertown plant site.

CSM currently releases landfill sludge that contains less than 10 pCi/g of U and Th to regional landfills pursuant to a specific license condition in SMB-920. CSM intends to continue disposing of sludge at regional landfills when it is cost effective to do so. Since license SMB-920 is in the renewal process, a dose assessment for this disposal practice was prepared. The limits derived herein would be used for releasing landfill sludge to the regional landfills.

This document follows the guidance provided in Appendices I, J and N of NUREG-1757 volume 2 for conducting dose assessments. It demonstrates that the landfill disposal option complies with acceptable dose limits and meets the ALARA requirements of NUREG-1757, Appendix N.

Technical reviewers at the Nuclear Regulatory Commission (NRC), who are familiar with NUREG-1757 (NRC, 2002) are the intended audience for this dose assessment.

This assessment addresses regulatory limits as well as more restrictive limits enforced as internal policy by the NRC. Regulations in 10 CFR 20.1301 provide limits for doses to the public of 100 mrem/year from all pathways and also establishes maximum radiation levels of 2 mrem/hour. More recent internal guidance from the NRC indicates that dose from free release of volume contaminated material should not exceed a few mrem/year. A modification of the single simulation method described in section J.5.2 of NUREG-1757 was used to estimate doses from sending waste to a sanitary waste landfill.

Plots of radionuclide concentrations in 42 landfill sludge samples from a 2002 study conducted by CSM indicated that the previous limit of 10 pCi/g for total U and Th did not address the fact that Pb-210 concentrations were independent of either U or Th concentrations. The limit established in this report incorporates all three radionuclides.

Limiting concentrations for free release to a sanitary landfill were derived for the three uncorrelated isotopes in the waste, U-238, Pb-210 and Th-232. Proposed concentration limits developed based on a dose of 5 mrem/year to a future resident living on the landfill are as follows:

- 56.9 pCi/g U-238,
- 55 pCi/g Pb-210, and
- 69 pCi/g Th-232.

These limits do not apply independently. Since all radionuclides are usually present, the limit for landfill sludge becomes:

Equation 1:

$$\frac{CU}{57}+\frac{CPb}{55}+\frac{CTh}{69}<1$$

where CU is the concentration U-238, CPb is the concentration of Pb-210 and CTh is the concentration of Th-232. These proposed release criteria take into account the average degrees of equilibrium in the decay chains and the average contributions from daughters.

Using the results from CSM's 2002 landfill sludge study, Equation 1 results in a value of about 0.4 for the average concentrations in landfill sludge and a value of about 0.8 for the maximum concentrations. This indicates that the 5 mrem/yr dose limit, which meets the NRC's internal policy, results in radionuclide concentration limits that will restrict off-site releases to values that are consistent with concentrations found in the sludge.

The following supplemental limit, based on the definition of source material, is also proposed:

Percent Uranium + Percent Thorium < 0.05%

1.2 ABOUT THE AUTHORS

Information about the authors is provided in Attachment A.

2. TECHNICAL APPROACH

The assessment of dose from disposal of landfill sludge at a sanitary or industrial waste landfill follows Section J.5.2 of NUREG-1757 Volume 2. Simulations were performed using DandD 2.1.0 with all default values except radionuclide concentrations. The default values were used because this is a generic assessment and does not address a single site-specific set of parameters, and because local or regional data are not available for the required input parameters.

Three local landfills already had approved the waste profiles for the landfill sludge. They were each contacted and two questions were posed:

- How much waste does the landfill accept per year?
- Does the landfill have a closure plan that restricts future land use?

The names of the landfills, and their responses to the questions, are provided in Table 1

Table 1. Landfill Information Obtained by Rick Haaker.

Landfill Name	Person Contacted	Date	Acceptance Rate (tons/year)	Future Land Use Restriction
Modern Landfill, York, PA	Tim O'Donald	4/21/03	Permit capacity: 1.4E6 Currently accepting > 1.3E6	none
BFI Conestoga Landfill, Morgantown, PA	Dale Leader	4/21/03	Annual average: 2.6E6	none
Lanchester Landfill, Honeybrook, PA	Terry Devine	4/21/03	Annual Limit: 6.0E5	none

The Pennsylvania landfills that were contacted had no future land use restrictions. In addition there is no known radionuclide contamination of groundwater associated with them. Consequently, the conditions for use of DandD 2.1.0 are satisfied. Other regional landfills may be used as well, provided that their waste acceptance criteria are satisfied.

3. SOURCE TERM ABSTRACTION

The objective of the source term abstraction process is to define free release concentrations in landfill sludge that will be transferred for disposal to regional landfills, such as those listed in Table 1.

3.1 RADIONUCLIDES OF CONCERN

Attachment B presents the data from the CSM landfill sludge sample study performed in 2002, and plots the individual results to determine the key independent radionuclides. As discussed in Attachment B, the principal radionuclides of interest are members of the U-238 and Th-232 decay series. The following conclusions regarding the landfill sludge concentrations are drawn from those plots:

- Thorium-232 and lead-210 in the landfill sludge are essentially independent of the uranium-238 concentration,[1] and
- Polonium-210, lead-214 (which infers radium-226) and thorium-230 concentrations are correlated with the uranium-238 concentrations.[2]

Thus, doses from landfill sludge can be estimated from routine measurements of just three radionuclides: uranium-238, thorium-232 and lead-210.

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[1] See figures B-1 and B-2.

[2] See figures B-3, B-4, B-5, B-6

3.2 COMPARISON OF AVERAGE CONCENTRATIONS IN LANDFILL SLUDGE AND AVERAGE LANDFILL WASTE

Based on Attachment B, the principal independent isotopes are U-238, Pb-210 and Th-232.

The average and maximum concentrations of landfill sludge, based on the 2002 sludge landfill study, are provided in columns 2 and 3 of Table 2. The amount that the average radionuclide concentration in landfill waste would be increased due to the presence of CSM's landfill sludge is given in Table 2, columns 4, 5 and 6. Those values are based on the limiting assumption that all of the landfill sludge goes to one landfill. To put these values in perspective, the range of soil concentrations in the United States are provided in column 7. It is important to note that results from a recent background soil study at the Boyertown site indicated average soil concentrations within the range shown for the country.

The values in columns 4, 5, and 6 fall within the range of background soil concentrations, with the exception of lead-210 and polonium-210 at the Lanchester landfill. Even if CSM sent all of its waste to one landfill, the incremental increase in the concentration of radioactive material in landfill waste would be small compared to the range of concentrations for those radionuclides in United States' soil. The dose from naturally occurring radioactive materials in the waste received by the landfills from locations other than CSM will be significantly greater than the dose from material added by CSM.

For the purposes of establishing free release limits for U-238, Pb-210 and Th-232 the following concentration ratios were assumed based on concentrations in the sludge samples as summarized in Table 2, Column 2.

- U-238, 1; U-234, 1; Th-230, 1.17; Ra-226, 0.43; Po-210, 3.45;
- Pb-210, 1
- Th-232, 1; Ra-228, 1; Th-228, 1; Ra-224, 1.

The ratios for the U-238 chain represent averages from the 2002 landfill sludge study after normalization to 1 pCi/g of U-238. The Th-232 chain is assumed to be in equilibrium.

3.3 PHYSICAL / CHEMICAL FORM

At the time that landfill sludge is generated, it is a fine-grained mixture of carbonates and fluorides of calcium and magnesium. It has a high moisture content at the time it is transferred to the landfill. The analytical data presented in Table 2 are on a dry weight basis, so no credit is being taken for the moisture content in this analysis. The landfill will be receiving other waste, which serves to further dilute the landfill sludge.

3.4 SPATIAL EXTENT OF THE MATERIAL

The smallest dilution factor that is proposed for the waste is 316 based on the results of the dose assessment that is discussed in section 5. In other words, the maximum amount of landfill sludge that will be transferred to any single landfill will be the annual tonnage of solid waste allowed by the landfill's operating permit divided by 316. CSM generates about 20,000 metric tons of landfill sludge per year. Based on an average density of 1.431 metric ton/m^3, 20,000 metric tons of landfill sludge would be diluted to a volume of 4.42E6 m^3/year with other landfill waste.

Table 2. Comparison of Mean and Maximum Concentrations for Freshly Generated Landfill Sludge, Average Landfill Waste Concentration, and Range of Background.

Decay Chain Part	Average Landfill Sludge (pCi/gram) Column 2	Maximum Landfill Sludge (pCi/gram) Column 3	Increase Due to Cabot Sludge: Modern Landfill (pCi/gram) [3] Column 4	Increase Due to Cabot Sludge: Conestoga Landfill (pCi/gram) [4] Column 5	Increase Due to Cabot Sludge: Lanchester Landfill (pCi/gram) [5] Column 6	Concentration Range in US Soil (pCi/gram) [6] Column 7
U-238	2.33	9.97	0.0358	0.0179	0.0776	0.11 to 3.81
Th-230	2.82	18.4	0.0434	0.0217	0.094	0.11 to 3.81
Ra-226	1.16	7.22	0.0178	0.0089	0.0387	0.11 to 3.81
Pb-210	17.8	34.0	0.273	0.137	0.59	0.11 to 3.81
Po-210	8.04	25.3	0.273	0.137	0.59	0.11 to 3.81
Th-232	0.31	0.68	0.00477	0.00238	0.010	0.11 to 3.54

[3] Includes only the Cabot contribution.

[4] Includes only the Cabot contribution.

[5] Includes only the Cabot contribution.

[6] See Table 5 in Annex A, UNSCEAR (1993).

3.5 DISTRIBUTION OF RADIONUCLIDES THROUGHOUT THE SOURCE VOLUMES

It is assumed that the concentrations of radionuclides are uniformly distributed throughout the landfill sludge material prior to delivery to the landfill. After dilution by disposal with other waste at the landfill, it is assumed to be uniformly mixed throughout the volume of waste received by the landfill that year.

3.6 SOURCES OF GROUNDWATER OR SURFACE WATER

Sources of groundwater and surface water are unknown since this is a generic assessment. The groundwater pathway is taken into consideration consistent with NUREG-1757, Volume 2, Appendix I by using DandD 2.1.0 pathway and parameter defaults.

3.7 SCENARIOS, PATHWAYS AND CRITICAL GROUPS

It appears that many sanitary landfills do not have future land use commitments in their closure plans. Therefore the critical group is assumed to be a resident farmer who ingests food that he/she produces. No cover is assumed to be present. This critical group is consistent with NUREG-1757, Appendices I and J.5.2.

This assumption tends to overestimate dose because farmers are not likely to till land that contains debris such as nails and rebar. Such items would damage the farm equipment used. A more plausible future land use would be grazing and perhaps limited gardening. Even then, a practical gardener would probably bring in clean topsoil and use raised bed gardening techniques.

Radon was excluded per NUREG-1757 Appendix I instructions and because DandD 2.1.0 lacks a radon diffusion model. All other pathways were included.

Default parameters were used for the settings in DandD 2.1.0 except for the initial dry weight concentrations in the sludge. Those values were calculated for unit concentrations in landfill waste (landfill sludge diluted with other waste received by the landfill) based on the isotopic ratios listed in Section 3.2. Using the dilution factor as described in Section 3.4, 316 pCi/gram in the landfill sludge translates to a maximum of 1 pCi/g of added radioactivity in landfill waste.

4. ADEQUACY OF DANDD 2.1.0 FOR THESE ASSESSMENTS

NUREG-1757 Appendix J recommends the use of DandD 2.1.0 or RESRAD. Both are considered adequate for modeling dose from the resident farmer scenario. There is no known radionuclide groundwater contamination at any of the potential landfill sites.

5. RESIDENT FARMER DOSE ESTIMATES

5.1 DOSE ESTIMATES BASED ON A DILUTION FACTOR OF 316

The 90th percentile peak dose estimates from disposal of waste in a landfill are:

Equation 2 :

$$Dose\left({}^{mrem}\!/\!_{year} \right) = (27.8 \times CU) + (28.8 \times CPb) + (22.8 \times CTh)$$

where CU, CPb and CTh are the concentrations of U-238, Pb-210 and Th-232 respectively in landfill sludge. This translates to the following limits in landfill sludge:

Equation 3:

$$1 > \frac{CU}{56.9} + \frac{CPb}{54.9} + \frac{CTh}{69.3}$$

5.2 LIMITS BASED ON OTHER DILUTION FACTORS.

Potential free release limits based on other dilution factors are provided in Table 4. Minimum dilution factors of 100 or lower are not feasible because of the relatively high concentration of lead-210 in landfill sludge, unless site-specific modeling is performed. In a similar fashion, a minimum dilution factor of 1000 might not be feasible because it would require that waste be sent to landfills outside of the region.

Table 4. Effect of the dilution factor on landfill capacity and on values in the denominator of factors in Equation 3.

Dilution Factor	Landfill Capacity Required (Ton/year)[a]	Corresponding U-238 Free Release Limit (pCi/g)	Corresponding Th-232 Free Release Limit (pCi/g)	Corresponding Pb-210 Free Release Limit (pCi/g)
1	20000	0.179856	0.219298	0.173611
3.16228	63245.6	0.568755	0.693482	0.549007
10.	200000.	1.79856	2.19298	1.73611
31.6228	632456.	5.68755	6.93482	5.49007
100.	$2. \times 10^6$	17.9856	21.9298	17.3611
316.228	6.32456×10^6	56.8755	69.3482	54.9007
1000.	$2. \times 10^7$	179.856	219.298	173.611

[a] The capacity required to achieve the desired dilution factor.

6. SENSITIVE PARAMETERS

No evaluation of sensitive parameters is required because no site-specific parameters were used in DandD 2.1.0.

7. ALARA CONSIDERATION

Appendix N of NUREG 1757 states that an ALARA evaluation is not required if DandD 2.1.0 is used with default parameters. Therefore no detailed ALARA analysis is required.

8. REFERENCES

NRC 2002. Consolidated NMSS Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria, NUREG-1757, Volume 2, Draft.

UNSCEAR (1993). Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR Report to the General Assembly with Scientific Annexes. United Nations, New York, 1993.

ATTACHMENT A: THE AUTHORS

Information about the authors, Rick Haaker and Robert Schoenfelder, is provided below.

Rick Haaker, CHP, CIH

Rick Haaker is a Certified Health Physicist and Certified Industrial Hygienist. He primarily serves as a lower tier subcontractor to Los Alamos National Laboratory. However, he has performed a number of tasks for NRC through a subcontract with Sandia National Laboratories over the last four years.

He documented and tested the Nuclear Regulatory Commission's (NRC) DandD 2.1.0 environmental dose assessment computer code per the requirements of ANSI/IEEE Std 829-1983 during 2001 and 2002. The point of contact at NRC for the software testing task was Mr. Ralph Cady.

Rick served as a NRC reviewer of the license termination plans submitted by the Maine Yankee Atomic Power Company, Saxton Nuclear Experimental Corporation License Termination Plans during 2000.

He also wrote draft NUREG/CR-5512, Volume 4, which was a pathway-by-pathway comparison of the models underlying the RESRAD, RESRAD-Build, and DandD computer codes.

On behalf of NRC, he provided comprehensive reviews of a number of burial sites in 1999. The following burial sites were reviewed and recommendations were provided to NRC about whether radioactive materials license termination criteria were satisfied:

- FAA burial site 3: Mike Monroney Aeronautical Center (MMAC), Oklahoma City.
- Mallinckrodt Veterinary, Inc: Terre Haute, Indiana.
- Pennsylvania State University, NRC License No 13-01264.
- US Department of Agriculture, Agricultural Research Service, Roman L. Hruska U.S. Animal Research Center, Clay City, Nebraska.
- Middlebury College, Middlebury, Vermont.
- Merck and Co., Inc., Rahway, New Jersey.
- Central Michigan University, Mount Pleasant, Michigan.

In addition, he provided model support in the development of probability distributions needed for the parameterization of the NRC's DandD computer code (1997) and is mentioned in the acknowledgements section of NUREG/CR 5512, Volume 3.

Robert Schoenfelder, CHP

Mr. Schoenfelder is a Certified Health Physicist with more than 23 years of experience in the field of radiation safety. He has extensive experience with uranium and thorium operations, including licensing, radiation safety program development and implementation, and dosimetry. He has assisted clients with U.S. Nuclear Regulatory Commission (NRC) and agreement-state license application preparation, environmental and occupational radiological monitoring and environmental impact analysis, design and implementation of radiological protection programs, and basic radiation safety training. He has evaluated potential health risks resulting from internal and external exposure to radioactive materials (particularly uranium and uranium decay products), arranged for transportation and disposal of radioactive waste, evaluated compliance with U.S. Department of Transportation (DOT) and NRC regulations, and performed emergency response planning; site characterization and radiological measurements in support of decontamination and decommissioning (D&D) projects; and scope of work and cost estimation for radiological programs.

Mr. Schoenfelder has served for ten years as WESTON's Corporate Radiation Safety Officer. He oversees the company's NRC and agreement-state licenses and associated radiation safety/waste disposal programs. He also has also served for nine years as a member and as chairman of WESTON's Corporate Radiation Safety Committee. He organized and led quarterly meetings, and developed corporate policy directives and OPs for radiation safety. He developed and implemented WESTON's companywide dosimetry program and developed/conducted 8-hour radiation safety training programs as needed. He also developed and managed radiation safety programs for contractors and clients.

ATTACHMENT B: 2002 LANDFILL SLUDGE STUDY

Table B-1 provides analytical data from the 2002 landfill sludge study. Only values that were above analytical detection limits are included in Table B-1.

Table B-1. Detected Radionuclide Concentrations in pCi/g on a dry weight basis.

Sample ID	Po-210	Th-228	Th-230	Th-232	U-234	U-238	Ac-228	Pb-214	Pb-210
71235049	5.81		1.71		0.705	0.623		0.183	8.06
71235050	8.21		1.1		0.807	1.41		0.353	19.4
71235051	8.79		1.14		0.908	0.657		0.339	17.8
71235052	8.87		0.699		0.841	0.768		0.33	21.2
71235053	5.16		3.7	0.624	1.53	1.26		0.692	8.88
71235054	4.99		1.84		0.927	1.36		0.621	11.4
71235055	11.8		1.42	0.478	1.32	1.94		0.496	22.2
71235056	3.37		0.833		1.22	0.705		0.317	19.3
71235057	5.17		1.03		0.903	0.688		0.308	18.6
71235058	4.62		1.19		0.984	1.27		0.516	6.86
71235059	1.69		1.5	0.679	0.922	0.554	0.709	0.721	3.32
71235060	5.4		3.23		1.96	1.82		1.05	8.7
71235061	5.72		1.81		0.678	1.22		0.367	22.7
71235062	4.37		2.32		1.5	1.08		0.121	10
71235063	5.93		2.46		1.88	1.26		0.846	11.2
71235064	12.3				2.07	2.32		0.483	23.5
71235065	8.51		0.883		2.32	2.26		0.584	24.1
71235066	8.7				2.14	2.05		0.65	26.4
71235067	4.97		0.934	0.181	1.42	1.25		0.389	21.1
71235068	4.67	0.294	1.16		0.726	1.37		0.348	20.8
71235069	4.03		0.91	0.167	0.881	0.863		0.39	20.9
71235070	4.68		1.75		2.42	1.97		0.295	28
71235071	8		0.535		0.983	1.45		0.323	15
71235072	4.39		2.19	0.253	0.991	1.4		0.765	7.29
71235074	4.45		1.92		2.09	1.74		0.757	7.91
71235075	4.54		1.25		1.52	1.72		0.569	9.73
71235076	4.53		2.12	0.225	1.6	1.46	0.195	0.755	8.6
71235078	3.89		0.938	0.157	1.29	0.897		0.303	18.5
71235079	4.62		0.921		1.79	1.04			20.3
71235080	6.1		1.12		1.24	1.11		0.21	33.8

Sample ID	Po-210	Th-228	Th-230	Th-232	U-234	U-238	Ac-228	Pb-214	Pb-210
71235081	5.36		0.836	0.181	3.24	2.5		0.376	27
71235082	6.27		1.02		2.99	1.75		0.169	22.3
71235083	2.31		1.16		1.09	0.579		0.203	8.11
71235084	6.09		0.625		0.982	1.55		0.285	30.4
71235085	25.3		3.89	0.328	9.68	9.61		0.369	10.7
71235086	13.9		1.12	0.13	1.41	1.16		2.87	34
71235087	20		18.4		8.89	8.58	0.741	7.22	16.5
71235088	9.03		2.15		3.09	3.24		0.76	14
71235089	19.7		4.51		5.1	5.36		1.88	31.5
71235090	19.6		6.74		5.33	6.11	0.794	6.51	20.3
71235091	17.2		13.8		7.64	9.97		6.54	19.8
71235092	14.7		15.9		7.07	8.03	0.57	6.13	16.5

Figure B-1 illustrates that there is no appreciable correlation between the concentrations of uranium-238 and thorium-232. In a similar fashion, Figure B-2 demonstrates that there is no appreciable correlation between lead-210 and uranium-238 activity.

