SCIENTECH

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Revision 2

DECOMMISSIONING PLAN FOR THE QUEHANNA, PENNSYLVANIA SITE

February 2003

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1	All	9962	L. Penney
2	All	11199	L. Penney

TABLE OF CONTENTS

Section **Page**

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ACM	asbestos-containing material
AEC	**U.S.** Atomic Energy Commission
ALARA	as low as reasonably achievable
ANSI/ANS	American National Standards Institute/American Nuclear Society
BRP	Bureau of Radiation Protection (Pennsylvania)
Canberra	Canberra, Inc.
CCE	contamination control enclosures
Ci	curies
Commonwealth	Commonwealth of Pennsylvania
CRA	change request authorization
CRSO	Corporate Radiation **Safety** Officer
COTS	Contained Over-head Transport System
D&D	decontamination and decommissioning
DCGL	derived concentration guideline limits
DCNR	Department of Conservation and Natural Resources (Pennsylvania)
DOE	**U.S.** Department **of** Energy
DOT	**U.S.** Department of Transportation
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQO	data quality objective
ECN	engineering change notice
FSAP	Final Sampling **and** Analysis Plan
FSSP	Final Status Survey Plan
GM	Geiger-Muller
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	high-efficiency particulate air
K_d	distribution coefficient
LLRW	low-level radioactive waste
LTR	License Termination Rule (10 CFR 20, Subpart **E)**
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
mg/l	milligrams per liter
mph	miles per hour
MMA	methylmethacrylate
mrad/hr	millirad per hour
mrem/hr	millirem per hour
mrem/yr	millirem per year
NES	NES, Inc.
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC Regulatory Guidance
NVLAP	National Voluntary Laboratory Accreditation Program
OSHA	**U.S.** Occupation Safety and Health Administration
PADEP	Pennsylvania Department of Environmental Protection
pCi/L	picocuries per liter
pCi/g	picocuries per gram
Penn State	Pennsylvania State University
PermaGrain	PermaGrain Products, Inc.
PPE	personal protective equipment

ACRONYMS AND ABBREVIATIONS (Continued)

QA	quality assurance
QAPP	Quality Assurance Project Plan
RCA	radiological control area
RedZone	RedZone Robotics, Inc.
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RWP	radiation work permit
SCIENTECH	SCIENTECH, Inc.(Formerly NES, Inc.)
SOTS	Stationary Overhead Transfer System
$Sr(NO_3)_2$	strontium nitrate
$SrTiO_3$	strontium titinate
SRSO	Site Radiation Safety Officer
SSHASP	Site-Specific Health and Safety Plan
UST	underground storage tank
WWTB	Waste Water Treatment Building
yd^3	cubic yard

1.0 INTRODUCTION

1.1 LICENSE INFORMATION

This Decommissioning Plan describes the plans for terminating **U.S.** Nuclear Regulatory Commission (NRC) Radioactive Materials License Number 37-17860-02 formerly held by PermaGrain Products, Incorporated (PermaGrain) of Newton Square, Pennsylvania and currently held by the Pennsylvania Department of Environmental Protection (PADEP). The PADEP took over the license following PermaGrain filing Chapter 7 bankruptcy in December 2002. The license covers residual radioactive material and contamination that are present at the manufacturing facility as a result **of** research, development, and production operations conducted by parties under contract to the former **U.S.** Atomic Energy Commission (AEC). The facility, commonly referred to **as** the Quehanna Site, is owned **by** the Department **of** Conservation and Natural Resources (DCNR) and is located near Karthaus, Pennsylvania.

The current NRC license, dated February 1, 2000, includes Revision **1** of this Decommissioning Plan. · The current license will expire March **31,** 2003. This Decommissioning Plan will be incorporated in the license renewal application and will subsequently become an amendment to the renewed license. Revision 2 **of** the Decommissioning Plan will supercede the previous plan.

The previous revision, Revision **1,** of this Decommissioning Plan **(NES** 1998a) delineates the proposed decontamination and decommissioning (D&D) of portions of the Hot Cells side of the Quehanna facility, including the six hot cells, the associated Service and Operations *Areas*, other support areas, and the Waste Water Treatment Building (WWTB). The PermaGrain side of the facility, which contains an irradiator pool in the Reactor Bay area and manufacturing areas for the production **of** wood flooring, was not addressed in Revision 1 of the Decommissioning Plan. Manufacturing and wood product irradiation operations have ceased since PermaGrain filed for Chapter 7 bankruptcy in December 2002.

The PADEP has expanded the scope of work to include the decontamination and demolition the entire Quehanna facility, including the Hot Cells side and the PermaGrain operations side **of** the facility, which includes the irradiator pool. Therefore, under Contract No. DGS-173-68, the PADEP has tasked SCIENTECH, Inc. of New Milford, CT (SCIENTECH), formerly NES, Inc. of Danbury, **CT** (NES), with preparing Revision 2 of the Decommissioning Plan to include the expanded D&D scope.

The scope of the D&D project has also been expanded because of the discovery **of** higher-than-expected levels of strontium-90 contamination in Hot Cell **4** in **1998. As** a result, robotic decontamination and dismantlement techniques have been added to the list of decommissioning technologies that will be used during the course of the project. Following the completion of the D&D operations on the hot cells, the strountium-90 contamination levels will have been reduced to releasable levels and, **as** such, the PADEP will likely request that the Quehanna facility be removed from the USNRC Site Decommissioning Management Plan (SDMP) list.

Because PermaGrain **has** filed for bankruptcy and ceased operations, the NRC has taken over primary administration of the radioactive material license previously held by PermaGrain that authorized the operation of the cobalt irradiator (NRC License Number 37-17860-01). Although the irradiator's inventory of sealed cobalt-60 sources must be removed and the irradiator pool drained, characterized, and decontaminated as necessary before decommissioning the 37-17860-02 license, the 37-17860-01 license will not be terminated under the actions described in this Decommissioning Plan.

Updates on the tasks described in Revision 1 of the Decommissioning Plan, the current state of the Quehanna facility, and the new tasks associated with the revised D&D effort are described in this revision.

1.2 SITE DESCRIPTION

The Quehanna facility **is** located at 115 Reactor Plant Road, Karthaus, Clearfield County, Pennsylvania. The site is approximately 21 miles northeast of Clearfield, Pennsylvania at approximately 41° 13' north latitude and 78" 14' west longitude. The site, identified in Figure 1-1, is located in the Quehanna Wild Area of the Moshannon State Forest. The area is heavily **wooded** and sparsely populated.

The Quehanna Site includes or included many affected structures and systems, such as the hot cells complex, the WWTB with associated underground tanks and piping, the Reactor Bay, and the hot cell ventilation system. Some of these have been removed as clean debris or partially decontaminated and disposed of radioactive waste. The facility also includes other laboratories, production and storage areas, and offices formerly used by PermaGrain. On-site radioactive material consists of fixed and removable strontium-90 contamination and discrete cobalt-60 sources. The layout of the facility is shown in Figures 1-2 through 1-4.

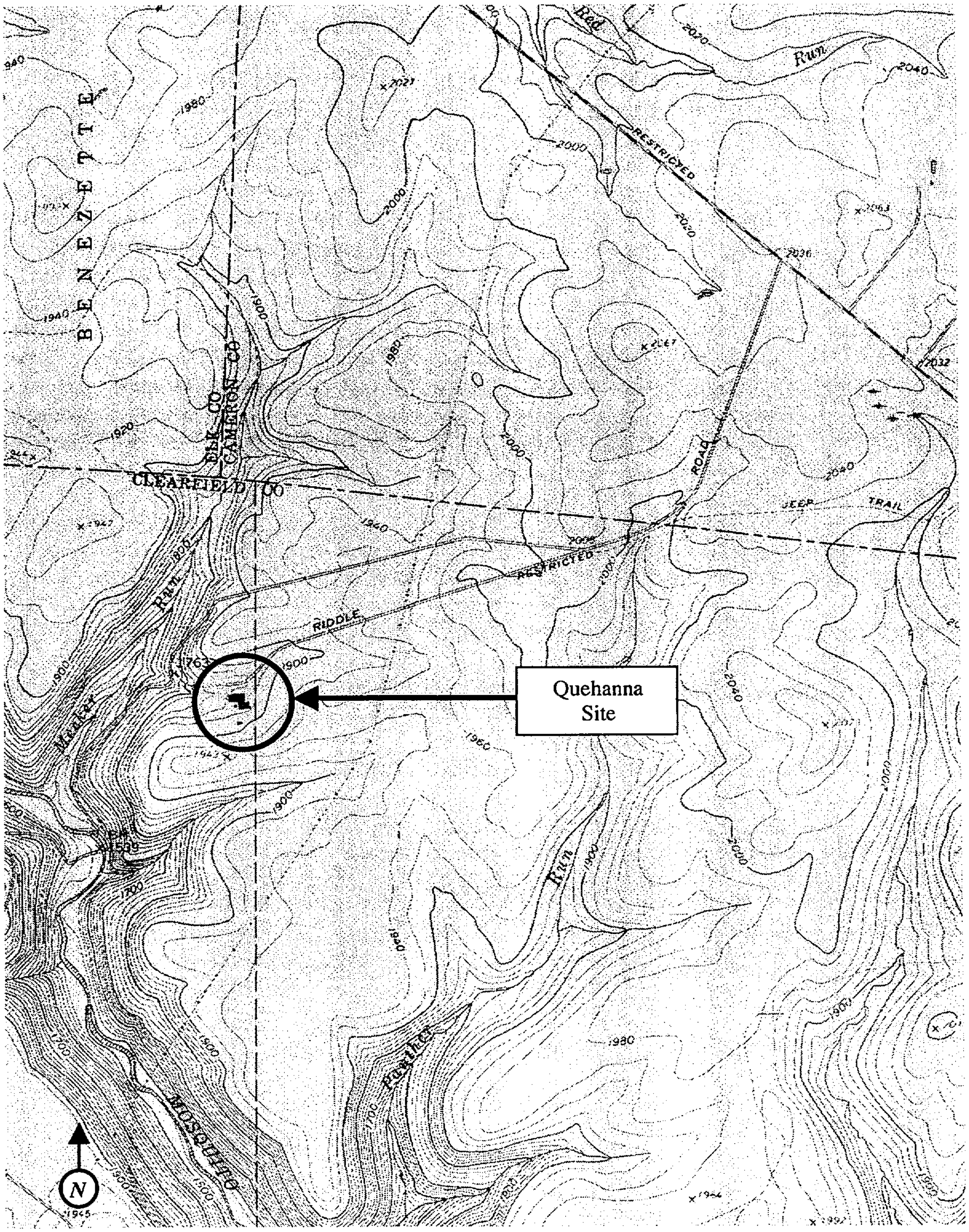
The DCNR expects to eventually return the Quehanna facility to a natural area following complete facility demolition and environmental restoration. However, the PADEP expects to terminate all NRC licenses before complete facility demolition and site restoration.

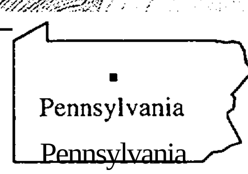
1.3 SUMMARY OF LICENSED ACTIVITIES

The 50,000-acre Quehanna Wild Area was originally state forestland that was transferred to the Curtiss-Wright Corporation by the Pennsylvania Bureau of Forestry for jet engine and nuclear research in 1955. In 1957, the AEC issued a license to the Curtiss-Wright to operate a swimming pool-type research reactor at the Quehanna facility. The facility license also included the use of hot cells, laboratories, and support features. Licensed isotopic activities began in 1958. In 1960, Curtiss-Wright donated the facility to Pennsylvania State University (Penn State) who, in turn, leased the hot cells to the Martin Marietta Corporation. Beginning in July 1962, Martin Marietta used the hot cells to manufacture several prototype thermoelectric generators under contract to the AEC. Martin Marietta's possession license allowed them to maintain megacurie amounts of high-specific activity strontium-90.

Martin Marietta terminated its lease with Penn State in 1967 and vacated the facility after partially decontaminating portions of the facility and Penn State released its interest in the Quehanna facility back to the Commonwealth of Pennsylvania (Commonwealth). The Commonwealth then leased the facility to NUMEC, a subsidiary of the Atlantic-Richfield Corporation. NUMEC managed a large irradiator containing in excess of 1 million curies of cobalt-60 for projects involving food irradiation, sterilization, irradiation of polymer-impregnated hardwood and other applications of intense gamma radiation in the reactor pool, which once contained a test reactor. Atlantic-Richfield used the hot cells for activities involving irradiated mixed oxide fuel. In 1978, a group of Atlantic-Richfield employees bought the wood irradiation process, including the cobalt pool irradiator and related equipment at the Quehanna facility and formed PermaGrain.

The current NRC License Number 37-17860-02 was initiated by PermaGrain in July 1998 and covers the residual contamination and radioactive materials from the AEC-contracted and other operations. The license allows for an unspecified amount of any byproduct or special nuclear material including strontium-90 and cobalt-60. The PADEP became the official licensee in December 2002 following PermaGrain's filing for Chapter 7 bankruptcy.

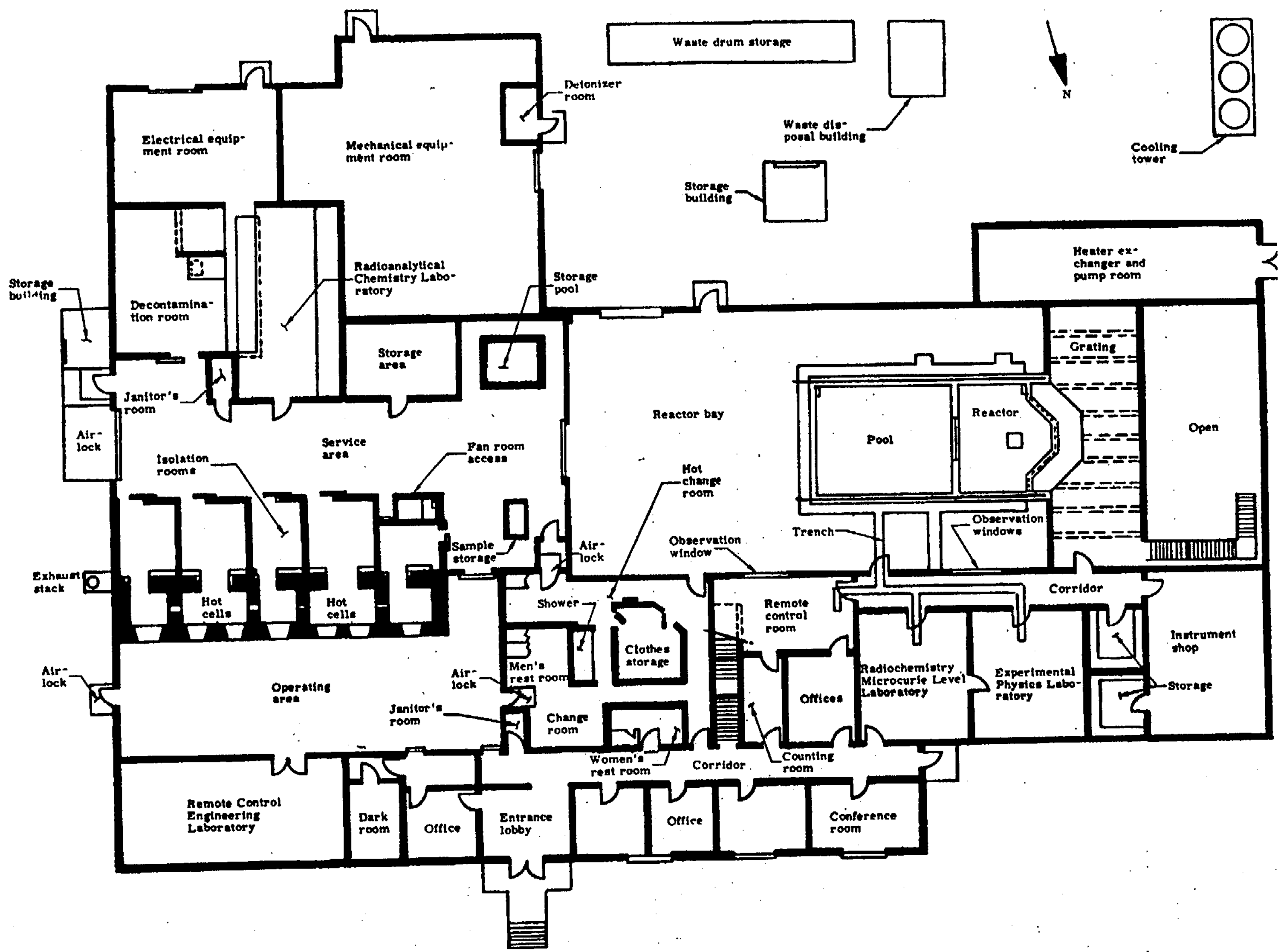




Source: U.S. Geological Survey
Devils Elbow, PA, Quadrangle
Photorevised 1971

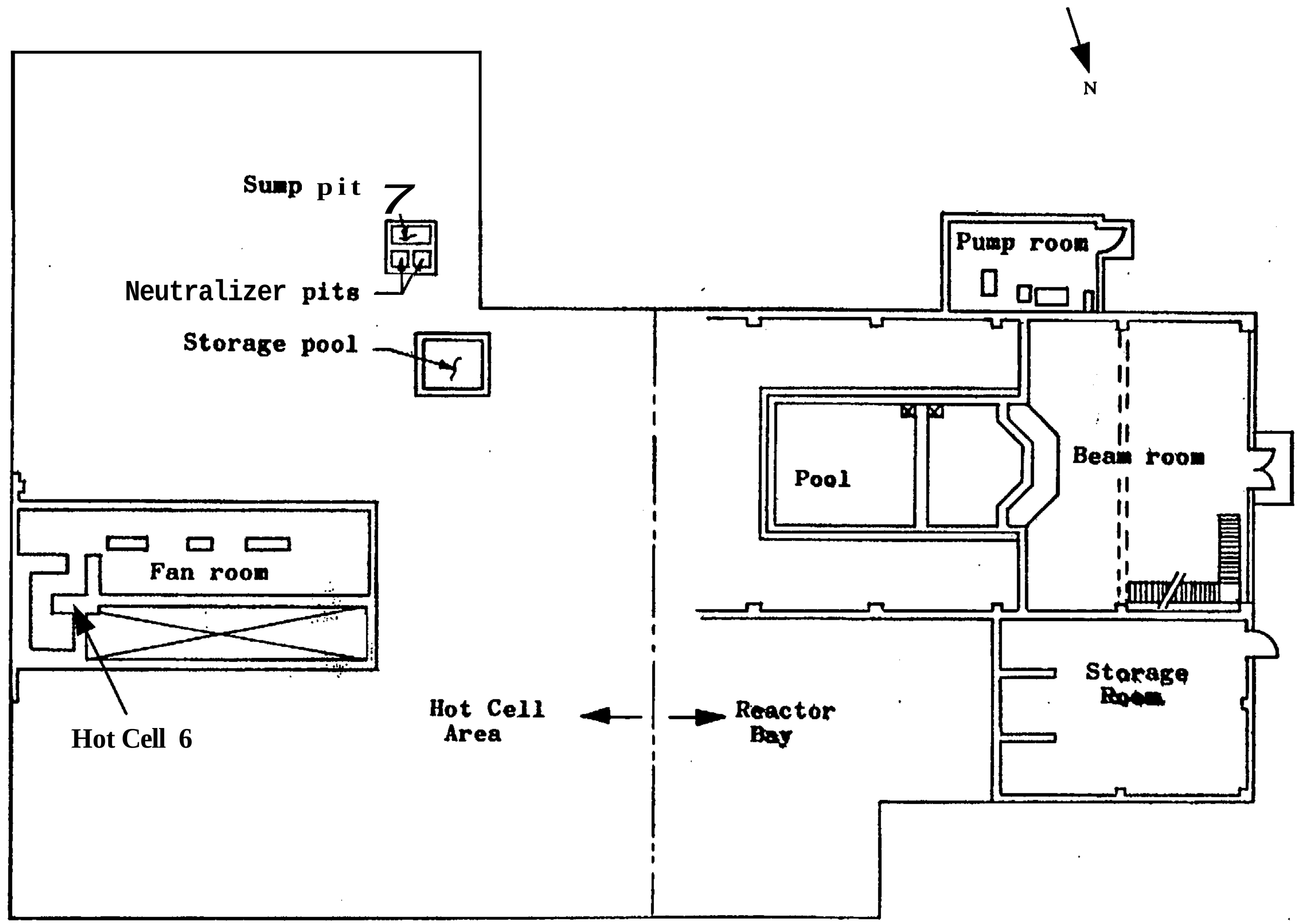
FIGURE 1-1

QUEHANNA SITE LOCATION MAP



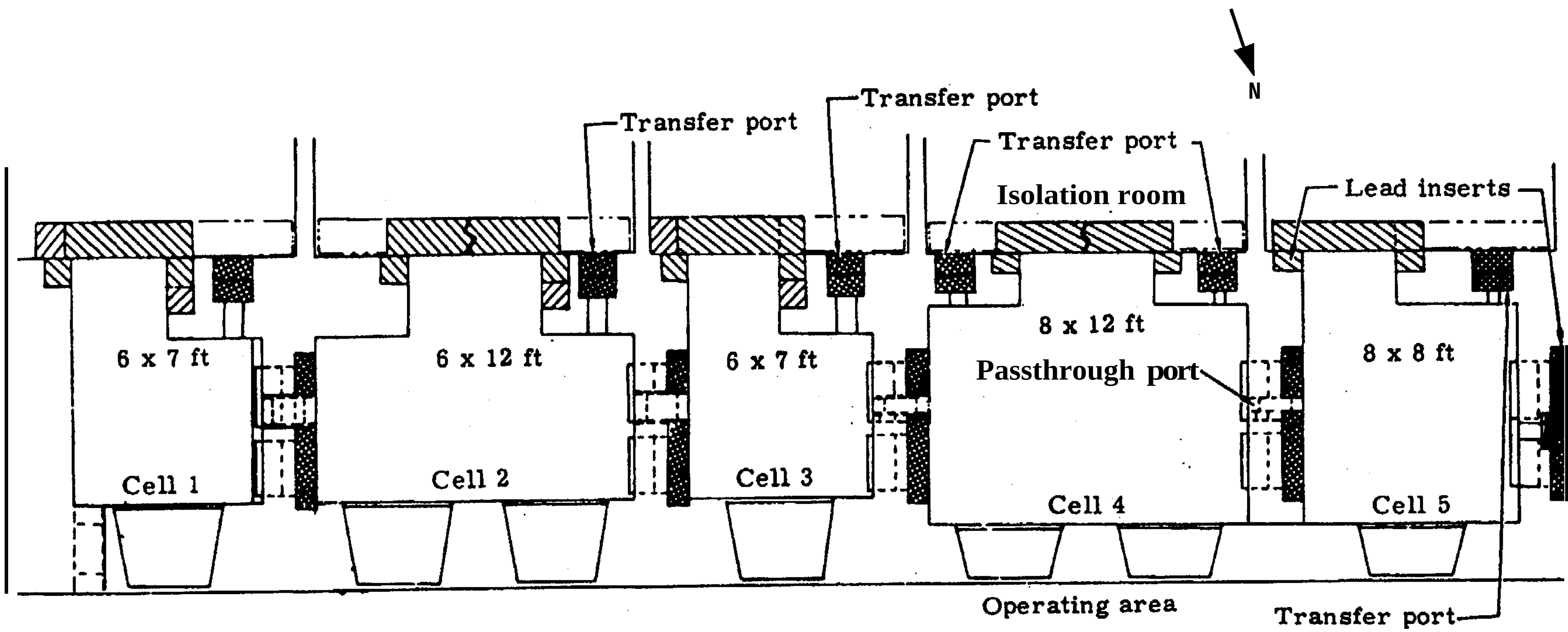
Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process

FIGURE 1-2
ORIGINAL MAIN FLOOR PLAN



Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process Martin Marietta, May 1966

FIGURE 1-3
ORIGINAL BASEMENT LEVEL FLOOR PLAN
QUEHANNA FACILITY



Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process

FIGURE 1-4
HOT CELLS 1 THROUGH 5

1.4 LICENSE DECOMMISSIONING

The objective of the D&D project is to decontaminate and free-release the entire Quehanna site, including newer structures constructed by PermaGrain and terminate NRC license number 37-17860-02. This Decommissioning Plan was prepared to conform to the regulatory guidance that was in effect at the time, Revision 1 of the Decommissioning Plan was prepared. The surface contamination release criteria will be those provided in the NRC's "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination **of** Licenses for Byproduct, Source, or Special Nuclear Materials," (NRC 1987), hereinto referred to as Regulatory Guide 1.86 criteria since these release criteria were adopted from the often-referenced Regulatory Guide 1.86 (AEC 1974). The NRC's "Current Guidelines on Acceptable Levels of Contamination in Soil and Groundwater in Property to be Released for Unrestricted Use" (NRC 1992a) establishes a release limit of 5 picocuries per gram (pCi/g) average concentration for strontium-90 in soil (15 pCi/g maximum) and **8** pCi/g average concentration for cobalt-60 in soil (24 pCi/g maximum). Following all D&D activities, SCIENTECH will conduct a final status survey to verify that the site property meets these limits before it is released for unrestricted use.

Some demolition materials and decontamination wastes will be disposed of **as** radioactive waste. This waste will be fully characterized to meet the waste acceptance criteria of the disposal facility and will be packaged and transported according to all state and federal regulations. Building materials and scrap equipment destined for disposal or recycling as clean waste and equipment released for reuse will meet the free-release average surface contamination limits of 1,000 disintegrations per 100 square centimeters ($dpm/100cm^2$) total strontium-90 contamination with 200 $dpm/100cm^2$ removable (cobalt40 limits are **5** time greater) (NRC 1987). These generic screening levels are generally considered to result in a future dose of not more than 25 millirem per year (mrem/yr) and **as** low as reasonably achievable (ALARA). The dose impact to future site users is evaluated later in this Plan in Section 5.0.

D&D activities began at the Quehanna facility in May 1998 when SCIENTECH (formerly NES, Inc.) mobilized to the facility and established operations. **It** is anticipated that SCIENTECH will decontaminate all facility structures and remove **all** contaminated debris from the site by the end of 2003. Any soil remediation and site restoration is also expected to be complete by the end of 2003. The PADEP anticipates the submission of the Final Status Survey .Report to the NRC in 2004.

With the submittal of Revision 2 of the Decommissioning Plan, the PADEP is requesting that NRC License Number 37-17860-02 be amended to incorporate this plan, superceding the previous version.

The PADEP has tasked SCIENTECH, under Contract No. DGS-173-68, with preparing Revision 2 of this Decommissioning Plan. Revision 2 of the Decommissioning Plan is necessary because of the modification in some of the decontamination methods that will be necessary to remove highly radioactive components, which were previously unidentified. In particular, one of the hot cells, Cell 4, contains extremely high levels of strontium contamination and will be partially decontaminated using a remotely operated robot. The beta radiation levels in nozzles of the process box in Cell 4 are currently as high as 40,000 rad per hour.

2.0 FACILITY OPERATING HISTORY

2.1 LICENSE STATUS

The PADEP currently maintains NRC Radioactive Materials License Number 37-17860-02. The license allows for an unspecified amount of any byproduct or special nuclear material including strontium-90 and cobalt-60. However, the license only authorizes the D&D of facilities, packaging of stock material and radioactive waste, and storage of material and packaged waste prior to shipment off site. The authorization **is** limited to radioactive contamination that existed at the facility on January 11, 1988, including specific cobalt-60 sources described in **a** letter to the NRC dated August 7,1997.

