DOCKET NO: 40-9027

LICENSE NO: SMC-1562

LICENSEE: CABOT PERFORMANCE MATERIALS, READING, PENNSYLVANIA

SUBJECT: SAFETY EVALUATION REPORT OF SITE DECOMMISSIONING PLAN, AND RADIOLOGICAL ASSESSMENT, DATED AUGUST 21, 2006

1.0 Executive Summary

Cabot Corporation (Cabot) holds U.S. Nuclear Regulatory Commission (NRC) Source Materials License SMC-1562, allowing the storage of radioactive materials at Cabot's Reading, Pennsylvania site. Former ore processing in the 1960s at the facility generated waste slag contaminated with uranium and thorium. A smaller amount of debris from facility decontamination was added to the site in the late 1970s. In the 1980s, Cabot began onsite decommissioning activities at the main processing building at its Reading site. Contaminated areas of the main building area were remediated in a series of cleanup actions in the early 1990s.

This Safety Evaluation Report (SER) addresses planned decommissioning activities for the Reading site's slag pile. Cabot originally submitted the decommissioning plan (DP) for the slag pile in 1998 and has revised it several times to address various NRC concerns. On August 21, 2006, Cabot submitted Revision 4 of its proposed DP. As discussed below, source term uncertainties in Cabot's data caused the staff to perform an independent dose assessment using conservative assumptions, which yielded a bounding annual dose to a worker at the site of 0.24 milliSieverts per year (mSv/yr) (24 millirem per year (mrem/yr)) for the bounding dose scenario.

The NRC staff has prepared this SER to support the review of Revision 4 of Cabot's DP. Successful implementation of the DP will lead to termination of the NRC license and release of the site for unrestricted use.

1.1 Description of Proposed Action

Under Revision 4 of Cabot's DP, Cabot will install an erosion barrier on the slag pile. The erosion barrier will be utilized to mitigate the potential erosion at the site, and was not considered as shielding in Cabot's dose analysis.

1.2 Purpose and Need for the Proposed Action

The purpose of this action is to decommission a source materials license site, in preparation for license termination. Furthermore, the intent is to allow unrestricted release of the site, thereby removing limitations on the future use of the property. Title 10, Section 40.42, "Expiration and Termination of Licenses and Decommissioning of Sites and Separate Buildings or Outdoor Areas," of the *Code of Federal Regulations* (10 CFR 40.42), known as the Decommissioning Timeliness Rule, requires this action.

1.3 Release Criteria

Subpart E, "Radiological Criteria for License Termination," of 10 CFR Part 20, "Standards for Protection Against Radiation," provides the radiological criteria for unrestricted use in 10 CFR 20.1402. This rule established a limit of 0.25 millisieverts per year (mSv/yr) (25 millirem per year (mrem/yr)), and requires that the dose is as-low-as-is-reasonably-achievable (ALARA) for license termination, without restrictions on future site use.

2.0 Facility Operating History

The NRC staff has reviewed the facility radiological history information provided in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Section 16.2, "Facility Operating History," of NUREG-1757, "Consolidated Decommissioning Guidance." Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information to aid the NRC staff in evaluating the licensee's determination of the radiological status of the facility and the licensee's planned decommissioning activities to ensure that the decommissioning can be conducted in accordance with NRC requirements.

2.1 License Number/Status/Authorized Activities

The current license, SMC-1562, authorizes the licensee to possess up to 100 tons (elemental) natural uranium and thorium in any chemical or physical form. The licensee is authorized only to possess this licensed material in the slag disposal area. Further waste disposal at this site is prohibited.

2.2 License and Operating History

Summary History

Cabot's predecessor, Kawecki Chemical Company, used an electric arc furnace to produce steel-grade niobium metal. This process involved the use of Malaysian tin slag as feedstock, containing natural uranium and thorium. On completion of the processing, uranium and thorium remained in the form of a waste silica slag.

In the 1960s, Kawecki Chemical Company obtained a source materials license from the Atomic Energy Commission (AEC), NRC's predecessor, to possess the waste slag containing greater than 0.05 percent by weight uranium and thorium. Cabot now holds NRC Source Material License SMC-1562, allowing the company to possess the slag material produced by the Kawecki Chemical Company. Currently, no source materials are used on the site, and no activities occur where the slag was deposited.

The initial processing of tin slags was authorized in April 1967, but full-scale processing did not commence until late 1967 or early 1968. On March 18, 1968, the State of Pennsylvania authorized disposal of slag waste containing natural thorium and uranium at the slag pile site.

Electric arc furnace operations ceased in May 1969, after operating for 25 months. About 600 tons of waste slag containing about 1.8 tons of source material was placed on the embankment.

Applied Health Physics (AHP), the licensee's contractor, began decontamination of the facility between 1969 and 1983 on an intermittent basis. Some of the waste materials from decontamination operations were sent to Cabot's site in Boyertown, PA, and some were disposed of on the Reading site's slag pile.

From May to June 1976, 25–41 truckloads of unused tin slag were shipped from Reading to Baltimore for export. In July 1976, 24,476 tons of tin slag were exported to West Germany via Holland.

From August 1976 to July 1977, extensive decontamination at the Baltimore site resulted in 286 truck shipments of contaminated sand and soil to Reading.

In 1977 and 1978, 580 tons of slightly contaminated debris and soil from decontamination of the Reading facilities were disposed of on the Reading site's slag pile. A 4-ft cover of 500 tons of crushed rock and soil was placed on top of the slag area. In 1979, all waste storage activities were suspended at the Reading site.

On December 12, 1993, license SMB-920 was split into two licences, putting the Revere and Reading sites into a new license, SMC-1562. On September 5, 2001, the Revere site was removed from Source Material License SMC-1562.

Addendum 1 to this SER provides a more detailed site history.

3.0 <u>Site Description</u>

The NRC staff has reviewed the site description information in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with NUREG-1757, Volume 1, Chapter 16, "Facility Description." Based on this review, the NRC staff has determined that the licensee, Cabot, has described the site and its environs sufficiently to allow the NRC staff to evaluate the conditions and potential safety and regulatory issues associated with the actions proposed in the DP.

3.1 Site Location and Description

The Cabot site is located in Reading, Berks County, Pennsylvania, east of the Schuylkill River, which is just south of the site and flows eastward.

Between the slag pile area and the Schuylkill River, there are an underdeveloped extension of the River Road right-of-way (ROW), a Norfolk Southern (Norfolk) railroad ROW, and remnants of the former Schuylkill Canal. Another Norfolk Southern ROW is located approximately 46 meters (m) (150 feet (ft)) northwest of the slag pile. Buttonwood Street is located approximately 183 m (600 ft) to the southeast of the pile. Topographical survey information was used to estimate the dimension of the radiological slag at the site. The cross-sectional area is approximately 103 square meters (m^2) (1125 square feet (ft^2)).

The ground surface rises from approximately 59 m (193 ft) above mean sea level (MSL) at the Schuylkill river to approximately elevation 81 m (266 ft) MSL at the top of the slag pile. The embankment has an overall slope of approximately 30 degrees, but locally can be as much as

40 to 45 degrees. The area at the top of the slope has been graded to drain away from the slag pile.

The total volume of industrial debris, radiological slag, nonradiological slag, and cover soil is estimated to be 5,000 cubic meters (m^3) (180,000 cubic feet (ft^3)). The top of the slag pile is a level area that is approximately 49 m (160 ft) long and extends back a maximum of 5 m (15 ft) from the top edge of the slag pile. The slag pile stability was evaluated using standard geotechnical engineering practices. Based on the model results and observations over approximately 30 years since the material was placed, it has been concluded that the slope is stable. Its elevation is approximately that of a much larger contiguous level area upon which industrial facilities are located. Currently, no licensed materials are used at the industrial property, which constitutes the site. Other than the slag pile area and the River Road ROW area, all areas where licensed material was handled have been decontaminated and released for unrestricted use. Because the licensee does not own the property, the staff has defined the area encompassing the radiological slag, including the River Road ROW, as the “site” for the purposes of discussion in this report.

Slag materials containing uranium and thorium were deposited on an existing slope adjacent to the former processing building. The slope comprises nonradiological slag from historical metals refinery and processing operations in the area and a mixture of building debris, slag, rock, and soil from previous decommissioning and decontamination work.

3.2 Population Distribution

The area surrounding the site is generally urban, but no residences are adjacent to or immediately near the site.

3.3 Current/Future Land Use

The Redevelopment Authority of the City of Reading took possession of the site by eminent domain on March 13, 2000. The City of Reading has a major, ongoing revitalization project in the surrounding area and has zoned the area for industrial/commercial purposes.

3.4 Metrology and Climatology

Berks County has a temperate, humid, maritime-type climate. The average temperature in the Reading area is approximately 12 °C) (54 °F), and average annual precipitation is approximately 100 centimeters (cm) (40 inches (in.)). Approximately one-half of the precipitation is returned to the atmosphere through evapotranspiration, with the remainder entering streams as direct runoff and ground water discharge. Precipitation is fairly evenly distribute throughout the year, with the monthly average ranging from approximately 6 cm (2.5 in) in February to 11 cm (4.5 in.) in August. Despite the higher precipitation in the summer months, runoff is lower because of higher rates of evapotranspiration.

3.5 Geology and Seismology

The site is located in the Great Valley section of the Valley and Ridge physiographic province near the boundary with the Reading Prong of the New England Highlands province. Bedrock beneath the site is mapped as the Cambrian Period-age Richland Formation. The Richland Formation geology is described by MacLachlan, 1983 as follows:

> Medium-gray thick-bedded dolomite and subordinate limestone arranged in cycles representing shallow marine deposition. Limestone beds commonly have argillaceous to silty laminae and may be sandy. Throughout the formation, some beds contain scattered nodules and stringers of dark-brownish-gray chert; some oolitic and cryptozoon layers are also present. Discrete dolomitic sandstone beds occur locally. Thickness is about 420 m (1,400 ft).

Between the base of the embankment and the Schuylkill River, the geology is mapped as Quarternary-age alluvium, which is described as follows:

> Saturated or seasonally wet, unconsolidated deposits along streams. Deposits along minor streams are variable depending on stream gradient and lithologies traversed. Along major streams deposits are predominantly fine grained (silty to sandy), containing only scattered coarser clasts. Alluvial anthracite is locally abundant along Schuylkill River. Maximum known thickness is about 24 m (80 ft).

The site characterization effort and observations indicate that fill associated with past operations at the industrial property and the transportation corridor covers both geologic formations.

Based on the boring logs and piezometer logs, Cabot developed a contour map depicting the top of bedrock elevation, which shows that the top of the bedrock surface slopes toward the Schuylkill River.

3.6 Surface Water Hydrology

No water courses other than the Schuylkill River are in the immediate vicinity of the site. As expected for granular fill material, the surface of the site and adjacent areas are well drained. The U.S. Geological Survey (USGS) has maintained a stream gauging station approximately 610 m (2000 ft) downstream from the site. The average daily flow rate is roughly 43 cubic meters per second (m^3/s) (1500 cubic feet per second (ft^3/s)).

The flood profile for the June 1972 flood (resulting from Hurricane Agnes) in Pennsylvania indicates that the maximum water level was at elevation 66.8 m (219.2 ft) above MSL at a location 137 m (450 ft) upstream from the Reading railroad bridge (approximately 500 ft upstream from the site) and at elevation 218.6 ft MSL at the Buttonwood Street Bridge (approximately 152 m (600 ft) downstream from the site). The 1972 flood data are the maximum reported flood levels for the area. The 100-year flood elevation at the site is mapped as 64 m (211 ft) above MSL.

Based on the above, the railroad ROW and the River Road ROW are within the Schuylkill River flood plain. The majority of the slag pile, which ranges in elevation from approximately 64 m (210 ft) to 79 m (260 ft) above MSL, is above the 100-year and the maximum reported flood levels. Following installation of the proposed riprap cover, the surface elevations of the slag pile would be approximately 65 m (214 ft) to 81 m (265 ft) above MSL, entirely above the 100-year flood level.

3.7 Ground Water Hydrology

The licensee developed a comprehensive conceptual model of the site geologic and hydrogeologic conditions, which is consistent with the site-specific and background information. The conceptual model shows a zone of seasonal ground water that occurs in the soil immediately above bedrock. This zone of saturation is thin and discontinuous. The gradient in this zone follows the surface contour of the top of the bedrock toward the Schuylkill River. A perched ground water condition may also occur above the clayey-silt layer during seasonal wet periods.

An apparent seep near the base of the slag pile is active during precipitation events. Analyses of the seep-water samples demonstrated that the seep water meets the criteria in the U.S. Environmental Protection Agency (EPA) drinking water standards for gross alpha and gross beta activity and is indistinguishable from the background water quality in the Schuylkill River.

Most of the ground water passing through the radiological slag flows to the Schuylkill River via the perched zone above the bedrock. This zone is too thin and does not have sufficient yield to support one domestic supply well. During the sampling effort, it took several hours to a full day for the wells to yield the required 2 liters for analysis. The expected hydraulic gradient in the underlying bedrock is convergent toward the river. This typical situation precludes the water in the soil zone from migrating downward into the bedrock because the bedrock gradient near the river is upward. The pathway for water that has passed through the radiological slag is restricted to a short, very shallow zone that cannot support a domestic supply well.

The small surface area limits the volume of infiltration passing through the slag. Approximately 50 cm (20 in.) of the 100 cm (40 in.) of annual precipitation is lost through evapotranspiration, and approximately 25 cm (10 in.) is lost as direct runoff. Therefore, only approximately 25 cm (10 in.) is available to infiltrate through the slag. A level of 25 cm (10 in.) of precipitation over the approximately 2,323 m^2 (25,000 ft^2) of the slag pile and slag in the ROW is equivalent to an average flow of less than 19 cubic centimeters per sec (cm^3/s) (0.3 gallons per minute (gal/min)).