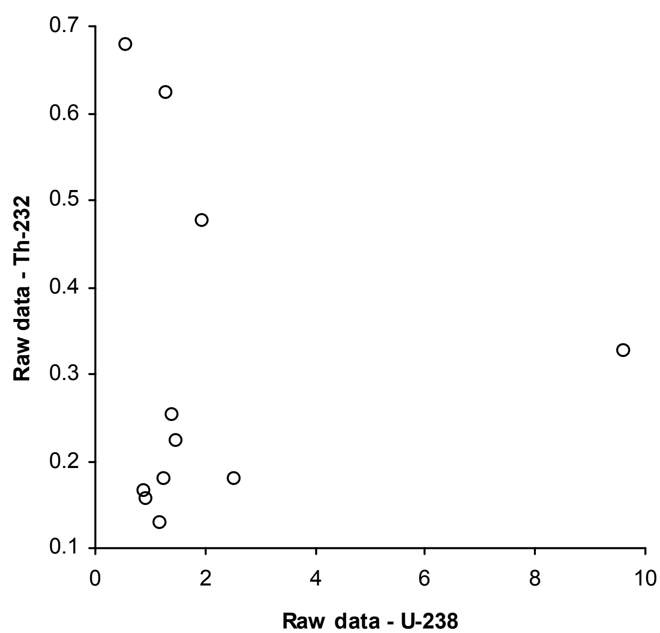


Figure B-1. Plot of thorium-232 and uranium-238 activity for landfill sludge samples.

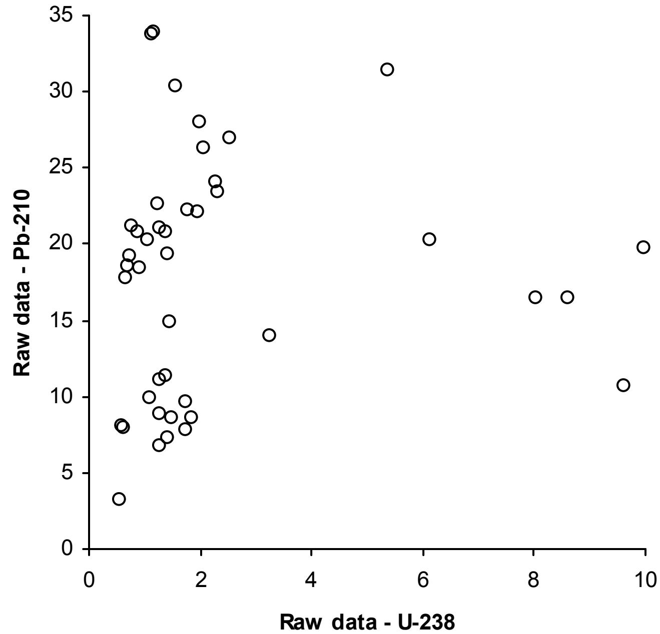


Figure B-2. Plot of lead-210 and uranium-238 activity for landfill sludge samples.

Figures B-3, B-4, B-5 and B-6 indicate that the concentrations of Po-210, lead-214 (and hence radium-226), thorium-230 and uranium-234 are positively correlated with uranium-238 concentrations in landfill sludge.

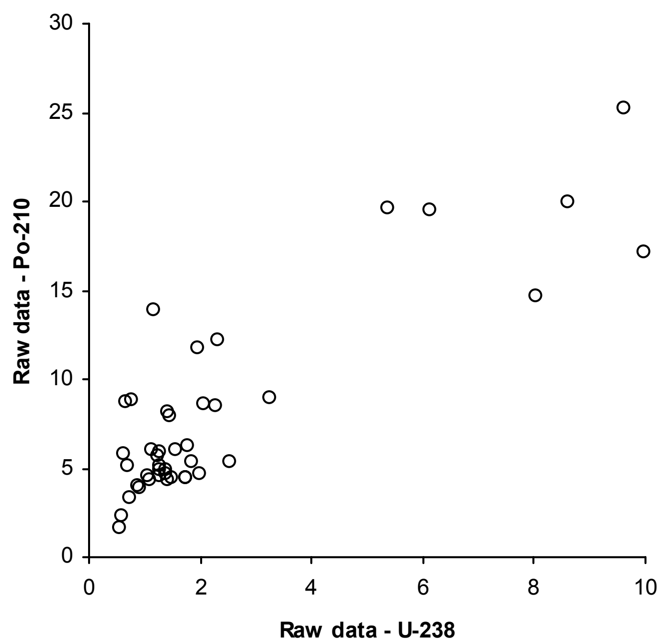


Figure B-3. Plot of polonium-210 and uranium-238 activity for landfill sludge samples.

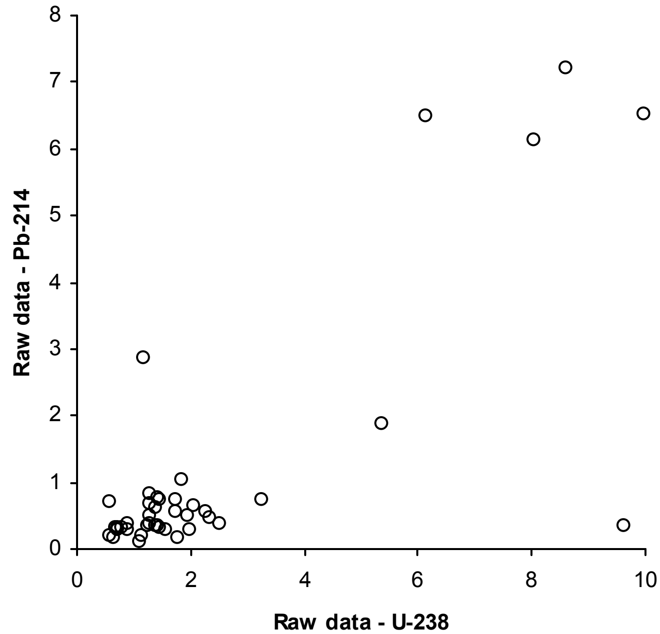


Figure B-4. Plot of lead-214 and uranium-238 activity for landfill sludge samples.

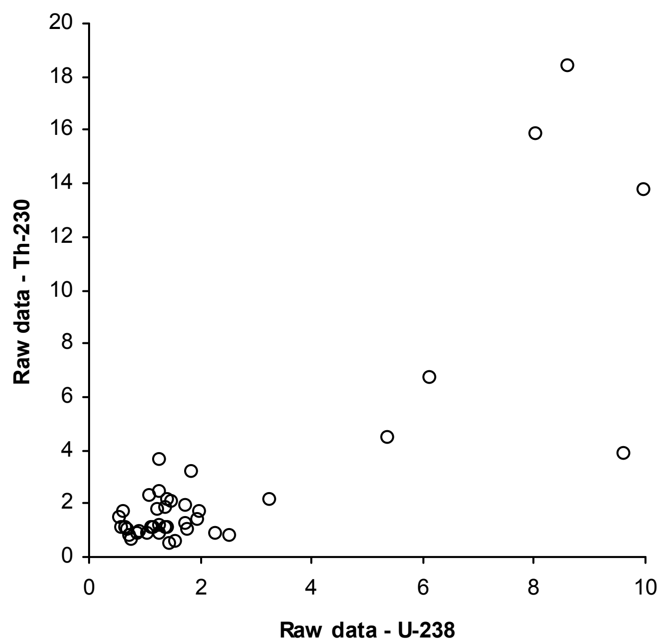


Figure B-5. Plot of thorium-230 and uranium-238 activity for landfill sludge samples.

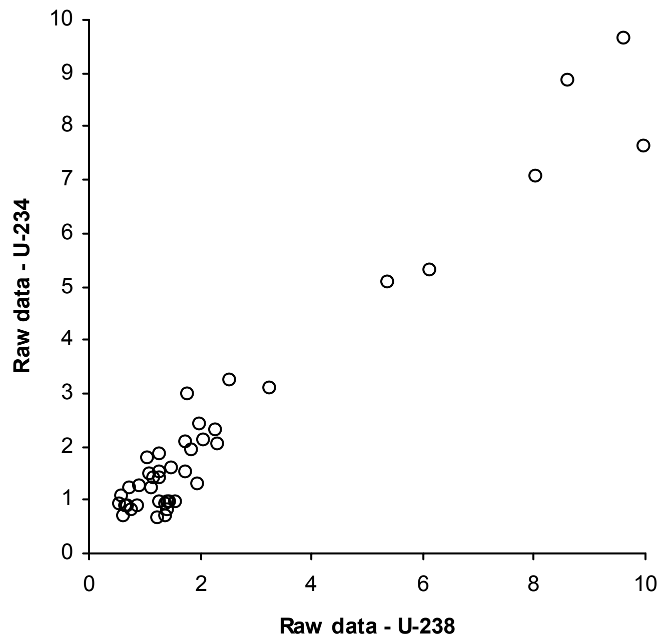


Figure B-6. Plot of uranium-234 and uranium-238 activity for landfill sludge samples.

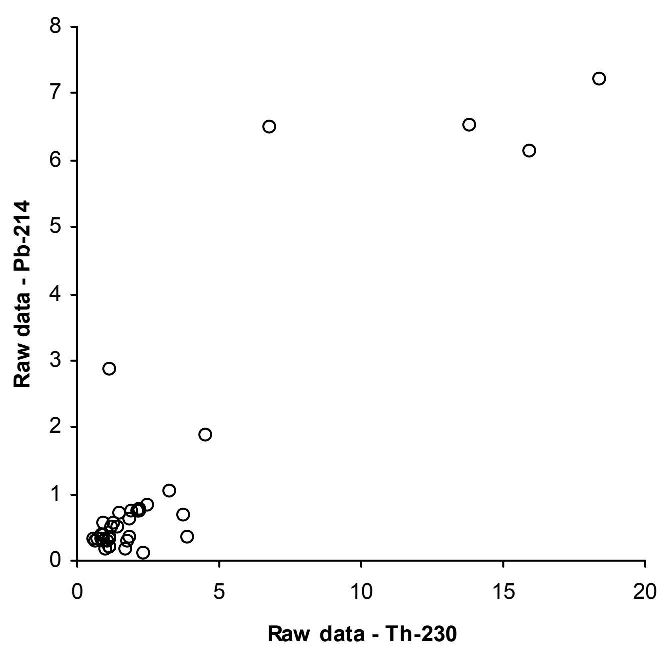


Figure B-7. Plot of lead-214 and thorium-230 activity for landfill sludge samples.

The processing of ores at the CSM Boyertown plant is not expected to result in significant fractionation of uranium isotopes, so the uranium-234/uranium-238 activity ratio was taken to be one. This assumption is consistent with the data presented in Figure B-6.

Based on Figure B-2, the concentration of lead-210 was modeled as independent of uranium-238.

Figures B-3 through B-5, show that the concentrations of polonium-210, lead-214, and thorium-230 were correlated with uranium-238. Therefore, the dose contributions of these radionuclides were included with the uranium-238 dose estimates.

It is notable that thorium-228, thorium-232 or actinium-228 were detected in only a small number of samples, and always at low concentrations. The ratio of radium-228 to thorium-232 is apt to be the same as the ratio of lead-214 to thorium-230. This is reasonable since: (1) lead-214 would be in equilibrium with radium-226 in the samples and (2) there is no reason to expect the isotopic ratio of radium-228 to thorium-232 to be different than the ratio of radium-226 to thorium-230, because any chemical separation that selectively reduced either the radium or the thorium would impact all the isotopes of that element in the same manner.

Application for Renewal of NRC License SMB-920

March 23, 2004

APPENDIX H

Cabot Supermetals, Inc. 2004 Decommissioning Cost Estimate for the Boyertown, Pennsylvania Site

Cabot Supermetals, Inc.

2004 Decommissioning Cost Estimate for the Boyertown, Pennsylvania Site

March 11, 2004

Prepared by:

Weston Solutions, Inc.

Approved by:

Robert P. Schoenfelder ______________________ March 23, 2004

Robert Schoenfelder
Project Manager

Date

Prepared for:

Cabot Supermetals, Inc.
County Line Road
Boyertown, PA 19512

EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) is providing a cost estimate for decommissioning the Cabot Supermetals, Inc. (CSM) Boyertown, Pennsylvania site. The cost estimate is based on a survey that was performed by the Scientific Ecology Group, Inc. (SEG) in 1993 (Reference 6.1); however, the estimate has been updated to reflect current decommissioning standards and unit costs. Conversations with CSM's Radiation Safety Officer indicate that no major spills or changes in configuration have occurred since 1993; therefore, the SEG information was used with certain minor modifications to estimate the radioactive materials presently on-site. WESTON then updated the cost estimate, following cessation of site operations, for site characterization; equipment, tank, concrete, and soil decontamination; radioactive waste volume reduction, packaging, shipping, and disposal; health physicist support; and final release surveys. The updated cost estimate is $5,740,722, which reflects typical 2003 costs and incorporates a 15% contingency. The 15% contingency is less than the standard value (25%) used by the U. S. Nuclear Regulatory Commission, but is justified by the following conditions:

- The approach to estimating costs is generally as would be performed by a contractor developing a construction bid. All labor costs are for private contractors at rates that include at least a 10% profit margin.

- The estimate is detailed and conservative in many of its assumptions, thereby limiting the potential for omitting relevant expenses.

- The conditions at the site are well known, the site has no periods of unknown or uncontrolled operations, and the site owners/operators have generally complied with regulatory requirements.

- The quantities of licensed radioactive materials and the site areas where they are handled are small compared with many industrial operations such as uranium mills. CSM is committed to having no more than 4,000 metric tons (MT) of presscake in its waste inventory. Cost estimates are based on disposing of approximately this quantity of presscake. This limits the potential for significant costs to be overlooked. Furthermore, CSM initiated a program in 2003 to dispose of the stored presscake and to discontinue the practice of stockpiling the material. The first shipment of presscake was made in March 2004. Thus, minimal quantities of presscake will remain on-site after June of 2004.

This estimate is for budgetary purposes only and is not a proposal or cost estimate for WESTON to perform work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 PURPOSE 1

1.2 SCOPE 1

1.3 DISCUSSION 1

2. GENERAL SITE DESCRIPTION 4

3. DESCRIPTION OF THE DECOMMISSIONING METHOD 6

3.1 BUILDING 73 6

3.1.1 Grinding Area 7
3.1.2 Repackaging/Screening Area 7
3.1.3 Digester Area 7
3.1.4 Filter Area 7
3.1.5 Outdoor Scrubber Area 8
3.1.6 Outdoor Bag Filter Area 8
3.1.7 Outdoor Compressor and Tank Area 8
3.1.8 Outdoor Feed Tank Area 8
3.1.9 Outdoor Presscake Storage Area 8
3.1.10 Roof Top Classifier and Bucket Elevators 9
3.1.11 Surrounding Outdoor Areas 9
3.1.12 Underground Drain Pipes 9

3.2 BUILDING 74 9

3.2.1 Feed Tank Area 10
3.2.2 Extraction Vessel Area 10
3.2.3 Floor Drains 10
3.2.4 Outdoor Acid Waste Tank Area 10

3.3 BUILDING 87 11

3.3.1 Digestion and Feed Area 11
3.3.2 Warehouse and Digester Area 11
3.3.3 Surrounding Outdoor Area 11
3.3.4 Outdoor Temporary Staging Area 11

3.4 BUILDING 18, STORAGE BUILDING 12

3.4.1 Ore Storage Area (Building 18) 12
3.4.2 Surrounding Outdoor Area 12

3.5 BUILDING 10, STORAGE BUILDING 12

3.6 BUILDING 23, LOADING DOCK 12

3.7 BUILDING 11, DEVELOPMENT LABORATORY (ROOM 17) 12

3.8 BUILDING 41, ANALYTICAL LABORATORY 12

3.8.1 Sample Introduction Room 13

3.8.2 General Laboratory Area (Room 12) 13
3.9 BUILDING 62, WASTE PROCESSING AND TRUCK BED WASH DOWN AREA 13
3.10 BULK STORAGE BINS 13
3.10.1 Buildings 99 and 102 13
3.10.2 Surrounding Outdoor Area 14
3.11 FORMER TIN SLAG STORAGE AREAS 14
3.12 WINTER STORAGE SLAG PILE 14
3.13 THORIUM DOPING ROOM (BUILDING 29) 15

4. SITE PRELIMINARY CHARACTERIZATION AND DOSE MODELING 16

4.1 BACKGROUND DOSE RATES AND SOIL CONCENTRATIONS 17
4.2 DIRECT COUNT RATE RESULTS 18
4.3 REMOVABLE ACTIVITY RESULTS 19
4.4 SOIL SAMPLE RESULTS 19
4.5 URANIUM AND THORIUM CHAIN EQUILIBRIUM DATA 19
4.6 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SOIL CONTAMINATION 21
4.6.1 Future Land Use and Exposure Scenario 21
4.7 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SURFACE CONTAMINATION 24

5. COST ESTIMATE 26

5.1 ESTIMATING APPROACH 26
5.1.1 Procedures used to estimate the areas requiring cleanup 26
5.2 ESTIMATING METHODOLOGY 27
5.2.1 Equipment and Tank Decontamination 27
5.2.2 Concrete and Surface Decontamination 28
5.2.3 Soil Decontamination and Determination of Volumes 28
5.2.4 Radioactive Waste Transportation and Disposal Cost 28
5.2.5 Radioactive Waste Volume Reduction Cost 29
5.2.6 Survey and Release 29
5.2.7 Health Physics Support Cost 29
5.2.8 Taxes and Contingency 30
5.3 THE TOTAL COST OF DECOMMISSIONING THE BOYERTOWN SITE 30

6. REFERENCES 31

LIST OF ATTACHMENTS

Attachment 1: Degree of Equilibrium in Ore Material and Presscake Solids
Attachment 2: D and D 2.1.0 Simulations Supporting the Soil DCGLs
Attachment 3: Net Exposure Rate and Deep Dose Equivalent Rate DCGL
Attachment 4: Summary Tables for DFP Cost Estimate
Attachment 5: ALARA Analysis

1. INTRODUCTION

1.1 PURPOSE

Weston Solutions, Inc. (WESTON®) prepared this document to provide an updated cost estimate for decommissioning the Cabot Supermetals, Inc. (CSM) Boyertown, Pennsylvania site (Boyertown site). The cost estimate includes those activities and cost factors, including a significant contingency factor as required by the Nuclear Regulatory Commission (NRC), applicable to removing residual radioactive material to levels that will allow release of the site for unrestricted use in accordance with NRC guidelines (See Reference 6.2, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, and Reference 6.3, *Draft Consolidated NMSS Decommissioning Guidance: Decommissioning Process*). Costs associated with the demolition and removal of non-contaminated equipment or structures are not included in this cost estimate. The date of actual decommissioning is not known or projected, as this facility is expected to continue licensed operations for an extended period of time. Other non-licensed CSM activities are expected to continue at Boyertown after license termination occurs. The configuration of the site after license termination will be suitable for ongoing industrial use. The costs listed in this report are estimates based on typical 2003 costs for contracted services. The cost estimate in this document should be used for budgetary purposes only and does not constitute a proposal or cost estimate for WESTON to perform the work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

1.2 SCOPE

The scope of this report is limited to the derivation of the cost required to remove residual radioactivity after cessation of operations at this site. Costs, in 2003 dollars, include the following:

- Costs of site characterization after site operations have ceased and all stores of licensed material have been removed from site.
- Costs of manpower and equipment to remove or reduce residual radioactivity to levels that will permit release for unrestricted use.
- Costs of radioactive waste packaging, volume reduction, transportation, and disposal.
- Costs of final site release survey.
- Applicable sales tax for contracted activities, and a contingency amount as would be applied in a construction cost estimate.

