SEC Petition Evaluation Report
Petition SEC-00173

Report Rev #: 0 Report Submittal Date: January 24, 2011

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Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Petition Receipt Date	Qualification Date	DOE/AWE Facility Name
SEC-00173	83.13	May 17, 2010	July 21, 2010	Norton Co.

Petitioner Class Definition

All employees of the Norton Company who worked in any building or area at the Norton Company location on New Bond Street in Worcester, Massachusetts, from 1960 through 1972.

Class Evaluated by NIOSH

All atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the residual radiation period from January 1, 1958 through October 31, 2009.

NIOSH-Proposed Class to be Added to the SEC

All atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

Related Petition Summary Information

SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00148	83.14	Norton Co.	Class added to SEC (January 1945-December 1957)

Related Evaluation Report Information

Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00148 (January 1, 1945 through December 31, 1957)	Norton Co.

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Evaluation Report Summary: SEC-00173, Norton Co.

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) addresses a class of employees proposed for addition to the Special Exposure Cohort (SEC) per the *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, 42 U.S.C. § 7384 *et seq.* (EEOICPA) and 42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000*.

Petitioner-Requested Class Definition

Petition SEC-00173 was received on May 17, 2010, and qualified on July 21, 2010. The petitioner requested that NIOSH consider the following class: All employees of the Norton Company who worked in any building or area at the Norton Company location on New Bond Street in Worcester, Massachusetts, from 1960 through 1972.

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified the petitioner-requested class. NIOSH evaluated the following class: All atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the residual radiation period from January 1, 1958 through October 31, 2009. The class under evaluation was expanded beyond that requested by the petitioner to provide a comprehensive review of the entire residual radiation period at Norton Co.

NIOSH-Proposed Class to be Added to the SEC

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort. NIOSH has determined that decontamination and decommissioning activities were conducted during the period from January 1, 1958 through October 10, 1962, for which NIOSH has insufficient source term and monitoring data to bound internal and external doses potentially received from exposures during that work.

NIOSH finds that it does have sufficient data to bound doses for the period from October 11, 1962 through October 31, 2009 (the end of the designated residual radiation period). For this period, NIOSH has obtained gross alpha air monitoring results collected at Norton Co. near the end of the Atomic Weapons Employer (AWE) operations period and during the residual radiation period. Using those data and the guidance in ORAUT-OTIB-0070, NIOSH can bound the internal doses potentially received from exposures to residual uranium and thoria. NIOSH can use the same set of gross alpha data to bound potential internal doses received from thoron by using decay and in-growth calculations

on sample recounts. The gross alpha air contamination data from the operational period and the methods described in Battelle-TBD-6000 allow NIOSH to bound external doses from residual uranium and thoria.

Feasibility of Dose Reconstruction

NIOSH finds it is not feasible to estimate internal and external exposures with sufficient accuracy for all workers at the site from January 1, 1958 through October 10, 1962, due to decontamination and decommissioning activities conducted during that period for which NIOSH has insufficient source term and monitoring data to bound potential doses. With the exception of this class, per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it has access to sufficient information to: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses more precisely than an estimate of maximum dose. Information available to NIOSH is sufficient to document or estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the period from October 11, 1962 through October 31, 2009.

The NIOSH dose reconstruction feasibility findings are based on the following:

- NIOSH has determined that, although AWE operations were not performed at Norton Co. after 1957, Norton Co. performed decontamination and decommissioning of AWE materials and wastes from January 1, 1958 through October 10, 1962, which potentially exposed Norton Co. workers to internal and external radiation.

- Principal sources of internal radiation for members of the proposed class included exposures to residual natural uranium and thorium metals, as well as associated dusts. The modes of exposure were inhalation and ingestion during the clean-up of these metals.

- Principal sources of external radiation for members of the proposed class included exposures to gamma and beta radiation associated with decontamination and decommissioning of the residual AWE materials and wastes. The modes of exposure were submersion in potentially-contaminated air and exposure to contaminated surfaces.

- NIOSH lacks sufficient source term and monitoring data to bound doses potentially received from exposures during the decontamination and decommissioning of AWE materials and wastes from January 1, 1958 through October 10, 1962.

- Based on lack of sufficient monitoring data for Norton Co. workers or operations, internal and external dose reconstruction for the portion of the Norton Co. residual radiation period from January 1, 1958 through October 10, 1962, is not feasible.

- NIOSH has identified sufficient information and data to support bounding internal dose for the remaining portion of the residual radiation period (October 11, 1962 through October 31, 2009) using air monitoring data obtained during the operational period and guidance given in ORAUT-

OTIB-0070, *Dose Reconstruction during Residual Radioactivity Periods at Atomic Weapons Employer Facilities.*

- Doses received from occupational medical X-rays are not considered part of the source term for the residual radiation period; therefore, medical doses were not evaluated.

- Pursuant to 42 C.F.R. § 83.13(c)(1), NIOSH determined that there is insufficient information (for the period from January 1, 1958 through October 10, 1962) to either: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred under plausible circumstances by any member of the class; or (2) estimate the radiation doses of members of the class more precisely than a maximum dose estimate.

- Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Norton Co. during the period from January 1, 1958 through October 10, 1962, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is required because NIOSH has determined that it does not have sufficient information to estimate dose for the members of the proposed class for the period from January 1, 1958 through October 10, 1962.

NIOSH did not identify any evidence supplied by the petitioners or from other resources that would establish that the proposed class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures. However, evidence indicates that some workers in the proposed class may have accumulated substantial chronic exposures through episodic intakes of radionuclides, combined with external exposures to gamma and beta radiation. Consequently, NIOSH has determined that health was endangered for those workers covered by this evaluation who were employed for at least 250 aggregated work days either solely under this employment or in combination with work days within the parameters established for one or more other SEC classes.

For the remainder of the residual period from October 11, 1962 through October 31, 2009, a health endangerment determination is not required because NIOSH has determined that it has sufficient information to estimate dose for the members of the evaluated class.

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SEC Petition Evaluation Report for SEC-00173

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: Mike Mahathy, Oak Ridge Associated Universities. The rationales for all conclusions in this document are explained in the associated text.

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the period from January 1, 1958 through October 31, 2009. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

This report does not make any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from NIOSH. This report also does not contain the final determination as to whether the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83, and the guidance contained in the Division of Compensation Analysis and Support's (DCAS) *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, OCAS-PR-004.[1]

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that the Department of Health and Human Services (HHS) add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[2]

42 C.F.R. § 83.13(c)(1) states: *Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, or if NIOSH has established that it has access to sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose.*

Under 42 C.F.R. § 83.13(c)(3), if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, then NIOSH must determine that there is a reasonable likelihood that such

[1] DCAS was formerly known as the Office of Compensation Analysis and Support (OCAS).
[2] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 C.F.R. pt. 82 and the detailed implementation guidelines available at http://www.cdc.gov/niosh/ocas.

radiation doses may have endangered the health of members of the class. The regulation requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for at least 250 aggregated work days within the parameters established for the class or in combination with work days within the parameters established for one or more other SEC classes (excluding aggregate work day requirements).

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and to the Advisory Board on Radiation and Worker Health (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of HHS.[3]

3.0 SEC-00173 Norton Co. Class Definitions

The following subsections address the evolution of the class definition for SEC-00173, Norton Co. When a petition is submitted, the requested class definition is reviewed as submitted. Based on its review of the available site information and data, NIOSH will make a determination whether to qualify for full evaluation all, some, or no part of the petitioner-requested class. If some portion of the petitioner-requested class is qualified, NIOSH will specify that class along with a justification for any modification of the petitioner-requested class. After a full evaluation of the qualified class, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

Petition SEC-00173 was received on May 17, 2010, and qualified on July 21, 2010. The petitioner requested that NIOSH consider the following class: *All employees of the Norton Company who worked in any building or area at the Norton Company location on New Bond Street in Worcester, Massachusetts, from 1960 through 1972* (Petition, 2010).

The petitioner provided information in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the Norton Co. workers in question because radiation monitoring records have been lost, falsified, or destroyed; or that there is no information regarding

[3] See 42 C.F.R. pt. 83 for a full description of the procedures summarized here. Additional internal procedures are available at http://www.cdc.gov/niosh/ocas.

monitoring, source, source term, or process from the site where the employees worked. By requesting this basis, the petitioner did not need to establish (through documentation or affidavit) that there are no monitoring records whatsoever for personal or area monitoring that was conducted for the class of employees, or that all the relevant records have been falsified.