Based on published reports and the geologic setting, the permanent regional ground water table occurs deeper in the bedrock, below the zone in the soil. The Schuylkill River is the topographic and hydrologic feature with the lowest elevation in the vicinity of the site. Based on USGS stream gauge data, the Schuylkill River is a gaining stream (flow volume increases downstream because of ground water discharge), as is typical for this climatic region. In the absence of significant withdrawals of ground water from wells, the natural direction of flow in the deep permanent ground water system will be convergent toward the river. The flow direction near the river will be upward. This flow regime restricts the pathway between the slag and the river to a very thin (no more than several feet thick), short (24 to 61 m (80 to 200 ft long) shallow zone.

The ground water is not expected to be contaminated because the leach rate of the slag is low. To confirm this conclusion, the licensee collected ground water samples on two occasions from wells installed in the River Road ROW directly downgradient from the slope and within the ROW area. Those samples were analyzed for gross alpha activity, gross beta activity, and for uranium and thorium using alpha spectroscopy. Results of that sampling and analysis indicate that the ground water quality meets the National Primary Drinking Water Standards for radionuclides.

The results confirm the leach rate calculations indicating that the leach rate of radionuclides from the slag is negligible. Based on measured values, concentrations of radionuclides in leachate from the slag pile are below EPA drinking water standards and are similar to Schuylkill River background water quality. The ground water directly downgradient of the slag pile and directly beneath the radiological slag in the ROW is not contaminated.

Ground water in the vicinity of the site is not used as a source for drinking water or industrial process water and is unlikely to be used in this way in the future. As stated above, no residences are adjacent to or immediately near the site. Local public water supplies are derived from surface water sources, and no known or suspected industrial wells exist in the vicinity of the site. Therefore, the Schuylkill River is the hydraulic base level for the area, and all local ground water gradients are toward the river. Regardless of the low probability of ground water use near the site, the low leach rate of radionuclides from the slag ensures that there has not been and should not be an impact to ground water.

Any future ground water supply could only be obtained from the deeper bedrock. The ground water that has passed through the slag could supply only a very small fraction of the total yield of a deep well. Typical deep supply wells require yields of 6309 cm^3/s (100 gal/min) or more to be viable as an industrial or public supply. Therefore, the already low (below drinking water standards) levels of radiological constituents in the perched zone would be further diluted. Based on the following considerations, the deep ground water beneath the site is not likely to be used in the future:

- The Reading area currently obtains its public water supply from Lake Ontelaunee (an impoundment on Maiden Creek, a tributary to the Schuylkill River). The lake is located approximately 13 kilometers (km) (8 miles (mi)) upstream of the site. The Schuylkill River and its tributaries will be able to support any conceivable future needs for the area.

- The City of Reading has indicated that it will require future development at the industrial property to connect to the city’s public water supply system.

- The quality and quantity of ground water available within an urban setting such as Reading is limited. It is not likely that ground water sources would be used in the future given that an ample supply of high-quality surface water is available.

- The area between the site and the Schuylkill River has been, is currently planned to remain, and is expected to continue in the foreseeable future to be used as a transportation corridor. Transportation uses preclude the development of ground water supply in this area.

3.8 Natural Resources

No natural resources of economic value have been identified on or in the immediate area of the site. The site has been a disposal area for industrial waste for more than 100 years.

3.9 Ecology/Endangered Species

A consultation with the U.S. Fish and Wildlife Service (FWS) on February 27, 2006, determined that no Federally listed or proposed threatened or endangered species under FWS jurisdiction are present at the site (ADAMS Accession No. ML060730519).

4.0 Radiological Status of Facility

The NRC staff has reviewed the radiological assessment information in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with NUREG-1757. Based on this review, the NRC staff has determined that the licensee, Cabot, has described the types and activity of radioactive material contamination at its facility sufficiently to allow the NRC staff to evaluate the potential safety issues associated with the proposed DP actions at the site, whether the proposed activities and radiation control measures proposed by the licensee are appropriate for the type of radioactive material present at the site, whether the licensee's waste management practices are appropriate, and whether the licensee's cost estimates are plausible, given the proposed activities.

4.1 Contaminated Structures

The site has no existing structures. A building ruin at the center base of the slope predates the Cabot operations. Chapter 11 of this SER further discusses this building ruin.

4.2 Contaminated Systems and Equipment

No contaminated systems or equipment remain at the site

4.3 Surface Soil Contamination

Cabot reports that based on the site characterization data and visual observations, the surface soils on top of the slag pile consist of mixed fill materials (i.e., primarily nonradiological slag mixed with construction debris, a small volume of radiological slag, and soil). Average net uranium and thorium concentrations in the soil near the surface (to a depth of 0.6 m (2 ft) or less) are approximately 925 becquerels per kilogram (Bq/kg) (25 picocuries per gram (pCi/g)]) total combined thorium and uranium, of which approximately 190 Bq/kg (5 pCi/g) is uranium-238 (U-238) and 280 Bq/kg (7.5 pCi/g) is thorium-232 (Th-232). These estimates are based on the results of surface soil measurements.

4.4 Subsurface Soil Contamination

Cabot reports that the average net activity concentration in the slag/soil/debris mix in the slag pile is approximately 2775 Bq/kg (75 pCi/g) of combined thorium (Th-232 and Th-228) and uranium (U-238 and U-234). This estimate is based on the average measured concentration from the surface to a depth of 5 m (16 ft).

4.5 Surface Water

No contaminated surface water has been identified at the site. A runoff seep at the base of the slag pile is active during precipitation events. Analysis of the seep water samples, as required by license condition, indicates that the surface runoff water meets the criteria in EPA drinking water standards for gross alpha and gross beta activity and is indistinguishable from the background water quality in the Schuylkill River.

4.6 Ground Water

No contaminated ground water has been identified at the site. Analysis of groundwater directly below the radiological material meets drinking water standards for radiological parameters and is similar to Schuylkill River water.

4.7 Uranium/Thorium-Contaminated Slag

The radionuclides of interest for the dose assessment were determined using operational history and the site characterization data. The radionuclides considered are naturally occurring uranium (U-238, U-234 and U-235), naturally occurring thorium (Th-232 and Th-228), and their radioactive progeny. The radioactive materials at concentrations distinguishable from background concentrations are primarily confined to slag from the processing of ores with small concentrations of naturally occurring uranium, thorium, and progeny nuclides. The slag, which retained the radioactive constituents, was deposited on the slag pile.

5.0 Dose Assessment

At the Reading site, uranium- and thorium-contaminated slag from metal processing activities is present on an embankment at the southwest end of the property and at the base of the slope in the River Road ROW. The slag extends approximately 48 m (160 ft) along the top of the embankment. Cabot performed a site radiological assessment for the Reading slag pile. Dose values were developed to demonstrate compliance with NRC regulations for establishing the site for unrestricted release. Cabot proposed five scenarios for determination of compliance with regulatory limits and also gave seven alternate scenarios.

The NRC staff reviewed the assessment in terms of the source term, the critical group, scenario and pathway identification, the modeling approach, input parameters, and model results, as discussed below.

5.1 Site Release Criteria

Cabot has requested unrestricted release of the site in compliance with requirements of 10 CFR 20.1402. In accordance with 10 CFR 20.1402, the residual radioactivity that is distinguishable from background remaining at the site at the time of license termination cannot result in a total effective dose equivalent to an average member of the critical group that will exceed 0.25 mSv/yr (25 mrem/yr). The residual radioactivity must also be ALARA.

5.2 Source Term

Contaminated slag is contained on an embankment and, in a small amount, in the ROW adjacent to the base of the embankment. Cabot prepared separate source term descriptions for these two slag areas. Cabot determined the average net activity concentration in the slag mix from data in an NES, Inc. site characterization report (NES, 1996). For the embankment, Cabot assumed a net average total uranium and thorium concentration in the near-surface mix of 930 Bq/kg (25 pCi/g) of combined thorium and uranium. Of the 930 Bq/kg (25 pCi/g), Cabot assumed about 280 Bq/kg (7.5 pCi/g) to be Th-232 and 190 Bq/kg (5.0 pCi/g) to be U-238. Cabot determined that radiological data from the River Road ROW indicated that the average radionuclide concentrations in near-surface soils in the ROW were about the same as concentrations in near-surface soils on the slag pile slope. Therefore, Cabot used the same source concentration for both areas.

The NRC staff recognized some uncertainty in the volume of waste that was shipped and disposed of at the Cabot Reading site. Further review of applicable reference documents indicated that the total thorium at the site could be five times greater than the estimate provided by Cabot (see Addendum 2 for details). This uncertainty results in a greater source concentration for deeper materials (greater than 0.6 m (2 ft) deep) on the embankment, but the source concentration values for the near-surface slag and for the ROW remain as the values reported by Cabot. The staff's independent review, as described in SER Section 5.6 below accounts for the uncertainty in the source term.

To estimate releases of radioactive material from the slag, Cabot modeled uranium leaching as a desorption process in which the uranium concentration in the leachate was assumed to be directly proportional to the concentration in the solid source. Cabot calculated a distribution coefficient (Kd) using the readily available uranium concentration measured in a leach test performed on a slag sample. Because the radioactivity is tightly bound in the slag matrix, modeling releases as a surface process requires an assumption of strong adsorption (i.e., represented by a high distribution coefficient) between the radionuclide and the solid medium. A Kd value of 655 milliliters per gram (mL/g) was used to calculate the leach rate of radionuclides from the source zone (i.e., slag). The same Kd value was also used for the U-238 progeny and Th-232 and its progeny. Although radionuclides are believed to leach incongruently from the slag, it is reasoned that using the uranium Kd value is appropriate because thorium is believed to leach at a slower rate.

The staff agrees that, based upon the nature of the slag (i.e., its glass-like structure) and its low weathering rate, the leach rate of radionuclides from the source zone are low (i.e., radionuclides should be generally immobile).

5.3 Critical Group, Scenario, and Pathway Identification and Selection

Cabot developed separate land use scenarios for the slag pile area and the River Road ROW. It analyzed three scenarios for the slag pile and two scenarios for the River Road ROW. In addition, Cabot developed seven alternate scenarios that it considered less likely to occur but still plausible.

The property containing the slag pile site has been used for industrial purposes for at least 100 years. As part of its process for urban redevelopment, The City of Reading Redevelopment Authority has also designated the site for industrial and commercial use. Cabot explained that the location, size, and physical arrangement of the slag material and its setting on an industrial property preclude resident and resident-farmer exposure scenarios. Accordingly, Cabot developed and analyzed 12 possible exposure scenarios based on industrial and commercial use of the site to ensure they have identified and considered the critical exposure group. NRC staff agree that based on historical usage and ongoing land use planning, the most likely land use in the foreseeable future is industrial and commercial use. The staff therefore finds that the 12 exposure scenarios developed and analyzed by Cabot are adequate to identify the critical group as required by 10 CFR 20.1402.

Cabot developed and evaluated the following three compliance scenarios for the slag pile area:

- a worker placing riprap on the slope (WRR-P)
- a trespasser on riprap after license termination (TRR)
- a worker on top of the slope and on riprap after license termination (WRR)

For the first scenario, the worker would be placing riprap on the slope, which would also include clearing of the area. The worker is assumed to work full time on the slope for the duration of the job, which is 1 month. This results in an occupation time of 160 hours per year (h/yr). For the second scenario, Cabot assumed that a trespasser walks on the slope covered with riprap 3 hours per week, 6 months per year. The third scenario assumes that a worker spends part of his work day in a facility located on the flat surface at the top of the slag pile and a portion of his work time in activities involving walking on the slope of the slag pile. The worker is assumed to spend 200 h/yr (10 percent of his total annual work time) on the site in the area where radioactive materials of interest are located. Of these 200 hours, Cabot assumed that the worker spends 20 h/yr on the slope and 180 h/yr in a small structure on top of the pile.

To evaluate the sensitivity of the scenarios, Cabot developed and evaluated three groups of alternate scenarios, which it considered less likely to occur but still plausible. The first set of alternate scenarios represents a worker and a trespasser, in the absence of the riprap cover. This set, which is intended to assess the dose in the event of erosion from the riprap cover, includes the following:

- a trespasser on the slope in its current condition (TC)
- a worker on the slope in its current condition (WC)

The second set relates to limited excavation into the riprap covered slag pile. This set consists of the following:

- a worker conducting limited excavation (e.g., laying pipe or cable) on the riprap-covered slope (WRR-LE)

- a trespasser on the covered slope after limited excavation (TRR-ALE)

- a worker on top of the covered slope after limited excavation (WRR-ALE)

The third set of alternate scenarios relates to major excavation in which the entire area containing the slag is excavated and relocated to an unspecified and uncontrolled surface location. This set of scenarios includes the following:

- a worker conducting major excavation (W-ME)

- a worker on debris material that was removed to another surface location following major excavation (W-AME)

Cabot developed two types of exposure scenario for the purposes of analyzing the River Road ROW area. Cabot considered the following scenarios sufficiently realistic to be compliance scenarios:

- a person who walks along the ROW (RWWLK)
- a worker on the ROW during excavation (RWWRK)

The walker is assumed to be exposed to radiation from slag radionuclides in soils along the ROW during walks (5 minutes per day, 200 days per year). The second scenario is for a worker exposed 40 h/yr along the ROW during the excavation of soils bearing concentrations of slag radionuclides.

For each of these scenarios (compliance and alternate scenarios), Cabot included in its assessment the pathways of direct exposure to external radiation from contaminated media, inhalation of airborne radionuclides, and ingestion of contaminated soil.

The slag pile has an estimated overall slope that ranges from 30 to 45 degrees. Therefore, very limited activity is expected to occur on the side slope of the pile. However, a structure could be built on the adjacent property because the area adjacent to the slag pile is level and much larger. Cabot's worker scenario WRR considered dose from a combination of dose from outside exposure and dose from exposure inside a hypothetical building adjacent to the slag pile. Therefore, the scenarios involving a worker are warranted. The critical group, scenario, and exposure pathways used in the assessment are considered to be appropriate given the configuration of the contaminated area along with the planned uses for the site.

Cabot's basis for excluding the ground water pathway includes the fact that (1) measured radionuclide concentrations in leachate from the slag are below drinking water standards, (2) the subsequent leachate will represent a small fraction of a water supply well, and (3) there is insufficient yield down gradient of the slag to support a well. Consistent with guidance in

NUREG-1757, the NRC staff finds excluding the ground water pathway to be acceptable based on the insufficient well yield.