1.3 DISCUSSION

This cost estimate represents an evaluation and study of the costs for the decommissioning and disposal of the radioactive portions of the CSM Boyertown site. The methodologies specified for decontamination and demolition were selected to minimize the decommissioning cost. This study is based on the physical condition of the Boyertown site as of 2003, data from routine contamination surveys performed under CSM's radiation protection programs, data from CSM ore analyses, data from a site survey performed by WESTON in January 2003, and information in the most recent decommissioning cost estimate prepared by the Scientific Ecology Group, Inc. (SEG) (Reference 6.1). The result of this study is a decommissioning cost estimate of $5,740,722, which represents a 45% increase over the amount in the 1993 cost estimate. The bases of the cost estimate are clearly documented in a concise spreadsheet calculation that can be easily updated. The following list of assumptions and bases were utilized in developing the cost estimate.

1. All stored ore is a valuable commodity. Tantalum products continue to be used in the electronics industry, and the electronics industry is not likely to become unimportant in the foreseeable future. The ore will either be sold by CSM, or in the event of bankruptcy it will be sold on behalf of CSM's creditors. There would be brokerage fees associated with sale of the ore, but these are expected to be a percentage of the revenue realized from the sale, so brokerage fees do not appear in the cost estimate.

2. Removal and disposal of the presscake stored in the bulk storage bins by contractors is included as a task in this estimate. A conservatively high quantity of presscake (3600 MT) is used for this estimate, despite the fact that less than 4000 MT were present on-site and quantities were being diminished as of March 2004.

3. The disassembly and decontamination of slightly contaminated equipment will be performed on-site utilizing contract labor including health physics and decommissioning project personnel.

4. On-site decontamination of equipment will be performed where possible.

5. Off-site volume reduction facilities may be used to minimize radioactive waste volume.

6. Contracted on-site soil segregation techniques or soil washing methods will be used to minimize radioactive soil waste volume.

7. Automatic data logging equipment will be used in the performance of site release surveys.

8. Licensed disposal sites will be used for disposal of wastes that exceed unrestricted release criteria and unimportant quantity source material, as defined in 10 CFR 40.13. Currently, Envirocare and Waste Control Specialists, Inc. (WCS) are designated to accept such material from the site. In addition, CSM's existing contract for transfer of material to the IUC uranium mill in Blanding, Utah provided the cost basis for disposal of the ore residues (presscake).

9. Residual source material that meet acceptance criteria will be transferred to a uranium mill or transferred to another licensee for further processing.

10. Cleanup and release activities will be conducted without generating any mixed wastes (chemical hazardous waste mixed with regulated quantities of radioactive material). This is reasonable because waste minimization processes will be employed, and the low levels of

radiation at the site and the known characteristics of the materials handled are unlikely to result in a mixed waste.

11. Volume reduction factors that were used in the 1993 cost estimate and accepted for this site by the NRC continue to be valid.

12. Dimensions of structure and inventories of equipment developed for the 1993 cost estimate are valid because the operations have not been significantly changed since that time and no new buildings have been constructed in affected areas.

13. Sediments in the settling pond will not be removed during license termination. There is no reason to expect them to be contaminated because contaminants are removed at the wastewater treatment plant. It is anticipated that ongoing CSM operations will continue to use the wastewater treatment plant.

14. CSM owns the Boyertown site, so it has no obligations to a landlord to restore the site to a particular configuration upon license termination. Existing CSM industrial operations that do not involve processing source material are expected to continue at the site.

15. Wastewater from pressure washing will be sent to the site's fully permitted treatment plant and released under its NPDES permit.

2. GENERAL SITE DESCRIPTION

The CSM facility at Boyertown, Pennsylvania, prepares tantalum and columbium (niobium) products for use in several U.S. industries. Chemical processes are used to recover the product materials from ores and slags that contain uranium and thorium. Other operations in the Boyertown facility include fabrication of products, treatment of acidic wastewaters, and storage of presscake containing the uranium and thorium contaminants. The concentrations of the uranium and thorium contaminants are such that they exceed the 0.05% by weight criterion of 10 CFR 40 and must be licensed and controlled in accordance with the requirements of the NRC.

The current operations involving source material are concentrated in two areas of the l60-acre site. The production area is located in the southeastern part of the site (on both sides of County Line Road), and the wastewater treatment plant, bulk storage bins, and principal raw material storage areas are located northwest of the production area. The remainder of the site consists of approximately equal areas of deciduous trees (e.g., oak, hickory, maple, elm, and ash) and open field (grassland and corn).

The licensed radioactive materials impact only a few of the many buildings on-site and very limited parts of the total site area. A diagram of the site indicating the areas where licensed materials are present and areas where contamination will be removed is provided in Figure 1.

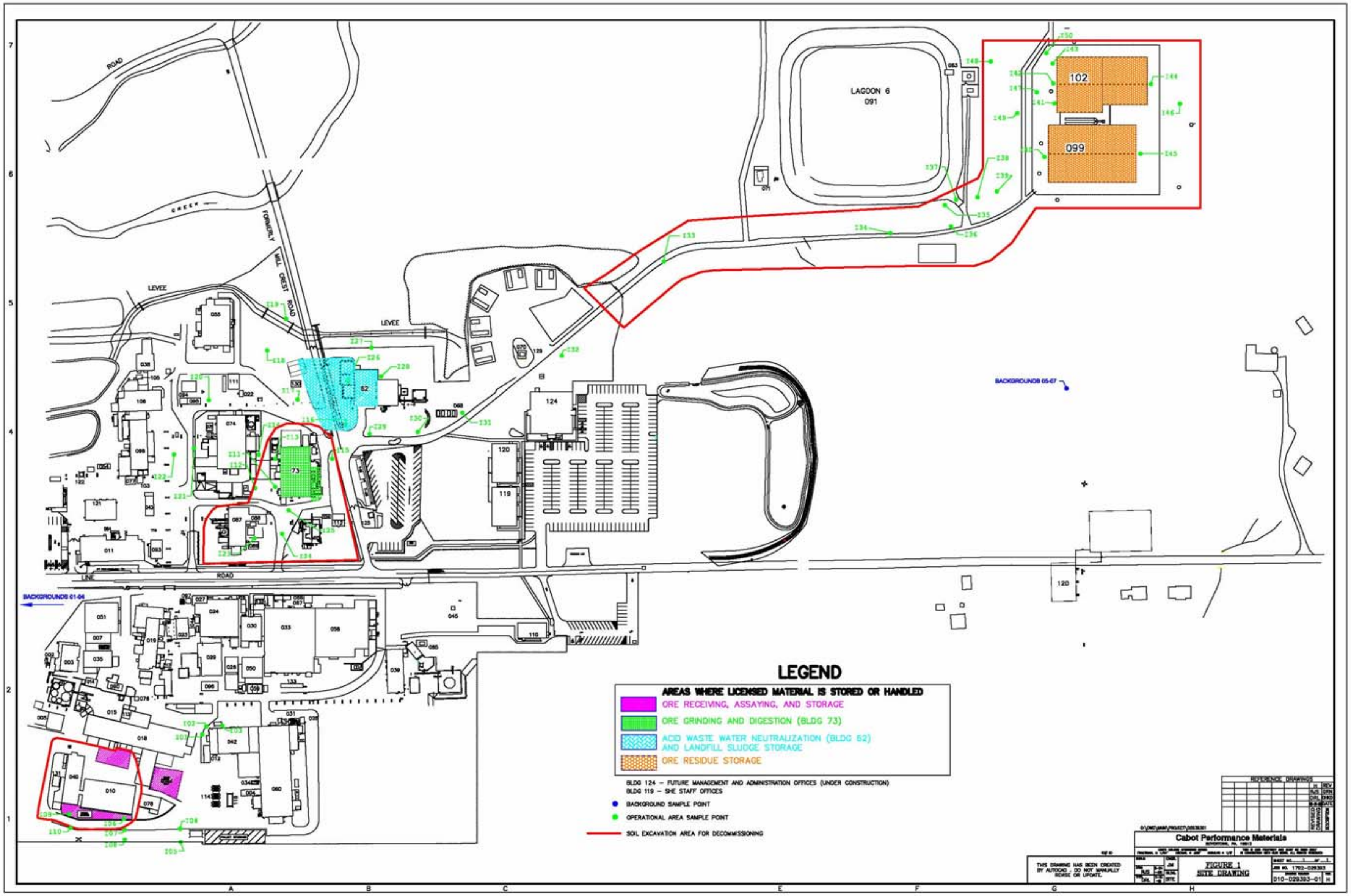

LAGOON 6
091
102
099
LEVEE
LEVEE
ROAD
124
120
119
LEGEND
AREAS WHERE LICENSED MATERIAL IS STORED OR HANDLED
ORE RECEIVING, ASSAYING, AND STORAGE
ORE GRINDING AND DIGESTION (BLDG 73)
ACID WASTE WATER NEUTRALIZATION (BLDG 62)
AND LANDFILL SLUDGE STORAGE
ORE RESIDUE STORAGE
BLDG 124 – FUTURE MANAGEMENT AND ADMINISTRATION OFFICES (UNDER CONSTRUCTION)
BLDG 119 – SHE STAFF OFFICES
BACKGROUND SAMPLE POINT
OPERATIONAL AREA SAMPLE POINT
SOIL EXCAVATION AREA FOR DECOMMISSIONING
Cabot Performance Materials
FIGURE 1
SITE DRAWING

Figure 1

3. DESCRIPTION OF THE DECOMMISSIONING METHOD

The decommissioning method presented in this section is taken primarily from Reference 6.1, *Decommissioning Cost Estimate for Boyertown, Pennsylvania Site*. This method requires that residual radioactive materials be removed after termination of operations at this site. For the purposes of this cost estimate, once structures and soils are decontaminated to releasable limits, no further decontamination or demolition is required.

When the site operations cease, it is assumed that unprocessed ore remaining on-site and the presscake in the bulk storage bins will be removed and disposed off-site. It is further assumed that ore exists in original shipping containers and will be trucked off-site for disposal or transfer to another licensee. Thoroughly cleaning equipment, building surfaces, and all other external and internal areas will remove residual material.

The following areas are considered for decommissioning in this cost estimate because they contain radioactive material or have previously contained radioactive material.

3.1 BUILDING 73

Grinding equipment is operated in an enclosed system within Building 73. The fine ore and slag particles from the grinding process are collected and segregated according to particle size with an air classification system. The effluent is cleaned in a baghouse that operates at a pressure slightly lower than that of the building.

With the exception of the outdoor presscake storage pad, surrounding outdoor areas, and underground drain pipes, all of the equipment and electrical boxes in Building 73 are assumed to contain ore dust. The ore dust is a loose material that is expected to be removable to release limits by conventional cleaning methods. The first step in the cleanup would be to perform a general cleaning of these areas, using appropriate equipment.

Electrical boxes, control panels, and other miscellaneous items from the walls of Building 73 will be compacted prior to disposal at a licensed facility. The Digester Area, Filter Area, Outdoor Scrubber Area, and Outdoor Feed Tank Area contain process piping and equipment that requires flushing and wipe down prior to survey and release (most of this piping is plastic or plastic-lined). The smaller pipe sizes may not be accessible for surveying and may be compacted for disposal.

The surfaces of metal ceilings and/or cinder-block walls will be vacuumed and wiped down prior to survey and release. In some areas the cinder-block walls have large open holes in the blocks. Additional holes will be made in these blocks to allow the dust to be vacuumed from within the blocks. For areas with corrugated fiberglass wall panels, the walls will be vacuumed, brushed, and wiped prior to survey and release. The concrete surfaces or floors and bases will be vacuumed and then scabbled to remove approximately 1/2 inch of concrete. The cracks will then be chipped out to remove contamination as necessary prior to surveying for release.

3.1.1 Grinding Area

Ore is ground in the Grinding Area in Building 73. The general cleaning outlined above would be followed by disassembly of the grinders, conveyors, hoppers, and support structures. This equipment would require further vacuum cleaning, brush cleaning, and wipe down prior to survey and release.

3.1.2 Repackaging/Screening Area

Materials are screened for appropriate size and repackaged in the repackaging/screening area, which is part of Building 73. The general cleaning outlined for Building 73 would be followed by disassembly of the drum handler/screener and support structures. This equipment would require further vacuum cleaning, brush cleaning, and wipe down prior to survey and release.

3.1.3 Digester Area

The finely ground ore is transferred, as needed, into the digester tanks containing hydrofluoric acid. The acid selectively dissolves tantalum and columbium to form fluorotantalic acid (H_2TaF_7) and f1uoroniobic acid (H_2NbF_7). The uranium and thorium contaminants react with the acid to form the insoluble compounds, UF_4 and ThF_4. Aluminum, calcium, magnesium, and potassium also react to form insoluble fluoride compounds. After a sufficient dissolution period, the mixture is passed through filter equipment where the insoluble compounds (containing the uranium and thorium) are removed from the solution and collected for disposal.

It is expected that equipment and floors may have the radioactive contamination strongly bonded as the result of the acid digestion process. Flushing and disconnection of the digester vessels would follow the general cleaning. The vessels have a rubber lining and a layer of graphite bricks inside to resist the hydrofluoric acid. These bricks will have absorbed activity and will need to be removed for disposal. It is expected that the tank lids will be removed and that the graphite bricks will be removed using a long-handled digging bar. The interior can then be flushed, surveyed, and released.

3.1.4 Filter Area

After digestion, the processed mixture is passed through filtration equipment where the insoluble compounds (containing the uranium and thorium) are removed from the solution and collected for disposal. This filtering step includes a press to reduce the moisture content of these solids (presscake) to about 40%. Filtrate is pumped to the metal-recovery process facility (Building 74).

It is expected that equipment and floors may have the radioactive contamination strongly bonded as the result of the acid digestion process. Flushing and disconnection of the filters would follow general cleaning. The disassembled filters can be further brushed and washed to remove contamination prior to being surveyed and released. The walls in the filter discharge area would receive an additional high-pressure wash to remove caked-on material.

3.1.5 Outdoor Scrubber Area

Air emissions are scrubbed in the outdoor scrubber area near Building 73. Flushing and disconnection of the scrubber vessels, piping, and fiberglass ductwork would follow the general cleaning. The disassembled vessels, process piping, and other process equipment would require flushing and wipe down prior to survey and release.

3.1.6 Outdoor Bag Filter Area

The bag filter plenums are located in the outdoor bag filter areas. The general cleaning would be followed by disassembly of the filter system. The disassembled filters, ductwork, and other equipment would require additional vacuum cleaning, brushing, and wipe down prior to survey and release.

3.1.7 Outdoor Compressor and Tank Area

The compressed air system is located in the outdoor compressor and tank area. The compressor is expected to have internal contamination that will not allow it to be surveyed for release. Disconnection and removal of the compressor would follow general cleaning. The pressure tank would be opened and all surfaces would be vacuumed and wiped down prior to surveying for release.

3.1.8 Outdoor Feed Tank Area

The tantalum and niobium-rich liquor that is produced during ore processing is initially transferred to a feed tank area outside Building 73. The cleanup of this area would involve a flush of all the tanks followed by a wipe down of the exterior of the fiberglass tanks. The tanks would then be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks. The tanks would then be removed and surveyed for release.

3.1.9 Outdoor Presscake Storage Area

The presscake from the dissolution and filtering operations is a mixture of $CaAlF_5$, $KMgAlF_6$, CaF_2, $CaMg_2AlF_{12}$, SiO_2, and SnO_2. The presscake also contains residual tantalum and niobium along with a combined uranium/thorium concentration of about 1%. The presscake is temporarily stored in open, portable hoppers on the northwest end of Building 73 until a truckload of containers is filled. The presscake containers are then transported to the bulk storage bins where they are emptied.

Presscake has been in contact with the concrete and asphalt surfaces in this temporary storage area. About half the area is concrete (where the presscake hoppers are staged) and half is asphalt. The cleanup consists of a general high pressure washing of the pad, scabbling the rough concrete surface to remove about 1/2 inch of concrete followed by chipping out the cracks to remove contamination. The asphalt would then be removed for disposal at a licensed facility prior to surveying the area for release.

3.1.10 Roof Top Classifier and Bucket Elevators

Building 73 contains equipment that sorts and transfers ore feed material. A sealed, size-sorting device or classifier is located on the roof, and the bucket elevator transfers scoops of ore to the grinding circuit. These systems would receive a general cleaning that would be followed by disassembly of the classifier system, bucket elevators, and ancillary equipment. This equipment would require additional vacuum cleaning, brushing, and wipe down prior to survey and release.

3.1.11 Surrounding Outdoor Areas

Ore, ore dusts, and presscake have been in contact with areas outside Building 73 due to ore handling operations, grinding operations, maintenance operations, and outdoor presscake hopper storage. Asphalt was added around the building after the building was initially put into operation. The areas not covered by asphalt are covered with a soil composed of gravel and clay that is over one foot deep. Deep soil samples could not be obtained in this area, but it is expected that contamination has penetrated to a depth of about one foot.

The area will be excavated to a depth of one foot. Most of the gravel would be washed to remove contamination, then surveyed and released. The portion of the soil that cannot be decontaminated would be packaged for disposal at a licensed facility prior to surveying the area for release.

3.1.12 Underground Drain Pipes

Outside drains that collect rainwater from the roof gutter system are likely contaminated. Floor drains in the building will also be contaminated. These drains will need to be removed and the soil around the drains monitored for contamination. The extent of contamination was not determined for this cost estimate. It is expected that the drainpipes could be located and monitored along their length to determine the extent of contamination. For this cost evaluation, it is expected that 100 yards of contaminated piping buried 4 feet below grade will require removal. It is also expected that 10% of the fill around the pipe is contaminated. The pipe is expected to have absorbed contamination that cannot be removed. The pipe will be removed and disposed at a licensed facility before the area is surveyed for release.

3.2 BUILDING 74

The solutions from the Building 73 filtering equipment are pumped to the processing equipment in the metal-recovery facility, Building 74. The tantalum and columbium are continuously extracted from the solutions by reactions with methyl-isobutylketone (MIBK), followed by sulfuric acid and hydrofluoric acid treatment. This process separates the mixture into two product streams containing either H_2NbF_7 or H_2TaF_7 and a liquid waste (raffinate) stream. The liquid waste stream is an aqueous solution of sulfuric and hydrofluoric acids, with possible traces of MIBK.

The disassembled process piping from the tanks and vessels would require flushing and wipe down prior to survey and release (most of the process piping is plastic or plastic lined). The smaller pipe sizes may not be accessible for surveying and may be compacted for disposal at a licensed facility. As decontamination of the process pumps would not be practical, the pumps would be compacted and packaged for disposal at a licensed disposal facility. The concrete surfaces around the tanks and vessels will be scabbled to remove about 1/2 inch of concrete, cracks in the concrete will be chipped to remove contamination, and the area will be monitored for unrestricted release.

3.2.1 Feed Tank Area

Six fiberglass tanks along the northeast wall, labeled 8A, 8B, 9A, 9B, 10A, and 10B, contain radioactive material, as indicated by elevated radiation readings on the tank bottoms (in the mR/hr range). Because of these readings, it is expected that the floor under the tanks will be contaminated from leakage, but that the general floor area will not be contaminated. Although the floor has an epoxy coating, this coating can be damaged when a tank fails and direct contact with the concrete floor occurs. The first step in the cleanup of this area would be to flush all the tanks and then to wipe down the exterior of the fiberglass tanks. The tanks would then be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks before they are surveyed for release.

3.2.2 Extraction Vessel Area

Two extraction tanks contain radioactive material, as indicated by elevated radiation readings on the tank bottoms (in the mR/hr range). It is expected that the floor under these vessels will be contaminated from leakage, but that the general floor area will not be contaminated. The cleanup of this area would begin with a flush of the vessels followed by a wipe down of the exterior. The vessels would then be disconnected and opened to allow brushing and flushing to remove solids caked in the vessels. The vessels would then be removed and surveyed for release.

3.2.3 Floor Drains

The floor drains for collecting process spills are contaminated and will need to be removed, and the soil around the drains will need to be monitored for contamination. The extent of contamination was not determined for this cost estimate. It is anticipated that the drainpipes could be located and monitored along their length to determine the extent of contamination. For this cost evaluation, it is expected that 50 yards of contaminated piping buried 4 feet below grade will require removal. Approximately 10% of the fill around the pipe may be contaminated. The pipe is expected to have absorbed contamination or have internal contamination that cannot be removed; therefore, the pipe will be disposed at a licensed facility before the area is surveyed for release.

3.2.4 Outdoor Acid Waste Tank Area

Two contaminated outdoor acid waste tanks are situated in an area with a high curb; one of them is abandoned. These tanks read about 500 μR/hr. The cleanup of these tanks would begin with a flush, after which they would be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks. The tanks would then be removed and surveyed for release.

