REMEDIAL INVESTIGATION REPORT

for

SAFETY LIGHT CORPORATION OPERABLE UNIT 1 (OU-1) - BUILDINGS

BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

Contract Number EP-S3-07-04
EPA Work Assignment Number 012-RICO-03DG
Tetra Tech Project Number 01037

JULY 2009

TETRA TECH

PHIL-21310

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TETRA TECH NUS, INC
RAC 3 PROGRAM
CONTRACT NUMBER - EP-S3-07-04

FOR THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

JULY 2009

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LIST OF ACRONYMS

ASQAB	Analytical Services and Quality Assurance Branch
AST	above ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
CLP	Contract Laboratory Program
cm^2	square centimeter
CEDE	committed effective dose equivalent
COC	Chemical of Concern
COPCs	chemicals of potential concern
cpm	counts per minute
DCGLs	Derived Concentration Guideline Levels
DOE	Department of Energy
dpm	disintegrations per minute
DOT	Department of Transportation
E&E	Ecology and Environment, Incorporated
EECA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FSP	Field Sampling Plan
FOL	Field Operations Leader
HASP	Health and Safety Plan
HSCA	Hazardous Sites Cleanup Act
HEAST	Health Effects Summary Tables
HHRA	Human health risk assessment
HTO	tritiated water vapor
ICR	Increased Cancer Risk
IDW	Investigation Derived Waste
MARRSIM	Multi-Agency Radiation Survey and Site Investigation Manual

LIST OF ACRONYMS (continued)

MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MPC	Multimetals Products Corporation
mRAD/hr	millirad per hour
MSC	Medium-Specific Concentration
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
OU	Operable Unit
PADEP	Pennsylvania Department of Environmental Protection
pCi	picocuries per gram
PID	photoionization detector
ppm	parts per million
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAS	Routine Analytical Services
RESRAD	Residual Radioactive Materials Model
RI/FS	Remedial Investigation/Feasibility Study
RLSC	Regional Laboratory Sample Coordinator
RMC	Radiation Management Corporation
SAP	Sampling and Analysis Plan
SF	Cancer Slope Factor
SLC	Safety Light Corporation
SOP	Standard Operating Procedure
SSO	Site Safety Officer
SVOC	semivolatile organic compound
TEDE	total effective dose equivalent

LIST OF ACRONYMS (continued)

Tetra Tech	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
USRM	USR Metals, Incorporated
μR/hr	microrem per hour
USRC	United States Radium Corporation
VOC	volatile organic compound

EXECUTIVE SUMMARY

INTRODUCTION

Tetra Tech NUS, Inc. (Tetra Tech) was tasked to conduct a remedial investigation/feasibility study (RI/FS) at the Safety Light Corporation (SLC) site located in Bloomsburg, Columbia County, Pennsylvania in response to Work Assignment Number 012-RICO-03DG under United States Environmental Protection Agency (EPA) Contract Number EP-S3-07-04.

This report presents the results of the RI conducted for Operable Unit 1 (OU-1) at the SLC site located in Bloomsburg, Columbia County, Pennsylvania. OU-1 includes the buildings and structures at the site. Other media (groundwater, surface water, sediments, and soils) are being investigated as separate OUs.

The objectives of the RI/FS were to

- Characterize the nature and extent of radiological contamination of onsite buildings and structures.
- Evaluate the buildings and structures for remedial alternatives in accordance with EPA and Nuclear Regulatory Commission (NRC) requirements.
- Provide a comprehensive assessment of the current and potential human health and environmental risks associated with radiological contamination of buildings at the site.

The SLC facility is located in South Centre Township, Columbia County in central Pennsylvania, about 6 miles east of Bloomsburg, Pennsylvania. The majority of the 10-acre site, including most buildings, is enclosed by a fence. SLC also owns a parcel located along the southeast corner of the site. Other residential tracts of land are adjacent to the east and west boundaries of the site. The site contains numerous structures and contaminated areas, including lagoons, dumps, an abandoned canal, and buildings. SLC utilized a 2-acre area of the site for its manufacturing operations which were terminated on December 31, 2007. These activities were conducted under NRC license No. 37-00030-08. A separate NRC license (No. 37-00030-02) was issued to SLC for the entire site for the amount of radioactive material in contaminated facilities, land, and equipment from previous operations.

BACKGROUND

The SLC facility was first used to manufacture wooden toys during World War II. In the late 1940s, United States Radium Corporation (USRC) purchased the facility to manufacture self-illuminating light sources containing radioactive materials (e.g., luminous paint). Early operations involved the handling of a wide variety of radionuclides and chemicals, including Radium-226 (Ra-226), Tritium (H-3), Strontium-90 (Sr-90), and Cesium-137 (Cs-137), fuel oil, solvents, and heavy metals. Activities at the site have varied over time and involved a number of different radionuclides. During the 1950s, USRC began producing light sources using H-3, Carbon-14 (C-14), Thallium-204 (Tl-204), and Krypton-85 (Kr-85); low-level ionization sources using Nickel-63 (Ni-63) and H-3; and beta radiation sources using Kr-85.

In 1956, the Atomic Energy Commission (AEC), a predecessor of the NRC, issued a license that authorized the use and distribution of products containing a wide variety of other radionuclides, including C-14, Iron-55 (Fe-55), Cobalt-60 (Co-60), Ni-63, Zinc-65 (Zn-65), Sr-90, Cs-137, Polonium-210 (Po-210), Neptunium-237 (Np-237), Uranium-238 (U-238), Promethium-147 (Pm-147), Cesium-144 (Ce-144), Ruthenium-106 (Ru-106), Actinium-227 (Ac-227), and Americium-241 (Am-241).

In the late 1960s, work with all radionuclides other than H-3 was discontinued. From 1969 to December 31, 2007, operations involving the production of H-3 devices have been carried out in a limited area of the site. As a result of operations, the site has become contaminated with the radioisotopes used. Studies of the site have found contamination by radioactive material in buildings, soil, and groundwater. Non-radiological operations were conducted in spaced leased to USR Metals, Incorporated (USRM) and Multimetals Products Corporation (MPC).

Twenty buildings or structures (as shown on Figure 1-2) are present on the 10-acre SLC Site. Six of these structures and a portion of a seventh building (Etching Building) were considered to be inaccessible during the RI due to their physical condition. These seven structures (also delineated on Figure 1-2), plus the Pole building which was used to store waste exhumed from the underground silo, have been evaluated for a removal action; an Engineering Evaluation/Cost Analysis (EE/CA) for demolition and disposal of these structures has been prepared (Tetra Tech, 2006a) and these structures are subject to EPA Removal Actions. The garage foundation (structure #18 on Figure 1-2) was primarily grass-covered soils; therefore, the investigation of this area was included in the OU-3 investigation. The scope of the OU-1 RI included investigation of the remaining 12 buildings or structures (including the portion of the Etching Building, identified as the Butler Building. Several buildings contained debris (e.g., equipment, files) and are contaminated with radionuclides.

RI FIELD INVESTIGATION

The RI was conducted in accordance with the Field Sampling Plan (Tetra Tech, 2006b) approved by EPA in June 2006. Prior to conducting the field investigation, building surface and structure Derived Concentration Guideline Levels (DCGLs) were established. The computer code Residual Radioactive

Materials (RESRAD) - BUILD was used to determine the DCGLs. RESRAD-BUILD is a pathway analysis model designed to evaluate the potential radiological dose or risk incurred by an individual who works or lives in a building contaminated with radioactive material. DCGLs in disintegrations per minute (dpm) per 100 cm^2 (used for static measurements) and in picocuries per gram (pCi/g) for building material samples were derived from the model for all potential radionuclides of concern. DCGLs helped to determine if debris contained in the structures was considered acceptable for release (no further action). Debris with radiological contamination exceeding DCGLs was either placed in a radiological control area or identified if conditions prevented moving of the object. Transferable (removable) contamination exceeding DCGLs was fixed in place, if possible, by applying paint to the contaminated area.

The RI field investigation included the following activities:

- Identification of survey units and classification of each survey unit
- Survey (scan and static measurements) of interior surfaces of buildings for radioactive contamination
- Survey of materials and debris contained in the buildings for radioactive contamination
- Collection of building material samples based on results of the surveys
- Collection of sample media (disc smears) for Ni-63, C-14, and H-3 analysis

As part of the RI, buildings were divided into survey units. Smaller buildings were most often a single survey unit, while large buildings (e.g., the Main Building) were divided into multiple survey units. Each survey unit was classified as 1, 2, or 3 dependent upon history and previous characterization data, with Class 1 being the most hazardous and Class 3 being the least hazardous. These classifications were used to determine the rigor of the survey and DCGLs to verify assumptions made on the potential for radiological contamination.

With the exception of the Tritium Building and Solid Waste Building, which were actively handling radioisotopes at the time of the initial field investigation, the field surveys were conducted from July 2006 through October 2006. Sampling was performed during October 2006. The Tritium Building was investigated in January 2008 after SLC closed. The Solid Waste Building contained waste materials after SLC closed precluding a detailed investigation of the building as planned.

Areas were first scanned to identify elevated activity above DCGLs. These areas of elevated activity were marked and surveyed in more detail. A static count was taken to quantify the amount of contamination. Once the scan surveys were complete, 15 static measurements were taken on an established grid in each survey unit to reinforce the conclusions drawn from the scan survey. Because of the three dimensional structure of the buildings, measurements were randomly divided between floor, wall, and ceiling surfaces.

A designated number of building material samples were taken in each survey unit. These samples were taken in known or suspected locations of contamination (biased sampling). Disc smears were also taken randomly (unbiased sampling) throughout the survey units (material/debris and building surfaces) for Ni-63, C-14, and H-3 analysis.

Investigation-derived waste (IDW) generated during field work included associated waste [i.e., non-contaminated items with radioactive markings of some type that cannot be disposed of as clean), sample media, decontamination materials, and used personal protective equipment (PPE) (gloves, boot covers, Tyvek coveralls, etc.)]. In accordance with the Field Sampling Plan, waste generation was minimized to every extent possible. IDW that was unavoidable was packaged and placed in a Radioactive Material Area along with items found to be contaminated during the RI.

RI RESULTS

Results from the building surveys and sampling generally indicated radiological contamination in the majority of structures at the site. A total of 21 survey units were investigated. Results from static measurements showed levels above DCGLs in all survey units, although in several instances, elevated readings are attributable to debris or other readily removable items and not the building surfaces. A summary of findings for each structure surveyed follows.

<u>Machine Shop</u>

The Machine Shop is a concrete block building used for machining operations by SLC. This building was radiologically posted as "Radioactive Material" and used daily. Elevated survey readings were found on an overhead heating unit, an area of the ceiling, an opening in the west floor and on the north wall. Although referred to as a sump by site workers, there is no known discharge point for this opening. Elevated measurements along the area on the north wall was thought to be influenced from the known contaminated ground area just outside of the building, and not the building surface. Two items of debris in the building were found to be contaminated (an old fan and a stool) and moved to a controlled area. Sampling results supported the assumption of the high activity on the north wall being from outside the building, not the building itself; however, isotopes found in the west floor showed elevated alpha, beta, and gamma readings. The tritium (H-3) in building material samples indicates contamination from currently licensed material.

<u>Multi-Metals Building</u>

The Multi-Metals Building is a concrete building divided into three rooms. All surfaces were surveyed with the exception of the ceiling in the east and middle rooms due to safety reasons. The Compressor Room, located on the west end of the building, was the only room with radioactivity above DCGLs. Fixed contamination was found in the majority of the room at levels up to 16,000 dpm/100cm^2 beta-gamma and 1,812 dpm/100cm^2 alpha. Static measurements showed activity above DCGLs throughout the building on floor and wall surfaces in addition to structures contained in the building, including compressors, pipes, and electrical panels. Transferable contamination (alpha) was found on the floor, back generator, front compressor, floor drain, and switch panel. The areas were either painted to fix the contamination in place or barricaded (and posted) to restrict access. Three layers of different color paint were sprayed on areas with removable contamination. Results from the building samples showed Ra-226, Cs-137, and Ac-227 at levels above DCGLs.

Carpenter Shop

The Carpenter Shop is a concrete block structure connected to the back of the Multi-Metals Building. Doors were sealed or nailed shut to prevent access by personnel and radiologically posted as “Radioactive Material”.

Most interior surfaces in the Carpenter Shop were found to be contaminated although the high background due to the nearby Pole Building prevented a building surface scan from being performed on the east end of the room. Also in the east end of the room, there were extremely high contamination levels due to the past explosion of a radioactive source. In this area, fixed contamination levels with a beta dose rate of 30 millirem per hour (mR/hour) above the already high background of 0.6 mR/hr were detected. The maximum fixed alpha contamination was 462,090 dpm/100cm^2. Fixed contamination (other than in the east corner) was found in the majority of the room at an average of 16,000 to 25,000 dpm/100cm^2 beta-gamma. Transferable contamination (alpha and beta-gamma) was also found in the area around the east wall and table. This area was barricaded and posted “Contamination Area”. No items were removed from the building. Doors were re-sealed upon survey completion. Ra-226 was detected in each of the 4 samples collected from this building and Lead-210 (Pb-210) was detected in three of the samples above DCGLs. The “hot spot” under the east window in the area of the source explosion also showed high levels of Co-60, Tl-204 and Am-241 in addition to Ra-226 and Pb-210.

Utility Building

The Utility Building is a concrete block structure used for non-radiological storage. The door was locked to prevent access by personnel and radiologically posted as “Radioactive Material”. Fixed contamination was found on the majority of the floor at levels up to 226,958 dpm/100cm^2 beta-gamma and 382 dpm/100cm^2 alpha. Walls and ceiling were not contaminated with the exception of some conduits, shelving, a door, and a wall mounted heater. One item in the building was found to be contaminated (hot plate) and moved to a controlled area. All building material samples showed Ra-226; Ac-227 was also detected in one sample (southeast floor).

8' X 8' Building

The 8'X8' Building is a concrete block structure used for H-3 operations storage. The door was locked to prevent access by personnel and radiologically posted as "Radioactive Material". Fixed contamination was found on accessible surfaces at levels up to 1,271,947 dpm/100cm^2 beta-gamma and 400 dpm/100cm^2 alpha. All walls and the floor and ceiling showed elevated readings. No debris items were surveyed because of the potential for high tritium levels. All waste (i.e., PPE) was bagged and left in the building. Four samples were taken in the 8'X8' Building; however, after packaging, the samples could not be sent to the lab because of high activity. Therefore, only smear samples for tritium, C-14, and Ni-63 were prepared. All smear samples showed elevated levels of H-3, C-14, and Ni-63. Based on the high activity of the samples which could not be shipped to the laboratory, it is expected that elevated levels of other isotopes are present in the structure.

Liquid Waste Building

The Liquid Waste Building is a metal structure built on concrete slab used for equipment storage and mixing sample cocktails for tritium at the time of the RI. The building is radiologically posted "Airborne Radioactive Material Area" and "Radioactive Material". The highest activity detected during the survey was at a large crack in the floor slab in the middle of the building. The only other contaminated areas in the building were fixtures that could easily be removed (sink, fan, junction box). Several debris items were found to be contaminated, marked as such, and left in the building. Samples from building materials showed elevated levels of H-3, Ra-226, and Ac-227 in the floor.

Metal Silo (Aboveground)

The Metal Silo is located on southeast side of the main property. The dirt floor was covered with plastic and concrete block circled the floor against the walls of about 30 percent of the structure. The silo was locked to prevent access by personnel and radiologically posted as "Radiation Area". The majority of items in the building were contaminated items with fixed and transferable contamination which were packaged and labeled as radioactive material. Labels on some items indicated H-3, including urine samples and drums marked as leaking; these were not disturbed during the RI.

All accessible surfaces of the silo were surveyed and fixed contamination was found at levels up to 345,973 dpm/100cm^2 beta-gamma and 2,677 dpm/100cm^2 alpha. One sample was taken from the dirt floor. No samples could be obtained from the metal enclosure, although results from smears taken from the interior metal surfaces showed elevated levels of H-3. The sample from the silo floor revealed elevated levels of H-3, Ac-227, Ra-226, and Cs-137.

Etching Building Addition (Butler Building)

The manufacturing addition of the Etching Building (also known as the Butler building or Etching building Addition) is a metal structure built on concrete slab. This survey unit included a small portion of the older building, which was used as a paint shop. The large room at the entrance was used to store equipment purchased from another facility; the remainder was a storage area for current tritium operations (posted as “Radioactive Material”).

Approximately 20 percent of the building surfaces were surveyed, with special attention to areas of highest potential for contamination. No contamination above DCGLs was found. Several debris items were contaminated. Smaller items were packaged, labeled, and placed in the Radioactive Material Area. The tops of the ovens in the paint shop indicated some activity, but were not accessible for survey.

Three samples were taken in the Butler Building. Two were ceiling samples (one each from the older section and newer section) and one was a floor sample taken from the southwest paint shop (old portion of building). Sample results showed levels of H-3, PB-210, Ra-226, and Ac-227 above DCGLs established for the survey unit.

Cesium Ion Exchange Hut

The Cesium Ion Exchange Hut is a concrete block structure attached to the east side of the main building. The room had one locked opening and was radiologically posted as “Radiation Area”. The surfaces were surveyed and found to be highly contaminated (fixed and transferable). The room contained no debris items with the exception of an installed pipe just inside the door having the highest fixed contamination of 3,115,191 dpm/100cm^2 beta-gamma and 35 dpm/100cm^2 alpha observed in the survey unit. Maximum transferable contamination was 144,136 dpm/100cm^2 beta-gamma and 15 dpm/100cm^2 alpha. Cs-137 was detected in all three building material samples and Ra-226, Ac-227, and Np-237 were detected in one sample each.

Main Building Attic

The Main Building Attic consisted of a finished room at the top of the stairs and two crawl spaces. A roof access door opened to the south end of the building. Surface materials were wood floors, plaster walls, and plaster ceiling. The stairwell door was posted “Airborne Radioactivity Area” for radon. Most material and debris in the area were non-releasable and not surveyed due to the condition of the room. Isolated areas of fixed contamination were detected during the survey; the maximum was 170,085 dpm/100cm^2 beta-gamma and 14,231 dpm/100cm^2 alpha. Most surfaces were covered with bird droppings, which could cause activity to be shielded. Crawl spaces were not accessible due to unknown safety and radiological conditions. Building material samples showed elevated levels of H-3 and Ra-226.

Main Building Second Floor A

This survey unit was made up of the east stairwell and several rooms. Access to this area was not controlled. Surface materials were wood floors and handrails, concrete steps, plaster walls, and plaster ceiling. All rooms contained excessive amounts of material and debris. All building surfaces and debris contained within the survey unit were surveyed. Fixed contamination was found on the majority of the surfaces at levels up to 1,600,000 dpm/100cm^2 beta-gamma and 96,000 dpm/100cm^2 alpha. All stairwell steps and rails showed elevated levels of contamination. Contaminated debris items were packaged and moved to a controlled area. H-3 and Ra-226 were the only radionuclides detected and were present in all building material samples.

Main Building Second Floor B

This survey unit was made up only of one room. The only entrance door to the room was locked and radiologically posted. Surface materials were wood floors, plaster walls, and plaster ceiling. The room contained a large oven, filing cabinets, and a table. The majority of building surfaces were surveyed and no contamination above DCGLs was found. Fixed contamination was found on all filing cabinets, shelves, the oven, and oven racks at levels up to 5,500 dpm/100cm^2 beta-gamma and 2,178 dpm/100cm^2 alpha. Since the room was a controlled area, no contaminated items were removed.

One sample was taken on a floor foot rack in the southeast corner and showed H-3, Ac-227, and Ra-226 above DCGLs. None of the building interior surfaces showed contamination; all contamination was associated with materials contained within the survey unit.

Main Building Second Floor C

This survey unit included several rooms (Rooms 201 through 214) and the west and south stairwells. Access to this area was not controlled. Surface materials were wood floors and handrails, concrete steps, plaster walls, and plaster ceiling. The majority of building surfaces were surveyed. The rooms were contaminated in isolated random areas at levels up to 1,200,017 dpm/100cm^2 beta-gamma and

3,526 dpm/100cm^2 alpha. All stairwell steps and rails were contaminated. Contaminated items of debris were packaged and moved to a controlled area. Radionuclides detected in samples included H-3, Ra-226, Pb-210, and Ac-227.

Main Building First Floor A

This survey unit included several rooms including Rooms 86 and 136. Access to the area was not controlled and the area was routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. All rooms contained excessive amounts of material and debris. Fixed contamination was found on a majority of wall surfaces at levels up to 160,000 dpm/100cm^2 beta-gamma and 5,948 dpm/100cm^2 alpha. In the largest room (Room 86), it was estimated that 60 percent of the concrete floor was greater than 3,600 dpm/100cm^2 beta-gamma and less than DCGLs for alpha. The other rooms in the units had only limited, isolated fixed contamination. An old fan was the only contaminated debris item which was subsequently packaged and moved to a controlled area.

Four samples were taken from this survey unit. Three were taken from Room 86; one in the south middle floor and two wall samples (west and northeast). The fourth sample was taken in from the back wall of Room 136. The samples from Room 86 showed elevated levels of H-3, Cs-137, Ra-226, and Np-237. The only radionuclide detected above DCGLs in the sample from Room 136 was Ac-227.

Main Building First Floor B

This survey unit included three rooms and a loading dock. Access was not controlled and the area was routinely occupied. Surface materials were concrete floor, plaster walls, and plaster ceiling. The largest room (Room 88) made up most of the survey unit area and contained large, operational cutting machines. All the rooms contained large amounts of material and debris. All building surfaces were surveyed. Fixed contamination was found on a large portion of the surfaces in rooms 88 and 88A at levels up to 369,259 dpm/100cm^2 beta-gamma and 2,396 dpm/100cm^2 alpha. Fixed contamination was found at a few random places on the surfaces in Rooms 87 and 88B at levels up to 211,089 dpm/100cm^2 beta-gamma and 362 dpm/100cm^2 alpha. No contaminated material and debris was found in this survey unit. Results from the building material samples showed elevated levels of Ra-226, Cs-137, and Ac-227.

Main Building First Floor C

This survey unit included four rooms. Access was not controlled and the area was routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (Room 93) made up most of the survey unit area. This room contained several large, operational machines, but all had many old materials that were no longer used. Rooms 95 and 98 contained operational ovens and equipment and were routinely occupied. Room 97 was used for storage of USRM equipment and material which were moved in November 2006.

All building surfaces were surveyed. Fixed contamination was routinely found on surfaces in the entire survey unit at levels of 400 to 1,400 dpm/100cm^2 beta-gamma. Activity above these general readings was found on a large portion of the surfaces at levels up to 592,592 dpm/100cm^2 beta-gamma and 34,615 dpm/100cm^2 alpha. Many contaminated materials and debris were found in this area. These were packaged and relocated to a controlled area. Three of the four building material samples showed elevated levels of contamination with Ra-226 and/or Cs-137. A smear sample from an exhaust in Room 97 showed high levels of H-3.

Main Building First Floor D

This survey unit included Rooms 96, 101,102, and 103. Access to this area was not controlled. Surface materials were concrete floors, plaster walls, and plaster ceiling. Rooms 96 and 102 were used for shipping and receiving and were routinely occupied. Other than the sink and microwave area, Room 101 was not used with the exception debris storage. Room 103 contained large machining equipment. All rooms contained large amounts of material and debris. Fixed contamination was found on building surfaces in only 4 places with a maximum level of 4,312 dpm/100cm^2 beta-gamma and 71 dpm/100cm^2 alpha. Contaminated debris items were packaged and moved to a controlled area.

Samples from Room 96 showed Ac-227 and Ra-226 in both samples and H-3 and Cs-137 in one of the samples. The sample from Room 101 showed elevated levels of H-3, Cs-137, Ra-226, and Sr-90. The sample from Room 103 revealed elevated levels of H-3, Cs-137, Np-237, and Sr-90.

Main Building First Floor E

This survey unit included Rooms 100, 104, 110, and 116. Access was not controlled and the area was routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (100) and Room 110 contained USRM equipment. During the RI, these materials were surveyed for release by a USRM subcontractor to be moved to a new location in November 2006. Room 104 was used for storage and Room 116 was a foyer that contained old wooden timecard racks. All rooms contained large quantities of material and debris.

Most building surfaces were surveyed. Fixed contamination was found on few isolated surfaces in Rooms 100 and 116 at levels up to 113,100 dpm/100cm^2 beta-gamma and 8,043 dpm/100cm^2 alpha. No contaminated building surfaces were found in Rooms 110 and 104, but a contaminated large cabinet was found in Room 110 that could not be moved. The room was posted as “Radioactive Material”. Due to surveys being performed by USR Metals, materials in these rooms were not surveyed as part of the RI. Several contaminated items found during building surface surveys were packaged and moved to a controlled area.

One of the samples from Room 100 showed elevated levels of tritium, Np-237, and Ra-226. One sample had Pb-210 at levels above DCGLs. No radionuclides above DCGLs were detected in the other sample; however a smear sample also showed elevated levels of tritium. No radionuclides were detected above DCGLs in the sample from Room 116.

Main Building First Floor F

This survey unit included Rooms 105, 106, 107, 108, 117, 119, and a loading dock. Access was not controlled but the most of the survey unit was rarely occupied during the time of the RI. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (Room 106) and Room 105 contained very large conveyor equipment and pallets of debris. Rooms 107 and 108 were being routinely used as a machine shop and Room 119 had a single piece of equipment that was also routinely used. All rooms contained large amounts of material and debris. Accessible building surfaces were surveyed. Fixed contamination was found on few isolated surfaces at levels up to 234,137 dpm/100cm^2 beta-gamma and 6,956 dpm/100cm^2 alpha. Any items found to be contaminated during building surface surveys were packaged and either controlled in place or moved to a controlled area. Results from building material samples showed elevated levels of Ac-227 in Room 106 and Ac-227 and Ra-226 in Rooms 107 and 117. A smear sample from a cabinet in Room 108 revealed high levels of H-3.

Main Building First Floor G

This survey unit included Rooms 99A-B, 111-115, 120-127, 129-132, 135 and washroom, and 139. Access was not controlled and the area was routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. This survey unit was the administrative area for SLC (east end) and USR Metals (west end) employees. All rooms contained excessive amounts of material and debris.

About 20 percent of building surfaces were surveyed, with areas having a history for potential contamination and areas where contamination was found subject to a 100 percent survey. Fixed contamination was found on a few isolated surfaces at levels up to 145,416 dpm/100cm^2 beta-gamma and 1,682 dpm/100cm^2 alpha. Many contaminated materials and debris were found in this area. They were packaged and relocated to a controlled area. Ra-226 was detected in all building material samples taken throughout the survey unit and tritium was found in three of the four samples. Cs-137 was detected above DCGLs in two of the samples and Co-60 and Pb-210 were contained in one sample.

Main Building Basement

This survey unit was made up of the two room basement and lower west stairwell of the Main Building. The basement was not originally identified as a survey unit, but was added after arrival on site and given a Class 1 rating (due to radiological posting). The door to the room was locked. Surface materials were concrete floors, wooden steps, handrails, plaster walls, and plaster ceiling. The largest room made up most of the survey unit area and contained a large heating unit, water heater, pump, and debris. The smaller room contained only debris.

All building surfaces were surveyed. The rooms were contaminated in isolated random areas at levels up to 325,111 dpm/100cm^2 beta-gamma and 221,548 dpm/100cm^2 alpha. Since the room was a controlled area, no contaminated items were removed. Ra-226, Ac-227, and Np-237 were detected in the floor sample from the northwestern end of the survey unit, the west wall had elevated levels of Ra-226 and Ac-227, and the sample from the floor in the southeastern section of the room showed elevated levels of Ra-226.

Tritium Building

The Tritium Building is a metal building (approx. 1,030 m^2) used for tritium operations by SLC. Two rooms in this building were posted “Radioactive Material” and all rooms were used daily during the time of the RI. No elevated readings were found on building surfaces. Several items of debris in the building were found to be contaminated, but were seemingly items that had been taken from the older buildings for use (i.e., tables and drying racks). These items were moved to a controlled area as addressed in Sections 2.2.3 and 2.4. Radiological surveys and samples of building materials identified no activity above the DCGLs established for the survey unit.

Solid Waste Building

The Solid Waste Building is a concrete block building (approx. 85 m^2) used by SLC for tritium operations waste storage. This building was radiologically posted. The building contains various wastes which precluded a through survey of the structure.

RISK ASSESSMENT RESULTS

A human health risk assessment was conducted based on the results of the RI activities. The conceptual site model developed during the RI identified the potential receptors that might occupy or frequent buildings at the site; occupational workers, site visitors, or construction workers involved with remediation or renovation activities. Of these, quantitative risks were estimated only for the most sensitive receptor, the full-time occupational worker, because this represents the most conservative exposure scenario. For assessing exposure to sources located within a particular room of a survey unit, at least two different receptor positions were assumed using separate RESRAD simulation runs in order to ensure that potential reasonable maximum exposure conditions were encompassed. RESRAD exposure simulation risks were then reviewed for each room source and only the receptor location associated with the highest estimated cancer risk was tabulated on Risk Assessment Guidance for Superfund Part D (RAGS D) tables. Ecological risks were not evaluated as no ecological habitat is present for this OU.

The following pathways of exposure were modeled in the risk assessment:

- External body exposure to radiation emitted directly from the source
- External body exposure to radiation emitted from particulates deposited on room surfaces
- External exposure to radiation due to submersion in airborne radioactive particulates
- Inhalation of airborne radioactive particulates
- Inhalation of radon gas and aerosol indoor radon decay products
- Inhalation of tritiated water vapor
- Incidental ingestion of radioactive particulates from contact directly with the source
- Incidental ingestion of radionuclides in removable particulates deposited on room surfaces

Results of the human health risk assessment showed increased carcinogenic risks in many of the survey units. The following table presents the total increased carcinogenic risk and radionuclides significantly contributing to the risk for each survey unit. All exposure scenarios are for the current/future occupational worker. Residential scenarios were not evaluated as the buildings/structures are not suitable for residential use. Residential scenarios will be evaluated for other OUs at the site.