5.4 Calculations and Input Parameters

Cabot used RESRAD Version 6.22 in the dose analysis to estimate potential doses from exposure through inhalation, soil ingestion, and external gamma radiation. It performed 12 separate dose analyses for the radioactive material. Tables 5.4.1 and 5.4.2 provide a summary of Cabot's input parameters for RESRAD. Cabot used MICROSHIELD to compute a ground dose reduction factor to account for the effects of shielding by the worker's structure. The structure is assumed to be 4.6 m x 4.6 m (15 ft x 15 ft) with a 0.15-m (6-in.) concrete slab floor located at the center of the area of slag that forms the top of the pile. The worker is assumed to work at the center of the structure.

To determine the breathing rate value, Cabot used two Sandia reports (Beyeler, 1998a and 1998b). It also used these reports to support the use of RESRAD default values for the soil ingestion rate of 0.1 gram per day.

Cabot used default RESRAD parameter values for many of the parameters that it considered would not significantly influence the dose for the provided exposure scenarios. Cabot explained that it used site-specific values to determine occupation times. It used information from Means construction cost data (Means, 2006) to support occupation time values related to the excavation scenarios.

The source concentration for the near-surface soils of the slag pile were derived from measured gamma exposure rates on the top of the slag pile. Based upon data about the ROW, Cabot determined that the near-surface soil concentrations in the ROW were similar to those of the slag pile. Therefore, it used a source concentration of 925 Bq/kg (25 pCi/g) for the five compliance scenarios.

Values for source concentration differed for the alternate scenarios. These values ranged between 230 Bq/kg (6.3 pCi/g) and 42,250 Bq/kg (1,142 pCi/g). The lower concentration values (i.e., 230 Bq/kg (6.3 pCi/g)) relate to the major excavation scenarios, where Cabot assumed that greater excavation activities would cause more mixing of the waste. Similarly, for limited excavation, less mixing is assumed to occur, and the source concentration is 42,250 Bq/kg (1,142 pCi/g). For the scenarios where a trespasser or worker traverses the slope after limited excavation, Cabot averaged the 42,250 Bq/kg (1,142 pCi/g) source concentration over the 1,820 m^2 (19,600 ft^2) area of the slope. This resulted in a concentration of 1,100 Bq/kg (29.7 pCi/g).

The NRC staff finds the input parameters to be acceptable with the exception of the source concentration for the scenarios related to major excavation and the exposure time parameters for the WRR, W-ME, and the W-AME scenarios. The staff analyzed these scenarios in further detail, as explained in SER Section 5.6 below.

Table 5.4.1 RESRAD Parameters for Compliance Scenarios

Scenario	Source* (U+Th) (pCi/g)	Cover** (ft)	Exposure Time (h/yr)	Inhalation Rate (10^4 m^3/yr)	Dust in Air (10^{-4} g/yr)
Worker placing riprap on the slope (WRR-P)	25	0	160	1.74	7
Trespasser on riprap after license termination (TRR)	25	0.8	72	1.24	2
Worker on top of the slope and on riprap after license termination (WRR)	25	0.8	180/20	1.24	2
person who walks along the right-of-way (RWWLK)	25	0	17	1.24	2
worker on the right-of-way during excavation (RWWRK)	25	0	40	1.74	7

* To convert pCi/g to Bq/kg, multiply given value by 37
** To convert ft to m, multiply by 0.305

Table 5.4.2 RESRAD Parameters for Alternates Scenarios

Scenario	Source* (U+Th) (pCi/g)	Cover (ft)	Exposure Time (h/yr)	Inhalation Rate (10^4 m^3/yr)	Dust in Air (10^{-4} g/yr)
Trespasser on the slope in its current condition (TC)	25	0	72	1.24	2
Worker on the slope in its current condition (WC)	25	0	180/20	1.24	2
Worker conducting limited excavation on the riprap-covered slope (WRR-LE)	1142	0	10	1.74	7
Trespasser on the covered slope after limited excavation (TRR-ALE)	29.7	0	72	1.24	2
Worker on top of the covered slope after limited excavation (WRR-ALE)	29.7	0	180/20	1.24	2
Worker conducting major excavation (W-ME)	6.2	0	160	1.74	7
Worker on debris material following major excavation (W-AME)	6.2	0	500	1.24	2

* To convert pCi/g to Bq/kg, multiply by 37

5.5 Licensee Results

The licensee calculated the peak annual total effective dose equivalent to the average member of the critical group expected within the first 1000 years after decommissioning, in accordance with 10 CFR 20.1401(d). Cabot's analysis evaluated annual doses at 0, 1, and 10 years after license termination. Evaluation for other times was unnecessary because equilibrium concentrations of progeny of long-lived parent radionuclides was assumed. The analysis used the peak calculated annual dose to compare against NRC criteria for unrestricted use. The peak dose was calculated to occur at year zero. Cabot ran RESRAD for each scenario to determine the maximum dose to the average member of the critical group. Tables 5.5.1 and 5.5.2 provide the results of Cabot's analysis for each of the 12 scenarios. The maximum dose calculated for the five compliance scenarios is 0.037 mSv/yr (3.7 mrem/yr) from the worker placing riprap (WRR-P). For the seven alternate scenarios, the maximum dose is 0.048 mSv/yr (4.8 mrem/yr) from a worker conducting limited excavation (WRR-LE).

Table 5.5.1 Licensee's Dose for Compliance Scenarios

Scenario	Dose* (mrem/yr)
WRR-P	3.7
TRR	0.02
WRR	0.78
RWWLK (ROW)	0.33
RWWRK (ROW)	0.93

*To convert mrem/yr to mSv/yr, multiply by 0.01

Table 5.5.2 Licensee's Dose for Alternate Scenarios

Scenario	Dose* (mrem/yr)
TC	1.4
WC	1.2
WRR-LE	4.8
TRR-ALE	1.6
WRR-ALE	1.2
W-ME	0.92
W-AME	2.4

*To convert mrem/yr to mSv/yr, multiply by 0.01

5.6 Independent Analysis

The NRC staff recognized that there was uncertainty in Cabot's input values for the source concentration and outdoor exposure time for certain scenarios. Because dose is expected to be most sensitive to the source concentration and outdoor exposure time parameters, the staff focused its review on these parameters.

The NRC staff analyzed Cabot's source term estimate and determined that the total thorium at the site could be five times the Cabot estimate of 2.19 tons. The uncertainty in the source term is expected to have the largest effect for the scenarios that relate to major excavation. Source term uncertainty would have minimal effect on scenarios related to existing site conditions since the exposures are known and corroborated. Source uncertainty would not apply to limited excavation scenarios in which the conceptual dose model is based on exposure to a fraction of pure slag, rather than an aggregated quantity. Therefore, for the W-ME and W-AME scenarios, NRC staff ran the RESRAD code with a source concentration of 1165 Bq/kg (31.5 pCi/g) (i.e., five times 233 Bq/kg (6.3 pCi/g)). As discussed below, using this conservative assumption yielded a bounding annual dose to a worker at the site of 0.24 mSv/yr (24 mrem/yr) for the W-ME scenario.

In addition, the staff found that there was uncertainty in Cabot's input values for exposure time. The staff focused its review on the site worker scenarios (W-ME, W-AME, and WRR-LE) because these scenarios showed a higher level of sensitivity to the exposure time parameter. To support its exposure time value for the W-ME scenario, Cabot compared its value of 160 h/yr to the Means construction and cost data value of 855 man-hours. Cabot explained that a time of 855 man-hours would require an impractically long excavation period of 5.3 months. Cabot found that an excavation timeframe of 1 month could be achieved with multiple shifts or multiple crew members per day. However, there is no certainty that this type of excavation would span only 1 month, and Cabot provided no basis for assuming this 1-month timeframe. Therefore, the NRC staff used an exposure time of 855 h/yr for its independent analysis.

The Means construction data for the W-AME scenario indicated a time value of 356 man-hours for unloading and placement activities and 889 man-hours for spreading the load. The NRC staff determined that a timeframe of 800 hours would provide a more conservative value. The assumption of 800 hours involves one worker for unloading and placement and the same worker conducting half of the load spreading activities (i.e., 356 h + 1/2 (889 h) = 800 h). The staff did not analyze this scenario at 800 hours because its independent review of the W-ME scenario should bound the W-AME scenario.

Cabot used a value of 10 h/yr for the WRR-LE scenario. Although this value is slightly lower than the Means construction data value of 11.5 hours, the staff's analysis showed that this scenario would require an exposure time of more than 50 h/yr to exceed the 0.25 mSv/yr (25 mrem/yr) dose limit.

Cabot did not provide a basis for the selection of a 20 h/yr exposure time for the WRR scenario. However, the staff's independent analysis of the W-ME scenario provides an exposure time of 855 h/yr and a source concentration of 1170 Bq/kg (31.5 pCi/g), which results in a bounding scenario for each of the licensee's scenarios, with the exception of the WRR-LE scenario. Therefore, the staff's analysis of the W-ME scenario also addresses the uncertainty of the occupation time for the WRR scenario provided by Cabot. The staff's assessment of the W-ME scenario resulted in a dose of 0.24 mSv/yr (24 mrem/yr), which is below the 0.25 mSv/yr (25 mrem/yr) dose limit.

5.7 Conclusion

The NRC staff has reviewed the dose assessment for the Cabot Reading site based upon the guidance in NUREG-1757, Volume 2, for conducting dose assessment to demonstrate compliance with the License Termination Rule.

The staff believes that the Cabot assessment used appropriate scenarios and conceptual models. However, the staff believes that the licensee could have provided a more conservative source term for the scenarios involving major excavation. There was also uncertainty in the exposure time values for the excavation scenarios and the WRR scenario. However, the staff's independent analysis found that using more conservative values, the dose limit was not exceeded. The dose to a worker at the site should be no greater 0.24 mSv/yr (24 mrem/yr) based upon the less likely but still plausible scenario involving a worker conducting major excavation of the site. Accordingly, it should be acceptable to release the site for unrestricted use.

6.0 Environmental Information

The NRC has prepared a separate environmental analysis (ADAMS Accession No. ML072390323) to consider the effects of the proposed action on the environment. The agency did not identify any significant environmental impacts.

7.0 ALARA Analysis

The staff has reviewed the information submitted by Cabot to demonstrate that the preferred decommissioning option is ALARA as required in Subpart E of 10 CFR Part 20, in accordance with the criteria in Chapter 6, "ALARA Analysis," of NUREG-1757, Volume 2. Based on this review, the staff concludes that the preferred option provides reasonable assurance that the proposed activities will result in residual radioactivity levels that are ALARA.

8.0 Planned Decommissioning Activities

The NRC staff has reviewed the decommissioning activities described in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Section 17.1, "Planned Decommissioning Activities," of NUREG-1757, Volume 1. Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information to allow the NRC staff to evaluate the licensee's planned decommissioning activities to ensure that the decommissioning can be conducted in accordance with NRC requirements.

8.1 Installation of an Erosion Barrier

The Cabot DP proposes installation of a riprap erosion barrier on top of the slag pile

8.1.1 Evaluation of Surface Water Hydrology and Erosion Protection

Introduction

NRC staff reviewed surface water hydrology and erosion protection issues related to long-term stability of the proposed riprap cover, and the technical bases for the acceptability of the licensee's decommissioning plan (DP). Review areas that are covered include: estimates of flood magnitudes; water surface elevations and velocities; sizing of riprap to be used for erosion protection; rock durability; and testing and inspection procedures to be implemented during construction. The review is based on information provided by the licensee in the decommissioning plan and the related erosion protection addendum (Cabot Corporation, 2006). Review methods and acceptance criteria in Section 3.0 of NUREG-1620, Rev.1 (NRC, 2003) and NUREG-1757 Vol. 2, Rev. 1 (NRC, 2006) were used in conducting the review. Although NUREG-1620 is not specifically applicable to decommissioning sites, it was used as a general guide for this review.

Hydrologic Description and Site Conceptual Design

The site is located near the east bank of the Schuylkill River in Reading, PA. The site is situated approximately 7.5 - 30.5 meters (m) (25-100 feet (ft)) above the level of the river, and the licensee proposes to stabilize the buried contaminated material in place on a steep slope. The design basis events for design of erosion protection include the Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF) events, both of which are considered to have very low probabilities of occurring during the 1000-year stabilization period.

As shown in the DP, the side slope will be constructed on a slope of about 1 vertical (V) on 1.5 horizontal (H). To protect against erosion, the slope will be covered with a layer of rock riprap. At the toe of the slope, a large rock riprap apron will be constructed to stabilize the bottom of the side slope and to provide protection against the erosive velocities of the river. The elevation of the river bottom is approximately 57 m (186 ft) MSL, and the rock apron will be constructed at an elevation of approximately 64 m (210 ft) MSL. Large rock will protect the slope from flooding on the Schuylkill River from elevation 64 m (210 ft) MSL to elevation 70 m (230 ft) MSL, and somewhat smaller rock will protect the slope from overland flows from elevation 70 m (230 ft) MSL to elevation 81 m (265 ft) MSL.

Flooding Determinations

Because of the elevation of the site, floods on the Schuylkill River pose a significant threat to the slope. A secondary flood and erosion threat to the buried contaminated material is from precipitation on the side slope and the resulting flow on the slope and drainage of water moving overland down the slope.

The computation of the peak flood discharge for overland flow down the side slope, resulting from local intense precipitation, was performed by the licensee in several steps. These steps included: (1) selection of a design rainfall event; (2) determination of infiltration losses; (3) determination of times of concentration; (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration; and (5) calculation of flood discharge.

Input parameters were derived from each of these steps and were then used to calculate the peak flood discharges to be used in the final determination of rock sizes for erosion protection.

To determine the PMF on the Schuylkill River, the licensee estimated the PMF using data from published, approved PMF studies in the Delaware and Susquehanna River basins. Additional discussion is found below.