3.3 BUILDING 87

Building 87 is the original digestion and press building that continues to be used for handling radioactive materials. Monitoring activities and potential decontamination will be required in the area when the license is terminated.

3.3.1 Digestion and Feed Area

Ore digestion and liquor extraction originally occurred in the digestion and feed area. The only area of this building that demonstrated measurable contamination was the concrete floor under the digester on the southwest side of the building. The digester and filter press did not have elevated radiation levels. For the concrete floor under the digester vessel, the concrete surfaces will be scabbled to remove about 1/2 inch of concrete and cracks will be chipped out to remove contamination prior to surveying for release.

3.3.2 Warehouse and Digester Area

Materials were stored and the digester was located in the warehouse and digester area. The only area of this building that demonstrated measurable contamination was the concrete floor where drums of ore and a contaminated bucket conveyor belt have been stored. The surface of the concrete floor may require scabbling to remove about 1/2 inch of concrete, and the cracks will need chipping to remove contamination before the area is surveyed for release.

3.3.3 Surrounding Outdoor Area

There is evidence of contamination outside Building 87. The area surrounding the building is covered with a soil composed of a gravel and clay mixture more than one foot deep. Deep soil samples could not be obtained in this area, but contamination is assumed to have penetrated to a depth of about one foot due to the porous nature of the soil.

The soil would need to be removed to a one-foot depth. It is expected that the soil could be washed to remove contamination, surveyed, and released. The remaining soil would need to be packaged for disposal at a licensed facility. The area would then be surveyed for release.

3.3.4 Outdoor Temporary Staging Area

There is evidence of contaminated material handling and equipment storage in the outdoor temporary storage area. The area is covered with a soil composed of a gravel and clay combination more than one foot in depth. Deep soil samples could not be obtained in this area, but contamination is expected to have penetrated to a depth of about one foot due to the porous nature of the soil.

The soil will be removed to a one-foot depth. It is expected that most of the soil could be washed to remove contamination, surveyed, and released. The portion of the soil that cannot be decontaminated would be packaged for disposal at a licensed facility before the area is surveyed for release.

3.4 BUILDING 18, STORAGE BUILDING

Building 18 is a former aluminum foundry building that was converted years ago into a warehouse. Most of the building is used to store drums and bags of ore, empty drums, and some chemicals. The rest of the building is used to store equipment and other operational supplies. The ore containers are sampled in this building.

3.4.1 Ore Storage Area (Building 18)

Ore containers were stored and sampled in the Ore Storage Area. Those activities may have resulted in some spillage of ore onto the floor. However, instrument readings in this building do not indicate that it is contaminated and it will not need to be cleaned prior to release. The cinder-block walls and metal ceiling are expected to be clean. This area will be surveyed for release.

3.4.2 Surrounding Outdoor Area

There is no evidence of contamination outside Building 18. No decontamination is planned for the outside area, which is mostly asphalt. However, the final survey of the outdoor area will include soil samples taken through the asphalt to reveal any contaminated soil that needs to be removed prior to releasing the area.

3.5 BUILDING 10, STORAGE BUILDING

The Storage Building is used to store palletized bags and drums of chemicals and materials produced at the Boyertown site. Some palletized drums and bags of ore are also stored here. There is no evidence of contamination in Building 10. Although no decontamination of this building is planned, a final survey of the area should include deep soil samples taken through the asphalt floor to reveal any contaminated soil that needs to be removed before the area is surveyed for release.

3.6 BUILDING 23, LOADING DOCK

Building 23 has a concrete loading dock with a surface-mounted scale used for weighing ore when it is received. There is no evidence of contamination on this loading dock. No decontamination of the area is planned. The area will be surveyed and released.

3.7 BUILDING 11, DEVELOPMENT LABORATORY (ROOM 17)

This laboratory is used in developing new processes for recovering metals from the contaminated ores and for recovering useful materials from the presscake produced in Building 73. There is no evidence of contamination in the laboratory. No decontamination is planned prior to surveying the area for release.

3.8 BUILDING 41, ANALYTICAL LABORATORY

The Analytical Laboratory includes a sample staging room as well as a wet chemical analysis room that are described below.

3.8.1 Sample Introduction Room

The sample introduction room is used to hold samples before and after analysis. It is anticipated that removal and wiping of all laboratory equipment will remove the contamination. No other decontamination of the area is planned prior to surveying the area for release.

3.8.2 General Laboratory Area (Room 12)

The general laboratory area is used for wet and dry chemical analysis. There is no evidence of contamination in this area. No decontamination is planned prior to surveying the area for release.

3.9 BUILDING 62, WASTE PROCESSING AND TRUCK BED WASH DOWN AREA

The presscake from Building 73 processing is transported to the bulk storage bins in open hoppers on flatbed trucks. During transit, small amounts of the presscake may fall onto the truck bed. After unloading, the truck beds are washed off on an asphalt area attached to the wastewater filter house (Building 62). Asphalt was installed in this area in 1993 and the area exhibited no evidence of contamination at that time. In addition, the wastewater treatment process produces a solid filtercake that is monitored for radioactivity and released off-site during daily plant operations. No decontamination of the area is planned prior to surveying it for release.

3.10 BULK STORAGE BINS

The presscake generated in Building 73 is temporarily stored in open, portable hoppers outside the building until a truckload of containers is filled. The presscake containers are then transported to and emptied into the bulk storage bins.

The presscake has historically been stored in the dedicated on-site bulk storage bins for further processing and/or disposal. This cost estimate includes removing, packaging, and transporting the presscake for uranium recovery processing at a qualified, licensed facility, which is about half as expensive as disposal at a radioactive waste disposal site. The bulk storage bins will be monitored for unrestricted release. Approximately 4,000 tons of presscake were stored at the time of this plan.

Beginning in 2003, CSM ceased accumulating the presscake on-site and arranged for disposal at regular intervals throughout the year. Therefore, the quantity of presscake stored in the bulk storage bins is expected to decrease throughout the remainder of 2003 and will reach and sustain a limited “staging quantity” in 2004 that will be far less than 4,000 tons. This cost estimate includes the costs for transporting and disposing of the current 4,000-ton quantity of presscake. Costs are also included for decontamination of the buildings and removal of the contaminated soils around them.

3.10.1 Buildings 99 and 102

Bulk storage bins 1 through 4 constitute Building 99, and bulk storage bins 5 through 7 constitute Building 102. Before each bin is used, it is refurbished with a seamless liner that wraps 6 feet up each wall and is topped by a sloped concrete floor. The presscake is dumped onto the lined floor of each bulk storage bin as a damp solid.

The buildings are constructed of poured concrete, except the upper areas, which are cinder block. The cinder blocks have been added on most of the walls to reduce the size of the opening between the tops of the walls and the bottoms of the roofs. Windblown rainwater is prevented from entering the bins by louvered vents and plastic weather strips above the gates to each bin. In addition, the entryway to each bin has been pitched such that rainwater is directed away from the entrance. Radioactive material is strongly bonded to these walls and floors. It is assumed that the presscake will be removed from the bulk storage bins before the decommissioning process begins. The cleanup of the facility would start with a high-pressure wash of the interior ceilings, walls, and floors to remove caked-on presscake. The ceiling and wall areas, including the cinder blocks, would be grit blasted to remove activity and then vacuumed before they are surveyed for release. Prior to surveying the area for release, the concrete surface would be scabbled in two separate passes to remove a total of 1/2 inch of material; then the cracks would be chipped out to remove contamination.

3.10.2 Surrounding Outdoor Area

There is evidence of presscake from the bulk storage bins in the soil outside the buildings. The soil is a clay type, and there are graveled roadways around the buildings and between Building 73 and the bins. Composite surface and deep soil samples obtained in this area indicate that contamination has penetrated to a depth of about 6 inches. This cost estimate assumes that the soil will be removed to a 12-inch depth. It is expected that most of the soil could be segregated or washed to remove contamination, and then surveyed and released. The portion of the soil that cannot be decontaminated would be packaged for transportation to a licensed facility prior to surveying the area for release.

3.11 FORMER TIN SLAG STORAGE AREAS

Tin slag is a black silicate glass with a wide range of particle sizes and irregular particle shapes. This material is the water-quenched waste from the tin smelting process in Malaysian countries and was delivered in 55-gallon drums and stored in a large field north and east of Lagoon 6 and also along the roadway to the bulk storage bins. Some of this slag was seen lying on the surface of the ground n 1993, and radiation levels were elevated throughout the area. The soil is a clay type, and there is a graveled roadway passing through the area to the bulk storage bins. Composite surface and deep soil samples were obtained in this area in 1993, and the area was re-sampled in 2003. Soil excavation along the haul road will include contaminated soils from this area. It is expected that most of the soil would be washed to remove contamination, surveyed, and released. The portion of the soil that cannot be decontaminated and exceeds release criteria would be packaged for disposal at a licensed facility before the area is surveyed for release.

3.12 WINTER STORAGE SLAG PILE

The tin slag in 55-gallon drums was initially stored in an area north and east of Lagoon 6. To avoid problems with obtaining frozen slag from the drums during the winter season, a pile of slag was formerly maintained in an area between Buildings 73 and 74. This area is a concrete pad with ore dust on it and no barriers to keep material from being washed off the pad onto the surrounding soil. Although the concrete pad was decontaminated, monitored, and found to meet release limits in 1993, about 3600 cubic feet of contaminated soil would be removed from the winter storage slag pile area, as stated in the original SEG cost estimate (Reference 6.1). The cost for disposal of that volume of material remains in this cost estimate although the area will not require further monitoring, excavation, or disposal.

3.13 THORIUM DOPING ROOM (BUILDING 29)

In the period since 1993, CSM has established a process for thorium doping of tantalum powder. The process is performed in a small room the size of a walk-in closet, about 7 feet wide by 10 feet long, in Building 29. Thorium is added to tantalum powder in the process through a number of steps. Equipment in the room includes a balance, a drying table that employs a steam heating system to drive moisture, a HEPA vacuum system, and two local exhaust ventilation devices. This room will be decontaminated and the equipment disposed of as contaminated debris.

4. SITE PRELIMINARY CHARACTERIZATION AND DOSE MODELING

The CSM Boyertown site was surveyed extensively by SEG in July of 1993 to gather physical facility and radiological data to support the cost estimate performed at that time. The physical data have not changed, other than the minor adjustments described in the previous sections of this document, such as the addition of the thorium doping process. The radiological measurements performed by SEG included direct beta monitoring of surfaces and direct monitoring of general areas with a μR meter, samples from soil areas that demonstrated elevated dose rate readings, and smears obtained to determine the levels of removable activity. The results of that characterization are considered valid today because there have been no significant changes in the site operations and no unplanned releases of radioactive material since 1993, and because routine radiological surveys conducted by CSM have indicated no significant increases in radiation levels around the site and in work areas. Updated radiological data were obtained for this cost estimate to verify current conditions for comparison with the observations and assumptions in 1993 and to support the development of cleanup criteria. WESTON also reviewed routine survey data that spanned the past several years to ensure that contamination levels had not increased significantly in the work areas since the 1993 characterization was performed.

The supplemental site sampling and monitoring performed in January 2003 by WESTON verified soil contamination levels in pertinent areas of the site, defined background radiation levels (external gamma dose rates and soil concentrations) at the site, and supported computer modeling that established new DCGLs for this decontamination cost estimate. Gamma dose measurements were taken using a Bicron tissue-equivalent microrem meter, and soil samples were collected at ten background locations and about 50 locations in areas that will require cleanup if the license were terminated. Samples were taken at 6-inch intervals to a depth of 2 feet and submitted to a contracted laboratory for isotopic analyses.

The typical raw ore processed at the Boyertown site contains uranium and thorium as contaminants. Table 4-1 shows actual average and maximum concentrations of uranium and thorium in the various ores received at the site during 2001. These data were also used in a recent study to determine recent radionuclide mixtures and calculate revised values such as derived air concentrations. The full set of data is provided as an appendix in the "Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown Pennsylvania Plant, June 9 2003" developed by WESTON.

Table 4-1. Average Concentration of Uranium and Thorium in Ore Materials Received by CSM During 2001 (Weight Percent).

	%Th	%U
Average	0.057	0.165
Maximum	1.128	0.647

Thorium-232 has much lower surface activity release limits than natural uranium. As a consequence, the site decommissioning will need to meet the lower release limits. Total alpha activity levels of 1,000 disintegrations per minute per 100 cubic centimeters (dpm/l00 cm^2) and removable activity levels of 200 dpm/100 cm^2 alpha are acceptable for unrestricted release of equipment and material from the site. Structures are assumed to meet the dose-based license termination criteria once total alpha contamination levels are reduced to approximately 50dpm/100 cm^2.

In addition, soil sample activities that exceed background by about 2.5 pCi/g of thorium-232 were considered potentially significant under the 25-mrem/yr dose-based standard. These areas were included in the remediation cost estimate. The total and removable activity limits for equipment and materials are based upon the NRC guidelines in Reference 6.2. Total activity limits for residual surface contamination on structures are based on the D and D Version 2.1.0[1] computer program (Reference 6.4) occupancy scenario simulations. The preliminary soil activity limits also are based on simulations using D and D Version 2.1.0. A thorough characterization should be performed prior to the projected decommissioning and after all radioactive ore has been removed from the site to establish with certainty the areas requiring remediation.

4.1 BACKGROUND DOSE RATES AND SOIL CONCENTRATIONS

Dose rate readings were taken using a μR survey instrument in all areas with the potential for residual activity in 1993. These results are summarized in Appendix 1 of the 1993 SEG report (Reference 6.1). That summary contains survey maps for the various locations and provides the associated instrument readings. The μR instrument was used in determining if elevated dose readings extended into the soil areas surrounding the process and storage buildings. The lower dose rate readings on-site and away from processing were in the range of 5 to 20 μR/hr. A value of 20 μR/hr was established as the background level for that report.

Weston Solutions measured background radiation levels and collected soil samples from two depths at 10 locations on the CSM Boyertown site on 13 January 2003. The RSO for CSM reviewed the locations that were selected and agreed that they were unaffected by licensed activities, structures, or equipment. A Bicron tissue equivalent MicroRem meter was used to perform the background dose equivalent rate measurements. Results are provided below in Table 4-2. The background value for the CSM plant site is 12 microrem/hour. The soil samples were sent to the Eberline Services Laboratory in Oak Ridge, Tennessee for analysis. Eberline Services analyzed all twenty of the samples by gamma spectroscopy. Ten of the samples were further characterized by chemical separation and analysis. The highest concentration for each radionuclide is provided in Table 4-3. These are the proposed background levels.

[1] In these simulations, it was assumed that people rinse heavily soiled food items with water, therefore D and D Version 2.1.0 parameters MLV (1), MLV (2), MLV (3) and MLV (4) were reduced by a factor of 10 (e.g., to 0.01).

Table 4-2. Tissue Equivalent Dose Rates at Background Locations [a] (microrem/hour)

Location I.D.	Reading on contact with ground surface	Reading at 1 meter above surface
B01	11	11
B02	11	11
B03	11	11
B04	11	11
B05	12	12
B06	12	12
B07	12	12
B08	11	11
B09	12	12
B10	12	12

[a] Background locations 1 – 4 are located in the southwest quadrant of the intersection of County Line Road and Swamp Creek Road. Locations 5 - 7 are located within the plant site fence approximately 235 feet south of the southwest corner of bulk storage bin #4. Location 8 – 10 are located at the southeast corner of the site fence, 100 feet south of County Line Road.

Table 4-3. Background Soil Concentrations

Isotope	Concentration (pCi/g)
Uranium-238	2.0
Uranium-234	1.5
Thorium-232	1.9
Thorium-230	1.6
Thorium-228	1.8
Actinium-228	2.6
Lead-214	1.4
Lead-212	3.6
Lead-210	2.1
Thallium-208	2.1
Potassium-40	43.8

4.2 DIRECT COUNT RATE RESULTS

Beta activity levels were measured by SEG (1993) in all structures and outdoor pads with the potential for residual radioactivity. The results are summarized in Appendix 2 of the SEG document (Reference 6.1), which contains the instrument readings and survey map locations for the various readings. SEG used a count rate meter with a shielded GM detector that was primarily sensitive to alpha and beta activity. In 1993, readings in all areas still being actively used for ore processing exceeded 3,000 dpm/l00 cm^2. Such areas would require decontamination.

Readings performed routinely as part of CSM's radiation protection programs indicate that conditions have not changed significantly since the 1993 surveys.

4.3 REMOVABLE ACTIVITY RESULTS

SEG took smears in all structures and outdoor pads with the potential for residual radioactivity. These results are summarized in Appendix 3 of Reference 6.1, which presents the counting results for these smears. Most portions of the ore processing facilities had activity levels exceeding 200 dpm/l00 cm^2. Results from routine surveys by CSM support those data, so they are assumed to require decontamination. Readings performed routinely as part of CSM's radiation protection programs indicate that conditions have not changed significantly since the 1993 surveys.

4.4 SOIL SAMPLE RESULTS

During the 1993 survey, SEG took soil samples in areas that they judged were likely to exhibit residual activity. The sample locations were based on historical records and preliminary measurement results. These results are summarized in Appendix 4 of Reference 6.1, which contains the instrument readings and the maps showing the survey locations. Most of the samples were surface composite samples taken within a couple of inches of the surface from within the sample areas. Soil activity levels of greater than the preliminary criterion of ~2.5 pCi/g of thorium-232 were considered significant. Most (31 of 46) of the surface samples were collected from active areas that exceeded the 2.5 pCi/g level. Deep soil samples were taken in areas where the activity level was expected to be well over this criterion. Four out of nine of the subsurface samples did not exceed 2.5 pCi/g of thorium-232. Deep soil samples were not obtained from near Buildings 73 and 74, as the soil was mostly gravel to a depth greater than 6 inches. It is important to note that the high quantities of gravel in some of these areas would allow ore products to penetrate deeper than could occur in the clay soil found in other areas.

In January 2003, WESTON collected soil samples at intervals of 0 – 6 inches and 6 – 12 inches below the ground surface from about 50 locations in potentially contaminated areas of the site. Based on those data, the areas for excavation were delineated and an excavation depth of 2 inches was established. This cost estimate uses soil volumes for excavation and disposal determined using these data.

4.5 URANIUM AND THORIUM CHAIN EQUILIBRIUM DATA

The ore material that is processed by CSM is a physical concentrate of niobium and tantalum minerals. It generally has no prior history of metallurgical extraction or chemical processing, so there is no reason to expect the uranium and thorium decay chains in the ore material to be out of equilibrium to a significant degree. Unprocessed ore material is present in the ore storage areas and ore grinding areas.

There is a mass balance between presscake (fluoride waste solids) and filtercake because the amount of radioactivity in discharged wastewater is negligible. The presscake that is produced by the tantalum extraction process is expected to be slightly deficient in lead-210 and polonium-210 compared to the other uranium decay chain isotopes that are present. Otherwise, the decay chains in presscake should be approximately in equilibrium. The presscake solids are likely to be a surface or soil contaminant in areas containing process equipment, the bulk storage bins, and on the haul road to the bulk storage bins.

Attachment 1 provides information on the degree of equilibrium among principal radioisotopes in soil contaminated by ore material and presscake. Based on the discussion and data in Attachment 1, affected soils have activity fractions of 42% Th-232 and 58% U-238. These activity fractions differ from the fractions that have been determined from analytical data used for other studies of site conditions, such as historical determinations of the fractions in ore material, and the most recent ore data that were used to establish a derived air concentration (DAC) based on data from recent ore shipments. The likely reason for this difference is variability in the ore fractions over the years the plant has operated. For purposes of remediation, these data support the assumption that both decay chains are in equilibrium with their gamma emitting progeny.

Lead-210 and polonium-210 appear to partition slightly into the liquid phase during the extraction of tantalum from the ore material with hydrofluoric acid. The filtercake that is directly disposed at regional landfills was studied in detail during 2002. Filtercake contains lead-210 and polonium-210 in higher concentrations relative to the rest of the uranium decay series.

On average, filtercake has the concentrations provided in Table 4-4.

Table 4-4. Average concentrations of radionuclides in filtercake.

Radionuclide	Average Landfill Sludge (pCi/gram)
U-238	2.33
Th-230	2.82
Ra-226	1.16
Pb-210	17.8
Po-210	8.04
Th-232	0.31
Th-228	0.31

The isotopes that are listed in Table 4-4 are the only ones present in the filtercake in significant concentrations. The *Dose Assessment for Recycling of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania* (Weston Solutions, 2003) presents plots and an extended discussion of the filtercake isotopic data. It concludes that:

- Appreciable amounts of licensed thorium-232 chain radionuclides do not appear to be present in the filtercake,
- U-238, Th-230, Ra-226 and Po-210 concentrations appear to be directly correlated, and
- Th-232, Pb-210 and U-238 concentrations do not appear to be correlated with one another.