BUILDING/SURVEY UNIT	TOTAL CARCINOGENIC RISK	RADIONUCLIDES OF CONCERN
Machine Shop	2.52E-06	--
Multi-Metals Building	1.08E-03	Ra-226, Pb-210
Carpenter Shop	3.38E-03	Ra-226, Pb-210, Co-60
Utility Building	4.08E-04	Ra-226, Pb-210
8 x 8 Building	2.28E-05 (1)	--
Liquid Waste Building	1.48E-03	Ac-227, Ra-226, Pb-210
Metal Silo (Aboveground)	2.43E-05	--
Etching (Butler) Building	4.13E-05	--
Cesium- Ion Exchange Hut	1.22E-04	Cs-137
Main Building Attic	1.33E-04	Ra-226, Pb-210

BUILDING/SURVEY UNIT	TOTAL CARCINOGENIC RISK	RADIONUCLIDES OF CONCERN
Main Building - Second Floor A	4.50E-03	Ra-226, Pb-210
Main Building - Second Floor B	8.38E-04	Ac-227, Ra-226, Pb-210
Main Building - Second Floor C	8.03E-03	Ac-227, Ra-226, Pb-210
Main Building - First Floor A	2.03E-04	Ra-226, Pb-210
Main Building - First Floor B	3.57E-04	Cs-137
Main Building - First Floor C	4.15E-04	Ra-226, Pb-210, Cs-137
Main Building - First Floor D	5.88E-06	--
Main Building - First Floor E	2.13E-02	Ra-226, Pb-210, Np-237, U-238, Th-229
Main Building - First Floor F	2.47E-04	Ra-226, Pb-210
Main Building - First Floor G	4.51E-05	--
Main Building – Basement	2.31E-03	Ac-227, Ra-226, Pb-210
Tritium Building	6.24E-08	--

(1) The risk is based on smear samples which do not include all potential radionuclides present at the site. Samples of building materials collected showed activity greater than what could be shipped via common courier. Static measurements of building surfaces showed counts exceeding DCGLs.

SUMMARY AND CONCLUSIONS

With the exception of the Machine Shop, Metal (Aboveground) Silo, the occupied portion of the Etching (Butler) Building, a portion of the first floor of the Main Building and the Tritium Building, which fall within EPA's acceptable increased carcinogenic risk range of 1.0E-04 to 1.0E-06, the buildings/structures at the site show increased carcinogenic risks of greater than 1.0E-04. As noted in the table above, the risks for the 8 X 8 Building could not be completely evaluated due to the high activity levels of the samples which prevented shipping the samples to the laboratory. Static measurements in this building showed levels above DCGLs. The Solid Waste Building contains various wastes which precluded a through survey of the structure; however, the contents of the building would be considered to contain elevated levels of activity. The building structure would require a survey after wastes are removed to determine the status.

The significant radionuclides include Ra-226 and Pb-210 in all cases and other isotopes including Ac-227, Cs-137, Np-237, U-238, and Th-229 in isolated survey units. The survey unit with the highest increased risk was the Main Building - First Floor Survey Unit E. It should be noted that static measurements showed activity exceeding DCGLs in all survey units at the site.

A review of the data indicates that the data is sufficient to characterize the nature and extent of contamination in the building/structures and remedial alternatives for OU-1 can be developed. One potential data gap is characterization of the footprint under the buildings; however, data for the structures themselves are adequate. The FS will evaluate remedial alternatives for each survey unit based on the distribution and location of the radioactive sources; size; construction; and condition of each survey unit at the site.

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report presents the results of the remedial investigation (RI) conducted at the Safety Light Corporation (SLC) site located in Bloomsburg, Columbia County, Pennsylvania. The RI was conducted by Tetra Tech NUS, Inc. (Tetra Tech) in response to Work Assignment Number 012-RICO-03DG under United States Environmental Protection Agency (EPA) Contract Number EP-S3-07-04. This work was performed in accordance with the Final Field Sampling and Quality Assurance Plans for Safety Light Corporation Operable Unit 1 (OU-1) (Tetra Tech, 2006b).

The objectives of the RI for were to

- Provide additional data to characterize the nature and extent of radiological contamination of onsite buildings and structures.

- Provide data to evaluate the buildings and structures for remedial alternatives in accordance with EPA and NRC requirements.

- Provide a comprehensive assessment of the current and potential human health and environmental risks associated with radiological contamination of buildings at the site.

In order to accomplish these objectives, Tetra Tech performed radiological surveys of interior surfaces in buildings where there was a potential for contamination by radionuclides. Additionally, material and debris in these buildings were surveyed and moved to either allow access to building surfaces, lower background readings, or to be properly packaged to prevent inadvertent exposure to site personnel. Surveys were not performed in selected buildings which presented unsafe conditions due to collapsed roofs and floors.

1.2 SITE BACKGROUND

1.2.1 <u>Site Description and Location</u>

The SLC facility is located at 4150-A Old Berwick Road, Bloomsburg, Pennsylvania, within the South Centre Township of Columbia County in central Pennsylvania, about 6 miles east of Bloomsburg and 6 miles west of Berwick (Figure 1-1). The north site boundary is the Old Berwick Road and the south site boundary is the Susquehanna River (Figure 1-2). The majority of the site, including most contaminated buildings and soil, is enclosed by fence. SLC also owns a parcel located along the southeast corner of the site. Other residential tracts of land are adjacent to the east and west boundaries of the site. The site is located on the U.S. Geological Survey Bloomsburg, Pennsylvania quadrangle topographical map at North 41º 00' 55" latitude and West 76º 22' 35" longitude. The site is about 10-acres in extent and contains numerous structures and contaminated areas, including lagoons, dumps, an abandoned canal, and buildings. SLC utilized a 2-acre area of the 10-acre site for its manufacturing operations. These activities were conducted under NRC license No. 37-00030-08. A separate NRC license (No. 37-00030-02) was issued to SLC for the entire site for the amount of radioactive material in contaminated facilities, land, and equipment from previous operations. Tenants at the property at the time of OU-1 RI included USR Metals, Inc. and Multimetals Products Corporation, which conducted non-radiological manufacturing processes that include metal finishing and plating. These tenants are in the process of moving their operations to another location.

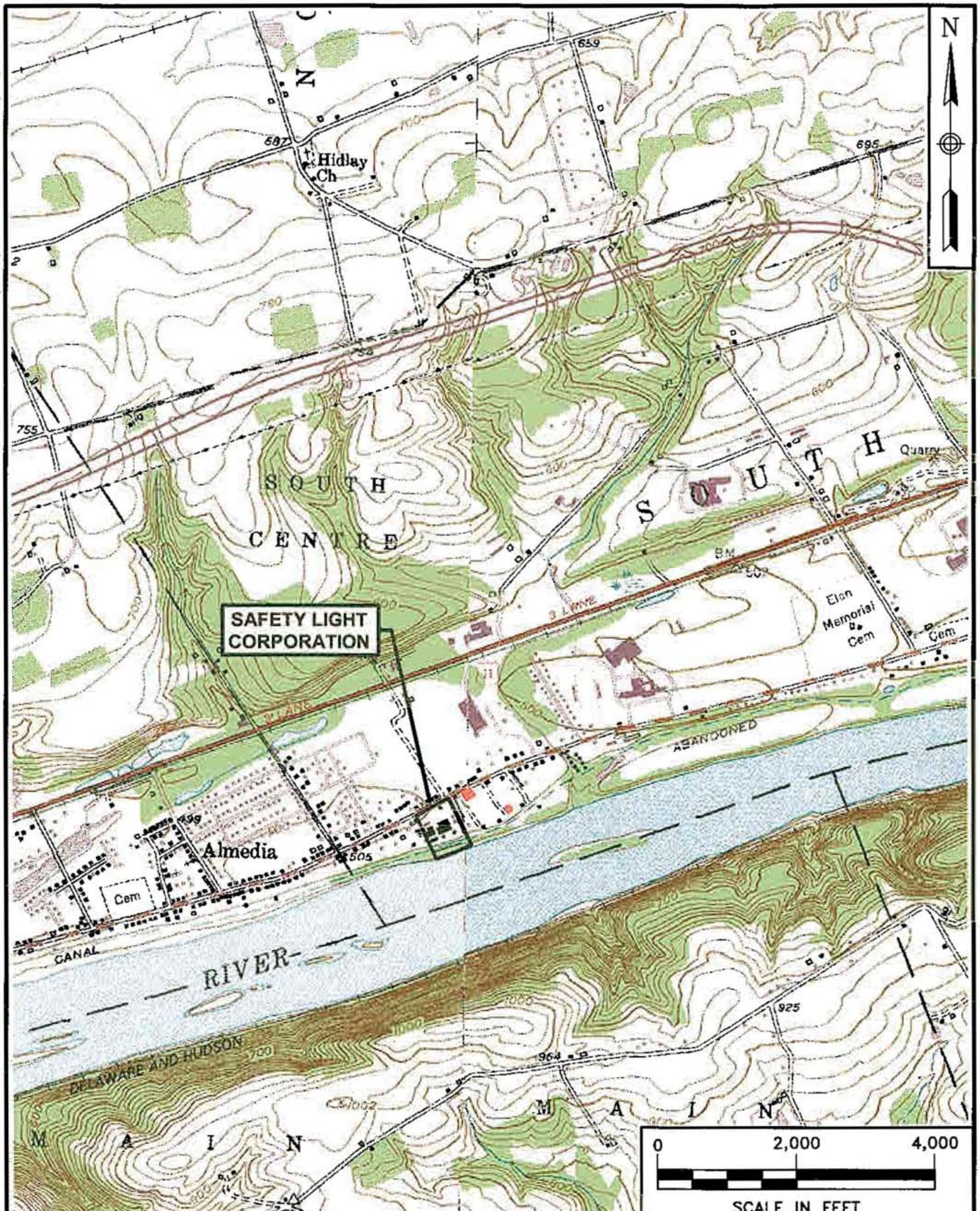
RIs for other OUs [groundwater (OU-2) and soils, surface water and sediment (OU-3)] at the site are currently being conducted. Results will be submitted under separate cover and contain a detailed description of the environmental setting at the site.

1.2.2 <u>Site History</u>

The SLC facility was first used to manufacture wooden toys during World War II. In the late 1940s, United States Radium Corporation (USRC) purchased the facility to manufacture self-illuminating light sources containing radioactive materials (e.g., luminous paint).

The facility has also been used for metal finishing and plating. Early operations involved the handling of a wide variety of radionuclides and chemicals, including radium-226 (Ra-226), tritium (H-3), strontium-90 (Sr-90), and cesium-137 (Cs-137), fuel oil, solvents, and heavy metals.

Activities at the site have varied over time and involved a number of different radionuclides. In 1948, the USRC radium operations were relocated from Brooklyn, New York, to the Bloomsburg site. At the time, USRC used mainly Ra-226 and minor amounts of polonium 210 (Po-210) in the manufacture of self-illuminating watch and instrument dials. During the early 1950s, USRC expanded its operations to include the manufacturing of civil defense check sources and radiation sources utilizing Cs-137 and the production of deck markers for the U.S. Navy involving the use of Sr-90. During this time period, Ra-226 was also used primarily for clocks and watches (dials and hands) and in the production of high level neutron and radiation therapy sources.



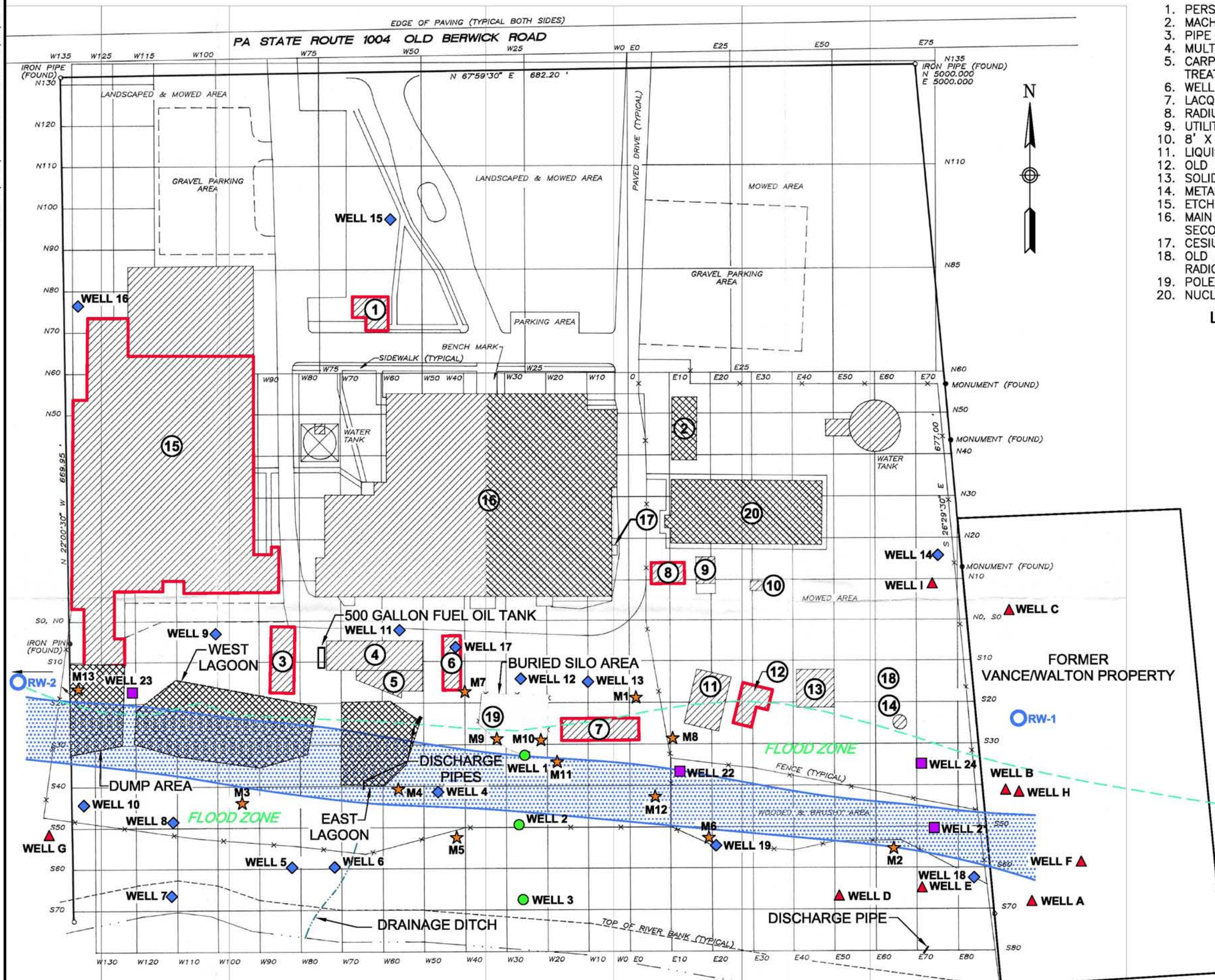
TETRA TECH NUS, INC.

SITE LOCATION MAP
SAFETY LIGHT CORPORATION
BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

SCALE	AS NOTED
FILE	112G01037CM01
REV 0	DATE 08/06/08
FIGURE NUMBER	FIGURE 1-1

AR300025

112G00338\1210\112G00338GM02.DWG 08/09/07 MKB



1. PERSONNEL OFFICE BUILDING (OLD NURSES STATION)
2. MACHINE SHOP
3. PIPE SHOP
4. MULTI-METALS WASTE TREATMENT PLANT
5. CARPENTER SHOP (ADJACENT TO MULTI-METALS WASTE TREATMENT PLANT)
6. WELL HOUSE
7. LACQUER STORAGE BUILDING
8. RADIUM VAULT
9. UTILITY BUILDING (SR-90 SOURCE VAULT)
10. 8' X 8' BUILDING
11. LIQUID WASTE BUILDING (INCLUDING UNDERGROUND TANKS)
12. OLD HOUSE
13. SOLID WASTE BUILDING
14. METAL SILO (ABOVE-GROUND)
15. ETCHING BUILDING
16. MAIN BUILDING – INCLUDES BASEMENT, FIRST FLOOR, SECOND FLOOR, AND ATTIC
17. CESIUM ION EXCHANGE HUT (ATTACHED TO MAIN BUILDING)
18. OLD GARAGE FOUNDATION (WHERE DRUMS OF REMOVED RADIOACTIVE WASTE WERE PREVIOUSLY STORED)
19. POLE BUILDING
20. NUCLEAR BUILDING (TRITIUM BUILDING)

LEGEND

- MONITORING WELL LOCATION, GILES DRILLING (1978)
- MONITORING WELL LOCATION, MEISER & EARLE (1979)
- MONITORING WELL LOCATION, SLC
- MONITORING WELL LOCATION, CNSI (1990)
- MONITORING WELL LOCATION, MONSERCO (1995)
- RESIDENTIAL WELL LOCATION
- PROPERTY CORNER
- WIRE FENCE
- STREAM/WATER EDGE
- 100 YEAR FLOOD ZONE
- BUILDING NUMBER
- CURRENT SLC OPERATIONS
- BUILDING TO BE DEMOLISHED (EPA REMOVAL ACTION)
- ABANDONED CANAL

0 80 160

SCALE IN FEET

TETRA TECH NUS, INC.

SITE LAYOUT
SAFETY LIGHT CORPORATION
BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

FILE	SCALE	
112G00338GM02.DWG	AS NOTED	
FIGURE NUMBER	REV	DATE
FIGURE 1-2	0	09/14/06

During the 1950s, USRC began producing light sources using H-3, carbon-14 (C-14), Thallium-204 (Tl-204), and Krypton-85 (Kr-85); low-level ionization sources using Nickel-63 (Ni-63) and H-3; and radiation beta sources using Kr-85. Wastes from these operations were buried in two underground silos (each 10 feet in diameter by 10 feet deep) south of the main building. Use of the silos was stopped in 1960 when the company began to ship the wastes offsite to licensed radioactive waste burial facilities. The company routed liquid wastes produced on the site to a nearby abandoned canal associated with the Susquehanna River or to a holding tank and evaporator system.

In 1956, the Atomic Energy Commission (AEC), a predecessor of the NRC, issued AEC License No. 37-00030-02 to USRC. The discussions of radionuclides covered by the original license are conflicting. However, it appears that this license may have authorized the use and distribution of products containing a wide variety of other radionuclides, including C-14, Iron-55 (Fe-55), Cobalt-60 (Co-60), Ni-63, Zinc-65 (Zn-65), Sr-90, Cs-137, Po-210, Neptunium-237 (Np-237), Uranium-238 (U-238), Promethium-147 (Pm-147), Cesium-144 (Ce-144), Ruthenium-106 (Ru-106), Actinium-227 (Ac-227), and Americium-241 (Am-241).

In the late 1960s, work with all radionuclides other than H-3 was discontinued. From 1969 to date, operations involving the production of H-3 devices have been carried out in a limited area of the site. As a result of operations, the site has become contaminated with the radioisotopes used. Studies of the site have found contamination by radioactive material in buildings, soil, and groundwater.

Prior to 1980, USRC created a new corporation known as USR Industries (USR). USRC subsequently became a subsidiary of USR. On November 24, 1982, following a complex series of reorganizations, corporate name changes, and sales of corporate entities, USRC activities were transferred to SLC without prior approval from the NRC. SLC was licensed by the NRC to use H-3 in the production of luminous signs and dials, paints, gas chromatograph foils, and accelerator targets. Although only H-3 has been used in the SLC facilities, most of the buildings on the USRC site were used for the previously discussed radioactive materials work. Non-radiological operations are conducted in space leased to USR Metals, Incorporated (USRM), and Multimetals Products Corporation (MPC). The leased space was historically used by USRC. USRM manufactures dials, nameplates, and other specialty materials, and MPC operations include anodizing aluminum products and applying protective films on metal surfaces. USRM and MPC are subsidiaries of USR.

1.2.3 <u>Site Layout</u>

Twenty buildings or structures are present on the 10-acre SLC Site (see Figure 1-2). Several of these are contain debris (e.g., equipment, files) some of which are contaminated with radionuclides. In addition, the following on-site structures are considered to be inaccessible at this time due to their physical condition: the floor of the Personnel Office Building has collapsed into the basement where a source of contamination is present; therefore access is unsafe. The Old House has a collapsed roof and unstable side walls. A tree has also fallen into the structure. This building is inaccessible. The Radium Vault has a collapsed roof and is therefore inaccessible. Large portions of the Etching Building have collapsed roofs; therefore, portions of this building present significant safety concerns for access. The roof beams of the Lacquer Storage Building have deteriorated so they no longer support the roof. The ceiling and portions of the walls of the Well House have collapsed, and portions of the ceiling of the Pipe Shop have collapsed. These structures have been evaluated for a removal action; an Engineering Evaluation/Cost Analysis (EE/CA) for demolition and disposal of these structures has been prepared (Tetra Tech, 2006).

The OU-1 RI included investigation of the remaining buildings. Sections 2.0 and 3.0 discuss each building in detail.

1.2.4 Waste Disposal History

Wastes generated at the SLC facility include solid and liquid waste streams contaminated with radioactive materials, including Ra-226, Sr-90, Cs-137, and H-3. These materials were disposed of in different areas of the site throughout the years. Although these areas are not covered in this RI/FS, some have an effect on building surveys being performed and are summarized below.

According to an Atomic Energy Commission Compliance Report (June 8, 1959), liquid wastes from various processes (not specified) were mixed with a clay ion-exchange material and evaporated to dryness then disposed. It is possible that these wastes may have been stored in the underground silos used for solid radioactive waste storage at the site. In 1999, Safety Light exhumed wastes from the two underground silos and staged wastes in numerous drums and B-25 containers in the Pole Building constructed for this purpose. Safety Light was unable to arrange for the majority of the exhumed wastes to be disposed of appropriately off-site, resulting in the EPA Removal Action. The Pole Building is not part of this RI/FS, but the high radiation dose rate affects the background in this area of the site. The wastes contained in the Pole Building and structure itself are being addressed in an EPA Removal Action. Wastes are being transported to an offsite facility for characterization for disposal. The silo area is also the presumed source of a Sr-90 and Cs-137 plume migrating towards the Susquehanna River.

An abandoned canal, located adjacent to the Susquehanna River, was divided into a series of lagoons and dump sites. Over time, the canal was used for the disposal of sewage, liquid waste (including silver plating wastes and anodizing solutions), low-level radioactive waste, disposal of Ra-226 contaminated ductwork, solid waste (such as Ra-226 dials and possibly Sr-90 deck markers) and process wastewater from the radium laboratory in the main building. In 1972, the lagoons were reportedly flooded and contents of the lagoons were dispersed on the site property and in the Susquehanna River. Contaminated laboratory glassware was also buried on the property. Therefore, soil and groundwater contamination could potentially raise the background in some locations across the site and interfere with building surveys.

Four aboveground storage tanks (ASTs) housed in the Liquid Waste Building contain H-3 contaminated wastewater from the Tritium (Nuclear) Building which is diluted and released to the Susquehanna River. Contaminated wastewater (H-3) was also contained in below-ground tanks in a vault in the basement of the Liquid Waste Building. In 1972, the flood uprooted one partially filled tank from its location and dispersed the contents in the flood water. The remaining tank was subsequently filled, the vault was filled with soil, and all were covered with a concrete slab. Plant personnel indicated that radium waste may have been placed in the vault before it was backfilled and capped.

1.2.5 Previous Investigations

Since the 1960 time frame, the company has undertaken various clean-up efforts including decontamination of buildings, backfilling of on-site lagoons and removal of soils contaminated with Ra-226. These clean-up efforts are not well documented.

According to site documents, eight environmental investigations of the SLC site have been conducted since 1978. Six environmental summary reviews were also prepared from available data. These investigations and environmental reviews are further described below.

1978 Giles Drilling Corporation, on behalf of USRC, initiated groundwater monitoring with the installation of monitoring wells 1, 2, and 3 located in the southern portion of the facility south of the underground silo area. Soil and groundwater from these wells provided initial data on contamination levels and suggested that additional monitoring was required. No investigational report or initial groundwater monitoring data is available from this investigation; however boring logs for these wells are included in the Meiser & Earl report discussed below.

1979 Meiser & Earl Hydrogeologists, on behalf of USRC, conducted a hydrogeological investigation, including installation of thirteen monitoring wells and three wells for background (wells 4 through 19). The thirteen monitoring wells were located around the abandoned canal, the east and west lagoons, and the disposal pits. Investigation activities commenced on January 29, 1979, and were completed in March 1979. Objectives of the investigation were to determine the depths to groundwater, water-table gradients and flow directions, existing water quality, extent of any radiological contamination from abandoned disposal areas, and to propose appropriate pollution abatement techniques. Investigation activities included the collection of interval soil samples for textural classification and radioactivity analysis and the construction of screened or cased wells from which water samples could be collected. The investigation activities revealed hydrogeological information at the site; the site is underlain by fluvio-glacial deposits and static water levels revealed that water flow across the site is essentially from the north to the south (towards the Susquehanna River), except during limited periods when flooding occurs and flow is temporarily blocked locally by a groundwater mound.

1979 Radiation Management Corporation (RMC) conducted a radiological investigation in conjunction with the Meiser & Earl Investigation. RMC reportedly used soil and groundwater collected both by Meiser & Earl and by themselves for radiological analysis. This report concluded that although contamination was evident, no significant public health hazard was present and remediation was neither appropriate nor justified at that time. However, continued and additional environmental monitoring was suggested.

1981 Oak Ridge Associated Universities (ORAU) performed an environmental survey under contract to the NRC. ORAU conducted survey activities at the SLC site in June and August, 1981. This survey reviewed the SLC's program for controlling and monitoring radiation and radioactivity levels. Data were collected to confirm measurements performed by the licensee, to evaluate the adequacy and accuracy of environmental controls and monitoring procedures, and to determine if environmental contamination was occurring. Survey activities include the measurement of direct radiation levels in unrestricted areas around the entire property, monitoring routine releases of tritium in stack air and liquid effluents from SLC activities and measurement of radionuclide concentrations in the environment as a result of present and previous operations of SLC and USRC. Boreholes were drilled for the collection of subsurface soils; however no monitoring wells were installed. Media sampled were surface and subsurface soil, groundwater, vegetation, surface water, and aquatic organisms, both on and off-site.

The main conclusions of this study were that direct radiation levels were above the regional background levels at the site, but were below federal guidelines for unrestricted use. However, on-site soil sampling indicated elevated levels of Ra-226, Sr-90, and Cs-137 and groundwater sampling showed levels of H-3 and Sr-90 exceeding NRC and EPA guidelines for unrestricted use. The study concluded that contaminants were migrating into soil and groundwater, but did not appear at that time to be accumulating off-site although ORAU indicated this to be a potential future concern.

1988 NRC performed an environmental evaluation of the site using available monitoring data. The objective of this evaluation was to compile information about on-site contamination, to assess the hazards to nearby residents, and to make recommendations about further remediation actions. The NRC concluded that the disposal of radioactive wastes at the SLC site had caused extensive contamination of groundwater on and off-site, and of soil on-site. The study identified areas where decontamination work should be focused. Decontamination efforts should focus on cleanup and control of the disposal silos, open dumps, and contaminated soils in order to minimize further contamination spread. The NRC evaluation also identified that further characterization work was necessary, covering both radiological and non-radiological hazardous constituents.

1990 Chemical Nuclear Systems, Inc. conducted a hydrogeological and radiological evaluation of the SLC facility in June and July 1990. This study was a response to a Partial Interim Settlement Agreement between USR Industries and the NRC. This settlement required partial studies of the nature, scope, location, and movement of radioactive contamination at the SLC facility. This evaluation was also intended to provide characterization data required to be collected by the NRC according to the settlement agreement. The evaluation was not considered comprehensive in scope. The primary objectives of this study were to assess the hydrogeologic flow regime and the potential for off-site radiological migration from the site. Activities conducted include soil coring, installation of 9 monitoring wells (wells A through I) and groundwater and rainwater sampling.

The study indicated that groundwater flow is in a southerly direction toward the Susquehanna River, and confirmed the presence of radioactive contamination within the soil and groundwater. Off-site wells showed evidence of H-3 and the highest level was measured at the Vance-Walton well. Groundwater samples also showed evidence of Sr-90 from adjacent properties to the east and west of the SLC site. Levels of radionuclides detected were below drinking water standards. The study recommended further environmental monitoring and site characterization work.

1991 NUS Corporation Superfund Division prepared a Preliminary Assessment (PA) for EPA using all existing SLC reports. This document concluded that the soil and groundwater remained contaminated primarily with Ra-226, Sr-90, Cs-137, and H-3 as a result of waste disposal practices employed during the history of the site.

1993 In 1993 and 1994, Roy F. Weston Technical Assistance Team, tasked by EPA Region 3, conducted soil and groundwater sampling at the SLC property and vicinity. The TAT recommended the following upon completing the sampling activities: clean out a tub full of blue-colored residue with standing liquid in the Metal Etching Building; remove empty, rusting drums scattered along the west lagoon edge; check state regulations for applicable laws regarding tank removal due to a tank overfill located east of MW11; and recommended that a filter/screen be placed at the outlet of a compressor exhaust in the Carpenter shop. The soil samples detected some contaminants, however none met or exceeded EPA action levels.