1. Selection of Design Rainfall Event. One of the phenomena most likely to affect long-term stability is surface water erosion. To mitigate the potential effects of surface water erosion, it is very important to select an appropriately conservative rainfall event on which to base the flood protection designs. Further, the staff considers that the selection of a design flood event should not be based on the extrapolation of limited historical flood data due to the unknown level of accuracy associated with such an extrapolation. The licensee utilized a Probable Maximum Precipitation (PMP) event, computed by deterministic methods (rather than statistical methods) and based on site-specific hydrometeorological characteristics. The PMP has been defined as the most severe reasonably possible rainfall event that could occur as a result of a combination

of the most severe meteorological conditions occurring over a watershed. No recurrence interval is normally assigned to the PMP; however, the staff has concluded that the probability of such an event being equalled or exceeded during the 1,000-year stability period is very low. Accordingly, the PMP is considered by the NRC staff to provide an acceptable design basis.

Prior to determining the runoff, the flooding analysis requires the determination of PMP amounts for the specific site location. Techniques for determining the PMP have been developed for the United States by Federal agencies in the form of hydrometeorological reports for specific regions. These techniques are widely used and provide straightforward procedures with minimal variability. For the Cabot site, PMP values were estimated by the licensee using Hydrometeorological Report No. 51 (HMR-51) (USACE, 1978) and HMR-52 (USACE, 1982). These reports also provide information on distributing the rainfall that falls over a particular drainage area. A 1-hour PMP of 45.2 centimeters (cm) (17.8 inches (in)) was used by the licensee as a basis for estimating a PMF for the side slope of the buried contaminated material. (The PMF is a hypothetical flood that is considered to be the most severe reasonably possible, based on comprehensive hydrometeorological application of the PMP and other hydrologic factors favorable for peak runoff. The PMF is considered by the NRC staff to provide an acceptable design basis for erosion protection.) The procedures for estimating PMP values were reviewed, and it was concluded that the PMP amounts are acceptable for the small drainage areas on the short, steep side slope.

<u>2. Infiltration Losses.</u> The determination of the peak runoff rate is also dependent on the amount of precipitation that infiltrates into the ground during its occurrence. If the ground is saturated from previous rains, very little of the rainfall will infiltrate and most of it will become surface runoff. The loss rate is highly variable depending on the vegetation and soil characteristics of the watershed. Typically, all runoff models incorporate a variable runoff coefficient or variable runoff rates. Commonly-used models such as the U.S. Bureau of Reclamation (USBR) Rational Formula (USBR, 1977) incorporate a runoff coefficient (C); a C value of 1 represents 100-percent runoff and no infiltration. Other models may separately compute infiltration losses within a certain period of time to arrive at a runoff amount during that time period.

In computing the peak flow rate for the small drainage areas at the site, the licensee used the Rational Formula (USBR, 1977). In this formula, the runoff coefficient was assumed to be 0.8; that is, the licensee assumed that very little infiltration would occur. Based on the conservatism associated with the use of a conservative PMP value and a resulting rainfall intensity, the staff concludes that this is an acceptable assumption.

<u>3. Time of Concentration.</u> The time of concentration (t_c) is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. The peak runoff for a given drainage basin is inversely proportional to the time of concentration. If the time of concentration is assumed to be smaller, the peak discharge will be larger. Times of concentration and/or lag times are typically computed using empirical relationships such as those developed by Federal agencies. Velocity-based approaches are also used when accurate estimates are needed. Such approaches rely on estimates of actual flow velocities to determine the t_c of a drainage basin.

Times of concentration for the riprap design were estimated by the licensee using the Kirpich Method (USBR, 1977). This method is generally accepted in engineering practice and is considered by the staff to be appropriate for estimating times of concentration at this site. The t_c on the steep side slope was calculated to be 0.3 minutes. Based a review of the calculations provided, the staff concludes that the t_c values used by the licensee were acceptably derived.

4. Rainfall Distributions. After the PMP is determined, it is necessary to determine the rainfall intensity corresponding to the short time of concentration. A typical PMP value is derived for periods of about one hour. If the time of concentration is less than one hour, it is necessary to extrapolate the data presented in the various hydrometeorological reports to shorter time periods. To determine peak flood flow for the slope, the 0.3-minute PMP rainfall was very conservatively extrapolated by the licensee and was determined to be 5.46 cm (2.15 in) (rainfall was assumed to be 5.46 cm (2.15 in) in 18 seconds). Based on a review of this aspect of the flooding determination, the staff concludes that the computed peak rainfall is very conservative and is, therefore, acceptable.

5. Computation of Peak Flood Discharges and PMF. Various methods are used to determine peak PMF flows, depending on the location of the feature, the drainage area, and other factors.

Side Slope. To estimate PMF peak discharges for the side slope, the licensee used the Rational Method (Chow, 1959). This method is a simple procedure for estimating flood discharges and is recommended in NUREG-1623 (Johnson, 2002). For a maximum slope length of 25 m (82 ft), the licensee estimated the peak flow rate to be about .03 cubic meters per second per meter of width (cms/m) (0.3 cubic feet per second per foot of width (cfs/ft)). Based on a review of the calculations, including the time of concentration, rainfall intensity, and runoff, the staff concludes that the estimate is conservative.

Apron. The licensee designed a rock apron to provide a transition section from the side slopes of the buried contaminated material to natural ground. Its purpose is to reduce flow velocities to non-erosive levels and to protect the side slope from undercutting from high-flow velocities in the river. PMF flow rates for overland flow for the downstream apron were estimated by the licensee and are similar to the flow rates for the side slopes. As discussed above, the flow rates are considered to be acceptable. However, as discussed below, the riprap size for the apron is controlled by velocities produced by floods on the Schuylkill River.

To estimate the PMF on the Schuylkill River, the licensee used data and flood analyses based on PMF studies in the Delaware and Susquehanna River basins. The PMF was estimated using a straight line interpolation on a log-log scale for 21 PMF calculations that had been accepted by the NRC and other government agencies for various locations and applications. The data were obtained from NRC Regulatory Guide 1.59, “Design Basis Floods for Nuclear Power Plants” and the Limerick Generating Station Final Safety Analysis Report. A drainage area of 2,200 square kilometers (km^2) (880 square miles ($mi^{2)}$)) at the Cabot site resulted in a PMF estimate of 8,500 m^3/s (300,000 ft^3/s).

The staff concludes that this PMF estimate is conservative, based on analyses associated with other floods that have occurred on the Schuylkill River. For example, the flood of record occurred in 1972, associated with Hurricane Agnes, and had a peak discharge of about 2,200 m^3/s (78,000 ft^3/s) (about 25% of the estimated PMF) at the Reading gauging station downstream of the site. Further, flood insurance studies indicate that the 100-year flood will have a peak flow of about 1,800 m^3/s (56,000 ft^3/s) (less than 20% of the PMF). In addition, the staff examined envelope curves of the maximum floods that have occurred in the northeastern

United States (Crippen and Bue, 1977). This review indicates that the maximum recorded flood for a drainage area of 2,200 km^2 (880 mi^2) would have a magnitude of about 5660 m^3/s (200,000 ft^3/s) (about 2/3 of the PMF).

Water Surface Profiles and Velocities

Following the determination of the peak flood discharge, it is necessary to determine the resulting water levels, velocities, and shear stresses associated with that discharge. These parameters then provide the basis for the determination of the required erosion protection features, including riprap size and layer thickness, needed to ensure stability during the occurrence of the design event.

Side Slope. In determining riprap requirements for the side slope (above the PMF level) to protect against overland flows, the licensee used the Stephenson Method (Stephenson, 1979). The validity of this design approach was verified by the NRC staff through the use of flume tests at Colorado State University. It was determined that the selection of an appropriate design procedure depends on the magnitude of the slope (Abt, et al., 1987). The staff, therefore, concludes that the procedures and design approaches used by the licensee are acceptable and reflect state-of-the-art methods for designing riprap erosion protection.

Below the PMF level at about elevation 70.1 m (230 ft) above mean sea level (msl), the rock size is controlled by velocities and shear stresses produced by flows in the Schuylkill River. The size of the rock on the slope was checked for overland flow, but due to its location, the size of the rock is controlled by velocities and shear stresses in the Schuylkill River. The water surface profile and velocities were calculated by the licensee using the HEC-RAS River Analysis System software (version 4.1.3) of the U. S. Army Corps of Engineers. The licensee developed cross-sections using USGS topographic data and also conducted a detailed survey of the site area. The HEC-RAS model was used to determine water surface elevations, velocities, and flow rates for various sub-sections across the river cross-section. For the design of the rock for the side slope, the peak velocity and flow rate were estimated to be 2.5 meters per sec (m/s) (8.2 feet per second (fps)) and 13.2 cms/m (142 cfs/ft).
Based on review of the information provided, the staff concludes that the water levels and velocities associated with large floods have been conservatively estimated by the licensee. For example, a flood similar to the Hurricane Agnes flood, with a discharge of about 2210 cms (78,000 cfs) would be expected to reach only to an elevation of about 66.75 m (219 ft) msl, slightly inundating the slag, but having a velocity much lower than the design velocity.

Side Slope. For the side slope above the PMF level, the licensee proposes to use a 30.5-cm (12-in) layer of rock with an average D_{50} of 15.25 cm (6 in) (riprap designated R-4 by PADEP). The Stephenson Method (Stephenson, 1979) was used to determine the required rock size of 3.3 cm (1.3 in). For the side slope below the PMF level, the licensee proposes to use a 61-cm (24-in) layer of rock with a D_{50} 30.5 cm (12-in) (designated R-6 by PADEP). Based on staff review of the licensee's analyses and the acceptability of using design methods recommendedby the NRC staff, the staff concludes that the proposed rock size for the side slope is adequate.

Apron. The design of the apron for the buried contamination must be adequate to withstand forces from several different phenomena and is based on the following general concepts: (1) provide riprap of adequate size to be stable against overland (downslope) flows produced by the design storm (PMP), with allowances for turbulence along the downstream portion of the toe; (2) provide uniform and/or gentle grades along the apron and the adjacent ground surface such that runoff is distributed uniformly onto natural ground at a relatively low velocity, minimizing the potential for flow concentration and erosion; (3) provide an adequate apron length and quantity of rock to allow the rock apron to collapse into a stable configuration if gullying occurs and erodes toward the site and (4) provide an apron with adequate rock size to resist flows that will occur in the Schuylkill River laterally along the apron.

The size of the rock in the apron was checked for overland flow, but due to its location, the size of the rock is controlled by velocities and shear stresses in the Schuylkill River. Similar to the side slope, water surface profiles and velocities were calculated by the licensee using the HEC-RAS River Analysis System software. For the design of the rock for the apron, the peak velocity and flow rate were determined to be 5.67 mps (18.6 fps) and 30.00 cms/m (323 cfs/ft). Based on review of the information provided, as discussed above, the staff concludes that the water levels and velocities associated with large floods have been conservatively estimated by the licensee.

Apron. The licensee proposes to use a 91.5-cm (36-in) layer of rock with a D_{50} of 45.75 (18 in) in the apron area (designated R-7 by PADEP) . The riprap for the apron was designed by the licensee using the criteria suggested in NUREG-1623 using the peak PMF flow. Based on review of the calculations provided, the staff concludes that the proposed rock size for the apron is acceptable.

Sizing of Erosion Protection

The ability of a riprap layer to resist the velocities and shear forces associated with surface flows over the layer is related to the size and weight of the stones that make up the layer. Typically, riprap layers consist of a mass of well-graded rocks that vary in size. Because of the variation in rock sizes, design criteria are generally expressed in terms of the median stone size, D_{50}, where the numerical subscript denotes the percentage of the graded material that contains stones of less weight. For example, a rock layer with a minimum D_{50} of 10.2 centimeters (cm) (4 inches (in)) could contain rocks ranging in size from 1.9 cm to 15.25 cm (0.75 in to 6 in); however, at least 50% of the weight of the layer will be provided by rocks that are 10.2 cm (4 in) or larger.

Depending on the rock source, variations occur in the sizes of rock available for production and placement, and it is therefore necessary to ensure that these variations in rock sizes are not extreme. Design criteria for developing acceptable gradations are provided by various sources (e.g., Simons and Li, 1982), and examples of acceptable gradations may be found in NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization." The licensee developed riprap gradations and layer thicknesses using criteria suggested in Pennsylvania Department of Environmental Protection (PADEP, 2000). Staff review of the information provided indicates that the proposed gradations are acceptable to assure adequate protection.

Riprap layers of various sizes and thicknesses are usually proposed for use at many sites, and the design of each layer is dependent on its location and purpose. To reduce the number of gradations that need to be produced, a licensee can place larger rock than is required in some areas. For ease of construction and to minimize the number of gradations, the licensee has purposely over-designed several areas of the side slope by proposing to use larger-than-necessary rock on the entire side slope. Thus, additional conservatisms are added to the design in those areas where larger rock than required will be used.

Side Slope. For the side slope above the PMF level, the licensee proposes to use a 30.5-cm (12-in) layer of rock with an average D_{50} of 15.25 cm (6 in) (riprap designated R-4 by PADEP). The Stephenson Method (Stephenson, 1979) was used to determine the required rock size of 3.3 cm (1.3 in). For the side slope below the PMF level, the licensee proposes to use a 61-cm (24-in) layer of rock with a D_{50} 30.5 cm (12-in) (designated R-6 by PADEP). Based on staff review of the licensee's analyses and the acceptability of using design methods recommended by the NRC staff, the staff concludes that the proposed rock size for the side slope is adequate.

Apron. The licensee proposes to use a 91.5-cm (36-in) layer of rock with a D_{50} of 45.75 (18 in) in the apron area (designated R-7 by PADEP) . The riprap for the apron was designed by the licensee using the criteria suggested in NUREG-1623 using the peak PMF flow. Based on review of the calculations provided, the staff concludes that the proposed rock size is acceptable.