Based on its Norton Co. research and data capture efforts, NIOSH determined that it lacks access to external and internal monitoring data for Norton Co. workers during the time period under evaluation. NIOSH also determined that air monitoring records are available for some of the time period for all radionuclides. NIOSH concluded that there is sufficient documentation to support, for at least part of the requested time period, the petition basis that radiation monitoring records for members of the proposed class have been lost, falsified, or destroyed; or that there is no information regarding monitoring, source, source term, or process from the site where the employees worked. The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS. The details of the petition basis are addressed in Section 7.4.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified the petitioner-requested class to provide a comprehensive review of the entire residual radiation period at Norton Co. Therefore, NIOSH defined the following class for further evaluation: All atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the residual radiation period from January 1, 1958 through October 31, 2009.

3.3 NIOSH-Proposed Class to be Added to the SEC

Based on its research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

As a standard practice, NIOSH completed an extensive database and Internet search for information regarding the Norton Co. The database search included the DOE Legacy Management Considered Sites database, the DOE Office of Scientific and Technical Information (OSTI) database, the Energy Citations database, the Atomic Energy Technical Report database, and the Hanford Declassified Document Retrieval System. In addition to general Internet searches, the NIOSH Internet search included OSTI OpenNet Advanced searches, OSTI Information Bridge Fielded searches, Nuclear Regulatory Commission (NRC) Agency-wide Documents Access and Management (ADAMS) web searches, the DOE Office of Human Radiation Experiments website, and the DOE-National Nuclear

Security Administration-Nevada Site Office-search. Attachment One contains a summary of Norton Co. documents. The summary specifically identifies data capture details and general descriptions of the documents retrieved.

In addition to the database and Internet searches listed above, NIOSH identified and reviewed numerous data sources to determine information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 Site Profile Technical Basis Documents

A Site Profile provides specific information concerning the documentation of historical practices at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. Although no Site Profile has been written for Norton Co., the following Technical Basis Documents were reviewed in support of this evaluation.

- *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals*, Battelle-TBD-6000; Rev. F0; December 13, 2006; SRDB Ref ID: 30671

4.2 ORAU Technical Information Bulletins (OTIBs) and Procedures

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance for preparing dose reconstructions at particular sites or categories of sites. An ORAU Procedure provides specific requirements and guidance regarding EEOICPA project-level activities, including preparation of dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIB as part of its evaluation:

- *OTIB: Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, ORAUT-OTIB-0070, Rev. 00; March 10, 2008; SRDB Ref ID: 41603

4.3 Facility Employees and Experts

To obtain additional information, NIOSH interviewed three former Norton Co. employees:

- Personal Communication, 2010a, *Personal Communication with Former Norton Co. Industrial Health Care Worker*; Telephone interview; September 14, 2010; SRDB Ref ID: 88131

- Personal Communication, 2010b, *Personal Communication with Former Norton Co. Machinist/Foreman*; Telephone interview; September 14, 2010; SRDB Ref ID: 88133

- Personal Communication, 2010c, *Personal Communication with Norton Co. Communications Specialist*; Telephone interview; September 21, 2010; SRDB Ref ID: 90292

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH OCAS Claims Tracking System (NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of December 19, 2010)

Table 4-1: No. of Norton Co. Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	64
Total number of claims submitted for energy employees who worked at any time during the period under evaluation (January 1, 1958 through October 31, 2009).	56
Number of dose reconstructions completed for energy employees who worked at any time during the period under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	18
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	0
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	0

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the claimant. As noted in Table 4-1, NIOSH has not received external or internal monitoring data from Norton Co. for any claimants. Of the eighteen dose reconstructions submitted by NIOSH for energy employees who worked during the period under evaluation, seven were full dose reconstructions and eleven were performed using overestimates.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. One hundred forty-seven documents in this database were identified as pertaining to Norton Co. (as of December 19, 2010). Of these, fifty-four were added after the date of NIOSH's last 83.14 SEC Evaluation (SEC-00148). These documents were evaluated for their relevance to this petition. The documents include historical background on the site and processes, air monitoring data, direct and removable contamination survey data, external radiation survey data, external monitoring data, and limited bioassay data.

4.6 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed the following documents submitted by the petitioners:

- *83.13 Form B Special Exposure Cohort Petition and supporting documents*, received by NIOSH on May 17, 2010 (Petition, 2010)

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the Norton Co. from January 1958 to October 2009 and the information available to NIOSH to characterize particular processes and radioactive source materials. AWE operations conducted onsite during the period from 1945 through 1957 determine the source term for the residual radiation period currently under evaluation. From available sources NIOSH has gathered process and source descriptions, information regarding the identity (and some information about quantities) of each radionuclide of concern, and information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

5.1 Norton Co. Plant and Process Descriptions

The purpose of this report is to evaluate exposures during the residual radiation period from January 1958 through October 2009; however, the EEOICPA-covered AWE operations at the Norton Co. facility (1945-1957) are summarized below because the source term for the residual radiation period is determined by the nature of the work conducted during the AWE operations period.

Norton Co. was located in Worcester, Massachusetts on a multi-building site consisting of over 100 acres. Building 112, a 50,000 square-feet building where Norton Co. conducted AWE radiological operations from 1945 through 1957, was located on the south end of the site (Radiation Safety Associates, 1997a). NIOSH has been unable to determine the size of the Norton Co. workforce for either the AWE period (1945-1957) or the residual radiation period under evaluation.

In 1945, under a Manhattan Engineer District (MED) contract, Norton Co. started fabricating hexagons containing beryllium oxide-uranium oxide at both the Worcester site and at Norton's Chippewa site in Ontario, Canada. The hexagon work at Worcester was performed on a laboratory scale until full production began soon after May 1947 (Randall, 1947, pdf p. 5). NIOSH has no information on the amount of uranium used in the hexagon process. In May 1947, the Atomic Energy Commission (AEC) asked Norton Co. to fabricate ten beryllium oxide cubes containing ten percent U_3O_8 by weight (Unidentified author, 1947). Additional orders were placed in 1947 for small quantities of beryllium cylinders (30 or less) containing uranium from either UO_2 or U_3O_8 (Daume, 1947). NIOSH has obtained data on a portion of the uranium inventory at Worcester (Inventory, various dates). Norton Co. provided UO_2 to the AEC in 1949 from stored materials (DOE, unknown date). In 1953, Norton Co. shipped scrap to Fernald for recovery of about 160 kilograms of uranium (Bate, 1953; Rudolph, 1953). Norton Co. continued making crucibles and cylinders containing some amount of uranium through at least 1954 (Harris, 1954; Henson, 1954a; Braiden, 1954). NIOSH has obtained survey results and urinalysis data that demonstrate that uranium was on site through at least 1956 (Benedict, 1956; Urinalysis, 1956).

By 1949, Norton Co. was producing materials using thorium (Geo Survey, 1949). Norton Co. made crucibles containing varying percentages of thorium and also produced an oxide compound known as "Norton fused oxide" (Henson, 1954b). In 1957, about twenty-five Norton Co. employees worked in the AWE programs (Personal Communication, 2010a). All work with radioactive materials (both

AWE and commercial) was performed in a building identified as Building 112 in a 1996 survey (Radiation Safety Associates, 1997a).

During the period from January 1, 1958 through October 7, 1962, in Building 112, Norton Co. employees performed tear-down operations and removed materials used in the AWE radioactive processes (e.g., refractory materials, equipment, and wastes) and performed contamination clean-up. After removing materials and performing clean-up activities, Norton Co. continued to conduct commercial thorium operations in Building 112 (Personal Communication, 2010a). As part of the AWE clean-up, areas, equipment, and materials used in AWE operations were cleaned with the debris being stored in drums and barrels. Refractory kilns and furnaces were dismantled brick-by-brick and transferred to barrels. Other equipment and materials were solvent-washed, dried with paper towels, dismantled, and transferred to barrels. Surface areas of the building were cleaned and the residue placed in barrels. The dismantling and cleaning processes sometimes led to dusty conditions (Personal Communication, 2010a). Materials removed included ceramic, aluminum oxide, silicon, carbide and zirconium oxide, bricks, batts, sagger plates, ventilation and dust collecting apparatus, pipes, and sheet steel pipe; all of these items came in contact with natural insoluble thoria (Th-232) and natural insoluble urania (U-238) (Mondor, 1962; Johnson, 1961; Johnson, 1962). In all, 287 barrels (25-gallon, 35-gallon, and 55-gallon) of materials and waste were collected. Norton Co. estimated that the gross weight of the barrels was between 18 to 20 tons and that the amount of radioactive materials present in that gross amount was 15 pounds of thorium and 25 pounds of uranium (Johnson, 1962).