Filtercake will not be present on-site to any appreciable degree because its routine disposal at local landfills is necessary for daily plant operations to continue. Filtercake is only likely to be present as a soil contaminant in the immediate vicinity of the wastewater neutralization plant, and may not be present in concentrations that exceed cleanup levels. Radionuclide concentrations would be very low in soils contaminated with filtercake, as indicated by data from samples collected in January of 2003 and presented in Table 4-5. The low levels are reasonable because the filtercake itself has very low concentrations.

Table 4-5. Soil Concentrations Around The Waste Water Filtration Building

	Sample Location I.D.					
	I26-06-061	**I26-12-062**	**I28-06-065**	**I28-12-066**	**I29-06-057**	**I29-12-058**
U-238	1.57 ±0.39	NR	0.95 ±0.30	NR	1.92 ±0.55	NR
U-234	1.40 ±0.36	NR	0.53 ±0.21	NR	1.88 ±0.54	NR
Th-232	1.20 ±0.37	NR	0.30 ±0.13	NR	0.46 ±0.23	NR
Th-230	1.37 ±0.40	NR	0.89 ±0.26	NR	1.54 ±0.47	NR
Th-228	1.11 ±0.35	NR	0.27 ±0.13	NR	0.45 ±0.22	NR
Pb-214	2.35 ±0.45	2.39 ±0.31	0.73 ±0.19	1.07 ±0.19	2.39 ±0.36	0.67 ±0.16
Pb-212	3.20 ±0.46	2.30 ±0.30	0.28 ±0.11	1.03 ±0.17	1.26 ±0.24	1.02 ±0.16
Pb-210	3.75 ±0.72	NR	1.73 ±0.55	NR	2.33 ±0.66	NR

4.6 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SOIL CONTAMINATION

4.6.1 Future Land Use and Exposure Scenario

The Boyertown site is located on the fringes of suburban Boyertown. Assuming no significant changes from past trends, land use around the site will be industrial or suburban within in the next decade or two. To be conservative, CSM assumes that the future land use will be suburban-residential. Therefore the critical group is assumed to be suburban gardeners.

Suburban-residential land use implies a number of modifications to the standard scenario represented by D and D 2.1.0 (McFadden 2001). Suburban-residential land use typically does not involve raising poultry, livestock, or aquaculture. In addition, commodity crops such as wheat, rye or barley are not typically found in suburban-residential gardens.

4.6.1.1 Average Consumption Rate of Homegrown Produce for the Northeastern U.S.

The Exposure Factors Handbook (EPA 1998) (EFH), Table 13-33 provides regional consumption rates of fruits and vegetables for the northeastern United States. The average consumption rates, Figures 1 and 2 were calculated from the EFH data using Crystal Ball 2000.

Crystal Ball Input for Homegrown Fruit Consumption Rate for Northeastern US.

Consumption Rate (kg/y)	Percentile
0	0
1.04E-01	0.01
5.17E-01	0.05
1.25E+00	0.1
4.54E+00	0.25
9.48E+00	0.5
1.72E+01	0.75
3.89E+01	0.9
7.88E+01	0.95
1.34E+02	0.99
1.48E+02	1

Crystal Ball Results for Homegrown Fruit Consumption Rate for Northeastern US.

Statistics:	Value:
Trials	25000
Mean (kg/y)	18.61
Median (kg/y)	9.72
Standard Deviation (kg/y)	26.26

Figure 4-1. Crystal Ball input and results for the homegrown fruit consumption rate for the northeastern US.

Crystal Ball Input for Homegrown Vegetable Consumption Rates for Northeastern US.

Consumption Rate (kg/y)	Percentile
0	0
3.05E-02	0.01
4.17E-01	0.05
9.35E-01	0.1
5.22E+00	0.25
1.19E+01	0.5
3.60E+01	0.75
8.72E+01	0.9
1.50E+02	0.95
2.30E+02	0.99
2.65E+02	1

Crystal Ball Results for Homegrown Vegetable Consumption Rate for Northeastern US.

Statistics:	Value:
Trials	25000
Mean (kg/y)	33.94
Median (kg/y)	11.94
Standard Deviation (kg/y)	49.35

Figure 4-2. Crystal Ball input and results for the homegrown vegetable consumption rate for the northeastern US.

Based on Figures 4-1 and 4-2, the values input into D and D 2.1.0 were: 19 kg per year of homegrown fruit, 34 kg/year of homegrown vegetables. The homegrown vegetable consumption distribution in Figure 2 includes all vegetables as well as grains. One half of the vegetables are assumed to be leafy for the purposes of running D and D 2.1.0. The grain ingestion rates in D and D 2.1.0 were set to zero since the grain contribution is already included in with the other vegetables in the EFH dataset.

4.6.1.2 Probability Distributions for MLV(1), MLV(2) and MLV(3)

The values of D and D variables MLV(1), MLV(2), and MLV(3) pertain to dry weight soil mass loading on homegrown fruits and vegetables that are consumed by humans. These were not assigned distributions in D and D 2.1.0. Nonetheless, these are very sensitive factors. A distribution for these variables was obtained using the Decisioneering Crystal Ball software package, D and D's dry to wet weight distribution for fruit and the soil adhesion distribution for fresh produce from page 104 of NCRP 129. The NCRP distribution had a geometric mean of 0.001 and geometric standard deviation of 2.2. The wet to dry distributions for leafy vegetables and roots were judged to be very similar to the distribution for fruit, so the MLV that was derived herein for fruit was used for all three.

Crystal Ball sampled both distributions to obtain a series of data pairs (or vectors) of *dry to wet weight* and *fresh produce soil adhesion fraction*. For each vector *i*, Crystal Ball computed a value of MLV:

$$MLV_i = \frac{(\text{fresh produce soil adhesion fraction})_i}{(\text{dry to wet weight fraction})_i}$$

The histogram for MLV, which was obtained from the Crystal Ball report for this simulation, was entered as "continuous linear distributions" for MLV(1), MLV(2) and MLV(3) into D and D 2.1.0. The MLV distributions may be viewed in the D and D reports that are provided in Attachment 2.

4.6.1.3 Proposed Soil DCGL Values

Based on these assumptions, the derived concentration guideline (DCGL) values for soil are provided in Table 4-6. The individual DCGL values, which represent a total effective dose equivalent of 25 mrem/year, do not apply independently. Instead, a sum of the ratios would be computed for each survey unit.

Table 4-6. DCGL Values for Residual Radioactivity in Soil

Isotope	DCGL (pCi/g) in excess of background
Thorium-232 equilibrium chain	2.94
Ra-228 + chain	3.48
Uranium-238 equilibrium chain	2.38
Ra-226 + short lived progeny	3.30
Pb-210 + chain	6.56

Net dose equivalent rate DCGL values were estimated using Microshield version 6, Attachment 3. One DCGL for soil contaminated by a mixture having a ratio of 42% Th-232 / 58% U-238 would have 1.55 pCi/gram of U-238 and 1.125 pCi/g of Th-232 in equilibrium with progeny. The net isotropic deep dose equivalent rate for this mixture would be 11.3 microrem/hr above background. These values apply strictly for the purpose of establishing a cost estimate for decommissioning and are not intended as a basis for license termination.

4.7 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SURFACE CONTAMINATION

D and D 2.1.0 was used to derive surface contamination DCGL values for structures. It is anticipated that structures will be decontaminated to satisfy the DCGL values stated in this section. The structures will then either be re-used or demolished by standard demolition techniques.

All default values are used in the building occupancy scenario calculation, with one exception. An effective indoor resuspension factor, RF_o^*, of 10^{-6} m^{-1} was used. This value is recommended and justified in draft NUREG-1720, *Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for License Termination* (NRC, 2002).

For the case of ore material on contaminated surfaces, equilibrium is assumed in the decay chains through Ra-226 and Ra-224. Rn-222 and Rn-220 are progeny are assumed to be present at 90% of their equilibrium values. Thorium-doping work areas are assumed to have the most unfavorable composition for gross radiation measurement that is possible: 42.4% equilibrium between Th-232 its progeny.

These assumptions lead to the DCGL values in Table 4-7.

Table 4-7. DCGL Values for Surface Contamination

	Isotope	**Gross Alpha/Beta DCGL values**
Ore Material or Presscake	U-238+chain	1862 dpm alpha/100 cm^2 1372 dpm beta/100 cm^2 245 dpm U-238/100 cm^2
	PbBiPo-210	2136 dpm alpha/100 cm^2 or 4272 dpm beta/100 cm^2 2136 dpm Pb-210/100 cm^2
	Th-232+chain	470 dpm alpha/100 cm^2 or 313 dpm beta/100 cm^2 82.5 dpm Th-232/100 cm^2
Thorium doping	Th-232+chain	288 dpm alpha/100 cm^2 157 dpm beta/100 cm^2 92 dpm Th-232/100 cm^2

Mixture DCGLs for surfaces contaminated by ore material or presscake solids are calculated as follows, assuming the activity ratios for soil contamination, 42% Th-232 and 58% U-238:

$$\text{Gross Alpha DCGL} = \frac{1}{\frac{0.42}{288} + \frac{0.58}{1862}} = 565\ \frac{\text{dpm}}{100\ \text{cm}^2}$$

$$\text{Gross Beta DCGL} = \frac{1}{\frac{0.42}{157} + \frac{0.58}{1372}} = 323\ \frac{\text{dpm}}{100\ \text{cm}^2}$$

These are the best estimates available and are provisional gross alpha and gross beta DCGL values for surface contamination. These values apply strictly for the purpose of establishing a cost estimate for decommissioning and are not intended as a basis for license termination. Prior to submitting a final decommissioning plan, the isotopic ratios for surface contamination should be determined from wipe sampling of representative surfaces.

5. COST ESTIMATE

The estimated cost for this project is $5,894,248 with the limitations and assumptions discussed previously. This estimate includes decontamination of equipment, concrete, and material (where feasible), radioactive waste disposal, radioactive waste volume reduction, health physics support, and final release survey. Details of the cost elements and methodologies are discussed below.

5.1 ESTIMATING APPROACH

This cost estimate is based on a detailed survey performed in 1993 by SEG (Reference 6.1), results of routine surveys performed at the site in the years since 1993, and supplemental measurements and laboratory analyses acquired in January 2003. This cost estimate reflects present day (2003) decommissioning standards and unit costs for labor, equipment rental, transportation, and disposal.

The Radiation Safety Officer at CSM indicated in 2002 that the licensed activities are continuing in essentially the same locations at the CSM facility as they were in 1993, with minor changes as noted in this report. In addition, no major spills or releases of radioactive materials have occurred since 1993. Therefore contamination levels in plant areas are considered to be unchanged from 1993. However, the depth of contamination in soils around the site is considered now to require excavation to a depth of 12 inches rather than the 6 inches used in the 1993 cost estimate.

The release criteria for standing structures and soil have changed from numerical concentrations to a dose-based standard of 25 mrem/y. This made it necessary for WESTON to modify certain assumptions that SEG made concerning the extent of contamination that would have to be removed from standing structures and soil. Those assumptions were that more extensive decontamination would be required for standing structures and additional contaminated soil would require off-site disposal.

5.1.1 Procedures used to estimate the areas requiring cleanup

Surface contamination estimates were based on physical dimensions for the CSM plant and information provided in the 1993 survey performed by the Scientific Ecology Group (SEG). The building surface contamination areas that required cleanup were updated to include new areas where licensed activities, such as thorium doping are taking place.

Soil contamination volumes requiring cleanup were based on the 1993 SEG decommissioning funding plan as well as a supplemental radiological characterization that was performed by WESTON in January 2003. The goals of the WESTON supplemental characterization were to define background, to better define depths of contamination, to characterize the extent of contamination around the bulk storage bins, and to provide data for the revised DCGL calculations.

Estimates of surface contamination in plant areas were similarly based on the 1993 SEG report and verified by a review of contamination data from routine surveys performed in the past several years by CSM.

Current labor rates, transportation fees, and disposal charges were applied to the activities, and volumes and quantities of materials associated with the decommissioning effort. Rates, fees, and charges came from three sources, as listed below.

- Current quotes or existing contract rates of transportations and disposal charges from the licensed disposal sites that are currently acceptable to CSM,
- Labor rates that would be quoted by Weston Solutions in a competitive bid for similar work, as taken from proposals completed in the past year, or
- Regional rates for construction labor and equipment rental quoted in industry references, such as "RS Means Labor Rates for Construction Industry, 2002" for the Reading. PA region.

5.2 ESTIMATING METHODOLOGY

WESTON developed tables that correlate closely with the guidance provided in NUREG 1757, Volume 3, Appendix A to provide the buildup to the total cost estimate. WESTON's cost estimate tables are provided in Attachment 4. The rationale for the values in those tables is explained in the following sections. Unit costs and explanations are provided for each of the major categories of work that would need to be performed. Contracted labor and health physics personnel were assumed to provide support for all decommissioning activities. Time estimating factors, hours by labor category, labor rates, labor costs by major decommissioning task, equipment rental rates, and laboratory charges are provided in Tables 4, 8, 9, 10, 12, and 13 of 4. Table 15 in Attachment 4 provides a summary roll-up and total of all costs. Attachment 5 provides an ALARA analysis of this methodology as required by NUREG-1757, Volume 2, Appendix N.

5.2.1 Equipment and Tank Decontamination

In 1993 SEG assumed that equipment decontamination would generate a compacted waste volume equivalent to 5% of the volume of the equipment being decontaminated. That value is applied for the new cost estimate for the following reasons:

- The NRC accepted that volume reduction ratio for the CSM site in the last cost estimate and has not provided more stringent values.
- SEG had extensive experience with such activities and based their estimate on that experience.
- Methods for compacting structural materials and equipment have continued to improve since 1993 and would, if anything, make the assumed volume reduction ratio easier to attain than in 1993.
- The volume estimate for equipment and tank decontamination includes both protective clothing and cleaning materials.

The numbers and dimensions of facility components are provided in Table 1 of Attachment 4. Unit labor factors for handling the equipment are provide in Table 4 of Attachment 4.

5.2.2 Concrete and Surface Decontamination

Concrete processing costs were estimated from WESTON construction experience with scabbling and pressure washing concrete surfaces, which correlated well with SEG's decommissioning experience described in the 1993 cost estimate. Labor costs and equipment rental rates are taken from WESTON proposal efforts developed in the past year for similar activities and from accepted construction pricing references such as "RS Means Labor Rates for Construction Industry, 2002" for the Reading, PA region. The percentage of the areas in the structures that will have to be decontaminated was increased beyond those previously defined by SEG to meet the current decommissioning criteria. Dimensions and calculations for the facility structures are provided in Table 2 of Attachment 4.

5.2.3 Soil Decontamination and Determination of Volumes

Soil decontamination includes the removal of three categories of material: residual ores, presscake, and contaminated soils around the operations buildings. The volume of ores was taken as the average quantity of ore held on-site to ensure continued operations of the site. Realistically, the ore feedstock should not be included in the cost estimate for decontamination because it is a valuable commodity and common sense dictates that CSM would use up all ores on-site prior to terminating its license. In addition, if ores were left at the site when CSM ceased operating, they would transfer them to another licensee who would pay for transportation, or they would sell them to another licensed operator to regain the price that had been paid for them. .

The volume of contaminated soil to be excavated was estimated by establishing contours around the process buildings based on the soil sample results and the DCGLs calculated in this document. This evaluation assumes that soils under the process building floors are not contaminated because the most common method of spreading contamination beneath concrete is by spills of liquids, and the liquids in the CSM process contain very limited amounts of the radionuclides. The presscake (fluoride residues that are disposed at the bulk storage bins) volumes were assumed to be the current amount of about 4,000 tons, which will diminish over the near future, as material is disposed at the Utah uranium mill site. Volumes of these materials are listed in Table 2 of Attachment 4.

5.2.4 Radioactive Waste Transportation and Disposal Cost

Contaminated piping, equipment, and objects that cannot be properly decontaminated or surveyed for surface contamination are assumed to be radioactive waste. These materials would be disposed of at a licensed disposal facility. Rates are provided in Table 11 that were acquired from WESTON proposals that had been completed since January 2001 for disposal of similar materials at Envirocare in Utah. Presscake, ores, and soils and concrete chips that exceeded release criteria would be transported to a licensed uranium mill in the western United States. CSM signed a contract with IUC in February 2004 and is listed on the IUC license as a source material supplier. Unlimited quantities of material may be transferred under this contract. The contract terms are valid for one year with options to extend the contract annually.

Transportation costs and disposal fees associated with uranium recovery processing are current CSM contract rates of $640 per ton and $298 per ton, respectively. Packaging, shipping, and disposal costs are provided in Table 11 of Attachment 4.

5.2.5 Radioactive Waste Volume Reduction Cost

Soil processing in the form of segregation will be applied to the soils and scabbling wastes because those materials are not homogeneously contaminated and are therefore readily addressed by this process. WESTON contacted a radiological services company that operates a segmented gate soil sorter to acquire current values for volume reduction rates and costs. The effectiveness of soil sorting will depend on how uniformly the radioactive material is distributed in the soil. Volume reduction factors have ranged from 0 to 99% at 15 project sites operated by the contractor, and the higher reduction rates were found under conditions that were similar to those at the CSM plant. For this estimate the volume reduction is assumed to be 95% because the contractor's recent experience supported that value and that correlates with the value used in the 1993 cost estimate that was previously accepted by the NRC.

The contractor estimated fully loaded costs at between $20 and $50 per cubic yard of soil processed, which correlated with the cost for that unit at a current WESTON pilot project in the Midwest. The higher price was applicable if the contractor had to provide excavation, soil handling, and health and safety support on the project. Costs for excavation, handling and safety support are included in other parts of this cost estimate, so commercially available soil sorting services were estimated at a fully loaded cost of $ 20 per cubic yard of soil processed. Volume reduction for equipment and debris involve cutting and sizing the materials as they are removed from the facility. The 95% volume reduction estimate provided by SEG in the 1993 cost estimate is believed to still be appropriate because the estimates were made by a well known and respected radiological services vendor, and the nature of the contaminated debris has not changed since 1993. Those costs are included in the construction labor rates used in this estimate. Soil volume reduction costs are listed as a line item in table 15 of Attachment 4.

5.2.6 Survey and Release

The costs for completing the final status surveys of the site were estimated using the measured areas of the excavations, floors, walls, and ceilings. Reasonable rates were established for performing each type of measurement, and current labor rates for several worker categories, including rad tech, decon tech, rad supervisor, and Certified Health Physicist were factored by the duration of each task. Hours and costs for Final Status Surveys are tallied as an individual line item.

5.2.7 Health Physics Support Cost

Labor rates for construction workers and health physics staff are provided in Table 9 of Attachment 4. The time required for a Radiological Technician to conduct final release surveys is itemized in Table 7 of Attachment 4, and the time required for support from a Radiological Supervisor and Site Manager is factored at one-third of the technician's time. A Certified Health Physicist is included as a lump sum of 300 hours to support the planning and final status survey data evaluation.

5.2.8 Taxes and Contingency

Tax is estimated at the 6% Pennsylvania state gross receipts rate. According to WESTON financial managers, state taxes are applicable only to the activities that are completed within the state. A 15% contingency is applied to the full subtotal cost. This is less than the standard value (25%) used by the U. S. Nuclear Regulatory Commission, but is justified by the following conditions:

- The approach to estimating costs is generally as would be performed by a contractor developing a construction bid. All labor costs are for private contractors at rates that include at least a 10% profit margin.

- The estimate is detailed and conservative in many of its assumptions, thereby incorporating contingencies into individual cost factors and limiting the potential for omitting relevant expenses.

- The conditions at the site are well known, the site has no periods of unknown or uncontrolled operations, and the site owners/operators have generally complied with regulatory requirements.

- The quantities of licensed radioactive materials and the site areas where they are handled are small compared with many industrial operations such as uranium mills. CSM is committed to having no more than 4,000 metric tons (MT) of presscake in its waste inventory. Cost estimates are based on disposing of approximately this quantity of presscake. This limits the potential for significant costs to be overlooked. Furthermore, CSM initiated a program in 2003 to dispose of the stored presscake, which represents 88% of the more than $4 million in packaging, transportation, and disposal costs. The first shipment of presscake was made in March 2004, shipments will continue until all stored presscake is disposed, and CSM plans to discontinue the practice of stockpiling the material. . Thus, minimal quantities of presscake will remain on-site and the estimated costs will be significantly reduced after June of 2004.