Rock Durability

Previous sections examined the ability of the proposed erosion protection design to withstand flooding events reasonably expected to occur in 1,000 years. In this section, rock durability is evaluated to determine if there is reasonable assurance that the rock itself is durable and will survive and remain effective for 1,000 years. Rock durability is defined as the ability of material to withstand the forces of weathering. For rock to remain effective to control erosion, the rock size selected should not be reduced by weathering processes. Therefore, if the rock size used for the cover does not diminish over the 1,000-year compliance period, its ability to control future erosion will be sustained. However, uncertainties exist with estimating future rock durability. For example, quantitative studies of weathering rates of various rock types and minerals are limited. As a result, NRC's decommissioning guidance in NUREG-1757 Vol., Rev. 1, "Consolidated NMSS Decommissioning Guidance." (NRC, 2006) suggests that licensees conduct three evaluations of rock durability to provide multiple and complimentary lines of evidence and greater confidence in the future durability of the rock source selected. These evaluations are: 1) rock durability testing and scoring; 2) absence of adverse minerals and heterogenities; and 3) evidence of resistance to weathering. Each of these evaluations was provided by the licensee and the staff's review is described below.

Selection and description of rock type and source

Cabot used the NRC guidance in NUREG-1623 (NRC, 2002) and NUREG-1757, Vol. 2, Rev. 1, Appendix P (NRC, 2006) to select and analyze available durable rock for use as a riprap cover. The NRC guidance in NUREG-1623 has been used successfully for over 10 years by the NRC and the U.S. Department of Energy to select durable rock for construction of erosion covers at numerous uranium mill tailings sites that are designed to remain stable for up to 1,000 years without reliance upon active ongoing maintenance (NRC, 2006).

In the general vicinity of the Cabot Reading site, there are numerous sources of rock types available including limestone, dolomite, granitic gneiss, diabase, and sandstone. The licensee believed that the diabase would be more resistant to weathering and quarries were closer to the site. The licensee's review resulted in the selection of the Dyer quarry in Birdsboro, PA as the source for the riprap cover material. The Dyer quarry is located approximately 11 kilometers (km) (7 miles) southeast of the site.

Diabase is a massive intrusive igneous rock. Diabase intrusions of late Triassic to early Jurassic age occur in southeast Pennsylvania. Three distinct types of diabase intrusives have been extensively studied in the literature: York Haven, Rossville, and Quarryville (Froelich, in Shultz, 1999; Smith, et al, 1975). These studies provide geological and geochemical information, including locations and distribution, chemical composition, mineralogy, and heterogenities. The Dyer quarry is of the York Haven type, and the Birdsboro sheet mined at the Dyer quarry consists of a nearly vertical mass over 200 meters (1,000 feet) thick. MacLachlan (1992) describes diabase in the area containing the Dyer quarry as dark gray, fine-grained in dikes, and medium-grained to locally pegmatitic (coarse-grained) in major bodies. These diabases are of the York Haven type. They are an excellent source of road material, riprap, railway ballast, building stone, embankment facing, and fill. The mineralogical composition of samples from the Dyer quarry were provided by the quarry and petrographic analyses were performed by the licensee. The quarry result indicated that the diabase consisted of 51-56 percent plagioclase feldspar, 17-36 percent pyroxene, 3-10 percent hornblende, 2-6 percent graphic quartz, 4-7 percent quartz, and 4 percent magnetite. Chemical composition data were also provided by the licensee from the Dyer quarry and published data from the same diabase sheet near the quarry (Gottfried, 1991) and for the York Haven type diabase sheets (Froelich, 1999).

Rock durability testing and scoring

The licensee provided rock test data provided by the Dyer quarry along with its own independent tests of specific gravity, absorption, sodium sulfate, and L/A abrasion. A procedure for determining the acceptability of a rock source presented in NUREG-1623 was developed by the NRC and used for selecting durable rock for erosion covers for uranium mill tailing sites. This procedure provides a consistent and quantitative way to evaluate rock sources at NRC-licensed sites using standard parameters that are good indicators of rock durability (i.e., specific gravity, absorption, sodium sulfate, and L/A abrasion).

The licensee developed rock scores using this procedure and the rock test results from the Dyer quarry and its own tests. The rock score for the data provided by the Dyer quarry was 93 percent, and the score for the licensee data was 97 percent. These scores exceed the 80 percent score, which is an indicator of high quality rock that can be use for most applications, according to NRC guidance in NUREG-1623. Therefore, the scores of 93 to 97 percent indicate rock of exceptional quality.

In addition to the rock scores developed by the licensee, the staff provided further insights regarding the durability test results. A U.S. Department of Interior Bureau of Reclamation report of the performance of rock covers on 149 earth dams, indicates that specific gravity and absorption are the most valuable parameters for identifying sound, durable rock (Esmiol, 1967). This report concludes that specific gravity of excellent rock ranged from 2.50 to 2.96. The licensee test results of 2.97 and 3.00 exceeded this range. Similarly, absorption of water for excellent rock is very low, ranging from 0 to 2.1 percent. The licensees' test results were 2.0-percent.

Absence of adverse minerals and heterogenities

The existence of adverse minerals, such as expanding clay minerals (smectites) or minerals that could rapidly weather, such as olivine, could lead to a reduction in the size of the riprap within the 1,000-year period of compliance. Therefore, the absence of these, or other adverse minerals, is desirable.

The licensee provided evidence from the literature and its own petrographic analysis of Dyer quarry samples to demonstrate the absence of olivine, clay minerals, shale seams, and carbonate minerals or veins. In addition, the staff notes that the mineralogical information published by Smith (1975), indicates that the York Haven-type diabase contains little or no olivine (1 to 2 percent), even though another diabase type in Pennsylvania can contain up to 15 percent olivine.

Heterogenities in rock can be planes of weakness or zones of water flow and associated chemical weathering or zones of breakage due to freeze thaw. The licensee evaluated potential adverse heterogenities in the diabase from the Dyer quarry including fractures, chilled margins, alteration zones, zones of higher porosity and groundwater flow, and large crystals called xenoliths. However, these features comprise an insignificant fraction of the overall rock mass and are easily identified and avoided during removal of rock. Observations during a site visit by the licensee and the NRC staff indicated that the typical fracture spacing ranges from several feet to 3 meters (10 feet) and extreme fracture spacing of less than 0.3 m (1 ft) and up to 9 meters (30 feet) or more. It did not appear that fractures remained in individual pieces of rock after being quarried. The size requirements for the riprap for use on the Cabot site will preclude use of rock from zones of closer fracture spacing. Chill zones, xenoliths, alteration zones, and flow zones are not believed to be common and can be easily identified and avoided during rock excavation.

Evidence of resistance to weathering

Evidence of resistance to weathering can be both direct and indirect. Direct evidence described by the licensee includes:

- Diabase and the igneous/metamorphic rocks of the Reading Prong underlay the highest topography in the Reading area and, thus, indicate general resistance to long-term weathering processes.

- The literature notes that diabase in Pennsylvania is highly resistant to weathering, slightly weathered to a shallow depth, and weathering results in large rounder boulders mixed with mantle (Geyer, 1982).

- Licensee observations of diabase weathering in the Dyer quarry upper level and though out the area include:

    - Many areas have thin soil or lack any significant soil cover and consist entirely of bedrock outcrops and large boulders. Residual soil, called saprolite, is uncommon.

– Subsurface bedrock and boulders consist of fresh rock with a thin weathering rind; some boulders displayed spheroidal weathering features with only a thin (millimeters to centimeter thickness) weathering rind beneath which the rock appears unweathered and hard. A few rock fragments that had been quarried in the upper zone had an occasional very thin weathering rind on preexisting fractures. Nearly all the quarried pieces displayed clean unweathered surfaces. Lower quarry benches displayed less indications of weathering.

– Based on the literature and licensee observations, the licensee described the weathering of diabase in the subsurface as consisting of a thin zone with a fairly distinct front, or weathering rind, that progresses into the rock. This thin zone separates the residual soil from fresh unweathered rock. The weathering rinds progress inward from the bedrock surface and along fractures. As the weathering rinds converge, they result in a spheroidal shape of the remaining boulders.

Because of the absence of quantitative weathering rate studies for diabase as well as other rock types, the staff considers that indirect evidence of resistance to weathering adds confidence in the slow weathering and durability of diabase. These geological and archeological/historical analogue studies provide strong support to the durability of diabase to remain resistant to weathering for thousands of years and well beyond the 1,000-year regulatory compliance period required.

Rock Durability Analogues

The licensee and NRC staff identified four geological analogue studies that are applicable to the Dyer quarry diabase rock type. The first two are from similar diabases from the same region and age, while the other two examples are of rocks from other locations but with similar mineralogy (i.e., plagioclase feldspars, that make up of over half of the mineral content of the Dyer quarry diabase).

– The NRC staff identified a study of glacial erratics of Palisades diabase found on the glacial smoothed bedrock of New York City that indicates that these boulders have resisted weathering for at least 16,000 years since the last glacial retreat (Sanders, et al, 1994).

– The NRC staff identified another indicator that diabase is resistant to weathering in a study of a diabase outcrop that crosses the Susquehanna River immediately south of Three Mile Island in Pennsylvania (Sevon, 1989). This study concludes that potholes and ripples have been carved in the diabase by sand grains carried by high-velocity flow during Pleistocene deglaciation nearly 20,000 years ago. Subsequently, these features have remained intact and have resisted general weathering and further river abrasion from reduced flow and smaller grain size sediment.

– The licensee provided another example of the general durability of mafic crystalline rocks from Chebeague Island, ME. At this location, the licensee observed that bedrock consisting of metavolcanics with a mafic composition show glacial striations that were formed approximately 10,000 years ago. Despite aggressive frost wedging affects and foliation, the glacial striations are still evident after 10,000 years.

– The licensee provided another natural analog study from the Coweeta basin in North Carolina that is one of the few basin-wide studies to determined the rate of weathering of crystalline rocks composed primarily of quartz, mica, plagioclase feldspar, and garnet. Geochemical mass-balance calculations permit quantification of mineral weathering rates and rates of saprolite (residual soil) formation. This unique, more quantitative study is relevent to the Cabot diabase because of the plagioclase feldspar content of both rock types. This study estimated the that the rate of saprolite formation from fresh bedrock in the study area is approximately 3.8 cm/1,000 yrs (Swank, 1988). The staff observed that the weathering rate for feldspar to create a weathering rind of altered minerals and reduction in rock size would likely be much less because a weathering rind is an intermediate stage occurring before the end result of saprolite formation. Furthermore, the Coweeta estimated rate would be a conservative estimate for weathering of plagioclase feldspar at the Cabot site because the average temperature and rainfall in the Cowettta basin is greater than in the Reading, PA area and the riprap will be located on a steep, well drained slope.

Three archeological/historical analogues identified by the licensee and NRC staff provide further indirect evidence of the resistence of diabase to weathering for long time periods.

– The licensee surveyed graveyards located in the same diabase dike area as the Dyer quarry. Several graveyards within two miles of the quarry contained gravestones made from the local diabase. After 115 years of exposure, the lettering and edges of one gravestone are sharp and only a slight staining is visible.

– The NRC staff identified an historical example from Gettysburg Battle Park in Pennsylvania, where there are massive boulders of the York Haven diabase type, which is the same diabase type and chemical composition as the Dyer quarry diabase. NRC staff comparisons of photographs taken of diabase boulders at Devil's Den at the time of the battle in 1863 to present day show no obvious signs of degradation and reduction in size of the boulder in over 140 years.

– The NRC staff identified that Stonehenge in England is a well-known archeological/historical analogue relevant to the Dyer quarry diabase. The inner bluestone circle of stones making up Stonehenge are diabase, commonly called Preseli bluestones brought from West Wales and erected in a circle around 2100 BC (Shearing, 2003). Therefore, this diabase has survived the weathering processes of a moist climate for over 4,000 years.

Based on the review of the licensees' evaluations, the staff concludes that: (1) durability test results and scores demonstrate exceptional physical properties of the diabase; (2) adverse minerals such as olivine and clay minerals are absent and adverse heterogenities, such as fractures, can be identified and avoided when rock is quarried for use at the Cabot site; (3) there is direct evidence from the Dyer quarry that diabase is resistant to weathering; and (4) indirect evidence from natural and archeological/historical analogues add confidence that diabase weathering rates are slow and diabase has resisted weathering for thousands of years. Based on these conclusions, the staff concludes that the Dyer quarry diabase is durable and should resist weathering and associated size reduction for at least the 1,000-year compliance period. Therefore, the staff considers that the Dyer quarry diabase is acceptable for erosion control at the Cabot site.

Testing and Inspection of Erosion Protection

The licensee provided information regarding testing, inspection, and quality control procedures to be used for the erosion protection materials (ML072630283 and ML072620294). The information included programs for durability testing, gradation testing, rock placement, and verification of rock layer thicknesses.

1. Rock Durability Testing. Durability test results will be used by the licensee to determine a rock durability rating, based on guidance found in NUREG-1623 as well as the absence of adverse heterogenities, such as fractures. The licensee has proposed that four durability tests will be conducted on representative samples. The licensee proposes that one initial test series will be performed prior to placing rock, and additional tests will be performed when approximately one-third and two-thirds of the total volume of the riprap have been delivered.

Based on a review of the proposed procedures, the staff concludes that an adequate durability testing program has been provided to ensure that rock of acceptable quality is produced. The testing program currently proposed is equivalent to many that were approved by the staff and have been implemented at other sites during construction.

2. Gradation Testing. The licensee proposes that rock gradation testing will be performed, using standardized tests such as ASTM C117 and C136, as appropriate. The testing will be performed on in-place samples to verify that rock gradations, as placed, meet construction specifications.

Based on a review of the proposed procedures, the staff concludes that the gradation testing program will ensure that rock layers with acceptable gradations are provided. The testing program is equivalent to several that were approved by the staff and have been implemented at other reclaimed sites during construction.

3. Riprap Placement. The licensee indicated that the rock would be placed using a program that generally meets the criteria outlined in NUREG-1623. Based on review of the program, the staff concludes that the program is acceptable.

4. Rock Layer Thickness Testing. The licensee has committed to a program where the thickness of the rock and filter layers will be verified using specific procedures for measuring and recording depths on a (7.5-meter) 25-foot grid pattern. Visual examinations will also be conducted, and measurements will be taken (using specific tolerances) to verify the uniformity of depths. Based on a review of the information provided, the staff concludes that the proposed testing program for rock layer thickness is adequate.

Wind Erosion

Because the side slope will be covered with large rock, the staff concludes that the site will be adequately protected for up to 1,000 years from wind erosion.