The November **4,** 1999 letter included by reference to Amendment No. **8** estimated that the total activity on-site was 104 curies (Ci) of strontium-90 remaining in the Cell **4** process system **(fixed** and loose contamination) and **8** Ci of dispersed strontium contamination in the remainder **of** the building. Historically, the strontum-90 was present in various chemical **forms** including strontium carbonate, strontium nitrate, and strontium titanate and is currently found **as** contamination on building surfaces and inside pipes and other enclosed systems.

About 100,000 Ci of sealed cobalt-60 source rods, controlled under License Number 37-17860-01, are being stored in the pool irradiator within the Reactor Bay area of the facility. Prior to the completion of *the* decommissioning of the 37-17860-02 license, these sources will be removed, the pool drained, characterized, and decontaminated as necessary.

The current NRC license, dated February 1, 2000, which includes Revision 1 of this Decommissioning Plan will expire March 31, 2003. The intent is for this Revision 2 to the Decommissioning Plan to be incorporated in the license renewal application and be included by reference in the renewed license. Revision 2 of the Decommissioning Plan will supercede the previous plan.

2.2 LICENSE HISTORY

In June 1955, Pennsylvania Governor George **M.** Leader signed into law several articles of legislation that paved way for the construction of a research facility to be operated by the Curtiss-Wright Corporation at the Quehanna site. The Commonwealth viewed the project as a contributor to the local economy and the Commonwealth acquired the real estate before the advent of Curtiss-Wright. The core area **was** sold to Curtiss-Wright and the balance of the site leased to them. Early plans for the facility included, among other things, an establishment for the development of nuclear jet engines. They also planned to perform research in nucleonics, metallurgy, ultrasonics, electronics, chemical, and plastics.

Following construction of the Quehanna facility in 1957, the AEC issued a license to Curtiss-Wright in 1958 to operate the swimming pool research reactor at the facility. The facility license also included the use **of** hot cells, laboratories, and support features. Figures 1-2 and 1-3 show the original floor plans for the main floor and the basement level of the Quehanna facility, respectively. Figure 1-4 provides a more detailed layout of the hot cells.

Licensed isotopic activities began in 1958. In September 1960, Curtiss-Wright donated the facility and land to Penn State. Penn State planned to use the reactor for training and research. They, in turn, leased the hot cells to the Martin Marietta Corporation.

Beginning in 1962, Martin Marietta used the hot cells to manufacture several prototype thermoelectric generators, known as Systems for Nuclear Auxiliary Power (SNAP-7) generators, for the AEC. These power sources, which were designed to furnish power for remotely operated, automatically reporting weather stations, navigation buoys, etc., contained very high specific activity strontium-90 in the form of strontium titanate ($SrTiO_3$).

In the production process, a $SrTiO_3$ precipitate was formed from a strontium nitrate [$Sr(NO_3)_2$] solution by adding inorganic nonflammable reagents. The $Sr(NO_3)_2$ solution was produced by combining strontium carbonate ($SrCO_3$) with nitric acid. The $SrCO_3$, a dry powder, was provided by the AEC's Hanford nuclear weapons facility. The $SrTiO_3$ precipitate was then filtered and dried. The resulting powder was then loaded and condensed and the fuel container was sealed and decontaminated. Measurements were made as needed and the final fuel container was loaded into a generator, cask, or storage facility.

Martin Marietta's radioactive materials possession license allowed them to maintain megacurie amounts of strontium-90. The average shipment of strontium carbonate feed material, which was received from the AEC's Hanford nuclear weapons facility, was about 140 kilocuries. Martin Marietta terminated its lease in 1967 and vacated the facility after a partial decontamination but licensable quantities of strontium-90 remained behind as structural contamination. Martin Marietta was the last licensee to use strontium-90 at the Quehanna facility.

During the Martin Marietta operations, the facility was limited to possess a maximum of 6,000 kilocuries (6 million curies) of strontium-90. Other limitations were established for maximum quantities of strontium-90 within the facility including storage tank T-31 (750 kilocuries), hot cell chamber 4A (150 kilocuries), hot cell chamber 4B (100 kilocuries), hot cell 5 (250 kilocuries) and the material storage pool (2,000 kilocuries). The following radioactive contamination limits in association with the 6,000 kilocuries of strontium were also established:

• strontium-89	1,800 kilocuries	(50.5 day half-life)
• cerium144	30 kilocuries	(284 day 'half-life)
• other gross fission products	30 kilocuries	

In 1967, Penn State gave its interest in the Quehanna facility back to the Commonwealth and the Commonwealth then leased the facility to NUMEC, a subsidiary of the Atlantic-Richfield Corporation. NUMEC used the pool, which once contained the test reactor, to hold a large cobalt-60 irradiator containing in excess of 1 million curies of cobalt. Projects involving the use of the irradiator included food irradiation, sterilization, irradiation of polymer-impregnated hardwood and other application of intense gamma radiation. The hot cells were used by Atlantic-Richfield for activities involving irradiated mixed oxide fuel.

In 1978, a group of ARCO-NUMEC employees bought the **wood** irradiation process, including the cobalt pool irradiator and related equipment at the Quehanna facility. The new company, PermaGrain, was issued NRC license number 37-17860-01 for the irradiator and also assumed "caretaker" responsibilities for the radioactive material left behind by previous tenants.

PermaGrain initiated the current ***NRC*** radioactive materials license in 1998. This license covers the residual contamination and radioactive materials that remained onsite from the AEC-contract and other operations. The Commonwealth currently owns the Quehanna facility and the surrounding real estate and the DCNR Bureau of Forestry administers the land. The **PADEP** is currently the official license holder of the 37-17860-02 license, since PermaGrain's filing for bankruptcy in December 2002.

Characterization of the facility has identified strontium-90 and cobalt40 as radioisotopes of concern. One or both of these contaminants have been identified in the Hot Cells, the Hot Cells Service and Operations Areas, the Radiochemical Laboratory, the hot cells ventilation system, and in other areas. Within the hot cells, removable strontium-90 surface contamination levels have been recorded as high as **3** to 4 rad per hour (rad/hr) per 100 square centimeters (100cm^2) and contact dose rates have been measured as high as 12,000 rad/hr. At least one concentrated location of strontium-90 isolated inside the Cell **4** process system has been measured at 40,000 rad/hr. Strontium-90 contamination has been inadvertently spread throughout the Quehanna facility over the years resulting in numerous areas of dispersed low-level contamination.

2.3 **PREVIOUS DECOMMISSIONING** ACTIVITIES

No information is available on the extent of the decontamination effort provided by Martin Marietta or ARCO-NUMEC prior to their vacating the Quehanna facility. Nonetheless, the PADEP contracted Camber to **perform** a facility characterization in the early 1990s. Based on this D&D activities have been underway at the Quehanna facility since 1998 under the methods **and** procedures outlined in Revision 1 of the Decommissioning Plan. SCIENTECH has removed significant volumes **of** contaminated material to reduce the on-site radiological hazard and has decontaminated much of the facility in order to reduce the volume of radioactive waste. **A** total of **23,400** cubic feet of low-level radioactive waste (LLRW) has been disposed of to date at Envirocare of Utah. Additionally, in 1998, about 2,000 Ci of cobalt-60 sources of unknown origin were removed from Hot Cell 1 and disposed **of in** Barnwell, South Carolina.

Typical decontamination methods include mopping, wiping, stripcoating, vacuum-blasting, scabbling, grinding, air chiseling, and roto-peening. The structures, facilities, and rooms included within the scope of the previous Decommissioning Plan included the following:

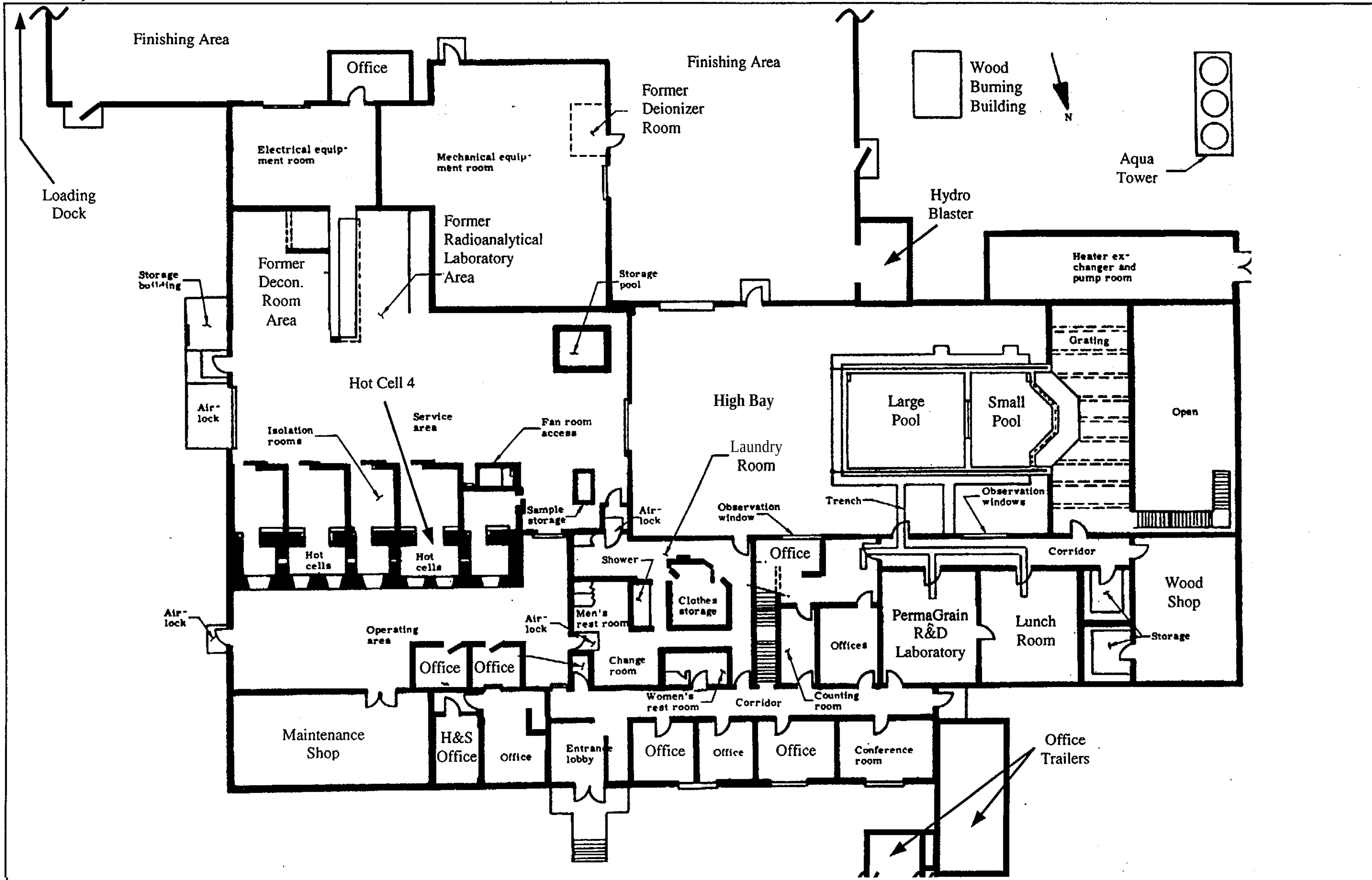
- Radioanalytical Laboratory
- Janitor's **Room**
- Laundry Room
- Deionizer Room
- Radioanalytical Laboratory Mezzanine (South Mezzanine)
- Hot Cells 1 through ***6*** and Associated Isolation Rooms
- Hot Cell Mezzanine (North Mezzanine)
- Storage, Neutralization and Valve Pits
- Stationary Overhead Transfer System **(SOTS)**
- Hot Cell Operations Area
- Service ***Area*** Overhead
- Service Area Floor
- Sample Storage Area
- Waste Water Treatment Building
- Underground Waste Water Tanks and Piping
- Waste Lines

The following paragraphs (Sections 2.3.1 through 2.3.13) describe the D&D activities that have already been completed by **SCENTECH** under Revision 1 of the Decommissioning Plan and appropriate site-specific procedures and the current conditions of the areas listed above. Descriptions **of** the pre-D&D and current contamination levels in these areas are provided in Section 4.1. Section **7.4** provides the additional activities that are necessary to complete the D&D project.

Figure 2-1 shows the current main level floor plan, including the newer PermaGrain areas such 'as the Finishing Area and the office trailers. Figure 2-1 can be compared to Figure 1-2 to see how the facility floor plan has changed as a result of D&D activities. Some noteworthy changes in the use of particular **rooms** in the office/laboratory area include PermaGrain's use of the former Radiochemistry Multicurie Level Laboratory and the Experimental Physics Laboratory as the Research and Development Laboratory and Lunch Room, respectively. PermaGrain has also built two offices into the part of the space occupied by the original Operations Area and uses the former Darkroom as the Health and Safety Office. Figure 2-1 also shows the current layout of the Service Area after SCIENTECH's demolition of the South Mezzanine and the removal of the exhaust stack.

2.3.1 Radioanalytical Laboratory

The Radioanalytical Laboratory (referred to as the Radioanalytical Chemistry Laboratory in Figure 1-2) was located across the Service Area from the Hot Cells. SCENTECH has decontaminated the Radioanalytical Laboratory to the maximum extent practicable. Following the decontamination efforts, the northern and eastern concrete block walls were dismantled and each block was individually surveyed. The concrete blocks and other debris were disposed of as either clean waste or LLRW depending on contamination levels. The floor and southern and western walls of the Radioanalytical Laboratory remain with only localized areas of fixed contamination (see Figure 2-1). A tool and equipment decontamination tent has been installed in the area of the former Radioanalytical Laboratory.



Source: Quehanna Radioisotopes Pilot Plant
Engineering Manual, Cell **4** Process
Martin Marietta, May 1966
Updated in 2002 based on information provided **by** *PermaGrain Products, Inc. and SCIENTECH, Inc.*

FIGURE 2-1
CURRENT MAIN FLOOR PLAN
QUEHANNA FACILITY

2.3.2 Janitor's Room

The Janitor's Room was located across the Service Area from the Hot Cells (see Figure 1-2). SCIENTECH has decontaminated the Janitor's Room to the maximum extent practicable. Following the decontamination efforts, the concrete **block** walls of Janitor's Room were dismantled and each **block** was individually surveyed. The concrete blocks and other debris were disposed of **as** either clean waste or LLRW depending on contamination levels. The floor of the Janitor's Room remains with only localized areas of fixed contamination.

2.3.3 Decontamination Room

The Decontamination Room is located across the Service Area **from** the Hot Cells (see Figure 1-2). SCENTECH has decontaminated the Decontamination Room to the maximum extent practicable. Following the decontamination efforts, the northern and western concrete block walls of Decontamination **Room** were dismantled and each block was individually surveyed. The concrete blocks and other debris were disposed of as either clean waste or LLRW depending on contamination levels. The **floor** and southern and eastern **walls** of the Decontamination Room remain with only localized areas of fixed contamination (see Figure 2-1).

2.3.4 Laundry Room

The Laundry Room (referred to **as** the Hot Change Room in Figure 1-2) is located between the High Bay area and the Clothes Storage area (see Figure 2-1). SCIENTECH has completed decontamination efforts and released **this** room for unrestricted use.

2.3.5 Deionizer Room

The Deionizer Room was located on the western side of **the** Mechanical Equipment Room, south of the Service Area (see Figure **2-1).** Much of the contaminated equipment was removed early in the project. Initial decontamination efforts in the Deionizer Room were limited to a simple wipe-down of areas of elevated radioactivity leaving only localized areas of low-level fixed contamination remaining. From March through May 2002, the remaining equipment was removed from the Deionizer Room, the room was dismantled, and the concrete blocks from the walls were individually surveyed and released. Approximately 95% of the equipment and building materials from the Deionizer Room was disposed of as clean waste.

2.3.6 Radioanalytical Laboratory Mezzanine (South Mezzanine)

SCIENTECH has completely removed the South Mezzanine, formerly located above a storage area and part of the Radioanalytical Laboratory (see Figures 1-2 and **2-1).** The removal included dismantling the high-efficiency particulate air **(HEPA)** filter system and ductwork. The concrete floor was disposed of as LLRW while the concrete blocks from the lower walls, which included the walls of the Radioanalytical Laboratory, the Janitor's Room, and the Decontamination Room, were individually surveyed to determine their disposal route **as** clean waste or LLRW.

2.3.7 Hot Cells and Isolation Rooms

The Hot Cells are located between the Operations Area and the Service Area. During June and July of 1999, the hot cell ventilation system was removed. The 14-inch ventilation ductwork was composed of 1/8-inch-thick stainless steel. Due to the very high levels **of** contamination expected inside the ductwork, it was filled with quickdrying, expanding foam to secure the contamination in the ducts. Utilizing a pneumatic cutting saw, the ductwork was then cut and disposed of as LLRW. The exhaust stack, located downstream of the **HEPA** filters and outside of the Service Area building, was then taken down, decontaminated, surveyed, and released **as** clean scrap metal.

The downcomers traveling from the hot cells down to the Pipe Chase Room are imbedded in poured concrete and will be removed during demolition of the hot cells. SCIENTECH cut the downcomers 6 inches from the Pipe Chase Room ceiling and sealed the openings.

SCIENTECH decontaminated Hot Cells 1, 2, 3, 5, 6, the Fan Room and Pipe Chase Room down to workable contamination levels using vacuum-blasting, scabbling, air-chiseling, etc., leaving a few remaining hot spots. Except for Cell **4,** windows were removed from each of the hot cells. The highest dose rate locations are usually pipes or penetrations, such **as** drains, holes in the concrete, doorstops, ventilation downcomers, shield plugs, and pass-through ports, that will eventually be removed.

During the fall of 1998 approximately 2,000 Ci of cobalt-60 was removed from Hot Cell 1, packaged, and shipped to Barnwell, South Carolina for disposal. Due to the high dose rates and lack of space in Hot Cell 1, the cobalt was transferred to Hot Cell 2 to be placed in the shipping casks. Four new manipulators were built to original specifications and installed in Hot Cells 1 and **2** to assist with the transfer and packaging of the sources. J.L. Shepherd was the primary contractor for the source removal task and was assisted by SCIENTECH project personnel **as** needed.

SCIENTECH removed the steel liners from Cells 1, 2, **3,** 5, and **6,** decontaminated the underlying concrete, and strip-coated the walls to fix any remaining loose contamination and to provide some shielding from the beta radiation.

SCIENTECH removed and decontaminated the massive steel doors from Hot Cells 1, 2, 3, and 5. Doors 1 and 2 were free-released in November 2002 and Doors 3 and 5 were free-released in January 2003. The doors were removed by Micale Construction Services and shipped to B&D Scrapyard in Weedville, PA.

SCIENTECH decontaminated each of the Hot Cell Isolation Rooms to working levels and then painted the walls painted each to fix any remaining loose contamination. Removal of the metal liners from the northern walls in Isolation Rooms 1 and 2 began in December 2002. If the metal liners met the release criteria, they were free-released and shipped off-site as scrap metal. If they could not be decontaminated, they were disposed of as LLRW.

SCIENTECH removed, decontaminated, surveyed, and released all of the cell plugs (ceiling plugs) and replaced them with temporary covers. In preparation for Cell 4 remediation, a removable, remotely-operate, batch covers have been installed over Cells 3 and 4.

The north and south walls of the Service Area also held the rails for the building 15-ton bridge crane. The crane and rails have been removed, decontaminated, and released.

2.3.8 Hot Cell Mezzanine (North Mezzanine)

The Hot Cell Mezzanine is the area above Cells 1 through 5. Access into the hot cells was provided from the mezzanine through ceiling plugs located in the top of the hot cells. SCIENTECH decontaminated the Hot Cell Mezzanine and surface activity levels are now mostly indistinguishable from background with only a few areas of low-level fixed contamination remaining. Following the decontamination of the Hot Cell Mezzanine, SCIENTECH removed the cell plugs and other equipment located on top of the mezzanine. The Hot Cell Mezzanine currently supports the containment system for the Cell 4 decontamination, the Contained Overhead Transfer System (COTS).

Originally, a structure referred to as the Stationary Overhead Transfer System (SOTS) was located immediately above Cells 3 and 4 to provide a means of remotely transferring materials between the two cells. The SOTS was highly contaminated and was subsequently dismantled and disposed of in March of 2000. In order to facilitate future Cell 4 remediation, the COTS was installed as a replacement containment structure in June of 2001. Installation included sealing the COTS to the mezzanine floor surface, installing a remotely operated traveling hoist and connecting all electrical services. The COTS will be used as the primary containment system during the decontamination of Cell 4.

2.3.9 Hot Cell Operations Area

The Operations Area was the area in which the hot cell operations were controlled. The area originally included viewing windows, manipulator arm controls, and other various instruments and controls. Following removal of the viewing windows (excluding the Cell **4** window) and some of the controls, SCIENTECH decontaminated the operations area trench located at the bottom of the cell face wall, such that only a few areas of fixed contamination remain. SCIENTECH also applied a layer of strippable paint to the cell face wall to fix residual removable contamination.

The cell face plugs and plug housings from Hot Cells 1, 2, **3,** and 5 have been removed. The plugs contained all of the connection ports that lead from the operations area into the hot cells. To support this activity, a containment tent with a HEPA ventilation system was constructed in the Operations Area. All plugs were wrapped in plastic and disposed of **as** radioactive waste. **Size** reduction of the cell plug housings was necessary to meet the size limit requirements of the disposal facility.

A major structural modification was engineered in the Operations Area to support the Service ***Area*** roof **and** northern wall during dismantlement of the Operations Area and Hot Cells. Structural modifications to the Service Area north wall were made to allow the safe removal the Hot Cell monolith structure without jeopardizing the structural stability **of** the building. Four steel columns were constructed in the Operations Area to transfer the load of the north wall from bearing on the Hot Cell monolith to new footings located in the Operations Area floor. These new columns tie into **the** existing columns of the wall above the North Mezzanine to allow future removal of the Hot Cell structure. All structural work was performed under the direction of and in accordance with plans approved by the professional engineering firm of Powers & Schram of State College, PA.

2.3.10 Service Area

The Service Area includes the large high-bay area outside the hot cell isolation rooms. Access from the Service Area into the hot cells is through the isolation **rooms. SCIENTECH** decontaminated the Service Area floor to the extent practicable such that only **a** few areas of the floor have measurable levels of fixed contamination. Because of the low contamination levels, SCIENTECH is able to use the Service Area **as** a staging area and work preparation area. SCIENTECH will further decontaminate the hot spots following removal of the hot cells.

Specific D&D activities in the Service Area have included:

- Decontaminate **and** recycle lead bricks;
- Removal, decontamination, and disposal of the overhead trolley system and support'structure;
- Removal and disposal **of** fiberglass insulation on the inner walls of the service area;
- Removal and disposal of miscellaneous piping and conduit;
- Removal of the original overhead lighting (replaced with a temporary lighting using high-intensity discharge floodlights);
- Removal and decontamination of the HVAC ductwork on the Service Area roof;
- Survey and decontamination of the floor and ceiling.

SCIENTECH has disposed of some of this material as clean waste while some waste was disposed of as LLRW.

In August and September 2001, SCIENTECH also addressed several security and safety issues in the Service Area. A new exterior roll-up door was installed along with new interior hinged doors to replace the old interior roll-up door. A stairway was constructed and installed to replace the temporary ladder system that was used to provide access to the North Mezzanine. Repairs were also made to the Service Area roof. Additionally, security cameras were installed in the Service Area to help ensure that the area remains secure during off hours.

The over-head crane, I-beams and trolley rails, were dismantled in February 2002 by cutting them into several sections. A decontamination tent was erected in Service *Area* and the crane pieces were Vac-Blasted in March and April 2002. Finally, each piece received a 100% surface survey, was decontaminated further as necessary, and released as clean waste. Approximately 15 tons of material was shipped off-site as clean waste. The only part of the over-head crane system that was disposed of as LLRW was the trolley assembly.

The Service Area has also been prepared to accommodate the Cell 4 process box mock-up and the control room to be used for the Cell 4 dismantlement and decontamination robotic operations.

2.3.11 Fan Room and Pipe Chase Room

The Fan Room and the Pipe Chase Room are located on the basement level below the Hot Cells. SCIENTECH decontaminated the rooms to acceptable working levels to minimize dose. The Fan Room and parts of the Pipe Chase Room were then painted with a non-strippable paint to fix removable contamination. Other areas of the Pipe Chase Room were painted with a strippable paint that can be pealed away *to* remove some of the removable surface contamination.

Ventilation ducts that were left in the Fan Room and Pipe Chase Room following the removal of the hot cell ventilation system have been removed. The duct sections, which were embedded within the concrete of the dividing wall between the two basement rooms, were filled with foam and the openings were sealed with wooden covers. The dose rates that remained within these sections ranged from 3 mRad/hr to 3 Rad/hr (beta). These were the most contaminated items that remained in the basement area aside from the ductwork coming down from the hot cells.

In 2001, the remaining contaminated duct sections in the center basement wall were removed in their entirety and discarded as LLRW. A concrete core-drilling machine was used to drill around the outside perimeter of the duct pipe through the clean concrete wall. The foam and wooden covers remained intact during the duct removal to prevent the mitigation of contamination. Water generated during the drilling was collected, filtered, and treated using an evaporative process.

2.3.12 Stationary Overhead Transfer System

In March 2000, SCIENTECH dismantled of the SOTS located above Cells 3 and **4** and disposed of as LLRW. The SOTS was composed of a ¼-inch-thick inner aluminum shell surrounded by a cinderblock structure. The entire structure was highly contaminated internally and was removed leaving the Cell **3** and **4** sealed hatches exposed. The area above Cells **3** and **4** were decontaminated to low mrad/hr levels.

2.3.13 Waste Water Treatment Building (WWTB)

The former WWTB, located south of the Reactor Bay building is currently referred to as the Wood Burner Building (see Figure 2-1). SCIENTECH removed miscellaneous tanks, equipment, and piping from the WWTB in the fall of 1998. Concrete core and soil samples revealed contamination underneath the concrete slab. During remediation of the WWTB, SCIENTECH removed about *5* cubic yards (yd^3) of concrete and 40 yd^3 of soil and disposed of it as LLRW. Excavation depths were as deep as nine feet where field screening suggested that the strontium-90 concentrations were as high as **13.5** pCi/g.

Laboratory analysis of composite subsurface samples indicated concentrations of more than **1** pCi/g in the 17.5 to 19.5-foot range. Because the contamination source was at the ground surface, contamination at such depths suggests that the chemical form of the strontium-90 is mobile in the soil. Assuming that contributions to the subsurface contamination began in **1967** when strontium-90 was last used at the Quehanna facility, the maximum vertical transport rate is approximately 0.65 feet per year.

After extensive soil analysis revealed that all of the contaminated soil was removed, SCIENTECH backfilled the excavated areas with clean soil and poured a new concrete floor.

2.3.14 Waste Tanks and Waste Lines

In August 1998, SCIENTECH removed four 3,000-gallon underground waste tanks from behind the WWTB. Samples taken indicated that there was no soil contamination. SCIENTECH also surveyed the underground concrete pad the tanks were placed on and detected no residual contamination. SCIENTECH surveyed and released two of the four tanks while the other two tanks were cut up for volume reduction and disposed of as LLRW.

SCEINTECH removed the LLRW and chemical waste lines that supplied liquid waste from the facility to the waste tanks as well as other WWTB pipes. SCIENTECH removed these lines from the point that they exit the main facility near the Service Area to the waste tanks. SCIENTECH also removed the WWTB effluent lines that lead from the WWTB to the outfalls at the on-site pond. The WWTB drain lines had fixed levels of contamination internally, but soil sampling in the areas immediately adjacent to the drain runs indicated no radioactive contamination.