Between October 8 and October 10, 1962, Norton Co. employees (Mondor, 1962) transported the wastes to a portion of the Norton Co. landfill and buried the wastes at a 30-foot depth (Personal Communication, 2010a; Petition, 2010, pdf p. 25; Mondor, 1962). The burial was monitored by Norton Co. Hygiene and Safety (Mondor, 1962). NIOSH further learned that some of that landfill was transferred to the State of Massachusetts for highway construction (Personal Communication, 2010a).

Norton Co. possessed an AEC material license (STB-00770) for commercial purposes through 1967, with that work being performed in Building 112 as well (Radiation Safety Associates, 1997a). Contamination resulting from such commercial work was not considered in this evaluation report.

5.2 Radiological Exposure Sources from Norton Co. Operations

For employment during the residual radiation period, only the radiation exposures defined in 42 U.S.C. § 7384n(c)(4) [i.e., radiation doses received from DOE-related work] must be included in dose reconstructions. That is, internal or external radiation exposure associated with commercial sources of exposure is not reconstructed. For example, the exposure incurred from the manufacture and distribution of commercial uranium and/or thorium products would not be reconstructed during the residual radiation period (NIOSH, 2009). However, under subparagraph B of 42 U.S.C. § 7384n(c)(4), radiation from a source that cannot be reliably distinguished from radiation covered under subparagraph A (i.e., radiation doses received from DOE-related work) is considered part of the employee's radiation dose and must be reconstructed (NIOSH, 2009).

During the residual radiation period, doses associated with radiation or radiation-generating devices used at the AWE facility for commercial purposes that are distinguishable from the non-commercial

sources are not included in the dose reconstruction. This includes, but is not limited to, doses from: (1) non-destructive testing devices such as radiography units; (2) process or flow gauges that employ radioactive sources; (3) moisture or density gauges; (4) electrostatic eliminators; and (5) radiation-generating laboratory instruments, such as X-ray diffraction units (NIOSH, 2009).

During the decontamination and decommissioning portion of the residual radiation period at the Norton Co. site, the primary source of exposures would have been from tear-down, clean-up, and removal of any remaining source materials and contaminated building materials and equipment.

The following subsections provide an overview of the internal and external exposure sources for Norton Co. operations that affect the residual radiation period under evaluation.

5.2.1 Internal Radiological Exposure Sources from Norton Co. Operations

During the residual radiation period currently under evaluation (January 1, 1958 through October 31, 2009), the primary source for internal exposure would have been from tear-down, clean-up, and disposal of the contaminated equipment and other materials used during the operational period as well as re-suspension of contamination. NIOSH has documentation showing that 15 pounds of thorium and 25 pounds of uranium were removed from Building 112 and buried in October 1962 (Mondor, 1962). Norton Co. workers dressed out in company-provided clothing, shoes, and gloves during these operations. Mine Safety Administration (MSA) dust respirators were sometimes used (Personal Communication, 2010a); however, NIOSH has no documentation to support airborne dust levels, how often respirators were used, or how respirators were fit-tested. Norton Co. workers showered in the hot shower room before entering the cold locker room.

5.2.2 External Radiological Exposure Sources from Norton Co. Operations

As established, uranium and thorium were used during Norton Co.'s AWE operations (NIOSH, 2009). During the residual radiation period currently under evaluation (January 1, 1958 through October 31, 2009), workers were potentially exposed to direct radiation from surface contamination as well as exposure resulting from submersion in air contaminated with re-suspended residual uranium and thorium. This would include re-suspension from incidental removal of residual contamination.

5.2.2.1 Photon

The majority of the photons from natural uranium metals are in the 30-250 keV energy range. Solid uranium objects provide considerable shielding of the lower-energy photons and harden the spectrum, causing the majority of the photons emitted from a solid uranium object (such as a billet or rod) to have energies greater than 250 keV. While it is recognized that solid uranium sources will have a hardened photon spectrum, exposure to a thin layer of uranium on a surface will result in a larger fraction of exposure to lower-energy photons (Battelle-TBD-6000).

Table 5-1 shows the primary isotopes and photon energies associated with the recovery and clean-up of uranium. Exposure to these photons was possible during the residual radiation period from direct radiation during metal-handling and to submersion in metal-contaminated air.

Table 5-1: Principal Radiation Emissions from Natural Uranium and Its Short-Lived Decay Products			
Radionuclide	**Half-life**	**Beta Energy (MeV Max)**	**Photon (x or γ) Energy (MeV)**
U-238	4.468 x 10^9 years	None	x: 0.013 (8.8%)
Th-234	24.1 days	0.096 (25%)	x: 0.013 (9.6%)
		0.189 (73%)	γ: 0.063 (3.8%)
			γ: 0.093 (5.4%)
Pa-234m	1.17 minutes	2.28 (98.6%)	γ: 0.765 (0.2%)
		~1.4 (1.4%)	γ: 01.001 (0.6%)
U-235	7.038 x 10^9 years	None	x: 0.013 (31%)
			x: 0.090-0.105 (9.3%)
			γ: 0.144 (10.5%)
			γ: 0.163 (4.7%)
			γ: 0.186 (54%)
			γ: 0.205 (4.7%)
Th-231	25.5 hours	0.206 (15%)	x: 0.013 (71%)
		0.288 (49%)	γ: 0.026 (14.7%)
		0.305 (35%)	γ: 0.084 (6.4%)
U-234	244,500 years	None	x: 0.013 (10.5%)
			γ: 0.053 (0.2%)

Source: Battelle-TBD-6000, pdf p. 20. The table shows the principal radiation emissions from natural uranium and its short-lived decay products that were of concern for external radiation (not including bremsstrahlung).

Thorium has a significant number of higher-energy photons in the Th-232 decay chain. Based on the half-lives of the progeny, only a partial equilibrium is possible; therefore, it is conservative to state that equilibrium would be reached in this decay chain. It has been assumed that Ra-228 and Th-228 progeny were in equilibrium with Th-232 during the residual radiation period. Therefore, air concentrations were assumed equal for all progeny. Under this assumption, the progeny are the major source of both penetrating and non-penetrating external exposure. Table 5-2 shows the primary isotopes and photon energies associated with Th-232 and its progeny.

Table 5-2: Principal Radiation Emissions from Th-232 and its Short-Lived Decay Products *Table 5-2 spans two pages.*			
Radionuclide	**Half-life**	**Beta Energy (MeV Max)**	**Photon (x or γ) Energy (MeV)**
Th-232	1.405 x 10^{10} years	None	0.059 (0.19%)
			0.126 (0.04%)
Ra-228	5.71 years	0.389 (100%)	0.0067 (6 x 10^{-5}%)
Ac-228	6.25 hours	0.983 (7%)	0.338 (11.4%)
		1.014 (6.6%)	0.911 (27.7%)
		1.115 (3.4%)	0.969 (16.6%)
		1.17 (32%)	1.588 (3.5%)
		1.74 (12%)	---
		2.08 (8%)	---
		(+33 more βs)	---

Table 5-2: Principal Radiation Emissions from Th-232 and its Short-Lived Decay Products *Table 5-2 spans two pages.*			
Radionuclide	**Half-life**	**Beta Energy (MeV Max)**	**Photon (x or γ) Energy (MeV)**
Th-228	1.9116 years	None	0.084 (1.19%)
			0.132 (0.11%)
			0.166 0.08%)
			0.216 (0.27%)
Bi-212	60.55 minutes	1.59 (8%)	0.040 (1%)
		2.246 (48.4%)	0.727 (11.8$)
		---	1.620 (2.75%)
Tl-208	3.1 minutes	1.28 (25%)	0.277 (6%)
		1.52 (21%)	0.5108 (21.6%)
		1.80(50%)	0.583 (85.8%)
		---	0.860 (12%)
		---	2.614 (100%)

Source: *Handbook of Health Physics and Radiological Health* (Rad Handbook, 1998). Intensities refer to the percentage of disintegrations of the nuclide itself, not to original parent of series. Gamma percents are given in terms of observable emissions, not transitions.