Evaluation Findings

Based on review of the information and calculations submitted by the licensee and on independent analyses of the data and calculations, the NRC staff concludes that the erosion protection design is adequate to provide reasonable assurance of protection for 1,000 years. The staff considers that adequate protection against flooding and erosion is provided by: (1) selection of proper and/or conservative rainfall and flooding events; (2) selection of appropriate and/or conservative parameters for determining flood discharges; (3) computation of flood discharges using acceptable, approved, and/or conservative methods; (4) computation of appropriate flood levels and flood forces associated with the design discharge; (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge; (6) selection of a rock type for the erosion protection that will be durable and capable of providing the necessary protection for a long period of time; and (7) placement of riprap layers in accordance with accepted engineering practice and in accordance with adequate testing and quality assurance controls.

9.0 Decommissioning Management Organization

The NRC staff has reviewed the description of the decommissioning project management organization, position descriptions, management and safety position qualification requirements, and the manner in which the licensee, Cabot, will use contractors during the decommissioning of its Reading site in accordance with Section 17.2, "Project Management and Organization," of NUREG-1757, Volume 1. Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information to allow the NRC staff to evaluate the licensee's decommissioning project management and organization to determine whether the decommissioning can be conducted safely and in accordance with NRC requirements.

9.1 Decommissioning Management Organization

Figure 9.1 shows the organizational structure of the Reading project and the roles and responsibilities of managers and staff that are relevant to the radiation safety programs at the site.

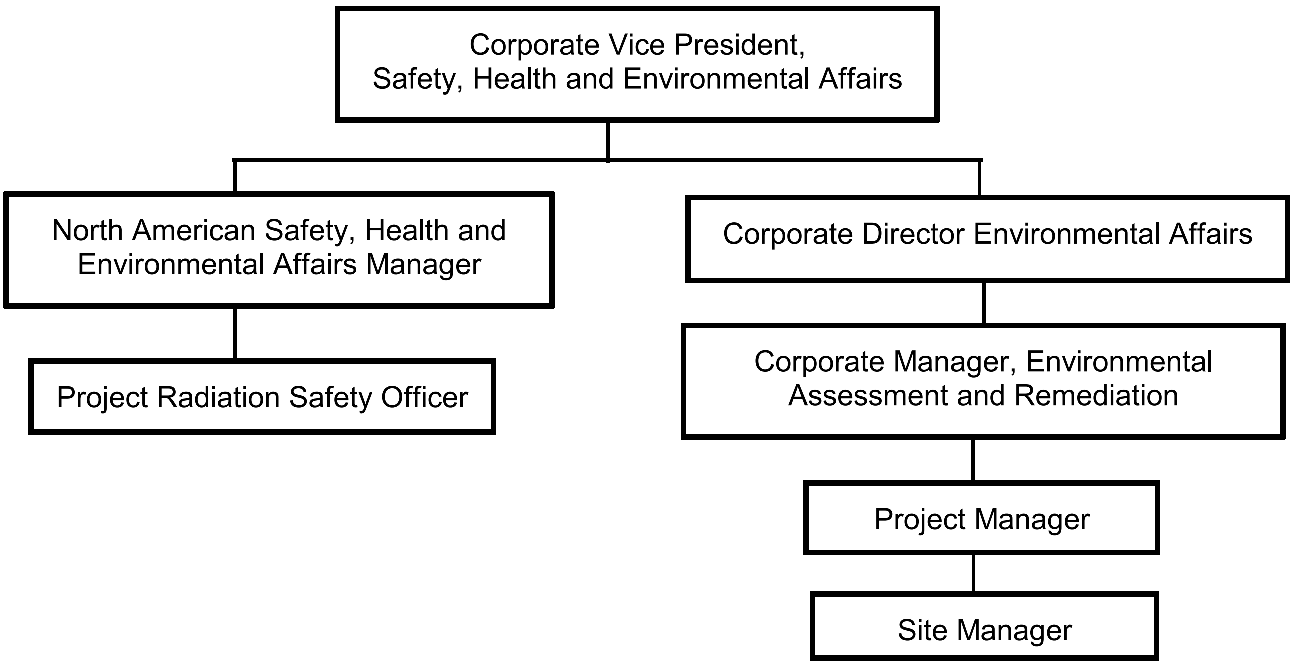

Figure 9.1 Organizational Structure of Reading Project

A license revision or notification to the NRC is required only for changes that negatively impact the independent reporting path for the Radiation Safety Officer (RSO), the authorities of the RSO, or the involvement of the RSO in the operational management of the project.

9.2 Decommissioning Management Positions and Responsibilities

The overall direction of Cabot operations for the Reading project is provided through intermediate-level management by the Corporate Vice President, Safety, Health, and Environmental Affairs. This person has overall responsibility for development and implementation of corporate policy and the ultimate management of all corporate personnel and activities.

The Reading Project Manager provides overall management of the Reading project. This person has overall responsibility for all project operations and is ultimately responsible for the health and safety of the project workers and protection of the environment and members of the general public from project activities.

The Reading Project Site Manager provides the day-to-day direct management of the Reading project site activities. This person has direct responsibility for ensuring that the Reading project site activities comply with the company's policies and procedures, including the site radiation safety programs.

The RSO is responsible for the development and implementation of a program for monitoring project and site activities and conditions to determine their status of compliance with the conditions of the radioactive materials license and relevant local, State, and Federal regulations. The RSO reporting chain is separate from the project and site management reporting chain. In this independent role, the RSO provides a mechanism by which any employee or contractor can report potentially unsafe conditions or safety concerns. The RSO promptly assesses and resolves any reported concerns.

All managers and the RSO have the authority to halt operations that appear to be unsafe, and they may be called upon to approve the restart of operations after such a shutdown.

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

- approving written operating procedures, radiation work permits, and other documents, including ensuring that they appropriately include ALARA principles

- 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 site and ensuring compliance with applicable regulations of the U.S. Department of Transportation and other appropriate agencies

- performing and arranging for calibration of instruments

- 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

9.3 Training

At a minimum, the RSO will have the following training and experience:

- B.S. degree in biology or a physical science
- completion of a basic radiation safety course
- at least 2 years experience in the safe use and handling of radioactive material

The RSO also attends a professional society meeting, seminar, or radiation safety training session at least once every 2 years for professional development.

10.0 Radiation Safety and Health Program

Cabot 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, personal dosimetry, air sampling, contamination surveys using wipe samples, instrument calibration and use, radiation safety orientation, and control of release of materials and equipment from restricted areas.

If the project extends longer than anticipated, Cabot will review existing procedures during the annual radiation safety program reviews and revise them as necessary to keep them current and accurate. Cabot will develop, review, authorize, and implement new procedures as necessary to document new processes. The licensee will track and maintain procedures 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 onsite inspections by the NRC.

The Reading Project Radiation Safety Program is designed and operated independent of other Cabot radiation safety programs, but it will draw upon Cabot Boyertown radiation safety resources for operational support.

10.1 Radiation Safety Controls and Monitoring for Workers

Cabot 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 10 CFR Part 19, “Notes, Instructions and Reports to Workers: Inspections and Investigations,” and 10 CFR Part 20. 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. During its annual review of the radiation safety programs, the ALARA Committee reviews and revises the information imparted during radiation safety training. Cabot includes reviews of radiation safety topics and training on new or revised radiation safety procedures and protocols on an ongoing, as-needed basis as part of its continuing safety training and employee meetings. In addition to this continuous retraining, Cabot requires restricted area workers to attend a refresher course at least once every 3 years. Cabot 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 before working without supervision in those areas. Class agendas and signup 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. The class typically covers the following topics:

- fundamentals of radiation safety, including the following:
  - 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 nonstochastic 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)
  - 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
- operation and limitations of radiation survey instruments
- storage, control, and disposal of licensed material
- requirements of pertinent Federal regulations

Ancillary Personnel—Ancillary personnel such as clerical, security, and administrative staff whose routine work activities 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 receive basic hazard recognition and emergency notification training that addresses the radiological hazards at the site. The class typically covers topics such as hazard recognition, locations of radioactive materials, and procedures to follow in case a radiological release is encountered.

Nonemployees—Appropriately trained Cabot employees will accompany nonemployees such as visitors and subcontracted workers who are expected to require access to restricted areas while on site. A locked security fence encloses the 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 nonemployee while on site. If nonemployees need to access restricted areas of the site without a Cabot escort, they will first receive the training for restricted area workers required for Cabot employees.

Methods of Exposure Control

Cabot has established routine work practices and procedures designed to minimize exposures to radioactive materials for employees and members of the general public. Work is performed in accordance with approved detailed procedures. The following provides a general description of methods used at the site.

Administrative Controls—Cabot employs administrative controls such as access control, postings, and frequent inspections. Workers are informed of restrictions during training sessions. Work areas are posted with signs and informational postings as required by the regulations and consistent with their conditions. Work is performed in accordance with approved written procedures under the supervision and monitoring of site management.

Engineering Controls—Cabot incorporates engineering controls to limit access to the areas containing radioactive materials. Control of excavation activities and dust management during riprap placement will be sufficient to ensure that no additional engineering controls will be required to ensure that exposure of workers or the public to airborne radioactive material does not exceed limits specified in 10 CFR Part 20.

10.1.1 Workplace Air Sampling Program

The NRC staff has reviewed the information in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Section 17.3.1.1, "Air Sampling Program," of NUREG-1757, Volume 1. Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information on airborne radioactivity levels (and corrective actions to be taken when these levels are exceeded) to allow the NRC staff to conclude that the licensee's air sampling program will comply with 10 CFR 20.1204, "Determination of Internal Exposure," 10 CFR 20.1501(a)–(b), 10 CFR 20.1502(b), 10 CFR 20.1703(a)(3)(i)–(ii), and Regulatory Guide 8.25, "Air Sampling in the Workplace."

The potential airborne radiological contaminant of concern at the Reading site is resuspended soil bearing naturally occurring uranium, thorium, and progeny nuclides. Based on technical evaluations in the radiological assessment, radionuclide concentrations in air are expected to be low and highly localized in areas of active work. Cabot will conduct work area air monitoring to meet the monitoring requirements of 10 CFR Part 20.

10.1.2 External Exposure Determination

The NRC staff has reviewed the information in the DP for Cabot Reading, License No. 040-09027, in accordance with Section 17.3.1.4, "External Exposure Determination," of NUREG-1757, Volume 1. Based upon this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information on methods to measure or calculate the external dose of a worker to allow the NRC staff to conclude that the licensee's program to determine external exposure will comply with the requirements of 10 CFR 20.1101(b), 10 CFR 20.1201(c), 10 CFR 20.1203, "Determination of External Dose from Airborne Radioactive Material," 10 CFR 20.1501(a)(2)(i) and (c), 10 CFR 20.1502(a), and 10 CFR 20.1601, "Control of Access to High Radiation Areas."

Personal or area dosimeters and exposure rate instrument surveys are used to track levels of radiation exposure in the work areas where radioactive materials are present. Area dosimeters may be considered an acceptable alternative to personal dosimeters in some areas of the site because of the low levels of radioactivity in the materials, the small quantities of materials that are present, and the short periods of time that workers are close to the material. Radiation levels are measured in locations where the highest dose rates are found as determined by the RSO and at locations of particular interest, such as restricted area boundaries.

10.1.3 Instrumentation Program

The NRC staff has reviewed the information in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Section 17.3.1.7, "Instrumentation Program," of NUREG-1757, Volume 1. Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information on the sensitivity and the calibration of instruments and equipment to be used to make quantitative measurements of ionizing radiation during surveys to allow the NRC staff to conclude that the licensee's instrumentation program will comply with 10 CFR 20.1501(b) and (c).

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. Table 10.1 describes the instruments which will be maintained at the site during decommissioning activities.

Table 10.1 Type and Purpose of Radiation Monitoring Instruments

TYPE	PURPOSE
Micro-R meter (NaI)	Dose assessment, area monitoring
Geiger-Mueller tube	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 cm^2)

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 will maintain onsite facilities as necessary to support the radiation safety programs. Cabot facilities in Boyertown, Pennsylvania, will also be used to the extent practicable. 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 office of the RSO 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.

11.0 Environmental Monitoring Program

The NRC staff has reviewed the information in the DP for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Section 17.4, "Environmental Monitoring and Control," of NUREG-1757, Volume 1. Based on this review, the NRC staff has determined that the licensee, Cabot, has provided sufficient information on environmental monitoring and control programs to allow the NRC staff to conclude that the licensee's environmental monitoring program will comply with 10 CFR Part 20 and is adequate to protect workers, the public, and the environment from ionizing radiation during decommissioning activities.

The operations to be conducted in the Reading Project are limited to installation of riprap on the portion of the site slope bearing radioactive material and associated clearing, grubbing, and surface preparation. The limited nature and scope of these activities ensures minimal impact on cultural, historical, land use, and environmental values. Radiological monitoring designed to protect workers will also monitor protection of the general public. Consequently, Cabot has not planned any radiation safety programs specifically focused on environmental impacts.

The NRC staff consulted with the Pennsylvania State Historic Preservation Office (SHPO), in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, and 35 CFR Part 800 (ADAMS Accession No. ML070430115). In response (ADAMS Accession No. ML071240260) SHPO indicated that there was a high probability of prehistoric and historic archaeological resources located in the project area and in the nearby Schuylkill Canal. However, the SHPO concluded that the proposed activity would have no effect on such resources. The NRC staff subsequently identified a building ruin at the bottom center of the slope (ADAMS Accession No. ML071450487). In a letter of July 25, 2007, SHPO determined that the ruin is not a historic property (ADAMS Accession No. ML072220371)

12.0 Site Radiation Surveys

The NRC staff has reviewed the information in the DP for Cabot Reading, License No. 040-09027, in accordance with Chapter 4, "Facility Radiation Surveys," of NUREG-1757, Volume 2. This review has determined that the radiological characterization of the site is adequate to permit planning for decommissioning activities that will be effective and will not endanger the workers, to demonstrate that it is unlikely that significant quantities of residual radioactivity have not gone undetected, and to provide information that will be used to design the final status survey.

A final survey will be performed after the cover is installed. Following termination of the license and release for unrestricted use, surveys will not be needed or required.