1994 Ecology and Environment, Inc. (E&E), tasked by the NRC Region I office, conducted a file review in support of the Hazard Ranking System (HRS) Package which was being prepared by E&E. The file review found that several inspection reports, two in 1980 and one in 1986, prepared by NRC indicate elevated H-3 concentrations in the neighboring residential wells, including the Vance Walton and Murphy wells; however, levels detected were below drinking water standards. It was also noted that NRC inspection reports revealed that H-3, Ra-226, and Sr-90 have been detected consistently in on-site groundwater at concentrations exceeding NRC guidelines for unrestricted area.

1994 In 1994, Monserco Limited prepared a Characterization Plan for SLC to quantify the physical and radiochemical characteristics of radiological contamination and distribution, assess non-radiological constituents and their effect on radiological constituents, evaluate environmental impacts, assess associated hazards from existing and potential future radiological contamination under the conditions of unrestricted use, and finally to provide sufficient information to develop a closure plan for the site. This plan outlined the methods and technologies to be used as part of the site survey and detailed each survey location in regards to area to be sampled and quantity of samples to be taken.

1995 SLC commissioned Monserco Limited to conduct a site characterization. These activities were conducted between May 1995 and December 1995. Objectives of the site characterization were to determine the extent of radiological contamination on ground surfaces, determine whether radioactive contaminated items are buried under the SLC grounds, gain access to the two underground silos and obtain information on their contents, drill new boreholes and wells (wells M1 through M13), sample and analyze the subsurface soils and waters, and determine the extent of radiological contamination inside the buildings.

Monserco conducted electromagnetic surveys at the site. Four anomalies indicating large metallic objects were detected using the survey: two underground silos, an anomaly located east of the Well House indicative of an underground storage tank, and linear anomalies located in the same vicinity that may be buried pipes associated with the underground storage tank. Two anomalies representing large metallic objects were located south of the Etching Building and west of the Pipe shop. Numerous anomalies associated with isolated buried objects were detected. The highest density of these anomalies was located south of the Solid Waste Building and Liquid Waste

Building in the abandoned canal. A number of linear anomalies identified across the property may indicate buried pipes or cables.

Eight trenches were excavated revealing the canal bottom, metal debris, and glass. Thirteen boreholes were drilled at various locations on the SLC site to assess the radiological and non-radiological condition of the subsurface soils and to install additional groundwater monitoring wells. Cored material was monitored every two feet for radiation using a contamination probe. Positive radiation readings were recorded for soils from boreholes M2, M3, M4, M5, M6, M7, M9, M10, M11, M12, and M13. Hydrocarbon odors were reported by field crew during drilling at boreholes M1, M8, M9, and M13. Organic vapors were monitored using a photo ionization detector (PID). Positive results were obtained from boreholes M1 and M7.

Results from monitoring well sampling showed elevated levels of radionuclides, most notably Cs-137, in groundwater near the buried silos (M9, M13) and in a southerly (downgradient) direction at wells M4 and M5. Vinyl chloride (up to 30 ug/l) was also detected in monitoring wells in the vicinity of the Liquid Waste Building in wells M1, M8, and M11.

2000 A Health Consultation Report documenting past sampling data was issued by the Agency for Toxic Substances and Disease Registry (ATSDR) in April 2000. The report concluded that radioactive materials, specifically Ra-226, Sr-90, Cs-137, H-3 and Am-241, have been used and disposed in silos, lagoons, and holding tanks associated with the SLC. From these disposal practices, radioactive material has contaminated the on-site areas of the SLC and perhaps nearby off-site residential wells (H-3 only). The contaminants in the residential wells are not at levels of public health concern. The amount of land contaminated has been exacerbated by a flood of the Susquehanna River in 1972.

ATSDR reviewed environmental sampling data collected during three characterization events from 1980 until 1996. The results indicated that surface soils are contaminated with Ra-226 and Cs-137 and that the contamination has apparently seeped from the soils to the groundwater. Soil contamination is mostly to the south and southeast of the main buildings. Although the contamination has not yet reached the river, data strongly suggest the contamination is migrating in that direction. Additional contamination associated with the site is predominately between the main site buildings and the river but external exposure to ionizing radiation is localized along the outside of the buildings.

2000-2001

The Pennsylvania Department of Environmental Protection (PADEP) implemented a Hazardous Sites Cleanup Act (HSCA) funded assessment of the SLC property. Foster Wheeler Environmental

Corporation was contracted to conduct the site assessment activities, which were completed in August 2000. The primary objectives of this assessment were to perform sample collection and analysis of surface water and groundwater in and around the site. Activities included collection of groundwater from monitoring wells, collection of surface water from the adjacent Susquehanna River, and collection of water from nearby residential wells. Sample results indicate that the groundwater and potentially the surface water at the SLC site are impacted by previous site activities.

Analytical results indicate that groundwater is impacted by radionuclides and some inorganic analytes. The majority of groundwater sample results confirm the presence of radionuclides above non-detect levels. Comparison of the groundwater analytical results indicated that many samples exceeded the EPA drinking water maximum contaminant levels (MCLs) for gross alpha, gross beta, Ra-226, Ra-228, and Sr-90. The highest concentrations of radionuclides were found in the groundwater collected from the monitoring wells closest to the location of the underground waste disposal silos, wells M9 and M10. None of the residential well sample results were found to exceed the EPA MCLs for radionuclides. There were inorganic analytes detected above the PADEP Act 2 Medium-Specific Concentration (MSCs). Some of these exceedances may be attributed to the elevated level of suspended solids in the groundwater samples. Lead and copper exceeded the PADEP Act 2 MSCs in one of the residential well water samples. As copper was not detected in other groundwater samples, the elevated copper levels may be attributed to the residential plumbing system.

Low-level organic contaminants were detected in the groundwater samples collected from the site. Vinyl chloride and bis(2-ethylhexyl)phthalate were the only organic contaminants to exceed the PADEP Act 2 MSCs, and were detected in samples from only one monitoring well, M9. None of the residential well samples exceeded the PADEP Act 2 MSCs for volatile organic compound (VOCs) or semivolatile organic compounds (SVOCs). Analyses for radionuclides in surface water collected from the Susquehanna River show that low concentrations are present. Standards for radionuclide concentrations in surface water were not used for data comparison, as none were determined applicable for this event by PADEP. All surface water sample results were below the inorganics Water Quality Criteria for Toxic Substances and surface water samples were not analyzed for VOCs or SVOCs.

2001 ICF Consulting submitted a Review and Evaluation of Characterization Data for SLC in October 2001. This report was prepared under contract to the NRC. The report presented prior characterization data, an evaluation of the completeness of the data, and suggested where additional data could increase the current understanding of the site and refine future cost estimates.

The ICF report concluded that operations have resulted in the radiological contamination of every building (except for the Old Radium Vault) at the site. It should be noted that, although it is believed that radioactive sources have been removed from the Old Radium Vault, access to the building was not possible due to a collapsed roof. Due to structural damage at some buildings, remediation is most likely not possible due to entry restrictions. Many buildings still contain contaminated waste, equipment, and source material. The majority of the surface soils at the site are contaminated with at least one radionuclide at levels exceeding the Derived Concentration Guidance Levels (DCGLs) as reported as either actually detected concentrations or presumed by analytical detection limits in excess of the DCGLs. The DCGLs were calculated in the Monserco report using guidelines in effect at that time. The DCGLs were considered remediation goals to achieve acceptable levels of radiological levels to return the property to unrestricted use. The primary radioactive isotopes of concern in surface and subsurface soils are Ra-226, Cs-137, Am-241, and Sr-90. The primary radioactive isotopes of concern in groundwater are H-3, Ra-226, Cs-137, Am-241, and Sr-90. Daughter isotopes of Ra-226, such as Pb-214 and Bi-214, have also been found in the surface and subsurface soils and groundwater.

2002-2004

A 1994 settlement by NRC with SLC required SLC to remove and dispose radioactive wastes stored in the underground silos. By June 2000, SLC had removed the waste and placed it in 176 55-gallon drums and 26 containers each containing approximately 3.55 cubic yards of material. These waste drums and containers; however, were placed in the floodplain of the Susquehanna River approximately 200 feet from the river. In 2002 EPA conducted a removal assessment of these materials and entered into an administrative order of consent with SLC to relocate the waste in a secure area on the property outside the floodplain and arrange for disposal at an NRC-licensed facility. SLC did not comply with the consent order and EPA commenced implementation of a RA. The drums and containers were moved to an onsite location (Pole Building) in December 2004 and are scheduled for further processing, transport, and disposal at a licensed facility. Containers filled with gravel have been placed adjacent to the outside wall of the Pole Building to provide additional shielding from the stored materials.

2004 Lockheed Martin Services, under contract to EPA, submitted an Aerial Photographic Analysis of SLC in December 2004, showing site conditions from 1938 until 1999. Significant site features, including lagoons and dump areas are shown, although resolution of several of the photographs is poor.

2006-2007

An EPA Removal Action was initiated to transport the wastes stored in the Pole Building to an offsite facility for characterization, processing and disposal. In addition, EPA prepared an EE/CA for demolition and disposal of unsafe structures at the site. Twenty buildings or structures were identified for characterization for the OU-1 investigation. However, several structures were determined to be inaccessible due to their physical condition including the Personnel Office Building (also known as the Nurses Station), the Old House, the Radium Vault, portions of the Etching Building, the Lacquer Storage Building, the Well House, and the Pipe Shop. The EE/CA addresses these structures; the OU-1 RI addresses the remaining structures at the site.

1.3 POTENTIAL RADIONUCLIDES OF CONCERN

SLC licenses, operating records, and radiation surveys were reviewed to identify those radionuclides of concern for this survey. From these reviews, the following radionuclides were present or potentially present at the SLC site:

H-3	Ce-144
C-14	Pm-147
Fe-55	Tl-204
Co-60	Pb-210
Ni-63	Po-210
Zn-65	Ra-226
Kr-85	Ac-227
Sr-90	Np-237
Ru-106	U-238
Cs-137	Am-241

Since 1969, SLC has only been authorized to possess tritium (H-3). Therefore, using a criterion of 10 half-lives, any radionuclide other than H-3 with a half life shorter than 3.6 years (10 half-lives from 1969) would have decayed away. The following radionuclides were used solely prior to 1969 and have half-lives less than 3.6 year; thus, these radionuclides are not considered radionuclides of concern.

Fe-55 (2.73 years)
Zn-65 (243.8 days)
Ru-106 (1.02 years)
Pm-147 (2.62 years)
Ce-144 (284.6 days)
Po-210 (138 days)

In addition, SLC possessed and/or used Kr-85. However, since this radionuclide is a noble gas, it is not likely to be present at the site as a contaminant.

Therefore, the radionuclides listed in Table 1-1 constitute the list of radionuclides that were considered for the OU-1 RI.

TABLE 1-1
POTENTIAL RADIONUCLIDES OF CONCERN
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Radionuclide	Half Life (years)	Radiation Emitted
H-3	12.3	Beta
C-14	5,730	Beta
Co-60	5.271	Beta, Gamma
Ni-63	100	Beta
Sr-90	29.1	Beta
Cs-137	30.17	Beta, Gamma
Tl-204	3.78	Beta
Pb-210	22.3	Beta, Gamma
Ra-226	1,600	Alpha, Beta, Gamma
Ac-227	21.77	Alpha, Beta, Gamma
Np-237	2.14×10^{6}	Alpha, Beta, Gamma
U-238	4.47×10^{9}	Alpha, Gamma
Am-241	432.7	Alpha, Gamma

1.4 DERIVED CONCENTRATION GUIDELINE LEVELS FOR SURFACES AND STRUCTURES

This section provides the technical basis for the methodology used to determine building surface and structure Derived Concentration Guideline Levels (DCGLs). The computer code RESRAD-BUILD was used to determine the DCGLs. The RESRAD-BUILD computer code is a pathway analysis model designed to evaluate the potential radiological dose or risk incurred by an individual who works or lives in a building contaminated with radioactive material. Seven exposure pathways are considered in the RESRAD-BUILD code: (1) external exposure directly from the source, (2) external exposure to materials deposited on the floor, (3) external exposure from airborne radioactive materials, (4) inhalation of airborne radioactive particulates, (5) inhalation of aerosol indoor radon progeny and tritiated water vapor, (6) inadvertent ingestion of radioactive material directly from the source, and (7) ingestion of materials deposited on the surfaces of the building compartments. Various exposure scenarios may be modeled with the RESRAD-BUILD code. These include, but are not limited to, office worker, renovation worker, decontamination worker, building visitor, and residency scenarios. The DCGLs were calculated assuming an office worker scenario.

A room with the dimensions of 6-meters long, 6-meters wide, and 2.5-meters tall was selected as a representative room for modeling the numerous industrial buildings of various dimensions. Each of the wall and floor surfaces were assumed to be contaminated. Contamination was assumed to erode from the wall and floor surfaces over a 25-year period. This simulates any situation where fixed contamination would be inadvertently or naturally released from the surface.

The receptor was placed in several locations within the room for modeling. The center for exposure was assumed to be 1-meter from the floor, approximately the center of mass of an average person. The location that resulted in the largest dose was selected for the DCGL determination. This location was 1-meter from the center of any wall. Other locations simulated but resulting in lower doses included the center of the room, and 1-meter from two of the walls. The time spent in the building by the receptor was assumed to be 2000-hours each year. This corresponds to the amount of time spent at work by a standard worker. It was also assumed that the worker spent 30 years at that location.

Each radionuclide was simulated in the model with an activity of 1 picoCurie per square meter, except for H-3. H-3 was modeled as a volume source to account for dissipation into the air and the exposure impacts associated with the H-3 vapor. The Tritium activity modeled was 1 picoCurie per gram.

HEAST slope factors were used for the dose and risk calculations. Other required inputs to the model not discussed above were selected from the standard inputs of the RESRAD-BUILD model. The results of the RESRAD-BUILD simulation were scaled to the appropriate dose limits (15 mrem/yr and 25 mrem/yr) and risk range (10^{-4} to 10^{-6} risk) to determine the DCGLs for each radionuclide. These values were then converted from picoCurie per square meter to dpm/100cm^2, which are listed in Table 1-2. Table 1-3 presents the DCGLs for these radionuclides expressed in terms of pCi/g.

1.5 DERIVED CONCENTRATION GUIDELINE LEVELS FOR RELEASE OF DEBRIS AND MATERIALS

DCGLs for the debris and materials are derived from Table 1 of NRC Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" Table 1-4 below, lists these limits for each of the radionuclides of interest at the SLC site. DCGLs were used to determine if debris contained in the structures was considered acceptable for release. Debris with radiological contamination exceeding DCGLs was either placed in a radiological control area or identified if conditions prevented moving of the object. Transferable (removable) contamination exceeding DCGLs was fixed in place, if possible. The results of debris surveys and handling of contaminated debris and transferable contamination for each survey unit is discussed in Sections 2.0 and 3.0.

TABLE 1-2
DERIVED CONCENTRATION GUIDELINE LEVELS (DCGLs) (dpm/100cm^2)
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Radionuclide	Release Criterion			
	25 mrem/yr	15 mrem/yr	1E-04 Risk	1E-06 Risk
C-14	1.88E+08	1.13E+08	1.72E+07	1.72E+05
Co-60	2.67E+04	1.60E+04	2.04E+04	2.04E+02
Ni-63	2.01E+08	1.20E+08	2.66E+07	2.66E+05
Sr-90	8.63E+05	5.18E+05	5.79E+05	5.79E+03
Cs-137	1.05E+05	6.31E+04	3.75E+04	3.75E+02
Tl-204	3.16E+07	1.90E+07	1.83E+07	1.83E+05
Pb-210	5.73E+04	3.44E+04	4.45E+04	4.45E+02
Ra-226	2.42E+04	1.45E+04	5.44E+03	5.44E+01
Ac-227	2.41E+02	1.45E+02	1.74E+03	1.74E+01
Np-237	2.78E+03	1.67E+03	1.17E+04	1.17E+02
U-238	1.30E+04	7.79E+03	2.44E+04	2.44E+02
Am-241	3.42E+03	2.05E+03	8.89E+03	8.89E+01

TABLE 1-3
DERIVED CONCENTRATION GUIDELINE LEVELS (DCGLs) (pCi/g)
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Radionuclide	Release Criterion			
	25 mrem/yr	15 mrem/yr	1E-04 Risk	1E-06 Risk
H-3	1.14E+03	6.85E+02	1.38E+03	1.38E+01
C-14	9.27E+06	5.56E+06	2.48E+06	2.48E+04
Co-60	3.76E+01	2.26E+01	2.52E+01	2.52E-01
Ni-63	7.18E+08	4.31E+08	9.31E+07	9.31E+05
Sr-90	1.67E+04	1.00E+04	4.42E+03	4.42E+01
Cs-137	1.47E+02	8.83E+01	4.12E+01	4.12E-01
Tl-204	5.71E+04	3.43E+04	5.66E+04	5.66E+02
Pb-210	2.43E+04	1.46E+04	8.62E+03	8.62E+01
Ra-226	3.67E+01	2.20E+01	6.83E+00	6.83E-02
Ac-227	1.66E+02	9.95E+01	6.36E+01	6.36E-01
Np-237	3.46E+02	2.08E+02	7.91E+01	7.91E-01
U-238	2.49E+03	1.49E+03	5.59E+02	5.59E+00
Am-241	2.69E+03	1.61E+03	8.66E+02	8.66E+00

TABLE 1-4
ACCEPTABLE SURFACE CONTAMINATION LEVELS
FOR DEBRIS AND MATERIALS (dpm/100 cm^2)
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Radionuclide	Average	Maximum	Removable[a]
H-3	5,000	15,000	1,000
C-14	5,000	15,000	1,000
Co-60	5,000	15,000	1,000
Ni-63	5,000	15,000	1,000
Sr-90	1,000	3,000	200
Cs-137	5,000	15,000	1,000
Tl-204	5,000	15,000	1,000
Pb-210	5,000	15,000	1,000
Ra-226	100	300	20
Ac-227	100	300	20
Np-237	100	300	20
U-238	5,000	15,000	1,000
Am-241	100	300	20

a. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that 100 cm^2 area with dry filter of soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument.

2.0 FIELD DATA COLLECTION

As previously discussed in Section 1.0, the objectives of the RI for OU-1 were to:

- Provide additional data to characterize the nature and extent of radiological contamination associated with historical activities in onsite buildings and structures.

- Provide data to evaluate the buildings and structures for remedial alternatives in accordance with EPA and NRC requirements.

- Provide a comprehensive assessment of the current and potential human health and environmental risks associated with radiological contamination of the buildings at the site.

To accomplish the above objectives, the following tasks were part of the RI/FS:

- Identification of survey units and classifications.
- Survey of interior surfaces of buildings for radioactive contamination.
- Survey of material and debris contained in the buildings.
- Collection of building material samples.
- Collection of sample media (disc smears) for Ni-63, C-14, and H-3 analysis.

The field surveys were conducted from July 2006 through October 2006. Sampling was performed during October 2006. Details of the investigation are found in the following sections.

2.1 SURVEY UNITS AND CLASSIFICATIONS

As described in the OU-1 Field Sampling Plan (FSP) approved by EPA in June 2006, buildings were divided into survey units. Smaller buildings were most often a single survey unit, while large buildings (e.g., the Main Building) were divided into multiple survey units. Each survey unit was classified 1, 2, or 3 dependent upon history and previous characterization data, with Class 1 being the most hazardous and Class 3 being the least hazardous. These classifications were used to determine the rigor of the survey and DCGLs to verify assumptions made on the potential for radiological contamination.

Initially, 20 buildings were listed for survey. The Personnel Office Building, Pipe Shop, Well House, Lacquer Storage Building, Radium Vault, Old House, and the old part of the Etching Building were not investigated due to unsafe conditions. These seven structures were evaluated for demolition and disposal in the EE/CA prepared for the site. The Pole Building was removed from the investigation because waste stored in the building had not yet been removed. The Old Garage Foundation was not evaluated because the concrete slab was not accessible due to soil and vegetation and would be better characterized during the OU-3 investigation. The Solid Waste Building and the Nuclear (Tritium) Building were not surveyed during the initial OU-1 investigation because of continued operations involving tritium. After SLC ceased operations, the Tritium Building was surveyed in January 2008 during the OU-3 investigation. The Solid Waste Building still contained waste materials and could not be surveyed. Results of the surveys are presented in Section 3.0.

2.2 FIELD SURVEYS

Two different types of field surveys were performed during the RI/FS and are detailed in the following sections. Instrumentation utilized during the investigation are also described. Survey and static measurement results are presented in Section 3.0.

2.2.1 Instrumentation

The instruments used for field surveys are summarized in Table 2-1. Some of these instruments are slight variations from the instruments listed in the FSP. Comparable instruments were used in some cases due to vendor availability and ease of use for field applications. Field measurements for low energy beta radiation associated with H-3, C-14, and Ni-63 were not performed due to limitations in field instrument detection capabilities.

Field instruments were calibrated by the vendor with NIST traceable sources prior to shipment to SLC. Once the instruments were received, an initial response check was performed to ensure no damage during shipment and to establish parameters specific to SLC (i.e. background, sources). Using the site background, minimum counting times (for background determinations and for measurement of contamination) were determined to obtain an acceptable minimum detectable concentration (MDC). MDCs were calculated to a 95 percent confidence level for both static counting and scan rate using the equations found in the FSP. Instruments were then response tested twice daily when used. Background and source measurements were taken as part of the instrument check and compared with the acceptance range for the instrument and site conditions. Instrument calibration records are included at the end of Appendix A (Radiological Surveys) as Appendix A-1.

TABLE 2-1
FIELD SURVEY INSTRUMENTATION
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Measurement Type	Meter Model	Detector Model	Detector Area	Window Thickness	Typical Total Efficiency
Surface Scans and Static Measurements (alpha and beta)	Ludlum 2390	Ludlum 43-93	Active = 100 cm^2 Open = 89 cm^2	1.2 mg/cm^2	19%(1) (Th-230) 11%(1) (Tc-99)
Surface Scans (beta)	Ludlum 12	Ludlum 44-9	Active = 15 cm^2 Open = 12 cm^2	1.7 mg/cm^2	11%(1) (Tc-99)
Removable Activity (alpha and beta)	Ludlum 2929	Ludlum 43-10-1	Active and Open = 20.3 cm^2	0.4 mg/cm^2	34% (Th-230) 31% (Sr/Y-90)
Dose Rates 0-5000 μR/hr (beta and gamma)	Ludlum 19	1" x 1" NaI Scintillator	NA	NA	10% (Cs-137)
Dose Rates 0-5000 mR/hr (beta and gamma)	Ludlum 9	NA	Active = 40 cm^2 Open = 30 cm^2	7 mg/cm^2	10% (Cs-137)

(1) Efficiencies are typical values. Actual efficiencies were provided on equipment calibration logs and were written on each instrument. The most common efficiencies (19% alpha and 11% beta) are presented on this table.

2.2.2 Habitability Surveys

Surveys to determine habitability were performed upon entering each new area. These surveys were performed in order to determine if the personal protective equipment being employed was adequate and to ensure proper instrumentation selection. Surveys were always performed for dose rate and transferable contamination in each area. Sampling was performed for airborne contamination as deemed appropriate due to history of the area and the amount of surface contamination found.

2.2.3 Survey of Material and Debris

The FSP required that material and debris in each survey unit be surveyed for unrestricted release. The objectives of the surveys were to determine if the items could create a background activity that would interfere with the building survey or allow movement of the item so that building surfaces could be exposed for survey. All items were surveyed for both fixed and transferable contamination before being handled or moved. These surveys identified materials within the buildings that would require management as low-level waste or be released for unrestricted use. Some items were too large to move, had a history that would not allow a release, had inaccessible surfaces, or were too extensive to survey during the allotted schedule. These items were marked or disposition was noted on survey records.

Items that were surveyed and found to meet unrestricted release criteria were moved to allow access to building surfaces that required survey. Items that were surveyed and found to be contaminated were labeled as “Radioactive Material” and moved to a radiologically controlled area. These areas were established in Main Building Room 88 (roped off), Room 88A (in cage placed by SLC), Room 203 (roped off), and Room 204 (roped off). If contamination was transferable, the item was packaged and labeled before removal. Items that were too large to move were labeled as “Radioactive Material” and left in place.

All radiological postings established during the performance of this scope were done in accordance with Tetra Tech procedures. SLC plant management and health physics staff were notified of area status before demobilization.

Surveys of material and debris were documented on Radiological Survey Forms and maintained in accordance with Tetra Tech procedures.

2.2.4 Survey of Interior Surfaces of Buildings

The primary goal of these surveys was to assess the degree of contamination in buildings and structures in order to determine if remedial measures (e.g., demolition and disposal) are required. The objectives of the surveys were to:

- Provide direct surface scan measurements to identify locations than exceed prescribed levels that require further investigation.
- Provide static measurements to verify assumptions for initial classification of survey units
- Identify areas that require sampling of material for further analysis.
- Identify areas that pose an immediate hazard to personnel or the environment (hazardous areas were marked for fixed contamination and painted to fix contamination into the surface if transferable contamination was found).

Surveys were performed in each survey unit for fixed contamination in accordance with the FSP and other site-specific plans. Because a characterization survey (not a final status survey) was being performed, it was determined that structural background determinations described were not necessary as described in the Field Sampling Plan.

The DCGL used for the building scans was 1,740 dpm/100cm^2 (the 1E-04 risk release criterion for Ac-227). The 1E-04 risk was the most appropriate for a characterization survey using field instruments and Ac-227 was the most conservative criterion within the risk level. Action levels for each Survey Unit Class were derived from this value; the Class 1 DCGL is 1,740 dpm/100cm^2, the Class 2 DCGL (75% of the most conservative DCGL as detailed in the OU-1 FSP) is 1,305 dpm/100cm^2, and the Class 3 DCGL (50% of the most conservative DCGL as detailed in the OU-1 FSP) is 870 dpm/100cm^2. The action levels were used in the field to determine if additional survey activities were required for that particular survey unit. If the action level was exceeded, additional scans were conducted. Because scan MDCs were well below the action levels, no additional measurements other than those described below were required for an elevated measurement comparison.

Areas were first scanned to identify elevated activity above action levels. These areas of elevated activity were marked and surveyed in more detail. A static count was taken to quantify the amount of contamination. Normally scan survey coverage recommendations from the FSP (Table 8-1) were followed, but often, additional information received on site warranted an increase in the amount of survey area. In addition, non-accessible areas were not surveyed when large amounts of contamination had already been found throughout the unit.

Once the scan surveys were complete, 15 static measurements were taken on an established grid in each survey unit to reinforce the conclusions drawn from the scan survey. Because of the three dimensional structure, measurements were randomly divided between floor, wall, and ceiling surfaces.

Surveys of building surfaces were documented on Radiological Survey Forms and maintained in accordance with Tetra Tech procedures (see Appendix A).

2.3 MEDIA SAMPLING

The objective of sampling was to provide a qualitative appraisal of the contamination to help characterize each building for release (no contamination) or to determine if remedial measures are required. Because field instrumentation can only distinguish types of radiation, analysis for identification of specific radionuclides must be performed in a laboratory. Samples were collected during the RI/FS to be analyzed for each Radionuclide of Concern listed in Table 2-1 of the FSP. Two different types of media sampling were performed and are detailed in the following sections. Sample results are presented in Section 3.

2.3.1 Collection of Building Material Samples

A designated number of building material samples were taken in each survey unit. These samples were taken in known or suspected locations of contamination (biased sampling). Building materials were collected in quantities sufficient to fill two-gallon bags from each sample location and assigned a unique sample tracking number. For quality control purposes, a duplicate sample was taken at a frequency of one per every 10 samples. These materials were to be size reduced in more controlled conditions by the laboratory to obtain the actual sample to be analyzed. To eliminate cross contamination, each sampling tool was surveyed and decontaminated before moving to the next sample location. Due to internal contamination that could not be removed, power tools were disposed of as radioactive waste at sampling completion. Each sample was double bagged and surveyed for transferable contamination and dose rate on the outside of the sample bag. These bags were labeled as “Radioactive Material”, including pertinent survey information. These bags were placed in a strong-tight container, which was sealed and also surveyed to ensure no transferable contamination as present. Chain of custody was transferred to a qualified shipping coordinator and containers were shipped in accordance with method-specific requirements, appropriate Tetra Tech procedures, and in accordance with applicable Department of Transportation (DOT) regulations.

2.3.2 Collection of Sample Media for Ni-63, C-14, and H-3 Analysis

Two hundred disc smears were taken randomly (unbiased sampling) throughout the survey units (material/debris and building surfaces) for Ni-63, C-14, and H-3 analysis. Glass sample vials filled with a cocktail solution were provided by the laboratory doing the analysis. A single smear was placed in each vial and given a unique sample tracking number. For quality control purposes, one blank smear was provided. Each sample and the vial containers were surveyed for transferable contamination and dose rate. The vial containers were labeled as “Radioactive Material”, including pertinent survey information. These containers were placed in a strong-tight container (with adequate absorbent), sealed, and also surveyed to ensure no transferable contamination as present. Chain of custody was transferred to a qualified shipping coordinator and containers were shipped in accordance with method-specific requirements, appropriate Tetra Tech procedures, and in accordance with applicable DOT regulations.

2.3.3 Evaluation for Background Radiation

As stated in the FSP, MDCs were calculated to determine if action levels could be seen with field instrumentation, given instrument efficiencies and background radiation in the area. Background radiation and radiation from materials and debris were not a problem in areas which were surveyed, with the exception of the background in isolated areas close to the Pole Building. The radioactivity found in the Carpenter Shop was high enough that it could be seen over the background. Portions of the Multi-Metals Building and the Main Building that were affected by higher background still had MDCs above DCGLs; thereby creating some uncertainty that low-level contamination may have been missed due to the effects of background. However, based on historical information and surveys that could be conducted, it is unlikely that contamination above DCGLs in areas with high background would be found.