2.3.15 PermaGrain Areas

SCIENTECH has conducted little decontamination or demolition in the former PermaGrain operations areas. However, in April 2002, SCIENTECH removed a significant amount of material from an area known as the "Office Mezzanine," which is located above the area containing change rooms, restrooms, and shower west of the Operations *Area.* Items removed from the office mezzanine consisted of two air compressors and a very large HVAC system and its miscellaneous components, such as the associated motors, radiators, ductwork, steam lines, water lines, and electrical lines. The HVAC system serviced the Operations Area and the front offices and had been isolated and shut down for a couple of decades. There were low levels of contamination. There are some hot spots, up to 6,000 dpm/100 cm^2, mostly inside the ductwork. All of the equipment removed from the Office Mezzanine was decontaminated to the extent practicable. Any material with inaccessible areas was compacted and disposed of as LLRW. Because there are still some HVAC systems on the Office Mezzanine that are being used, only 20 to 25% of the equipment located on the Office Mezzanine was removed.

2.4 SUMMARY OF RELEASED AREAS

The Laundry Room and the former WWTB are the only affected areas that were part of the original scope of the D&D project that currently meet the criteria for unrestricted release provided in Regulatory Guide 1.86. However, contamination levels in many other areas have also been reduced to below or near acceptable release limits to limit the spread of contamination and to lower the area dose rates.

2.5 SPILLS, UNCONTROLLED RELEASES, AND ON-SITE BURIALS

There is no documented evidence of a major spill or uncontrolled release of radioactive materials at the Quehanna facility prior to the start of decontamination efforts. There is also no documented evidence of on-site burial of radioactive materials. Although site characterization activities resulted in the identification of many areas of surface contamination within the facility structures and areas of soil contamination below the WWTB, the characterization did not reveal any contamination that could be directly connected to a single release event. Soil contamination appears to be a result of general site operations and routine leakage associated with the waste water treatment system.

Since decontamination efforts were initiated, there has been only one incident of an airborne release that resulted in contamination of site personnel, equipment, and the immediate surroundings. On Friday, October 9, 1998, during decommissioning activities, SCIENTECH radiation protection personnel noted relatively high general area radiation levels on the order of 800 mrad/hr in the northeastern area of the Hot Cell 4 Annex. Later that day, shielding was used in the area to reduce the working area dose rate to approximately 100 mrad/hr.

On Monday, October 12, 1998 SCIENTECH personnel used a hand-held shearing device to cut out a short piece of process tubing in the Annex in an attempt to reduce exposure rates for future dismantling activities. Subsequent to removal of the tubing, during a routine frisk, SCIENTECH health physics personnel identified one worker who handled the tube as being contaminated with strontium. Further investigation by SCIENTECH radiological personnel showed that contamination from the tube migrated from the Annex to the Cell 4 Isolation Room, Service Area, and Operations Area (see Figure 2-1). Two other SCIENTECH employees were also contaminated who were directly involved in the removal and handling of the tube. Very low levels of strontium surface contamination were also discovered in the PermaGrain reception area (labeled "Entrance Lobby" on Figure 2-1) and the PermaGrain receptionist was found to have low levels of Contamination on her shoes, clothing, hair, and lower neck. The receptionist indicated that the likely path for personal contamination was through cross contamination stemming from the handling of her shoes. The PermaGrain areas contaminated during this incident, including the reception area, were decontaminated shortly after the incident. The reception area was released without restrictions. The other contaminated areas are located inside previously defined controlled areas. Details of this contamination event including personnel dose assessments were fully documented in a subsequent report to the NRC.

This incident demonstrated the need for a durable containment system and controlled ventilation for future Cell 4 D&D operations. Additionally, the high radiation levels discovered during subsequent investigations inside Cell 4 in 1999 were the primary factor in choosing a robotic approach to the decontamination and dismantling of Cell 4.

As a result of the 1998 incident, Cell 4 was put into a standby mode described in Amendment 7 of the NRC license.

3.0 FACILITY DESCRIPTION

3.1 SITE LOCATION AND DESCRIPTION

The Quehanna site is located at 115 Reactor Plant Road, Karthaus, Clearfield County, Pennsylvania. The site, located at approximately 41° 13' north latitude and 78" 14' west longitude, is about 9 miles from downtown Karthaus and approximately **21** miles northeast of Clearfield, Pennsylvania. Figure 1-1 provides a topographic map showing the general location of the site within the Clearfield County near the boarders of Elk and Cameron Counties (USGS 1971).

The Quehanna site is located in the Quehanna Wild Area of the Moshannon State Forest at an elevation of 1,860 feet above sea level. The area surrounding the site is heavily forested. The topography is typical of the Appalachian Plateau such that the area is relatively flat with an average elevation of 2,000 feet above mean sea level. The edge of the facility property is incised by several gorges up to one-half mile in width and 1,000 feet in depth that radiate from their origin near the center of the site. The area around the site also has a significant number of granite outcroppings that are characteristic of the region.

The nearest population centers to the Quehanna facility are Sinnemahoning and Karthaus, each about nine miles away. The nearest residents to the site are located at the Quehanna Boot Camp, owned and operated by the Pennsylvania Department of Corrections. The Boot Camp, located approximately five miles east-northeast of the Quehanna facility, is a military-style motivational boot camp. The minimum-security Boot Camp typically houses about 200 inmates, both male and female, and supports a staff of about **150** administrators, Corrections Officers, and other support personnel.

The Quehanna site is approximately 7-acres in size and has been improved with several permanent and temporary structures, an asphalt parking lot, and several paved and gravel driveways. The original primary structure included the hot cells area and the reactor bay. Original laboratory and office areas are also still in use (see Figure 1-2). Several areas previously occupied by PermaGrain have been added onto the primary structure to support their wood treatment operations (see Figure **3-1).** The site also includes a small 0.5-acre pond and a septic system leach field that is used to manage sanitary sewer waste from the facility. Several aboveground storage tanks are used to store methylmethacrylate (MMA), the polymer chemical used in PermaGrain's wood treatment process. The tanks are located west of the main facility structure and north of the pond. A small stream bisects the site property north of the facility's main building and parking lot. Figure 3-1 shows the layout of the Quehanna site.

3.2 POPULATION AND LAND USE

The Moshannon State Forest surrounds the facility and has a low permanent population density. Within a 25-mile radius of the site, the population density is approximately 27 individuals per square mile with a total population of about 54,000. Table **3-1** provides population centers by county and their 1999-estimated population for the area within a 25-mile radius of the Quehanna facility. The population of the 25-mile radius area has remained almost constant for the last 35 years.

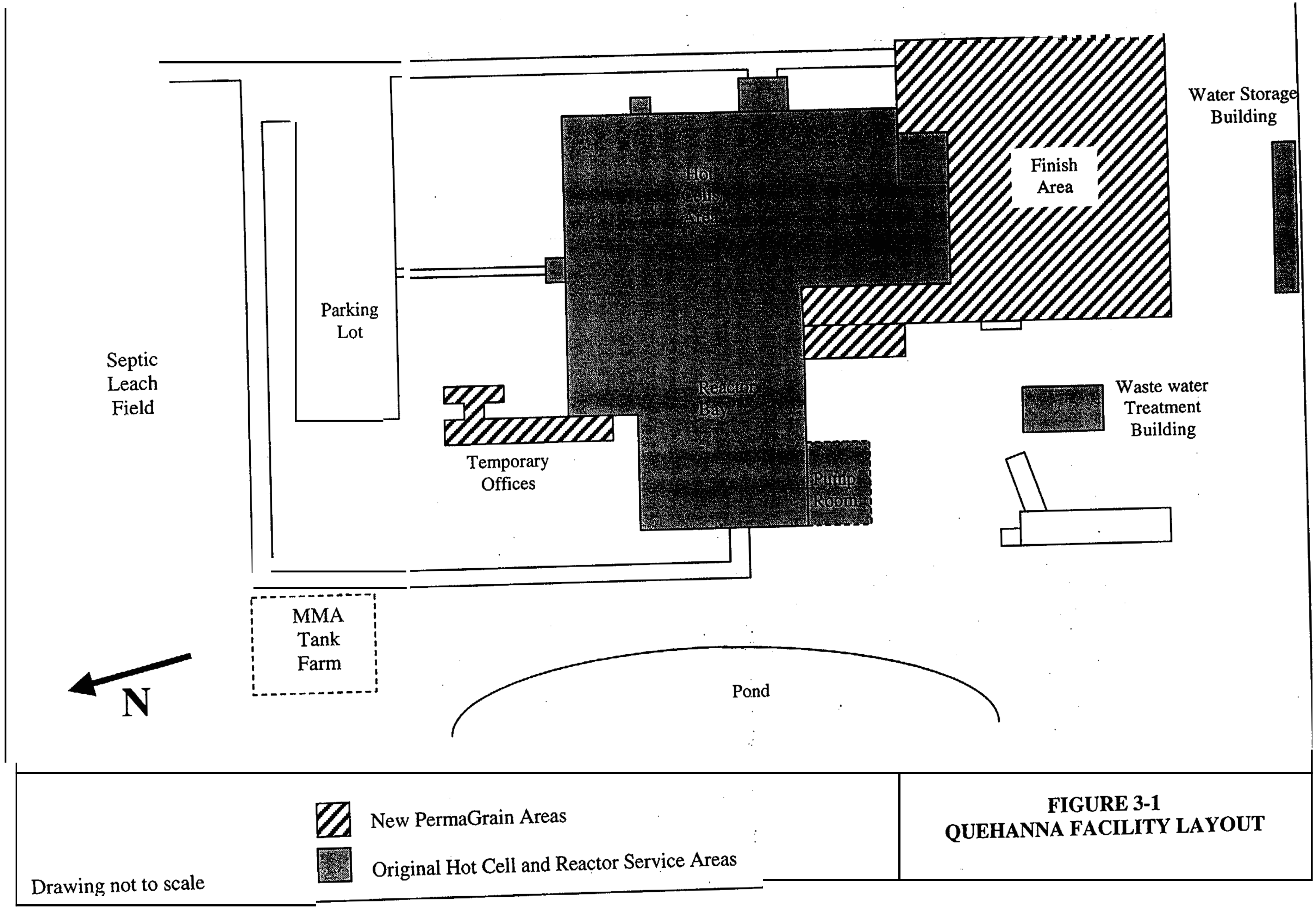


FIGURE 3-1
QUEHANNA FACILITY LAYOUT

TABLE 3-1
POPULATION ESTIMATES FOR AREAS NEAR THE QUEHANNA SITE

Population Centers			
City/Town/Village (County)	Population	City/Town/Village (County)	Population
Driftwood (Cameron)	110	Clearfield (Clearfield)	6,516
Emporium (Cameron)	2,303	Curwensville (Clearfield)	2,937
Bellefonte (Centre) *	6,022	Dubois (Clearfield) *	8,006
Howard (Centre)	713	Osceola Mills (Clearfield)	1,284
Philipsburg (Centre)	2,875	Wallaceton (Clearfield)	329
State College (Centre) **	39,017	Johnsonburg (Elk) *	3,153
Snow Shoe (Centre)	806	Ridgeway (Elk) *	4,423
Chester Hill (Clearfield)	932	Saint Marys (Elk)	13,830

County Totals		
County	Total of Above Areas	Balance of County
Cameron	2,413	3,158
Centre	49,433	82,757
Clearfield	20,004	60,728
Elk	21,406	34,344

Source: **U.S.** Census Bureau internet site, www.census.gov

Notes:

* Town slightly outside the 25-mile radius of the Quehanna facility

** State College is 45 miles southeast of the Quehanna facility

Based on 1998 census estimates, the percentage of minorities in this area of Pennsylvania is very low. The minority populations for Cameron, Clearfield, and Elk Counties, which surround the site in all compass directions, are less than one-percent. The minority population in Centre County is about nine-percent, with most of the minority population residing in State College, 45 miles southeast of the Quehanna facility. According to 1995 census estimates, between 10 and 15 percent of the population lives below the poverty line in Cameron, Centre, and Clearfield Counties. In **Elk** County, approximately eight-percent of the population lives below the poverty line.

Non-residential land in the vicinity of the Quehanna facility primarily supports seasonal recreation activity including hiking, camping, and hunting. Beyond the Moshannon State Forest, within the outlying communities, there is also small-scale agricultural activity. Because of the areas designation as a State Forest, uses of the surrounding land are unlikely to vary from the current uses.

3.3 METEOROLOGY AND CLIMATE

Comparatively short cool summers and long cold winters with 40 to 50 inches of precipitation well distributed throughout the year characterize the climate of the Quehanna area. Average summer temperatures are near 68°F with highs in low 80s and lows in the mid 50s. Many **of** the winter months have mean temperatures below 25°F with January 1918 being the coldest month **of** record when temperatures averaged 13°F and the monthly mean low was **3°F.** The daily temperature range is generally smaller in winter than in any other season due to widespread cloudiness that is prevalent from late November through March.

Although daytime temperatures normally reach into the 50s by April and into the low 70s in May, nights remain cool until mid May. The average date of the last 32°F-temperature in spring is May 19. In the fall the average date of the first 32°F-temperature is September 29, even though daily highs climb into the 60s in October. Year-to-year variations in weather patterns have resulted in 32°F-temperatures as late as mid June and as early as the end of August over the period of record. The growing season, defined as the interval between the last 32"-temperature in spring and the first in fall, averages 133 days, but seasons have ranged from 100 to 170 days.

3.3.1 Wind How and Air Quality

The predominant wind directions at the Quehanna site are from the west-northwest and the south-southeast. From a population distribution standpoint, these are favorable in the event of an accidental release from the Quehanna Site since they are not directed at the major population centers of the region or into areas with above average population density.

Wind speeds during daylight hours vary from a maximum average of about 12 miles per hour (mph) in the spring to about eight mph in the summer. Nighttime speeds are somewhat lower, with a highest average wind speed of about 10 mph in the winter to a lowest average speed of about four mph in the summer. Maximum wind speeds are generally from the west with a maximum sustained wind speed of 50 mph and peak instantaneous gusts of 80 to 90 mph. The most frequent winds are between 4 and 12 mph.

In the period between 1930 and 1965, only five tornadoes were reported in the five-county area around the site. Fifteen tornadoes were reported in the five-county area between 1965 and 1995. A tornado passed very close by the Quehanna facility in 1985 laying a path of downed trees over 100 yards wide and ripping the roof off of parts of the facility structure.

The Pennsylvania Department of Environmental Protection (PADEP), Bureau of Air Quality, has two air quality monitoring stations in Centre County south of the Quehanna facility. One monitoring station is located in State College and the other is located 10 to 12 miles south of State College. During the period from January 2000 through December 2000, the pollutant standards index was in the "Good" range 156 days and in the "Moderate" range for 56 days (PADEP 2001). No days were reported as "Unhealthful," "Very Unhealthful," or "Hazardous."

3.3.2 Precipitation

The average annual precipitation at the Quehanna Site is estimated to be between 40 and 50 inches per year. Maximum precipitation occurs in May through July and the minimum precipitation occurs in November and December. The average precipitation is 2.5 to 4.5 inches per month; however, because of the frequency of storms, precipitation is quite variable. Amounts of as much as 1.7 inches in one hour and 7.5 inches in 24 hours have been observed in the area. Dry spells may develop at anytime but are most numerous during summer and fall.

From November through March most of the precipitation is in the form of snow that is both frequent and abundant. Snowfall is estimated to be an average of about **40** inches per year. Heavy snowfalls are not uncommon resulting **in** up to 10 inches in a single storm. The maximum snowfall recorded in a 24-hour period was 20 inches. A snow cover of varying depths is present most of the winter season.

3.4 GEOLOGY

The Quehanna Site lies near the northeastern edge of the Pittsburgh Low Plateau physiographic province of Pennsylvania **(DCNR** 2000). The province **is** dominated by smooth to irregular undulating surface and, narrow, relatively shallow valleys with low to moderate local relief. The underlying rock types include shale, siltstone, sandstone, limestone, and coal. The origin of the province is fluvial erosion and periglacial mass washing. (DCNR 2000)

The Quehanna Site *area* consists of three major geologic formations present at various depths below the ground surface. The surficial formation, the Pottsville formation, extends **to** about 200 feet below the ground surface. The Pottsville formation is of the Pennsylvanian Age (290 to 330 million years) and consists of massive coarse-grained gray-to-white sandstone with large pebbles. The sandstone is a productive water-bearing formation below drainage levels and generally yields small to moderate supplies elsewhere.

The Pottsville formation is underlain by a formation of Mauch Chunk shale from the Mississippian Age (330 to 365 million years). The shale formation **is** about 50-feet thick and is characterized by red and green argillaceous shale with some sandstone. This formation is not generally exposed and it is not a water-bearing horizon. The formation likely forms an impervious strata retarding downward percolation of water in most areas.

The 600-foot thick Knapp (Pocono) formation lies under the Mauch Chunk formation. This formation is from the Mississippian or Devonian Age (365 to 405 million years) and is characterized by a succession of alternating olive-gray, gritty, micaceous sandstones and gray-green argillaceous shales. These interbedded layers form the steep slopes of the gorges in the area. The formation can be a productive water-bearing formation below the drainage layer.

3.5 STRUCTURE AND SEISMOLOGY

In the Quehanna Site area, the geologic beds are generally horizontal and demonstrate the lack of structural disturbances in the area. In the northern portion of the site area, there is field evidence of gentle folding. The physiographic province is characterized by a geological structure has low- to moderate-amplitude open folds, decreasing in Occurrence northwestward. Faults, joints, and fractures are probably not abundant at the site and the area is considered geologically stable.

Geological hazards in Pennsylvania include landslides, sinkholes, and earthquakes. Case histories of sinkhole Occurrence reveal that sinkholes Occur only in certain parts of Pennsylvania in areas that are underlain by carbonate bedrock. These areas are located in the central to southeastern portions of the state and do not include Clearfield County (DCNR 1999a). The Pittsburgh Low Plateau physiographic province of Pennsylvania, which includes northern Clearfield County and the Quehanna facility is considered high to moderately susceptible to landslides (DCNR 2001). Earthquakes are also rare in this part of Pennsylvania.

The only recorded earthquake with its epicenter in one of the five Pennsylvania counties in the area of the Quehanna Site was in Centre Hall, Centre County, on August 15,1991. That quake registered **a 3.0** on the Richter scale. The epicenters of quakes in Susquehanna, Centre, Blair, and Somerset Counties fall roughly along the Allegheny Front, the position of which may reflect an antecedent tectonic feature, possibly the Iapetan rift margin of Laurentia. Epicenters in northwestern Pennsylvania appear to represent a westward extension of the western New York seismic zone, which itself may be an extension of the zone of seismicity along the St. Lawrence Paleozoic rift. Thus, all Pennsylvania seismicity may be caused by reactivation of faults associated with crust that experienced Paleozoic or Mesozoic rifting.

Complete earthquake histories of Pennsylvania and the states that are within a 200-mile radius of the Quehanna site can be found on the **U.S.** Geological Survey web site, **www.neic.cr.usgs.gov/neis/states.** .

3.6 HYDROLOGY

3.6.1 Surface Water Hydrology

Surface drainage from the area surrounding the Quehanna facility is from four major radial streams; Mix Run (north), Wykoff Run (northeast), Upper Three Run (southeast), and Mosquito Creek (south). The former two streams drain into Sinnemahoning Creek, which flows into the west branch of the Susquehanna River. The later two streams drain directly into the Susquehanna River.

Of prime interest are Reactor Run and Meeker Run, the primary creeks that drain the Quehanna facility site. Surface water around the Quehanna facility flows into Reactor Run and then successively into Meeker Run, Mosquito Creek, and ultimately into the west branch of the Susquehanna River. The river has a rather large average flow rate of more than 2,400 cubic feet per second (cfs) at Karthaus, Pennsylvania with maximum and minimum flows rates approximately 51,000 and 100 cfs, respectively (Martin Marietta 1964). There is no available data on the flow of the smaller runs and creeks.

A pond, about 0.5 acre in size, is located west of the Quehanna facility outside of the fence line. **A** man-made earthen dam is located on the western side of the pond. **A** spill way allows water from the pond to flow though the dam into Reactor Run Creek and eventually into Meeker Run Creek. The water source of the pond is surface water run-off from the Quehanna Site area and at least one underground spring.

Formerly, water for the facility was obtained from a dam on Meeker Run Creek. The dam was located upstream from the facility and was capable of releasing water at a rate of 120 gallons per minute. There are two additional reservoirs within the surrounding site area, both **of** which are several miles from the facility

Due to the site's location, elevated nearly 300 feet above Meeker Run and Mosquito Creeks, the possibility of the site flooding is extremely unlikely.

3.6.2 Subsurface Hydrology

As stated in Section 2.4, the predominant aquifer in the **area** is contained in the Pottsville formation, though it is not very productive. Since the Pottsville formations form the surface exposure of the area, it collects water and transmits it downward to **a** saturated sandstone member about 40 feet thick near the interformational contact with the impervious Mauch Chunk shale formation. Streams cutting the Pottsville provide secondary recharge. Discharge occurs at springs at the interformational contact. The evapotranspiration rate for the area is **4** to 8 inches per year.

The underlying impervious Mauch Chunk shale prevents downward transmission of potential contaminants released to the Pottsville formation. Lateral transmission within the Pottsville aquifer would be of a somewhat limited nature and would not **pose** a significant subsurface contamination problem in the light of the large unpopulated area surrounding the facility. In fact, movement of soluble contaminants within the Pottsville formation would be on the order of tens to a few hundred feet per year (DeBuchananne 1956).

The contaminants of concern are considered slow-moving in saturated subsurface layers under normal conditions. Strontium-90 has a default distribution coefficient (K_d) of 30 milliliters per gram (ml/g) **and** cobalt-60 has a default K_d of 1,000 ml/g (RESRAD 6.1). Some other reported values of K_d for strontium-90 range from 85 to 150 ml/g (Eisenbud 1987).

Field studies in the former Soviet Union showed that strontium-90 migrated at a rate of 1.1 to 1.3 centimeters per day through saturated soils with moderately high exchange capabilities. Since the average life of a strontium-90 atom is about 30 years, under these conditions, a strontium-90 atom would typically travel only about 200 meters before it decayed. The total amount of strontium-90 would then diminish to 0.1% in less than 10 half-lives (300 years), by which time the mean distance traveled would be 1,400 meters (Eisenbud 1987).

The groundwater in Clearfield, Elk, and Cameron Counties is used of for public and private water supplies. The percentages of public water that comes from groundwater sources in Clearfield, Elk, and Cameron Counties are 36%, 8% and 35%, respectively. The percentages **of** homes that have private wells in Clearfield, Elk, and Cameron Counties are 20%, 37% and 37%, respectively. Each of these counties has 15 to 29 private wells per square mile (DCNR 1999b).

3.7 NATURAL RESOURCES

Natural resources in the five counties in the area surrounding the Quehanna facility include primarily timber, minerals, oil, natural gas, and to a lesser extent, brine and agriculture. However, the most significant natural resources in the immediate vicinity of the facility are the Moshannon State Forest and the Quehanna Wildlife Area.

In recent years there has been an increasing demand for types of recreation that only large tracts of forestlands such as the Moshannon State Forest can provide. Traditional outdoor activities such as hunting and fishing have been stable, but such things as cross-country skiing, mountain biking, backpacking, horse back riding and motorized recreational activity increase each year. Some of these have required the construction of new or the upgrading of older trails systems. Maps have been created for a number of the specialty trails.

The Quehanna Wild Area is set aside to maintain the undeveloped character of the forest environment. This 50,000-acre area was originally state forestland that was transferred to the Curtiss Wright Corporation for jet engine and nuclear research in 1955 and returned to the Commonwealth in 1966. Today this area shows the stark evidence of extensive oak leaf roller mortality and the massive destruction caused by the 1985 tornado. Natural regeneration has become evident on a number of these sites, holding the promise of a future forest. The Quehanna Wild area is jointly administered by the Moshannon and Elk Forest Districts of the Pennsylvania DCNR. Certain special regulations guide the types of activities that are permitted in the wild area. Contact the district forester for more details.

The near-by 975-acre Marion Brooks Natural Area is the site of a pure stand of white birch trees. It is adjacent to the Quehanna Wild Area. This area is preserved so that nature may take its course, free from human intervention.

There are three State Parks within the Moshannon State Forest. Two of them are administered from the same office. They are: Parker Dam State Park, S.B. Elliott State Park, and Black Moshannon State Park.

The **1998** natural gas, oil, and brine production rates for Cameron, Centre, Clearfield, Clinton, and **Elk** Counties are provided in Table **3-2.**

TABLE 3-2
FUEL RESOURCES SURROUNDING THE QUEHANNA AREA

County	Gas Quantity (MCF)	Oil Quantity (Bbl)	Brine Quantity (Bbl)
Cameron	223,017	0	420
Centre	2,028,003	0	21,740
Clearfield	4,652,381	463	892
Clinton	2,163,349	0	3,063
Elk	1,957,269	341,255	5,144
Percent of States Total	8.5%	30%	1.6%

Source: Pennsylvania Department **of** Conservation and Natural Resources internet site, www.dcnr.state.pa.us/topogeo/WIS/Gas1998.html

Notes:

MCF Millions of cubic feet

Bbl Barrels

According to the ***1997 Directory* of the *Nonfuel-Mineral Producers in Pennsylvania,*** there are no major mineral produces in the Quehanna area and only a few producers in the five county areas. The nonfuel-mineral or industrial resources covered by the directory include abrasives, agricultural minerals, borrow and general fill, bricks, carbonate for SO_2 absorption, cement raw materials, coal-mine rock dust, construction aggregate, dimension stone, fillers, fluxstone, high-calcium limestone, high-magnesium dolomite, lime, quartz crystals, railroad ballast, refractories, roofing materials, specialty clay and shale, specialty sand, **talc,** and topsoil. There are no mineral, fuel, **or** hydrocarbon resources near the site, which, if exploited, would affect the radiological impact of the post-remediation site.

3.8 ECOLOGY AND ENDANGERED SPECIES

Wildlife in the area of the Quehanna facility is diverse and includes populations of large mammals including elk, bear, and deer. The Quehanna facility is located on the northern edge of state designated game lands Area No. **34.** The primary game in **the** area includes bear and deer. In **1999,** the harvesting totals for bear, antlered deer, and antlerless deer in the five counties in the Quehanna area were **476, 17,572,** and **12,867,** respectively. There are no known commercially or recreationally important invertebrate or floral species located in the vicinity of the Quehanna facility.

The statewide elk population, which has risen from less than 100 in **1971** to almost **600** in **1998,** is concentrated in the Quehanna Wildlife Area. Although the population has been successfully reestablished in the area, elk hunting is not currently allowed by the Pennsylvania Board of Game Commissioners.

Creeks and streams within the immediate vicinity of the Quehanna site can provide brook and brown trout to recreational fisherman. Parker Dam State Park and S. B. Elliott State Park, each located within 15 miles of the Quehanna facility, are popular destinations for recreational fisherman. The streams and ponds at the parks support populations of trout, bass, bluegills, crappie, and catfish.

There are several federally endangered species in Pennsylvania. These species include the bog turtle, the peregrine falcon, the short nose sturgeon, the Indiana bat, and the Delmarva fox squirrel. The bald eagle, now federally designated as threatened, is also present in Pennsylvania. The proximity of breeding populations of these endangered or threatened species to the Quehanna facility is not known. Additionally, 20 percent of the state's native vascular plants are designated as endangered by the state. It is uncertain if any of these plants are located at the Quehanna facility. However, Pennsylvania Natural Diversity Inventory (PNDI) information system records do not indicate Occurrences of plant or animal species of special concern within a five-kilometer radius of the Quehanna site (PNDI 2001). Therefore, it is not anticipated that decommissioning activities will have an impact on endangered, threatened, or rare species.