5.2.2.2 Beta

Tables 5-1 and 5-2 show the principal beta emitters and their energies for the uranium and thorium metal used during the residual radiation period. As indicated in these tables, there are a significant number of high-energy beta radiations that represent a shallow dose exposure concern to site workers. Workers who handled the uranium and thorium metal would have received shallow dose exposures. The primary exposure areas would have been the hands and forearms, the neck and face, and other areas of the body that might not have been covered.

5.2.2.3 Neutron

Neutrons were not measured at Norton Co. during the AWE operations period. During the AWE operations period, Norton Co. did fabricate hexagon fuel elements containing uranium oxide and beryllium; therefore, neutrons could have arisen from the α-n reaction with light elements, interactions with the oxides, and through spontaneous fission. Data provided in Battelle-TBD-6000 show that during the residual radiation period, any neutron dose rate would be negligible compared to beta/gamma dose rates in dose calculations.

5.2.3 Incidents

During the dismantling, clean-up, and disposal of AWE equipment and materials, Norton Co. workers encountered some material spills. The interview source for this information stated the spills were small; however, no quantifications were provided (Personal Communication, 2010a). Spill areas were cleaned and checked for surface contamination using the contamination limits that were in place in 1962. According to an interview with a former Norton Co. employee, reports of all incidents were prepared and copies were sent to the Norton Co. medical director and to company management

(Personal Communication, 2010a). NIOSH has not identified any documentation on Norton Co. incidents.

6.0 Summary of Available Monitoring Data for the Class Evaluated by NIOSH

The following subsections provide an overview of the state of the available internal and external monitoring data for the Norton Co. class under evaluation.

6.1 Available Norton Co. Internal Monitoring Data

Norton Co. records were reviewed to identify internal monitoring data. The available data are in the form of *in vitro* bioassay data, air monitoring data, and area survey data.

In vitro Bioassay Data

Thirty-one *in vitro* bioassay sample results were identified in the Norton Co. records available to NIOSH. There is no information available on the minimum detectable activities or the counting systems used for any of these samples.

- Five samples were submitted to the AEC's New York Operations Office Health and Safety Laboratory (HASL) on June 14, 1955 and were analyzed by fluorometry for uranium (Urinalysis, 1955).

- Eight samples were submitted to HASL on December 17, 1956 (Urinalysis, 1956) and analyzed by fluorometry for uranium.

- Seven samples were taken on July 11, 1957 during a radiological survey by the Massachusetts Department of Labor and Industries, Division of Occupational Hygiene. These samples were analyzed for Pb-212; however, there is no indication who conducted the analysis (Elkins, 1957).

- Eleven samples were taken during a Massachusetts Department of Labor and Industries survey conducted on May 13, 1958. These samples were analyzed for Pb-212 and are the only samples taken during the class period under evaluation (Pagnotto, 1958).

Air Monitoring Data

Ninety-eight air monitoring results were identified in the Norton Co. records available to NIOSH (8 from 1955; 41 from 1957; 44 from 1958; and 5 total from 1962, 1963, and 1964).

- Two samples were collected on June 3, 1955 by the Norton Co. and counted on a low-background counting system in an argon-methane atmosphere (Rad Survey, 1955a). One sample was taken in a thorium area and the other was taken in a uranium area. Results are listed in units of µCi/cc. The system's counting efficiency and Minimum Detectable Activity (MDA) are not indicated.

- Six samples were taken by the Liberty Mutual Insurance Company's Office of Industrial Hygiene (two on July 6, 1955; two on August 1, 1955; and two on October 26, 1955). The samples were collected at a sampling rate of approximately 20 liters per minute and counted on a Model PCC-10 Counter Scaler and Keleket Model K-281 (Rad Survey, 1955c). The samples could not be readily associated with a specific process area. Results are listed in units of µCi/ml. The system's counting efficiency and MDA are not indicated.

- Thirteen samples were collected in April 1957 and analyzed by HASL for gross alpha (Air Dust Samples, April 1954 & 1957). Only five of the samples could be associated with an identifiable location due to illegibility; four of the samples were from a contaminated locker room; one was from a thorium processing location. Results are listed in units of $d/min/m^3$. The system's counting efficiency and MDA are not indicated.

- Twenty-eight sample results (short-lived and long-lived alpha-emitters) were reported for 14 samples collected on July 11, 1957 by the Massachusetts Department of Labor and Industries, Division of Occupational Hygiene (Elkins, 1957). Fourteen of the sample results (from seven samples) could be associated with the thorium processing area. The samples were counted with an alpha scintillation counter with a reported efficiency of 24%. Results are listed in units of µCi/ml. The system's MDA is not indicated.

- Forty-two sample results (short-lived and long-lived alpha-emitters) were reported for 21 samples collected on May 13, 1958 by the Massachusetts Department of Labor and Industries (Pagnotto, 1958). Sixteen of the sample results (from eight samples) could be associated with the thorium processing area; six of the sample results (from three samples) could be associated with the uranium processing area. The system's counting efficiency and MDA are not indicated. Results are listed in units of µCi/ml.

- Two samples were collected on September 9, 1958 by the Liberty Mutual Insurance Company (Rad Survey, 1958). One sample was taken in the thorium processing area and the other was taken in the uranium processing area. Samples were collected at a sampling rate of approximately 19.8 liters per minute and counted on a Gas Flow Proportional Counter. The system's counting efficiency and MDA are not indicated. Results are listed in units of µCi/ml.

- Five samples were collected in 1962, 1963 and 1964. All five could be identified as being taken in a thorium area. All results are listed in units of µCi/cc; system counting efficiencies and MDAs are not indicated. Two samples were collected on February 2, 1962 (Rad Survey, 1962) and one sample was collected on February 20, 1963 (Rad Survey, 1963) by Liberty Mutual Insurance Company using an NMC Gas Flow Alpha Proportional Counter. Two samples were collected on July 24, 1964 by Liberty Mutual Insurance Company and counted for alpha activity using an NMC Alpha-Beta Proportional Counter, Model PC-3A (Rad Survey, 1964a).

Area Survey Data

Six hundred seventy-three area survey results were identified in the Norton Co. records. Of those 673 results, 271 were taken prior to 1955 and had either unknown units (9 results) (Rad Survey, 1953-

1954) or specified microamperes for alpha (262 results) (Gustafson, 1954). The instrument type, the radioactive source being measured, instrument efficiency, and MDA are not identified.

Of the 673 results, 336 were taken in 1955. Units ranged from counts per minute (cpm), disintegrations per minute (dpm) to µCi/ml to unknown. In all cases, instrument efficiency and MDA are not identified. Of the 336 results, 33 were reported as removable contamination measurements.

- The Norton Co. performed surveys on February 2, 1955 (Rad Survey, 1955d) and March 14, 1955 (Benedict, 1955) using a Sampson D5 survey meter. During another survey on June 3, 1955, a Sampson alpha survey meter was employed and removable contamination samples were counted with an alpha scintillation counter (Rad Survey, 1955a).

- The Liberty Mutual Insurance Company performed surveys on July 2 and 28, 1955 (Rad Survey, 1955b) and October 26, 1955 (Rad Survey, 1955c), all using a Sampson alpha survey meter. Another survey on December 7, 1955 (McAllister, 1955) also employed a Sampson alpha survey meter; wipe samples were counted with a Tracerlab survey meter with an end window GM tube.

During a November 19, 1956 survey, the Norton Co. obtained six results (Benedict, 1956). It is not known whether the results reflect direct survey or removable contamination. Measurement units, instrument efficiency, and MDA are not identified.

During a March 8, 1957 survey, the Liberty Mutual Insurance Company obtained ten results, all of which were identified as removable contamination samples (McAllister, 1957). The samples were counted on a gas flow proportional counter. Instrument efficiency and MDA are not identified; units are identified as cpm.

During a September 9, 1958 survey, the Liberty Mutual Insurance Company obtained ten results (Rad Survey, 1958). These removable contamination samples surveyed approximately 100 cm^2 of surface. Instrument type, efficiency, and MDA are not identified. Units are identified as dpm.

In a July 26, 1961 letter of application to the AEC requesting approval to bury "waste licensed source material," Norton Co. indicated that the readings from the waste ranged from 0 to 1000 counts per minute with several pieces reading in excess of 12,500 counts per minute (Johnson, 1961). The waste had been surveyed indiscriminately with a Sampson alpha meter using a 100-cm^2 window. Exterior surfaces of the waste barrels were monitored with a Nuclear Instrument and Chemical Corporation beta-gamma meter. Those readings ranged from 0.03 to 0.9 mr/hr. Instrument efficiency was not provided (Johnson, 1961).