Note that background samples of building materials were not obtained due to the complicated logistics (i.e., identifying and obtaining access to offsite buildings of similar age and construction materials for destructive sampling); therefore, background comparisons for building samples were not included in the risk evaluation. As stated in the FSP, "after consideration of the construction materials, the structural layout of the survey units, and the high variability of naturally occurring radioactivity in the construction material, it was determined that the best approach for surface and structure surveys would be to determine compliance with the DCGLs without consideration of a reference material background."

2.4 INVESTIGATION-DERIVED WASTE DISPOSAL

Investigation-derived waste (IDW) generated during RI/FS activities included associated waste (i.e. non-contaminated items with radioactive markings of some type that cannot be disposed of as clean), sample media, decontamination materials, and used personal protective equipment (PPE) (gloves, boot covers, Tyvek coveralls, etc.). In accordance with the FSP, waste generation was minimized to every extent possible. IDW that was unavoidable was packaged in accordance with Tetra Tech procedures and placed in a Tetra Tech Radioactive Material Area along with items found to be contaminated during the RI/FS. These debris items included documents, glassware, containers, and other miscellaneous items. The IDW and radioactive debris were staged in Rooms 88, 88A, 203, and 204 in the Main building.

2.5 DOCUMENTATION

All field records were documented and are maintained in accordance with Tetra Tech procedures. Sample data from the laboratory were validated in accordance with the OU-1 Quality Assurance Project Plan and the Field Sampling Plan.

3.0 NATURE AND EXTENT OF CONTAMINATION

3.1 BUILDING SURVEYS AND SAMPLE RESULTS

Results of the radiological analyses performed during this RI, including field measurements and laboratory analysis, are presented in this section. Figures and tables are also included in this section. Figures show the building surveyed or locations where samples were taken. Tables consolidate field measurement data and laboratory analysis data above calculated DCGLs based on increased cancer risks of 1E-06 and 1E-04. Only locations with exceedances of DCGLs for static counts and/or building material samples are shown on the tables in this section. DCGLs for counts are based on the most conservative calculated DCGL (Ac-227) at increased cancer risks of 1E-06 and 1E-04 as shown on Table 1-2. DCGLs used for individual isotopes are based on those calculated at 1E-06 and 1E-04 risks as shown on Table 1-3. Sketches of survey units showing survey and sample locations and survey results are included in Appendix A. Spreadsheets of complete laboratory data can be found in Appendix B.

3.1.1 <u>Machine Shop (Class 1)</u>

The Machine Shop (Building 2 on Figure 1-2) is a concrete block building (approx. 90 m^2) still being used for machining operations by SLC (high occupancy). This building was radiologically posted as “Radioactive Material” and used daily.

3.1.1.1 Building Survey

All interior building surfaces were surveyed. Elevated readings were found on an overhead heating unit, an area of the ceiling, an opening in the west floor (sump with removable cover), and on the north wall. Elevated measurements along the area on the north wall was thought to be influenced from the known contaminated ground area just outside of the building, and not the building surface. Two items of debris in the building were found to be contaminated (an old fan and a stool) and moved to a controlled area as addressed in Sections 2.2.3 and 2.4. The pictures below show the interior of the Machine Shop.



3.1.1.2 Samples and Results

Two samples were taken in the Machine Shop. One sample was taken from the northwest wall of the building. The other sample was taken from the middle of the floor slightly toward the northwest end of the building. The photos below show the sample area for the north wall and west floor.


Table 3-1 presents results of the static measurements and building material samples from this survey unit. Results for static measurements and sample media identified above the 1E-06 DCGL only are in on the table. Results above the 1E-04 DCGL are bolded.

TABLE 3-1
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MACHINE SHOP
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Machine Shop / Class 1	**Field Data**			**Lab Results**			
	Dose Rate (µR/hr)	**Measurement ($dpm/100cm^2$)**		**Radionuclides Present Above Limit (pCi/g)**			
		α	**βγ**	**Cs-137**	**H-3**	**Np-237**	**Ra-226**
East Middle Ceiling	14	57	**1748**				
Middle Ceiling	14	69	**1790**				
North Wall	23	160	**1873**		811	0.61	0.97
North Wall	23	113	**1815**				
Overhead Heater	15	248	**2364**				
West Floor @ sample location	44	1498	**3628**		270		1.13
West Floor	44	1510	**3474**				
DCGL (1E-04/1E-06 RISK)	--	17.4/1,740	17.4/1,740	0.41/41.2	13.8/1,380	0.79/79.1	0.068/6.83

All results shown are greater than 1E-06 risk; bolded results exceed 1E-04 risk.

Sampling results support the assumption of the high activity on the north wall being from outside the building, not the building itself. The isotopes in this sample explain the elevated alpha readings, not the beta-gamma. The isotopes found in the west floor explain the elevated alpha, beta, and gamma readings. The tritium in both samples indicates contamination from currently licensed material. Results for H-3, Np-237, and Ra-226 are above the 1E-06 DCGL but below the 1E-04 DCGL.

3.1.2 Multi-Metals Waste Treatment Plant (Class 1)

The Multi-Metals Building (Building 4 on Figure 1-2) is a concrete building divided into three rooms (approx. 185 m^2). All rooms were low occupancy and not posted for radiological hazards.

3.1.2.1 Building Survey

All surfaces were surveyed with the exception of the ceiling in the east and middle rooms due to safety reasons. The Compressor Room, located on the west end of the building, was the only room with radioactivity above DCGLs. Fixed contamination was found in the majority of the room at levels up to 16,050 $dpm/100cm^2$ beta-gamma and 1,812 $dpm/100cm^2$ alpha. Transferable contamination (alpha) was found on the floor, back generator, front compressor, floor drain, and switch panel. After coordinating with the Plant Manager, the areas were either painted with three layers of different color paint to fix the contamination in place or barricaded (and posted) to restrict access. The photo below shows the Compressor Room.

3.1.2.2 Samples and Results

Four samples were taken in the Multi-Metals Building. Two floor samples were taken in the Compressor Room (pictured above), one on the northeast end of the building and one on the northwest end. The other two samples were taken in the Tank Room, one on the northwest wall and the other on the southwest corner floor. The pictures below show the Tank Room floor and wall sample areas.

Table 3-2 presents the results of the static measurements and building material samples from this survey unit. Results for static measurements and sample media identified above the 1E-04 DCGL are bolded on the table. Results from the building samples showed Ra-226 (3 of 4 samples) and Cs-137 (2 of 4 samples) above the 1E-06 DCGL, but below the 1E-04 DCGL. Ac-227 (1 of 4 samples) was detected but below DCGLs. Static measurements showed activity above DCGLs throughout the building on floor and wall surfaces in addition to structures contained in the building including compressors, pipes, and electrical panels.

3.1.3 Carpenter Shop (Class 1)

The Carpenter Shop was a concrete block structure connected to the back of the Multi-Metals Building (approximately 55 m^2). Doors were sealed or nailed shut to prevent access by personnel and radiologically posted as "Radioactive Material".

TABLE 3-2
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MULTI-METALS BUILDING
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Multi-Metals Building / Class 1	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement (dpm/100cm^2)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	Ac-227	Cs-137	Ra-226
COMPRESSOR ROOM						
Center Compressor	20	200	**2236**			
Center Compressor	22	187	**1842**			
Center Compressor	22	206	**1794**			
Drain	40	206	**3268**			
E Wall	18	48	**3490**			
Electrical Panel	24	331	**2673**			
Electrical Panel	24	375	**6210**			
Electrical Panel	29	262	**3215**			
N Floor	22	275	**1868**			
NE Floor	32	88	1618			1.84
NE Compressor	22	125	**3310**			
NE Compressor	20	75	**3147**			
NW Floor	26	160	**918**			0.49
NW Floor	20	825	**4668**			
NW Compressor	20	137	**3084**			
Overhead Pipe	32	**1763**	**16050**			
Overhead Pipe	18	<1K	**13121**			
Overhead Pipe	26	<1K	**5905**			
Overhead Pipe	26	<1K	**11448**			
Overhead Pipe	26	<1K	**12384**			
Overhead Pipe	26	<1K	**6910**			
Overhead Pipe	26	<1K	**6127**			
S Floor	29	268	**10147**			
SE Floor	40	106	**4587**			
SE Generator	30	593	**2863**			
SW Floor	26	**1812**	**5231**			
SW Floor	26	175	**6768**			
SW Floor	26	125	**5489**			
SW Generator	29	393	**10089**			
SW Generator	26	493	**3115**			
W Floor	26	187	**3042**			
W Floor	26	125	**4120**			
TANK ROOM						
SW Wall	52	24	**2430**			
SW Corner Floor	52	<DCGL	<DCGL		0.99	
NW Wall	30	28	1218			0.89
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740	0.63/63.6	0.41/41.2	0.068/68.3

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.3.1 Building Survey

All interior building surfaces on the west half of the building were surveyed and most found to be contaminated. The high background due to the Pole Building prevented a building surface scan from being performed on the east end of the room. Also in the east end of the room, there are extremely high contamination levels due to the explosion years ago of a radioactive source. In this area, fixed contamination levels with a beta dose rate of 30 mRAD/hour above the already high background of 0.6 mR/hr were detected. The maximum fixed alpha contamination was 762,090 dpm/100cm^2. Fixed contamination (other than in the east corner) was found in the majority of the room at an average of 16,000 to 25,000 dpm/100cm^2 beta-gamma. Transferable contamination (alpha and beta-gamma) was also found in the shop, but at lower levels than the fixed. The area around the east wall and table (highest transferable contamination) was barricaded and posted “Contamination Area”. No items were removed from the building. Doors were re-sealed upon survey completion. The picture below shows the east end of the Carpenter Shop.

3.1.3.2 Samples and Results

Four samples were taken in the Carpenter Shop. The “East Window” and “East Machine Table” samples were taken on the wall and table shown in the above picture. The “SE Wall” sample was taken on the back wall and the “S Floor” sample was taken on the south floor along the wall. The pictures below show the south wall and the east wall sample areas.

Table 3-3 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media identified above the 1E-06 risk DCGL established for the survey unit are presented on the table with results above the 1E-04 DCGL in bold. Ra-226 was detected in each of the 4 samples collected from this building above the 1E-06 risk DCGL. Three of these samples exceeded the 1E-04 risk DCGL. Pb-210 was detected in three of the samples above the 1E-06 DCGL. The “hot spot” under the east window in the area of the source explosion also showed high levels of Co-60, Tl-204 and Am-241 in addition to Ra-226 and Pb-210.

3.1.4 Utility Building (Sr-90 Source Vault) (Class 1)

The Utility Building (Building 9 on Figure 1-2) is a concrete block structure (approx. 20 m^2) used for non-radiological storage. The door was locked to prevent access by personnel and radiologically posted as “Radioactive Material”.

TABLE 3-3
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - CARPENTER SHOP
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Carpenter Shop / Class 1	**Field Data**			**Lab Results**					
	Dose Rate (µR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limit (pCi/g)**					
		α	**βγ**	**Cs-137**	**Co-60**	**Tl-204**	**Pb-210**	**Ra-226**	**Am-241**
Center Floor	90	143	**4409**						
E Ceiling	140	491	**11696**						
E Drill Press	60	792	**52376**						
E Drill Press	90	**13195**	**69198**						
E Floor	60	308	**20952**						
E Floor	140	672	**21961**						
E Floor	60	756	**11866**						
E Machine Table	600	3940	**357228**				78.7	**41.3**	
E Machine Table	90	484	**21171**						
E Machine Table	600	804	**270276**						
E Wall	300	5795	**386588**						
Hot Spot Under E Window (Beta Contact Reading)	4000	NA	30 mRad/hr	5.84	6.71	1060	5130	**2950**	175
N Wall	60	39	**2238**						
N Wall	50	36	**2368**						
NE Floor	90	160	**5016**						
NW Electrical Panel	50	**24018**	**20957**						
NW Electrical Panel	50	**15762**	**24388**						
NW Floor	50	107	**2292**						
S Floor at Wall	300	**2621**	**77448**					6.73	
S Wall	80	40	**11000**						
S Wall	80	72	**13572**						
S Wall	80	34	**8138**						
S Wall	80	1352	**3102**						
SE Wall	600	620	**22590**		0.15		4170	**402**	
SE Wall	600	348	**18852**						
SE Wall	600	228	**17847**						
SE Wall	300	60	**16471**						
SE Wall	300	60	**16152**						
SE Wall	300	88	**14185**						
SW Ceiling	50	135	**1949**						
Under E Window	4000	**158375**	**3576737**						
Under E Window	4000	**8795**	**696961**						
Under E Window	4000	**762090**	**987505**						
W Ceiling	50	468	**2469**						
W Wall	50	91	**3186**						
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740	0.41/ 41.2	0.25/ 25.2	566/ 56,600	86.2/ 8,620	0.068/ 6.83	8.66/ 866

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.4.1 Building Survey

All interior building surfaces were surveyed. Fixed contamination was found on the majority of the floor at levels up to 226,958 dpm/100cm^2 beta-gamma and 382 dpm/100cm^2 alpha. Walls and ceiling were not contaminated with the exception of some conduit, shelving, a door, and a wall mounted heater that could not be removed prior to building removal. One item in the building was found to be contaminated (hot plate) and moved to a controlled area. Small amounts of mercury were found in a storage cabinet, placed in an appropriate container, and relocated to the main building. The pictures below show the interior of the building.

3.1.4.2 Samples and Results

Three samples were taken in the Utility Building. Two floor samples were taken, one to the southwest and one to the southeast (just inside the door to the left). A sample was also taken on the west wall. No pictures are available of the sampled areas. Table 3-4 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media are identified above the 1E-06 risk DCGL established for the survey unit are presented in the table with exceedances of the 1E-04 risk DCGL presented in bold. All samples showed Ra-226 above the 1E-06 but below the 1E-04 DCGL; Ac-227 was also detected in one sample (southeast floor) below the DCGLs.

3.1.5 8' X 8' Building (Class 1)

The 8'X8' Building (Building 10 on Figure 1-2) is a concrete block structure (approx. 6 m^2) used for tritium operations storage. The door was locked to prevent access by personnel and radiologically posted as "Radioactive Material".

TABLE 3-4
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - UTILITY BUILDING
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Utility Building / Class 1	Field Data			Lab Results
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)
		α	βγ	Ra-226
NE Wall Mounted Heater	32	ND	**28427**	
Center Floor	39	45	**204601**	
Center Floor	39	ND	**226958**	
Center Floor	39	ND	**131450**	
SW Floor	37	ND	**16745**	
SE Wall Conduit	40	99	**120670**	
SE Floor	40	ND	**46806**	
S Floor	40	ND	**42697**	
S Floor Crack at Entry	40	ND	**17992**	
S Double Door Bar	37	382	**21261**	
NW Floor	28	277	**9253**	
W Floor	39	73	**3598**	
NW Floor	28	277	**9253**	
W Floor	28	73	**3598**	
NE Floor	28	35	**1924**	
N Floor	28	ND	**3516**	
W Wall	39	39	**11843**	
N Floor	28	98	**2028**	
W Wall	39	13	**3662**	
SE Floor	40	20	**1774**	
W Wall	39	9	**3508**	0.84
SW Floor	28	50	**2428**	5.99
SE Floor	40	46	**39985**	1.71
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740	0.068/6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.5.1 Building Survey

Due to lack of tritium instrumentation, no items could be moved or removed from the building and all interior building surfaces could not be surveyed. Of the areas surveyed, fixed contamination was found on accessible surfaces at levels up to 1,271,947 dpm/100cm^2 beta-gamma and 215 dpm/100cm^2 alpha. All walls and the floor and ceiling showed elevated readings. No debris items were surveyed because of the potential for high H-3 levels. All waste (i.e., PPE) was bagged and left in the building. The picture below shows the interior of the building

3.1.5.2 Samples and Results

Four samples were taken in the 8'X8' Building. Two wall samples were taken (south and northeast) and two floor samples were taken (southwest and just inside the door). After packaging, the samples could not be sent to the lab because of high activity; therefore only smear samples for H-3, C-14, and Ni-63 were prepared. The pictures below show the floor at the door and the south wall sample locations. Table 3-5 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media above the 1E-06 DCGLs established for the survey unit are presented on the table and results above the 1E-04 DCGL are bolded. The smear sample showed elevated levels of H-3 and Ni-63. Based on the elevated levels of activity of the building samples which could not be shipped, other isotopes are expected to be found at elevated levels.

TABLE 3-5
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - 8' X 8' BUILDING
SAFETY LIGHT CORPORATION OU-1
BLOOMSBURG, PENNSYLVANIA

8' X 8' Building / Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit Smears in dpm/100cm²	
		α	βγ	H-3	Ni-63
Ceiling close to middle	140	26	**2631**		
East Center Floor	100	61	**11066**		
NE Floor	100	33	**3365**		
NE Floor	100		**1816**		
NE Floor	100		**9381**		
NE Wall	100	27	**106015**		
NE Wall	100	27	**106015**		
NW Floor	140		**1965**		
S Wall	220	33	**14454**		
S Wall	220	33	**14454**		
SE Floor	220	41	**2415**		
SE Floor at Door	400	215	**1271947**	1170	4410
SW Floor	80		**3785**		
SW Floor	80		**2731**		
W Floor	60	26	**2169**		
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740	--	--
Release Criteria for Smears (Table 1-4)	--	17.4/1,740	17.4/1,740	1,000 *	1000 *

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

Note results for building samples showed activity in excess of what could be shipped by common carrier.

3.1.6 Liquid Waste Building (Class 1)

The Liquid Waste Building (Building 11 on Figure 1-2) is a metal structure (approx. 115 m^2) built on concrete slab. The building was being used for equipment storage and mixing sample cocktails for H-3 at the time of the RI. The building is radiologically posted "Airborne Radioactive Material Area" (with stay time on posting) and "Radioactive Material".

3.1.6.1 Building Survey

All surfaces were surveyed and the highest activity occurred at a large crack in the floor slab running the middle length (north to south) of the building. Alpha levels fluctuated throughout the day with the highest readings occurring in the morning. Historical documents indicated the presence of underground tanks in this area, but site personnel stated that the slab covered an area where an old building was taken down and radium was poured into the hole were the foundation had been. The only other contaminated areas in the building were fixtures that could easily be removed (Sink, Fan, Junction Box). Several items in the building were found to be contaminated, marked as such, and left in the building which was posted

“Radioactive Material”. The picture below shows the interior of the building and the area where H-3 cocktails are made.

3.1.6.2 Samples and Results

Two samples were taken from the floor, one was near the work table in the northeast portion of the survey unit and one was taken at the crack described above in the center of the building. The pictures below show the exhaust fan and the crack in floor after the sample was taken. Table 3-6 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media above the 1E-06 DCGLs established for the survey unit are presented on the table and results above the 1E-04 DCGL are bolded. Radioisotopes detected at elevated levels in both floor samples were H-3 and Ra-226 with Ra-226 exhibiting activity above the 1E-04 risk DCGL.

TABLE 3-6
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - LIQUID WASTE BUILDING
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Liquid Waste Building Class 1	Field Data: Dose Rate (μR/hr)	Field Data: Measurement (dpm/100cm²) α	Field Data: Measurement (dpm/100cm²) βγ	Laboratory Data: Sample ID	Laboratory Data: Radionuclides Present Above Limits (pCi/g) H-3	Laboratory Data: Radionuclides Present Above Limits (pCi/g) Ra-226
Crack in Middle Floor	50	737	**3816**	LIQ-W-FLOOR(#71)	92.8	1.81
N Disconnect Box	38		**5648**			
NE Floor	34		1188	LIQ-W-FLOOR(#73)	70.5	**14.1**
NW Sink	50	603	**3222**			
S Exhaust Fan	40	281	**14537**			
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740		13.8/1,280	0.068/6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.7 Metal Silo (Class 1)

The Metal Silo (Building 14 on Figure 1-2) was a metal structure (approx. 2 m^2) on the outer southeast side of the main property. The floor was soil covered with plastic and concrete block circled the floor against the walls of about 30 percent of the structure. The silo was locked to prevent access by personnel and radiologically posted as “Radiation Area”. The majority of items in the building were contaminated items with fixed and transferable contamination which were packaged and labeled as radioactive material. Labels on some items indicated H-3, including urine samples and drums marked as leaking; these were not disturbed during the RI. Pictured below is the silo exterior; no interior pictures of the silo are available.

3.1.7.1 Building Survey

All accessible surfaced of the silo were surveyed and fixed contamination was found on all accessible surfaces at levels up to 345,973 dpm/100cm^2 beta-gamma and 20,366 dpm/100cm^2 alpha. These readings were above the high background readings from the garage foundation adjacent to the silo. All waste (i.e. PPE) was bagged and left in the building.

3.1.7.2 Samples and Results

One sample was taken from the northeast dirt floor. No samples could be obtained from the metal enclosure although results from smears taken from the interior metal surfaces showed elevated levels of H-3. Table 3-7 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media identified above the DCGLs established for the survey unit are shown on Table 3-7 with exceedances of the 1E-04 DCGL in bold. The sample from the silo floor showed elevated levels of H-3, Ra-226, and Cs-137 above DCGLs with H-3 and Cs-137 levels above the 1E-04 DCGL. The smear samples from the doors and walls all showed elevated levels of H-3.

3.1.8 <u>Etching Building Addition (Class 3)</u>

The manufacturing addition of the Etching Building (northernmost section of Building 15 on Figure 1-2) was a metal structure (approx. 1,260 m^2) built on concrete slab. This survey unit included a small portion of the older building, which was being used daily as a paint shop. The large room at the entrance was being used to store equipment purchased from another facility; the remainder was a storage area for current tritium operations (posted as “Radioactive Material).

3.1.8.1 Building Survey

Approximately 20 percent of the building surfaces were surveyed, with special attention to areas of highest potential for contamination. No contamination above DCGLs was found. Several debris items were contaminated. Smaller items were packaged, labeled, and placed in the Radioactive Material Area. The tops of the ovens in the paint shop indicated some activity, but were not accessible for survey.

TABLE 3-7
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - METAL SILO
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Metal Silo / Class 1	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²		
		α	βγ	Cs-137	H-3	Ra-226
Door	100	433	**2419**		1840**	
Door	100	481	**2389**			
E Block Wall	250	674	**11527**		2960**	
E Wall	120	396	**3208**			
E Wall	250	369	**3167**		7230**	
Lead Pig in SW Side	100	**2677**	**345973**			
N Floor	100		**4355**			
N Wall	100	433	**2419**			
NE Floor	250	148	**3131**			
NE Floor	100		**5442**			
NE Floor Dirt inside door	100	40	**10411**	**232***	**4860***	1.59*
NE Wall	250	248	**2315**			
NW Floor	100		**4381**			
NW Wall	100	174	**4235**			
S Block Wall	100	**20366**	**92185**		3840**	
S Floor	100	26	**30496**			
S Floor	100	22	**5315**			
S Pump	100	1200	**9504**			
S Wall	120	307	**7038**		1810**	
SE Floor	120	18	**36435**			
SE Floor	120		**9265**			
SE Wall	120	1622	**49454**			
SW Wall	70	1100	**6215**			
W Floor	70	18	**10173**			
W Wall	100	307	1708		7500**	
DCGL (1E-06/1E-04 RISK)	--	17.4/1,740	17.4/1,740	0.41/41.2	13.8/1,380	0.068/6.8
Release Criteria for Smears (from Table 1-4)				--	1000	--

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

*Building Samples in pCi/g

**Smears in dpm/100cm²

3.1.8.2 Samples and Results

Three samples were taken in the Etching Building. Two were ceiling samples (one each from the older section and newer section) and one was a floor sample taken from the southwest paint shop (old portion of building). The pictures below show the ceiling sample location outside of restrooms and the floor sample. Table 3-8 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements were below DCGLs; however, sample results showed levels of H-3 and Pb-210 slightly above the 1E-06 DCGL established for the survey unit. All samples showed Ra-226 above the 1E-06 DCGL with one sample above the 1E-04 DCGL.

TABLE 3-8
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - ETCHING BUILDING
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Etching Building / Class 3	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	H-3	Pb-210	Ra-226
NW Ceiling in RMA – Grid C	13	<DCGL	<DCGL	24.2	136	4.37
SW Floor in Paint Shop (by oven) – Grid K	10	<DCGL	<DCGL		146	**7.31**
SE Ceiling o/s Restrooms – Grid O	13	<DCGL	<DCGL	40.7	106	2.41
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8/ 1,380	86.2/ 8,620	0.068/6.8

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.9 Cesium Ion Exchange Hut (Class 2)

The Cesium Ion Exchange Hut (Building 17 on Figure 1-2) is a concrete block structure (approx. 2 m^2) attached the east side of the main building. The room had one locked opening and was radiologically posted as “Radiation Area”.

3.1.9.1 Building Survey

Because of the small size of the room, the majority of the surfaces were surveyed and found to be highly contaminated (fixed and transferable). The room contained no items with the exception of an installed pipe just inside the door having the highest fixed contamination of 3,115,991 dpm/100cm^2 beta-gamma and 35 dpm/100cm^2 alpha. Note that alpha result is from a second survey; the first survey showed non-detected alpha contamination. Maximum transferable contamination was 144,136 dpm/100cm^2 beta-gamma and 15 dpm/100cm^2 alpha. The picture below shows the interior of the hut.

3.1.9.2 Samples and Results

Three samples were taken in the Ion Exchange Hut: a wall sample from the southwest corner; a sample from the wooden door; and a sample from the floor adjacent to the contaminated pipe. Table 3-9 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media identified above the 1E-06 DCGLs established for the survey unit are presented on the Table 3-9 with results above the 1E-04 DCGL in bold. Cs-137 was detected in all three samples with two locations above the 1E-04 DCGL. Ra-226 was detected in one sample above the 1E-06 DCGL.

TABLE 3-9
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - CESIUM ION EXCHANGE HUT
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Cesium Ion Exchange Hut Class 2	**Field Data**			**Lab Results**	
	Dose Rate (μR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limit (pCi/g)**	
		α	**βγ**	**Cs-137**	**Ra-226**
Center Floor	800	ND	**11269**		
Door	1000	NA	NA	**845**	1.29
E Wall	800	ND	**22613**		
E Wall	800	ND	**425860**		
E Wall	800	ND	**10404**		
N Ceiling	1000	ND	**13412**		
N Floor	1000	ND	**108249**		
N Floor	1000	ND	**14560**		
NE Floor by Pipe	1000	ND	**3115991**	**919**	
NE Wall	800	ND	**10404**		
NE Wall	800	ND	**108249**		
NW Floor	1000	ND	**2569340**		
NW Wall	800	ND	**17509**		
NW Wall	800	ND	**11269**		
Pipe in NE Corner	1000	ND	**3115191**		
S Floor	600	ND	**117056**		
S Floor	600	ND	**21404**		
S Wall	600	ND	**530404**		
S Wall	600	ND	**425860**		
SE Ceiling	600	ND	**26491**		
SE Floor	600	ND	**530404**		
SE Wall	800	ND	**21404**		
SE Wall	600	ND	**10849**		
SW Wall	800	ND	**137234**		
SW Wall	600	ND	**38765**	5.51	
SW Wall	600	ND	**137234**		
W Wall	800	ND	**172047**		
W Wall	800	ND	**22613**		
W Wall	800	ND	**172047**		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.41/41.2	0.068/6.8

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.10 Main Building Attic (Class 2)

The Main Building (Building 16 on Figure 1-2) Attic (approx. 230 m^2) consisted of a finished room at the top of the stairs and two crawl spaces (east and west). A roof access door opened to the south end of the building. Surface materials were wood floors, plaster walls, and plaster ceiling. The only personnel allowed access to the attic is for necessary maintenance (i.e. heating and cooling repair). The stairwell had broken windows causing a problem with pigeons and their droppings in both the stairwell and attic. The stairwell door was posted "Airborne Radioactivity Area" for radon only (with established stay times), but maintenance personnel wore respiratory protection for health reasons associated with the bird waste. Most material and debris in the area was non-releasable and not surveyed due to the condition of room. No pictures are available for the attic, with the exception of the door at the bottom of the stairs shown below.

3.1.10.1 Building Survey

Approximately 50 percent of all surfaces were surveyed and isolated areas of fixed contamination were detected; the maximum was 162,448 dpm/100cm^2 beta-gamma and 14,231 dpm/100cm^2 alpha. Most surfaces were covered with bird droppings, which could cause activity to be shielded. Crawl spaces were not safely accessible due to unknown safety and radiological conditions.

3.1.10.2 Samples and Results

Two samples were taken in the attic. One sample was taken in the north wall and one was taken in the northwest floor. No samples were taken in the crawl spaces. Table 3-10 presents results of the static measurements and building material samples from this survey unit. Results presented for static measurements and sample media identified above the 1E-06 DCGL established for the survey unit are presented in Table 3-10 with results above the 1E-04 DCGL in bold. Building material samples both showed elevated levels of H-3 and Ra-226 with one sample showing Ra-226 above the 1E-04 DCGL.