4.0 RADIOLOGICAL STATUS OF THE FACILITY

The unoccupied areas of the Quehanna facility received a mdiological characterization by Canberra Industries, Inc. (Canberra), in 1991. The results of Canberra's characterization are reported in ***Radiological Characterization of the Quehanna, Pennsylvania Site*** (Canberra 1993). The report indicated that contaminated structures and systems within the Quehanna facility consisted of the following:

- The WWTB
- The underground waste water holding tanks adjacent to **the** WWTB
- The Radioanalytical Laboratory
- The Decontamination Room
- Hot Cells **1** through ***6*** and Isolation Rooms
- The Hot Cell Mezzanine (North Mezzanine)
- The Fan Room and ventilation system located directly **below** the hot cells
- The **SOTS**
- The South Mezzanine
- Miscellaneous areas including the Service ***Area*** floor, the overhead crane, the Laundry Room, and the utilities trench in the Operations Area

As indicated in Section **2.3,** SCIENTECH has **performed** a significant amount of decontamination and remedial activities within these areas. The radiological conditions, characterized by Canberra and the current radiological status of **the** facility, are provided in the following sections.

4.1 CONTAMINATED STRUCTURES

Prior to initiating the D&D project, it was found that many of the structures associated with the hot cell operations were contaminated with strontium-90 (Canberra 1993). Much of the pre-decontamination strontium-90 contamination data presented in the following sections was reported by Canberra in 1993. SCIENTECH has decontaminated much of the Operations, Service, and Hot Cells ***Areas,*** while only limited measurements have been made in the Reactor **Bay** and Beam Room (PermaGrain side of the facility). These measurements show only disperse spots of strontium-90 contamination **on** building materials such **as** steel I-beams in the Reactor **Bay** area.

Because the strontium-90 contamination is disperse and can be found on many large and small surfaces, no maps are provided in this Decommissioning Plan designating the exact location and level of contamination.

4.1.1 Radioanalytical Laboratory

The Radioanalytical Laboratory faced the hot cell isolation rooms in the Service Area and was reportedly decommissioned prior to the Canberra characterization. The laboratory contained only counters, lab benches, and fume hoods. The room was serviced with its own ventilation system located directly overhead **on** the South Mezzanine. Liquid waste from the laboratory was directed to the low-level waste holding **tank.**

Prior to decontamination efforts by SCIENTECH, Canberra identified low-level strontium-90 contamination in all areas of the Radioanalytical Laboratory except the overhead ventilation system, which had very high levels of contamination. The tile flooring demonstrated total activity levels between 200 and 8,000 dpm/100 cm^2, with no removable contamination. No contamination was detected on the counter or lab bench except for three isolated areas. The fume hoods contained spotty **fixed** contamination ranging from 1,000 to 1,500,000 dpm/100 cm^2. The drop ceiling had levels of activity up to 15,000 dpm/100 cm^2 and removable contamination levels up to 1,000 dpm/100 cm^2.

The exhaust ducts from the fume hoods were severely contaminated. Levels approaching 200,000 dpm/100 cm^2 removable and 3,000,000 dpm/100 cm^2 total were measured inside these ducts.

In 1999, SCIENTECH decontaminated the Radioanalytical Laboratory so that only very low levels of residual radioactivity remain. Most surface measurements indicated that there was little Contamination detectable above background (50 – 60 cpm with a GM frisker). **A** few areas, however, still have contamination that measures several thousand cpm above background. There are also a few locations with contact dose rates in the low mrad/hr range.

4.1.2 Janitor's Room

The Janitor's Room was a small storage **room** located between the Radioanalytical Laboratory and the Decontamination Room. Canberra identified strontium-90 contamination from 3,000 to 70,000 dpm/100 cm^2 total activity, with removable activity less than ***300*** dpm/100 cm^2 on the floor of the Janitor's Room. **A** wooden shelf in the room was also contaminated with levels less than 10,000 dpm/100 cm^2.

SCIENTECH decontaminated the Janitor's Room so that only very low levels of residual radioactivity remain. Most post-decontamination surface measurements indicate that there is little contamination detectable above background (50 to 60 cpm). Subsequently, the Janitor's Room has been dismantled.

4.1.3 Decontamination Room

The Decontamination Room, used for storage of containerized equipment, was nearly **filled** with over 100 items at the time of the Canberra characterization, including waste drums that were considered to be contaminated or to contain radioactive materials. In addition, the room contained a fume hood, decontamination booth, and overhead crane. The room was serviced with its own ventilation system located directly overhead on the South Mezzanine. Liquid waste from the room was directed to the low-level waste holding tank.

The Decontamination Room floors were slightly contaminated with strontium-90 to levels as high as 10,000 dpm/100 cm^2 total and 200 dpm/100 cm^2 removable contamination. The decontamination booth floor was highly contaminated with activity levels ranging from 400,000 to 2.4 million dpm/100 cm^2 total and less than **1,000** dpm/100 cm^2 removable contamination. The fume hood and overhead fixtures (crane, heater, pipes) were also contaminated with fixed activity from 30,000 to more than 2 million dpm/100 cm^2. Several of the stored components such as a manipulator arm, glove box and metal plates were also contaminated to similar levels.

The Decontamination Room ventilation system was also highly contaminated with strontium-90, with ducts from the decontamination booth measuring 300,000 dpm/100 cm^2 fixed contamination. Filters still in place at the time of the Canberra characterization had total (fixed plus removable) surface contamination levels as high as 410,000 dpm/100 cm^2. The remainder of the system, down stream from the filters, was less contaminated with levels up to 30,000 dpm/100 cm^2 fixed and little removable activity.

In 1999, SCIENTECH decontaminated the Decontamination Room so that only very low levels of residual radioactivity remain. Most surface measurements indicate that there is little contamination detectable above background (50 – 60 cpm), A few areas, however, still have contamination that measures several thousand cpm above background. There are also a couple of locations with contact dose rates in the low mrad/hr range.

4.1.4 Fan Room and Pipe Chase Room

The Fan Room is a large concrete room on the basement level below the hot cells. The room is divided into two sections. The rear section, also known as the Pipe Chase Room, housed only overhead ductwork that exited the hot cells above. These ducts were part of the cell ventilation system that is discussed in **Section** 3.2.3. The front section of the room, the Fan Room, contained the filter housings, pumps, and exhaust ducts that led to the exhaust stack.

Canberra found that most of the exterior surfaces in the Fan Room were contaminated with strontium-90. Levels on the floors ranged from 3,000 to 500,000 **dpm/100** cm^2 total and 140 to 12,000 dpm/100 cm^2 removable in the Pipe Chase Room. Levels in the Fan Room approached 5 million dpm/100 cm^2 total activity and 60,000 dpm/100 cm^2 removable. As in other areas, SCIENTECH painted the floor to fix surface Contamination. The Pipe Chase Room also contained 80 highly contaminated **HEPA** filters that were removed and disposed of as LLRW in 1998.

The exterior surfaces of equipment in the Fan Room were also slightly contaminated, with levels from 200 to 6,800 dpm/100 cm^2 removable activity present. The Fan Room walls also had similar levels of contamination.

SCIENTECH decontaminated the Fan Room down to a maximum removable contamination level of 5,000 dpm/100cm^2 and a maximum dose rate of 75 mrad/hr. Most areas within the Fan Room have a dose rate less than 1 mrad/hr and have removable contamination levels less than 1,000 dpm/100 cm^2.

4.1.5 South Mezzanine

The South Mezzanine was located above the Radioanalytical Laboratory, the Decommissioning Room, and the Janitor's Room. The area was not surveyed as part of Canberra's characterization; however, SCIENTECH surveys identified residual strontium-90 contamination.

SCIENTECH removed the South Mezzanine floor, which was the ceiling of the Radioanalytical Laboratory, the Decommissioning Room, and the Janitor's Room. All of the concrete from the floor was disposed of as LLRW. As part of the mezzanine removal, SCIENTECH removed the lower block walls, which included the walls of the Radioanalytical Laboratory, the Decommissioning Room, and the Janitor's' Room. SCIENTECH surveyed each of the concrete blocks from the lower walls to determine the appropriate disposal method.

4.1.6 Hot Cells and Isolation Rooms

The Quehanna facility contains six hot cells. Cells 1 through 5 are located on the facility main floor. Each has an associated Isolation Room to serve as a transition area from the Service Area. Each hot cell also had a viewing window for remote work from the Operations Area (all windows except for the Cell 4 window have been removed). Cell 6 is located directly below Cell 1 and is accessed from the Fan Room. Strontium-90 contamination levels measured during the initial surveys conducted by Canberra and the current status of the Hot Cell with recent measurements are provided in the following paragraphs.

Cell 1

Cell 1 has the interior dimensions of 6 feet by 7 feet. At the time of the Canberra characterization, the cell contained a worktable, a lead storage shield, and slightly less than 3,000 curies of cobalt-60. Approximately 2,400 curies was contained in two irradiation plates with the remainder of the activity contained in various forms including two 12-inch panels, 27 two-inch slugs, and nearly 7,500 microspheres.

Due to the high radiation levels present, Canberra characterized Cell 1 using remotely operated equipment External exposure levels at the cell door were 1 R/hr with levels in the cell ranging from 3 to 400 R/hr. Removable contamination levels ranged from 1,300 to 41,000 dpm/100 cm^2 and consisted primarily of cobalt-60. Fixed contamination levels could not be determined during the Canberra survey due *to* the high ambient radiation fields present from the cobalt-60 sources.

At the time of the Canberra survey, the Cell 1 Isolation Room contained five 55-gallon drums and three shipping casks. One cask contained cobalt-60 sources and read **400 mR/hr** on contact and 30 mR/hr at 1 meter from the surface of the cask. Removable strontium-90 contamination of 100 to 2,200 dpm/100 cm^2 was present on the Isolation Room floor.

After SCIENTECH removed the cobalt sources and other materials from Cell 1 and the Isolation Room, repackaged the materials, and shipped the material off-site, SCIENTECH was able to characterize the stronium-90 surface contamination levels and decontaminate the area. SCIENTECH's initial decontamination efforts in Cell 1 reduced the maximum removable strontium-90 contamination levels to 10,000 dpm/100 cm^2 and the maximum dose rate to 600 mrad/hr.

Following the initial decontamination, SCIENTECH removed the steel cell liner and subsequently completed decontamination efforts inside the cell. The maximum removable contamination and contact dose rate levels underneath the steel cell liner were 300 mrad/100 cm^2 and 30 rad/hr, respectively. After removal of the liner and extensive decontamination of the walls behind the liner, the current maximum removable contamination levels inside the cell **are** 5,000 dpm/100 cm^2 and the maximum contact dose rate **is** 210 mrad/hr. SCIENTECH has also decontaminated the ceiling plug from Cell 1 and disposed of it as clean waste.

Cell 2

Cell 2 has the interior dimensions of 6 feet by 12 feet. At the time of the Canberra characterization, the cell contained two worktables and a large shipping cask. The cell had a metal plate on the floor and a metal liner on the walls. All surfaces had been painted at least once **prior** to the characterization survey.

Radiation and strontium-90 contamination levels in Cell 2 were reported to be relatively low. The highest beta dose level measured by Canberra **was** 100 mrad/hr. Other readings were 5 to 10 mrad/hr dose rates and 1 to 5 mR/hr exposure rates. Removable contamination levels ranged from 100 to 17,000 dpm/100 cm^2. The predominant contaminant was strontium-90.

The Cell 2 Isolation **Room** formerly contained eleven 55-gallon drums, 26 used filters, a workbench, and a handcart. Exposure rates were less than 1 mR/hr and Contamination levels were less than 500 dpm/100 cm^2 except for areas on the floor near the cell door.

SCIENTECH discovered the strontium-90 contamination levels in Cell 2 to be much greater than reported by Canberra. SCIENTECH's initial decontamination efforts in Cell 2 reduced the maximum removable contamination levels to 20,000 dpm/100 cm^2 and maximum dose rate to **4.5** Rad/hr. Following the initial decontamination, SCEINTECH removed the steel cell liner and subsequently completed decontamination efforts inside the cell.

SCIENTECH did not detect any significant contamination underneath the steel cell liner. The current maximum removable contamination levels and dose rates inside the cell are 5,000 dpm/100 cm^2 and **160** mrad/hr, respectively. SCIENTECH has also decontaminated the ceiling plugs from Cell 2 and disposed of them as clean waste.

Cell 3

At the time of the Canberra facility characterization, Cell 3 contained a stainless steel glove box that occupied nearly all of the 6-foot by 7-foot floor space. The box was formerly used for studies on mixed oxide fuel rods and was reportedly decontaminated upon completion of the work. A Canberra survey indicated relatively low levels of both cobalt-60 and strontium-90 contamination in Cell 3.

General exposure **rates** in Cell **3** were 1 to 3 mR/hr. Contamination levels on the metal plates coverings the floor and walls ranged from 100 to 5,500 dpm/100 cm^2. Removable contamination inside the glove box ranged from 200 to 20,000 dpm/100 cm^2. No removable alpha contamination was detected.

Canberra reported that the Cell 3 Isolation Room contained a glove box, used filters and a hand dolly. Exposure rates and contamination levels were near background.

SCIENTECH's decontamination efforts in Cell **3** reduced the maximum removable contamination levels to 5,000 dpm/100 cm^2 and the maximum dose rate to 150 mrad/hr. SCIENTECH has also removed the cell liner.

Cell **4**

Cell **4** contains a stainless steel process box, divided into two sections (4A and 4B), that encompasses most of the 8-foot by 12-foot cell. Access to the process box is available only from overhead by way of the Cell 4 hatches. All major process equipment was removed from the process box and the box interior was painted after reportedly being decontaminated. However, complete decontamination was not achieved and very high levels of contamination remain.

Canberra measured contact beta dose rates on the floor inside the Cell **4** Isolation Room as high as **1** rad/hr and 3.8 million dpm/100 cm^2 removable strontium-90 contamination. Canberra could not gain access to the remainder of the cell.

Canberra characterized the process box from overhead using the SOTS. Radiation levels near the floor in section **4B** were 100 mrad/hr beta dose rate **and** 20 mR/hr exposure rate. Levels near the floor in section 4A were **400** mradhr beta dose rate and 30 **mR/hr** exposure rate. Removable strontium-90 contamination ranged from 100 to 10,000 dpm/100 cm^2 in section **4B** and **1,300** to 1 million dpm/100 cm^2 in section **4A.**

In October 1998, a small amount of strontium-90 was released into the Service Area from Cell 4 during dismantling work being performed in the Cell 4 Annex. SCIENTECH estimated that the amount released was approximately 10 to 100 millicuries. Investigation into the source of this event led to the discovery of high levels of residual strontium by-product material remaining within the Cell 4 process equipment. A partial characterization survey of the inside of the process box provided data on the deep dose rates from the bremsstrahlung radiation. These dose rates were used to backcalculate an estimate of the total strontium-90 activity in the process box. SCIENTECH estimates that about 100 curies of strontium-90 remains in localized areas internal to the hot cell process equipment (NES 1999).

Cell 5

Cell 5 is an 8-foot by 8-foot cell that contained a worktable, source storage vault, and miscellaneous small items at the time of the Canberra characterization. At that time, the vault contained two containers of cobalt-60 in the form of mini-pellets with a total activity of approximately 18 curies.

Canberra measured radiation levels in Cell 5 at 2 to 5 mR/hr in most places except on the floor near the vault door, where levels up to 500 mR/hr were recorded. Strontium-90 contamination levels were found to be relatively low with a maximum reading of 4,000 dpm/100 cm^2 on the manipulator arms.

The Cell 5 Isolation Room contained six used filters and a glove box at the time of the Canberra characterization. Strontium-90 contamination levels in the room were less than 100 dpm/100 cm^2 removable. A beta dose rate of 8 mrad/hr was measured on the glove box.

SCIENTECH's initial decontamination efforts in Cell 5 reduced the maximum removable contamination levels to 5,000 dpm/100 cm^2 and the maximum dose rate to 3 mrad/hr. Following the initial decontamination, SCEINTECH removed the steel cell liner and subsequently completed decontamination efforts inside the cell. The current maximum removable strontium-90 contamination levels and dose rate inside the cell are 5,000 dpm/100 cm^2 and 2 mrad/hr, respectively. SCIENTECH has also decontaminated the ceiling plugs from Cell 5 and disposed of them as clean waste.

Cell 6

Cell 6 is located directly below Cell 1 on the basement level. The cell has a shielded maze entrance, no windows and no remote handling capabilities. The cell was empty at the time of Canberra characterization.

Elevated radiation levels were present in Cell 6 due to cobalt-60 stored in Cell 1, located directly above Cell 6. Levels were 10 mR/hr at 3 feet and 20 mR/hr at 6 feet above the cell floor, and continued to increase while approaching the ceiling. The cell floor was also highly contaminated, with beta dose rates of 200 mrad/hr and removable strontium-90 contamination greater than 500,000 dpm/100 cm^2.

SCIENTECH's initial decontamination efforts in Cell 6 reduced the maximum removable strontium-90 contamination levels to 5,000 dpm/100 cm^2 and the maximum dose rate to 450 mradhr. Following the initial decontamination, SCEINTECH removed the steel cell liner and subsequently completed decontamination efforts inside the cell. The maximum removable contamination levels and dose rates underneath the steel cell liner were 1.2 Rad/100 cm^2 and 90 Rad/hr, respectively. The current maximum removable contamination levels inside the cell are 20,000 dpm/100 cm^2 and the maximum dose rate is 210 mradhr.

4.1.7 North Mezzanine

The mezzanine above the hot cells, known **as** the Cell Mezzanine or the Noah Mezzanine, used to contain a filter housing and associated ventilation ductwork that Canberra reported to be contaminated internally up to 45,000 dpm/100 cm^2 on the duct work and 750,000 dpm/100 cm^2 on the filters.

The mezzanine floor also showed total contamination measurements up to 15,000 dpm/100 cm^2 during the Canberra surveys. Dose rate measurements on the mezzanine over Cell **1** were elevated due to the presence of the cobalt-60 sources in the cell.

SCIENTECH has decontaminated most of the North Mezzanine to near background levels with only scattered areas **of** fixed contamination. Most of the higher-activity areas are around the openings into the hot cells below. The **COTS** has been installed above the Cell 3 and Cell 4 hatches.

4.1.8 Operations Area

The Operations Area is the area on the north side of the hot cells where the operations within the cells were controlled. In this area, operators used manipulator arms to **perform** tasks within the cells and viewed their work through thick windows in the cell faces. Canberra found that the utility trench immediately adjacent to the cell faces was highly contaminated with fixed strontium-90 Contamination. Measurements ranged from 60,000 to more than **4** million dpm/100 cm^2 in the trench. Removable levels were generally less than 1,000 dpm/100 cm^2. Residual contamination also appeared to extend above the trench to the cell face walls near the floor.

Currently, the operations area has fixed strontium-90 contamination on the cell face. Most of the contamination is low level and is located under a lining of strippable paint. The operations area trench has be decontaminated to near background levels with only a few locations **as** high **as** a few thousand cpm) with one spot in front of Cell 2 that reads 300 mradhr through a crack. The cell plugs and plug housings from Cells 1, 2, 3, and 5 have been removed and disposed of as radioactive waste.

4.1.9 Service Area

The Service Area floor, a sealed concrete surface, exhibited low-level fixed strontum-90 'contamination during the Canberra characterization surveys. Levels ranged from 200 to 1,000 dpm/100 cm^2, with isolated hot spots up to 12,000 dpm/100 cm'. Canberra found that streaming from Isolation Room doors made quantification difficult near the hot cells.

The Canberra surveys also showed that most of the overhead fixtures in the Service Area were also slightly contaminated with strontium-90. Canberra measured contamination levels from 1,000 to 30,000 dpm/100 cm^2 total and 100 to 28,000 dpm/100 cm^2 removable on the large overhead crane, tracks, and walkway. Thirty overhead light fixtures had levels ranging from 1,000 to 30,000 dpm/100 cm^2. Accessible overhead beams and surfaces exhibited similar levels **of** contamination strontium-90.

In 2002, SCIENTECH removed the overhead crane and walkway and decontaminated the Service Area floor. The floor has **fixed** contamination with contact dose rates ranging from less than 0.2 to 200 mrad/hr. Because the Service Area is a high-traffic **area,** SCENTECH will decontaminate the hot spots when the floor is more accessible. The Service Area walls and ceiling are mostly clean with isolated areas with contact dose rates in the low mrad/hr range.

4.1.10 PermaGrain Areas

A number of areas in the former PermaGrain operations areas have not been characterized due to the previous ongoing manufacturing operations. However, since PermaGrain vacated the facility in December of 2002, further characterization efforts will be expended to assess radiological conditions in previously inaccessible areas. Of particular interest will be the pipe trenches that originate in the Radiochemistry and Experimental Physics Laboratories (see Figure 1-2) and the rooms themselves. These areas were most recently PermaGrain's R&D Laboratory and Lunch Room respectively (see Figure 2-1). Also, the irradiator pool and associated tanks and piping will be characterized once the cobalt sources **are** removed and pool drained. Because the pool was once used as a nuclear test reactor, there may be some activation of the concrete walls and floor of the pool.

CONTAMINATED **SYSTEMS** AND EQUIPMENT

Many of the support systems and equipment associated with the hot cell operations were heavily contaminated with strontium-90 (Canberra 1993). SCENTECH has decontaminated most of these systems to some degree or removed the systems completely. Contaminated equipment, drums, casks, and other debris have been decontaminated and disposed of as either clean waste or LLRW. SCENTECH and PermaGrain have made limited measurements on the process systems and equipment routinely used prior to PermaGrain vacating the facility. It is anticipated that most **of** PermaGrain's equipment is not contaminated and will be released.

4.2.1 Waste Water Treatment Building (WWTB)

The waste water treatment equipment occupied one half of the 30-foot by 40-foot single-story WWTB located behind the main facility structure. The building is currently referred to **as** the Wood Burning Building. The plant heating system, a wood and sawdust-burning boiler, occupies the second half of the building. The building was constructed of insulated corrugated metal walls and roof on a concrete pad.

Canberra speculated that the entire waste water treatment system was internally contaminated with strontium-90, with the possible exception **of** small portions of the "suspect" waste lines. The Canberra characterization report stated that it appeared that most of the components had been flushed and/or cleaned following **use;** however, significant levels of contamination remain primarily **as** fixed contamination.

The system pumps and associated pipes designated as 401A, 401B, 402A, and 402B exhibited low levels of contamination during the Canberra surveys. Canberra measured activity in the "suspect" system (401) near background levels with count rates at the open piping ranging from 50 to 150 cpm gross beta activity with **a** G-M tube. Canberra measured activity in the "low-level" system (402) with count rates ranging from 1,000 to 15,000 cpm at pipe openings. **Smears** from "low-level" system pipe interiors were 1,500 to 3,500 dpm per **smear.**

Canberra also found that the vacuum receiver tank (T-404) was internally contaminated with levels estimated at 15,000 dpm/100 cm^2. Internal contamination was found to be higher in the gravity tank (T-403) and was estimated to be as high **as** 500,000 dpm/100 cm^2 with a dose rate of 1 to 10 mrad/hr. The evaporator tank (T-401) was similarly contaminated with estimated levels approaching 400,000 dpm/100 cm^2 total activity but only 5,000 to 7,000 dpm/100 cm^2 removable. Piping associated with these **tanks** was also highly contaminated. Measurements at pipe openings were **as** high **as** 30,000 cpm. The only identifiable contaminant in these components was strontium-90.

SCIENTECH also performed **a** radiological characterization **of** the WWTB in 1999. The characterization resulted in a 100-percent surface scan, **46** surface soil samples, 42 subsurface soil samples, and **8** concrete core samples. The results of this characterization indicated the presence of strontium-90 contamination in the soil and lead to the remediation of the area.

4.2.2 Waste Water Holding Tanks and Waste Lines

The waste water holding tanks consisted of four 3,000-gallon stainless steel tanks, mounted on a concrete slab ten feet below the ground surface, located directly behind the WWTB. Each tank had a two-foot diameter manhole on the top of the tank approximately four feet below the ground surface. Each tank also had a gauging hatch that was accessible from the surface. The concrete pad was sloped to a collection sump, which was accessible via a 4-inch pump-out line.

The **"suspect"** waste tanks were designated as T-401A and T-401B and the "low-level" waste tanks were designated as T-402A and T-402B. Canberra detected no elevated **beta** activity in T-401A and T-401B and the liquid sampled from the bottom of these tanks had strontium-90 activities of 17 and 30 picocuries per liter (pCi/L), respectively.

Canberra did detect strontium-90 contamination in tanks T-402A and T402B. Contamination levels were approximately 10,000 dpm/100 cm^2 total activity and 500 dpm/100 cm^2 removable. At the time of the Canberra characterization, **tank** T-402A had about three inches of liquid in the bottom of the tank and tank T-402B was *dry.*

In August 1998, SCENTECH removed the four underground waste tanks as well as the associated piping. Samples taken indicated that the soil around the tank was not radiologically contaminated. The belowground concrete pad the tanks sat on was surveyed and no residual contamination was detected. SCIENTECH surveyed and released tanks T-401A and T-401B and cut up tanks T-402A and T-402B for volume reduction **and** disposal **as** LLRW. SCIENTECH then backfilled the excavations leaving the concrete pad and sump in place.

Canberra also collected surface and subsurface soil samples from around the four waste tanks (Canberra 1993). These soil samples showed no elevated activity. Canberra also collected a water sample from the sump that contained 105 pCi/L strontium-90.

The Canberra characterization report stated that the liquid waste lines from the Hot Cells, Laundry Room, and storage pool to the WWTB are presumed contaminated. SCIENTECH removed the low-level drain (LLD) and the chemical drain (CD) lines from the Iocation where they exited from under the Service Area to the WWTB. SCIENTECH also removed the drain lines from the WWTB to the outfalls.

Previous waste water treatment operations resulted in the release **of** liquid effluents to an outfall area about **40** meters south. Canberra surveys in this area did not detect radiation above background levels. SCENTECH also collected soil samples at the outfall in November 2000. These samples showed no strontium-90 concentrations greater than background levels.

4.2.3 Cell Ventilation System

During normal plant operations, air exiting the hot cells was exhausted through a pre-filter and a pair of absolute filters to the exhaust stack. The pre-filters were located in filter housings in the hot cell walls. The absolute filters, pumps, and exhaust ducts were located in the Fan Room directly below the hot cells. These components comprised the hot cell ventilation system.

A second ventilation system was constructed to handle exhaust from the strontium-90 heat source production, This system, termed the dry box exhaust, exited from each cell and connected to **a** single pump and filter assembly in the

Fan Room. An auxiliary filter/pump system was available as a backup to each cell and dry box exhaust system.

Canberra found that the entire hot cell ventilation system was highly contaminated with strontium-90, with the contamination primarily located upstream of the absolute filter housing. Dose measurements taken on the outside of the ducts in the rear section of the Fan Room were as high as 500 mrad/hr on contact with the dry box exhaust line. In the front section of the Fan Room, total contamination levels on the interior of the ducts ranged from 10,000 dpm/100 cm^2 in the Cell 5 exhaust to more than 1 million dpm/100 cm^2 in the dry box and auxiliary system ducts. Beta surface dose rates on the interior of the duct were as high as 4 rad/hr in the auxiliary duct and 3 rad/hr in the dry box duct. Removable contamination ranged from 450 to 750,000 dpm/100 cm^2.

During June and July of 1999, most of the hot cell ventilation system was removed; however, some portions of the imbedded ventilation ductwork remains. The downcomers traveling from the cells down to the Pipe Chase Room which remain imbedded in concrete will be removed during demolition of the hot cells. The lateral ventilation ductwork traveling through the 2-foot-thick wall between the Pipe Chase Room and the Fan Room were filled with expanding foam and then capped. Later the ducts were removed intact by coring around the ducts. The ducts were disposed of as radioactive waste. The dose rates in the ducts ranged from 0.003 to 3 rad/hr.