This estimate is for budgetary purposes only and is not a proposal or cost estimate for WESTON to perform work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

5.3 THE TOTAL COST OF DECOMMISSIONING THE BOYERTOWN SITE

The grand total estimated for decommissioning is $5,740,722. In general, the increase in decommissioning costs resulted from the restrictive cleanup levels that are implied by the current dose-based license termination standard, inflation related increases in labor and equipment rates and disposal fees, and the addition of costs to handle the presscake. These increased costs were offset to a degree by locating facilities that will accept contaminated soil as feed material or as solid waste for land disposal. The 2003 decommissioning cost estimate represents a 45% increase over the SEG decommissioning cost estimate given in Reference 6.1.

6. REFERENCES

6.1 Scientific Ecology Group, Inc. (SEG), Decommissioning Cost Estimate for Boyertown, Pennsylvania Site, 1993.

6.2 NRC, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, 1984.

6.3 NRC, Consolidated NMSS Decommissioning Guidance: Decommissioning Process, Draft NUREG-1757, Volume 1, 2002.

6.4 NRC, Residual Radioactive Contamination From Decommissioning, User's Manual D and D Version 2.1, NUREG/CR-5512, Vol. 2, 2001.

6.5 EPA 1998. Exposure Factors Handbook, Volume 2, PB98-124233, Chapter 13. Washington, DC.

6.6 K McFadden, et al. 2001. Residual Radioactive Contamination From Decommissioning: User's Manual D and D Version 2.1. NUREG/CR-5512, Vol. 2, SAND2001-0822P. Sandia National Laboratories, Albuquerque, NM.

6.7 NCRP 1999. Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies. NCRP Report No. 129. National Council on Radiation Protection and Measurements, Bethesda, MD, Page 104.

6.8 NRC 2002. Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for License Termination, Draft NUREG-1720, Nuclear Regulatory Commission.

6.9 Weston Solutions 2003. Dose Assessment for Recycling of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania. Submittal to NRC by Weston Solutions, Inc.

APPENDIX H

ATTACHMENT 1

Degree of Equilibrium in Ore Material and Presscake Solids

Attachment 1: Degree of Equilibrium in Ore Material and Presscake Solids

This attachment provides isotopic ratio data for the general area of the site. This section does not address the wastewater treatment plant. Uranium, thorium and lead-210 values were based on chemical separation and analysis. Lead-212, actinium-228 and lead 214 were based gamma spectroscopy. Review of the data leads to the following impressions:

- U-238 and U-234 are approximately in equilibrium (Figure A-1),
- The ore material and the presscake solids are difficult materials to dissolve, leading to systematically low concentration estimates of uranium, thorium, and lead-210 (Figures A-2, A-3, A-6),
- Since equilibrium is present within the analyte pairs Th-228 - Th-232 (Figure A-5) and Ac-228 – Pb-212 (Figure A-7), the entire Th-232 decay chain appears to be in equilibrium.
- It would be conservative to assume that the uranium decay chain is in equilibrium for the purposes of deriving soil DCGL values.
- The average activity percent in soil is 58% U-238: 42% Th-232 (Figure A-4).

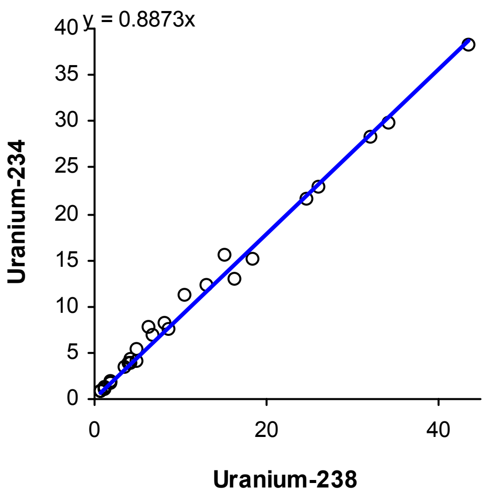


Figure A-1. U-238/U-234 Ratio

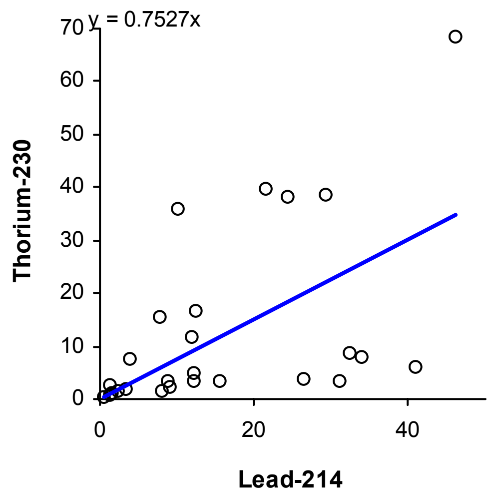


Figure A-2. Pb-214/Th-230 Ratio

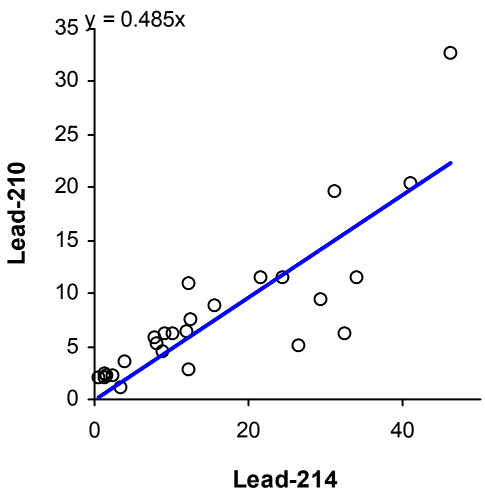


Figure A-3. Pb-214/Pb-210 Ratio

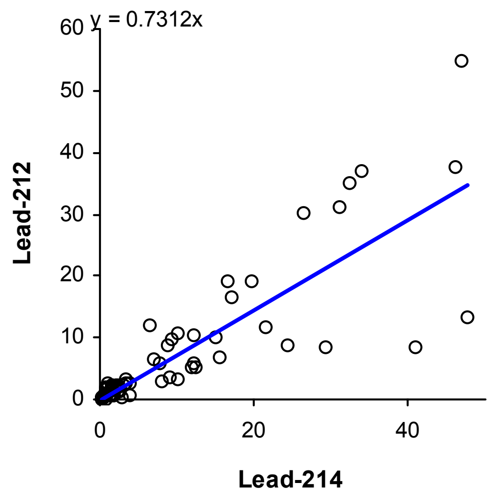


Figure A-4. Pb-214/Pb212 Ratio

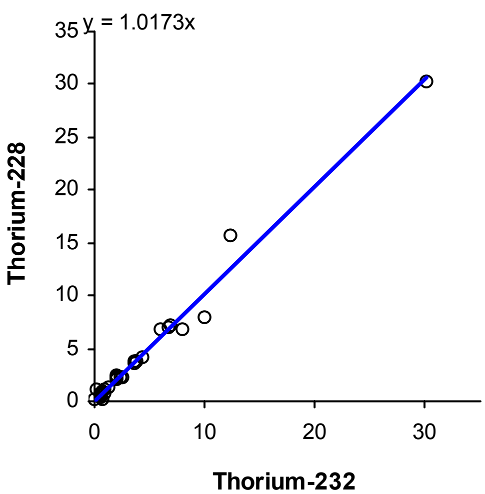


Figure A-5. Th-232/Th-228 Ratio

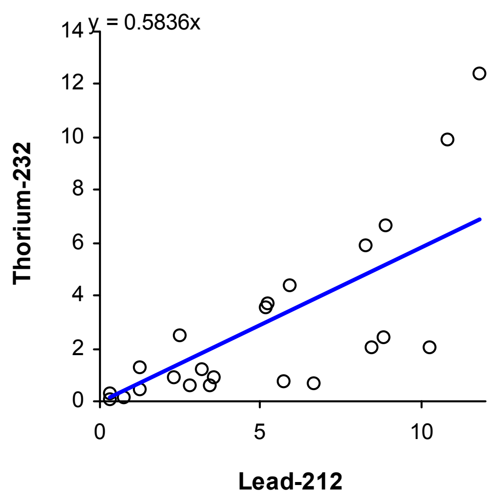


Figure A-6. Pb-212/Th-232 Ratio

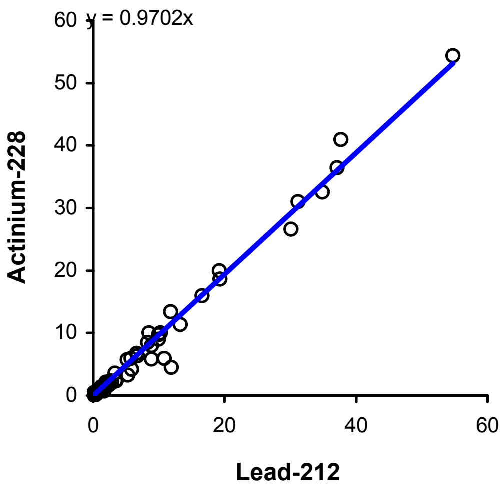


Figure A-7. Pb-212/Ac-228 Ratio

Based on Figures A-1 through A-7, it is apparent that areas affected by either presscake solids or ore material are not in decay equilibrium. However, cleanup can be verified by gamma spectroscopy using the analytes Pb-212 or Ac-228 as surrogates for the Th-232 chain and Pb-214 as a surrogate for the U-238 decay chain. Direct gamma measurements can guide routine excavation.

APPENDIX H

ATTACHMENT 2

D and D 2.1.0 Simulations Supporting the Soil DCGLs

Attachment 2: D and D 2.1.0 Simulations Supporting the Soil DCGLs

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/14/2003 4:19:44 PM
Site Name: Cabot Boyertown -Suburban resident -U238 + chain
Description: Cabot Boyertown -- Suburban resident +U-238+chain
FileName:C:\D and D_Docs\UraniumResidential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentrations for each radionuclide		Value 1.40E+01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)

Parameter Name	Description	Distribution
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02

Parameter Name	Description	Distribution	
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01

Parameter Name	Description	Distribution
		3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 1.04E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 8.64E+00 **to** 1.28E+01 **mrem/year**

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/9/2003 11:06:06 AM
Site Name: Cabot Boyertown -Suburban resident -Pb-210
Description: Cabot Boyertown -- Suburban resident Pb-210 + Po-210
FileName:C:\D and D_Docs\Pb210-Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
210Pb	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL value		Value 1.00E+00
210Bi	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calculation		Value 1.00E+00
210Po	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calculation		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a		Value 0.00E+00

Parameter Name	Description	Distribution
suburban activity		
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page		Value Probability

Parameter Name	Description	Distribution	
104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01

Parameter Name	Description	Distribution
		4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 3.81E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 3.24E+00 **to** 5.04E+00 **mrem/year**

D and D Building Occupancy Scenario

D and D Version: 2.1.0
Run Date/Time: 6/14/2003 4:43:36 PM
Site Name: Building Occupancy
Description: Radium226+ Chain Building Occupancy
FileName:C:\D and D_Docs\Ra-6-BO-6-10-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
226Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Po	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: presumed degree of equilibrium		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 100 **calculated TEDE values are <** 1.58E-02 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 1.58E-02 **to** 1.58E-02 **mrem/year**

D and D Building Occupancy Scenario

D and D Version: 2.1.0
Run Date/Time: 6/14/2003 5:04:29 PM
Site Name: Building Occupancy
Description: Ra-228+chain, ore material Building Occupancy,
FileName:C:\D and D_Docs\Ra-228+chain-BO-OreMaterial.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 1.00E+00
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01

Nuclide	Area of Contamination (m^2)	Distribution
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed equilibrium value		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 100 **calculated TEDE values are <** 5.70E-02 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 5.70E-02 **to** 5.70E-02 **mrem/year**

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/9/2003 10:56:20 AM
Site Name: Cabot Boyertown -Suburban resident -Radium-226
Description: Cabot Boyertown -- Suburban resident
FileName:C:\D and D_Docs\Radium226Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
226Ra	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: unit concentration for DCGL		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a		Value 0.00E+00

Parameter Name	Description	Distribution
suburban activity		
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page		Value Probability

Parameter Name	Description	Distribution	
104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01

Parameter Name	Description	Distribution	
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 7.58E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 6.84E+00 **to** 8.78E+00 **mrem/year**

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/9/2003 11:18:05 AM
Site Name: Cabot Boyertown -Suburban resident -Ra228 ch
Description: Cabot Boyertown -- Suburban resident Ra-228 +Th-228 chain
FileName:C:\D and D_Docs\Radium8Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
228Ra	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calcualtion		Value 1.00E+00
228Th+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calculation		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a		Value 0.00E+00

Parameter Name	Description	Distribution
suburban activity		
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page		Value Probability

Parameter Name	Description	Distribution	
104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01

Parameter Name	Description	Distribution
		4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 7.19E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 6.92E+00 **to** 7.61E+00 **mrem/year**

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/18/2003 5:32:53 PM
Site Name: CSM-Suburban resident -58%U238-42%TH232
Description: Cabot Boyertown -- Suburban resident
FileName:C:\D and D_Docs\rESIDENTIAL-58u-42TH-6-19-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: 0.58 pCi/g for each nuclide in chain		Value 8.12E+00
232Th+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: 0.42 pCi/g of each nuclide in chain		Value 4.20E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a		Value 0.00E+00

Parameter Name	Description	Distribution
suburban activity		
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page		Value Probability

Parameter Name	Description	Distribution	
104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01

Parameter Name	Description	Distribution	
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)	
Justification for modification: See the explanation for MLV(1)		Value	Probability
		2.20E-04	0.00E+00
		2.30E-03	5.00E-02
		3.20E-03	1.00E-01
		3.90E-03	1.50E-01
		4.70E-03	2.00E-01
		6.20E-03	3.00E-01
		7.90E-03	4.00E-01
		9.90E-03	5.00E-01
		1.20E-02	6.00E-01
		1.60E-02	7.00E-01
		2.10E-02	8.00E-01
		2.50E-02	8.50E-01
		3.10E-02	9.00E-01
		4.20E-02	9.50E-01
		3.90E-01	1.00E+00
		Default CONSTANT(none)	
		Value	1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 9.33E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 8.29E+00 **to** 1.10E+01 **mrem/year**

D and D Building Occupancy Scenario

D and D Version: 2.1.0
Run Date/Time: 6/14/2003 4:50:34 PM
Site Name: Building Occupancy
Description: Thorium+chain, ore material Building Occupancy,
FileName:C:\D and D_Docs\Th-232+chain-OreMaterial.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentrations		Value 1.00E+00
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 1.00E+00

Nuclide	Area of Contamination (m^2)	Distribution
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed equilibrium value		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 100 **calculated TEDE values are <** 3.03E-01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 3.03E-01 **to** 3.03E-01 **mrem/year**

D and D Building Occupancy Scenario

D and D Version: 2.1.0
Run Date/Time: 6/14/2003 4:53:28 PM
Site Name: Building Occupancy
Description: Thorium doping Building Occupancy, worst case equilibrium assumption
FileName:C:\D and D_Docs\Th-232+chain-doping.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentrations		Value 1.00E+00
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium assumption		Value 4.24E-01
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01

Nuclide	Area of Contamination (m^2)	Distribution
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: worst case equilibrium value		Value 4.24E-01
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 100 **calculated TEDE values are <** 2.70E-01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.70E-01 **to** 2.70E-01 **mrem/year**

D and D Residential Scenario

D and D Version: 2.1.0
Run Date/Time: 6/9/2003 11:10:56 AM
Site Name: Cabot Boyertown -Suburban resident -Th232 ch
Description: Cabot Boyertown -- Suburban resident Th232 chain
FileName:C:\D and D_Docs\Thorium232Residential-6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentrations for derivation of DCGL		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00

Parameter Name	Description	Distribution
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve D and D's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01

Parameter Name	Description	Distribution
		3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01

Parameter Name	Description	Distribution
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01 4.20E-02 / 9.50E-01 3.90E-01 / 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 113 **calculated TEDE values are <** 8.55E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 7.88E+00 **to** 9.44E+00 **mrem/year**

D and D Building Occupancy Scenario

D and D Version: 2.1.0
Run Date/Time: 6/13/2003 11:17:13 AM
Site Name: Building Occupancy
Description: Uranium Chain Building Occupancy
FileName:C:\D and D_Docs\U-BO-6-10-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
234Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
234Pa	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
234U	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
230Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00

Nuclide	Area of Contamination (m^2)	Distribution
226Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Po	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: presumed degree of equilibrium		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 1.02E-01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 1.02E-01 to 1.02E-01 mrem/year.

APPENDIX H

ATTACHMENT 3

Net Exposure Rate and Deep Dose Equivalent Rate DCGL

Attachment 3: Net Exposure Rate and Deep Dose Equivalent Rate DCGL

DCGL values in terms of net exposure rate and isotropic deep dose equivalent rate are derived in this section. These values are for use with air equivalent and tissue equivalent detectors respectively. All calculations are based on ANSI/ANS-6.6.1-1987 soil.

Figure C-1. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 mixture DCGL consisting of 58% U-238 activity and 42% Th-232 in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

Page	:1		
DOS File	:CABOT-GENERAL AREA-58U-42TH.ms6	**File Ref**	:
		Date	:
Run Date	: June 19, 2003	**By**	:
Run Time	: 5:54:16 AM	**Checked**	:
Duration	: 00:00:00		

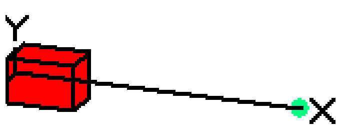
Case Title: Net U and Th
Description: EXTERNAL GAMMA DCGL ASSUMING 58% U- 42% TH
Geometry: 16 - Infinite Slab

Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	X	Y	Z
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in



Shields

Shield N	Dimension	Material	Density
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	1.8004e-006	6.6615e-002
Bi-210	2.4795e-006	9.1742e-002
Bi-212	1.8004e-006	6.6613e-002
Bi-214	2.4795e-006	9.1742e-002
Pb-210	2.4795e-006	9.1742e-002
Pb-212	1.8004e-006	6.6615e-002
Pb-214	2.4795e-006	9.1742e-002
Po-210	2.0305e-014	7.5127e-010
Po-212	1.1535e-006	4.2679e-002
Po-214	2.4790e-006	9.1722e-002
Po-216	1.8009e-006	6.6634e-002
Po-218	2.4800e-006	9.1760e-002
Ra-224	1.8009e-006	6.6634e-002
Ra-226	2.4800e-006	9.1760e-002
Ra-228	1.8004e-006	6.6615e-002
Rn-220	1.8009e-006	6.6634e-002
Rn-222	2.4800e-006	9.1760e-002
Th-228	1.8004e-006	6.6614e-002
Tl-208	6.4687e-007	2.3934e-002

Buildup : The material reference is – Source Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr/sec No Buildup	Exposure Rate mR/hr/sec With Buildup
0.015	8.476e-02	3.775e-05	1.176e-04	3.238e-06	1.009e-05
0.04	6.811e-04	1.658e-05	9.269e-04	7.335e-08	4.099e-06
0.05	4.730e-03	2.171e-04	1.715e-02	5.783e-07	4.569e-05
0.06	3.340e-04	2.363e-05	2.174e-03	4.694e-08	4.317e-06
0.08	4.990e-02	6.156e-03	5.220e-01	9.741e-06	8.260e-04
0.1	4.851e-03	8.584e-04	6.901e-02	1.313e-06	1.056e-04
0.15	2.772e-03	8.799e-04	4.198e-02	1.449e-06	6.913e-05
0.2	4.607e-02	2.175e-02	8.112e-01	3.840e-05	1.432e-03
0.3	3.630e-02	3.003e-02	7.168e-01	5.697e-05	1.360e-03
0.4	3.668e-02	4.549e-02	6.846e-01	8.864e-05	1.334e-03
0.5	1.088e-02	1.855e-02	2.028e-01	3.640e-05	3.981e-04
0.6	6.541e-02	1.450e-01	1.206e+00	2.831e-04	2.354e-03
0.8	2.989e-02	1.009e-01	5.815e-01	1.918e-04	1.106e-03
1.0	6.751e-02	3.168e-01	1.310e+00	5.840e-04	2.414e-03
1.5	2.640e-02	2.272e-01	6.583e-01	3.823e-04	1.108e-03
2.0	2.475e-02	3.270e-01	7.506e-01	5.056e-04	1.161e-03
3.0	2.389e-02	5.708e-01	1.029e+00	7.744e-04	1.396e-03
Totals	**5.158e-01**	**1.812e+00**	**8.604e+00**	**2.958e-03**	**1.513e-02**

A net exposure rate of 15.1 µR/hour corresponds to a net isotropic deep dose equivalent rate of 11.3 µRem/hour, according to the Microshield 6 Dose Equivalent Report.