TABLE 3-10
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - ATTIC
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Attic in Main Building Class 2	**Field Data**			**Lab Results**	
	Dose Rate (μR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limits (pCi/g)**	
		α	**βγ**	**H-3**	**Ra-226**
E Crawlspace Rafter	25	411	**4633**		
E Floor at crawlspace opening	25	481	**2533**		
N Heater	25	696	**4030**		
N Wall Shelves	25	526	**2715**	16.6	3.14
N Wall (A)	25	78	**27970**		
NW Corner Floor	25	785	**12556**	16.2	**32.2**
SE corner under watch dials	27	**14231**	**162448**		
W Crawlspace Rafter	25	**222**	**1137**		
W Window Ledge	25		770		
West Floor (E)	35	119	**2074**		
West Wall ©	25	448	**2333**		
Stairs	32	781	**8937**		
Stairs	32	**2581**	**9763**		
Stairs	32	230	**10563**		
Stairs	30	**10855**	**17085**		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8/ 1,380	0.068\ 6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

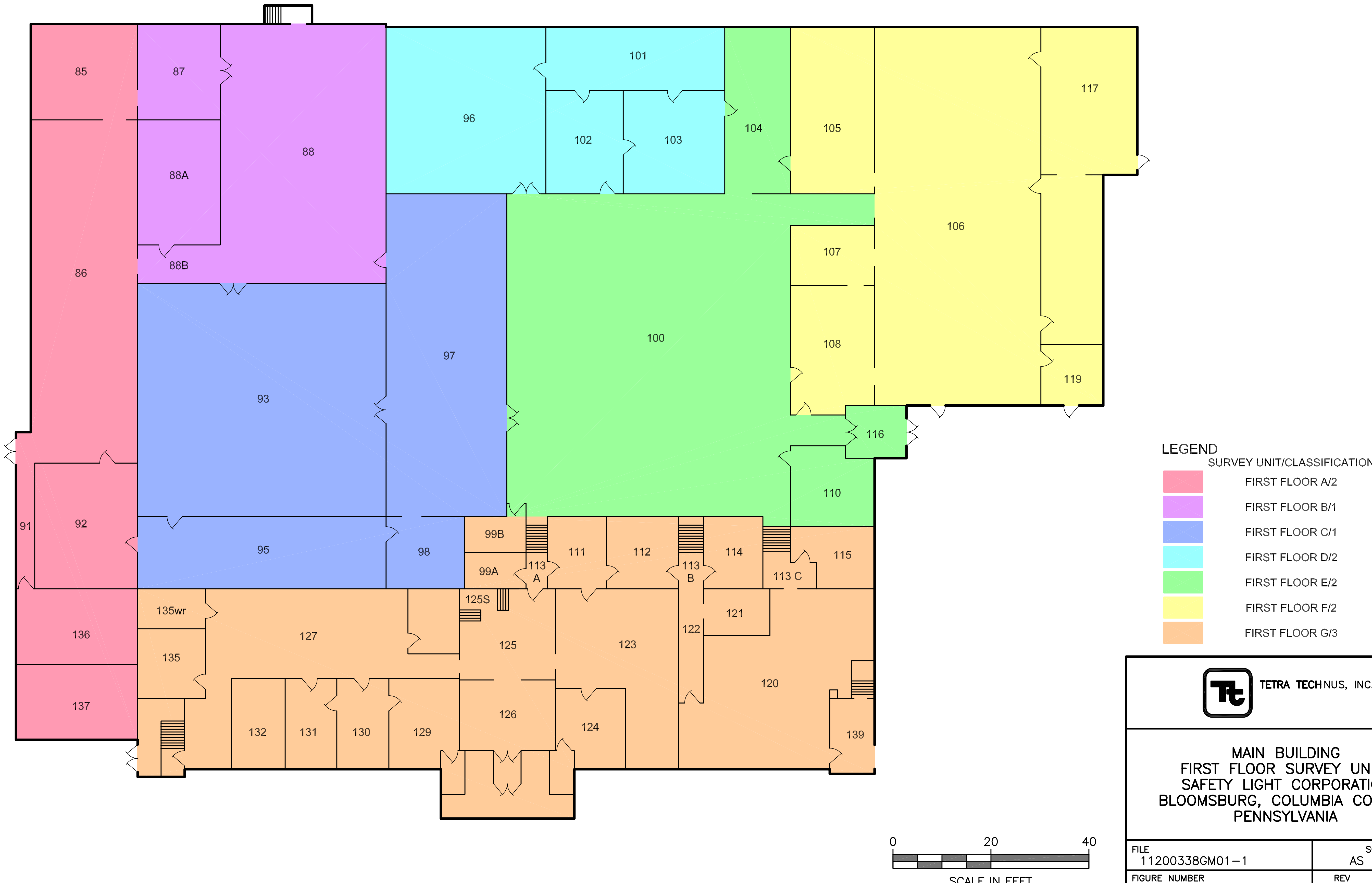
3.1.11 Main Building Second Floor A (Class 1)

This survey unit was made up of the east stairwell and rooms 215, 216, and 218 (approx. 210 m^2). Figures 3-1 and 3-2 show the Main Building survey units and room numbers. Access to this area was not controlled. Surface materials were wood floors and handrails, concrete steps, plaster walls, and plaster ceiling. The largest room (218) made up most of the survey unit area and contained a large oven, dumb waiter, and closet. Room 215 was a restroom and room 216 was completely filled with five-foot stacks of boxed records. All rooms contained excessive amounts of material and debris. Portions of the ceiling had collapsed and material was covered due to asbestos potential.

3.1.11.1 Building Survey

All building surfaces and debris contained within the survey unit were surveyed. Fixed contamination was found on the majority of the surfaces at levels up to 1,600,000 dpm/100cm^2 beta-gamma and 421,918 dpm/100cm^2 alpha. All stairwell steps and rails showed elevated levels of contamination. Contaminated

11200338\0110\112G00338GM01-1.DWG 01/23/08 MKB

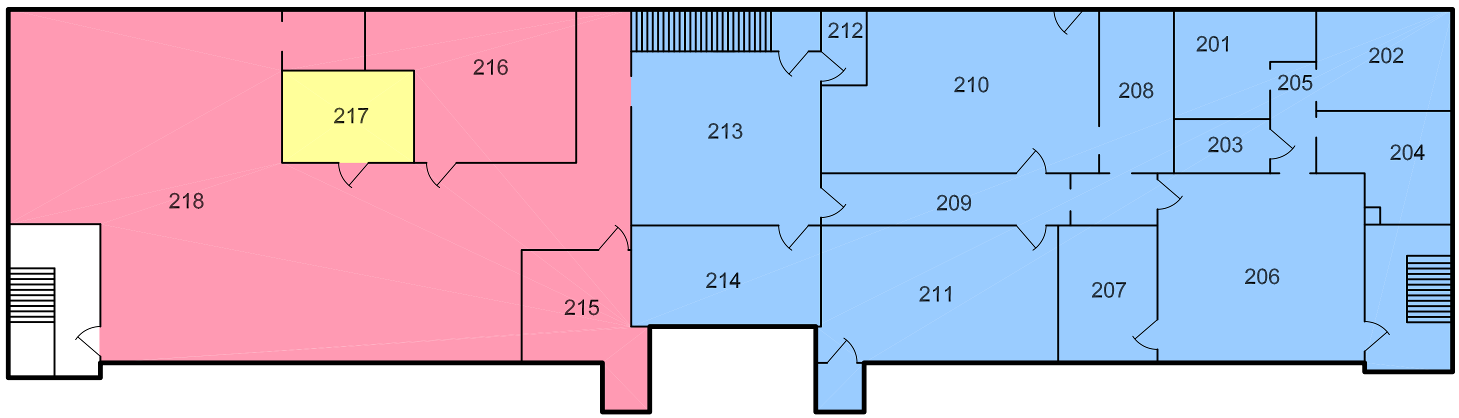


TETRA TECH NUS, INC.

MAIN BUILDING
FIRST FLOOR SURVEY UNITS
SAFETY LIGHT CORPORATION
BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

FILE 11200338GM01-1	SCALE AS NOTED
FIGURE NUMBER FIGURE 3-1	REV 0 / DATE 01/23/08

AR300070



LEGEND

SURVEY UNIT/CLASSIFICATION

- SECOND FLOOR A/1
- SECOND FLOOR B/1
- SECOND FLOOR C/2

0 20 40

SCALE IN FEET

TETRA TECHNUS, INC.

MAIN BUILDING
SECOND FLOOR SURVEY UNITS
SAFETY LIGHT CORPORATION
BLOOMSBURG, COLUMBIA COUNTY, PENNSYLVANIA

SCALE	AS NOTED
FILE	11200338GM01-2
REV 0	DATE 08/09/07
FIGURE NUMBER	FIGURE 3-2

Debris items were packaged and moved to a controlled area. The pictures below show Room 218 west, 218 east, 218 southwest hall, and 218 closet (clockwise from left).

3.1.11.2 Samples and Results

Four samples were taken in Survey Unit A. The first sample was taken in the south wall of the closet (south end of the building behind Room 217) under the window. Two wall samples were taken in Room 218, one on the northwest wall and one on the east wall next to the dumb waiter. A floor sample was taken from the east stairwell landing. The pictures below show the stairwell and wall beside dumbwaiter sample locations. Table 3-11 presents results of the static measurements and building material samples from this survey unit above DCGLs. H-3 and Ra-226 were the only radionuclides detected and were present in all building material samples. Ra-226 was detected in two samples above the 1E-04 DCGL.

TABLE 3-11
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT A
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 1 OF 3

Main Building 2nd Floor - A Class 1	Field Data			Lab Results	
	Dose Rate (µR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²	
		α	βγ	H-3	Ra-226
E Stairwell 1st Floor Doors	20	35	**5985**		
E Stairwell 1st Floor Landing	20	32	1700		
E Stairwell 1st Floor Rails	20	1007	**2279**		
E Stairwell 1st Floor Steps MAX	20	668	**33100**		
E Stairwell 2nd Landing Floor MAX	20	242	**2600**	68.2*	**32.4***
E Stairwell 2nd Landing Heater	20	256	**2558**		
E Stairwell 2nd Landing Heater	20	315	**2795**		
E Stairwell 2nd Landing Heater	20	298	**2197**		
E Stairwell Top Doorway	23	37	**5996**		
E Stairwell Top Handrail Going E Stairwell Down	23	138	**5815**		
E Stairwell Top Heater	23	369	**2926**		
E Stairwell Top Steps Going Down MAX	23	190	**2000**		
E Stairwell Top Window	23	77	**1710**		
Door For Shower Stall	30	579	**272728**		
Door for Toilet Stall	30	526	**227273**		
Left Sink	30	ND	**9091**		
N Wall	30	311	**5836**		
NE Wall	30	ND	**9091**		
S Floor	30	ND	**9091**		
Toilet	30	ND	**5455**		
W Wall	30	ND	**9091**		
W Wall	30	ND	**9091**		
W Wall	30	ND	**45455**		
W Wall	30	ND	**18182**		
W Wall	30	ND	**45455**		
Window Sill Left	30	ND	**9091**		
Books	45	174	**9091**		
Ceiling	30	ND	**18182**		
Shelf	45	1226	**25455**		
Sprinkler	30	ND	**10909**		
Wall	45	**2368**	**52727**		

*Building Samples in pCi/g
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

TABLE 3-11
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT A
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 2nd Floor - A Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²	
		α	βγ	H-3	Ra-226
Wall	45	ND	**7273**		
Window Seal	45	**3332**	**127800**		
Closet Center Floor	28	ND	**3636**		
Closet E Floor	30	<DCGL	**3636**		
Closet I/S N Cabinet	23	1372	**3636**		
Closet I/S N Cabinet	23	1579	**5455**		
Closet I/S W Cabinet	23	658	**5955**		
Closet NW Floor	30	32	**2727**		
Closet NW Wall	30	32	**2727**		
Closet O/S N Cabinet	30	421	**3636**		
Closet O/S W Cabinet	30	68	**3227**		
Closet S Wall	28	416	**10837**	44.9*	0.97*
Closet SE Window	32	137	**7273**		
Closet SW Window	23	105	**3636**		
E End Column	25	**2681**	**96173**		
E End Column	25	**3606**	**37721**		
E End Column	25	300	**175415**		
E End Column	25	75	**3563**		
E End Column	25	344	**3815**		
E End Pipe in Floor	25	1375	**5831**		
E End Pipe in Floor	25	19	**5342**		
E Floor	26	356	**4000**		
E Floor Under Duct Work	22	1020	**4139**		
E Wall	22	620	**10620**		
E Wall	26	**96000**	**1600000**		
E Wall at Floor	22	240	**2800**		
E Wall Column	26	148	**3000**		
E Wall Column	26	176	**4000**		
E Wall Door Frame	30	ND	**56126**		
E Wall	35	969	**13973**		
E Wall Window	35	275	**5263**		
E Wall Window Sill	30	257	**4426**		
NW Wall	38	467	**53040**	53.9*	**10.8***
NE Floor by Stairs	38	200	**4818**		

*Building Samples in pCi/g

TABLE 3-11
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT A
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 3 OF 3

Main Building 2nd Floor - A Class 1	**Field Data**			**Lab Results**	
	Dose Rate (μR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²**	
		α	**βγ**	**H-3**	**Ra-226**
NE Floor in Front of Window	38	164	**3657**		
Oven (Max)	NA	**421918**	**409091**		
SE Floor beside Duct Work	32	20	**4000**		
SE Wall by Dumb Waiter	26	**2022**	**4737**	743*	0.79*
SW Floor by Plastic	28	631	**23000**	2580**	
W End Column	30	807	**5331**		
W End Column	30	163	**12157**		
W End Column	30	375	**4473**		
W End Column	30	262	**3305**		
W End Column	30	169	**4737**		
W End Electrical Panel	30	ND	**6442**		
W End Electrical Panel	30	ND	**11579**		
W End Electrical Panel	30	ND	**23684**		
W End Wall	30	993	**3157**		
W End Wall	30	138	**3157**		
W End Wall	30	575	**12884**		
W End Wall	30	ND	**15789**		
W End Wall	30	882	**12315**		
W End Wall	30	600	**5579**		
E Wall Column	26	336	**4736**		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8/ 1,380	0.068/ 6.83

*Building Samples in pCi/g
**Smears in dpm/100cm²; release criteria for transferable contamination is 1,000 dpm/100cm² for H-3
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.12 Main Building Second Floor B (Class 1)

This survey unit was made up only of room 217 (approx. 15 m^2). The only entrance door to the room was locked and radiologically posted. Surface materials were wood floors, plaster walls, and plaster ceiling. The room contained a large oven, filing cabinets, and a table.

3.1.12.1 Building Survey

The majority of building surfaces were surveyed and no contamination above DCGLs was found. Fixed contamination was found on all filing cabinets, shelves, the oven, and oven racks at levels up to 50,000 dpm/100cm^2 beta-gamma and 11,463 dpm/100cm^2 alpha. Since the room was a controlled area, no contaminated items were removed.

3.1.12.2 Samples and Results

One sample was taken on a metal rack located on the floor in the southeast corner. Table 3-12 presents results of the static measurements and building material sample from this survey unit. Results presented for static measurements and sample media identified above the DCGLs established for the survey unit are in bold. The sample collected from the survey unit showed H-3 and Ra-226 above the 1E-06 DCGL. None of the building interior surfaces showed contamination; all contamination was associated with materials contained within the survey unit.

TABLE 3-12
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT B
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 2nd Floor – B Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)	
		α	βγ	H-3	Ra-226
Metal Rack; Floor in SE Corner	26	1052	**8182**	27.7	2.62
Shelves SE Corner	26	1053	**7100**		
Oven Rack SE Corner	26	368	**2727**		
Cabinets S End O/S	26	**3368**	**20727**		
Cabinets S End I/S	26	321	**4427**		
Cabinets E End O/S	26	**3916**	**2155**		
Cabinets E End O/S	26	174	**8282**		
Cabinets NE End I/S	26	**2105**	**7273**		
Cabinets NE End O/S	26	**6126**	**10609**		
I/S Oven	26	74	**13045**		
I/S Oven	26	1605	**2464**		
I/S Oven – Door	26	**11463**	**50000**		
O/S Oven	26	163	**7182**		
I/S Oven	26	216	**5709**		
O/S Oven	26	121	**6545**		
O/S Oven	26	79	**5455**		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8\ 1,380	0.068/ 6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.13 Main Building Second Floor C (Class 2)

This survey unit includes rooms 201 through 214 (approx. 290 m^2), and the west and south stairwells. Access to this area was not controlled. Surface materials were wood floors and handrails, concrete steps, plaster walls, and plaster ceiling. Though not used for storage like the remainder of the second floor, this survey unit contained materials used in historical operations and was set up much as it was when in use.

3.1.13.1 Building Survey

The majority of building surfaces were surveyed. The rooms were contaminated in isolated random areas at levels up to 1,200,017 dpm/100cm^2 beta-gamma and 3,526 dpm/100cm^2 alpha. All stairwell steps and rails were contaminated. Contaminated items of debris were packaged and moved to a controlled area. The pictures below show Rooms 206 and 211.

3.1.13.2 Samples and Results

Four samples were taken in the survey unit. A portion of the bottom rail in the south stairwell, the floor in the hallway (Room 209), a portion of wall material and a light switch in Room 211, and a large built-in cabinet in Room 214 were sampled. The pictures below show the light switch and cabinet sample areas. Table 3-13 presents results of the static measurements and building material samples from this survey unit above the 1E-06 DCGL. Results presented for static measurements and sample media identified above the 1E-04 DCGL are in bold.

TABLE 3-13
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT C
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 2nd Floor - C Class 2	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	H-3	Pb-210	Ra-226
Rm 201 Floor Under Sink	36	578	**18,181**			
Rm 201 Light Box	36	705	**9090**			
Rm 202 Shelf on Wall	34	**3,526**	**90,909**			
Rm 203	32	NA	NA			
Rm 204 W Floor	34	363	**15,699**			
Rm 205 Floor	32	**2,894**	**181,818**			
Rm 206 Floor	34	79	**309,090**			
Rm 206 Floor	34	58	**36,364**			
Rm 206 Floor	34	ND	**90,909**			
Rm 206 Floor	34	ND	**181,818**			
Rm 207	32	NA	NA			
Rm 208 Metal Sander	18	**2,179**	**33,333**			
Rm 208 Metal Cabinet	14	**2,105**	**5,000**			
Rm 209 Hallway Floor	110	1,125	**133,333**	32	111	**50.7**
Rm 210 NW Floor	30	**2,105**	**12,500**			
Rm 210 NE Floor (under ceiling debris)	40	ND	**4,166**			
Rm 210 Center Floor	30	ND	**3,333**			
Rm 211 W Floor	45	ND	**2,500**			
Rm 211S Floor (next to plotter)	45	ND	**25,000**			
Rm 211 S Floor (under plotter)	45	ND	**3,333**			
Rm 211 SW Wall Light Switch	45	147	**1,200,017**	34.9	<DCGL	**86.4**
Rm 212 (At Doorway - Unsafe to Enter)	40	NA	NA			
Rm 213 Book Shelf on E Wall	24	ND	**67,500**			
Rm 213 W Floor	20	ND	**6,667**			
Rm 213 Light Switch on NW Wall	20	237	**5,000**			
Rm 213 E Floor	24	ND	**25,000**			
Rm 214 S Wall	17	395	**38,133**			
Rm 214 SE Wall	18	105	**17,525**			
Rm 214 Light Switch	17	126	**5,833**			
Rm 214 NE Cabinet on NE Wall (inside)	18	1579	**2,283**			
Rm 214 NE Cabinet O/S of door by handle	18	263	**419,167**			5.52
W Stairwell 3rd floor top of window	25	368	**4,000**			
W Stairwell 3rd floor side of window	25	316	**3,500**			
W Stairwell 3rd floor landing	25	1,058	**23,333**			
W Stairwell 3rd floor steps max (all over 5K)	25	237	**6,667**			
W Stairwell 2nd floor landing	25	684	**5,000**			
W Stairwell 2nd floor steps max	25	237	**13,333**			

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

TABLE 3-13
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - SECOND FLOOR, SURVEY UNIT C
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 2 OF 2

Main Building 2nd Floor - C Class 2	**Field Data**			**Lab Results**		
	Dose Rate (μR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limit (pCi/g)**		
		α	**βγ**	**H-3**	**Pb-210**	**Ra-226**
W Stairwell 1st floor steps max	25	158	**5,000**			
W Stairwell 1st floor window	25	158	**3,083**			
W Stairwell 1st floor landing	25	174	**4,000**			
W Stairwell 1st floor landing	25	632	**16,667**			
S Stairwell Bottom Floor Landing	25	62	**3,796**			
S Stairwell Bottom Rail	25	641	**9,108**			
S Stairwell Bottom Rail	25	1,130	**104,827**	35.4		**53.3**
S Stairwell Bottom Rail	25	**2,852**	**16,681**			
S Stairwell Top Rail	28	216	**5,009**			
S Stairwell Top Rail	28	36	**6,735**			
S Stairwell Top Rail	28	26	**2,570**			
S Stairwell Top Steps	28	<DCGL	**10,235**			
S Stairwell Bottom Steps	25	36	**2,370**			
S Stairwell Bottom Steps	25	24	**4,130**			
S Stairwell Bottom Steps	25	64	**39,322**			
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8/ 1,380	86.2/ 8,620	0.068/ 6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

Radionuclides detected in samples above DCGLs included H-3 (3 of 4 samples), Ra-226 (4 of 4 samples), and Pb-210 (1 of 4 samples). Three of the Ra-226 samples showed activity above the 1E-04 DCGL.


3.1.14 Main Building First Floor A (Class 2)

This survey unit included rooms 85, 86, 91, 92, 136, and 137 (approx. 300 m^2). Access to the area was not controlled and the area was routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (86) made up most of the survey unit area and contained a work area, hood, and pallets of boxes. Room 85 was a plexi-glass work area, Room 92 was a screen print shop, Room 136 was flammable storage (i.e. paint), and Room 137 was used for other storage. All rooms contained excessive amounts of material and debris.

3.1.14.1 Building Survey

A large portion of the wall surfaces were surveyed and the entire floor was surveyed in room 86. Fixed contamination was found on a majority of wall surfaces at levels up to 160,000 dpm/100cm^2 beta-gamma and 5,948 dpm/100cm^2 alpha. It was estimated that 60 percent of the concrete floor was greater than 3,600 dpm/100cm^2 beta-gamma and less than DCGLs for alpha. The other rooms in the units had only limited, isolated fixed contamination. An old fan was the only contaminated debris item which was subsequently packaged and moved to a controlled area.

3.1.14.2 Samples and Results

Four samples were taken from Survey Unit A. Three were taken from Room 86; one in the south middle floor and two wall samples (west and northeast). The fourth sample was taken in from the back wall of Room 136. Table 3-14 presents results of the static measurements and building material samples above the 1E-06 DCGL for this survey unit; results above the 1E-04 DCGL are in bold. The samples from Room 86 showed elevated levels of H-3 (2 of 3 samples), Cs-137 (2 of 3 samples), and Ra-226 (1 of 3 samples).

3.1.15 Main Building First Floor B (Class 1)

This survey unit includes rooms 87, 88, 88A-B, and a loading dock (approx. 250 m^2). Access was not controlled and the area is routinely occupied. Surface materials were concrete floor, plaster walls, and plaster ceiling. The largest room (88) made up most of the survey unit area and contained large, operational cutting machines. Room 88A was used frequently workers for passage and 88A is a caged storage area (with limited access). Room 87 was a storage room of large equipment. Rooms 88, 88A, and 87 contained large amounts of material and debris.

TABLE 3-14
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT A
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor - A Class 2	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	Cs-137	H-3	Ra-226
Rm 136 Back Wall	15	660	**3156**			
Rm 137 Center Floor in half closest to Mn Bldg	20	ND	**4000**			
Rm 86 Doorway in from Rm 91 (Bare Concrete)	25	ND	**4000**			
Rm 86 W Wall	20	28	**10568**			
Rm 86 W Wall	20	24	**55288**			
Rm 86 W Wall	20	8	**24388**			
Rm 86 W Wall	30	44	**9004**			
Rm 86 W Wall	30	ND	**21904**			
Rm 86 W Wall	40	ND	**27052**			
Rm 86 W Wall	40	ND	**28972**			
Rm 86 W Wall	40	**5948**	**17536**	49*	106*	
Rm 86 W Wall	50	ND	**160000**			
Rm 86 Floor (just south of center)	40	ND	**4000**			
Rm 86 Floor under east wall window	30	ND	**4800**			
Rm 86 N Floor	25	ND	**52137**			
Rm 86 N Floor	25	ND	**21718**			
Rm 86 NE Floor	25	128	**16896**			
Rm 86 NE Radiator	20	ND	**8000**			
Rm 86 NE Wall	25	20	**15568**		21.8*	
Rm 86 NE Wall	25	28	**4628**			
Rm 86 NE Window	20	ND	**3200**			
Rm 86 S Middle Floor	20	ND	**28324**	28.7*		0.47*
Rm 86 SE Radiator	50	ND	**4000**			
Rm 86 SE Window Sill	50	ND	**32000**			
Rm 91 W Wall	20	ND	**3200**			
Rm 85 S Floor	50	ND	**2107**			
Rm 85 E Wall	50	ND	**1923**			
Rm 85 Floor at Door	50	ND	1365			
Rm 86 S Floor	50	ND	**4385**			
Rm 91 W Wall	20	ND	**2371**			
Rm 86 Middle Floor	40	ND	**1463**			
Rm 86 E Wall	20	ND	**3548**			
Rm 86 N Floor	25	ND	**28324**			
Rm 86 NW Wall	20	ND	**3416**			
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.41/412	13.8\1,380	0.068\ 6.83

*Combined highest results from split samples

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.15.1 Building Survey

All building surfaces were surveyed. Fixed contamination was found on a large portion of the surfaces in rooms 88 and 88A at levels up to 369,259 dpm/100cm^2 beta-gamma and 2,396 dpm/100cm^2 alpha. Fixed contamination was found at a few random places on the surfaces in rooms 87 and 88B at levels up to 211,089 dpm/100cm^2 beta-gamma and 362 dpm/100cm^2 alpha. No contaminated material and debris was found in this area.

3.1.15.2 Samples and Results

Four samples were taken from this survey unit. Three of these were taken in Room 88: two from the wall (south and northeast) and one from the floor of the north doorway leading to room 93. The fourth sample was taken from the southeast wall of Room 87. Table 3-15 presents results of the static measurements and building material samples from this survey unit above the 1E-06 DCGL. Results identified above the 1E-04 DCGL are in bold. Results from the building material sample Rooms 87 and 88 showed Ra-226 and Cs-137 above DCGLs.

3.1.16 Main Building First Floor C (Class 1)

This survey unit included rooms 93, 95, 97, and 98 (approx. 360 m^2). Access was not controlled and the area is routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (93) made up most of the survey unit area. This room contained several large, operational machines, but all had many old materials that were no longer used. Personnel did not occupy the areas with the older material. Rooms 95 and 98 contained operational ovens and equipment and were routinely occupied. Room 97 was used for storage of USRM equipment and material which were to be moved in November 2006.

3.1.16.1 Building Survey

All building surfaces were surveyed. Fixed contamination was routinely found on surfaces in the entire survey unit at levels of 400 to 1,400 dpm/100cm^2 beta-gamma. Activity above these general readings was found on a large portion of the surfaces at levels up to 592,592 dpm/100cm^2 beta-gamma and 46,153 dpm/100cm^2 alpha. Many contaminated materials and debris were found in this area. These were packaged and relocated to a controlled area.

TABLE 3-15
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT B
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor – B Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)	
		α	βγ	Cs-137	Ra-226
Rm 87 E Wall	50	317	**9474**		
Rm 87 E Wall	50	160	**3865**		
Rm 87 S Wall	50	362	**7238**		
Rm 87 S Wall	50	356	**7111**		
Rm 87 S Wall	50	226	**8467**		
Rm 87 SE Wall	50	42	**2753**	1.22	4.72
Rm 88 Center Floor	50	104	**12681**		
Rm 88 Center Floor	90	30	**10611**		
Rm 88 Center Floor	90	178	**6889**		
Rm 88 Center Floor	90	141	**4889**		
Rm 88 E Wall	80	326	**43267**		
Rm 88 N Wall	140	133	**369259**		
Rm 88 N Wall	140	100	**233744**		
Rm 88 N Wall	50	263	**13089**		
Rm 88 N Center Floor	60	1072	**9852**		
Rm 88 N Doorway Floor	50	356	**28519**		0.52
Rm 88 N Doorway Floor	60	155	**10588**	0.56	
Rm 88 N Floor	80	1512	**16369**		
Rm 88 NW Wall	80	352	**47388**		
Rm 88 NW Wall	80	93	**50174**		
Rm 88 NW Wall	80	122	**140174**		
Rm 88 NW Wall	80	137	**47837**		
Rm 88 NW Wall	80	89	**76840**		
Rm 88 NW Wall	80	ND	**10000**		
Rm 88 NW Wall	80	<DCGL	**10000**		
Rm 88 NW Wall	80	**2396**	**342322**		
Rm 88 NW Wall	80	207	**332693**		
Rm 88 NW Wall	80	281	**369259**		
Rm 88 NW Floor	50	830	**15419**		
Rm 88 NW Floor	50	192	**2009**		
Rm 88 S Floor	90	256	**3352**		
Rm 88 S Wall by dock door	80	548	**11453**	0.74*	**6.89***
Rm 88 SW Floor	60	985	**12507**		
Rm 88 SW Wall	60	974	**12248**		
Rm 88 SW Wall	60	174	**2785**		
Rm 88 SW Wall	60	68	**6374**		

*Combined highest results from split samples

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

TABLE 3-15
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT B
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor – B Class 1	Field Data			Lab Results	
	Dose Rate (µR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)	
		α	βγ	Cs-137	Ra-226
Rm 88 W Floor	50	300	**9196**		
Rm 88A E Floor	60	303	**13521**		
Rm 88A E Center Overhead Ledge	60	62	**8734**		
Rm 88A E Wall	60	94	**234137**		
Rm 88A E Wall	60	96	**206138**		
Rm 88A E Wall	60	52	**12344**		
Rm 88A E Wall	40	60	**6096**		
Rm 88A E Wall	40	42	**3996**		
Rm 88A E Wall	40	29	**2829**		
Rm 88A N Floor	40	46	**19396**		
Rm 88A NW Floor	40	581	**9746**		
Rm 88A W Floor	40	516	**8843**		
Rm 88A W Floor	40	548	**19034**		
Rm 88A W Floor	40	414	**9155**		
Rm 88A W Floor	60	637	**15580**		
Rm 88A W Floor	60	785	**16023**		
Rm 88A W Floor	60	266	**52650**		
Rm 88A W Center Overhead Ledge	60	76	**9780**		
Rm 88B Center Floor	50	88	**23635**		
Rm 88B N Floor	50	289	**99715**		
Rm 88B N Floor	50	341	**211089**		
Rm 88B NE Wall	20	44	**25192**	0.41	3.53
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.41/41.2	0.068/6.83

*Combined highest results from split samples

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

Pictures below, from left to right, are Room 93 and Room 97.