4.2.4 Stationary Overhead Transport System

The SOTS was an enclosed housing located on the cell mezzanine over Cells 3 and 4. Access to the SOTS was through two removable aluminum doors. Three steel doors on the SOTS floor could be raised to allow overhead access to Cells 3 and 4. Canberra reported that the interior of the SOTS was decontaminated and painted after it was no longer needed for hot cell operations. However, Canberra reported that the decontamination was incomplete and relatively high levels of residual activity remained.

The Canberra characterization survey of the SOTS identified high levels of fixed strontium-90 contamination. Surface beta dose rates ranged from 50 to 400 mradhr. Removable contamination was less than 5,000 dpm/100 cm^2 in all areas but the overhead hoist and beam where removable contamination levels of nearly 160,000 dpm/100 cm^2 were detected.

In March 2000, SCIENTECH dismantled the SOTS and disposed of it as LLRW. The SOTS was composed of a ¼-inch-thick inner aluminum shell surrounded by a cinderblock structure. Removable contamination levels inside SOTS reached several hundred mrad/hr with contact dose rates reaching 30 rad/hr. SCIENTECH removed the entire structure leaving the Cell 3 and 4 hatches sealed and exposed. SCIENTECH decontaminated the area above Cells 3 and 4 to low mradhr levels.

4.2.5 PermaGrain Systems

Very few of PermaGrain's operating systems, such as the irradiator pool and water treatment system, ventilation, piping, and other retired or currently active systems, have been characterized. As described in Section 2.3.15, portions of the HVAC system located on the Office Mezzanine were contaminated with levels as high as 6,000 dpm/100 cm^2. The system serviced the Operations Area and some of the front office space. Because much of the equipment located on the Office Mezzanine is still in use, only about 20 to 25% of the HVAC and supporting equipment has been removed.

4.3 SURFACE AND SUBSURFACE SOIL CONTAMINATION

In 1998, SCIENTECH performed surface and subsurface soil investigations below and around the WWTB prior to its decontamination. During the investigation, SCIENTECH collected 46 surface soil samples and 42 subsurface soil samples to a depth of up to 42 feet. SCIENTECH determined that the surface and subsurface soils under the north half of the building were not contaminated. However, soils from the south side of the building had strontium-90 concentrations ranging from 1 to 518 pCi/g. Most of the contamination was determined to be three to four feet below the surface. The concrete foundation also had fixed strontium-90 contamination in the southwestern comer of the building with levels ranging from 20,000 to 40,000 dpm/100 cm^2. Subsequently, SCIENTECH conducted remediation of the area using 5 pCi/g strontium-90 as a cleanup criterion removing about 49 yd^3 of contaminated soil and backfilled the area with clean soil.

Canberra also collected a limited number of off-site surface soil samples in 1991. The analytical results, which are provided in the Canberra characterization report, showed no off-site impact to the surface soils from site activities. Canberra's background characterization included 18 soil samples from 9 locations. Of the 18 samples, only 6 showed strontium-90 concentrations greater than the analytical method detection limit. Of these six samples, the average strontium-90 concentration was 0.27 pCi/g with a maximum concentration of 0.55 pCi/g ± 31%, consistent with background levels.

In November 2000, SCIENTECH conducted a scoping-level surface and subsurface soil sampling effort covering a large portion of the Quehanna facility. The characterization was designed to investigate areas that most likely would be impacted by site activities. These areas included the sanitary sewer leach field located north of the facility parking lot, the area immediately east of the Hot Cells Service Area, the area south of the Reactor Bay, the outfalls from the former WWTB, and the reactor pool and locations directly below the Operations Areas.

As part of the soil characterization, SCIENTECH collected approximately 200 soil samples from locations on and off of the Quehanna site with most of the samples taken from around or beneath the Service and Reactor Bay areas. The soil samples were first analyzed using an on-site gamma spectrometer for gamma-emitting contaminants. No gamma-emitting radionuclides were identified above background concentrations in any of the soil samples. Following the gamma spectroscopy analysis, 50 samples were sent off-site for analysis for strontium-90 (EPA Method 905.0/SM704). The sample with the highest strontium-90 concentration, 4.3 pCi/g, was collected from under the Decontamination Room concrete slab floor. The clean-up/release level for strontium-90 is 5 pCi/g. Table 4-1 provides a summary of the 50 soil samples that were analyzed for strontium. Those samples that contained strontium-90 at levels greater than 0.91 pCi/g (the mean concentration plus one standard deviation) are described in Table 4-2.

TABLE 4-1
SUMMARY OF STRONTIUM-90 SOIL SAMPLES (November 2000)

Summary Statistic	Value
Number of samples	50
Maximum value[a]	4.3 ± 0.62 pCi/g
Minimum value[a]	-0.66 ± 0.65 pCi/g (<MDC)
Mean[b]	0.17 ± 0.62 pCi/g
Standard deviation	0.74 pCi/g
Mean + 1 standard deviation	0.91 pCi/g

TABLE 4-2
ELEVATED STRONTIUM-90 SOIL SAMPLES (November 2000)

Sample Location	Concentration (pCi/g)
WWTB area	1.0 ± 0.73
North of main building	2.0 ± 0.70
Under the Decontamination Room concrete floor	**4.3** ± 0.62

SCIENTECH collected four additional soil samples during the course of performing structural modifications to the Service Area structure (see Section 1.3.7 for a description of the structure modifications). The highest measured gross strontium-90 concentration was **0.41** pCi/g. This sample was collected directly below the Operations Area trench and is consistent with background levels. The three other samples collected during the structural modification task were less than the laboratory detection limits, which ranged from **0.23** to 0.39 pCi/g.

SCENTECH will conduct soil analyses during the removal of subsurface **tanks,** pipes, and other equipment and materials that have detectable levels of contamination on their outer surfaces. In order to assess the impact contaminated materials may have had on the surrounding soil, SCENTECH will scan the soil and collect soil samples in areas where contaminated materials are removed. If contaminated soils are identified, SCIENTECH will remove the soil and dispose of it as LLRW.

4.4 SURFACE WATER AND GROUNDWATER CONTAMINATION

Although surface water and groundwater data are minimal, there is no evidence of surface water or groundwater contamination from radioactive materials at the Quehanna facility.

As part of their site characterization effort, Canberra collected water samples from three locations in 1991 and 1992. The results from these sampling activities ***are*** presented in the Table 4-3.

TABLE 4-3
STRONTIUM-90 GROUNDWATER CONCENTRATIONS

Sample Location	Collection Date	Strontium-90 Concentration (pCi/l)
Groundwater well near subsurface waste **tanks**	8/27/91 6/17/92	< 0.8 < 0.5
Stream 50 meters west of the facility (Reactor Run)	8/15/91 4/22/92	< 0.7 < 0.5
Tap water from residence north of the facility	8/27/91 4/22/92	< 0.8 < 0.5

5.0 DOSE MODELING FOR DECOMMISSIONING

SCIENTECH prepared this Decommissioning Plan to direct the D&D of the Quehanna facility according to the regulatory guidance for the release of materials that **was** in effect at the time Revision 1 of the Decommissioning Plan was prepared. The applicable limits for unrestricted release used for the D&D project are provided in the 1.86 Regulatory Guidance. For strontium-90, these limits **are:**

- 3,000 dpm/100cm^2 maximum total contamination
- 1,000 dpm/100cm^2 average total contamination
- 200 dpm/100cm^2 removable contamination

For cobalt-60, these limits are:

- 15,000 dpm/100cm^2 maximum total contamination
- 5,000 dpm/100cm^2 average total contamination
- 1,000 dpm/100cm^2 removable contamination.

Unrestricted release **of** the site will be obtained using screening criteria for surface and subsurface residual radioactivity. Limits on soil contamination are provided by the NRC (NRC 1992a). The established release limit for strontium-90 in soil is 5 pCi/g average and 15 pCi/g maximum. The established release limit for cobalt-60 in soil is 8 pCi/g average and 24 pCi/g maximum.

Because the NRC is allowing this D&D project to be "grandfathered" in under these established limits, this Decommissioning Plan does not need to demonstrate compliance with the new license termination rule requirements set forth in 10 CFR 20, Subpart E, also known as the License Termination Rule (LTR). However, the strontium-90 release criteria were evaluated to ensure that they are protective of human health and that the dose to the maximum exposed **future** receptor is less than 25 mredyr. No evaluation was performed on the cobalt release criteria because all previous D&D activities indicate that cobalt is not present as disperse surface contamination or **as** a contaminant in the soil.

The strontium-90 average surface contamination release criterion **of 1,000** dpm/100cm^2 was compared against the acceptable license termination screening values present in Table 1 of the supplemental guidance provided to the LTR (NRC 1998), which are based on an unrestricted release **limit** of 25 mrem/yr to a future occupant. Table 1 gives 8,700 dpm/100cm^2 **as** an acceptable screening level for unrestricted release. Because the contamination level-to-dose relationship is linear, it can be assumed that the resulting dose to a future occupant of the Quehanna facility with contamination evenly dispersed at 1,000 dpm/100cm^2 would be less than **3** mredyr. For this comparison, it is assumed that the exposure conditions used to evaluate the Table 1 screening values are acceptable for the future occupant of the Quehanna facility.

All on-site soil sampling efforts indicate that the greatest potential for soil contamination is below the Service Area basement floor and not at the ground surface. Therefore, for analysis of the soil release criterion for strontium-90, a rudimentary dose assessment was performed using the U.S. Department of Energy's (DOE) RESRAD dose assessment code (Version 6.21). This dose assessment assumed that a 2-meter thick layer of contaminated soil is located at a depth of about 12 feet **(4** meters) below the ground surface at the approximate depth of the Service Area basement floor. The area of the contaminated zone is assumed to be 1,000 square meters. With all exposure pathways **turned** on and using default values for all other RESRAD parameters, the maximum dose is 9.02E-3 mrem/yr at time = **196** years with more than 90% **of** the dose coming from the drinking water pathway. Table 5-1 summarizes the pathways that were included in the analysis and the values that were changed **based** on the exposure scenario assumptions. The RESRAD output file for this subsurface dose assessment is provided as Attachment A.

TABLE 5-1
RESRAD DOSE ASSESSMENT SUMMARY FOR SUBSURFACE CONTAMINATION

Pathway	Status
External Gamma	On
Inhalation	On
Plant Ingestion	On
Meat Ingestion	On
Milk Ingestion	On
Aquatic Foods	On
Drinking Water	On
Soil Ingestion	On
Radon	Off
Parameter	**Value**
Nuclide concentration	Strontium-90 @ 5 pCi/g
Time since material placement	30 years
Area of contaminated zone	1,000 square meters
Cover depth	4 meters
All others	Default

To ensure that the average soil release criterion **of** 5 pCi/g for strontium-90 is protective of human health even if the activity were located at the surface, a second rudimentary dose assessment was performed using RESRAD. Using primarily default parameters and a soil concentration of 5 pCi/g, the dose assessment indicated that a future resident of the Quehanna facility would receive a maximum dose of 4.82 mrem/yr. The maximum dose is received in the first **year** of exposure (time=0) and, because of the relatively short half-life of strontium-90 ***(28.6*** years), the dose decreases to less than 1 mrem/yr after **60** years. The primary exposure pathway, resulting in about **82%** of the dose, is the plant ingestion pathway. **An** additional 16% **of** the dose comes from meat ingestion.

For the future resident, it was assumed that only 10% of the fruits and vegetables consumed by the resident **(38** pounds per year) are grown in contaminated soil and 10% of **the** meat consumed **(14** pounds per year) is obtained from hunting animals that grazed in the contaminated soil (livestock exposure assumptions). Also, it is assumed that the resident obtains 100% of his drinking water **from** the site but does not consume fish ***or*** dairy products from the site. These assumptions are presumed to be realistic because the land is **part** of the Moshannon State Forest owned and managed by the **DCNR and** will likely stay under the Commonwealth's control. These assumptions are also considered very conservative for a recreational user such **as** a camper or hunter. Table 5-2 summarizes the pathways that were included in the analysis and the values that were changed based on the exposure scenario assumptions. The RESRAD output file for this surface dose assessment is provided as Attachment B.

TABLE 5-2
RESRAD DOSE ASSESSMENT SUMMARY FOR SURFACE CONTAMINATION

Pathway	Status
External Gamma	On
Inhalation	On
Plant Ingestion	On
Meat Ingestion	On
Milk Ingestion	Off
Aquatic Foods	Off
Drinking Water	On
Soil Ingestion	On
Radon	Off
Parameter	**Value**
Nuclide concentration	Strontium-90 @ 5 pCi/g
Time since material placement	30 years
Contaminated fraction – Plant food	0.10
Contaminated fraction – Meat	0.10
All others	Default

6.0 IMPACTS OF DECOMMISSIONING ALTERNATIVE

The following paragraphs provide the decommissioning alternatives that were examined before selecting the current proposed alternative. Because of unexpected high levels of contamination, the current proposed alternative differs from the alternative proposed in Revision 1 of the Decommissioning Plan.

6.1 EVALUATION OF REVISED ALTERNATIVES

The decommissioning alternative proposed in Revision 1 of the Decommissioning Plan involved the decontamination and dismantlement of selected areas that contained legacy contamination from the previous hot cell activities. The original objective of this D&D project was to decontaminate the hot cell complex, including all associated support structures, building enclosures, equipment, and systems of the facility in order to achieve "unrestricted release" of these areas and termination of the NRC License Number 37-17860-02. To accomplish this objective, the original Decommissioning Plan proposed to use a variety of commercially available decontamination methods along with selective dismantlement and disposal for materials that could not be decontaminated to levels below the free release limits.

However, unexpected quantities of high-specific activity strontium-90 by-product material were discovered within the hot cells. Decontamination efforts on the remaining material with both abrasive and commercial chemical methods proved ineffective with no significant reduction in fixed contamination levels. These conditions precluded the possibility of achieving a release for unrestricted use by means of standard surface decontamination methods specified in the original Decommissioning Plan.

Additionally, **SCIENTECH** discovered high levels of residual strontium by-product material remaining within the Cell 4 process equipment. Estimates of the amount of source material remaining in Cell 4 suggest that approximately 100 curies of strontium-90 remain in localized areas internal to the hot cell process equipment (NES 1999).

Therefore, additional decommissioning alternatives were evaluated (NES 1999). The three alternatives evaluated were: 1) total demolition and disposal of the hot cell complex resulting in an unrestricted release of the area; 2) a restricted release of the hot cell complex; and 3) in-place stabilization. The facility end-state of each of these alternatives is provided as follows.

<u>Unrestricted Release</u>

In order to achieve an "unrestricted release" of the facility, the following end-state conditions represent the minimum extent of facility demolition:

a) The Service Area crane would be removed, disassembled and decontaminated.

b) The hot cell complex, including the SOTS and the Isolations Rooms would be removed entirely.

c) The hot cell basement concrete floor would be at least partially removed.

d) The Service *Area* building shell would be gutted of all insulation and utilities.

e) The Radioanalytical Laboratory and the Decontamination Room would remain assuming they could be decontaminated to release levels.

f) Imbedded drain lines would be excavated from the Service Area floor.

g) The Service Area building would be dismantled due to contamination on structural members.

h) Groundwater monitoring wells would be installed.

Restricted Release

In order to achieve a "restricted release" **of** the facility, the following end-state conditions represent the minimum extent of facility alterations/demolition:

a) Hot Cells **1** through ***5*** and the associated Isolation Rooms would become **a** monolithic cement and concrete structure after being filled with grout. Openings in the cell faces and other locations would also be grouted.

b) The Service Area shell would be removed.

c) The Radioanalytical Laboratory and the Decontamination Room would be demolished and removed to prevent occupancy.

d) The floors of the Service Area, the Radioanalytical Laboratory and the Decontamination Room would remain.

e) The basement and Hot Cell **6** would be filled with grout and would be inaccessible.

f) The hot cell monolith may also be sealed and capped with a stainless steel skin to further isolate the cells from the environment.

g) Access controls, instructional controls, and long-term monitoring would also be established.

In-Place Stabilization

In order to achieve an in-place stabilization of the facility, the following end-state conditions represent the minimum extent of facility alternations/demolition:

a) Cell **4** and the Cell **4** Annex Room would be fully grouted in **an** as-is condition, with out dismantling the cell process equipment and without removing the strontium-90 by-product material. All penetrations and the SOTS would be permanently sealed. An oversized, monolithic, reinforced concrete structure would be constructed to support the weight of the grouted **Cell 4.**

b) The Service Area, Operations Area, Radioanalytical Laboratory, Decontamination Room, the WWTB and other areas of the plant that were identified as affected would be decontaminated to meet restricted release criteria.

c) Cells 1 through 5 and the SOTS would be decontaminated to the extent practicable with access to areas of residual contamination permanently sealed.

d) Cell **6** and the basement would be decontaminated to the extent practicable with the ventilation system and other components removed. The basement and Cell 6 would be filled with grout and permanently sealed.

e) The Commonwealth would establish institutional controls, including deed restrictions and periodic inspection and monitoring. Based on the 28.6-year half-life of strontium-90, the controls would be required for approximately 290 years or roughly 10 half-lives.

6.2 PROPOSED ALTERNATIVE

Since the Chapter 7 bankruptcy filing of PermaGrain and their subsequent abandonment of the Quehanna facility in December 2002, the scope of the D&D project has been expanded to include the former PermaGrain areas, including the Reactor Bay and the irradiator pool. The current proposed D&D alternative is similar to the Unrestricted Release alternative presented in Section 6.1; however, with the expanded scope **of** work, some modifications to the overall project have been made.

The final status survey for the proposed Unrestricted Release would be **a** combination of surface surveys, concrete core samples, and surface and subsurface soil sampling. The final status survey will be designed and implemented according the protocols established in NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (NRC 2000).

Unrestricted Release

In order to achieve an "unrestricted release" of **the** facility, the following represent the anticipated end-state conditions:

a) Using robotic dismantlement techniques, the Cell 4 Process System will be removed and packaged for disposal. **(Note: After the large strontium-90 source term has been removed from** Cell **4, PA** will **petition the NRC for SDMP delisting.)**

b) All equipment and services will be removed from the Service Area. This includes all pipes, conduit, wires, fixtures, rigging, insulation, containment structures, etc.

c) The Service Area floor, walls, and ceiling will be decontaminated to levels below the release criteria. Some sections of the floor, walls, or ceiling may be removed because further decontamination may not be practicable.

d) Imbedded drain lines will be excavated from the Service Area floor with the surrounding soil sampled for contamination and remediated as required.

e) The hot cell complex will be removed entirely exposing the basement below (Cell *6* and **Pipe** Chase and Fan Rooms).

f) The concrete floor in the hot cell basement will be decontaminated to levels below the release criteria. Some sections of the floor or walls may be removed because further decontamination may not be practicable.

g) The PermaGrain operations areas (including offices) will be surveyed and decontaminated to levels below the release criteria. Any woodworking equipment sold as part of the bankruptcy will be surveyed prior to release. Utilities, fixtures, piping, insulation and building systems will likely remain.

h) The irradiator pool will be emptied (Co-60 sources and water removed), surveyed, and remediated as necessary to meet the release criteria. The water handling and treatment systems will be removed, surveyed and disposed **of.** Volumetric release criteria will be established and approved by the NRC if the irradiator pool concrete is found to be volumetrically contaminated. **(Note: The NRC is the lead agency on the emergency removal of the PermaGrain cobalt-60 irradiator sources.)**

i) Once SCIENTECH is confident that all structures and systems remaining on site meet the unrestricted release criteria, a final status survey will be conducted. After the survey, a final status survey report will be generated and submitted to the NRC in support of the application for license termination.

j) SCENTECH will provide split samples of all excavated areas to the NRC as necessary to facilitate the independent verification process.

7.0 ALARA ANALYSIS

The decommissioning of the Quehanna facility has been grandfathered in under previous NRC positions and guidance on decommissioning and site restoration of licensed facilities such that the requirements of 10 CFR 20, Subpart E do not apply. The current regulation, which establishes a decommissioning criterion of 25 mrem/yr, also establishes the requirement that the decommissioning release criteria also be ALARA. Therefore, demonstrating that the proposed decommissioning actions described in this Decommissioning Plan are ALARA, is not required. However, NUREG 1727 (NRC 2000) was consulted for guidance on ensuring that, in practice, the ALARA requirement was met.

According to Section 1.5 of Appendix D of NUREG 1727, a mathematical cost-benefit ALARA analysis is not required to demonstrate that the ALARA requirement of the current regulation has been met for the unrestricted release alternative described in Section 6.2. The mathematic analysis is not needed and the ALARA requirement will be assumed to be met because (1) in general, loose residual radioactivity on building surfaces, as well as fixed contamination, is being removed; (2) large volumes of LLRW are being removed from the site and transported to a LLRW disposal facility; and (3) NRC soil screening criteria, which were applicable at the time the original Quehanna Decommissioning Plan was submitted to the NRC, are being used for remediation guidelines. Therefore, the decommissioning alternative would meet the ALARA requirement of 10 CFR 20, Subpart E, if directly applicable.

8.0 PLANNED DECOMMISSIONING ACTIVIITES

This section provides the overall objectives of the Decommissioning Plan for the unrestricted release alternative. It also provides the major activities that will be or have been performed to meet the decommissioning objectives. A revised version of the decommissioning schedule, that was originally provided in Revision 1 of the Decommissioning Plan is also presented in Attachment C. The schedule provides a projected timeline for completing the project and highlights those activities that have been completed.

8.1 DECOMMISSIONING OBJECTIVES

As the prime contractor for this decommissioning project, **SCIENTECH** is responsible for ensuring that all **aspects** of this Decommissioning Plan **are** implemented and that all work **is performed** in accordance with approved procedures. **SCIENTECH** will provide all project management, supervisory, technical and operations personnel, as well as supplies and necessary equipment to meet the objectives of the Decommissioning Plan, except for the cobalt-60 source removal.

The primary objectives of the D&D project described in this Decommissioning Plan are to:

- Decontaminate all facility structures to levels that are below the applicable release criteria provided in Section 5.0 (including some selective demolition and equipment removal);
- Decontaminate the hot cells.
- Remove the hot cell structure and any associated contaminated soil;
- After the irradiator sources have been removed, drain, characterize, and decontaminated the irradiator pool as necessary;
- Remove contaminated soil and concrete associated with the irradiator pool as necessary;
- Conduct a final status survey of the remaining structures and land;
- Terminate NRC License Number 37-17860-02;
- Restore excavated areas.

As part of the removal actions, material and equipment that meet the Regulatory Guide 1.86 (NRC **1987)** release limits for fixed and removable surface contamination may be free-released for reuse, recycle, or disposal **as** clean waste. However, the Commonwealth will make the final decision on the deposition of material that meets the Regulatory Guide **1.86** release limits.

Demolition materials and decontamination wastes that do not meet the release criteria will be disposed of **as** LLRW. These wastes will be fully characterized to meet the waste acceptance criteria of the selected disposal facility and they will be packaged and transported according to all state and federal regulations.

The final release of the site will be based on surface contamination on remaining structures and on environmental conditions (i.e., concentrations of contaminants **of** concern in *the* soil, sediments, and water).

8.2 DECOMMISSIONING TASKS

The revised decommissioning effort at the Quehanna site will have two separate yet equally important paths leading toward a final unrestricted release of the entire site. The first path includes the decommissioning tasks described in Revision 1 of the Decommissioning Plan with the addition of a remotely operated decontamination and removal effort for Hot Cell **4** and other necessary operations to support changes in the decommissioning **tasks** (e.g., building modifications to support the Service Area structure after the hot cells have been removed). The second path incorporates all characterization, decontamination, and release of areas formerly occupied by PermaGrain that were not a part of Revision 1 of the Decommissioning Plan.

The following lists provide the major tasks that are to be conducted or have been .conducted during the decommission project. Discussions of each task are presented in Sections **6.4.2** and **6.4.3.** The **tasks** that were included in Revision 1 of the Decommissioning Plan, and the status of those tasks, are provided below. The **tasks** listed below **are** not necessarily presented in the sequence in which they were or will be performed.

Path 1 – Complete Original Decommissioning Scope

- Site Mobilization (complete)
- Installation of Roll-up Fire Door (complete)
- Decontamination of Decontamination Room (decontaminated to workable levels and partially removed)
- Decontamination **of** Radioanalytical Laboratory (decontaminated to workable levels and partially removed)
- Decontamination of Janitor's Room (complete and removed)
- Decontamination of Laundry (complete and released)
- Decontamination of Deionizer Room (complete and removed/released)
- Decontamination of South Mezzanine (complete and removed)
- Decontamination **of** Isolation Rooms and Hot Cells 1, **3,** and 5 (decontaminated to working levels)
- Decontamination of Hot Cell 2 (ongoing)
- Decontamination of Hot Cell **4** (planning and preparation are ongoing)
- Decontamination of Hot Cell 6 (decontaminated to working levels)
- Decontamination of WWTB (complete)
- Removal of Underground Tanks and Piping (removed)
- Decontamination of Storage, Neutralization, and Valve Pits (complete)
- Decontamination of SOTS (complete and removed)
- Removal of Waste Lines (partially removed)
- Decontamination of Fan Room (decontaminated to working levels)
- Removal of Hot Cell Ventilation System (>95% removed)
- Decontamination of Operations Area (partially complete)

- Decontamination of North Mezzanine (partially complete)
- Decontamination of Service Area Floor (partially complete)
- Removal **of** Equipment and Material Exceeding the Release Criteria (ongoing)
- Remove Hot Cell structure (planned)

Path 2 – Complete Decommissioning of PermaGrain Areas

- Survey, decontaminate (if necessary) and release the remaining PermaGrain equipment per Regulatory Guide **1.86**
- Drain source pool and characterize
- Characterize other affected and unaffected PermaGrain area
- Decontaminate areas **as** needed
- Dismantle/demolish systems and structures that cannot be decontaminated to levels below the release criteria
- Characterize on-site pond and remove all **drain** lines leading to the pond
- Properly package, label, and dispose of waste materials

Final Project Tasks

- Prepare a Final Status Survey Plan **(FSSP)**
- Perform **final** status survey on all remaining structures and land areas according to the **FSSP**
- Submit **Final** Status Survey Report to the NRC
- Terminate license
- Backfill any excavated areas to grade with clean soil and restore with natural vegetation
- Demobilization

Other site activities may occur concurrently with the activities described above that would likely have no impact on the D&D project. For example, the MMA tanks may be removed or some ancillary structures (not affect by license activities) may be removed. These activities may or may not be conducted by the D&D contractor. Furthermore, following license termination, the PADEP may have **SCIENTECH** restore the site to a "green field" by removing all structures and restoring the land prior to demobilization.

8.3 DECOMMISSIONING METHODS AND **TASK** DESCRIPTIONS

This section of the Decommissioning Plan provides a description **of** each of the decommissioning activities and tasks listed in Section **6.2,** a short description of the status of the task and the methodology that will be used or **was** used to complete each activity.

The selected approach was based on the 1993 Canberra characterization report data and actual site conditions encountered during completed or ongoing decontamination tasks. The tasks described in Sections 6.4.2 through 6.4.4 are presented in a typical or suggested sequence. However, deviations from the scheduled work performance sequence may occur at the discretion of SCIENTECH site supervision in order to enhance productivity, resource utilization, industrial safety, **or** ALARA benefit.