Figure C-2. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 DCGL consisting of the U-238 chain in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

Page	:1	**File Ref**	:
DOS File	:CABOT-GENERAL AREA-100%U.ms6	**Date**	:
Run Date	: June 19, 2003	**By**	:
Run Time	: 4:54:59 AM	**Checked**	:
Duration	: 00:00:00		

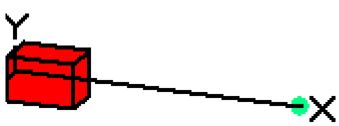
Case Title: Net U
Description: EXTERNAL GAMMA DCGL ASSUMING 100% U
Geometry: 16 - Infinite Slab

Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	X	Y	Z
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in



Shields

Shield N	Dimension	Material	Density
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	µCi/cm³	Bq/cm³
Bi-210	1.9417e-011	7.1844e-007
Bi-214	3.8072e-006	1.4087e-001
Pb-210	3.0832e-010	1.1408e-005
Pb-214	3.8072e-006	1.4087e-001
Po-210	3.1178e-014	1.1536e-009
Po-214	3.8064e-006	1.4084e-001
Po-218	3.8080e-006	1.4090e-001

Ra-226	3.8080e-006	1.4090e-001
Rn-222	3.8080e-006	1.4090e-001

Buildup : The material reference is - Source
Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.089e-02	9.305e-06	2.899e-05	7.981e-07	2.487e-06
0.05	1.558e-03	7.150e-05	5.648e-03	1.905e-07	1.505e-05
0.08	3.248e-02	4.006e-03	3.397e-01	6.340e-06	5.376e-04
0.1	1.912e-04	3.384e-05	2.720e-03	5.177e-08	4.162e-06
0.2	1.517e-02	7.166e-03	2.672e-01	1.265e-05	4.716e-04
0.3	2.907e-02	2.405e-02	5.740e-01	4.562e-05	1.089e-03
0.4	5.390e-02	6.685e-02	1.006e+00	1.303e-04	1.960e-03
0.5	2.516e-03	4.290e-03	4.691e-02	8.421e-06	9.209e-05
0.6	6.792e-02	1.506e-01	1.252e+00	2.939e-04	2.444e-03
0.8	1.331e-02	4.491e-02	2.589e-01	8.542e-05	4.925e-04
1.0	4.411e-02	2.070e-01	8.555e-01	3.815e-04	1.577e-03
1.5	2.682e-02	2.308e-01	6.687e-01	3.883e-04	1.125e-03
2.0	3.770e-02	4.980e-01	1.143e+00	7.700e-04	1.768e-03
Totals	**3.456e-01**	**1.238e+00**	**6.421e+00**	**2.124e-03**	**1.158e-02**

A net exposure rate of 11.6 μR/hour corresponds to a net isotropic deep dose equivalent rate of 8.6 μRem/hour, according to the Microshield 6 Dose Equivalent Report.

Figure C-3. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 DCGL consisting of the Th-232 chain in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

e	:1		
File	:CABOT-GENERAL AREA-100%Th.ms6	**File Ref**	:
		Date	:
Date	: June 19, 2003	**By**	:
Time	: 5:11:47 AM	**Checked**	:
ition	: 00:00:00		

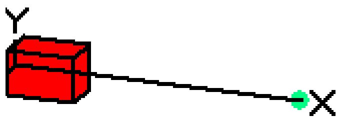
Case Title: Net Th
Description: EXTERNAL GAMMA DCGL ASSUMING 100% Th
Geometry: 16 - Infinite Slab

Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	X	Y	Z
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in



Shields

Shield N	Dimension	Material	Density
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	μCi/cm³	Bq/cm³
Ac-228	4.7040e-006	1.7405e-001
Bi-212	4.7040e-006	1.7405e-001
Pb-212	4.7040e-006	1.7405e-001
Po-212	3.0128e-006	1.1147e-001
Po-216	4.7040e-006	1.7405e-001
Ra-224	4.7040e-006	1.7405e-001
Ra-228	4.7040e-006	1.7405e-001
Rn-220	4.7040e-006	1.7405e-001
Th-228	4.7040e-006	1.7405e-001
Tl-208	1.6896e-006	6.2514e-002

Buildup : The material reference is - Source
Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr/sec No Buildup	Exposure Rate mR/hr/sec With Buildup
0.015	1.276e-01	5.684e-05	1.771e-04	4.875e-06	1.519e-05
0.04	1.780e-03	4.333e-05	2.422e-03	1.916e-07	1.071e-05
0.06	8.726e-04	6.174e-05	5.679e-03	1.226e-07	1.128e-05
0.08	7.511e-02	9.266e-03	7.857e-01	1.466e-05	1.243e-03
0.1	1.235e-02	2.185e-03	1.757e-01	3.343e-06	2.688e-04
0.15	7.242e-03	2.299e-03	1.097e-01	3.786e-06	1.806e-04

0.2	9.454e-02	4.464e-02	1.665e+00	7.880e-05	2.938e-03
0.3	4.538e-02	3.754e-02	8.960e-01	7.121e-05	1.700e-03
0.4	4.118e-03	5.107e-03	7.686e-02	9.951e-06	1.497e-04
0.5	2.414e-02	4.115e-02	4.500e-01	8.077e-05	8.833e-04
0.6	5.532e-02	1.226e-01	1.020e+00	2.394e-04	1.991e-03
0.8	5.545e-02	1.871e-01	1.079e+00	3.558e-04	2.052e-03
1.0	1.013e-01	4.756e-01	1.966e+00	8.766e-04	3.624e-03
1.5	2.335e-02	2.009e-01	5.821e-01	3.380e-04	9.794e-04
2.0	5.282e-04	6.977e-03	1.602e-02	1.079e-05	2.477e-05
3.0	6.239e-02	1.491e+00	2.687e+00	2.023e-03	3.645e-03
Totals	**6.915e-01**	**2.626e+00**	**1.152e+01**	**4.111e-03**	**1.972e-02**

A net exposure rate of 19.7 μR/hour corresponds to a net isotropic deep dose equivalent rate of 14.8 μRem/hour, according to the Microshield 6 Dose Equivalent Report.

APPENDIX H

ATTACHMENT 4

Summary Tables for DFP Cost Estimate

Table 1. A.3.5 Number and Dimensions of Facility Components

Building or Area	Description	Number of Components	Mass (lb)	Volume (ft^3)	Reference*
73	Digester System	322	22492	419	1
73	Filter Sludge Storage Area	12	9814	640	2
73	Filtration System	129	30428	2741	1
73	Kiln System	37	15218	378	1
73	Ore Grinding System	141	49361	4285	1
73	Outside Feed Tank Area	6	8892	1028	2
73	Outside Grinding Bag Filter Area	22	12812	183	2
73	Outside Kiln Bag Filter Area	17	3114	341	2
73	Outside Off-gas Scrubber System	68	9568	410	2
73	Roof Ore Classifier System	19	3203	298	2
73	Tanks	28	76523	6879	4
74	Extraction Systems	42	4011	82	2
74	Tanks	10	12936	5500	4
All	Pipe, conduit, stair railing	48	87583	1170	3
Bulk Storage Bins	Miscellaneous hardware	121	1760	539	2
Thorium doping systems	Miscellaneous (HEPA vac, ducts, 2 tables)	3	400	15	Current estimate
Total debris			**348,115**	**24,908**	

* Pages from Appendix 5 of 1993 SEG cost calculation sheets for the Boyertown Site.

Table 2. A.3.5 Number and Dimensions of Facility Buildings

Building or Area	Description	Area (ft^2)	% Contaminat	Depth (in)	Volume (ft^3)	Reference*
73	Ceiling	13585	0	0	0	6
73	Floor	13585	100	0.25	283	6
73	Wall	16285	100	0.25	339	6
74	Ceiling	13585	0	0	0	6
74	Floor	13900	100	0.25	290	6
74	Wall	16285	100	0.25	339	6
87	Ceiling	13585	0	0	0	6
87	Floor	3440	100	0.25	72	6
87	Wall	22760	66	0.25	313	6
99&102	Ceiling	53845	100	0.25	1122	6
99&102	Floor	53845	100	0.5	2244	6
99&102	Wall	35866	100	0.25	747	6
Bulk storage bins	Soil	62500	100	12	62500	Current estimate
Thorium doping room	Ceiling	64	0	0	0	Current estimate
Thorium doping room	Floor	64	100	0.25	1	Current estimate
Thorium doping room	Wall	256	100	0.25	5	Current estimate
Winter Slag Storage	Slab	2558	100	0.5	107	6
Building 73/74/87 soil	Soil	62500	100	12	62500	Current estimate
Haul road	Soil	56000	100	12	56000	Current
Total		**454,508**			**186,862**	

* Pages from Appendix 5 of 1993 SEG cost calculation sheets for the Boyertown Site, or other source.

Table 3. A.3.7 Dismantling of Radioactive Facility Components (Hours)

Building or Area	Description	Decon Method	Rad Tech	Demolition Worker	Heavy Equipment Operator	Rad Supervisor	Site Manager
73	Digester System	Remove, size, place in roll-offs	4	4	2	1	1
73	Filter Sludge Storage Area	Remove, size, place in roll-offs	6	6	3	2	2
73	Filtration System	Remove, size, place in roll-offs	27	27	14	9	9
73	Kiln System	Remove, size, place in roll-offs	4	4	2	1	1
73	Ore Grinding System	Remove, size, place in roll-offs	43	43	21	14	14
73	Outside Feed Tank Area	Remove, size, place in roll-offs	10	10	5	3	3
73	Outside Grinding Bag Filter Area	Remove, size, place in roll-offs	2	2	1	1	1
73	Outside Kiln Bag Filter Area	Remove, size, place in roll-offs	3	3	2	1	1
73	Outside Off-gas Scrubber System	Remove, size, place in roll-offs	4	4	2	1	1
73	Roof Ore Classifier System	Remove, size, place in roll-offs	3	3	1	1	1
73	Tanks	Remove, size, place in roll-offs	69	69	34	23	23
74	Extraction Systems	Remove, size, place in roll-offs	1	1	0	0	0
74	Tanks	Remove, size, place in roll-offs	55	55	28	18	18
All	Pipe, conduit, stair railing	Remove, size, place in roll-offs	12	12	6	4	4
Bulk Storage	Miscellaneous hardware	Remove, size, place in roll-offs	5	5	3	2	2
Thorium doping systems	Miscellaneous (HEPA vac, ducting, 2 tables)	Remove, size, place in roll-offs	0	0	0	0	0
Totals			**249**	**249**	**125**	**83**	**83**

Table 4. A.3.7 Unit Labor Factors

Unit Labor Factors (hours per ft^2 or ft^3)						
Operation	**Rad Tech**	**Decon Tech**	**Demolition worker**	**Rad Superv (1)**	**Heavy equip operator**	**Site Manager**
Pressure Washing (2)	1.7E-03	1.7E-03	0	5.56E-04	0	5.56E-04
Scabbling (3)	1.00E-02	1.00E-02	0	3.33E-03	0	3.33E-03
Excavation (4)	5.00E-04	0	0	1.67E-04	5.00E-04	1.67E-04
Final Status (5)	5.00E-03	0	0	1.67E-03	0	1.67E-03
Remove, size equip't & debris(4)	1.00E-02	0	0.01	3.33E-03	5.00E-03	3.33E-03

(1) 1 Rad Supervisor per 3 rad techs
(2) Pressure washing rate of 600 ft^2 per hour
(3) Scabble or remove/size eqpt/debris rate of 100 ft^3/hour
(4) Excavation rate of 2000 ft^3 per hour
(5) Final status survey rate is 200 ft^2/hour

Table 5. A.3.7 Decontamination of Radioactivity Facility Components (Hours)

Building	Description	Flag 1-Pressure wash, Grit blast, Vacuum (1=yes, 0=no)	Flag 2:Scabble, chip (1=yes, 0=no)	Flag 3: Excavate (1=yes, 0=no)	Rad Tech	Decon Tech	Heavy Equipment Operator	Rad Supervisor	Site Manager
73	Ceiling	1	0	0	23	23	0	8	8
73	Floor	1	1	0	25	25	0	8	8
73	Wall	1	1	0	31	31	0	10	10
74	Ceiling	1	0	0	23	23	0	8	8
74	Floor	1	1	0	26	26	0	9	9
74	Wall	1	1	0	31	31	0	10	10
87	Ceiling	1	0	0	23	23	0	8	8
87	Floor	1	1	0	6	6	0	2	2
87	Wall	1	1	0	41	41	0	14	14
99&102	Ceiling	1	0	0	90	90	0	30	30
99&102	Floor	1	1	0	112	112	0	37	37
99&102	Wall	1	1	0	67	67	0	22	22
Bulk Storage Bins	Soil	0	0	1	31	0	31	10	10
Thorium doping room	Ceiling	1	0	0	0	0	0	0	0
Thorium doping room	Floor	1	1	0	0	0	0	0	0
Thorium doping room	Wall	1	1	0	0	0	0	0	0
Winter Slag Storage	Slab	1	1	0	5	5	0	2	2
Building 73/74/87 soil	Soil		0	1	31	0	31	10	10
Haul road	Soil		0	1	28	0	28	9	9
Total hours					**594**	**503**	**91**	**198**	**198**

Table 6. A.3.8 Restoration of Contaminated Areas

Building	Description	Heavy Equipment Operator
Bulk Storage Bins	Soil	31.25
Building 73/74/87 soil	Soil	31.25
Haul road	Soil	28
Total hours	0	90.5

Table 7. A.3.9 Final Radiation Survey (Work Hours)

Building	Description	Rad Tech
18, 10, 23, 11, 41, 62	Floors/soil	142.5
73	Ceiling	67.925
73	Floor	67.925
73	Wall	81.425
74	Ceiling	67.925
74	Floor	69.5
74	Wall	81.425
87	Ceiling	67.925
87	Floor	17.2
87	Wall	113.8
99&102	Ceiling	269.225
99&102	Floor	269.225
99&102	Wall	179.33
Bulk storage facility	Soil	312.5
Thorium doping room	Ceiling	0.32
Thorium doping room	Floor	0.32
Thorium doping room	Wall	1.28
Winter Slag Storage	Slab	12.79
73/74 soil	Soil	312.5
Haul road	Soil	280
Total hours		2415.04

* Excludes Rad Supervisor, Site Manager, and CHP. Their costs show as factored values in Tables 8 and 10.

Table 8. A.3.11 Total Work Hours by Labor Category

Man Hours by Task							
Task	**Rad Tech**	**Decon Tech**	**Demolition worker**	**Rad Supervisor**	**Heavy equip't operator**	**Site Manager**	**CHP**
Planning and Preparation	0	0	0	100	0	100	200
Decon & Dismantling	843	503	249	281	215	281	0
Restoration*	0	0	0	0	30	30	0
Final Status	2,415	0	0	805	0	805	100
Total	**3,258**	**503**	**249**	**1,186**	**245**	**1,216**	**300**

*Recontouring is estimated at 1/3 the excavation time

Table 9. A.3.12 Worker Unit Cost Schedule

	Rad Tech	**Decon Tech**	**Demolition worker**	**Rad Superv**	**Heavy equip operator**	**Site Manager**	**CHP**
Fully loaded hourly billing rate	$64	$35	$26	$78	$37	$63	$133
Total Cost per day	$514	$278	$206	$623	$294	$504	$1,062

Table 10. A.3.13 Total Labor Costs by Major Decommissioning Task

Activity	**Rad Tech**	**Decon Tech**	**Demolition worker**	**Rad Superv**	**Heavy equip't operator**	**Site Manager**	**CHP**
Planning and Preparation	$0	$0	$0	$7,788	$0	$6,300	$26,550
Decon & Dismantling	$54,109	$17,513	$6,426	$21,880	$7,903	$17,699	$0
Restoration	$0	$0	$0	$0	$1,109	$1,901	$0
Final Status Surveys	$155,046	$0	$0	$62,694	$0	$50,716	$13,275
Total	$209,155	$17,513	$6,426	$92,362	$9,011	$76,616	$39,825

Table 11. A.3.14 Packaging, Shipping, and Disposal of Radioactive Material (Excluding Labor Costs)

A. Material Costs					
Waste Type	**Material Quantity (**MT)	**Number of Containers**	**Type of Container** (20 cu yd)	**Container Unit Cost**	**Total Packaging Costs**
Debris	158	2.3	Roll-off Bin	$390	$899
Scabbling Dust & Soil	422	17.3	Roll-off Bin	$390	$6,748
Presscake	3628	268.7	Roll-off Bin	$390	$52,404
Total					$60,052
B. Shipping Costs					
Waste Type	**Number of Loads**	**Cost per Load Truck/train ($)**	**Total Ship'g Cost**		
Debris	2	$12,800	$29,521		
Scabbling Dust & Soil	17	$12,800	$221,466		
Presscake	269	$8,640	$2,321,920		
Total			$2,572,906		
C. Disposal Costs					
Waste Type	**Disposal Quantity** (MT)	**Unit Cost (**$/MT)	**Surcharge**	**Total Disposal Costs**	
Debris	158	$650		$102,852	
Scabbling Dust & Soil	422	$298	$66	$153,734	
Presscake	3628	$298	$66	$1,321,144	
Total				$1,577,730	

Table 12. A.3.15 Equipment/Supply Cost (Excluding Containers)

Equipment & Supplies	Quantity days	Unit Cost ($/day)	Total Equipment and Supply Cost
Crane	30	$347	$10,414
Front end loader/Backhoe	60	$122	$7,327
Cherry Picker	60	$37	$2,241
Expendables	870	$39	$33,918
Rad Equipment	90	$100	$9,000
Total			$62,900

Table 13. A.3.16 Laboratory Costs

Activity	Total Cost
Gamma Spec	$30,400
Shipping	$1,000
Total	$31,400
Based on 400 samples	

Table 14. A.3.17 Miscellaneous Costs

Cost Item	Total Cost
Mob/Demob	$50,000
Total	**$50,000**

Table 15. A.3.18 Total Decommissioning Cost

Task Component	Cost
Planning/Preparation (Table 10)	$40,638
Decon & Dismantling (Table 10)	$125,530
Restoration of Contaminated Areas (Table 10)	$3,009
Final Status Surveys (Table 10)	$281,731
Site Stabilization and Long Term Surveillance	$0
Volume Reduction Costs	$138,416
Packing Material Costs (Table 11)	$60,052
Laboratory Costs (Table 13)	$31,400
Miscellaneous Costs (Table 14)	$50,000
Equipment /Supply Costs (Table 12)	$62,900
Subtotal	$793,676
Pennsylvania Sales Tax (6%)	$47,621
Transportation Costs (Table 11)	$2,572,906
Waste Disposal Costs (Fees) (Table 11)	$1,577,730
Full Subtotal	$4,991,933
15% Contingency	$748,790
Total Decommissioning Cost Estimate	**$5,740,722**

APPENDIX H

ATTACHMENT 5

ALARA Analysis

ALARA Analyses

NUREG-1757, Volume 2, Appendix N gives guidance to NRC licensees on how to do "as low as reasonably achievable" (ALARA) analyses. This attachment to the CSM Decommissioning Funding Plan addresses the NRC's ALARA requirements for termination of the source materials license under which the CSM Boyertown plant operates. This analysis follows guidance in the above referenced document, and uses the appropriate default parameters from the guidance document and site-specific information taken from the Decommissioning Funding Plan (DFP) Cost Estimate.

This ALARA analysis is tentative because the CSM Boyertown plant is still an active facility. CSM can provide reasonable cost estimates for decontamination to the derived concentration guideline levels (DCGL). It is unrealistic, however, to expect CSM to characterize an active facility to the point that they can accurately predict how decommissioning costs will vary as functions of alternative cleanup levels. Therefore, CSM has based the ALARA analyses on objective data for this situation, and made reasonable estimates and calculations on how the decommissioning costs would vary with changes in the cleanup level.

The decommissioning of the site will require two general activities, structure decontamination and surface soil remediation. These activities are distinctly different in terms of the methods and the cleanup levels required. The ALARA analyses for these two work activities are necessarily different, and so they are considered individually.