An August 10, 1962 letter of application to the Massachusetts Department of Public Health states that 1,510 pieces of waste material had been surveyed with a Sampson Alpha Survey Model D-5 ionization type instrument using a 100 cm^2 window (Johnson, 1962). Results reported in that August 1962 correspondence give only a maximum reading of 500 counts per minute (Johnson, 1962). The same document states that spectrographic analyses were performed on random waste samples, indicating there was less than one part per million of thorium and uranium in the body of the waste materials.

Correspondence to the Director of Environmental Health, dated October 11, 1962, indicates that during the burial of barrels from October 8 through 10, 1062, Norton Co. Hygiene and Safety monitored worker clothing contamination with a Sampson Alpha meter using a 100-cm^2 window (Mondor, 1962). Results are not provided, with the exception of a statement saying that meter readings were zero (Mondor, 1962).

During a January 10, 1964 survey by an unknown party, 16 results were obtained (Rad Survey, 1964b). The samples appear to have been analyzed by HASL. The samples were counted on an alpha counter with a geometry of 44.14% and a smear position factor of 0.81. It is not clear if the samples were taken by direct survey or by smear. Units are identified as dpm.

During a July 24, 1964 survey, the Liberty Mutual Insurance Company collected 19 removable contamination samples, each representing approximately 100 cm^2 of surface (Rad Survey, 1964a). These samples were counted for alpha activity using an NMC alpha-beta proportional counter. The efficiency and MDA are not identified. Units are identified as dpm.

During a September 8, 1965 survey, the Norton Co. collected seven samples (Johnson, 1965). It is not clear if the samples were taken by direct survey or by smear. Units are identified as cpm. Instrument type, efficiency, and MDA are not identified.

6.2 Available Norton Co. External Monitoring Data

Records for Norton Co. were reviewed to identify external monitoring data. These data can take the form of direct readings using a survey instrument or data collected from film badges and/or thermoluminescent dosimeters.

- Twelve dose rate measurements were taken by Norton Co. from September 20 to October 1, 1945 (Norton, 1945). These results were taken with a Victoreen Glasser-Seitz Model 70 R-meter. Instrument efficiency and MDA are not identified. Results are reported in R/24 hours.

- Eighteen dose rate measurements were made by Norton Co. on February 18, 1954 (Gustafson, 1954). Instrument type, efficiency, and MDA are not identified. Results are reported in mR/hr.

- Twenty-one dose rate measurements results were taken by the Massachusetts Department of Labor & Industries, Division of Occupational Hygiene on July 11, 1957 (Elkins, 1957). These results were collected using a Thyac survey meter. Instrument efficiency and MDA are not identified. Results are reported in mR/hr.

- Twenty-four film badge results were identified for 1958 (Badge Results, 1958). The film badges, analyzed by Tracerlab, measured beta and gamma radiation and had a quoted MDA of 20 mR. While it appears that these badges were worn by individuals, this cannot be absolutely determined. Results are reported in mR.

- One dose rate measurement was taken by Norton Co. on September 8, 1965 (Johnson, 1965). Instrument type, efficiency, and MDA are not identified. The measurement unit is mR/hr.

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

The feasibility determination for the class of employees under evaluation in this report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(1). Under that Act and rule, NIOSH must establish whether or not it has access to sufficient information either to estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed that could have been incurred under plausible circumstances by any member of the class, or to estimate the radiation doses to members of the class more precisely than a maximum dose estimate. If NIOSH has access to sufficient information for either case, NIOSH would then determine that it would be feasible to conduct dose reconstructions.

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class as summarized in Section 7.5. This approach is discussed in DCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00173 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Norton Co. Data

This subsection answers questions that need to be asked before performing a feasibility evaluation. Data Pedigree addresses the background, history, and origin of the data. It requires looking at site methodologies that may have changed over time; primary versus secondary data sources and whether they match; and whether data are internally consistent. All these issues form the bedrock of the researcher's confidence and later conclusions about the data's quality, credibility, reliability, representativeness, and sufficiency for determining the feasibility of dose reconstruction. The feasibility evaluation presupposes that data pedigree issues have been settled.

7.1.1 Internal Monitoring Data Pedigree Review

As discussed in Section 6.1, internal monitoring data are available for Norton Co. While there is no direct evidence that Norton Co. conducted a routine urinalysis or air monitoring program, data are available for the facility.

Available records provide thirty-one urine sample results from 1955 to 1958. Samples collected in 1955 and 1956 were analyzed for uranium (Urinalysis, 1955; Urinalysis, 1956). The data are reported in handwritten entries on HASL forms. The remaining samples from 1957-1958 were analyzed for the thorium daughter Pb-212 to determine exposure to Th-228 (Elkins, 1957; Pagnotto, 1958). While records indicate that the samples were collected as part of a visit from the Massachusetts Department of Labor and Industries, there is no indication of who performed the analysis. The results appear in a typed memo from the Massachusetts Department of Labor and Industries to the Norton Co.

There are ninety-eight air monitoring results from 1955 to 1964. Sample results prior to January 1, 1958 (i.e., during the operational period) were collected either by the Norton Co. (Rad Survey, 1955a), Liberty Mutual Insurance Co. (Rad Survey, 1955c), HASL (Urinalysis, 1956), or the Massachusetts Department of Labor and Industries (Elkins, 1957). In all situations, the data were either handwritten on the original analysis forms (Urinalysis, 1956) or in typed memos (Elkins, 1957; Rad Survey, 1955a; Rad Survey, 1955c). While there is some limited information on the type of counting system used to perform the analysis for each of the data sets, the MDA is never provided. Although limited information is available on the type of contamination being sampled (i.e., U or Th), the majority of data was collected in an unknown radionuclide environment.

There are forty-nine air monitoring results for samples collected after January 1, 1958. One data set was collected by the Massachusetts Department of Labor and Industries (Pagnotto, 1958). Four other data sets were collected by Liberty Mutual Insurance Co. (Rad Survey, 1958; Rad Survey, 1962; Rad Survey, 1963; Rad Survey, 1964a). In all cases, the data are reported in typed memos from the respective organizations. While there is some limited information on the type of counting system used to perform the analysis for each of the data sets, the MDA is never provided. Although limited information is available on the type of contamination being sampled (i.e., U or Th), the majority of data was collected in an unknown radionuclide environment.

NIOSH has identified 673 survey results from 1954 to 1965. The 1954 data documentation does not identify who collected the results; the results are handwritten on lined paper and there is no information on instrumentation or the type of radionuclide environment (Rad Survey, 1953-1954; Gustafson, 1954). Approximately half of all survey data (336 of 673 results) was generated in 1955. Three sets of data were collected by the Norton Co. (Rad Survey, 1955d; Rad Survey, 1955a; Benedict, 1955). One of these data sets contains removable contamination (wipe) survey data (Rad Survey, 1955a). In all three records, the data are reported in a typed memo. Three other data sets were collected in 1955 by the Liberty Mutual Insurance Company (Rad Survey, 1955b; Rad Survey, 1955c; McAllister, 1955). One of these data sets contains removable contamination (wipe) survey data (McAllister, 1955). In all three records, the data are presented in a typed memo. For all of the data sets above, there is varying information on the counting systems used, but no mention of the MDA.

Survey data were collected by the Norton Co. in 1956 (Benedict, 1956) and by the Liberty Mutual Insurance Co. in 1957 (McAllister, 1957). The information in the 1957 data set indicates removable contamination survey results. The data above were reported in typed memos; there is no information on the MDA or counter efficiency.

Data collected after the AWE operational period are very limited. Ten wipe sample results were recorded in 1958 by the Liberty Mutual Insurance Co. (Rad Survey, 1958). The results are reported in

a typed memo; no information on instrument type, efficiency, or MDA is provided. Sixteen results were identified for 1964 from an unknown party (Rad Survey, 1964b). Data were reported in a copy of what appears to be a logbook page with handwritten results. It is clear that a standard was used for efficiency determination; a background sample was also recorded. The samples appear to have been analyzed by HASL. Nineteen wipe data results were collected by the Liberty Mutual Insurance Company and reported in a typed memo format (Rad Survey, 1964a). No information on the counting system or MDA is provided. Seven wipe results were collected in 1965 by the Norton Co. (Johnson, 1965). The results are reported in a typed memo with no information on the counting system, efficiency, or MDA.