8.3.1 General Decontamination and Decommissioning Methods

The general approach that will be followed for the D&D activities will be to first survey components, such **as** ductwork, cranes, **beams,** etc. to determine if they can be released for unrestricted use by applying convention decontamination techniques. A large number of these items can be decontaminated to unrestricted release limits through the use of strippable paint, HEPA filter vacuum cleaning, damp wiping, scabbling, or grinding. If an item cannot be released using these techniques, or more advanced techniques such **as** Vacu-Blasting, the item will undergo volume reduction and contaminated portions will be packaged for disposal as **LLRW.**

Areas that have high beta dose rates caused by fixed and/or removable contamination will typically be sprayed with a strippable paint. During previous D&D projects, this has been shown to be an effective method of shielding much of the beta radiation and removing much of the contamination by subsequently peeling the paint from the surface. In most instances items cannot be immediately released for unrestricted use using this technique; however, the contamination levels **are** significantly reduced and other decontamination methods can then be employed with lower dose rates.

Special remote operations will be used in certain **areas** with significantly elevated radiation levels. These include remote handling of high activity cobalt-60 sources and remote decontamination and dismantling in Cell **4** because of high contamination levels and dose rates. These remote methods are discussed further where applicable.

Concrete and metal surfaces may be decontaminated using either a Blastrac™ or a Vacu-Blast™ unit. The Blastrac™ unit is used on concrete floors while the Vacu-Blast™ unit **is** typically used for walls and ceilings. Both of these systems use a shot blasting system that incorporates a vacuum recovery system. The air discharged from these units passes through a HEPA filter system. These units remove up to **1/8** ***of*** an inch of concrete per pass. Additional passes can be made to remove deeper contamination. If contamination has migrated deeply into the concrete, for example at a seam or expansion joint, the contamination may require removal using jackhammers or concrete saws.

Dismantling and volume reduction of the various systems and components will entail the use of a variety of standard industrial tools and equipment and may require the use **of** specialized subcontractors. Tools likely to be used throughout the project will include common hand and power tools, cutting torches, abrasive saws, metal nibblers and jackhammers. Scaffolding, man-lifts, excavators, coring and drilling equipment, trenchers, backhoes, and mobile cranes will also be used as necessary.

Local contamination control enclosures (CCE) will be used to prevent the spread of contamination during tasks where high levels of removable contamination are present or where decontamination methods will generate an excessive amount of potentially contaminated dust. CCE's will be constructed with negative air pressure such that all potentially contaminated air is drawn through local HEPA filter units. CCE's will be inspected for containment integrity and tested for proper airflow by health physics personnel prior to use. Notation of satisfactory CCE inspection and testing will be made on the appropriate radiation work permit (RWP) prior to issuance.

In the event that a specific D&D task requires special attention because of its complexity, safety concerns, or exposure potential, a task-specific Task Plan will be developed to guide the work. Task Plans must be approved by the Radiation Safety Committee (see Section 9.1.1) before beginning any work.

8.3.2 Decommissioning Task Descriptions – Path 1

Path 1 of this Decommissioning Plan is to complete all applicable operations outlined in Revision 1 of the Decommissioning Plan. The following descriptions of the decommissioning tasks included in Revision 1 of the Decommissioning Plan present the current status of each task at the time this plan was prepared and present any updates on proposed decontamination methods. SCENTECH has completed many of the decontamination activities described in this section.

Site Mobilization and Setup

SCENTECH mobilized to the Quehanna site in May 1998. Upon arriving, SCIENTECH prepared for on-site activities by leveling a site for the project trailer, grading the access road, extending the perimeter security fence to enclose the project trailer area, and setting up the project trailer. Equipment, supplies, and expendable materials were ordered and temporary storage areas were constructed. SCIENTECH also established a field laboratory for counting smears and performing instrument calibrations.

SCIENTECH performed other activities as part .of the site mobilization. Radiological instrumentation and other tools and equipment were tested and staged. Radiological control points were established following preliminary surveys to identify affected and unaffected areas. A roll-up fire door was also installed between the Reactor Bay and the Service Area to isolate the D&D operations from PermaGrain operations.

Ongoing Activities

The primary ongoing D&D activities involve decontamination and selective dismantlement in the Hot Cells, Operations, and Service Areas. Ongoing activities also include installation and testing of the COTS and the Cell 4B glove box; design and installation of a fire suppression system in the COTS; and design, manufacturing, and testing of new remotely operated hatches for Cells 3 and 4. Planning and testing for the robotic decontamination and dismantling of

Cell 4 efforts have included construction of a Cell 4 process box "mock-up," deployment and removal planning, and off-site and on-site testing of the robot.

Planned Activities

1. Cell 4 Decontamination and Dismantlement

Due to the high beta dose rate and the mobile nature of the strontium by-product material, the decontamination and demolition efforts in Cell 4 require special care and precaution. Therefore, SCIENTECH has constructed and installed the COTS, a custom-designed temporary containment system. This two-room containment system has been installed on top of the North Mezzanine. The first room, located on the western side of the COTS, will be used as a contamination control zone while the second larger room will cover the access hatches into Cells 3 and 4. The COTS will be equipped with appropriate ventilation systems, radiation monitors, fire suppression system, equipment pass-throughs, and a remotely operated overhead hoist system. For an additional layer of contamination control, the COTS will be entirely enclosed inside a third chamber constructed of herculite on a wooden framed structure.

Using the overhead crane system in the COTS, SCIENTECH will deploy a remotely controlled robot equipped with special decontamination and dismantlement tools into the Cell 4 process box, which takes up most of the space in Cell 4. The robot, which was delivered to the Quehanna site in April 2002, will be used to dismantle and remove the internal components and equipment of the process box. Details on the capabilities of the robot and proposed dismantling methods are provided in Attachment D. Personnel who will be operating the robot during decontamination activities will receive extensive training and will practice decontamination operations in an on-site Cell 4 mock-up. Robotic operators will demonstrate proficiency in all facets of remote operation prior to actual deployment.

Prior to deployment of the robot, SCIENTECH personnel will perform preparatory activities inside of Cell 4 such as capping of the tubing nozzles, removal of stripcoating and installation of surveillance cameras.

The robot will use specially designed and adapted dismantling tooling for activities such as grinding, cutting, crimping and material handling. After material is removed from Cell 4 by the robot and the overhead hoist through the Cell 4 hatch inside the COTS, it will be lowered into Cell 3 through the Cell 3 hatch into radwaste containers. Health physics technicians inside Cell 3 will survey the material for waste profiling purposes and remove it to be shipped as LLRW.

After the Cell 4 process equipment has been removed from the process box and the dose rates are acceptable for entry, SCIENTECH personnel will enter the process box to complete decontamination and dismantling of the remaining cell materials.

Following the robotic decontamination, SCIENTECH will remove the robot from Cell 4 and decontaminate it to the extent practicable. If the robot cannot be decontaminated to acceptable levels, the robot will be disposed of as LLRW or transferred to another licensee.

When decontamination efforts inside Cell 4 are complete, SCIENTECH will survey, decontaminate, and dismantle the COTS. If necessary, contaminated portions of the COTS will be disposed of as LLRW. After the COTS is removed, the North Mezzanine floor will be decontaminated and full demolition of the hot cells will be performed.

2. Hot Cell Ventilation System Removal

The only components of the Hot Cell Ventilation System remaining are the downcomers within the hot cells. SCENTECH has sealed the downcomers at both ends to contain the contamination inside the ducts. SCIENTECH will cut out the highly contaminated downcomers so that they are not breached during demolition of the hot cells resulting in cross contamination. Also to avoid cross contamination, each downcomer will be removed in one piece. The downcomers interiors will not be decontaminated and will be disposed of as LLRW.

3. North Mezzanine Decontamination and Hot Cell Demolition

SCIENTECH has decontaminated the North Mezzanine floor to the maximum extent practical. Additionally, SCIENTECH removed the cell plugs and other equipment located on top of the mezzanine. The old Cell 3 and Cell 4 hatches have been replaced with remotely operated hatches.

4. Contained Over-head Transport System

The COTS is currently stationed on top of the North Mezzanine over Cells 3 and Following the decontamination efforts in Cell 4, the COTS will be removed from the mezzanine and the mezzanine will be surveyed and further decontaminated to the extent practicable. If necessary, contaminated portions of the North Mezzanine will be disposed of as LLRW.

Because the mezzanine currently supports the north wall of the Service Area, SCIENTECH implemented some structural building modifications to support the wall after the mezzanine has been removed. The mezzanine will be demolished, along with the Hot Cells 1 through 5, and the rubble will disposed of appropriately according to the residual contamination levels.

5. Operations Area Decontamination

Most of the decontamination effort in the Operations Area is complete, including decontamination, to the extent practical, of the trench along the southern wall and removal of the cell plugs from Cells 1, 2, 3, and 5. Additionally, new building support footings and structural members have been installed in the Operations Area to support the Service Area roof after the Hot Cells have been removed.

In order to facilitate the structural modifications and to satisfy concerns about the aging of the previous containment structure inside the Operations Area that provides a buffer zone between former PermaGrain operations and D&D operations, SCIENTECH built an airtight, non-permeable containment around the face of Cell 4. This provides a first line of defense against the possibility of contamination leaking through any of the sealed cell face penetrations. The containment was smoke tested while under negative pressure to ensure 100% leak-tight integrity. There is currently no access available to the face of Cell 4 through this containment.

Additionally, a full-height, full-length containment wall was built approximately 18 inches in front of the cell structure sealing the cell face from Cell 1 to Cell 5 including the utility trench from the Operations Area. This containment is under continuous HEPA filtration with sampling of the effluent discharge. Once construction of the new containment was completed, tested and fully functional, the existing original containment structure, which was built further back from the Cell Operations face to facilitate manipulator work, was disassembled, surveyed, decontaminated as necessary and disposed of.

The southern wall of the Operations Area (cell face wall) will be demolished and removed during the demolition of the hot cells (number 4 above). Following all demolition efforts in the Operations Area, the area will be surveyed and decontaminated to free-release limits and the containment structures will be removed.

6. Service Area Decontamination

The Service Area currently provides a work area and staging area for decontamination operations, including mock-up testing of the Cell 4 robot. SCENTECH has decontaminated and removed the overhead crane and removed the fiberglass insulation from the Service Area walls. SCENTECH is continuing to decontaminate areas of the Service Area and remove equipment and materials such as unused pipes and conduit while awaiting startup of the Cell 4 decontamination. Following the demolition of the hot cells, SCIENTECH will excavate drainlines imbedded in the Service Area floor and survey and decontaminate the surrounding concrete as necessary. Finally, SCIENTECH will decontaminate the Service Area floor, walls, ceiling, and structural members to below the free-release criteria, Currently, the Service Area walls and ceiling are mostly clean with isolated areas measuring in the low mrad/hr range.

8.3.3 Decommissioning Task Descriptions – Path 2

1. Decontamination of Office Mezzanine

In April 2002, SCIENTECH removed a significant amount of material from an area known as the "Office Mezzanine." However, because there were still some HVAC systems on the Office Mezzanine that were being used, only 20 to 25% of the equipment located on the Office Mezzanine was removed. The remainder of the equipment on the Office Mezzanine will be surveyed and dismantled as necessary when they are no longer needed.

2. Survey and Release PermaGrain Equipment

SCENTECH will smear and survey all remaining PermaGrain equipment. If contamination levels exceed the free-release criteria as provided in Section 4.0, SCIENTECH will decontaminate the equipment to the extent practicable. If release limits are met after decontamination efforts, the equipment will be released for disposal or reuse. If contaminated equipment is not decontaminated to levels below the release limits and it is impractical to attempt further decontamination, the equipment will not be released and it will be disposed of as LLRW. Scoping surveys of the equipment indicate a low probability of the equipment being contaminated.

3. Cobalt-60 Source Removal

Cobalt-60 source removal from the PermaGrain irradiator will be performed under the direction of the NRC.

4. Drain and Characterize Source/Reactor Pool

SCIENTECH will drain and characterize the source/reactor pool after the cobalt-60 sources have been removed. The water in the pool will be sampled for tritium and a broad spectrum of gamma emitters. If the water meets discharge limits, it will be drained to the on-site pond. After the pool has been drained and the walls and floor are dry, the walls and floor will be surveyed. The characterization methods will include fixed and removable contamination measurements for alpha and beta contamination and *in situ* gamma spectroscopy. If no contamination is identified on the surface of the pool walls and floor, it will be assumed that the concrete is not volumetrically contaminated. Furthermore, if there is no contamination on the concrete surfaces, there is no reason to suspect soil contamination under the irradiator pool and soil samples from beneath the irradiator pool will only be collected as part of the final status survey.

If contamination is identified, the pool will be decontaminated as necessary to levels that are below the release criteria. If the concrete is volumetrically contaminated, SCIENTECH will develop release criteria for the volumetrically contaminated material. Before implementing these criteria, the NRC will approve the proposed limits. If areas of contamination exist above the release criteria, these areas may be selectively removed.

5. Characterization of PermaGrain Areas

SCENTECH will characterize impacted and non-impacted areas that were used to support PermaGrain operations in order to identify the nature and extent of fixed and removable surface contamination. This will include conducting surveys on floors, walls, ceilings, below floor tiles, in trenches and pipes, and other suspect areas. Because the strontium-90 beta radiation can be shielded by thin layers of material, characterization activities may include stripping paint and removing floor coverings to access the original structure surfaces. All rooms and structures NOT described in Sections 3.1 and 3.2 will receive a characterization survey based on the potential for contamination.

6. Decontamination of All Remaining Areas

SCENTECH will decontaminate areas to levels that meet the Regulatory Guide 1.86 release criteria. Decontamination methods will include those discussed in Section 1.2.1. Areas that cannot be decontaminated to levels less than the Regulatory Guide 1.86 release limits will be marked as requiring selective removal and disposal as LLRW.

7. Characterize Pond Sediments and Remediate as Necessary

SCIENTECH will collect and analyze sediment samples from the bottom of the on-site pond. The samples will be analyzed using gamma spectroscopy to identify gamma-emitting isotopes and analytical chemistry separation methods to identify strontium-90. Additional analysis will be performed for possible organic and inorganic contaminants, such as petroleum hydrocarbons and lead, as well as other radiological contaminants of concern that may be identified during activities such as the D&D of the irradiator pool.

In the event that contamination is identified, SCIENTECH will develop remediation alternatives for the removal of contaminated soil or sediments based on potential dose impact. Once the remediation alternative is selected and agreed upon by all interested parties and if remediation is required, SCENTECH will prepare a work plan to specifically outline the methods that will be used to complete the remediation. The remediation alternative may require draining the pond, excavating contaminated sediments, and reestablishing the wetland.

8.3.4 Final Project Tasks

Following the decommissioning tasks described in the previous sections, SCIENTECH will conduct the final tasks required to restore the site to "green field" conditions and complete the radiological cleanup effort and terminate the license. The tasks necessary to complete the project are described below. All work will be performed according to approved procedures and site-specific work plans and health and safety plans.

1. Final Status Survey

Following the preparation of a FSSP, SCIENTECH will perform a final status survey and collect confirmatory soil samples at the Quehanna site. The FSSP will be developed using the guidance provided in NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (NRC 2000). The boundaries of each survey unit and the level of the survey and sampling effort will depend on the final classifications of the areas according to the protocols in MARSSIM. As such, each survey unit will be classified as Class 1, Class 2, or Class 3 impacted areas or non-impacted areas. A description of the final status survey and confirmatory sampling are described in Section 13.0.

2. Terminate License

Following review and approval of the Final Status Survey Report and verification surveys and sampling by the NRC, the NRC will notify the PADEP of the termination of NRC License Number 37-17860-02. After the license has been terminated, the site can be released for unrestricted use.

3. Demobilization

Following the unrestricted release of the Quehanna facility, SCIENTECH will demobilize from the project site. Demobilization will include the disconnection of utilities, removal of support structures such as field trailers and storage buildings, and removal of the perimeter fence (if not already removed during site grading activities).

8.4 DECOMMISSIONING SCHEDULE

Attachment C of this plan provides an estimated schedule for performing the decommission tasks identified herein. The estimated duration of each task is provided as well as the overall project length. The schedule presented is subject to revision as deemed necessary by SCIENTECH project management. Updated schedules will be provided to the NRC if the decommissioning cannot be completed as outlined in the schedule.

9.0 PROJECT MANAGEMENT AND ORGANIZATION

The PADEP has established an administrative and technical organization for management of the decommissioning project that includes the PADEP and SCENTECH. An organizational chart is provided in Attachment D. Descriptions of the responsibilities of SCIENTECH project personnel are provided in the following sections.

9.1 RESPONSIBILITES OF PROJECT PERSONNEL

The following section describes the responsibilities of key project personnel and outlines the chain-of-command for site operations.

9.1.1 Radiation Safety Committee

The Radiation Safety Committee (RSC) currently consists of the PADEP project manager, the PADEP Decommissioning and Environmental Surveillance Division Chief, the PADEP license RSO, the SCIENTECH Corporate RSO or alternate, the SCIENTECH Site Radiation Safety Officer and the SCIENTECH Project Manager.

The PADEP project manager chairs the RSC. Specific responsibilities of the Chairperson include scheduling meetings and maintaining records of the meetings. The Chairperson is the final authority in matters with the RSC. Meetings may be conducted in person or by conference call. When approval signatures are required, they may be provided by facsimile.

A quorum of the RSC shall consist of the Chairperson, the PADEP RSO, and the SCENTECH Corporate RSO or designee. In the event of an emergency, the committee shall be immediately notified and will initiate an investigation based on the severity of the incident.

The RSC shall meet regularly but at least quarterly. The Chairperson shall call the meetings. Minutes will be taken and distributed in writing to all members.

9.1.2 SCENTECH Project Manager

The SCENTECH Project Manager, who reports directly to SCENTECH senior management and the RSC, will have overall responsibility for the project. This responsibility encompasses all phases of the project including the on-site and off-site work activities. The Project Manager will be the main contact with the PADEP and will be able to meet on short notice to discuss progress, goals and concerns. The Project Manager will be responsible for the management of the project including budgeting, scheduling, staffing, logistics, report preparation and other administrative matters. The Project Manager will also review technical data and ensure that the technical requirements are fulfilled.

The SCIENTECH Project Manager will have full stop work authority. The Project Manager also has the authority to make decisions regarding policies and procedures for the operations and activities regarding the Quehanna project. This management approach provides the Project Manager the flexibility and resources necessary for efficient management and decision-making.

9.1.3 SCIENTECH Corporate Radiation Safety Officer

The SCIENTECH Corporate Radiation Safety Officer (CRSO), who is a Certified Health Physicist and a member of the RSC, has overall responsibility for the radiological aspects of the project. The CRSO will also review technical data and ensure that the technical requirements are fulfilled and valid. The CRSO, or designee, will also conduct periodic audits of various on-site activities, procedures, and or records.

9.1.4 SCIENTECH Site Supervisor

The Site Supervisor, who reports directly **to** the Project Manager, will be responsible for the day-to-day on-site activities and decommissioning **task** management. He will have the authority to make operational decisions and will be responsible for ensuring that the decommissioning activities are performed in the most effective and economical manner while maintaining a safe **work** environment. The Site Supervisor is responsible for ensuring that the project plans **and** procedures are implemented. The Site Supervisor is also responsible for conducting the daily safety briefings and previewing the day's planned activities with site personnel. The Site Supervisor will also have full stop work authority.

The Site Supervisor is responsible for maintaining the project log and records. Records to be maintained on site include, but are not limited to, training, medical clearance, respirator fit-testing, dosimetry, survey, sampling, and instrument calibration records.

The Site Supervisor is also responsible for preparing waste shipments and assuring that all packaging, characterization, manifesting, and transportation requirements are met.

9.1.5 SCIENTECH Site Radiation Safety Officer

The SCENTECH Site Radiation Safety Officer **(SRSO)** will be responsible for ensuring that all activities are performed in accordance with the radiological safety requirements as established by the NRC in Title 10 of the Code of Federal Regulations, **Part** 20 (10 CFR 20). The SCIENTECH SRSO, who reports to the Project Manager and the CRSO, will be responsible for reviewing all project activities and documents that may have a radiological safety impact. The **SCENTECH SRSO** will ensure that all radiological data collected **is** complete and in accordance with the procedures. The SCIENTECH SRSO will conduct specialized safety briefings when activities **are** planned which may have a significant radiological hazard such **as** decontamination of or entry into a high activity area. The SCIENTECH **SRSO** will approve all RWPs and direct the inspection and testing as required on all CCE's. The SCIENTECH **SRSO** will also have full stop work authority.

9.1.6 PADEP Radiation Safety Officer

The PADEP RSO will represent the RSC and the licensee at the work site on a routine basis and reports to the PADEP project manager. The PADEP RSO, as the RSO listed on the NRC license, ensures that the operations are in accordance with the project Radiation Safety Manual, NRC regulations, and sound health physics practices. The PADEP RSO participates in the deliberations of the RSC and is a full committee member. The PADEP RSO also has the authority to stop work if it is not being performed in accordance with the Decommissioning Plan or NRC regulations.

9.1.7 Health Physics Technicians

The Health Physics Technicians will be responsible for providing health physics coverage for the decommissioning activities and maintaining the ALARA principles to limit project personnel exposure. They report to the Site Supervisor and the SRSO. They will also perform release surveys for equipment and building materials and the final release survey for the facility. They will also perform the environmental monitoring. Senior Health Physics Technicians will meet the qualifications for ANSI/ANS 3.1 (ANSI 1991).

9.1.8 PADEP Bureau of Radiation Protection Staff

This project has the complete support of the PADEP. In addition to the PADEP the RSO, the radiological and health physics staff will be available to support the project when needed.

9.2 DECOMMISSIONING TASK MANAGEMENT

Project tasks will be managed through the use of approved procedures and task plans. Plans and procedures will be approved by the RSC prior to implementation. Procedures shall be tracked using SCIENTECH document control procedures. Procedures shall be used when performing tasks in the following areas: employee training, radiation safety, ALARA, writing RWPs, effluent monitoring, instrument calibrations, personnel monitoring, access control to work areas, sampling and laboratory analysis of samples, environmental monitoring, interim waste storage, transportation and disposal of waste, verification sampling, emergency planning, and other specific operations.

RWPs will be issued for specific tasks within the decommissioning project. The RWPs will describe the specific task involved and include the estimated radiation and dose levels in the work environment, the necessary personnel protective equipment, exposure time limits, and dosimetry requirements. The SCENTECH SRSO will prepare and issue all RWPs and the RSC will review them prior to being implemented. Personnel must read and sign the RWP before performing entering any area covered by the RWP. The RSC will review and approve all major changes to a RWP. The SCIENTECH SRSO will inform personnel of major changes to an RWP during daily safety briefings and will be required to have all affected personnel read and sign the amended RWP. Each RWP has an expiration date that will be no more than one year from the initiation date.

9.3 TRAINING

Personnel working in radiologically controlled areas (RCA) will be trained as radiation workers and will also receive site-specific radiation safety training. The training program will emphasize the nature of the beta, gamma, and x-ray radiation; protection requirements for high-level beta radiation; beta dosimetry; beta measurements; and internal exposure concepts. Training will also include the principles and practices of radiation protection, radioactivity measurements, standardization, monitoring techniques, monitoring instrumentation, and the biological effects of radiation. Furthermore, topics related to specific job tasks. will be discussed in daily safety briefings to better prepare personnel for the tasks at hand. Annual refresher training is required for radiation worker qualifications.

The SRSO or Site Supervisor will conduct daily "tailgate" meetings or safety briefings to discuss the work activities of the day. General safety topics will also be discussed to maintain personnel awareness of certain safety issues.

The SCIENTECH SRSO will maintain training documents for SCIENTECH personnel during employment and two years after employment. The SCIENTECH SRSO will also maintain the training records of on-site project personnel, including non-SCIENTECH personnel.

Visitors to the Quehanna facility and some subcontractor personnel may not required to obtain radiation safety or OSHA training to enter an RCA as long as they are escorted by a fully-trained SCIENTECH employee at all times. Visitors are, however, required to read, understand, and sign all appropriate RWPs' before entering an RCA.

9.4 CONTRACTOR SUPPORT

SCENTECH is managing and conducting the decommissioning project under contract to the PADEP (Contract No. DSG-173-68). Under certain occasions, SCIENTECH will employ the services of subcontractors to perform specific project tasks or operations. Subcontractors will be directed by the Site Supervisor and will work directly under SCIENTECH's SSHASP, RWPs, and safety and operational procedures as applicable. Subcontractors will also receive site-specific radiation safety training focusing on the general radiological condition of the site and specific work areas applicable to the subcontractor. All subcontractors will provide a "Commitment of Compliance" by signing site-specific safety documents, RWPs, attending tailgate meetings, and signing other applicable documents. It is the responsibility of the SRSO to obtain the appropriate commitments from the subcontractors.

Under contract to SCIENTECH, JLSA previously provided handling, packaging, transportation, and disposal of the discrete cobalt-60 sources located in Hot Cells 1 and 5. JLSA provided personnel and equipment, including shielded shipping containers, to accomplish this task. JLSA also removed the obsolete and non-functional manipulators that were installed in Hot Cells 1, 2, and 5. SCIENTECH provided detailed work plans describing the collection, handling, removal, packaging, shipping, and disposal of the cobalt-60 source materials located in Hot Cells 1 and 5.

RedZone Robotics, Inc. (RedZone), of Pittsburgh, PA, has delivered a Houdini® crawler robot with certain modifications to perform decontamination and decommissioning activities in Hot Cell 4. RedZone has prepared a feasibility report, "Feasibility of Utilizing Robotic Equipment for Cell 4," (RedZone 1999) detailing the applications of the robot. SCIENTECH designed and manufactured additional tools for the robot to meet site-specific needs.

SCIENTECH is currently contracting LLRW disposal directly with Envirocare of Utah. SCIENTECH will contract LLRW transportation services from experienced and licensed transportation brokers

SCIENTECH contracted the services of L.G. Hetager Drilling, Inc., a drilling company experienced in collecting subsurface environmental samples, to assist in the scoping-level environmental characterization of the site conducted in November 2000. SCIENTECH may require additional services from a drilling company to install groundwater-monitoring wells or to collect sub-surface soil samples.

SCIENTECH contracted Barringer Laboratories to analyze samples collected during the characterization. Additional off-site laboratory analysis has been, and may continue to be procured from Severn Trent Laboratories and General Engineering Laboratories.

SCIENTECH currently contracts with Landauer for whole body and extremity dosimetry.

All analytical laboratories and instrument calibration and repair facilities must meet the requirements of the SCIENTECH Quality Assurance Program Plan.

Other subcontractors have included:

- DEW Steel Contractors fabricated and erected the steelwork used for the Service Building structural modifications.
- Powers and Schram provide professional engineering services.
- Micale Construction Services removed the overhead crane from the Service Area and provides on-call mobile crane services.

10.0 HEALTH AND SAFETY PROGRAMS

The PADEP and SCIENTECH are all committed to conducting safe operations during this D&D project. This includes using properly trained personnel, limiting radiation exposure, performing work in a safe manner, and operating equipment according to the manufactures' specifications.

10.1 ALARA PROGRAM

SCIENTECH operates under general and site-specific procedures that include ALARA principles and define specific ALARA-related tasks. For example, SCIENTECH will conduct an ALARA review for each Task Plan presented to the RSC. The RSC shall consider the ALARA review during its review and approval of the Task Plan.

All individuals associated with this decommissioning project are responsible for implementing the ALARA Plan. The SCIENTECH Corporate RSO has the responsibility for administering the ALARA Pian. The RSO will approve all ALARA task reviews and ensure the items in the task reviews are being implemented.

There are a number of techniques that are currently being used or may be used during this project that have proved effective in reducing radiation exposure. These include pre-job planning, temporary shielding, engineering controls, specialized training, improved access to areas, special procedures, and the use of remote handling tools and equipment. The specific ALARA techniques that will be used for a particular job will be included in a Task Plan based on the ALARA review.