ALARA Analysis for Soil Contamination

Based on CSM's experience at other sites in the State of Pennsylvania, it would be difficult to obtain approval from the Pennsylvania Department of Environmental Protection to create a disposal cell that will receive low-level radioactive remediation waste onsite. Consequently, disposal on-site is not considered an option in this analysis. Surface soils and materials such as gravel or pavement that do not meet the DCGL will be excavated and transported to a disposal facility in the western United States that is licensed to receive the types of materials removed from the site. CSM signed a contract in February 2004 for transfer of presscake and contaminated soil to the IUC facility, which is located in Blanding, Utah. The remediation and transportation unit costs are the same whether the material is sent to IUC or Envirocare. However the transfer fees are somewhat lower for sending source material to IUC rather than low-level waste to Envirocare ($298 per MT vs. ~$650 per MT). The overall cost differences are sufficiently small that the conclusions provided by example 3, "Removing Surface Soil" of NUREG-1757 Volume 2, Appendix N remain valid, and it is not cost effective to further reduce residual soil contamination levels because wastes will be shipped off-site.

Section N.1.5 of NUREG 1757, Volume 2 provides guidance on when the requirement for a mathematical ALARA analysis is waived. The intent of the exception to the requirements of a mathematical ALARA analysis is met for the proposed off-site shipment of material. Consequently, no detailed ALARA analysis is required for surface soil remediation at the CSM Boyertown facility.

ALARA Analysis for Decontamination of Structures

Structures where licensed activities have occurred at CSM's Boyertown plant will be surveyed and will be decontaminated to meet free release limits prior to license termination. The following conditions apply:

(1) All process equipment will be removed and either be disposed as radioactive waste or decontaminated and free released in accordance with NRC Regulatory Guide 1.86 and

(2) All affected areas inside of structures will be vacuumed and/or pressure washed to remove as much loose contamination as possible.

The chief variables that affect the cost of structure decontamination are:

- Lower cleanup levels result in increased costs for remediation, transportation and disposal. These costs are assumed to be approximately proportional to F, the fraction of material removed. This is reasonable since the volume of waste generated will increase as F increases.
- Lower cleanup levels translate to increased final status survey costs. This is reasonable since the minimum detectable activity for a scan decreases with the square of the count time. Increasing the count times by 33%, which would significantly increase the monitoring costs, will result in reducing MDAs to only 86.7% of the initial MDA.
- Continuing plant operations are less efficient while license termination activities are occurring causing increased operational costs and decreased revenues.

Mathematical ALARA Analysis for Structure Decontamination.

The derived concentration guideline equivalent to the average concentration of residual activity that would give a dose of 25 mrem/y to the average member of the critical group (DCGLw) for gross beta activity due to ore dust under the building occupancy scenario is 323 dpm/100 cm^2, as established in section 4 of the DFP Cost Estimate. This ALARA analysis will consider the question of whether it is feasible to impose a lower dose criterion for gross beta activity. In this calculation, ***f*** is the fraction of contamination that remains, while **F** is the fraction that is removed. The relationship between these variables is represented as:

$$\mathbf{F} = 1 - \boldsymbol{f}.$$

Default values that are acceptable to NRC were taken from Table N.2 "Acceptable Parameter Values for Use in ALARA Analyses" and used in this analysis. These values are presented below in Figure 1.

Figure 1. NRC Default Values for ALARA Analysis.

$$fw := 4.2 \times 10^{-8} / \text{hour}$$ (*worker accident rate*)

$$ft := 3.8 \times 10^{-8} / \text{km}$$ (*transport fatal accident rate*)

$$cf := \frac{2000\ \text{dollar}}{\text{person rem}}$$ (*dollars per person rem*)

$$r := 0.07 / \text{year}$$ (*monetary discount rate*)

$$n := 70\ \text{year}$$ (*building life in years*)

$$pd := 0.09\ \text{person} / \text{meter}^2$$ (* building population density*)

$$vship := 13.6\ \frac{\text{meter}^3}{\text{shipment}}$$ (* waste volume per shipment*)

cfa: $3000000 (*cost of a fatal accident*)

Site-specific costs are provided in Figure 2. The site-specific parameters are taken from the cost estimate, but have been simplified by omitting the factors that will insignificantly impact the outcome of this evaluation to prevent the ALARA analysis from becoming unduly complicated. The fully burdened cost for the scabbling was calculated using the labor rates, hours, packaging costs, transportation costs, and disposal fees for the scabbling activities in the DFP Cost Estimate. The cost per metric ton of scabbling waste produced was established using volumes from Table 2 and unit costs from Tables 4, 5, 7, 9, and 11 of the cost estimate to represent the volume of material and costs that apply only to the scabbling material. It will cost $64,000 to remove, package, manifest, transport, and dispose of the 12.2 metric tons of scabbling waste that were estimated. This cost per metric ton of scabbling waste is represented by the following term and is also listed in Figure 2.

$$\frac{64000 \text{ dollar}}{12.2 \text{ MetricTon}}$$

Figure 2. Site Specific Parameters for ALARA Analysis.[1]

$f := 0.867$ (*fraction of contamination that remains*)

$\text{FSStf} := 1.33$ (* Final status survey incremental time factor *)

$dt = 2087\ \frac{\text{mile}}{\text{way}} \times \frac{2\ \text{way}}{\text{shipment}} \times \frac{0.621\ \text{km}}{\text{mile}}$ (* Boyertown to Farmington, NM distance: *)

$\frac{2592.05\ \text{km}}{\text{shipment}}$

$va = 12.2\ \text{MetricTon} \times \frac{13.6\ \text{meter}^3}{20\ \text{MetricTon}} \times (1 - f)$ (* incremental volume of scabbling dust: *)

$1.10337\ \text{meter}^3$

$tc = 12800\ \frac{\text{dollar}}{\text{shipment}} \times \frac{\text{shipment}}{13.6\ \text{meter}^3}$ (* transportation cost/meter^3 *)

$\frac{941.176\ \text{dollar}}{\text{meter}^3}$

$cc = \frac{\text{shipment}}{13.6\ \text{meter}^3} \times 390\ \frac{\text{dollar}}{\text{shipment}}$ (* container cost/meter^3 *)

$\frac{28.6765\ \text{dollar}}{\text{meter}^3}$

$dc = 650\ \frac{\text{dollar}}{\text{MetricTon}} \times \frac{20\ \text{MetricTon}}{13.6\ \text{meter}^3}$ (* disposal cost / meter^3 *)

$\frac{955.882\ \text{dollar}}{\text{meter}^3}$

$es := 646\ \frac{\text{dollar}}{\text{day}}$ (* personal protective equipment and supplies *)

$decon = \frac{64000\ \text{dollar}}{12.2\ \text{MetricTon}}$ (* scabbling cost *)

$\frac{5245.9\ \text{dollar}}{\text{MetricTon}}$

$area = 84770\ \text{foot}^2 \times \left(\frac{0.303\ \text{meter}}{\text{foot}}\right)^2$ (* floor area requiring decon *)

$7782.65\ \text{meter}^2$

$\text{RadTechHours} := 1426\ \text{hour}$ (* final status survey rad tech hours for structures *)

$\text{SiteMgrHours} = \text{RadTechHours} / 3$

$\frac{1426\ \text{hour}}{3}$

$\text{RadSuperHours} = \text{RadTechHours} / 3$

$\frac{1426\ \text{hour}}{3}$

$\text{PlantDepreciationExpense} := 7 \times 10^6\ \frac{\text{dollar}}{\text{year}} \times \frac{\text{year}}{2080\ \text{hour}}$ (* Depreciation Expense, unlicensed activities *)

$\frac{3365.\ \text{dollar}}{\text{hour}}$

$\text{RadSuperHours} = \text{RadTechHours} / 3$

$\frac{1426\ \text{hour}}{3}$

$\text{PlantDepreciationExpense} := 7 \times 10^6\ \frac{\text{dollar}}{\text{year}} \times \frac{\text{year}}{2080\ \text{hour}}$ (* Depreciation Expense, unlicensed activities *)

[1] The relationship between **FSStf** and ***f*** is assumed to be:

$\left(\frac{1}{f}\right)^2 - \text{FSStf} == 0$

There are 13 factors described in Table 2 that are used to define the site-specific parameters for this ALARA analysis. The individual values that are used to define each of those 13 factors are taken directly from tables in the cost estimate. It should be noted that the third parameter, "Boyertown to Farmington, NM distance" is used to represent the transportation distance for material that will be sent to IUC in Utah. Farmington, NM was used as the end point in estimating this distance (2087 miles) because it was the nearest identifiable rail station location to the Utah location and provided a reasonably accurate, yet conservative value for the distance the waste is transported.

Incremental costs of decontamination, equipment and supplies, and labor for decontamination and final status survey are taken from the cost estimate and provided in Figure 3. In Figures 2 and 3, the following term is a unit conversion factor that represents the net weight per truckload of scabbling dust divided by its volume using the values for trucks taken from the DFP Cost Estimate:

$$\frac{20\ \text{MetricTon}}{13.6\ \text{meter}^3}$$

Figure 3. Incremental costs of decontamination, equipment and supplies, and labor for decontamination and final status survey.

$$\text{DecontaminationCost} = \text{decon} \times \text{va}\ \frac{20\ \text{MetricTon}}{13.6\ \text{meter}^3} \qquad (\ast\ \text{Scabbling and decontamination}\ \ast)$$

8512. dollar

$$\text{MaterialEquipmentCost} = \text{es} \times \frac{\text{SiteMgrHours}}{8\ \text{hour / day}} \times (\text{FSStf} - 1) \quad (\ast\ \text{Equipment and supplies}\ \ast)$$

12666.4 dollar

$$\text{FSSLabor} = (\text{FSStf} - 1) \times \left(\left(\text{SiteMgrHours} \times \frac{63\ \text{dollar}}{\text{hour}}\right) + \left(\text{RadTechHours} \times \frac{65\ \text{dollar}}{\text{hour}}\right) + \left(\text{RadSuperHours} \times \frac{78\ \text{dollar}}{\text{hour}}\right)\right)$$

52705. dollar

$$\text{crem} = \text{DecontaminationCost} + \text{MaterialEquipmentCost} + \text{FSSLabor} \quad (\ast\ \text{total remediation and FSS cost}\ \ast)$$

73883.4 dollar

Figure 3 identifies labor costs for three categories of workers used in the cost estimate: a site manager, a radiological supervisor, and a radiological technician. It is assumed in the cost estimate, and shown in Figure 3, that there are three rad techs and one site manager in each work group. Unit and incremental transportation and disposal costs were calculated from the tables in the DFP Cost Estimate and are provided in Figure 4.

Figure 4. Unit and incremental transportation and disposal costs.

Unit Transportation and Disposal Cost, **costv**

$$\mathbf{costv} = \mathbf{tc} + \mathbf{cc} + \mathbf{dc}$$

$$\frac{1925.74\ \text{dollar}}{\text{meter}^3}$$

Incremental transport and disposal monetary costs, **ctwd**

$$\mathbf{ctwd} = \mathbf{costv} \times \mathbf{va}$$

2124.79 dollar

One term in the equation provided by the NRC in section N.1.2 of Appendix N is "other costs as appropriate for the particular situation". Page N-9 of that appendix provides clarification of the types of other costs that are typical for this term of the equation, including "Loss of Economic Use of the Property". Such loss of economic use is relevant for the particular situation at CSM because several production operations at the Boyertown site do not depend on the processing of source material and are expected to remain economically viable during D&D activities. Those operations will be adversely impacted by the D&D activities. It is assumed that the efficiency of ongoing plant operations is reduced to 98% of normal during the period when D&D activities are conducted.[2] This is based only on the estimated hourly depreciation expense for plant equipment that is used for unlicensed activities. Of course this cost will increase if the incremental cost of lower labor efficiency is also included, or if critical plant systems such as the wastewater treatment plant must be taken off-line for a significant period of time. These other cost impacts are noted as defense in depth, but they are not specifically included in the ALARA calculation, which is simplified to include only the hourly depreciation expense. An estimate of the incremental costs related to decreased efficiency of ongoing plant operations during D&D activities is provided in Figure 5.

Figure 5. Incremental costs related to loss of plant efficiency during decontamination and decommissioning.

$$\mathbf{cother} = \mathbf{PlantDepreciationExpense} \times (\mathbf{FSStf} - \mathbf{1}) \times \mathbf{SiteMgrHours} \times \mathbf{0.02}$$

10557.9 dollar

Figure 6 shows costs that could be accounted for in accordance with the guidance in Appendix N of NUREG-1757, Vol. 2, but were neglected to simplify the calculation. It is CSM's prerogative to exclude these costs from the ALARA analysis because they are insignificant when compared to the factors that remain in the calculation and would not materially effect the result.

[2] In addition to extraction of tantalum from ore, the Boyertown plant makes specialty tantalum, niobium and titanium compounds. Milling activities at the plant include the preparation of specialty alloys of zirconium, niobium and tantalum as thin film, wire, and bar stock and other forms. The plant also houses CSM's Research and Development Group.

Figure 6. Negligible incremental costs.

Incremental worker accident monetary cost, **cwacc**, is small and is rounded to zero.

cwacc := 0

Incremental traffic fatalities monetary cost, **ctf**, is small and is rounded to zero.

ctf := 0

Incremental worker dose monetary cost, **cwdose**

cwdose := 0

Incremental monetary cost of public dose, **cpdose**

cpdose := 0

Figure 7 provides the total incremental increases in final status survey costs that result from increasing the count time by 33%, which would significantly impact decommissioning costs. That change would reduce the contamination levels from 323 dpm/100 cm^2 to 280 dpm/100 cm^2, a 13% reduction of the DCGL that was based on 25 mrem/year.

Figure 7. Total incremental cost of reducing contamination levels to 86.7% of the DCGL.

totalcost = crem + ctwd + cwacc + ctf + cwdose + cpdose + cother

86566.1 dollar

Figure 8 provides the ratio of cost over DCGL below which it is not ALARA to further decrease residual contamination levels. Figure 8 shows that the ratio is greater than 1, so it is not ALARA to reduce doses below about 33 mrem/year. However, CSM will exceed the ALARA requirements and reduce contamination levels to the regulatory limit of 25 mrem/year. CSM also commits to pressure washing the affected areas within buildings where licensed activities occurred.

Figure 8. Ratio of concentration to DCGL below which it is not ALARA to further reduce contamination levels.

$$\mathrm{ConcOverDCGL} = \frac{\mathrm{totalcost}}{\mathrm{cf} \times (1 - \mathrm{f}) \times 0.025\ \frac{\mathrm{rem}}{\mathrm{year}} \times \mathrm{area} \times \mathrm{pd} \times \frac{1 - e^{-r \times n}}{r}}$$

1.31069

Proposed License Conditions for Renewal of License SMB-920
Cabot Supermetals, Inc., March 23, 2004

6. Byproduct, Source, and/or Special Nuclear Material	7. Chemical and/or Physical Form	8. Maximum amount that Licensee May Possess at Any One Time Under This License
Natural uranium and thorium	Any	400 tons as elemental uranium and thorium
Sealed Sources		
A. Strontium-90	electroplated metal	5uCi
B. Thorium-230	electroplated metal	5uCi
C. Natural uranium	metal	5 nCi
D. Radium-226	metal	5 uCi

(Applicable Amendment No. 6)

9. Authorized place of use: The licensee's facility at County Line Road, Boyertown, Pennsylvania.

10. Authorized use: Receipt, possession, and processing at the Boyertown, Pennsylvania facility in accordance with the statements, representations, and conditions specified in the license renewal application dated March 23, 2004.
(Applicable Amendment No. 6)

11. The licensee shall document all ALARA Committee's recommendations for achieving ALARA in radiation protection, proposed in each meeting. A copy of the recommendations shall be provided to the Plant General Manager.

12. Deleted by Amendment 1, June 1997.

13. Release of equipment, facilities, or packages to the unrestricted area or to uncontrolled areas onsite shall be in accordance with applicable NRC guidance, such as "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993.
(Applicable Amendment No. 6)

14. The licensee shall sample at the Boyertown site at least quarterly, and analyze for uranium and radium-226 and radium-228, as specified in the licensee's monitoring plans in the license renewal application:

   a. The effluent at Outfall 001, when effluent is discharged.

   b. Upstream and downstream (relative to Outfall 001) surface water in West Swamp Creek.

   c. Groundwater from Monitoring Wells MW-3, 4, 95-01, 95-03, 95-04, 97-06, and Production Well 2 identified in Figure 1.

   d. Sediments from upstream and downstream locations in West Swamp Creek.

   The licensee shall collect and analyze air samples at background (upwind from the site) and downwind site boundary locations as follows.

   a. Continuous air particulate samples from 3 locations analyzed quarterly for isotopic uranium and thorium.

b. Continuous air samples from 4 locations analyzed quarterly for radon-222 concentrations.

If the concentration of a radionuclide specified in the licensee's monitoring plan exceeds 30 percent of the corresponding value in 10 CFR Part 20 Appendix B, Table II, the licensee shall implement a response that consists of internal notification of management and investigation of potential causes of the elevated readings. If the concentration exceeds 80 percent of the applicable value, the licensee shall include reporting the incident to the NRC Region I Administrator within 30 days after the licensee receives the analytical results.

The licensee shall maintain a record of all monitoring results obtained in accordance with this license condition for at least 5 years.
(Applicable Amendment No. 6)

15. Every two years, starting on January 30, 2006, the licensee shall evaluate and submit to the NRC, the estimated decommissioning and closure costs, if accomplished by a third party, for all existing operations and any planned expansions or licensed operational changes for the upcoming year. Such costs include all cited activities and groundwater restoration, as well as off-site disposal of all material. Along with each proposed revision or update of the surety, the licensee shall submit supporting documentation showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15 percent contingency, changes in engineering plans, activities performed, and any other conditions affecting estimated costs for site closure.

    The amended financial surety instrument (letter of credit) incorporating the revised decommissioning cost shall be provided to NRC within 60 days of NRC's approval of the new surety amount. The surety instrument shall not be changed without NRC approval. The currently approved amount is $5,740,722.

    Any required original, signed surety documents should be sent to:

    Chief, Fuel Cycle Facilities Branch,
    Division of Fuel Cycle Safety and Safeguards, Mailstop T8-A33,
    U.S. Nuclear Regulatory Commission, 11545 Rockville Pike, Rockville, MD 20852-2738.
    (Applicable Amendment No. 6)

16. In accordance with the provisions of 10 CFR 40.14, "Specific Exemptions" and notwithstanding the requirements of 10 CFR 40.5, "Communications," the licensee is hereby authorized to submit electronically any communication or report concerning the regulations in Part 40 and any application filed under these regulations.
    (Applicable Amendment No. 5)

17. The final, detailed decommissioning plan will be submitted for approval at least 6 months before the planned start of site decommissioning.
    (Applicable Amendment No. 6)

18. The licensee shall ensure that the duties of the Radiation Safety Officer (RSO) are assigned to and carried out by a responsible, qualified individual at all times during plant operation. The licensee may define and implement a system to provide back-up, on-call support to ensure that lapses in RSO

coverage do not occur.
(Applicable Amendment No. 6)

19. The licensee shall maintain documentation on unplanned release of source material and related process chemicals. Documented information shall include, but not be limited to: date, volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of post remediation surveys (if taken), and a map showing the spill location and the impacted area.

    The licensee shall evaluate the consequences of the spill or incident/event against 10 CFR 20, Subpart "M," and 10 CFR 40.60 reporting criteria. If the criteria are met, then report to the NRC Operations Center as required. Incident and event notifications, which require telephone notification under 10 CFR 20.2202 and 10 CFR 40.60, shall be made to the NRC Operations Center at (301) 816-5100.

    If the licensee is required to report any spills or leaks of source material, and process chemicals that may have an impact on the environment, or any other incidents/events, to State or Federal Agencies, a notification shall be made to the NRC Headquarters Project Manager (PM) by telephone or electronic mail (e-mail) within 48 hours of the event. This notification shall be followed, within thirty (30) days of the notification, by submittal of a report to the NRC Headquarters PM and the Region I Administrator detailing the conditions leading to the spill, leak, or incident/event, corrective actions taken, and results achieved.
    (Applicable Amendment No. 6)

20. The source material limit for releasing the filtercake for landfill disposal is the sum of fractions as follows: activity of uranium/10 pCi/g + activity of thorium/3 pCi/g = 1. This limit applies to the monthly average source material value in filtercake released.
    (Applicable Amendment No. 6)