A substantial volume of data was collected in 1997. A four-volume report written about the site (Radiation Safety Associates, 1997a; Radiation Safety Associates, 1997b; Radiation Safety Associates, 1997c; Radiation Safety Associates, 1997d) indicates that Decontamination and Decommissioning (D&D) activities occurred in 1968. The report also states that "…some of the remediation practices used, are not currently appropriate for residual natural uranium or natural thorium." As a result, additional remediation activities occurred in 1996.

While any single set of data discussed above may or may not be sufficient to develop a dose reconstruction methodology for the residual radiation period under evaluation, a dataset that combines these multiple data sets is sufficient to allow NIOSH to develop a workable methodology. All data used by NIOSH were taken directly from scanned copies of actual hard-copy data sheets and reports.

7.1.2 External Monitoring Data Pedigree Review

During the review of the Norton Co. records in the SRDB, NIOSH identified external monitoring data. These data were from real-time monitoring with a hand-held external dose survey meter and from film badge results that integrated exposure over time.

Real-time monitoring data collected by the Norton Co. were located for 1945 (Norton, 1945). Results are reported in a typed memo from that time period. Although the instrument type is identified, the instrument efficiency and the MDA are not provided.

Real-time monitoring data collected by the Norton Co. were located for 1954 (Gustafson, 1954). Results are presented in a typed memo from that time period. Instrument type, efficiency, and MDA are not identified.

Data collected by the Massachusetts Department of Labor and Industries, Division of Occupational Hygiene, were located for 1957 (Elkins, 1957). Results are presented in a typed memo from that time period. Although the instrument type is identified, the instrument efficiency and the MDA are not provided.

Records included film badge data collected in 1958 (Badge Results, 1958). Results were supplied by Tracerlab and are reported in a typed Tracerlab memo. Gamma exposures were recorded, and where beta exposures occurred, beta dose was also recorded. The Minimum Measured Dose as identified in the report is 20 mR.

Survey data of waste barrels and clothing obtained during the clean-up period from January 1, 1958 through October 10, 1962, were reported in counts per minute and mr/hr on typed Norton Co. memos (Mondor, 1962; Johnson, 1962; Johnson, 1961).

One record identified an external dose range recorded by the Norton Co. in 1965 (Johnson, 1965). Results are presented in a typed memo from that time period. Instrument type, efficiency, and MDA are not provided.

The external monitoring data listed above are sufficient to allow NIOSH to develop a dose reconstruction methodology for the Norton Co. residual radiation period under evaluation. All data used by NIOSH were taken directly from scanned copies of actual hard-copy data sheets and reports.

7.2 Evaluation of Bounding Internal Radiation Doses at Norton Co.

The principal source of internal radiation doses for members of the residual radiation period under evaluation would have been uranium and thorium from the tear-down, clean-up, and disposal of the contaminated equipment and other materials used during the operational period as well as re-suspension of contamination. The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Residual Radiation Period Internal Doses

The following subsections summarize the extent and limitations of information available for reconstructing the internal doses of members of the class under evaluation.

7.2.1.1 Urinalysis Information and Available Data

Urinalysis data are not available for the residual radiation period.

7.2.1.2 Airborne Levels

A limited amount of air dust results for uranium and thorium were taken during the AWE operational period (Air Dust Samples, April 1954 & 1957; McAllister, 1962; Elkins, 1957; Elkins, 1958; Pagnotto, 1958; Rad Survey, 1955a; Rad Survey, 1955c; Rad Survey, 1958). NIOSH has also obtained limited air monitoring results for samples collected during the residual radiation period (Rad Survey, 1963; Rad Survey, 1964a). However, these latter results represent monitoring of commercial operations (Personal Communication, 2010a) and are not considered for the feasibility of bounding internal radiation doses from thoria.

Short-lived and long-lived alpha air monitoring data collected by the Massachusetts Department of Labor and Industries on May 13, 1958 (Pagnotto, 1958) are useful in determining the feasibility of bounding internal radiation doses from thorium and thoron.

7.2.2 Methods for Bounding Residual Radiation Period Internal Dose at Norton Co.

NIOSH does not have adequate internal monitoring or workplace monitoring data to bound doses that were potentially received during the dismantling, clean-up, packaging, and burial of AWE materials and contamination. While NIOSH does have air monitor data obtained during the AWE operations period that can be used to bound doses in the residual period following the burial which culminated on October 10, 1962, those data cannot be assumed to bound all radioactive contamination and radiological contamination levels that could have arisen from the dismantling, clean-up, packaging and burial processes which were documented to have generated dust.

In order to determine the feasibility of bounding potential internal doses received from exposures to residual radiation received after the burial of AWE materials, NIOSH evaluated air monitoring data in the form of long-lived gross-alpha results obtained on May 13, 1958 (reported on May 28, 1958) by the Massachusetts Department of Labor and Industries (Pagnotto, 1958) to derive the air concentration starting on October 11, 1962 through the end of the residual radiation period, October 31, 2009. The average of the long-lived alpha results was calculated from the data shown in Table 7-1 to estimate the starting air concentration (4.662 dpm/m^3) on October 11, 1962.

Table 7-1: Air Monitoring Results, Long-Lived Alpha Emitters

Sample Number	Time Sampling Completed (hours)	Location	Long-Lived Alpha Emmiters (uCi/mL)	Thorium Air Concentration (dpm/m^3)
1M	9.2	End of hood - thoria area	4E-13	-
7M	2.5	End of hood - thoria area	4E-13	-
13	2.5	End of hood - thoria area	2E-12	-
5M	1.15	Thoria processing area	2E-12	-
3	10	General area on bench	2E-12	-
7	11.2	Hood - thoria area	1E-12	-
11	2	Bench near thoria area	2E-12	-
14	2.5	By glass cutting wheel	7E-12	-
		Average - thoria area samples	2.1E-12	4.662

Average daily intake rates for inhalation and ingestion were calculated based on an inhalation rate of 1.2 m^3/hr, 8-hour workday, and 250 workdays per year, resulting in a value of 30.654 dpm/day for the period from October 11, 1962 through December 31, 1963. Intake rates for the following years through October 31, 2009 have been adjusted due to source term depletion per guidance in ORAUT-OTIB-0070. The air monitoring results are reported in units of gross alpha and are not isotopic-specific; therefore, the most claimant-favorable radionuclide and solubility class will be assigned by NIOSH. The Norton Co. processed both uranium oxide and thoria. Because Norton Co. processed both uranium and thorium oxides, uranium can be assumed to be U-234 (Types M and S) and thorium can be assumed to be Th-232 (Types M and S).

Table 7-2: Intake Rates for Uranium or Thorium				
Applicable Period	**ORAUT-OTIB-0070 Adjustment**	**Inhalation (dpm/day)**	**Ingestion (dpm/day)**	**Distribution**
01/1958 - 10/10/1962	not feasible	not feasible	not feasible	N/A
10/11/1962 - 12/31/1963	1	30.654	0.747	Constant
01/01/1964 - 12/31/1964	0.03	0.920	0.022	Constant
1965 and later	0.0007	0.021	0.001	Constant

NIOSH does not consider radon as an exposure source, as Norton Co. only had uranium metals and associated dust onsite. NIOSH has identified thoron monitoring data in the form of short-lived thoria results obtained on May 13, 1958 (reported on May 28, 1958) (Pagnotto, 1958). NIOSH used the reported average short-lived values as actual values of thoron, as provided in Table 7-3 to calculate the intake rate of thoron from the end of the burial operation through December 31, 1963. Working level (WL) and working level months (WLM) were calculated for each result and for the average of the reported short-lived results.

Table 7-3: Air Monitoring Results, Short-Lived Alpha Emitters					
Sample Number	**Time Sampling Completed (hours)**	**Location**	**Short-Lived Alpha Emmiters (uCi/mL)**	**Thoron (WL)**	**Thoron (WLM)**
1M	9.2	End of hood - thoria area	3.3E-11	0.00440	0.0518
7M	2.5	End of hood - thoria area	4E-11	0.00533	0.0627
13	2.5	End of hood - thoria area	3.6E-11	0.00480	0.0565
5M	1.15	Thoria processing area	4.2E-11	0.00560	0.0659
3	10	General area on bench	5.2E-11	0.00693	0.0816
7	11.2	Hood - thoria area	4.1E-11	0.00547	0.0643
11	2	Bench near thoria area	2.26E-10	0.03013	0.3545
14	2.5	By glass cutting wheel	3.1E-11	0.00413	0.0486
		Average - thoria area samples	6.2625E-11	0.00835	0.0982

Intake rates for the following years have been adjusted due to source term depletion per guidance in ORAUT-OTIB-0070. Thoron intake rates for the Norton Co. residual radiation period are provided in Table 7-4.