10.2 HEALTH PHYSICS PROGRAM

The RSC has reviewed and approved a set of SCIENTECH procedures and manuals that makes up the project Health Physics Program. These procedures address airborne radioactivity, high contamination levels, high beta dose rates, methodology for radiological surveys, effluent monitoring, instrumentation control and calibration, personnel monitoring, access control to work areas, sampling and analysis procedures, packaging and storage of waste, and emergency situations. SCIENTECH will incorporate additional procedures into the Health Physics Program as needed. Additional procedures will be approved by the RSC before they are implemented. Many of SCIENTECH's general operating procedures, including SCIENTECH's *Radiation Protection Manual* (SCIENTECH Document No. 82A8042), have been provided to the NRC under SCIENTECH's Radioactive Materials License Number 06-20775-01.

10.2.1 Air Sampling Program

SCENTECH currently collects air samples from six permanent general work areas on a daily basis. These sampling locations include two locations on the North Mezzanine, one location in the Service Area, two locations in the Operations Area, and one location in the Reactor Bay near the Service Area roll-up door. Air sampling is also done to support various work activities to monitor for releases and ensure that respiratory protection is adequate. During the Cell 4 remote decontamination, a task-specific Remote Monitoring Plan will be developed to direct the air sampling efforts. During this task, air sampling will include alarming air monitors positioned at several locations including inside the COTS and the Service Area.

Since PermaGrain bas vacated the facility, the sampling locations in the Operations Area and the Reactor Bay may be eliminated as permanent sampling locations. These locations were originally selected to provide an indication of the air concentrations in the areas occupied by PermaGrain. The RSC will approve of any change in the routine air monitoring program before it is implemented.

Air sampling is also conducted during certain work activities that may generate airborne radioactivity.

10.2.2 Respiratory Protection Program

SCIENTECH's Respiratory Protection Program is governed by SCIENTECH's ***Radiological Respiratory Protection Manual*** (SCIENTECH Document No. 82A8044). The manual is designed to comply with the requirements of NRC Regulatory Guide 8.15, ***Acceptable Programs for Respiratory Protection,*** (NRC 1999).

Currently, SCIENTECH uses a subcontractor to provide clean respirators on a regular basis and each respirator is typically worn for only one entry into an airborne radiation area. The administrative action limit for use of a full-face air-purifying respirator is 5% of the derived air concentration (DAC) established in 10 CFR 20. SCENTECH personnel will typically ugrade the protection factor to a supplied air (air-line) respirator if airborne concentrations are expect to approach several DAC. Supplied air respirators are mandatory under conditions that exceed 50 DAC.

10.2.3 Control of Internal Exposures

SCIENTECH will collect air samples as described in Section 10.2.1 during decontamination activities to assess the levels of airborne contaminants. Airborne contamination levels may trigger the use of respiratory protection or non-routine bioassay sampling. SCIENTECH's CRSO will establish additional monitoring protocols for internal exposures and direct non-routine bioassay analysis should they become necessary.

SCIENTECH's routine bioassay program includes collecting one sample from on-site personnel before they begin working on the job site and one sample on their last day at the job site.

10.2.4 External Exposure Determination

The Quehanna dosimetry program is jointly managed by **PADEP** and SCIENTECH **and** includes personnel monitoring utilizing a National Voluntary Laboratory Accreditation Program (NVLAP) approved personal dosimeters capable of monitoring the beta radiation from strontium-90 (NVLAP Categories V and VII) or cobalt-60 when working around cobalt sources. The dosimeters to be used on site are capable of discriminating shallow dose from deep dose exposures. Additional extremity dosimeters are also used for certain decontamination **tasks.**

Whole-body dosimeters are typically exchanged on a monthly basis. Extremity dosimeters are sent off for reading monthly. If an unusual exposure event is suspected, whole-body dosimeters will be collected immediately from the personnel potentially exposed and the **CRSO** will **be** notified. The **CRSO,** or designee, will review all routine and non-routine external dose monitoring reports.

SCIENTECH will also assign a visitor a dosimeter if the visitor will be engaged in activities beyond touring the facility in radiological areas. Visitors will only be provided **a** dose report if there is a reportable dose measured on the dosimeter.

10.2.5 Contamination Control

The spread of radiological contamination will be controlled according to the methods and procedures described in the established SCIENTECH radiation protection procedures. Engineering controls such as local **HEPA** filters, access control points with step-off pads and frisking stations, barriers, and postings will all be used **to** maintain contamination control. Additionally, only necessary tools and equipment are brought into the RCA's and they will stay in the RCA until they are no long needed. At that point, they will be thoroughly surveyed before they are removed from the RCA.

10.2.6 Instrumentation

SCIENTECH will use survey instruments capable of detecting the beta radiations associated with strontium-90 decay during all facility operations. These instruments will include gas proportional detectors, Geiger-Muller (GM) detectors, beta scintillation detectors, and dose rate meters. Additional instruments, such as gamma scintillation detectors and high-purity germanium detectors, will be used to identify cobalt-60 contamination where suspected. Because of uncertainties in the types of contaminants that might be present in the irradiator pool, additional instruments, such **as** alpha scintillation detectors, will be **used** during the source pool characterization.

All instruments used on-site will be managed according to established SCIENTECH calibration and maintenance procedures. The SCIENTECH SRSO, or designee, is responsible for maintaining all on-site instruments according to these procedures.

10.2.7 Nuclear Criticality Safety

There are no fissile materials on site that could contribute to a nuclear criticality incident.

10.2.8 Audits, Inspections, and Record Keeping

SCIENTECH will conduct at least one audit annually during the on-site decommissioning activities to ensure compliance with Decommissioning Plan commitments and regulatory requirements. The audit will be conducted by the CRSO or designee and will focus on data quality, instrumentation usage, and radiation safety.

Project records, including those related to personnel training, surveys, inspections, and instrument calibrations, will be maintained on-site by the SRSO. The records are subject to audit by the CRSO, the Pennsylvania BRP, or the NRC at any time.

Record retention, custody and submittal requirements will be described in detail in the project QAPP, which is further described in Section 13.

11.0 ENVIRONMENTAL MONITORING AND CONTROL

Work at the Quehanna facility will be conducted in a manner as to control releases of airborne or liquid radioactive materials into the environment to levels that are ALARA. Engineering controls that may be used include CCE's to control airborne releases and storm water control and secondary containment to control the transport and release of contaminated liquids. SCIENTECH will conduct an ***ALARA*** review prior to being implementing environmental control measures.

During decontamination activities and demolition of the hot cell complex, SCIENTECH will conduct work-area air monitoring **as** well **as** effluent air monitoring from the **HEPA** ventilation system. If site work **is** a potential to release radiological contaminants into the on-site pond or stream, these water sources will be sampled to ensure compliance with surface water contamination limits.

Airborne concentrations of radionuclides will be limited to the effluent concentration **limits** provided in 10 CFR 20, Appendix **B,** Table 2. Surface water concentrations should not exceed the EPA's maximum contaminant level **(MCL)** for drinking water. If either **of** these limits is exceeded, SCIENTECH will identify the source of the elevated concentrations and take corrective measures to decrease the media concentrations.

SCIENTECH will discharge the water in the irradiator pool directly into the on-site pond if sampling from the pool indicates that concentrations of all isotopes of concern (cobalt-60, strontium-90, uranium-238, and various fission products) are below the effluent concentration limits provided in 10 CFR 20, Appendix B, Table and other water quality parameters such **as** pH, temperature, and non-radiological contaminant concentrations are acceptable according to PADEP regulations. SCIENTECH may also discharge treated or untreated waste water from decontamination activities directly into the pond if sampling indicates that contaminant concentrations are below the effluent discharge limits. Some environmental monitoring action limits are provided in Table 11-1.

TABLE 11-1
ENVIRONMENTAL MONITORING ACTION LIMITS

Isotope	Airborne Limit [a] (uCi/ml)	Water Effluent Limit [b] (pCi/L)	Surface Water Limit [c] (pCi/L)
Cobalt-60	2E-10	3,000	100
Strontium-90	3E-11	500	8

Notes:
a 10 CFR 20, Appendix B, Table 2, Column 1.
b **10** CFR 20, Appendix B, Table 2, Column 2.
c **EPA** established or proposed MCLs.

12.0 RADIOACTIVE WASTE MANAGEMENT

SCIENTECH has established that efficient waste reduction and LLRW minimization will be an operational goal throughout the life of the project. Most of the volume reduction will occur as components or equipment are dismantled and removed from their installed location. Some components may be moved to a controlled area established specifically for volume reduction activities. The controlled area will have the proper radiological controls to ensure that potential contamination generated during the volume reduction activities is contained.

Through the course of the decontamination project, SCIENTECH has primarily generated strontium-90 contaminated solid LLRW consisting of personal protective equipment (PPE), metal debris (such as piping and equipment), wood, concrete, and soil. Future LLRW may also include slab and rubblized concrete, structural steel, sheet metal siding, and other construction and demolition debris.

SCIENTECH has generated small volumes of liquid decontamination wastes contaminated with strontium-90. Some liquid waste has been added to solidifying agents in 55-gallon drums and then managed as solid waste. About 500 gallons of liquid waste in the form of water from core drilling operations was collected, filtered, and treated on-site using an evaporative process. Future liquid waste streams may include contaminated water from core drilling, concrete cutting, and pressure washing and hydrolasing. Although much of the process water will be recycled, it is anticipated that a significant volume of liquid waste will be generated during the robotic decontamination of Cell 4. Much of this water will be stored and treated on site using a filtration and evaporation process.

SCIENTECH has transferred of 3,000 pounds of radiologically contaminated lead brick shavings, a lead "pig", lead sheets, and lead wool (total of about 7,300 pounds) to a waste broker for treatment and disposal as a mixed waste. The amount of contaminated lead bricks was reduced by about 52,000 pounds as a result of milling the lead bricks to shave off the contaminated external surface.

SCIENTECH's radioactive waste broker has the responsibility of ensuring that waste packages meet DOT and NRC shipping requirements.

12.1 ESTIMATED WASTE VOLUMES

Through May 2002, nearly 870 yd^3 of solid LLRW have been shipped off site for disposal as LLRW, excluding oversized shipments and lead waste. The waste has consisted of primarily metal (50%), concrete and soil (30%), wood (10%), and other dry solid waste such as PPE, paper, and plastic (10%) and various levels of strontium contamination. Through 2001, 33 waste shipments have gone to the Envirocare of Utah (Envirocare) disposal facility in Clive, Utah, two high-activity shipments were sent to the Chem-Nuclear LLRW disposal facility in Barnwell, SC, one shipment of an oversized item was shipped to the Alaron Corporation, and one shipment of contaminated lead was transferred to Radiological Assistance, Consulting and Engineering (RACE), LLC of Memphis, Tennessee. The shipments to Chem-Nuclear included over 2,000 curies of cobalt-60 sources, two storage casks, and four 55-gallon drums. The shipment to Alaron included the waste water tanks, a manipulator arm, a lab sink, resin columns, concrete filled barrels, two glove box sections, and some other over-sized items. In March 2002, approximately **7,300** pounds **of** contaminated lead were shipped to RACE, LLC treatment and disposal.

It is anticipated that the decontamination project will generate less than 300 yd^3 of **LLRW** during the remainder of the project. This waste will consist primarily of metal components (such as ducting, piping and structural steel), concrete, soil, and other dry wastes such as PPE, plastics, and paper.

SCIENTECH excavated approximately **40** yd^3 of contaminated soil during remediation around the WWTB in 1998. Based on the scoping-level surface and subsurface soil characterization conducted in November 2000, it is estimated that only small volumes of contaminated soil will need to be excavated and disposed of **as** **LLRW** during other removal actions.

12.2 **STORAGE,** TRANSPORTAION, AND DISPOSAL,

The majority of contaminated material to be removed during the decommissioning project **will** meet the disposal requirements **for** Envirocare. Envirocare can also accept certain types of mixed and hazardous wastes generated during the decommissioning project. Items that exceed the acceptable curie value for disposal at Envirocare will be sent to Barnwell, ***SC.***

LLRW will be packaged in approved **U.S.** Department of Transportation (DOT) containers such as metal B-25 boxes or roll-off containers. These large containers will be stored outside the building in a designated and posted area prior to shipment. All waste material will be packaged, labeled and transported in accordance with 10 CFR 71 and **49** CFR regulations. External dose rates on containers shall be limited to the values specified in **49 CFR** 173.441 and removable and fixed contamination shall be limited to the values specified in **49** CFR **173.443.** Additionally, **LLRW** will be characterized as required per the Pennsylvania DEP **LLRW** reporting requirements.

To reduce shipping costs, SCIENTECH will accumulate small waste quantities and store then on site in a designated storage area until a truckload is collected. At that point a shipment will be made in accordance with all applicable law and regulations.

The cobalt-60 sources will be handled, packaged, and disposed **of** by **JLSA,** who is licensed to perform these activities. They will be responsible for providing a turnkey service for this activity that will include providing the appropriate casks and the transportation to the disposal or recycling facility.

SCIENTECH will maintain all shipping and disposal documents generated in the performance of this project in the SCIENTECH Site Supervisor's office trailer. The **SCIENTECH SRSO** will maintain the health physics data on the waste. This will include, but will not be limited to, waste characterization data and shipping container survey data.

13.0 QUALITY ASSURANCE PROGRAM

Decommissioning activities at the Quehanna facility will be performed in accordance with the SCIENTECH Radiological Control, Safety and Quality Assurance Program Manual (SCIENTECH Document No. 82A8041). Additional activities affecting quality are described in documented instructions, procedures, and manuals prepared by SCIENTECH or other parties (i.e., an instrument manufacturer). SCIENTECH procedures and manuals were prepared such that they are consistent with regulatory, licensing, and quality assurance (QA) program requirements. All procedures and manuals are reviewed and approved by the **CRSO** and SCIENTECH's Decommissioning Services Operations Manager.

13.1 ORGANIZATION

The primary project personnel in the QA management organization are the Project Manager and the CRSO. The Project Manager is the designated Quality Coordinator and is responsible for ensuring that all contractual obligations are met and that all QA requirements are fulfilled in accordance with the site-specific Quality Assurance Project Plan (QAPP) and this Decommissioning Plan. Additional responsibilities of the Project Manager are outlined in the QAPP. The CRSO is responsible for designing site surveys and sampling efforts that meet specific data needs and objectives and ensuring that radiological hazards are appropriately addressed. The Project Manager or the **CRSO** will evaluate work performance against the requirements of the QAPP and other site-specific plans and procedures. The SRSO and Site Supervisor have the on-site responsibilities of the day-today implementation **of** the QAPP.

13.2 QUALITY ASSURANCE PROJECT PLAN

The QAPP will be the site-specific QA document implemented during the course of the D&D project. The QAPP will address such topics as QA coordination, audits, document requirements, equipment maintenance and calibration, data management, and field analysis. Addenda may be added to the QAPP to cover data quality needs, such as QA sampling during the final site-sampling event, that are not addressed in the current version.

The QAPP will provide description and detailed directions on specific quality issues such as:

- Data quality objectives (DQO) (see Section 14.7)
- QA actions to be implemented during the decommissioning project
- Collection, handling, chain of custody preparation, packaging, and shipping of samples
- QA sample requirements
- Data review and approval procedures.

13.3 DOCUMENT CONTROL

All site-specific documents, including this Decommissioning Plan and the QAPP, will be controlled documents maintained on site by SCIENTECH personnel. Off-site management personnel such as the SCIENTECH Project Manager and the SCIENTECH CRSO will **also** maintain controlled copies **of** project-specific documents. The NRC will receive controlled copies of the Decommissioning Plan and the Final Status Survey Plan. The SCIENTECH document control procedure is outlined in the Radiological Control, Safety and Quality Assurance Program Manual.

A complete ***set*** of applicable and current procedures will be readily available for reference and review by all members of the project staff. Should changes to operating procedures be found necessary, an Engineering Change Notice (ECN) can be issued for changes that do not fundamentally change the intent of the procedure. For more substantive procedural changes, a Change Request Authorization (CRA) must be issued for approval by SCIENTECH project management and the CRSO. All revised operational procedures will be distributed to owners of controlled copies of the operating procedures.

Changes or revision to a RWP require only the approval of the Site Supervisor and the SRSO.

13.4 CONTROL OF MEASURING AND TEST EQUIPMENT

SCIENTECH maintains survey instruments according to the Calibration and Maintenance **of** Survey Instruments Procedure (SCIENTECH Document No. 82A8034). Other equipment is generally maintained according to the manufactures specifications, unless an instrument-specific procedure has been developed. SCIENTECH has specific procedures for the calibration and operation of the Canberra ISOCS/HPGe detector and the Protean WPC 9550 alpha, beta, and gamma counter.

Calibrations **are** performed at least annually. All survey instruments are operationally checked each day that the instrument is used. If the instrument response is outside the acceptable range **as** determined following the instrument calibration, the instrument will not be used. **A** daily log is maintained by the **SRSO,** or designee, of the instruments that are in use at **the** facility. When instruments are not in use, they are stored in the field laboratory trailer, which is locked at the end of each workday. Instruments that are out of calibration or are not functioning properly are taken out of service and labeled so that they will not be used.

13.5 CORRECTIVE ACTION

If actions currently described in this Decommission Plan are unable to meet the QA objectives outline in the QAPP, corrective actions will be necessary. The licensee must receive formal NRC approval prior to implementation of actions involving major scope or intent changes which deviate from the approved Decommissioning Plan.

13.6 QUALITY ASSURANCE RECORDS

The Site Supervisor and the SRSO will maintain **QA** records on-site. The records will be available at all time for review by the Project Manager or the CRSO. Upon completion of the project, the project **QA** documents will be maintained by the CRSO for the minimum periods defined in Appendix **F** of the SCIENTECH Radiation Protection Manual. The documents will be stored in a manner **as** to preclude loss or destruction.

13.7 AUDITS AND SURVEILANCE

SCIENTECH will continue to perform periodic audits during decommissioning activities to ensure compliance with the requirements of this plan. The Pennsylvania Bureau of Radiation Protection may also **perform** independent audits. The Project Manager and the CRSO, or designee, will conduct SCIENTECH's internal audits, depending on the scope of the audit. Likely audit scopes include the following:

- Reviews of the health and safety training program (Project Manager).
- Reviews of the radiological control program including instrument usage and calibration and personnel and area monitoring procedures (CRSO).
- Reviews of work procedures with regard to public health and safety and the principles of ***ALARA*** (CRSO).
- Review of records including training, radiation surveys, instrument calibration, and waste shipments (Project Manager).

Following an audit, the Project. Manager or CRSO will generate a letter to the Site Supervisor identifying the findings of the audit. The Project Manager and the Site Supervisor will maintain a copy of this letter. The letter will instruct the Site Supervisor of the corrective actions necessary and request a response from the Site Supervisor indicating that the corrective actions have been initiated or completely implemented.

13.8 DATA QUALITY ASSESSMENT

The data quality assessment process is a five-step process that begins with a review of the planning documentation and ends with an answer to the question proposed during the planning phase of the final site sampling (see Section **14.7).** The five steps are summarized below:

1. ***Review the DQOs and Sampling Design:*** Review the DQO outputs to assure that they are still applicable. Review the sampling design and data collection documentation for consistency with the DQOs.

2. ***Conduct a Preliminary Datu Review:*** Review the **QA** reports, calculate basic statistical quantities and generate graphs of the data. Use this information to learn about the structure of the data and identify patters, relationships, or potential anomalies.

3. ***Select the Statistical Test:*** Select the most appropriate procedure for summarizing and analyzing the data, based on the preliminary data review. Identify the key underlying assumptions that must hold for the statistical procedure.

4. ***Verify the Assumptions of the Statistical Test:*** Evaluate whether the underlying assumptions hold, or whether departures are acceptable, given the actual data or other information.

5. ***Perform the Statistical Test:*** Perform the calculations required for the statistical test and document the inferences drawn as a result of the calculations.

14.0 FACILITY RADIATION SURVEYS

Radiation surveys are an integral **part** of the Quehanna facility **D&D** project. The surveys conducted to date have had a variety of goals and have included a variety of instruments and methods. Surveys have been conducted for facility characterization, radiation protection, decontamination and remediation support, equipment and material release, waste characterization, and free-release of areas. Each **of** these has required a different level of data and data quality. The following sections discuss the release criteria and the various survey types.

14.1 RELEASE CRITERIA

The Quehanna D&D project has established separate release criteria for construction debris and equipment and the land area (soil). These release criteria **are** not dose-based derived concentration guideline limits (DCGL). **Due** to the circumstances described in Section 5.0 of this Decommissioning Plan, demonstrating compliance with dose-based DCGL's is not required for this decommissioning project; rather, demonstrating compliance with regulatory guidance-based release criteria is acceptable. The respective regulatory guidance-based criteria for the unrestricted release of material and land are provided in the following sections.

14.1.1 LIMITS FOR **UNRESTRICTED** RELEASE OF CONSTRUCTION DEBRIS AND EQUIPMENT

Allowable residual contamination levels for the unrestricted release of structures, construction debris, and equipment will be based on the **NRC** release limits presented in Regulatory Guide 1.86. The acceptable surface contamination levels (in dpm/100cm^2) for the primary isotopes **of** concern are as follows:

Isotope	Average	Maximum	Removable
cobalt-60	5,000	**15,000**	**1,000**
strontium-90	**1,000**	**3,000**	**200**

SCIENTECH has applied these release limits during the course of this **D&D** project for determining the disposal path **of** waste materials. That is, if waste is contaminated above the release limits, it is disposed of **as** LLRW. If **SCIENTECH** happens to identify other isotopes of concern other than cobalt-60 and strontium-90 during the decommissioning activities, their release limits will also be obtained from Regulatory Guide 1.86. The need for special exemptions from these release guidelines is not anticipated; however, NRC approval for exemptions will be requested on a case-by-case basis.

14.1.2 LIMITS FOR UNRESTRICTED RELEASE OF LAND

Allowable residual levels of contamination in site surface and subsurface soils are based on the NRC guidelines (NRC 1992a). The soil limits (in pCi/g) for this decommissioning project **are** as follows:

Isotope	Average	Maximum
cobalt-60	**8**	**24**
strontium-90	***5***	**15**

In order to meet the average soil concentration limits, the soil sampling results can be averaged over an area no greater than 100 square meters. The maximum concentration refers to any single sample from a **volume** of soil within a surface ***area*** of 100 square meters and a thickness of one meter.

14.2 CHARACTERIZATION SURVEYS

SCIENTECH characterization surveys at the Quehanna facility have been thorough and well documented. The surveys have identified levels of contamination ranging from **a** few hundred dpm/100 cm^2 to millions of dpm/100 cm^2. SCIENTECH has used **the** characterization surveys to design decontamination methods from simple **HEPA** vacuuming to remote robotic dismantlement of Cell **4.**

After all contamination has been removed from the facility to levels that **are** ALARA, and selective dismantling and demolition is complete, existing survey data will be examined to identify characterization data gaps. Areas of the facility with insufficient characterization data will be surveyed.

14.3 REMDIAL ACTION SUPPORT SURVEYS

SCIENTECH will support all decontamination, demolition, and excavation operations with remedial action surveys in all **areas** of the facility. These surveys will include surveys **of** building materials and systems that were inaccessible prior to excavation or demolition. Demolition debris, such **as** concrete foundation material or floors, that comes from areas where all pervious surveys (characterization and final release surveys) indicate that the material will be suitable for disposal **as** clean waste will receive a 100% surface scan survey with fixed point measurements. M a t e d that does not meet the free release criteria established in Section 14.1.1, will be segregated and disposed of as LLRW. Newly accessible surface of demolition debris generate in areas where the debris is destined for LLRW disposal will be spot checked to aid in waste characterization and to help identify areas of potential soil contamination within the facility footprint.

Because strontim-90 is the primary isotope of concern, **SCIENTECH** will use GM, scintillation, or gas proportional detectors to support the r e d i a l action surveys. Scan and fixed point surveys will have **an** MDC below the release criteria for average contamination levels established in Section 14.1.1. Removable contamination swipes will be analyzed using either an alpha/beta scintillation detector or a low-background bench proportional counter. If characterization data from **the** accessible surfaces in the area being demolished indicate cobalt-60 contamination, or contamination from other isotopes, the remedial action surveys in these areas will also use survey instruments capable of detecting the radiations of interest.

14.4 FINAL STATUS SURVEY PLAN

The first step of the final status survey process will be to prepare the FSSP. The plan will outline the survey and sampling methods that SCIENTECH will use to release the site for unrestricted use and the basis for the methods proposed. Once the RSC has approved the FSSP, the final survey and sampling effort will be conducted accordingly.

The final status survey and sampling effort will include all structures and surrounding land. The survey and sampling areas will be divided into "impacted" and "non-impacted" areas. Impacted areas will be further subdivided into Class 1, 2, and 3 survey units according to MARSSIM protocols (NRC 2000). Table 14-1 provides the final site survey and sampling areas and their preliminary classification. The classification of some of these areas may change during the course of the project as a result of additional characterization data. The FSSP will provide the final classifications and identify specific survey units.

TABLE 14-1
PRELIMINARY CLASSIFCATION OF SITE AREAS
***(See* Figure 2-1)**

Impacted – Class 1	
Service Area and Basement	Operations Area
Waste Water Treatment Building (inc. soil)	Irradiator Pool
Former Decontamination Room Area	Former Radioanalytical Laboratory Area
Impacted – Class 2	
Reactor (High) Bay	Mechanical Equipment Room (DI Room)
Electrical Equipment Room	PermaGrain R&D Laboratory
Lunch Room	Storage Areas
Restrooms and Change Rooms	Wood Shop
Corridor north of Reactor Bay	Offices south of Northern Corridor
Heater Exchanger and Pump Room	Waste water Drain Line Pathways
Radioactive Waste Storage Areas	Reactor Bay Basement
Impacted – Class 3	
Maintenance Shop	Offices north of Northern Corridor
Septic Leach Field (see Figure 3-1)	Outside Areas east of the Service Area
Non-Impacted	
Finish Area	Hydro-Blast Area
Office Trailers	Storage Building west of Reactor Bay
Water Storage Building (see Figure 3-1)	Aqua Tower

The FSSP will clearly identify all DQOs. The process of identifying the applicable DQOs ensures that the FSSP requirements, results, and data evaluation are of sufficient quality, quantity, and robustness to support the decision that the site has met the free release criteria. The major elements in the DQO process are:

- A clear statement of the problem
- Identification of all related decision statements and alternative actions
- Identification of the information needed to support the decision-making process
- Definition of the site physical, temporal, and spatial boundaries for survey and reference areas
- Development of a decision rule in defining action levels
- Specifying limits on Type I and II decision errors in support of hypothesis testing
- Optimization of data collection

The number of survey and sampling locations in each survey unit will be determined based on the methods provided in MARSSIM (NRC 2000). Portions of MARSSIM or other similar documents (such as EPA sampling protocols), will be used as practicable during the sub-surface soil assessment phase.

Following the final status survey and sampling effort, SCIENTECH will prepare a Final Status Survey Report. The report will include a summary of D&D activities and present the final site radiological data. All statistical evaluations and calculations used to support the conclusion that the Quehanna site is acceptable for an unrestricted release will also be provided in the report. The draft of the report will be submitted to the RSC for review and comment. Comments will be resolved and a final version of the document issued for the NRC for review and approval. All survey data sheets and analytical results will be provided as an attachment to the report.

14.5 SURVEY OF IMPACTED AREAS

Class 1 and Class 2 survey areas will be divided into square grids to ensure that the minimum number of measurements, as determined by the methods described in MARSSIM, will be collected at evenly spaced intervals. The starting point for the systematic measurement pattern will be chosen randomly. Technicians will take a direct surface-activity measurement, an exposure-rate measurement, and a smear sample for removable contamination at each grid node on. structure surfaces Similarly, technicians will take a direct surface-activity measurement, an exposure-rate measurement, and a soil sample at each grid node on land areas.