13.0 Financial Assurance

13.1 Cost Estimate

GeoSystems Consultants, Inc., performed an engineering estimate of the cost to install the riprap cover. Attachment 3 of the DP addendum contains those calculations. The total estimated cost, including contingencies, is approximately $450,000–$500,000. In August 2006, Cabot submitted a letter of credit in the amount of $460,000 from the Bank of America.

The NRC staff has reviewed the cost estimate for Cabot Reading, License No. 040-09027, located in Reading, Pennsylvania, in accordance with Chapter 15, "Financial Assurance for Decommissioning," of NUREG-1757. Based on this review, the NRC staff has determined that (1) the cost estimate submitted by the licensee adequately reflects the costs to carry out all required decommissioning activities before license termination and, if the license is being terminated under restricted conditions, to enable an independent third party to assume and carry out responsibilities for any necessary control and maintenance of the site, (2) the financial assurance mechanism submitted by the licensee is adequate to ensure that sufficient funds will be available to carry out all required decommissioning activities before license termination, and (3) the certification statement submitted by the licensee specifies the appropriate information and level of financial assurance coverage.

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Addendum 1. CABOT READING SITE HISTORY

Site Chronological History:

(Note that references beginning with the “ML” designation are located in ADAMS main library, while documents started with “Accession No.” are references for the ADAMS legacy library or public document room.)

On January 21, 1963, the Atomic Energy Commission (AEC, predecessor to the NRC) issued license STC-681 to Kawecki Chemical Company (KCC, predecessor to Cabot) for 11,000 tons of Malayan Tin Slag containing less than 0.1 percent thorium by weight for storage only at their site in Boyertown, PA (ML072250463).

On June 21, 1963, the AEC amended license STC-681 to increase the quantity to 14,000 tons of tin slag and to change the storage location to the B-11 Yard at the Canton Railroad Piers in Baltimore, MD (ML072250484). The tin slag was due to arrive via ship in Baltimore in June 23, 1963.

On August 23, 1965, the AEC issued a new license, STB-849, to KCC for possession and storage of 17,000 tons of tin slag containing 0.11 percent thorium oxide. Storage for 100 tons was authorized at the Vanadium Corporation of America (VCA) plant in Cambridge, OH, and the balance at the B-11 Yard at the Canton Railroad Piers in Baltimore, MD (ML07220550). Pilot studies, including slag characterization, were conducted at the VCA plant under their license, SMB-850. KCC’s contractor, Applied Health Physics, Inc. (AHP), performed health physics testing during VCA prototype plant operations served as a basis for a health physics program for the KCC facility in Reading (ML072250557).

On January 18, 1967, the AEC amended license STB-849 to include the licensee’s facility in Reading, PA as an authorized place of storage (ML072250563).

On February 10, 1967, the AEC confirmed that KCC may store tin slag from the VCA site at the Reading site (ML072250564). This was in response to a January 17, 1967, request by KCC to move 45,000 pounds of tin slag then at the VCA plant to the Reading site (ML072250420), and is consistent with their license amendment request of January 11, 1967, (ML072250372) in which they proposed removal of the VCA site from the license.

On February 25, 1967, the KCC requested the AEC authorize an exemption to the waste disposal restrictions in Title 10, Part 20 “Standards for Protection Against Radiation” for the Reading site. At that time, they anticipated about nine million pounds of slag waste containing 1 percent or less thorium and uranium in the form of inert glassified slag (ML072250330). The proposed disposal location is an existing slag dump that has been in use for decades by American Chain & Cable (Accession No. 8005130354).

On March 16, 1967, a Commonwealth of Pennsylvania memo indicated that the AEC would forward KCC’s request for burial authorization to Pennsylvania for consideration. The memo noted that AEC indicated that burial requests must be approved by the State Health Department before the AEC would grant an exemption (ML072250565).

On March 17, 1967, the AEC issued license SMB-920 to KCC. This license authorized 30,000 tons of tin slag containing up to 0.20 percent thorium and 0.05 percent uranium for use at the KCC facility in Reading, PA. The licensee was not authorized to dispose of tin slag residues containing 0.05 percent or more source material other than as authorized by 10 CFR 20.301 (ML072250326). Shipment of tin slag to Reading followed, with the first processing testing reported in April 1967 (ML072250557).

In April 1967, orders were given for the transfer of tin slag to Reading and initial processing began, which continued for about seven months. In an October 1967 Health Physics report, KCC indicated that the smelting furnace operated 18 hours per week for the first six months (ML072250323, ML072250557, Accession No. 8005130397).

On October 4, 1967, AHP (also KCC's contractor) provided a Health Physics report covering the period from April through September 1967, during which KCC was conducting testing of their refinery processes at the Reading facility. They reported that waste slag, where most of the thorium resides, is first cooled, then broken into 1- to 2-foot chunks by the use of a drop ball, and finally placed on the slag pile. The report data showed that 86 percent of the thorium in the original tin slag ends up in the waste slag. Additionally, sampling indicated that the highest airborne concentrations of thorium occurred during drop-balling crushing operations, which were to be modified to reduce exposures. (ML072250557). At some time later, the operation was changed to pouring molten slag over the side of the slag dump (Accession No. 8005130351).

On October 31, 1967, the AEC terminated license STB-849, and authorized KCC to process tin slags in license SMB-920. The renewal to SMB-920 authorized 210,000 pounds of thorium and uranium, as contained in tin slag, for processing. Usage was authorized at the Reading site and storage only was authorized at the B-11 Yard, Canton Railroad Pier (ML072250322).

In a November 10, 1967, letter to KCC from AHP, AHP indicated that plant operations were still under development at the Reading facility, and that operations had been suspended by the Pennsylvania Department of Health (ML072410570).

In a February 6, 1968, AHP report (provided as part of a November 21, 2002, information supplement from the licensee), AHP indicated that the current license authorized possession, processing, and storage of various slags and ore residues containing up to 0.5-percent natural uranium and up to 0.3-percent natural thorium as contained in 60-million pounds of slag.

The report further indicated that the Reading Plant, and the B-1 Canton Railroad Pier, were on the current license but would need to be amended to allow processing and storage at the Boyertown, PA plant. The license also did not permit disposal of any unwanted thorium residue in concentrations in excess of 0.05 percent thorium, except to other licensees. However, storage on site at Reading was authorized. The report indicated waste sludge could be disposed of at an off-site facility, but approval was to be sought from the regional sanitary engineer. At the time of the report, the Pennsylvania Sanitary Water Board was not authorizing KCC to discharge liquid wastes at Reading until KCC resolved some concerns with the Boyertown plant.

This report also stated that waste slag measured 0.07 to 0.5 millirem/hr at contact. However, during radiation surveys, higher radiation levels were observed, including the slag dump with a gamma activity of 1.0 to 1.5 millirem/hr. AHP found that significant radiation in areas of the site were from a 2 Mev Van De Graaf machine being used by U.S. Testing Company for industrial radiography.

On March 18, 1968, the Commonwealth of Pennsylvania granted KCC a permit for the burial of radioactive materials at the Reading site. The permit authorized disposal by burial of 105 tons of natural thorium and uranium contained in slag residue (ML072250320).

On December 1, 1968, AEC amended license SMB-920 (Amendment 1), to allow disposal of tin slag residues at the Reading site under 10 CFR 20.302. The amendment also changed the licensee name to Kawecki Berylco Industries, Inc. (KBI) to reflect a corporate merger (Accession No. 8005130404).

In May 1969, electric arc furnace operations at the Reading site ceased after operating for 25 months. About 600 tons of waste slag was placed, either molten or as furnace “skulls’ on the embankment, during the two years of operation. The waste slag contains about 1.8 tons of source material (Accession No. 8005130397) (NUREG 1027, November 1983) (Accession No. 9309020402).

On June 25, 1969, AEC amended license SMB-920 (Amendment 2) to add the Revere, PA site to the license as an authorized place of storage (ML072250312).

On November 4, 1969, AEC amended license SMB-920 (Amendment 3) to add Cabots Boyertown, PA facility to the license as an authorized place of storage (ML072250299).

On January 6, 1970, AEC amended license SMB-920 (revised in entirety) to allow 210,000 pounds of thorium and uranium for processing at the Reading site; storage only at the B-11 Yard Railroad Pier in Baltimore, MD; and storage only at the Revere, PA site. Disposal of tin slag residues containing uranium and thorium was also authorized under 10 CFR 20.302 (ML072250297).

On May 28, 1970, AEC amended license SMB-920 (Amendment 1) to allow unlimited processing at the Boyertown, PA and Reading, PA facilities, and up to 4,000 pounds of ore concentrates to be processed at the Revere, PA facility. (ML072250311) The B-11 Yard Railroad Pier in Baltimore, MD continued to be authorized for storage only. The licensee was still working to develop a process to extract columbium-tantalum from ore concentrates, and requested small-scale experimental processes at the Boyertown and Revere facilities (ML072250301, and ML072250306).

On August 19, 1970, AEC amended license SMB-920 (Amendment 2) to allow processing of up to 60 tons of ore or slag at the Revere, PA facility. The processing at the Revere facility was by alumina-thermic reduction (ML072250292).

In an April 14, 1971, inspector’s evaluations, AEC staff noted that the license authorizes use at the Reading, Revere, and Boyertown plants. The authorized possession limit was 210,000 pounds of uranium and thorium. No processing had been done at the Reading plant since October 1, 1968, and the site was being used for storage only (ML072220391).

On August 5, 1971, AEC amended license SMB-920 (Amendment 3) to allow unlimited processing at the Revere, PA facility (ML072250290).

On October 24, 1972, AEC renewed license SMB-920 to authorize unlimited quantities of uranium and thorium in the form of slag and ore residues. Processing was authorized at the

Boyertown and Revere, PA facilities. License condition 9 authorized storage only at the Reading site, while License Condition 10 authorized disposal of solid tin slag residues containing uranium and thorium at the Reading facility. The B-11 Yard site in Baltimore, MD was not included as part of the license because Maryland became an agreement state and issued a State license for that facility on November 24, 1972 (Accession No.8005130347).

In March 1975, tin slags were inappropriately moved from a paved storage area onto a low-lying, unpaved area 800 feet long called the mainline. Heavy rains, which interrupted the slag movement resulted in "grinding the radioactive tin slag into the unprotected ground..." in the mainline area. Additionally, considerable residue was left on the ground in excess of the State and Federal limits in the original B-1 storage area, primarily due to movement of tin slag by wind and water and erosion. This area was cleaned up by June 1975 in accordance with the existing standards. The slag piles were subsequently reconsolidated and covered and groundwater monitoring conducted (ML072410570).

From May to June 1976, 25 to 41 truckloads of radioactive material were shipped from Reading to the Canton Railroad yard in Baltimore for export by bulk shipment West Germany via Holland (ML072410570).

In July 1976, approximately 30,000 tons of tin slag at the Baltimore site was exported to Holland via Germany (NUREG 1027, November 1983) (Accession No. 8402090446). Detailed records show 25,476 tons of tin slag were loaded and shipped to Holland (ML072410570).

From August 1976 to July 1977, KBI conducted decontamination at their Baltimore site. There were 286 truck shipments were made from Baltimore to Reading during this time (ML023110304).

- During slag movement in preparation for the September 1976 bulk shipment, slag was again placed or dumped on unpaved areas at the rail yard (ML072410570).

- Large quantities of tin slag were left in the Canton Railroad yard Mainline area. During loading, heavy rains in this low-lying area resulted in the loader's wheels digging in and mixing tin slag with soil to a depth of two to three feet (ML072410570).

- During loading operations during September 18 and 19, port stevedores bulldozed areas of the pier that contained piles of residual tin slag, resulting in extensive contamination of the entire pier area. Radiation surveys conducted on September 21, 1976, revealed large amounts of tin slag had spread into low lying areas and possibly deeper into the ground (ML072410570).

- On October 25, 1976, two inches of additional rainfall caused heavy damage to the pier area that still needed decontamination (ML072410570).

- On October 27, 1976, the State of Maryland conducted surveys of the pier and mainline areas of the rail yard. AHP indicated that the State of Maryland utilized very sensitive detection equipment, which "surpasses anything that is commercially available." The State rejected the area where a truckload of tin slag had been inadvertently dumped during loading on September

14, and an area where tin slag residue had been scrapped to the far end of the pier. AHP noted that the thoroughness of the State's inspection was such that this likely included tin slag residue from the initial unloading back in the 1960's. The pier required extensive decontamination by removal of surface soils. AHP estimated a waste volume at hundreds of tons (ML072410570).

By November 14, 1976, 114 truckloads of waste source materials had been moved from the Canton rail yard to Boyertown and Reading. As of November 30, 1976, 2,447 tons of material had been removed. AHP estimated that about 10-20 loads remained to be sent to Pennsylvania (ML063450204)(ML072220404).

In 1977 and 1978, 580 tons of contaminated debris and soil from decontamination of the Reading facilities were disposed in the slag area containing an average of 0.51 pCi/gm thorium and 0.35 pCi/gm uranium based on 293 representative samples. A four-foot cover, consisting of approximately 500 tons of crushed rock and soil, was placed on the slag area (NUREG 1027, November 1983, Accession No. 8203240516, ML0235040107).

In 1979, all waste storage activities were suspended at the Reading site (NUREG 1027, November 1983).

An NRC inspection on October 3, 1980, found contact readings of 0.2 mrem/hr and an average soil concentration of 6 pCi/gm natural thorium. Water samples indicated no measurable contamination. The inspection also noted that the electric arc furnace lining and other debris from the plant facilities had been deposited on the slag dump, and then covered with 500 tons of crushed rock and soil. The metal fence around the slag dump was in construction during the inspection (Accession No. 8203240516).

On December 20, 1983, license SMB-920 was renewed to Kawecki Berlyco Industries (KBI, KCC's successor). Further disposal at the Reading site was specifically prohibited. The amendment specified quarterly erosion inspections, groundwater sampling, and direct radiation measurements along the site boundaries. The amendment also identified the need for decommissioning plans for waste materials located at Reading. Alternatives were to include stabilization in place, and removal and disposal at other sites. This amendment authorized 500 tons as elemental uranium and thorium at the Boyertown, Reading and Revere sites (Accession No. 8312270132).