Table 7-4: Intake Rates for Thoron			
Applicable Period	**ORAUT-OTIB-0070 Adjustment**	**Thoron (WLM))**	**Distribution**
01/1958 - 10/10/1962	not feasible	not feasible	N/A
10/11/1962 - 12/31/1963	1	0.0982	Constant
01/01/1964 - 12/31/1964	0.03	0.0029	Constant
1965 and later	0.0007	0.0001	Constant

7.2.3 Internal Dose Reconstruction Feasibility Conclusion

As presented in Section 5.1, between October 8 and October 10, 1962, Norton Co. employees transported clean-up wastes to a portion of the Norton Co. landfill and buried the wastes. NIOSH has insufficient data to bound potential internal exposures during these waste burial operations. NIOSH therefore concludes that reconstruction of potential internal radiation doses resulting from exposures to residual uranium, thorium, and thoron at the Norton Co. is not feasible for the period from January 1, 1958 through October 10, 1962. NIOSH concludes that reconstruction of potential internal radiation doses resulting from exposures to residual uranium and thoron at the Norton Co. is feasible for the period from October 11, 1962 through October 31, 2009 (the period after the Norton Co. waste was buried).

NIOSH has determined that reconstruction of internal dose received during Norton Co. decontamination activities from January 1, 1958 through October 10, 1962, is not feasible. Although NIOSH found that it may not be possible to completely reconstruct internal radiation doses for all workers for the period from January 1, 1958 through October 10, 1962, NIOSH intends to use any available internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Norton Co. during the period from January 1, 1958 through October 10, 1962, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.3 Evaluation of Bounding External Radiation Doses at Norton Co.

The principal source of external radiation doses for members of the evaluated class was direct radiation from surface contamination as well as exposure resulting from submersion in air contaminated with re-suspended residual uranium and thorium.

The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

7.3.1 Evaluation of Bounding Residual Radiation Period External Doses

Workers involved in the decontamination activities were monitored by TracerLab film badges (Personal Communication, 2010a); however, NIOSH has not identified any external dosimeter results obtained during the residual radiation period. Personnel were potentially subjected to direct external exposure from surface radioactive contamination and to submersion in contaminated air as a result of re-suspension of surface contamination. Using the air contamination data obtained during the operational period and the methods in Battelle-TBD-6000, there are sufficient data and methods to support bounding the external dose during the residual radiation period from October 11, 1962 through October 31, 2009.

7.3.2 Norton Co. Occupational X-Ray Examinations

Doses received from occupational medical X-rays are not considered as part of the source term for the residual radiation period; therefore, medical X-rays were not evaluated.

7.3.3 Methods for Bounding Residual Radiation Period External Dose at Norton Co.

In order to determine the feasibility of bounding potential external doses received from exposures to residual radiation, NIOSH evaluated air monitoring data obtained during the operations period. The 95th percentile of the gross alpha air dust results was calculated to estimate the highest contamination levels present after the AWE materials had been buried starting on October 11, 1962. It is assumed that the material deposited on the floor with a deposition velocity of 0.00075 m/s from October 11, 1962 through December 31, 1963. This results in a maximum contamination level of 1.83×10^{6} dpm/m^2. Using these assumptions, daily doses can be calculated based on the maximizing potential radionuclide. The external doses are from penetrating photons with energies between 30 and 250 keV and electron energy range of >15 keV for penetrating exposures. Table 7-5 shows the external dose rates for the residual radiation period adjusted for source term depletion per the guidance provided in ORAUT-OTIB-0070 and Battelle-TBD-6000.

NIOSH has identified no personnel or workplace monitoring data that can be used to quantify such contamination or accurately bound external doses potentially received during the period from January 1, 1958 through October 10, 1962, during the clean-up and burial operations. Therefore, NIOSH finds that it is not feasible to reconstruct doses received from potential external exposures to radioactive contamination during the period of January 1, 1958 through October 10, 1962.

Table 7-5: External Dose Rates for the Residual Radiation Period

Applicable Period	ORAUT-OTIB-0070 Adjustment	Gamma (rem/year)	Beta (rem/year)
01/1958 - 10/10/1962	not feasible	not feasible	not feasible
11/11/1962 - 12/1963	1	0.026	0.233
01/1964 - 12/1964	0.03	0.001	0.007
1965 onward	0.0007	<0.001	<0.001

7.3.4 External Dose Reconstruction Feasibility Conclusion

NIOSH has not identified any external dosimeter results obtained during the residual radiation period, and consequently has insufficient external monitoring data to bound potential external exposures during waste burial operations through October 10, 1962. NIOSH therefore concludes that reconstruction of potential external radiation doses resulting from exposures to residual contamination at the Norton Co. is not feasible for the period from January 1, 1958 through October 10, 1962. NIOSH concludes that reconstruction of potential external radiation doses resulting from exposures to residual uranium and thorium at Norton Co. is feasible for the period from October 11, 1962 through October 31, 2009 (the period after the Norton Co. waste was buried).

NIOSH has determined that reconstruction of external dose received during Norton Co. decontamination activities from January 1, 1958 through October 10, 1962, is not feasible. Although NIOSH found that it may not be possible to completely reconstruct external radiation doses for all workers for the period from January 1, 1958 through October 10, 1962, NIOSH intends to use any available external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions

for individuals employed at the Norton Co. during the period from January 1, 1958 through October 10, 1962, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.4 Evaluation of Petition Basis for SEC-00173

The following subsections evaluate the assertions made on behalf of petition SEC-00173 for the Norton Co.

7.4.1 Petition Basis

SEC-00173: The petitioner selected as the petition basis that the records relating to some types of radiation exposures and doses incurred by the class, or relating to certain periods of time, certain operations, or certain exposure incidents involving the class, have been lost, falsified, or destroyed, or that there is no such information (Petition, 2010).

NIOSH has concluded that it is not feasible to reconstruct doses received from potential exposures to residual contamination for Norton Co. workers involved in the clean-up and burial of AWE materials and equipment, as discussed in Sections 7.2 and 7.3.

7.4.2 Waste Disposal Area on I-190 Ramp

SEC-00173: In the petition for SEC-00173, the petitioner included information about Norton Co. waste that had been buried on land that eventually was used to build a ramp to Interstate I-190 (Petition, 2010).

In Section 5.1, NIOSH documented that during the residual radiation period activities in 1962, materials and equipment were buried in a portion of the Norton Co. landfill located on Norton Co. property. NIOSH further learned that some of that landfill was transferred to the State of Massachusetts for highway construction (Personal Communication, 2010a). NIOSH has concluded that it is not feasible to reconstruct doses received from potential exposures to residual contamination for Norton Co. workers involved in the clean-up and burial of AWE materials and equipment, as discussed in Sections 7.2 and 7.3.

7.5 Summary of Feasibility Findings for Petition SEC-00173

This report evaluates the feasibility for completing dose reconstructions for all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. during the period from January 1, 1958 through October 31, 2009. NIOSH found that the available monitoring records, process descriptions and source term data available are sufficient to complete dose reconstructions for the evaluated class of employees for the period from October 11, 1962 through October 31, 2009. However, NIOSH also found that it lacks sufficient monitoring records, process descriptions, and source term data to complete dose reconstructions for the evaluated class of employees for the period from January 1, 1958 through October 10, 1962.

Table 7-6 summarizes the results of the feasibility findings at Norton Co. for each exposure source during the residual radiation period from January 1, 1958 through October 31, 2009.

Table 7-6: Summary of Feasibility Findings for SEC-00173
January 1, 1958 through October 31, 2009 (residual radiation period)

Source of Exposure	Jan. 1, 1958 - October 10, 1962		October 11, 1962 - Oct. 31, 2009	
	Reconstruction Feasible	**Reconstruction Not Feasible**	**Reconstruction Feasible**	**Reconstruction Not Feasible**
Internal		**X**	**X**	
Uranium		X	X	
Thorium		X	X	
Thoron		X	X	
External		**X**	**X**	
Gamma		X	X	
Beta		X	X	
Neutron	N/A			
Occupational Medical X-ray	N/A			

As of December 19, 2010, a total of 56 claims have been submitted to NIOSH for individuals who worked at Norton Co. and are covered by the class definition evaluated in this report. Dose reconstructions have been completed for eighteen individuals (~32%).