3.1.16.2 Samples

Four samples were taken in this survey unit. All four were taken in Room 93. Two of these samples were wall samples taken from the east wall and the northeast (1^{st}) support column; the other two were taken from the floor (northwest and south by door). Table 3-16 presents results of the static measurements and building material samples with levels above the 1E-06 DCGL. Results above the 1E-04 DCGL are in bold. Three of the four samples showed elevated levels of contamination with Ra-226. A smear sample from an exhaust in Room 97 showed high levels of Ni-63.

3.1.17 Main Building First Floor D (Class 2)

This survey unit included rooms 96, 101,102, and 103 (approx. 230 m^2). Access to this area was not controlled. Surface materials were concrete floors, plaster walls, and plaster ceiling. Rooms 96 and 102 were used for shipping and receiving and were routinely occupied. Other than the sink and microwave area, Room 101 was not used with the exception for storage of debris. Room 103 contained large machining equipment. All rooms contained large amounts of material and debris.

TABLE 3-16
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING –FIRST FLOOR, SURVEY UNIT C
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 1 OF 2

Main Building 1st Floor – C Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²	
		α	βγ	Ni-63	Ra-226
Rm 93 Average - most of floor has activity	30	NA	1200		
Rm 93 NE Corner Post	20	11	**38461**		
Rm 93 NE Wall	20	22	**30769**		
Rm 93 NE Wall	20	17	**3076**		
Rm 93 NE Wall	20	12	**11111**		
Rm 93 NE Wall	20	14	**18515**		
Rm 93 NE Wall	20	7	**44444**		
Rm 93 NE Wall	20	16	**19816**		
Rm 93 NE Wall	20	34	**15384**		
Rm 93 NE Wall	20	14	**38461**		
Rm 93 NE Wall Support	20	117	**148148**		
Rm 93 NW Floor	20	80	**4074**		1.19*
Rm 93 S Center Wall	120	52	**2970**		
Rm 93 S Floor at Door	30	**7692**	**168115**		0.69*
Rm 93 SE Wall	20	196	**7692**		
Rm 93 SE Wall	20	55	**3846**		
Rm 93 SE Wall	20	229	**5384**		
Rm 93 SE Wall	20	196	**7407**		
Rm 93 SE Wall	20	ND	**11111**		
Rm 93 SE Wall	20	16	**37037**		
Rm 93 SE Wall	20	6	**7467**		
Rm 93 SE Wall		32	**30491**		
Rm 93 SW Floor	20	204	**2030**		
Rm 93 SW Floor	30	185	**3356**		
Rm 93 SW Floor	60	**34615**	**592592**		
Rm 93 SW Floor	60	414	**28900**		
Rm 93 SW Floor	80	834	**9322**		
Rm 93 SW Floor	80	**46153**	**15284**		
Rm 93 SW Floor	80	**13640**	**23859**		
Rm 93 SW Wall		68	**3731**		
Rm 93 SW Wall Max (whole wall has readings)	80	223	**11538**		

*Building Samples in pCi/g
**Smears in dpm/100cm²
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

TABLE 3-16
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT C
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 2 OF 2

Main Building 1st Floor – C Class 1	Field Data			Lab Results	
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²	
		α	βγ	Ni-63	Ra-226
Rm 95 Average-most of floor has activity	20	NA	800		
Rm 95 N Wall	20	22	**3846**		
Rm 95 N Wall	20	52	**11538**		
Rm 95 N Wall	20	20	**3846**		
Rm 95 N Wall	20	25	**7407**		
Rm 95 NE Wall	18	52	**461538**		
Rm 95 NE Wall	18	17	**3846**		
Rm 95 NE Wall	18	<DCGL	**3846**		
Rm 97 Average –most of floor has activity	30	NA	1400		
Rm 97 Group of empty dial envelopes from S file cabinet-30mR/hr @ 30 cm	1000	NA	NA		
Rm 97 N Exhaust	20	NA	NA	2970**	
Rm 97 N Wall	20	89	**3456**		
Rm 98 Average-most of floor has activity	20	NA	500		
Rm 98 W Access Door	20	**13640**	**23076**		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	1000***	0.068/ 6.83

*Building Samples in pCi/g
**Smears in dpm/100cm²
*** Acceptable transferable contamination level for Ni-63 is 1,000 dpm/100cm²
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.17.1 Building Survey

Most building surfaces were surveyed. Fixed contamination was found on building surfaces in only 4 places with a maximum level of 4,312 dpm/100cm^2 beta-gamma and 71 dpm/100cm^2 alpha. Many contaminated items were packaged and moved to a controlled area.

3.1.17.2 Samples and Results

Four samples were taken in this survey unit. Two samples were taken in Room 96; one on the north wall and one in the northwest corner in front of the door. A sample was taken from the northeast wall of Room 101, and another from the southwest floor of Room 103. Table 3-17 presents results of the static measurements and building material samples above the 1E-06 DCGL for this survey unit. Results above the 1E-04 DCGL are in bold. Samples from Room 96 showed Ra-226 in both samples and H-3 and Cs-137 in one of the samples. The sample from Room 101 showed elevated levels of H-3, Cs-137, and Ra-226. The sample from Room 103 showed elevated levels of H-3, Cs-137, and Np-237.

TABLE 3-17
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING –FIRST FLOOR, SURVEY UNIT D
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor – D Class 2	Field Data			Lab Results			
	Dose Rate (μR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit (pCi/g)			
		α	βγ	Cs-137	H-3	Ra-226	Np-237
Rm 96 Center Switch Box on E Wall	50	ND	**1941**				
Rm 96 Floor in front of N Door	40	71	**4312**	15.2	15.2	2.84	
Rm 96 Left Switch Box on E Wall	50	43	**2127**				
Rm 96 N Wall	40	ND	**3853**			0.35	
Rm 96 NW Wall	40	22	1419				
Rm 101 NE Wall	50	29	1731	0.97*	16.8*	2.01*	
Rm 103 Floor in SW Door	30	ND	1235		73.7*		1.73*
Rm 103 Floor in NW Corner	30	ND	**1917**				
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.41/4.12	13.8/ 1,380	0.068 /6.83	0.79/ 79.1

*Combined highest results from split samples

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.18 Main Building First Floor E (Class 2)

This survey unit included rooms 100, 104, 110, and 116 (approx. 450 m^2). Access was not controlled and the area is routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (100) and Room 110 contained USRM equipment. These materials were being surveyed for release by a USRM subcontractor to be moved to a new location in November 2006. Room 104 was used for storage and Room 116 was a foyer that contained old wooden timecard racks. All rooms contained large quantities of material and debris.

3.1.18.1 Building Survey

Most building surfaces were surveyed. Fixed contamination was found on few isolated surfaces in Rooms 100 and 116 at levels up to 113,100 dpm/100cm^2 beta-gamma and 8,043 dpm/100cm^2 alpha. No contaminated building surfaces were found in Rooms 110 and 104, but a contaminated large cabinet was found in Room 110 that could not be moved and the room was posted as “Radioactive Material”. Due to surveys being performed by USR Metals, materials in these rooms were not surveyed as part of the RI. Several contaminated items found during building surface surveys were packaged and moved to a controlled area. The photo below shows Room 100.

3.1.18.2 Samples and Results

Four samples were taken in this survey unit. In Room 100, a sample was taken in the center floor, the floor of the hall at the end of the southwest hallway, and from the northeast door. The last sample was taken from Room 116 from the timecard rack in the southeast corner. The photo below shows the sample location of the center floor in Room 100. Table 3-18 presents results of the static measurements and building material samples above the 1E-06 DCGL; results above the 1E-04 DCGL are in bold. One of the samples from Room 100 showed elevated levels of H-3, Np-237, and Ra-226. One sample had Pb-210 at levels above DCGLs. No radionuclides above DCGLs were detected in the other sample; however a smear sample also showed elevated levels of H-3. No radionuclides were detected above DCGLs in the sample from Room 116.

TABLE 3-18
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT E
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor - E Class 2	**Field Data**			**Lab Results**		
	Dose Rate (µR/hr)	**Measurement (dpm/100cm²)**		**Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²**		
		α	**βγ**	**H-3**	**Pb-210**	**Ra-226**
Rm 100 Floor Center of Room	30	377	**3770**			
Rm 100 Floor Center of Room	30	**8043**	**113100**		639*	
Rm 100 Floor Center of Room	30	ND	**5027**			
Rm 100 Floor Center of Room	30	ND	**94250**			
Rm 100 NE Door	30	1113	ND	19.1*		**2.69***
Rm 100 South Floor	20	822	**78510**			
Rm 100 South Solutient Tech Decon Area	20	NA	NA	2499**		
Rm 100 SW Doorway Floor	40	ND	**8796**			
Rm 100 SW Doorway Wall	40	ND	**8168**			
Rm 100 W Central Ceiling	30	ND	1489			
Rm 100 W Central Ceiling	30	ND	**3796**			
Rm 100 W South Floor	40	ND	**2944**			
Rm 116 SE Wall Time Card Box	20	**3770**	**8796**			
Rm 116 SW Wall Time Card Box	30	**1885**	**3141**			
Rm 116 W Exit Floor	30	ND	**2513**			
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	13.8/ 1,380	86.2/ 8,620	0.068\ 6.83

*Building Samples in pCi/g
**Smears in dpm/100cm²; transferable contamination limit of 1,000 dpm/100cm²
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.19 Main Building First Floor F (Class 2)

This survey unit included rooms 105, 106, 107, 108, 117, 119, and a loading dock (approx. 490 m^2). Access was not controlled but the most of the survey unit was rarely occupied during the time of the RI. Surface materials were concrete floors, plaster walls, and plaster ceiling. The largest room (106) and Room 105 contained very large conveyor equipment and pallets of debris. Rooms 108 and 107 were being routinely used as a machine shop and Room 119 had a single piece of equipment that was also routinely used. All rooms contained large amounts of material and debris.

3.1.19.1 Building Survey

Accessible building surfaces were surveyed. Fixed contamination was found on few isolated surfaces at levels up to 234,137 dpm/100cm^2 beta-gamma and 6,956 dpm/100cm^2 alpha. Any items found to be contaminated during building surface survey were packaged and either controlled in place or moved to a controlled area.

Four samples were taken in this survey unit. A sample was taken from the north middle post in Room 106 and one was taken from the northwest corner wall in Room 107. Two samples were taken from Room 117; one was taken from the south corner floor and one was taken from the northeast wall, about 20 feet from the back door. Table 3-19 presents results of the static measurements and building material samples above the 1E-06 DCGL; results above the 1E-04 DCGL are in bold. Ra-226 above the 1E-06 DCGL in Rooms 107 and 117. A smear sample from a cabinet in Room 108 showed high levels of Ni-63.

3.1.20 Main Building First Floor G (Class 3)

This survey unit included rooms 99A-B, 111-115, 120-127, 129-132, 135 (+WR), and 139 (approx. 620 m^2). Access was not controlled and the area is routinely occupied. Surface materials were concrete floors, plaster walls, and plaster ceiling. This survey unit was the administrative area for Safety Light Corporation (east end) and USRM (west end). All rooms contained excessive amounts of material and debris.

3.1.20.1 Building Survey

About 20 percent of building surfaces were surveyed, with areas having a history for potential contamination and areas where contamination was found subject to a 100 percent survey. Fixed contamination was found on a few isolated surfaces at levels up to 145,416 dpm/100cm^2 beta-gamma and 6,956 dpm/100cm^2 alpha. Many contaminated materials and debris were found in this area. They were packaged and relocated to a controlled area.

3.1.20.2 Samples and Results

Four samples were taken from this survey unit. A vanity partition was sampled in Room 115. The door between Rooms 120 and 139 was sampled. Two samples were taken of concrete floors. The first was taken from the front entrance to the building where several contaminated spots were found. The other was taken from Room 127 by the restroom. This was originally an old stairway to the laboratory, but was covered except for the top step that was sampled. These sample locations were filled in with concrete for safety, due to their location. Table 3-20 presents results of the static measurements and building material

TABLE 3-19
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT F
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Main Building 1st Floor - F Class 2	Field Data			Lab Results	
	Dose Rate (µR/hr)	Measurement (dpm/100cm²)		Radionuclides Present Above Limit *Building Samples in pCi/g **Smears in dpm/100cm²	
		α	βγ	Ni-63	Ra-226
Max on dock	20	144	**20409**		
Rm 105 E Floor	40	60	1704		
Rm 105 NE Floor	25	332	**3530**		
Rm 105 NE Floor	25	84	**3161**		
Rm 105 NW Floor	25	88	**3239**		
Rm 105 SE Floor	40	68	**2922**		
Rm 105 SE Radiator	40	215	**8328**		
Rm 105 SW Wall	40	ND	**7868**		
Rm 105 W Floor	40	48	1426		
Rm 105 W Floor	40	88	1569		
Rm 106 SE Wall	20	464	**11400**		
Rm 106 SE Wall	20	728	**9278**		
Rm 106 SE Wall	20	1331	**40930**		
Rm 106 SE Wall	30	238	**24430**		
Rm 106 SE Wall	30	238	**17372**		
Rm 106 W Floor	25	60	**6096**		
Rm 106 N Middle Post	25	60	**6096**		
Rm 107 E Door	20	ND	**4739**		
Rm 107 NW Corner Wall	20	94	**234137**		0.35*
Rm 108 NW Corner Wall	26	ND	**17949**		
Rm 108 SE Glass Window	27	**6956**	**6929**		
Rm 108 W Cabinet	22	NA	NA	1150**	
Rm 108 W Wall	22	1463	**13425**		
Rm 117 E Floor	25	96	**206138**		
Rm 117 NE Wall (20' from back door)	25	52	**12344**		5.19*
Rm 117 S Corner-back of room	20	NA	NA		
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	--	0.068/6.83

*Building Samples in pCi/g
**Smears in dpm/100cm²; transferable contamination limit of 1,000 dpm/100cm²
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

TABLE 3-20
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT G
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 1 OF 2

Main Building 1st Floor - G Class 3	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement ($dpm/100cm^2$)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	Cs-137	H-3	Ra-226
Rm 113B Hot Spot on SW Wall	25	52	**6935**			
Rm 113B Hot Spot on L Handrail	25	41	**1635**			
Rm 113C Hot Spot on R Handrail	22	33	**3469**			
Rm 115 Radiator on SW Corner Wall	22	441	**6746**			
Rm 115 Exhaust Fan on SW Corner Wall	22	24	**2313**			
Rm 121 Conduit on S Wall	19	422	**6554**			
Rm 120 Junction Box on S Wall	21	27	**2427**			
Rm 115 Vanity Partition	22	30	**10288**		30.5	**11.4**
Rm 115 Radiator on SW Corner Wall	22	185	1227			
Rm 115 Radiator on SW Corner Wall	22	141	1000			
Rm 122 Disconnect on E Wall	14	605	**6769**			
Rm 120 Door to Rm 139	45	556	**74795**		18.6*	**200***
Rm 120 NE Ceiling Light	17	580	**4130**			
Rm 120 NW Radiator	17	124	1508			
Rm 113A L Handrail	26	36	**1883**			
Rm 99A Sink	24	ND	1545			
Rm 99A Partitions	24	ND	1626			
Rm 99A Partitions	24	ND	**15102**			
Rm 99A Partitions	24	64	**18332**			
Rm 111 Door	22	144	**7261**			
Rm 111 Door	22	108	**4452**			
Rm 112 SE Wall	30	200	**145416**			
Rm 112 NE Wall	42	89	**63543**			
Rm 125 Hall Closet Floor	30	1682	**7383**			
Rm 112 N Outlet	28	185	**5682**			
Rm 125 W Wall	25	12	**4100**			
Rm 126 Exterior Door	15	24	**2087**			
Rm 126 Exterior Door	15	636	**1756**			
Rm 124 Bathroom Sink	18	142	**1420**			
Front porch R screen door	18	68	**2547**			
Rm 125 SE Corner Floor	20	769	**1667**			
Max activity of 10 hot spot found on front porch floor inside screen doors	18	294	**18891**	3.3		2.71
Rm 135wr R Sink	22	96	**2150**			
Rm 127 Floor at BR Door (Top step of old covered stairway)	20	331	**7169**	4.41*	27.7*	1.32*
Rm 128 R Disconnect	14	374	1604			

TABLE 3-20
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - FIRST FLOOR, SURVEY UNIT G
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 2 OF 2

Main Building 1st Floor - G Class 3	Field Data			Lab Results		
	Dose Rate (μR/hr)	Measurement ($dpm/100cm^2$)		Radionuclides Present Above Limit (pCi/g)		
		α	βγ	Cs-137	H-3	Ra-226
Rm 128 C Disconnect	14	630	**1824**			
Rm 128 L Disconnect	14	715	**2062**			
Rm 135 Crack in Floor	16	400	**20461**			
Rm 130 Chimney	18	37	**2789**			
Rm 129 BR SE Corner Wall	19	85	**20562**			
Rm 129 BR SW Corner Wall	19	ND	**10250**			
Rm 129 BR Sink	24	22	950			
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.41/41.2	13.8/1,380	0.068/6.83

*Combined highest results from split samples
All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

samples above the 1E-06 DCGL; results above the 1E-04 DCGL are in bold. Ra-226 was detected in all samples taken throughout the survey unit, including two samples above the 1E-04 DCGL, and tritium was found in three of the four samples. Cs-137 was detected above DCGLs in two of the samples.

3.1.21 Main Building Basement (Class 1)

This survey unit was made up of the two room basement and lower west stairwell (approx. 25 m^2). The basement was not originally known about or included as a survey unit, but was added after arrival on site and given a Class 1 rating (due to radiological posting). The door to room was locked and radiologically posted. Surface materials were concrete floors, wooden steps, and handrails, plaster walls, and plaster ceiling. The largest room made up most of the survey unit area and contained a large heating unit, water heater, pump, and debris. The smaller room contained only debris.

3.1.21.1 Building Survey

All building surfaces were surveyed. The rooms were contaminated in isolated random areas at levels up to 325,111 $dpm/100cm^2$ beta-gamma and 221,548 $dpm/100cm^2$ alpha. Since the room was a controlled area, no contaminated items were removed.

3.1.21.2 Samples

Three samples were taken from this unit. The floor was sampled in two places, in the northwest area and in the southeast corner by the brick debris. The third sample was taken from the west wall by the stairs. Table 3-21 presents results of the static measurements and building material samples above the 1E-06 DCGL; results above the 1E-04 DCGL are in bold. Ra-226 was detected in the floor sample from the northwestern end of the survey unit, the west wall of the survey unit, and the sample from the floor in the southeastern section of the room. Two of these samples showed Ra-226 above the 1E-04 DCGL.

TABLE 3-21
RADIOLOGICAL SURVEY AND SAMPLE RESULTS - MAIN BUILDING - BASEMENT
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Basement / Class 1	**Field Data**			**Lab Results**
	Dose Rate (µR/hr)	**Measurement ($dpm/100cm^2$)**		**Radionuclides Present Above Limit (pCi/g)**
		α	**βγ**	**Ra-226**
E Wall Conduit	18	**221548**	**325111**	
N Wall Beside Chimney	20	ND	**2502**	
N Wall Chimney	20	ND	**3170**	
NW Floor	19	**3000**	**45061**	**23.8**
NW Wall Disconnect Box	17	340	**2477**	
SE Floor	18	227	**5386**	
SE Floor	18	116	**4433**	
SE Floor	18	386	**10067**	
SE Floor by brick debris	18	386	**10067**	1.0
Supports Under Stairs	23	ND	**1900**	
W Wall by Steps	28	415	1208	
W Wall Pipe under stairs	17	1221	**1911**	**11.6**
DCGL (1E-06/1E-04 RISK)	--	17.4/ 1,740	17.4/ 1,740	0.068/6.83

All results shown are greater than 1E-06 risk unless otherwise indicated; bolded results exceed 1E-04 risk.

3.1.22 Nuclear (Tritium) Building (Class 3)

The Nuclear Building (Building 20 on Figure 1-2) is a metal building (approx. 1,030 m^2) used for tritium operations by SLC. Two rooms in this building were posted “Radioactive Material” and all rooms were used daily during the time of the RI.

3.1.22.1 Building Survey

All accessible interior building surfaces were surveyed with the exception of two rooms accessed from the second door on the left when entering the building from the west entrance (sketch on survey form in Appendix A identifies these rooms as "Tritium Rooms/Inaccessible"). These two rooms were still being used for tritium operations and had changing conditions with specific entry requirements (SLC radiological training and tritium surveillance program). No elevated readings were found on building materials. Several items of debris in the building were found to be contaminated, but were seemingly items that had been taken from the older buildings for use (i.e. tables and drying racks). These items were moved to a controlled area as addressed in Sections 2.2.3 and 2.4. Radiological surveys identified no activity above the DCGLs established for the survey unit.

3.1.22.2 Samples and Results

Three samples were taken in the Nuclear Building. One sample was taken from the east wall of the Health Physics Office. Another sample was taken from the ceiling in the Prep Area Room. The third sample was taken from the floor of the Men's Restroom. Laboratory analysis results for sample media identified no radiological activity above the DCGLs established for the survey unit.

3.1.23 <u>Solid Waste Building (Class 1)</u>

The Solid Waste Building (Building 13 on Figure 1-2) is a concrete block building (approx. 85 m^2) used by SLC for tritium operations waste storage. This building was radiologically posted. The building contains various wastes which precluded a through survey of the structure.

3.1.23.1 Building Survey

No interior building surfaces were surveyed. Waste from current tritium operations is being stored in this building and Tetra Tech employees did not meet the entry requirements (SLC radiological training and tritium surveillance program). Dose rates were taken from the door with an extendable detector dose rate instrument and all reading were < 0.2 mrem/hr. Activity above the DCGLs established for the survey unit could not be determined.

3.1.23.2 Samples and Results

No samples were taken in the Solid Waste Building since access was not permitted. Activity above the DCGLs established for the survey unit could not be determined.

It is unknown when this building was erected or what past uses might have been, therefore, no conclusions can be made about the likelihood of contamination in this building.

4.0 FATE AND TRANSPORT

4.1 FACTORS AFFECTING RADIONUCLIDE FATE, RELEASE, AND TRANSPORT

This section provides a discussion of the fate and transport of radionuclide contaminants associated with on-site buildings, building materials, and interior fixtures. At the Safety Light Site, radionuclide contamination associated with buildings could be released into the environment through gradual or event-specific processes. Incident-specific releases could be triggered by structural collapse, flooding, wind, or demolition events, while lower level releases may occur on an ongoing basis through processes such as dust resuspension and airborne migration of particulates.

The dominant factors affecting fate and transport of radionuclide contaminants in buildings involve considerations of structural integrity, the physical and chemical properties of contaminated surfaces, and the chemical and nuclear properties of individual radioisotopes. External structural barriers prevent or inhibit radionuclide releases to the environment, while structural decay and collapse accelerate contaminant migration. Wipe sampling is used to categorize interior surfaces or fixtures with regards to radionuclide contamination being fixed or erodible. The extent of contaminant erodibility depends on the chemical form of a radionuclide, the material composition, porosity, and surficial depth of contamination, and the presence or absence of fixation coatings applied to reduce the potential for radionuclide erodibility. The half-lives of parent isotopes and their associated decay chains dictate the timeframe over which individual radionuclides will exist and emit alpha, beta, or gamma radiation, and in some cases controls the transformation of the physical state of matter, for example when a solid element decays to a gaseous element or vice versa.

The rate of isotopic decay is an unalterable, intrinsic property of the nuclear physics of each isotope. However, the physical release and transport of radionuclide contaminants and the emission of radiation into the environment may be moderated by engineering controls. Engineering controls may restrict certain pathways for contaminant migration (for example, by using wet dust suppression methods or surface fixation coatings) or provide a material barrier which absorbs emitted radiation using various shielding materials effective for a particular type of radiation. Control strategies can be applied to limit exposures and spread of contaminants within intact and/or occupied buildings, or may be designed to limit dispersion of radionuclides during remediation, demolition, and removal.

4.2 CURRENT CONDITIONS OF ON-SITE BUILDINGS

As explained in Section 2.1, out of a total of 20 buildings on-site, seven represent physically unsafe conditions: the Personnel Office Building, Pipe Shop, Well House, Lacquer Storage Building, Radium

Vault, Old House, and the old part of the Etching Building. These buildings currently have compromised structural barriers to the outside environment, including deteriorated and/or collapsed roofs, which greatly increase the potential for further environmental releases and prevent safe access for sampling surveys. (Detailed descriptions of all buildings are provided in Section 1.2.3). For the remaining onsite buildings, radiation surveys were conducted and are documented in Section 3.1. The following summarizes some of the major survey observations relevant to the potential for release of radionuclides based on observed structural integrity, source locations, and wipe sampling results for erodible contamination:

- **Main Building, comprising the basement, the attic, the first floor (survey units A through G) and the second floor (survey units A through C)**: The attic has a structurally intact roof and finished interior. Most material and debris in the attic were non-releasable, based on the building survey. Isolated areas of fixed contamination were detected on surfaces. The second floor contains multiple rooms and survey units. Access was controlled for Survey Unit B. Fixed contamination was found on many of the second floor surfaces. Portions of the ceiling of the second floor had collapsed. The first floor also contains multiple rooms and survey units. Access was not controlled for this area. Fixed contamination was found on many of the first floor surfaces, with some survey units displaying a greater prevalence of contamination than other areas. The basement was locked and radiologically posted. Several isolated areas of contamination were identified in the basement.

- **Cesium Ion Exchange Hut**: The concrete block structure is intact, locked, and radiologically posted. Interior surfaces were tested and both fixed and transferable contamination was identified.

- **8 x 8 Building**: The concrete block structure is intact, locked, and radiologically posted. Interior surfaces were tested and contamination was identified.

- **Carpenter Shop**: The concrete block structure is intact, with sealed or nailed doors, and radiologically posted. Interior surfaces were tested and both fixed and transferable contamination was identified.

- **Machine Shop**: The concrete block structure is intact, is currently in daily use, and is radiologically posted. Interior surfaces were tested and contamination was identified.

- **Multi-Metals Building**: The concrete block building consists of 3 rooms, which are not radiologically posted. Fixed and transferable contamination was found on surfaces and heavy equipment contained in this building. Areas were painted to fix contamination and radiologically posted and barricaded to restrict access. Structural problems were noted that prevented a complete survey in two rooms.

- **Utility Building**: The concrete block structure is intact, with locked doors, and radiologically posted. Interior surfaces were tested and fixed contamination was identified.

- **Liquid Waste Building**: The intact metal building is built on a concrete slab. The building was in-use at the time of the survey and was posted for airborne radioactive contamination. Contamination was identified at maximum levels above a crack in the floor, which covers an area where an old building was dismantled and radium was poured into the hole where the foundation had been.

- **Etching Building (active portion aka Butler Building)**: The manufacturing addition of the etching building is an intact metal structure built over a concrete slab. The survey unit includes a small portion of the older building, currently used as a paint shop. The large room is currently used for equipment storage, and another area for current operations (radiologically posted). Only 20 percent of the building surfaces were surveyed. Areas in the active paint shop were not accessible for survey.

- **Silo**: The intact silo is a metal structure over a dirt floor. The silo is locked, radiologically posted, and in current use for storage of objects with fixed and transferable contamination. Fixed contamination was identified on all accessible surfaces.

- **Tritium Building**: The metal structure is intact, with locked doors, and radiologically posted in two rooms. Interior surfaces were tested, with exception of the posted rooms where tritium operations continued, and no contamination was observed.

- **Solid Waste Building**: The intact building was in-use at the time of the survey and was posted for radioactive contamination. The presence of radiological materials precluded investigation of this building.

In summary, those survey units where transferable contamination was identified and buildings where structural decay was evident present the greatest current risk for migration of radionuclides. Future deconstruction and demolition activities could potentially release significant quantities of radionuclide-contaminated dust and debris. Therefore, engineering controls would need to be considered to contain radionuclide releases during demolition, even for areas where sources of contamination have been currently categorized as "fixed" contamination.