On May 29, 1984, KBI indicated disposal costs were highly uncertain due to the uncertainty of the ultimate disposal locations, and indicated their desire to leave the material on site (Accession No. 8407110193).

On March 4, 1985, KBI indicated they would resurvey the site, and move any accrued material from decontamination to their Boyertown facility for processing. At this time, they were cleaning up in accordance with an October 5, 1981 NRC Branch Technical Position that specified concentration based cleanup criteria (Accession No.8503270640).

On March 13, 1985, NRC amended license SMB-920 to remove the need for specific decommissioning plans, but required KBI at the end of the plant life to decontaminate the facilities so that they are releaseable for unrestricted use (Accession No. 8503210308).

From April 6 to May 23, 1985, KBI (now a Division of Cabot Corporation) reported the status of clean-up at the Reading site. KBI reported 310 drums filled with 590 cubic feet of low-level waste were packaged and shipped to their Boyertown facility The waste consisted of tantalum ore mixed with coke that had been used in the Reading operations. Furnace dust from eight pits was excavated, packaged, and shipped to Boyertown. In July 1985, KBI reported an additional 67 drums of decontamination debris from the building mixing and crushing areas (Accession No.8508190343).

In December 1985, a confirmatory radiological survey was performed by Oak Ridge Associated Universities (ORAU). The survey indicated contamination remained in the processing building, and several outside soil areas that were above the guideline of the NRC “Guidelines for Decontamination fo Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for By-Product, Source or Special Nuclear Material, July 1982.” (Accession Nos. 9107240205 and 9107240205).

Due to contamination in the main processing building remaining above unrestricted release limits, on May 12, 1987, NRC requested KBI submit a decommissioning plan for the Reading Facility (Accession No. 8705190294).

On June 1, 1987, the licensee (now identified as Cabot Corporation) indicated their intent to release the Reading building, parking lot, and rail areas for unrestricted release, but leave the dump area under license. (Cabot, June 1987) The license name was changed to “Cabot Corporation” on June 3, 1987 (Accession No. 8706050325).

In a January 13, 1988, memo, the license Radiation Safety Officer (RSO) indicated that “rain water had eroded the area just where our material is buried.” The licensee repaired the erosion, and installed a catch basin and drain system to route the water away from the eroded area. The RSO indicated that this type of maintenance must continue under their license (ML072250569).

In 1988, further decontamination was performed by Bullinger’s Mills, Inc. Areas of the processing building were removed, vacuumed, and scrubbed. Contaminated grounds were excavated and backfilled with stone. Other buildings were removed by the property owner and backfilled (Accession No. 9107240205).

From July 26 through August 2, 1991, ORAU conducted a confirmatory radiological survey of the main processing building and surrounding areas. The survey identified numerous areas of residual contamination that exceeded the surface contamination guidelines on the floors, walls, and overhead beams of the processing building, and outdoor measurements identified several locations where soil concentrations exceeded the inspection guidelines (Accession No. 9702180323).

On August 4, 1992, Cabot reported recent surveys that had identified low-levels of contamination at the toe of the slag pile slope. They committed to corrective action to reestablish an adequate soil cover to reduce surface activity starting in September 1992 (Accession No. 9210140183).

On December 12, 1993, license SMB-920 was split into two licences. The Boyertown site remained on SMB-920 and the Reading and Revere sites were moved to SMC-1562, and a new docket file was created (40-9027). This change was enacted so that the Reading and Revere sites could be managed within the Decommissioning Branch as these two sites were undergoing decommissioning. The 500-ton limit of uranium and thorium was split, leaving a limit of 400 tons in license SMB-920 and instituting a 100-ton limit in new license SMC-1562. The Safety Evaluation Report provided no detailed analysis for the allotment of licensed material between the two licenses. The 100-ton limit as elemental uranium and thorium for license SMC-1562 has remained to the current version, Amendment 8, dated September 5, 2001 (Accession Nos. 9312090140, 9312090146, and 9312090149; and ML020860370).

Cabot submitted a Radiological Characterization Survey Report in 1994 (Cabot, 1994), which included a gamma survey at 1 m (3 ft) and 1 centimeter (0.4 in) above ground surface, establishment of background radiation levels, and surface samples analyses. Additionally, Cabot developed a Radiological Subsurface Sampling Report (Craig, 1994) consisting of collection and analysis of subsurface slag, soil, and selected water samples. Subsurface slag samples were used to measure the readily available uranium (RAU) leach rate from slag. The leach rate constants of thorium and radium were also determined, along with an evaluation of the weathering rate of slag.

In late 1994 and early 1995, Cabot continued remedial actions within the main processing building and adjacent outdoor areas. The waste from these activities was transferred to Boyertown (Accession No. 9702180323).

On January 18 and 19, 1995, the NRC collected 80 smears and 160 direct reading of the main processing building walls and ceiling. A second survey was conducted by ORAU on January 30 and 31, 1995, on the main processing building floor. In total, 14 elevated areas were identified and immediately decontaminated by the licensee (Accession No. 9505100117).

On April 10, 1995, ORAU submitted a final confirmatory survey report for the reading processing building and surrounding areas. The report found results consistent with the licensee's, and in support of release for unrestricted release (ML022940565).

On August 18, 1995, by Amendment 2 to license SMC-1562, the NRC released the Reading processing building and surrounding area for unrestricted use. The license did not allow remediation, but did allow transfer of decommissioning wastes to Boyertown for storage. The license also required a site characterization plan for the slag pile to be completed and monitoring for erosion, groundwater, and direct radiation levels (Accession Nos. 9508300215, 9508300216).

On October 11, 1995, the NRC approved the Cabot site Characterization plan for the Reading Slag Pile (Accession No. 9510170356).

On November 17, 1995, Cabot submitted a Conceptual Decommissioning Alternative for the Reading Slag Pile, which included establishment of erosion controls prior to license termination (Accession Nos. 9512010040, 9512010041).

On December 11, 1995, the NRC issued Amendment 3 to license SMC-1562. This Amendment authorized site characterization work at the Reading slag pile. (Accessions No. 9512190346, 9512190347).

On April 30, 1995, Cabot submitted a revised site characterization report for the Reading slag pile (Accession No.9604120170).

Amendment 4 of SMC-1562, issued August 20, 1996, revised the licensee schedule for submitting a site Decommissioning Plan or Environmental Report for the Reading Slag area (Accession No. 9608270066).

On October 25, 1996, the NRC approved Cabot's April 4, 1996 Characterization Report for the Reading Slag Pile. (Accession No. 9611080070)

Amendment 5 of license SMC-1562, issued 9/3/1997, deleted or modified several license conditions to reflect the possession-only status at the Reading site (Accession Nos. 9709150172, 9709150175).

Amendment 6 of license SMC-1562, issued 12/12/1997, revised the Decommissioning Plan submission date for the Reading site (Accession Nos. 9712180233, 9712180241, and 9712180243).

On August 28, 1998, Cabot submitted the revision 0 of their Reading Decommissioning Plan (Accession No. 9809140068). A *Federal Register* Notice and opportunity for hearing was published on October 28, 1998 (FR Doc. 98-28815). Hearings were requested by the Redevelopment Authority of the City of Reading on November 24, 1998, and the Jobert Trucking Company on December 1, 1998 (Accession Nos . 9812030025 and 981260030).

Amendment 7 of License SMC-1562, issued 9/13/1999, changed the name of the RSO (Accession Nos. 9909170173, and 9909170176).

Revision 1 of the Cabot Reading Slag Pile Decommissioning Plan was submitted in March 2000, to reflect revised dose modeling scenarios.

On May 16, 2000, Jobert Trucking Company's request for hearing was denied for lack of standing. (ML003715331). On October 31, 2000, the Redevelopment Authority of the City of Reading's and Cabot's joint motion to withdraw the hearing request was granted. (ML003765068).

Amendment 8 of License SMC-1562, issued 9/5/2001, removed the Revere site from the license (ML020860370).

On March 21, 2003, the NRC staff requested additional information

Revision 2 of the Cabot Reading Slag Pile DP was submitted on June 5, 2005. (ML051330369, ML051330364). Revision 2 incorporated a rip-rap erosion barrier to address NRC staff questions about erosion at the site. Revision 3 was submitted on June 14, 2005, to reflect changes to the rip-rap design after Cabots consultation with the Redevelopment Authority. (ML053560277).

Cabot submitted Revision 4 of the DP in August and September 2006 to revise the rip-rap design and include design analysis. (ML062360138, ML062360159, ML062360164, ML062210261, and ML062640081).

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Addendum 2. **CABOT READING SITE SOURCE TERM UNCERTAINTY**

State of Pennsylvania Concern of the Underestimation of Reading Site Source Term

A review of the Cabot source term information was made based on the State of Pennsylvania Department of Environmental Protection (PADEP) statements in a May 2, 2002, letter to Larry Camper, NRC/NMSS. The PADEP letter indicated Cabot underestimated the amount of radioactivity used in the Radiological Assessment Report and that Cabot has not accounted for the large volume of waste that was shipped from out-of-state and disposed of at the Cabot Reading site in 1977.

A May 2, 2002, letter from PADEP provided more details as an appendix. It cited a reference in the March 2000 draft Johns Hopkins report concerning characterization of radioactive slags. The reference referred to a July 25, 1977, Maryland DEP letter that indicated that 286 20-ton truckloads of tin slag and sand (5,720 tons total) were shipped from Baltimore to the Cabot Reading site. A Cabot/NES report indicated that 1000 tons of tin slag and sand were shipped from Baltimore. PADEP observes that this is a factor of 6-fold underestimate (5720 tons versus 1000 tons). Further, PADEP indicates that 5720 tons (of tin slag and sand) translates into 153 tons of Th + U compared to the Cabot/NES estimate of 33 tons.

Johns Hopkins Final Report (NUREG-1703)

The Johns Hopkins report on the characterization of radioactive slags was issued as NUREG-1703 “Characterization of Radioactive Slags”, Section 1.4, Radioactive Source Term, indicates that because of limited records it was difficult to determine the source term. The NUREG-1703 indicates that it is beyond the scope of the report to quantity the amount of materials used.

Cabot & Baltimore Canton Railroad Yard Tin Slag Storage

Cabot has provided NRC copies of records and reports prepared by their radiation protection consultant AHP concerning the tin slags at Baltimore in the 1976 time frame. An AHP report dated December 3, 1976, provides a summary of the events surrounding the March 1976 unintended relocation of slags (that contaminated some Baltimore property) that were being stored at the Canton Railroad Yards in Baltimore, and Cabot’s actions in September 1976 to load and ship 25,476 tons of tin slag to Holland, and to clean up or decontaminate the Baltimore storage location. The tin slag loading operation and/or dock operations causes additional contamination by tin slag, and this contamination was removed under the oversight of the State of Maryland.

Also, in the December 3, 1976 report, AHP indicates that 2,447 tons of material had been removed from Baltimore between September and November 30, 1976, after the tin slags had been shipped to Holland. Some materials were sent to the Boyertown site for potential reprocessing, and other truckloads were sent to the Reading site. AHP indicated that each truckload had been sampled so an approximation of the total amount of source materials can be determined. Also, in the report dated December 3, 1976, AHP estimated that 7 to 10 truckloads remain in (tin slag) piles on the mainline rail line, and 10 to 20 truckloads needed to be removed from other areas. Apparently 800 feet of the mainline railroad yard needed to be cleaned up, and the railroad tracks removed so that soil underneath the tracks could be removed to meet the

Maryland Department of Radiological Health contamination criteria. The decontamination and verification surveys were expected to be completed by January 30, 1977.

Cabot's November 21, 2002, letter to Larry Camper, NRC/NMSS, indicates that information in the draft John Hopkins report on the Reading site source term is not accurate. Johns Hopkins had assumed 2-percent source materials in the waste slag versus the actual Th content in the 0.1 - 0.3 percent range. Also, Cabot indicates that 28,000 tons of tin slag were in Baltimore, and records indicate that 25,476 tons were shipped to Holland in September 1976.

Source Term Estimates Based on Records Available
PADEP Estimate
The PADEP concern that 5,720 tons of waste was returned to PA from Baltimore, MD may be accurate. AHP reported that 2,447 tons had been shipped by November 30, 1976, and that additional decontamination efforts were needed. A 153-ton Th+U source term estimate in the Johns Hopkins draft assumes 2-percent content and 0.3-percent Th content is more realistic. If the 5,720 ton shipments were all tin slag (at 0.3 percent) with no sand then the Tn content would be 17 tons. Cabot workers have indicated that 5 percent of the shipment was tin slag or 0.85 ton of Th and most of the material shipped was sand.

NRC Staff Estimate
Using the Cabot information in Ref. 2 and Ref 4. as a basis, it could be assumed that approximately 2,524 tons of tin slag (28,000 tons in storage - 25, 476 tons shipped) was spilled or otherwise remained at the Baltimore Canton Railroad Yard, or that 9 tons of Th and 6 tons of U in tin slag was removed and returned to Boyertown or Reading. This tonnage estimate assumes 0.3-percent Th and 0.2-percent U content in the tin slag. AHP indicated that some tin slag was shipped to Boyertown for recovery and use. The tin slag spilled at the Baltimore storage facility was removed and the facility was surveyed under the oversight of the State of Maryland.

This 2,524 tons of tin slag translates into 9 tons of Th and 6 Tons of U. Cabot's current estimate in their radiological assessment and decommissioning plan is a Reading site source term of 2.19 tons Th. The total Thorium at the Reading site should not exceed approximately 11 tons (9 tons from Baltimore + 2 ton from Reading operations) or approximately 5 times the current Cabot estimate of 2.19 tons.

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References:

1. David J. Allard, PADEP, letter to Larry Camper, NRC/NMSS dated May 2, 2002

2. Wayne M. Reiber, Cabot, letter to Larry Camper, NRC/NMSS, dated November 21, 2002

3. NUREG-1703, Characterization of Radioactive Slags

4. Robert G. Gallagher, Applied Health Physics Inc., *Health Physics Report of the Radiological Safety Aspects Associated with the KBI Tin Slags Stored at the Canton Railroad Yards, Baltimore, MD*, dated December 3, 1976