8.0 Evaluation of Health Endangerment for Petition SEC-00173

The health endangerment determination for the class of employees covered by this evaluation report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(3). Under these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must also determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. Section 83.13 requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

NIOSH has obtained gross alpha air monitoring results collected at the Norton Co. near the end of the AWE operations period and during the residual radiation period. Using those data and the guidance in ORAUT-OTIB-0070, NIOSH can bound the internal doses potentially received from exposures to

residual uranium and thoria for the period from October 11, 1962 through October 31, 2009. The gross alpha air contamination data from the operational period and the methods described in Battelle-TBD-6000 allow NIOSH to bound external doses from residual uranium and thoria for the period from October 11, 1962 through October 31, 2009. NIOSH's evaluation determined that it is feasible to estimate radiation dose for members of the NIOSH-evaluated class for the period from October 11, 1962 through October 31, 2009, with sufficient accuracy based on the sum of information from available resources. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is not required for the October 11, 1962 through October 31, 2009 period. However, NIOSH's evaluation determined that it is not feasible to estimate radiation dose for members of the NIOSH-evaluated class for the period from January 1, 1958 through October 10, 1962, with sufficient accuracy. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is required for the January 1, 1958 through October 10, 1962 period.

9.0 Class Conclusion for Petition SEC-00173

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort. NIOSH has determined that decontamination and decommissioning activities were conducted at Norton Co. from January 1, 1958 through October 10, 1962, for which NIOSH lacks sufficient source term and monitoring data to bound doses potentially received from exposures during that work. NIOSH finds that it does have sufficient data to bound doses for the period from October 11, 1962 through October 31, 2009.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00173. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

These actions are based on existing, approved NIOSH processes used in dose reconstruction for claims under EEOICPA. NIOSH's guiding principle in conducting these dose reconstructions is to ensure that the assumptions used are fair, consistent, and well-grounded in the best available science. Simultaneously, uncertainties in the science and data must be handled to the advantage, rather than to the detriment, of the petitioners. When adequate personal dose monitoring information is not available, or is very limited, NIOSH may use the highest reasonably possible radiation dose, based on reliable science, documented experience, and relevant data to determine the feasibility of reconstructing the dose of an SEC petition class. NIOSH contends that it has complied with these

standards of performance in determining the feasibility or infeasibility of reconstructing dose for the class under evaluation.

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42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort Under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule; May 28, 2004; SRDB Ref ID: 22001

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Attachment One: Data Capture Synopsis

Table A1-1: Summary of Holdings in the SRDB for Norton Co.			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
Primary Site/Company Name: Norton Co.; BE 1944-1956; AWE 1945-1957; Residual Radiation 1958-July 2006 Other Site Names: St. Gobain (Successor): *[Name, title, and contact information redacted]*	Tracer Lab Inc. film badge radiation dosage report, various survey results, assessment of thorium exposure due to grinding of thoriated tungsten electrodes, state department of labor and industries division of occupational hygiene site visit, final radiological status report, and industrial hygiene surveys. Note: Awaiting final response from *[Name and company name redacted]* who provided monitoring service for Norton Company.	02/01/2010 OPEN	30
State Contacted: *[Name, title, and contact information redacted]; [Name, title, and contact information redacted]*	No relevant data identified.	08/31/2010	0
DOE Germantown	Elimination and security information, thoria, heavy oxide, uranium and thorium inventory, radiation survey after thorium oxide fusion, procedures and policies, exposure data, and hazards and safety information.	03/12/2008	6
DOE Hanford	Journal of Industrial Hygiene and Toxicology article on lung cancer hazards. Note: Awaiting results of data search request.	11/14/2006 OPEN	1
DOE Legacy Management - Grand Junction Office	FUSRAP investigation, urinalysis and air dust samples, fusions of uranium and thorium oxides, progress reports, MSA contract obligations 1946, and uranium oxide refractory and crucibles.	06/11/2010	9
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Thorium production, engineering and development through 1954, trip report for Los Alamos Scientific Laboratory, ORNL purchase of fused thoria and crude material, fabrications of urania crucibles by Norton Company for Argonne, handling of uranium oxide, established maximum allowable concentration for airborne uranium, reduction of Ra-226 and Ra-228 in plant effluents, and NLO/Norton AEC contract information.	05/21/2008	26
DOL/Paragon	Weekly and monthly reports and a request for special material.	01/01/2009	4
Environmental Measurements Laboratory (EML) / Health and Safety Laboratory (HASL)	Site visit reports, 1953 annual report, and thorium sampling and storage information.	03/08/2005	1
Internet - Comprehensive Epidemiologic Data Resource (CEDR)	No relevant data identified.	06/24/2010	0

Table A1-1: Summary of Holdings in the SRDB for Norton Co.			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
Internet - DOE Hanford Declassified Document Retrieval System (DDRS)	No relevant data identified.	06/24/2010	0
Internet - DOE Legacy Management Considered Sites	Tonawanda area report and AEC source material license. Note: One document added by site association.	06/24/2010	2
Internet - DOE OpenNet	Historical report and monthly status and progress reports.	06/24/2010	7
Internet - DOE OSTI Energy Citations	No relevant data identified.	06/24/2010	0
Internet - DOE OSTI Information Bridge	Pacific Northwest National Laboratory activities report.	06/24/2010	1
Internet - Google	Fusion process for production of stoichiometric UO2, improvements in or relating to a process for the preparation of uranium dioxide, information regarding license number STB-00770, process for the extraction of relatively pure thorium, process of making nuclear fuel element, and weekly information reports. Note: Two documents added by site association.	06/24/2010	10
Internet - HP Journal	No relevant data identified.	10/04/2010	0
Internet - Journal of Occupational and Environmental Health	No relevant data identified.	10/04/2010	0
Internet - National Academies Press (NAP)	No relevant data identified.	06/24/2010	0
Internet - National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant data identified.	06/24/2010	0
Internet - NRC Agencywide Document Access and Management (ADAMS)	NRC FUSRAP sites review. Note: One document added by site association.	06/24/2010	1
Internet - US Army Corps of Engineers	No relevant data identified.	06/24/2010	0
Internet - Washington State University (U.S. Transuranium and Uranium Registries)	No relevant data identified.	06/24/2010	0
NARA - Atlanta	Trip report and Norton Company information.	02/21/2007	5
NARA - College Park	Beryllium issues at Norton Company, personal notes, and a health hazard survey.	07/16/2010	5
Oak Ridge National Laboratory	Health hazards information and brown and black oxide at Norton.	07/08/2004	1
ORAU Team	Confirmation of the Radiation Control Program of the Massachusetts Department of Public Health and documented communications.	01/23/2007	3
Unknown	Air dust, breath, and water samples, urine sample results, multiple site historical information and thorium procurement and investigations.	Unknown	15
Total			**127**

Table A1-2: Database Searches for Norton Co.			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called "Data Capture Synopsis for Norton Co."			
DOE CEDR http://cedr.lbl.gov/ COMPLETED 06/24/2010	See note above	0	0
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 06/24/2010	See note above	81	0
DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 06/24/2010	See note above	5	1
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 06/24/2010	See note above	20	7
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 06/24/2010	See note above	447	0
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 06/24/2010	See note above	382	1
Google http://www.google.com COMPLETED 06/22/2010	See note above	5,978,565	8
HP Journal http://journals.lww.com/health-physics/pages/default.aspx COMPLETED 10/04/2010	See note above	24	0
Journal of Occupational and Environmental Health http://www.ijoeh.com/index.php/ijoeh COMPLETED 10/04/2010	See note above	0	0
National Academies Press http://www.nap.edu/ COMPLETED 06/24/2010	See note above	93	0
NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 06/24/2010	See note above	0	0

Table A1-2: Database Searches for Norton Co.			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called "Data Capture Synopsis for Norton Co."			
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html COMPLETED 06/24/2010	See note above	1,065	0
USACE/FUSRAP http://www.lrb.usace.army.mil/fusrap/ COMPLETED 06/24/2010	See note above	0	0
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 06/24/2010	See note above	3	0