4.3 RADIONUCLIDE DECAY CHAIN AND FATE PROCESSES

Table 4-1 presents the radionuclide half lives, decay chain progeny, and type of radiation emitted for each radionuclide of interest at the Safety Light Site. Radionuclide decay chain data were obtained from the public domain software utility, "Radiation Decay, Version 4", (Hacker, 2005) and are discussed below:

TABLE 4-1
DECAY CHAINS FOR POTENTIAL RADIONUCLIDES OF CONCERN
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 1 OF 3

Radionuclide	Half Life (years)	Radiation Emitted	Decay Chain Description [1] Element-Atomic Weight $_{\text{Half Life}}$ → (Radiation Emitted) + Daughter Product $_{\text{Half Life}}$
H-3	12	β^-	H-3 $_{\text{12 yrs}}$ → (β^-) + He-3 $_{\text{stable}}$
C-14	5,700	β^-	C-14 $_{\text{5700 yrs}}$ → (β^-) + N-14 $_{\text{stable}}$
Co-60	5.3	β^-, γ	Co-60 $_{\text{5..3 yrs}}$ → (β^-,γ) + Ni-60 $_{\text{stable}}$
Ni-63	100	β^-	Ni-63 $_{\text{100 yrs}}$ → (β^-) + Cu-63 $_{\text{stable}}$
Sr-90	29	β^-	Sr-90 $_{\text{29 yrs}}$ → (β^-) + Y-90 $_{\text{64 hrs}}$ → (β^-) + Zr-90 $_{\text{stable}}$
Cs-137	30	β^-, γ	Cs-137 $_{\text{30 yrs}}$ → (β^-,γ) + Ba-137m $_{\text{2.6 min}}$ → (γ) + Ba-137 $_{\text{stable}}$
Tl-204	3.8	β^-	Tl-204 $_{\text{3.8 yrs}}$ → Two daughter progeny: Lead and Mercury Lead: 97.1% (β^-) + Pb-204 $_{\text{stable (t ½ > 1.4E+17)}}$ Mercury: 2.9% (electron capture) + Hg-204 $_{\text{stable}}$
Pb-210	22	α, β^-, γ	Pb-210 $_{\text{22 yrs}}$ → (β^-,γ) + Bi-210 $_{\text{5.0 days}}$ → (β^-,γ) + Po-210 $_{\text{140 days}}$ → (α,γ) + Pb-206 $_{\text{stable}}$
Ra-226	1,600	α, β^-, γ	Ra-226 $_{\text{1600 yrs}}$ → (α,γ) + Rn-222 $_{\text{3.8 days}}$ → (α,γ) + Po-218 $_{\text{3.1 min}}$ → (α) + Pb-214 $_{\text{27 min}}$ Pb-214 $_{\text{27 min}}$ → (β^-,γ) + Bi-214 $_{\text{20 min}}$ → (β^-,γ) + Po-214 $_{\text{160 µsec}}$ → (α,γ) + Pb-210 $_{\text{22 yrs}}$ Pb-210 $_{\text{22 yrs}}$ → (β^-,γ) + Bi-210 $_{\text{5.0 days}}$ → (β^-,γ) + Po-210 $_{\text{140 days}}$ → (α,γ) + Pb-206 $_{\text{stable}}$

TABLE 4-1
DECAY CHAINS FOR POTENTIAL RADIONUCLIDES OF CONCERN
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA

Radionuclide	Half Life (years)	Radiation Emitted	Decay Chain Description [1] Element-Atomic Weight $_{\text{Half Life}}$ → (Radiation Emitted) + Daughter Product $_{\text{Half Life}}$
Ac-227	22	α, β⁻, γ	Ac-227 $_{\text{22 yrs}}$ → Two progeny decay chains: Thorium and Francium Thorium chain: 98.6% (β^-,γ) + Th-227 $_{\text{19 days}}$ → (α,γ) + Ra-223 $_{\text{11 days}}$ Ra-223 $_{\text{11 days}}$ → (α,γ) + ** Rn-219 $_{\text{3.9 sec}}$ → (α,γ) + Po-215 $_{\text{1.8 msec}}$ → (α,γ) + Pb-211 $_{\text{36 min}}$ Pb-211 $_{\text{36 min}}$ → (β^-,γ) + Bi-211 $_{\text{2.1 min}}$ → (α,γ) + Tl-207 $_{\text{4.8 min}}$ → (β^-,γ) + Pb-207 $_{\text{stable}}$ Francium chain: 1.4% (α,β^-) + Fr-223 $_{\text{22 min}}$ → (β^-,γ) + Ra-223 $_{\text{11 days}}$ → (α,γ) + Rn-219 $_{\text{3.9 sec}}$ Rn-219 $_{\text{3.9 sec}}$ → (α,γ) + Po-215 $_{\text{1.8 msec}}$ → (α,γ) + Pb-211 $_{\text{36 min}}$ Pb-211 $_{\text{36 min}}$ → (β^-,γ) + Bi-211 $_{\text{2.1 min}}$ → (α,γ) + Tl-207 $_{\text{4.8 min}}$ → (β^-,γ) + Pb-207 $_{\text{stable}}$
Np-237	2.1×10^{6}	α, β⁻, γ	Np-237 $_{\text{2,100,000 yrs}}$ → (α,γ) + Pa-233 $_{\text{27 days}}$ → (β^-,γ) + U-233 $_{\text{160,000 yrs}}$ → (α,γ) + Th-229 $_{\text{7,300 yrs}}$ Th-229 $_{\text{7,300 yrs}}$ → (α,γ) + Ra-225 $_{\text{15 days}}$ → (β^-,γ) + Ac-225 $_{\text{10 days}}$ → (α,γ) + Fr-221 $_{\text{4.9 min}}$ Fr-221 $_{\text{4.9 min}}$ → (α,γ) + At-217 $_{\text{32 msec}}$ → (α,γ) + Bi-213 $_{\text{46 min}}$ Bi-213 $_{\text{46 min}}$ → Two progeny decay chains: Polonium and Thallium Polonium chain: 97.9% (β^-,γ) + Po-213 $_{\text{19 days}}$ → (α,γ) + Pb-209 $_{\text{3.3 hrs}}$ → (β^-) + Bi-209 $_{\text{stable}}$ Thallium chain: 2.1% (α,γ) + Tl-209 $_{\text{19 days}}$ → (β^-,γ) + Pb-209 $_{\text{3.3 hrs}}$ → (β^-) + Bi-209 $_{\text{stable}}$

TABLE 4-1
DECAY CHAINS FOR POTENTIAL RADIONUCLIDES OF CONCERN
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA
PAGE 3 OF 3

Radionuclide	Half Life (years)	Radiation Emitted	Decay Chain Description [1] Element-Atomic Weight $_{\text{Half Life}}$ → (Radiation Emitted) + Daughter Product $_{\text{Half Life}}$
U-238	4.5×10^9	α, γ	U-238 $_{\text{4,500,000,000 yrs}}$ → (α,γ) + Th-234 $_{\text{24 days}}$ → (β^-,γ) + Pa-234m $_{\text{1.2 min}}$ Pa-234m $_{\text{1.2 min}}$ → (β^-,γ) + U-234 $_{\text{250,000 yrs}}$ → (α,γ) + Th-230 $_{\text{75,000 yrs}}$ Th-230 $_{\text{75,000 yrs}}$ → (α,γ) + Ra-226 $_{\text{1,600 yrs}}$ Ra-226 $_{\text{1,600 yrs}}$ → (see decay chain above)
Am-241	430	α, γ	Am-241 $_{\text{432 yrs}}$ → (α,γ) + Np-237 $_{\text{2,100,000 yrs}}$ Np-237 $_{\text{2,100,000 yrs}}$ → (see decay chain above)

(1) Hacker, C, 2005. Radiation Decay. Version 4. Griffith University, School of Engineering. Gold Coast, Australia. September.

4.3.1 Radium, Radon, and Associated Progeny

Radium (Ra-226) is a parent isotope for the radon decay chain and is considered persistent due to a relatively long half life (1600 years). Intermediate progeny are short-lived (Rn-222, Po-218, Pb-214, Bi-214, and Po-214); each with half lives less than 4 days, and so within a few half-lives of the progeny will reach equilibrium with the parent isotope such that the progeny decay rate will match the decay rate of the parent isotope Ra-226. The subsequent daughter product of this decay chain is Pb-210, which has an intermediate half life of 22 years. Pb-210 will then decay to short lived progeny (Bi-210 and Po-210), which in turn decay to a stable lead isotope (Pb-206), which is not radioactive. Therefore, the production of radon gas will continue as long as the source Ra-226 is present, while this source exhibits a very slow decay rate due to a long half life.

Inhaled radon is mostly exhaled before it decays. The exposure hazards from radon arise from its progeny, which exist in the solid phase and are deposited on lung surfaces. The physical properties of Rn-220 and its progeny are almost the same as those of Rn-222 and its progeny, and their short-lived alpha-emitting daughter nuclides create health risks from their decay. Once radon decays, the decay products become solids with ionic charges as a result of decay reactions. These charged ions quickly attach to airborne aerosol particles.

Removal by air exchange of indoor air with the outside air and gradual deposition of radon progeny on surfaces within a building are important fate processes because the decay and ingrowth time is much longer for indoor radon than for outdoor radon. Indoors, radon decay progeny may deposit on various surfaces and plate-out is a complex process involving multiple deposition surfaces (DOE, 2001). The rate of plate-out is termed the deposition velocity, and is expressed as a ratio of mass deposited on a surface (atoms per unit area per unit time) divided by air concentration (atoms per unit volume). Estimated plate-out deposition velocities have been published which range from 0.05 cm/s for the highly reactive unattached fraction to 0.00075 cm/s for the fraction that has already attached to aerosol particles (Knutson et al. 1983; Bodansky et al. 1987). For a room with a floor area of 12 m^2 and a ceiling height of 2 m, this corresponds to a removed mass fraction (out of the total airborne particulate aerosol mass) per unit time of 0.065 per minute for the unattached fraction and 0.00090 per minute for the attached fraction. Given typical air exchange rates of 0.3 to 1.0 room air replacement volumes per hour, this equates to removal rates of 0.005 to 0.0167 airborne particulate aerosol mass fractions removed per minute. The unattached fraction of radon progeny in indoor air is estimated to range from 1% to 10% (National Research Council, 1991).

4.3.2 Actinium-227 and Associated Progeny

Actinium-227 (Ac-227) is the parent isotope for two separate progeny decay chains and is considered to have intermediate persistence due to a relatively short half life (22 years). One decay chain starts with the daughter product thorium-227 (Th-227 - 98.6%, half life 19 days), while the other begins with francium-223 (Fr-223 - 1.4%, half life 22 minutes). When Th-227 decays, the intermediate progeny are short-lived (Ra-223, Rn-219, Po-215, Pb-211, Bi-211, and Tl-207, each with half lives less than 11 days). The end product of this decay chain is a stable lead isotope (Pb-207), which is not radioactive. The other daughter product of the decay of Ac-227, Fr-223, generates progeny that are short-lived (Ra-223, Rn-219, Po-215, Pb-211, Bi-211, and Tl-207, each with half lives less than 11 days). The end product is Pb-207, which is not radioactive. Therefore, the production of radon gas (Rn-219) as an intermediate in this decay chain will continue as long as the source Ac-227 is present, since the parent isotope exhibits a slower decay rate.

4.3.3 Neptunium-237 and Associated Progeny

Neptunium-237 (Np-237) is considered to be persistent due to a long half life (2.1 million years). Initially, Np-237 decays to uranium-233 (U-233). U-233 has a half life of 160,000 years and decays to thorium-229 (Th-229), which in turn has a half life of 7300 years. Th-229 generates several short-lived radioisotopes, each possessing a half life on the order of a few days or less. The intermediate short-lived progeny are produced in the sequence: Ra-225, Ac-225, Fr-221, At-217, and Bi-213. The product Bi-213 then decays to form two radioisotopes - polonium-227 (Po-227 - 98.6%) and francium-223 (Fr-223 - 1.4%). Po-213 and Tl-209 have identical half lives of 19 days each, and both decay to form lead-209 (Pb-209), which has a half life of 3.3 years. Pb-209 decays to form a stable isotope, bismuth-209 (Bi-209), which terminates the decay sequence.

4.3.4 Tritium

H-3 has an intermediate persistence due to a relatively short half life (12 years). It decays to a stable helium isotope (He-3), which is not radioactive. The chemical form of tritium is likely to be tritiated water vapor (HTO), which readily evaporates from contaminated surfaces and is therefore highly mobile in the air phase. However, in some cases H-3 may not be in the chemical form of HTO and could be incorporated into the entity of the building material through molecular exchange, which would prohibit the vaporization of HTO (DOE, 2003).

4.3.5 Thallium-204

Tl-204 has an intermediate persistence due to a relatively short half life (3.8 years). It decays to form two radioisotopes, lead-204 (Pb-204 - 97%) and mercury-204 (Hg-204 - 3%), both of which are stable (not radioactive).

4.3.6 Cesium-137

Cs-137 has an intermediate persistence due to a relatively short half life (30 years). It decays to form a very short-lived metastable radioisotope, barium-137m (Ba-137m), which has a half life of 2.6 minutes. Ba-137m then decays to form the stable barium isotope, Ba-137.

4.3.7 Strontium-90

Sr-90 has an intermediate persistence due to its half life of 29 years. It decays to form a short-lived radioisotope, yttrium-90 (Y-90), which has a half life of 64 hours. Y-90 then decays to form the stable zirconium isotope, Zr-90.

4.3.8 Nickel-63, Cobalt-60, and Carbon-14

Ni-63, Co-60, and C-14 are radioisotopes with half lives of 100 years, 5.3 years, and 5,700 years, respectively. Each of these radioisotopes decays to form stable isotopes - copper-63 (Cu-63), nickel-60

(Ni-60), and nitrogen-14 (N-14), respectively. All of the decay end products are solids except for nitrogen, which is a gas.

4.3.9 Americium-241

Am-241 has a half life of 432 years. It decays to form the persistent radioisotope, Np-237, which has a very long half life of 2.1 million years. The progeny, Np-237, generates a decay chain which produces several intermediate radioisotopes as described in Section 4.3.3.

4.3.10 Uranium-238

U-238 has a very long half life of 4.5 billion years. It decays into a short-lived chain of two radioisotopes, thorium-234 (Th-234 - half life 24 days), followed by protactinium-234m (Pa-234m - half life 1.2 minutes). Pa-234m decays to form uranium-234 (U-234 - half life 250,000 years), which then decays to form thorium-230 (Th-230 - half life 75,000 years). Th-230 decays to form radium-226 (Ra-226 - half life 1,600 years), which then generates a sequence of several intermediate radioisotope decay products as described in Section 4.3.1.

5.0 HUMAN HEALTH RISK ASSESSMENT

This section describes the human health risk assessment (HHRA) performed as part of the OU-1 RI/FS for SLC. The scope of this HHRA is to evaluate potential exposures by human receptors to radionuclides present in buildings located on-site, and apply appropriate dose-based and cancer risk-based toxicity factors to risk assessment calculations in accordance with current EPA, NRC, and DOE guidance. The tables associated with the HHRA follow the format adopted by EPA RAGS, Volume I, Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments (EPA, 2001a). All cancer risk estimates and dose estimates for radionuclides were generated using the radionuclide exposure modeling program, RESRAD-BUILD (DOE, 2007).

5.1 EXPOSURE ASSESSMENT

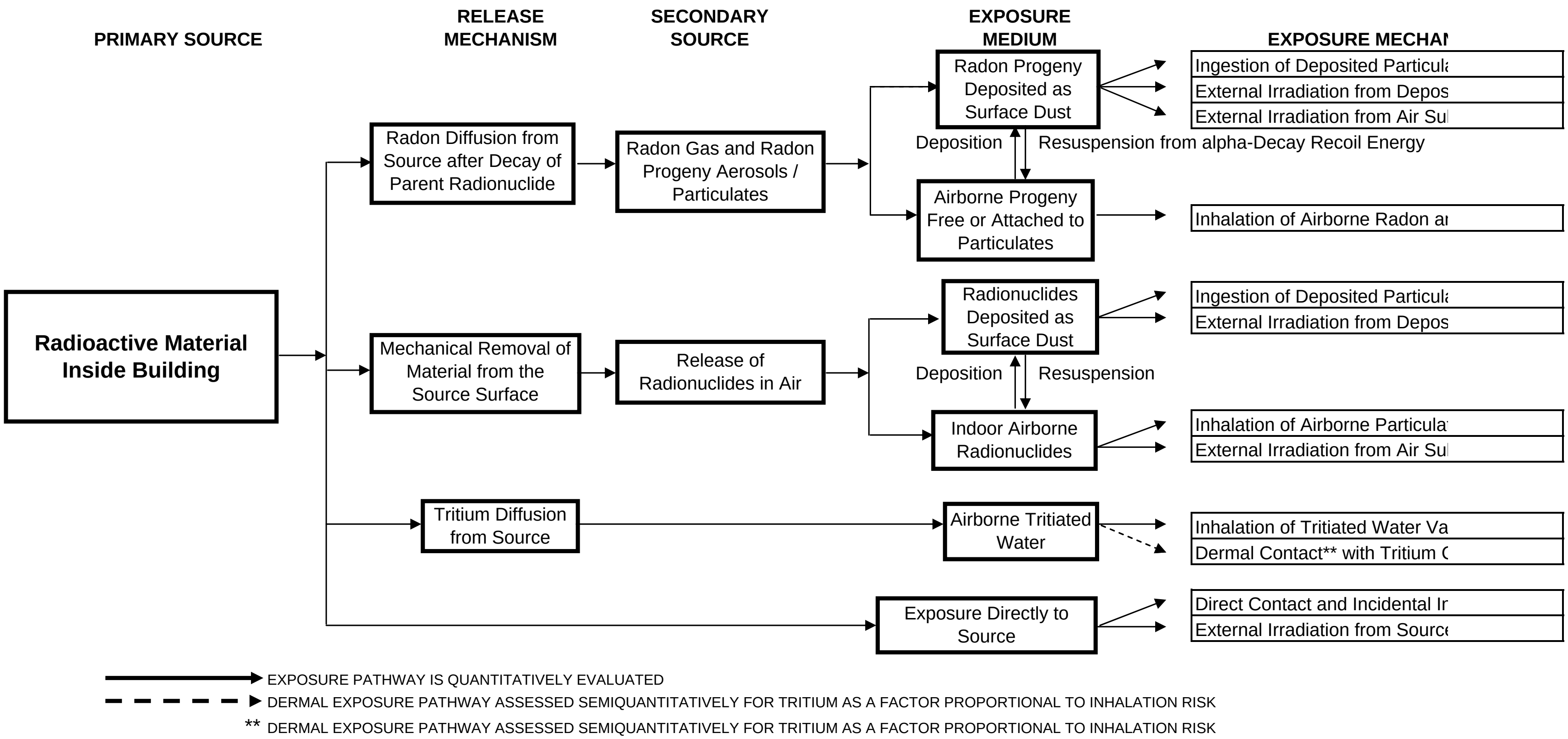
5.1.1 <u>Receptors and Activity Patterns</u>

As illustrated in the conceptual site model shown in Figure 5-1, the potential receptors that might occupy or frequent buildings at the site include occupational (office) workers, site visitors, and construction workers involved with remediation or renovation activities. Of these, quantitative risks were estimated only for the full-time occupational (office) worker, because this represents the most conservative exposure scenario. Risks would be lower for the other receptors because, when compared to the occupational worker, exposure frequency in days per year would be much shorter for a site visitor and exposure duration in years would be shorter for a construction worker.

5.1.2 <u>Buildings Selected for Exposure Evaluation</u>

Exposure evaluations were conducted for those buildings where quantitative survey data were able to be gathered. Radionuclide surveys were able to be conducted if building structural conditions were safe enough to allow entry and monitoring/sampling. As explained in Section 2.1, out of a total of 20 buildings on-site, seven were excluded from sampling due to unsafe physical conditions: the Personnel Office Building, Pipe Shop, Well House, Lacquer Storage Building, Radium Vault, Old House, and the old part of the Etching Building. In addition, the Pole Building was not evaluated at this time because wastes stored in the building have not yet been removed, and the Old Garage Foundation was not evaluated because the concrete slab was not currently accessible due to vegetation overgrowth. These areas are planned for a later characterization during the OU-3 investigation. The Nuclear (Tritium) Building underwent a radionuclide survey investigation in January 2008, after the other building surveys were completed, since at the time of the OU-1 initial field survey this area was still an active facility under NRC license to handle radioisotopes. As of the date of this report, a radionuclide survey of the solid waste building was not able

FIGURE 5-1
CONCEPTUAL SITE MODEL - HUMAN HEALTH RISK ASSESSMENT
SAFETY LIGHT CORPORATION SITE OU-1
BLOOMSBURG, PENNSYLVANIA



to be completed because the building currently contains quantities of stored radiological waste. All other onsite buildings were evaluated for receptor exposure to radionuclides, and quantitative risks were estimated using RESRAD-BUILD for each of the following areas of interest:

- Main Building, comprising the basement, the attic, and floors 1 and 2
- Cesium Ion Exchange Hut
- 8 x 8 Building
- Carpenter Shop
- Machine Shop
- Multi-Metals Building
- Utility Building
- Liquid Waste Building
- Etching Building (portions not in current use for radioactive waste storage)
- Silo (considered only for dose evaluation, not applicable to full time worker occupancy
- Tritium Building

5.1.3 Exposure Points Assessed: Survey Units and Sources

As described in section 2.1, buildings were subdivided into one or more survey units so that the rigor of each radiation survey could be optimized for the potential hazards in that area. Smaller buildings were usually designated as a single survey unit, while larger buildings encompassed multiple survey units. Surface scan measurements for radionuclides were performed separately for individual sources within each survey unit. Surface scan data were reported in units of disintegrations per minute per square meter (dpm/m2), whereas wipe sample results were reported in picocuries per square meter (pCi/m2).

For assessing exposure to sources located within a particular room of a survey unit, at least two different receptor positions were assumed using separate RESRAD simulation runs in order to ensure that potential reasonable maximum exposure conditions were encompassed. Generally, receptors were assumed to be located 1 meter from the floor and 1 meter from a source, and either at the midpoint along a wall source or else near the room corner. RESRAD exposure simulation risks were then reviewed for each room source and only the receptor location associated with the highest estimated cancer risk was tabulated on RAGS D tables.

5.1.4 Additivity of Receptor Exposures Across Multiple Sources

Within each survey unit, receptor cancer risks were assumed to be additive across all source locations. However, to avoid overestimating the total risks from a worker exposed simultaneously to several sources positioned in different rooms or at different locations in a room, the fraction of time exposed to any one source was assumed to be the reciprocal of the number of sources measured for that survey unit. Cumulative risks from all sources were summed in an external spreadsheet file since only a limited number of sources – up to 10 – can be included in a single RESRAD-BUILD simulation run. For example, a typical survey unit might consist of 10 sources included in one simulation run (output file labeled "Field No. 1"), 10 more sources in a second simulation (file labeled "Field No. 2"), and three more sources from wipe samples (file labeled "Samples"). Hence, in this exposure scenario, an office worker would be assumed to be exposed to each source for 1/23 x 40 hours over the course of a work-week.

Further details regarding the measured geometry of each room, radionuclide source locations, and simulated receptor locations are provided in the RESRAD model outputs in Appendix C for each survey unit evaluated.

5.1.5 Exposure Duration Assumptions for the Occupational Worker

Cumulative cancer risks were estimated over a reasonable maximum duration of employment for an occupational worker, assuming a 25 year period of full-time employment and in most cases 100 percent of the worker's time spent in one survey unit. Therefore, the fraction of the year occupancy for most survey units was assumed to be (50/52 weeks per year) x (5/7 days per week) x (8/24 hours per day). For very small space or limited use survey units, only 1 hour per day was assumed. The starting timeframe for worker exposure was assumed to be the present year (time = 0). This represents a conservative estimate of exposure because dose simulations conducted at different starting times reveal that the highest annual receptor dose rate would occur in the first year. (Appendix C, Part 2 contains RESRAD simulation runs which illustrates the relative difference in dose rates that would result from one year of exposure beginning at different starting times. Similarly, Appendix C, Part 3 shows a similar trend in the relative difference in cancer risks resulting from one year of exposure beginning at different starting times.) This tapering reduction in annual dose rate is a consequence of radioactive decay processes that deplete source materials over time, in conjunction with gradual mechanical erosion of radioactive dust from contaminated surfaces until surface contamination is depleted.

5.1.6 Exposure Pathways

The conceptual site model shown in Figure 5-1 describes several exposure pathways which may result in radiation exposures to building occupants. The following pathways of exposure were modeled:

- External body exposure to radiation emitted directly from the source
- External body exposure to radiation emitted from particulates deposited on room surfaces
- External exposure to radiation due to submersion in airborne radioactive particulates

- Inhalation of airborne radioactive particulates
- Inhalation of radon gas and aerosol indoor radon decay products
- Inhalation of tritiated water vapor (HTO)
- Incidental ingestion of radioactive particulates from contact directly with the source
- Incidental ingestion of radionuclides in removable particulates deposited on room surfaces

The first three pathways would result in external body exposure, and the last five would result in internal exposure due to internal contamination of the exposed individual. In RESRAD-BUILD, the external radiation doses are evaluated as the effective dose equivalent, and the internal exposure is evaluated as the committed effective dose equivalent (CEDE). Note that biological dose from external exposure occurs only for a limited timeframe while the receptor is within proximity to allow direct irradiation by the source. In contrast, internal irradiation dose associated with radionuclide ingestion or inhalation can continue to occur long after the initial contact due to the persistence of the radionuclide in the body. The total radiation dose, which is the sum of the external and internal doses, is expressed as the total effective dose equivalent (TEDE).

The RESRAD-BUILD model utilizes an indoor air quality model to estimate the release rate of radionuclides from contaminated surfaces, whether through diffusion, mechanical erosion, or resuspension (DOE, 2003). Air exchange coefficients are used to estimate the airborne mass removal rates from room ventilation, and deposition and resuspension rates are estimated for each radionuclide using the input parameters specified in Appendix D, Table 4.01.

5.1.7 <u>RESRAD Dose Estimation</u>

An evaluation of radiological dose (mrem/yr) exposure was performed separately from the evaluation of cancer risks. Dose assessment involved estimating the total effective dose equivalent (TEDE) resulting from one year of external radiation exposure plus one year of internal radionuclide uptake from ingestion and inhalation, followed by lifetime internal exposure based on the persistence and decay of each radionuclide within the body. The TEDE from a one year exposure can be compared to established NRC dose criteria. NRC criteria for annual exposure are expressed as mrem/yr, and are intended for assessment of general protectiveness for most types of exposed workers, but are not specifically designed to model the long-term activity patterns for a particular type of receptor.

For the dose assessment, four scenarios were modeled, each of which involve one year of exposure -- beginning at the present time (year zero), year 1, year 5, or year 30. Note that the year zero exposure represented the highest dose in each case.

The significant differences between the input parameters used in the RESRAD modeling performed for cancer risk assessment and reported on RAGS D Tables versus the dose assessment reported in Appendix C, Part 2 are summarized as follows:

- **Exposure Duration:** The cancer risk assessment assumed 25 years of on-site exposure starting at the present time, while the dose assessment assumed one year of on-site exposure, with multiple starting times for comparison purposes.

- **Indoor Time Fraction:** In the dose assessment, the RESRAD-BUILD indoor time fraction was assumed to be 0.5. This corresponds to 12 hours per day of exclusive exposure to one source over 365 days per year. Generally, dose was not totaled across all source locations within a survey unit. In contrast, the cancer risk assessment assumed 40 hours per week of exposure, with an equal fraction of time apportioned to different sources. Risks were then totaled across source locations.

- **Ingestion Pathway Assumptions:** Incidental ingestion from direct contact with the source was assumed only for the cancer risk assessment, and was is in addition to incidental ingestion from radionuclide dusts that are eroded from surfaces and deposited on other room surfaces. In contrast, the dose assessment considered only indirect ingestion exposure from redeposited dusts. As noted in the uncertainty section, the RESRAD-BUILD model only accounts for mass balance from gradual depletion of the source over time within the air quality model used for suspension and deposition of radionuclides, whereas there is no internal control over mass balance with direct ingestion from the source.

5.1.8 <u>Summary of RESRAD-BUILD Input Parameters and Calculation Methods</u>

For the exposure assessment, site-specific and receptor-specific input parameters for RESRAD-BUILD are listed in Appendix D, Table 4.01. Any RESRAD input parameters not otherwise listed in this table were accepted as default values from the model. The RESRAD-BUILD model employs a complex series of equations to estimate the time-varying transport, fate, decay, and integrated receptor dose arising from multiple exposures to radionuclides. The model incorporates isotopic decay chains, dynamic indoor air quality modeling, and route-specific biologic dosimetry considerations. Equations associated with all aspects of this simulation model are described in detail in Appendices A through G of the RESRAD-BUILD User's Guide (DOE, 2003).

5.2 DATA EVALUATION

The following discussion summarizes the data evaluation process that was used to evaluate the analytical data sets for each survey unit and select concentrations of radionuclides for use in estimating receptor exposure.

5.2.1 Data Quality Evaluation

Before analytical data could be used in the risk assessment, a data quality evaluation was performed by reviewing validated data for any problems with detection limit adequacy, rejected data, blank qualified data, and bias or imprecision. Rejected or blank qualified data are not considered acceptable for use in the risk assessment, while estimated values are accepted for use, but may be associated with caveats in the HHRA uncertainty analysis.

5.2.2 Identification of COPCs

As discussed in Section 2.2.4, radionuclide survey Derived Concentration Guideline Levels (DCGLs) were used to select a list of radionuclides as chemicals of potential concern (COPCs). Analytical results from all COPCs were used for RESRAD modeling.

5.2.3 Exposure Point Concentrations for Source Locations

The exposure point concentration (EPC) provides a mathematical procedure for estimating the chemical input into each of the exposure pathways. The EPC represents an estimated chemical concentration to which a receptor is assumed to be instantaneously exposed while in contact with an environmental medium. Each source measurement location was considered an independent exposure point, so that risk-based decisions for remedial options can be considered separately for each contributing source within a survey unit. For evaluation of direct ingestion cancer risk, a receptor's intake rate was divided equally among the different source locations within one survey unit. Therefore, statistical estimates of the 95 percent Upper Confidence Limit (UCL) were not calculated because only one data point was considered for each individual exposure point source.