Table 14-2 provides the scanning and direct measurement requirements for each classification.

TABLE 14-2
RECOMMENDED CONDITIONS FOR FINAL STATUS SURVEYS

Survey Unit Classification		Scanning	Direct Measurements
Impacted	Class 1	100% Coverage	Systematic
	Class 2	10 to 100% Coverage	Systematic
	Class 3	Judgmental	Random
Non-impacted		None	None

Since Class 1 survey units have the highest potential for small areas of elevated activity, they will receive both a 100% surface scan and systematic measurements. The number of measurements will be based on a Type I false-positive error rate of 5% (this type of error leads the tester to conclude that a survey unit meets the release criteria when in fact it does not), detection sensitivities for mixed and scanning measurements, and other factors. Class 2 and Class 3 survey units are less dependent on scanning surveys because of the decreased probability of small areas of elevated activity.

14.6 SURVEY OF NON-IMPACTED AREAS

Non-impacted areas are not suspected of being impacted from site radiological operations and are therefore, not subjected to radiological surveys.

14.7 INDEPENDENT VERIFICATION SURVEY

The NRC may wish to conduct an independent verification survey after the SCIENTECH FSS is complete. Alternatively, the NRC may wish to review the FSS as it is being conducted to verify the FSS effort. SCENTECH will provide the necessary communication and support to the NRC for either effort as it becomes necessary. SCENTECH will notify the NRC regarding the anticipated schedule of the FSS effort in event the NRC wishes to review the in-progress FSS.

15.0 FUNDING

The Commonwealth of Pennsylvania is providing funding for the Quehanna facility. As such, a decommissioning funding plan and documented financial assurance is not required.

16.0 REFERENCES

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ATTACHMENT A

RESRAD Output File for Subsurface Dose Assessment

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

lenu	Parameter	current Value	Default	Parameter Name
I-1	Dose conversion factors for inhalation, mrem/pCi:			
3-1	Sr-90+D	1.310E-03	1.310E-03	DCF2(1)
1-1	Dose conversion factors for ingestion, mrem/pCi:			
1-1	Sr-90+D	1.530E-04	1.530E-04	DCF3(1)
)-34	Food transfer factors:			
)-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(1,1)
1-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,2)
1-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
1-5	Bioaccumulation factors, fresh water; L/kg:			
)-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(1,1)
)-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	3.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.960E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00		T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Sr-90	5.000E+00	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	4.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(1
R016	Unsaturated zone 1 (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCU(1
R016	Saturated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCS(1
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(1
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1
R017	Ring 2	not used	2.732E-01	---	FRACA(2
R017	Ring 3	not used	0.000E+00	---	FRACA(3
R017	Ring 4	not used	0.000E+00	---	FRACA(4
R017	Ring 5	not used	0.000E+00	---	FRACA(5
R017	Ring 6	not used	0.000E+00	---	FRACA(6
R017	Ring 7	not used	0.000E+00	---	FRACA(7
R017	Ring 8	not used	0.000E+00		FRACA(8
R017	Ring 9	not used	0.000E+00	---	FRACA(9
R017	Ring 10	not used	0.000E+00	---	FRACA(10
R017	Ring 11	not used	0.000E+00		FRACA(11
R017	Ring 12	not used	0.000E+00	---	FRACA(12

Site-Specific Parameter Summary (continued)

e	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
318	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
318	Milk Consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
1018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
018	soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
3018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
3018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
1018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
9018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
3018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
3018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
3018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.500E-01	FMEAT
R018	Contamination fraction of milk	-1	-1	0.500E-01	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R01	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R0	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05		C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02		C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02		CSOIL
C1	Fraction of vegetation carbon from air	not used	9.800E-01		CAIR

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not 'used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR-T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR-T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR-T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR-T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR-T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR-T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR-T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions			Initial soil Concentrations, pCi/g	
Area:	1000.00	square meters	sr-90	5.000E+00
kness:	2.00	meters		
Cover Depth:	4.00	meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
TDOSE(t):	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.0153-03	2.200E-03	3.2313-11
M(t):	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.606E-04	8.8023-05	1.2933-12

Maximum TDOSE(t): 9.015E-03 mrem/yr at t = 196.0 ± 0.4 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	so mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Dependent Pathways

Radio-Nuclide Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All PE mrem/yr
Sr-90	8.2213-03	0.9119	4.1693-06	0.0005	0.000E+00	0.0000	6.8103-04	0.0755	7.0613-05	0.0078	3.861E-05	0.0043	9.015E-(
Total	8.221E-03	0.9119	4.1693-06	0.0005	0.000E+00	0.0000	6.810E-04	0.0755	7.061E-05	0.0078	3.861E-05	0.0043	9.015E-(

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As **mrem/yr** and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+(
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+(

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) €or Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

ladio-	Ground		Inhalation		Radon		Plant		Meat		Milk		so
luclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
'otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

tadio-	Water		Fish		Radon		Plant		Meat		Milk		All Pa
Juclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

*Sum of all water independent and dependent pathways

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Sc
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yı
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+(
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+(

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All P
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/y
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	So mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0,0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground mrem/yr	 fract.	Inhalation mrem/yr	 fract.	Radon mrem/yr	 fract.	Plant mrem/yr	 fract.	Meat mrem/yr	 fract.	Milk mrem/yr	 fract.	So mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio- Nuclide	Water mrem/yr	 fract.	Fish mrem/yr	 fract.	Radon mrem/yr	 fract.	Plant mrem/yr	 fract.	Meat mrem/yr	 fract.	Milk mrem/yr	 fract.	All Pa mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Petal	0.000E+00	0.0000	0.000E+00	0.6000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Independent Pathways (Inhalation excludes radon)

adio-	Ground		Inhalation		Radon		Plant		Meat		Milk		So
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
r-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Dependent Pathways

adio-	Water		Fish		Radon		Plant		Meat		Milk		All Pa
Juclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	8.221E-03	0.9119	4.169E-06	0.0005	0.000E+00	0.0000	6.810E-04	0.0755	7.061E-05	0.0078	3.861E-05	0.0043	9.015E-0
Total	8.221E-03	0.9119	4.169E-06	0.0005	0.000E+00	0.0000	6.8103-04	0.0755	7.061E-05	0.0078	3.861E-05	0.0043	9.015E-0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

adio- uclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	So mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio- luclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fraet.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
51-90	2.006E-03	0.9118	1.018E-06	0.0005	0.000E+00	0.0000	1.663E-04	0.0756	1.728E-05	0.0079	9.4323-06	0.0043	2.200E-0
Total	2.006E-03	0.9118	1.018E-06	0.0005	0.000E+00	0.0000	1.663E-04	0.0756	1.728E-05	0.0079	9.432E-06	0.0043	2.200E-0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		so
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pa
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	2.946E-11	0.9118	1.495E-14	0.0005	0.000E+00	0.0000	2.443E-12	0.0756	2.541E-13	0.0019	1.386E-13	0.0043	3.231E-1
Total	2.946E-11	0.9118	1.495E-14	0.0005	0.000E+00	0.0000	2.443E-12	0.0756	2.5413-13	0.0079	1.386E-13	0.0043	3.231E-1

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

a (i)	Product (j)	Branch Fraction*	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
			DSR(j,t) (mrem/yr)/(pCi/g)							
r-90	Sr-90	1.000E+00	7.162E-34	7.081E-34	6.923E-34	6.396E-34	5.1003-34	1.803E-03	4.401E-04	6.4633-12

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j
'he DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

uclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	*1.365E+14	*1.365E+14	*1.365E+14	*1.365E+14	*1.365E+14	1.387E+04	5.681E+04	3.868E+12

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 196.0 ± 0.4 years

Nuclide	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Sr-90	5.000E+00	196.0 ± 0.4	1.8033-03	1.387E+04	1.8033-03	1.387E+04

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.015E-03	2.200E-03	3.2313-11

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	5.000E+00	4.856E+00	4.579E+00	3.729E+00	2.075E+00	1.597E-02	7.568E-04	9.241E-13

BRF(i) is the branch fraction of *the* parent nuclide.

RESCALC.EXE execution time = 1.92 seconds

ATTACHMENT B

RESRAD Output File for Surface Dose Assessment

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Men.	Parameter	Current Value	Default	Parameter Name
3-1	Dose conversion factors for inhalation, mrem/pCi:			
3-1	**Sr-90+D**	1.310E-03	1.310E-03	DCF2(1)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
1-1	Sr-90+D	1.530E-04	1.530E-04	DCF3(1)
1-34	Food transfer factors:			
1-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(1,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
3-5	Sr-90+D , fish	**6.000E+01**	**6.000E+01**	BIOFAC(1,1)
3-5	***Sr-90+D*** , crustacea and mollusks	**1.000E+02**	**1.000E+02**	BIOFAC(1,2)

Site-Specific Parameter Summary

Me	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	:
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	3.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.960E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Sr-90	5.000E+00	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R0	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R0	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(
R016	Unsaturated zone 1 (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCU(
R016	Saturated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCS(
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHA
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHA
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHA
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHA
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(
R017	Ring 2	not used	2.732E-01	---	FRACA(
R017	Ring 3	not used	0.000E+00	---	FRACA(
R017	Ring 4	not used	0.000E+00	---	FRACA(
R017	Ring 5	not used	0.000E+00	---	FRACA(
R017	Ring 6	not used	0.000E+00	---	FRACA(
R017	Ring 7	not used	0.000E+00	---	FRACA(
R017	Ring 8	not used	0.000E+00	---	FRACA(
R017	Ring 9	not used	0.000E+00	---	FRACA(
R017	Ring 10	not used	0.000E+00	---	FRACA(
R017	Ring 11	not used	0.000E+00	---	FRACA(
R017	Ring 12	not used	0.000E+00		FRACA(

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	1.000E-01	-1	---	FPLANT
R01B	Contamination fraction of meat	1.000E-01	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R'	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

Site-Specific Parameter Summary (continued)

	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFGS
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR-T(2
STOR	Milk	1.000E+00	1.000E+00	---	STOR-T(3
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR-T(4
STOR	Fish	7.000E+00	7.000E+00	---	STOR-T(5
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR-T(6
STOR	Well water	1.000E+00	1.000E+00	---	STOR-T(7
STOR	Surface water	1.000E+00	1.000E+00	---	STOR-T 8
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR-T 9
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover mater al	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R0	Diffusion coefficient for radon gas (m/sec)				
R0	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions			Initial soil Concentrations, pCi/g	
Area:	10000.00	square meters	Sr-90	5.000E+00
kness:	2.00	meters		
Co. Depth:	0.00	meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture *Sum* M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
TDOSE(t):	4.820E+00	4.681E+00	4.415E+00	3.595E+00	2.000E+00	2.592E-02	3.2453-03	2.9623-11
M(t):	1.928E-01	1.872E-01	1.766E-01	1.438E-01	8.001E-02	1.0373-03	1.298E-04	1.185E-12

Maximum TDOSE(t): 4.820E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	so mrem/yr
Sr-90	6.832E-02	0.0142	4.131E-04	0.0001	0.000E+00	0.0000	3.936E+00	0.8166	7.948E-01	0.1649	0.000E+00	0.0000	2.064E-0
Total	6.832E-02	0.0142	4.131E-04	0.0001	0.000E+00	0.0000	3.936E+00	0.8166	7.948E-01	0.1649	0.000E+00	0.0000	2.064E-0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.820E+C
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.820E+C

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		S
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/y
Sr-90	6.635E-02	0.0142	4.011E-04	0.0001	0.000E+00	0.0000	3.822E+00	0.8166	7.719E-01	0.1649	0.000E+00	0.0000	2.004E-
Total	6.635E-02	0.0142	4.011E-04	0.0001	0.000E+00	0.0000	3.822E+00	0.8166	7.719E-01	0.1649	0.000E+00	0.0000	2.004E-

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All E
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/y
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.681E+
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.681E+

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		So
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	6.257E-02	0.0142	3.783E-04	0.0001	0.000E+00	0.0000	3.605E+00	0.8166	7.280E-01	0.1649	0.000E+00	0.0000	1.890E-0
Total	6.257E-02	0.0142	3.783E-04	0.0001	0.000E+00	0.0000	3.605E+00	0.8166	7.2803-01	0.1649	0.000E+00	0.0000	1.890E-0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pa
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.415E+C
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.415E+C

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		S
tuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract,	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/y
Sr-90	5.0963-02	0.0142	3.081E-04	0.0001	0.000E+00	0.0000	2.936E+00	0.8166	5.929E-01	0.1649	0.000E+00	0.0000	1.539E-
Total	5.096E-02	0.0142	3.081E-04	0.0001	0.000E+00	0.0000	2.936E+00	0.8166	5.929E-01	0.1649	0.000E+00	0.0000	1.539E-

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All P
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/y
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.595E+
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.595E+

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Iuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	so mrem/yr
;r-90	2.8353-02	0.0142	1.714E-04	0.0001	0.000E+00	0.0000	1.633E+00	0.8166	3.298E-01	0.1649	0.000E+00	0.0000	8.564E-0
'otal	2.835E-02	0.0142	1.7143-04	0.0001	0.000E+00	0.0000	1.633E+00	0.8166	3.298E-01	0.1649	0.000E+00	0.0000	8.564E-0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-Iuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
3r-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.000E+0
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.000E+0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	S mrem/y
Sr-90	2.1823-04	0.0084	1.3193-06	0.0001	0.000E+00	0.0000	1.2573-02	0.4849	2.5393-03	0.0979	0.000E+00	0.0000	6.591E-
Total	2.1823-04	0.0084	1.3193-06	0.0001	0.000E+00	0.0000	1.257E-02	0.4849	2.5393-03	0.0979	0.000E+00	0.0000	6.591E-

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.960E+02 years

Water Dependent Pathways

Radio-nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All P mrem/y
Sr-90	1.019E-02	0.3929	0.000E+00	0.0000	0.000E+00	0.0000	1.688E-04	0.0065	1.7503-04	0.0067	0.000E+00	0.0000	2.592E-
Total	1.019E-02	0.3929	0.000E+00	0.0000	0.000E+00	0.0000	1.6883-04	0.0065	1.7503-04	0.0067	0.000E+00	0.0000	2.592E-

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	So mrem/yr
Sr-90	1.0343-05	0.0032	6.2533-08	0.0000	0.000E+00	0.0000	5.9583-04	0.1836	1.2033-04	0.0371	0.000E+00	0.0000	3.124E-0
Total	1.034E-05	0.0032	6.2533-08	0.0000	0.000E+00	0.0000	5.9583-04	0.1836	1.2033-04	0.0371	0.000E+00	0.0000	3.124E-0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pa mrem/yr
Sr-90	2.434E-03	0.7498	0.000E+00	0.0000	0.000E+00	0.0000	4.034E-05	0.0124	4.1923-05	0.0129	0.000E+00	0.0000	3.245E-0
Total	2.4343-03	0.7498	0.000E+00	0.0000	0.000E+00	0.0000	4.034E-05	0.0124	4.192E-05	0.0129	0.000E+00	0.0000	3.2453-0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	S mrem/y
Sr-90	1.263E-14	0.0004	7.6353-17	0.0000	0.000E+00	0.0000	7.275E-13	0.0246	1.4693-13	0.0050	0.000E+00	0.0000	3.814E-
Total	1.263E-14	0.0004	7.6353-17	0.0000	0.000E+00	0.0000	7.2753-13	0.0246	1.469E-13	0.0050	0.000E+00	0.0000	3.814E-

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All E mrem/y
Sr-90	2.7793-11	0.9382	0.000E+00	0.0000	0.000E+00	0.0000	4.608E-13	0.0156	4.794E-13	0.0162	0.000E+00	0.0000	2.962E-
Total	2.7793-11	0.9382	0.000E+00	0.0000	0.000E+00	0.0000	4.6083-13	0.0156	4.794E-13	0.0162	0.000E+00	0.0000	2.962E-

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Pr (.	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	9.641E-01	9.3623-01	8.829E-01	7.191E-01	4.001E-01	5.185E-03	6.4913-04	5.9243-12

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j
The DSR includes contributions from associated {half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	2.593E+01	2.670E+01	2.832E+01	3.477E+01	6.249E+01	4.822E+03	3.852E+04	4.220E+12

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Sr-90	5.000E+00	0.000E+00	9.641E-01	2.593E+01	9.641E-01	2.593E+01

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)		DOSE(j,t), mrem/yr							
			t=	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00		4.820E+00	4.681E+00	4.415E+00	3.595E+00	2.000E+00	2.592E-02	3.245E-03	2.962E-11

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)		S(j,t), pCi/g							
			t=	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.960E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00		5.000E+00	4.856E+00	4.579E+00	3.729E+00	2.075E+00	1.5973-02	7.568E-04	9.241E-13

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 1.66 seconds

ATTACHMENT C

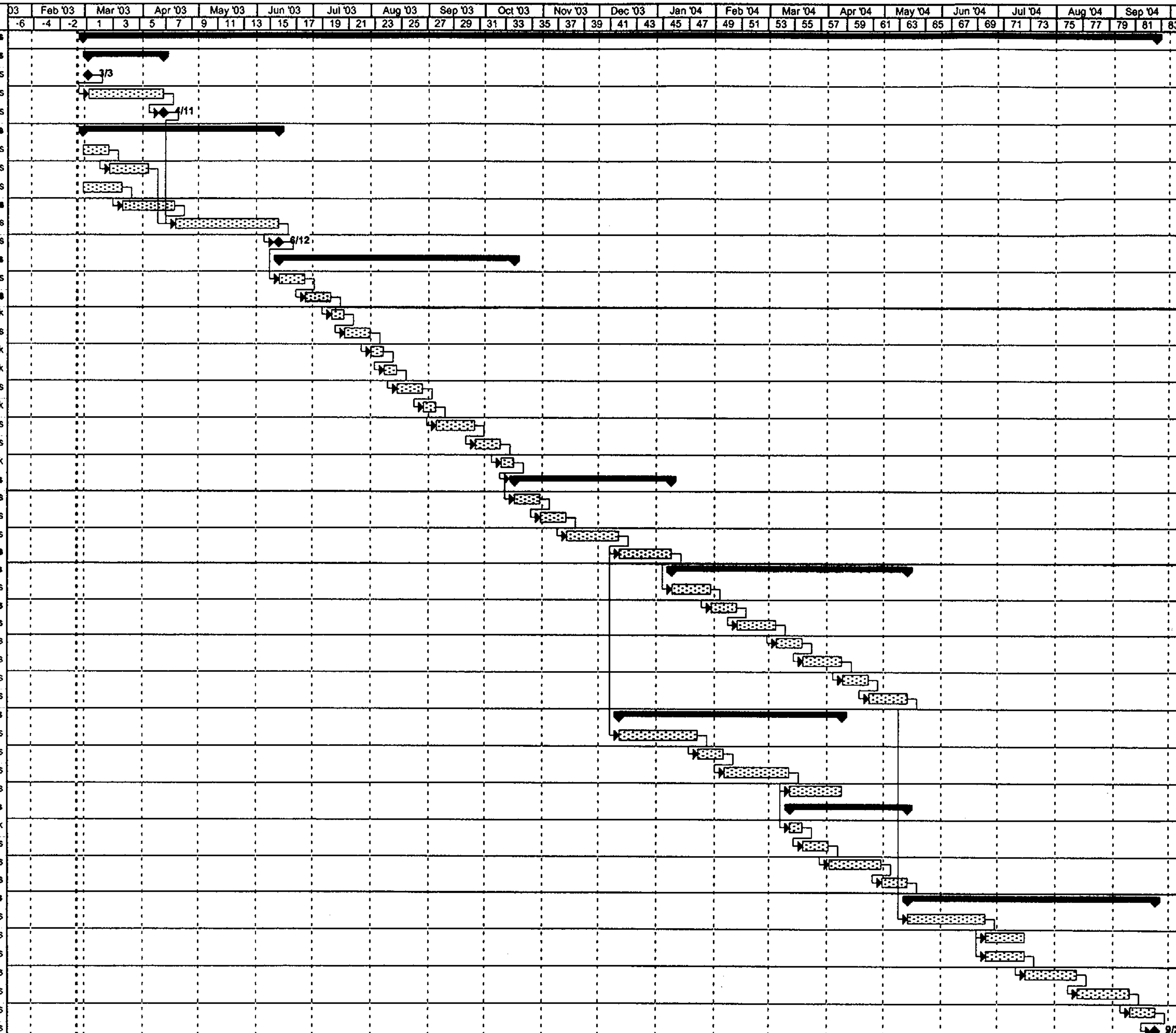
Decommissioning Schedule

Quehanna Decommissioning Project
License Termination Plan

Decommissioning Production Schedule

SCIENTECH Document No. **82A9089**
Attachment C

ID	Task Name	Duration
1	**Quehanna License Termination Plan**	**82 wks**
2	**Project Engineering**	**6 wks**
3	Submit Revised Decommissioning Plan	0 wks
4	NRC Review & Comment Period	6 wks
5	NRC D-Plan Approval	0 wks
6	**Cell 4 Preparations**	**15 wks**
7	Remote Tooling Final Acceptance Testing	2 wks
8	Final Houdini Operator Training	3 wks
9	Final Testing of Cell 4 Containment System	3 wks
10	Final Robitic Preparations	4 wks
11	Final Engineering Preps & Plans	8 wks
12	RSC Approval to Proceed w/Cell 4	0 wks
13	**Hot Cell 4 Remediation**	**18 wks**
14	Personnel Entry - Cell 4 Preps	2 wks
15	Houdini Deployment	2 wks
16	Remove Center Cell Wall	1 wk
17	Remove Back Wall & Process Piping	2 wks
18	Remove Surge Tanks	1 wk
19	Interim Cell Decontamination	1 wk
20	Dismantle Remainder of Process Box	2 wks
21	Demobilize Houdini	1 wk
22	Complete Process Box Dismantling (Manual)	3 wks
23	Remove Containment Structure	2 wks
24	Decontaminate & Secure Area	1 wk
25	**Irradiator Removal Support**	**12 wks**
26	Smear & Clear PPI Equipment	2 wks
27	Support Irradiator Removal	2 wks
28	Support Co-60 Source Removal	4 wks
29	Survey and Release PPI Admin Areas	4 wks
30	**Hot Cell Demolition**	**18 wks**
31	Demolition Prep & Setup	3 wks
32	Remove Isolation Rooms	2 wks
33	Remove Hot Cell Structure	3 wks
34	Remove Hot Cell Support Slab	2 wks
35	BlastTrak Service Area Slab	3 wks
36	Perform Soil Sampling	2 wks
37	Survey Remaining Structure	3 wks
38	**Reactor Bay Remediation**	**17 wks**
39	Survey Remaining Building Equipment	6 wks
40	Drain and Sample Reactor Pool	2 wks
41	Survey & Remediate Reactor Pool	5 wks
42	Survey & Release Reactor Bay Slab	4 wks
43	**Subsurface Sampling**	**9 wks**
44	Perform Exterior Subsurface Sampling	1 wk
45	Perform Interior Surface Sampling	2 wks
46	Sampling Analysis	4 wks
47	Analyze Sampling Results & Report	2 wks
48	**Facility Release**	**19 wks**
49	Perform Final Status Survey	6 wks
50	Demobilize Project	3 wks
51	Prepare FSSR	3 wks
52	Submit Final Status Survey Report to NRC	4 wks
53	NRC Renew & Comment	4 wks
54	NRC Verification	2 wks
55	NRC License Termination	0 wks



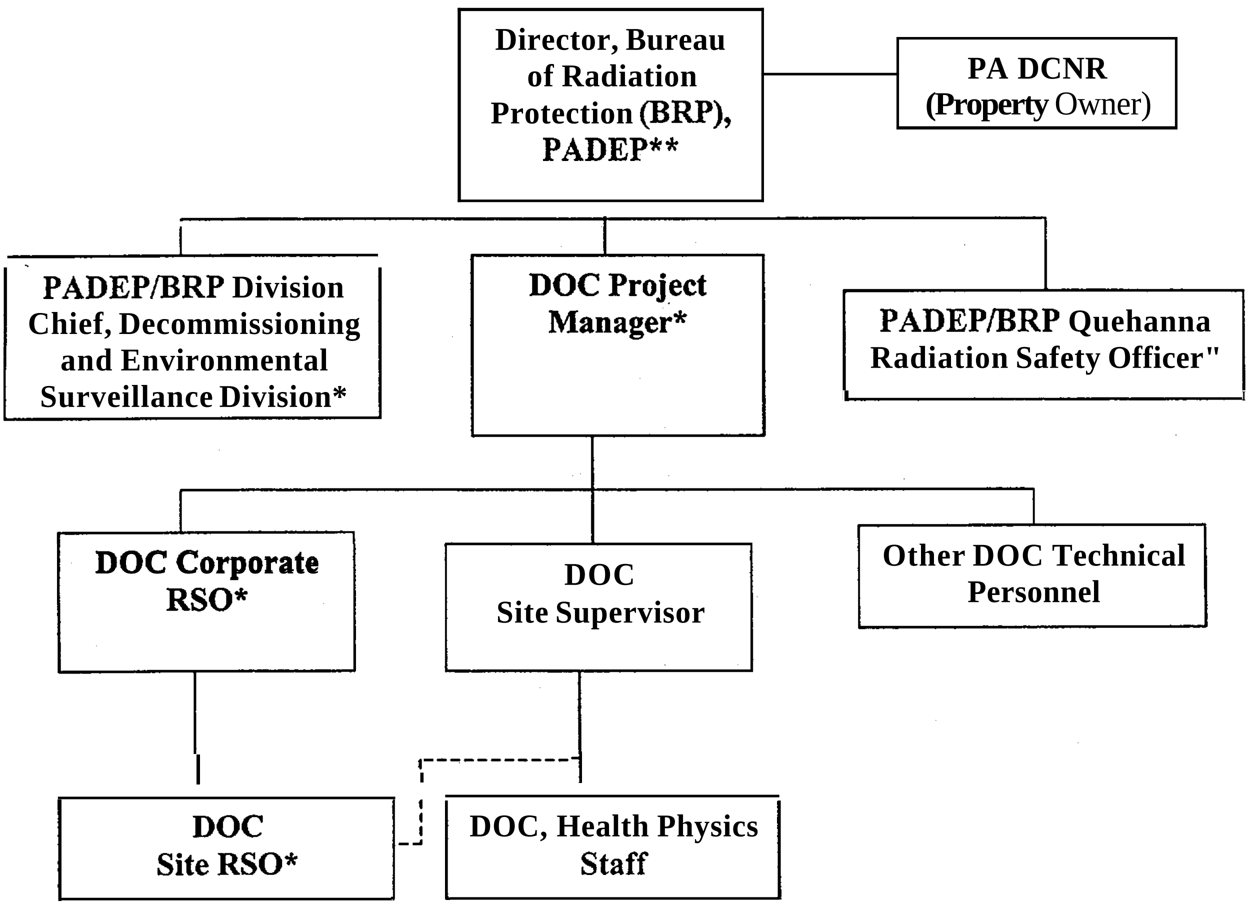
Task	Milestone	Rolled Up Split	External Tasks	Deadline
Split	Summary	Rolled Up Milestone	Project Summary	
Progress	Rolled Up Task	Rolled Up Progress	External Milestone	

Project: 82A9089, Rev.2 Attachment D
Date: Tue 2/25/03

ATTACHMENT D

Project Organizational Chart

QUEHANNA DECOMMISSIONING PROJECT ORGANIZATIONAL CHART



* - Radiation Safety Committee
** - Radiation Safety Committee Chairperson