For each survey unit, Appendix D, RAGS D Table 3s present the radionuclide exposure point concentrations associated with each source. However, these values are only a snapshot of the initial concentrations at the beginning of the exposure period, whereas RESRAD-BUILD incrementally estimates the time-varying radionuclide concentrations which are then integrated to yield cumulative receptor exposure over time.

5.3 TOXICITY ASSESSMENT

The toxicity assessment presents the available cancer and noncancer toxicity factors for each exposure route and for each COPC. In the case of radionuclide risk assessment, the benchmark concentration representing the threshold for unacceptable cancer risk is typically a more sensitive endpoint than the concentration corresponding to a reference dose which is only protective against adverse noncancer toxicity effects. For the radionuclides detected in this risk assessment, noncancer effects were not necessary to separately evaluate due to the generally low concentrations detected.

Oral, inhalation, and external radiation cancer slope factors (SFs) for all COPCs are provided in Appendix D on RAGS D Tables 6.1, 6.2, and 6.4, respectively. SFs have been listed in units of risk per picocurie (risk/pCi). These slope factors can be converted to different units if desired in order to match the RESRAD-BUILD output slope factors listed in Appendix C in units of risk per disintegrations per minute (risk/dpm) or the EPA Federal Guidance Report No. 13 (FGR 13) slope factors listed in units of risk per Becquerel (risk/Bq) as follows: (Risk/pCi) / 2.22 = (Risk/dpm) and (Risk/pCi) x 27.027 = (Risk/Bq). For most radionuclides, RESRAD-BUILD utilized slope factors obtained from EPA Health Effects Summary Tables (HEAST - EPA, 2001b) or FGR 13 (EPA, 1999).

5.3.1 <u>EPA Weight of Evidence</u>

The weight-of-evidence designations indicate the preponderance of evidence regarding carcinogenic effects in humans and animals. All radionuclides are considered known human carcinogens (Class A), based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiogenic cancers in humans. At Superfund radiation sites, EPA generally evaluates potential human health risks based on the radiotoxicity, i.e., adverse health effects caused by ionizing radiation, rather than on the chemical toxicity, of each radionuclide present. These evaluations consider the carcinogenic effects of radionuclides only. In most cases, cancer risks are limiting, exceeding both mutagenic and teratogenic risks.

5.4 RISK CHARACTERIZATION

This section presents the potential human health risks from exposure to radionuclide concentrations in building materials. Incremental cancer risks (ICRs) were estimated for cumulative occupational exposure and are summarized on RAGS Part D Tables in Appendix D. For each survey unit, Appendix D, Table 8s present the exposure point concentrations, cancer slope factors, and ICRs associated with each source location. These tables total the estimated cancer risk across all radionuclides and routes of exposure, and provide subtotals for individual sources within each survey unit. Note that the RESRAD-BUILD model internally combines the calculated dose or risks across all routes of exposure before presenting the risks for one individual radionuclide and also consolidates the risks across all radionuclides before presenting route-specific risk estimates. Therefore, the RAGS D Table 8s and 10s shown in Appendix D were not able to provide route-specific-chemical-specific risks, whereas all of the marginal subtotals were able to be extracted from RESRAD-BUILD output files that are documented in Appendix C, Part 1. Note that the same limitations apply with the second set of RESRAD-BUILD simulations that estimate dose instead of cancer risk, as presented in Appendix C, Part 2.

5.4.1 Comparison of Cancer Risk Estimates to Benchmark Criteria

In order to interpret risks to aid risk managers in determining the need for remediation at a site, quantitative cancer risk estimates were compared to typical benchmarks. EPA has defined the range of 10^{-4} to 10^{-6} as the ICR target range such that, when the sum of cancer risks for all site-related COPCs in a given medium is greater than 1×10^{-4}, this generally indicates that EPA will require consideration of remediation options. ICRs below 1×10^{-4} normally do not require remediation for a given medium. Whenever the overall ICR for a medium is greater than 1×10^{-4}, individual chemicals are selected as chemicals of concern (COCs) which contributed significantly to overall risk, typically those chemicals with an individual ICR greater than 1×10^{-6}.

5.4.2 Comparison of Estimated Radionuclide Dose to Benchmark Criteria

NRC provides a benchmark range which uses different measurement units to evaluate the acceptability of radionuclide exposures during decommissioning of licensed radionuclide-handling facilities. Using the TEDE assessment approach specified in NRC guidance, a survey unit is evaluated by calculating DCGLs specific to each radionuclide (MARRSIM, 2000; NRC, 1974). Criteria for release of a site are based on not exceeding concentrations that correspond to an annual receptor TEDE of 15 mrem/yr or 25 mrem/yr. DCGLs for each of the site-specific radionuclides are presented in Table 1-2 for source measurements expressed in dpm/100cm^2 and in Table 1-3 for analytical sample results reported in units of pCi/g.

5.4.3 Cancer Risk Estimates for Building Survey Units

5.4.3.1 Survey Unit: 8' X 8' Building

Appendix D, Table 8.01 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the 8' X 8' Building survey unit. The estimated ICR was 2.3×10^{-5}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.01, summarizes the cumulative risks for this survey unit and documents that no chemicals of concern (COCs) were selected because the ICR is within EPA's acceptable risk range.

5.4.3.2 Survey Unit: Basement of Main Building

Appendix D, Table 8.02 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the Basement of the Main Building. The estimated ICR was 2.3×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.02, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ac-227 (ICR of 7.0×10^{-4}), Ra-226 (ICR of 1.0×10^{-3}), and Pb-210 (ICR of 5.7×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F1-1 (ICR of 1.9×10^{-3}) and F1-3 (ICR of 1.8×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 1.3×10^{-6}.

5.4.3.3 Survey Unit: Attic of Main Building

Appendix D, Table 8.03 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide exposure sources located within the survey unit designated as the Attic of the Main Building. The estimated ICR was 1.3×10^{-4}, which is near the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.03, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 8.6×10^{-5}) and Pb-210 (ICR of 4.7×10^{-5}). The sources that contributed to the majority of risk for this survey unit include F1-4 (ICR of 5.9×10^{-5}), S0-4 (ICR of 3.0×10^{-5}), and F1-2 (ICR of 1.0×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 2.1×10^{-8}.

5.4.3.4 Survey Unit: Carpenter Shop

Appendix D, Table 8.04 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Carpenter Shop survey unit. The estimated ICR was 3.4×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.04, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Co-60 (ICR of 1.9×10^{-4}), Ra-226 (ICR of 1.9×10^{-3}), and Pb-210 (ICR of 1.3×10^{-3}). The sources that contributed to the majority of risk for this survey unit include F1-6 (ICR of 1.5×10^{-3}), F4-2 (ICR of 1.4×10^{-3}), S0-2 (ICR of 1.9×10^{-4}), and S0-4 (ICR of 1.2×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 6.4×10^{-6}.

5.4.3.5 Survey Unit: Etching Building

Appendix D, Table 8.05 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Etching Building survey unit. The estimated ICR was 4.1×10^{-5}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.05, summarizes the cumulative risks for this survey unit and documents that no COCs were selected because the ICR is within EPA's acceptable risk range.

5.4.3.6 Survey Unit: First Floor, Survey Unit A of Main Building

Appendix D, Table 8.06 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit A of the Main Building. The estimated ICR was 2.0×10^{-4}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.06, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 8.9×10^{-5}) and Pb-210 (ICR of 4.9×10^{-5}). The sources that contributed to the majority of risk for this survey unit include F1-5 (ICR of 9.5×10^{-5}) and F1-6 (ICR of 4.2×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 3.7×10^{-7}.

5.4.3.7 Survey Unit: First Floor, Survey Unit B of Main Building

Appendix D, Table 8.07 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit B of the Main Building. The estimated ICR was 3.6×10^{-4}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.07, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. One radionuclide contributed significantly to cancer risks for this survey unit -- Cs-137 (ICR of 3.0×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F2-2 (ICR of 3.4×10^{-5}), F2-3 (ICR of 2.1×10^{-5}), F3-1 (ICR of 1.3×10^{-5}), F3-6 (ICR of 3.8×10^{-5}), F3-7 (ICR of 3.1×10^{-5}), F3-8 (ICR of 3.4×10^{-5}), F4-9 (ICR of 2.1×10^{-5}), F4-10 (ICR of 1.9×10^{-5}), and F6-6 (ICR of 2.0×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 4.1×10^{-6}.

5.4.3.8 Survey Unit: First Floor, Survey Unit C of Main Building

Appendix D, Table 8.08 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit C of the Main Building. The estimated ICR was 4.2×10^{-4}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.08, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Cs-137 (ICR of 1.9×10^{-4}), Ra-226 (ICR of 1.5×10^{-4}), and Pb-210 (ICR of 8.0×10^{-5}). The sources that contributed to the majority of risk for this survey unit include F1-1 (ICR of 1.1×10^{-5}), F1-10 (ICR of 8.0×10^{-5}), F2-4 (ICR of 2.3×10^{-5}), F2-10 (ICR of 7.7×10^{-5}), F3-5 (ICR of 9.6×10^{-5}), F3-8 (ICR of 8.3×10^{-5}), F3-9 (ICR of 2.6×10^{-5}), F3-10 (ICR of 1.2×10^{-5}),), F4-1 (ICR of 2.1×10^{-5}), F4-7 (ICR of 2.6×10^{-5}), and F5-2 (ICR of 2.6×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure - inhalation, external, deposition, immersion, and radon - yielded only minor contributions to risks, representing a subtotal of 5.7×10^{-7}.

5.4.3.9 Survey Unit: First Floor, Survey Unit D of Main Building

Appendix D, Table 8.09 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit D of the Main Building. The estimated ICR was 5.9×10^{-6}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.09, summarizes the cumulative risks for this survey unit and documents that no chemicals of concern (COCs) were selected because the ICR is within EPA's acceptable risk range.

5.4.3.10 Survey Unit: First Floor, Survey Unit E of Main Building

Appendix D, Table 8.10 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit E of the Main Building. The estimated ICR was 2.1 x 10^{-2}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.10, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 1.4 x 10^{-2}), Pb-210 (ICR of 7.6 x 10^{-3}), and Np-237 (ICR of 1.2 x 10^{-4}). In addition, two other radionuclides are part of the same decay chain as Np-237, and so are also considered as candidate COCs: U-233 (ICR of 4.2 x 10^{-9}) and Th-229 (ICR of 2.0 x 10^{-11}). The sources that contributed to the majority of risk for this survey unit include F1-1 (ICR of 3.6 x 10^{-4}), F1-2 (ICR of 1.1 x 10^{-2}), F1-3 (ICR of 4.8 x 10^{-4}), F1-4 (ICR of 8.9 x 10^{-3}), F1-6 (ICR of 3.7 x 10^{-4}), and S0-1 (ICR of 1.7 x 10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 1.2 x 10^{-5}.

5.4.3.11 Survey Unit: First Floor, Survey Unit F of Main Building

Appendix D, Table 8.11 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit F of the Main Building. The estimated ICR was 2.5 x 10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.11, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 1.6 x 10^{-3}) and Pb-210 (ICR of 8.6 x 10^{-4}). The sources that contributed to the majority of risk for this survey unit include F2-3 (ICR of 1.1 x 10^{-4}), F2-9 (ICR of 6.3 x 10^{-4}), F3-4 (ICR of 5.5 x 10^{-4}), and S0-4 (ICR of 5.5 x 10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 1.8 x 10^{-6}.

5.4.3.12 Survey Unit: First Floor, Survey Unit G of Main Building

Appendix D, Table 8.12 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the First Floor, Survey Unit G of the

Main Building. The estimated ICR was 4.5×10^{-5}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.12, summarizes the cumulative risks for this survey unit and documents that no COCs were selected because the ICR is within EPA's acceptable risk range.

5.4.3.13 Survey Unit: Second Floor, Survey Unit A of Main Building

Appendix D, Table 8.17 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the Second Floor, Survey Unit A of the Main Building. The estimated ICR was 4.5×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.17, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 2.9×10^{-3}) and Pb-210 (ICR of 1.6×10^{-3}). The sources that contributed to the majority of risk for this survey unit include F2-4 (ICR of 2.4×10^{-4}), F2-5 (ICR of 2.0×10^{-4}), F4-3 (ICR of 1.1×10^{-4}), F5-7 (ICR of 1.4×10^{-3}), F6-7 (ICR of 1.4×10^{-3}), F7-8 (ICR of 3.7×10^{-4}), and S0-4 (ICR of 5.5×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 1.0×10^{-5}.

5.4.3.14 Survey Unit: Second Floor, Survey Unit B of Main Building

Appendix D, Table 8.18 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the Second Floor, Survey Unit B of the Main Building. The estimated ICR was 8.4×10^{-4}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.18, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ac-227 (ICR of 1.2×10^{-4}), Ra-226 (ICR of 4.7×10^{-4}), and Pb-210 (ICR of 2.6×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F1-4 (ICR of 1.1×10^{-4}) and F2-2 (ICR of 2.7×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 2.0×10^{-6}.

5.4.3.15 Survey Unit: Second Floor, Survey Unit C of Main Building

Appendix D, Table 8.21 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the Second Floor, Survey Unit C of the Main Building. The estimated ICR was 8.0×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.21, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ac-227 (ICR of 4.1×10^{-3}), Ra-226 (ICR of 2.5×10^{-3}), and Pb-210 (ICR of 1.4×10^{-3}). The sources that contributed to the majority of risk for this survey unit include F1-3 (ICR of 1.2×10^{-4}), F1-7 (ICR of 3.9×10^{-4}), F1-9 (ICR of 1.2×10^{-4}), F1-10 (ICR of 2.3×10^{-4}), F2-4 (ICR of 1.7×10^{-4}), F3-1 (ICR of 1.5×10^{-3}), F4-2 (ICR of 5.3×10^{-4}), F4-3 (ICR of 4.1×10^{-3}), and F5-5 (ICR of 1.4×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 1.2×10^{-5}.

5.4.3.16 Survey Unit: Ion Exchange Hut

Appendix D, Table 8.13 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Ion Exchange Hut survey unit. The estimated ICR was 1.2×10^{-4}, which is near the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.13, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. One radionuclide contributed significantly to cancer risks for this survey unit -- Cs-137 (ICR of 1.2×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F1-8 (ICR of 3.2×10^{-5}), F2-1 (ICR of 2.6×10^{-5}), and F2-4 (ICR of 3.2×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure - inhalation, external, deposition, immersion, and radon - yielded only minor contributions to risks, representing a subtotal of 1.6×10^{-7}.

5.4.3.17 Survey Unit: Liquid Waste Building

Appendix D, Table 8.14 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Liquid Waste Building survey unit. The estimated ICR was 1.5×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.14, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ac-227 (ICR of 1.5×10^{-4}), Ra-226 (ICR of 8.6×10^{-4}), and Pb-210 (ICR of 4.8×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F1-1 (ICR of 1.0×10^{-3}) and F1-5 (ICR of 3.4×10^{-4}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 2.5×10^{-7}.

5.4.3.18 Survey Unit: Machine Shop

Appendix D, Table 8.15 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Machine Shop survey unit. The estimated ICR was 2.5×10^{-6}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.15, summarizes the cumulative risks for this survey unit and documents that no chemicals of concern (COCs) were selected because the ICR is within EPA's acceptable risk range.

5.4.3.19 Survey Unit: Multi-Metals Building

Appendix D, Table 8.16 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the survey unit designated as the Multi-Metals Building. The estimated ICR was 1.1×10^{-3}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.16, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 6.7×10^{-4}) and Pb-210 (ICR of 3.7×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F4-1 (ICR of 6.5×10^{-4}), F4-2 (ICR of 8.6×10^{-5}), F3-9 (ICR of 2.1×10^{-5}), F3-3 (ICR of 2.1×10^{-5}), F2-10 (ICR of 2.5×10^{-5}), F2-9 (ICR of 2.3×10^{-5}), F2-7 (ICR of 2.7×10^{-5}), and F2-6 (ICR of 3.6×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 2.1×10^{-7}.

5.4.3.20 Survey Unit: Silo

Appendix D, Table 8.19 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Silo survey unit. The estimated ICR was 2.4×10^{-5}, which is within EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.19, summarizes the cumulative risks for this survey unit and documents that no chemicals of concern (COCs) were selected because the ICR is within EPA's acceptable risk range.

5.4.3.21 Survey Unit: Utility Building

Appendix D, Table 8.20 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Utility Building survey unit. The estimated ICR was 4.1×10^{-4}, which exceeds the upper end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.20, summarizes the cumulative risks for this survey unit and lists the radionuclide contributors which may be considered candidate COCs. Radionuclides that contribute significantly to cancer risks for this survey unit include Ra-226 (ICR of 2.6×10^{-4}) and Pb-210 (ICR of 1.5×10^{-4}). The sources that contributed to the majority of risk for this survey unit include F1-2 (ICR of 8.8×10^{-5}), F1-3 (ICR of 9.8×10^{-5}), F1-4 (ICR of 5.7×10^{-5}), F1-6 (ICR of 5.2×10^{-5}), and F1-7 (ICR of 2.0×10^{-5}). Incidental ingestion of radionuclides via direct contact with exposure sources was the dominant pathway contributing to the majority of estimated cancer risk. Other modeled pathways of exposure – inhalation, external, deposition, immersion, and radon – yielded only minor contributions to risks, representing a subtotal of 5.3×10^{-7}.

5.4.3.22 Survey Unit: Tritium Building

Appendix D, Table 8.22 presents the estimated ICRs associated with exposure of an occupational worker to radionuclide sources located within the Tritium Building survey unit. The estimated ICR was 6.2×10^{-8}, which is less than the lower end of EPA's target acceptable risk range of 10^{-4} to 10^{-6}. Appendix D, Table 10.22, summarizes the cumulative risks for this survey unit and documents that no COCs were selected because the ICR is less than EPA's acceptable risk range.

5.5 UNCERTAINTY ANALYSIS

As discussed in EPA (1989), the risk measures used in Superfund site risk assessments are not fully probabilistic estimates of risk but rather are conditional estimates based on a considerable number of assumptions about exposure and toxicity. There are uncertainties associated with each aspect of risk assessment, from environmental data collection through risk characterization. This section addresses uncertainties in the RESRAD model mainly from a qualitative standpoint. The main uncertainties in the radionuclide risk assessment for the SLC OU-1 Site fall into the following categories:

- Representativeness of Samples
- Analytical Data Usability

- Selection of the EPC
- Worker Activity Patterns
- Overview of Uncertainties in Modeled Routes of Exposure
- Model Input Parameters
- Uncertainties Associated With Toxicity Assessment
- Uncertainties Associated with Risk Characterization

5.5.1 Uncertainties in the Representativeness of Samples

The number and location of samples collected, the sampling coverage within the areas of interest, and the methods for sample collection all contribute to uncertainties in sampling representativeness. These types of uncertainties were minimized through the development and implementation of field radionuclide survey plans that utilized MARRSIM guidance (MARRSIM, 2000) as the basis for these plans. Site history was carefully reviewed to ensure that all appropriate areas were sampled for the appropriate radionuclides. Comprehensive field screening was conducted to locate areas where readings were in excess of DCGLs to ensure that quantitative data were obtained in all significant areas for the HHRA. For the Tritium Building, sampling could not be conducted in portions (two rooms with ongoing tritium operations accessed from the second door of the west entrance as noted on the survey forms in Appendix A) of the building; therefore, this creates a data gap that will have to be addressed during the FS or in future investigative and remedial activities. Sampling could also not be performed in the Solid Waste Building due to storage of waste materials; therefore, this presents a data gap that will have to be addressed during the FS or future remedial activities.

5.5.2 Analytical Data Uncertainty

All analytical data were validated in accordance with EPA Region 3 procedures. Estimated (J-qualified) data were retained for use in the HHRA. Data used in the HHRA did not include blank-qualified or rejected values.

5.5.3 Uncertainties in the Selection of the EPC

The EPC was selected using one analytical result for each point source, so statistical considerations involving number of data points to estimate the distributional shape were not applicable.

5.5.4 Uncertainties in Worker Activity Patterns

The occupational office worker scenario involves 25 years of 40 hours per week exposure to one survey unit, which exceeds the cumulative exposure time compared to other plausible types of receptor activities. However, note that only one hour per day occupancy was assumed for certain survey units that are too small or otherwise not plausible for worker occupancy for 8 hours per day (Attic, Ion Exchange Hut, 8 by 8 Building, Silo, and Utility Building). The full-time occupational worker exposure scenario is considered to be more conservative and protective than other potential indoor receptor activities under similar building conditions. However, in the event of building demolition or major renovation, the estimated dust generation would be much higher than the low-disturbance assumptions utilized in the RESRAD-BUILD model runs. In such cases, construction worker risks would need to be considered separately to determine the need for appropriate protective controls.

5.5.5 Overview of Uncertainties in Modeled Routes of Exposure

The different radionuclide exposure routes that contribute to estimated cancer risk are each associated with varying degrees of uncertainty. Mathematical models used in RESRAD-BUILD simulate radionuclide decay, transport, and internal and external body dose incurred via several exposure routes. Uncertainties in RESRAD's exposure pathway modeling are addressed in DOE publications (DOE, 2003; NRC, 2000).

An overview of the relative significance of these exposure pathways suggests that direct ingestion from the source is associated with the greatest uncertainty and also greatest over-conservatism (high bias in estimated risk). In this HHRA, this pathway dominated by approximately 3 orders of magnitude in the relative contribution to cancer risks compared to all other pathways combined (inhalation, external, deposition, immersion, and radon exposures).

The deposition pathway also contributed to incidental ingestion risks, but the net contribution was shown to be orders of magnitude lower than the pathway risks that are labeled as direct ingestion from the source. A separate series of simulation runs was performed which restricted ingestion exposures to only indirect ingestion of material redeposited from the source, as shown in the RESRAD-BUILD outputs in Appendix C, Part 3. Cancer risks were estimated for a one year exposure duration rather than 25 years, but the overall trend showed that indirect ingestion receptor risks were in nearly all cases within an order of magnitude, plus or minus, compared to the risks via inhalation, external, deposition, submersion, and radon pathways. Note that the modeling algorithms employed for deposition, inhalation, and immersion are subject to significant uncertainties caused by variability in the underlying air quality model's source erosion rates and resuspension rates for radionuclide dusts. However, mass balance conservation is maintained in the RESRAD-BUILD model calculations for these pathways, which prevents excess errors caused by overestimation of the total quantity of radionuclide released over time from the source.

Risks estimated for the external pathway of exposure are considered to have the least amount of uncertainty compared to other modeled routes of exposure. A removable fraction of 0.5 was assumed for all RESRAD simulations, which ensures that a reasonable approximation to an intact source was assumed over most of a receptor's 25 year exposure duration. In addition, external dose is modeled using algorithms which mainly depend on accurate input parameters, including physical properties of nuclear decay rates and on easily measured data for source activity, source geometry, and possible receptor locations. In addition, dust generation is frequently minimal in an office environment that does not involve active renovation, and adult rates of incidental ingestion in an office environment are often near zero. Therefore, under such conditions radiation exposures via external irradiation of the body would be expected to represent the majority of TEDE for most situations involving members of the public.

5.5.6 <u>Uncertainties in Model Input Parameters</u>

The input parameters used for RESRAD-BUILD were selected to be conservative. Input values were selected where possible that are consistent with EPA exposure factors or RESRAD default values. RESRAD-BUILD input parameters and parameter uncertainties are described in detail in published model documentation (DOE, 2003; NRC, 2000). Several input parameters have significant impact on the accuracy of risk and dose estimates. These are discussed briefly as follows:

5.5.6.1 Rate of Ingestion Directly From Source

Instead of using the model default value of zero grams per hour (g/hr) for direct ingestion from the source, a value of 0.1 g/day was selected to account for incidental transfer of radionuclide contaminants from the source to mouth (for example, via oral contact with contaminated hands, clothing, or other materials that have physically contacted the source). A major source of uncertainty with this input parameter arises out of a limitation that the RESRAD-BUILD model does not incorporate a conservation of mass calculation to ensure that the cumulative activity or mass of radionuclide directly ingested from the source as time goes on does not eventually exceed the total amount estimated to be present in the source, given the ongoing rates of source depletion occurring from both direct ingestion and erosion of particulate dusts. The RESRAD-BUILD User's Manual discusses this and other caveats regarding the direct ingestion parameter in Appendix J, Section J.4.8 (DOE, 2003).

The degree to which cumulative cancer risks from ingestion may be overestimated by ignoring source mass balance varies from one survey unit to another and depends on the size of each source and the number of sources per survey unit. However, in all cases, direct ingestion from the source was the dominant pathway contributing to estimated cancer risks, usually by approximately 3 orders of magnitude. The degree of positive bias in this exposure pathway is estimated to span approximately one to two orders of magnitude.

5.5.6.2 Rate of Indirect Ingestion of Deposited Dusts

This quantity represents the receptor ingestion of particulate dusts that have eroded from the source over time and which have been subsequently redeposited on other surfaces in the same room or in adjacent rooms where receptor contact and incidental ingestion may occur. The uncertainty in the cumulative intake of radionuclides that represents indirect ingestion is a time-varying and complex function of several parameter uncertainties, which include the following:

- Receptor ingestion rate of surface dusts deposited onto horizontal surfaces (0.0001 m^2/hr). This value was adopted as the model default and represents a conservative upper limit of ingestion rates belonging to a data category referred to as the "lower ingestion rate distribution" (DOE, 2003). There is high uncertainty with the underlying studies upon which this parameter is based.
- Exposure duration (25 years x 365 days per year), fraction of time at work (50/52 weeks per year x 5/7 days per week x 8/24 hours per day), and fraction of time spent in the survey unit (assumed equal to 1). The 25 year exposure duration is a conservative upper limit based on demographic data (EPA, 1997).
- Air exchange coefficients between rooms and outdoor air exchange rate of the ventilation system.
- Calculated areas of horizontal room surfaces where dust can collect.
- The size of each source and measured activity which generates particulate dusts.
- The source erosion rate for a volume source or the removable fraction for an area source. The removable fraction is assumed to be linearly removed between the starting time and the source lifetime, the latter of which is equal to the exposure duration.
- The air release fraction or the portion of the removed material that is released into the air and represents particulates in the respirable range (0.1). This parameter depends strongly on the erosion process – dusting involves a low rate of source erosion but a high fraction becoming suspended in air; vacuuming results in a higher erosion rate but a smaller airborne fraction; and scraping or chipping generates high erosion but a most of the material falls to the floor rather than remaining suspended in air.

- The deposition rate of particulate dusts (0.01 m/s). This is a time-varying function of several variables in the dynamic air quality model used in RESRAD-BUILD, as described in Appendix A of the User's Manual (DOE, 2003).
- The resuspension rate of particulate dusts (5 x 10^{-7} m/s). This is a time-varying function of several variables in the dynamic air quality model used in RESRAD-BUILD, as described in Appendix A of the User's Manual (DOE, 2003).

5.5.6.3 Radon and Tritium Model Uncertainties

The concentrations of radon and tritium are estimated in RESRAD-BUILD using special algorithms which take into account gas phase transport as radon gas or HTO. The decay rates of Ra-226, radon progeny, and tritium are accurately predicted based on nuclear properties. However, the atmospheric plate-out rates of ionized radon progeny and attachment rates to aerosols and suspended particulates represent significant uncertainties due to the complexities in modeling all of the species involved and the different properties of sink materials in the room. In addition, the diffusion rates of radon and tritium from sources is also dependent on the particular composition and porosity of the source materials.

5.5.7 <u>Uncertainties Associated With Toxicity Assessment</u>

Cancer risks were estimated based on radionuclide slope factors for ingestion, inhalation, and external exposure from established sources (HEAST, 2001; EPA, 1999). The uncertainty in the estimates of cancer morbidity rates are relatively low because all radionuclides are considered Class A carcinogens and the dosimetry data upon which estimates are based have been well studied in human populations.

5.5.8 <u>Uncertainties Associated With Risk Characterization</u>

As noted earlier, the most significant source of uncertainty in the risk characterization involves the relative accuracy of the direct ingestion pathway. The RESRAD-BUILD model does not contain appropriate mass balance controls to ensure a realistic approximation to this pathway. However, it may be desirable to model both the direct ingestion from the source as well as indirect ingestion of deposited dusts. Incidental ingestion of deposited dusts is separately modeled in the RESRAD model, so to a first approximation the cumulative risks presented on RAGS D Tables for the direct ingestion pathway can be considered in isolation from the contribution from other pathways. To provide a more balanced perspective of conservatism in the assessment of cumulative risk, the Risk Characterization of this report cites two numbers for the cumulative cancer risks for each survey unit: The cancer risk cited first includes contributions from all pathways, including the dominant pathway, direct ingestion from the source.

Secondly, at the end of each discussion, the cumulative risks for the survey unit are presented after exclusion of the pathway for direct ingestion from the source.

The first estimate is considered biased high, to a degree that depends on mass balance. The second estimate may be biased slightly low because Appendix C, Part 3 modeling results do not include direct source ingestion but do include indirect ingestion from deposited dusts. These results yield a much smaller risk in the category reported as "ingestion", but cannot be used to replace the RAGS D Table entries for ingestion due to a 1 year exposure duration rather than 25 years. However, review of all RESRAD outputs in Appendix C, Part 3 indicates that in every case the risks from indirect ingestion from deposited dusts are never more than 3 times greater than the sum of the other pathways. Therefore, when extrapolating to the RAGS D Tables, it can be assumed that the cumulative risk reported for all pathways without direct source ingestion can be multiplied by 4 to yield an upper bound for cumulative pathway risk that would include indirect ingestion from deposited dusts. In each survey unit, the risks from all other pathways, multiplied by 4, is within the acceptable risk range of 10^{-4} to 10^{-6}.

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