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Mr. Jim Kottan
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U.S. Nuclear Regulatory Commission
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King of Prussia, PA 19406

37-17860-02
03029288

Subject: **Final Status Survey Plan**

Dear Mr. Kottan:

On behalf of the Commonwealth of Pennsylvania, Energy*Solutions*, LLC is pleased to submit the "Final Status Survey Plan for the Quehanna, Pennsylvania Site," Rev. 1, Document No. 82A9604. Enclosed you will find three (3) controlled copies of the report.

Please complete and return the top copy of the enclosed Energy*Solutions* Document Transmittal Form to indicate receipt of your controlled copies.

Please feel free to contact me at 864-235-3694, if you have any questions or Bryan Werner from the Commonwealth at 717-787-2781.

Sincerely,

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FINAL STATUS SURVEY PLAN FOR THE QUEHANNA, PENNSYLVANIA SITE

Prepared for:
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October 2006

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REVISION LOG

Revision Number	Affected Pages	CRA Number	Approval
1	1, 2, 19, 26	11817	K. Taylor

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
Commonwealth	Commonwealth of Pennsylvania
CRA	Change Request Authorization
DCGL	derived concentration guideline limits
DCNR	Department of Conservation and Natural Resources (Pennsylvania)
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
GM	Geiger-Müller
HP	Health Physicist
IL	Investigation Level
LBGR	Lower Bound of the Gray Region
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrad/hr	millirad per hour
mrem/hr	millirem per hour
mrem/yr	millirem per year
NRC	U.S. Nuclear Regulatory Commission
PADEP	Pennsylvania Department of Environmental Protection
pCi/g	picocuries per gram
Penn State	Pennsylvania State University
PermaGrain	PermaGrain Products, Inc.
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
WRS	Wilcoxon Rank Sum
WWTB	Waste Water Treatment Building

BRIEF DESCRIPTION OF FACILITY AREAS

- Basement – the area below where the hot cells stood. The Fan Room and Pipe Chase constitute the basement.
- Beam Room – the lowest section of the Reactor Bay on the west side of the reactor pool. This area allowed access to the reactor beam ports.
- Chemistry Lab – a small room that once housed a radio analytical chemistry laboratory adjacent to the Service Area.
- Decontamination Room – a small room adjacent to the Service Area and next to the Chemistry Lab.
- Dungeon – room in the lowest level of the facility north of the Beam Room and accessible from Beam Room and the Loading Zone.
- Electrical Room – Room adjacent to and accessible from the eastern side of the north wall of the Finishing Area.
- Electrician's Office- a small room between the Electrical Room and the Finishing Area.
- Fan Room – the south half of the basement level below the hot cells.
- Finishing Area – self explanatory.
- Finishing Area Bunker – small room in the north, central section of the Finishing Area.
- Finishing Area Office – office area in the north central section of the Finishing Area.
- Finishing Area Tool Crib – small room in the north, central section of the Finishing Area adjacent to the Boiler Room.
- Gamma (Storage) Pool – small, deep, pit in the Service Area near the Reactor Bay entrance.
- Hydro-Blast Area – small area between Reactor Bay and Finishing Area used by PPI to water blast the irradiator casings.
- Loading Zone – the paved area between the pond and the main facility on the west side of the main facility (Reactor Bay, Dungeon).
- MMA Tank Area – the area containing large stationary tanks used for storing MMA, which was used in the wood treatment process (non-radiological). This area is adjacent to the Loading Zone.
- Office Mezzanine (HVAC Room) – area located above the Administration Area overlooking the Service Area.
- Old Loading Dock – from old photographs and drawings, a loading dock appeared to be located near the entrance to the Reactor Bay adjacent to the Boiler Room. The soil in this area was evaluated (sampled) to ensure that it was not affected by radiological operations and then covered with new structures and foundations.
- Pipe Chase - the north half of the basement level below the hot cells.
- Pump Room – small room in the lowest level of the facility south of the Beam Room. Only accessible through an outside door that leads to the Loading Zone.
- Reactor Bay (RB) – Includes the building that houses the reactor pool and surrounding area, and the Beam Room.
- Reactor Pool – self explanatory
- Sawdust Shed – stand-alone metal building west of Finishing Area used to store sawdust (structure has collapsed).
- Service Area – self explanatory.
- Source Storage Shafts – 12-14 feet long tubes that are buried vertically in the west end of the Service Area with one end that penetrates at about grade level. These shafts may have been used to store irradiator sources and have shielded end caps.
- Storage Building – metal, garage-type structure located in the Loading Zone near the pond.
- Tank 411 – buried water storage tank south of Reactor Bay. This tank was part of reactor pool water handling and treatment system.

- Vestibule – the garage-style, metal building that covers the east (main) opening into the Service Area.
- Waste Water Treatment Building – small structure west of the Finishing Area, which now houses a non-operational wood burner.

1.0 INTRODUCTION

This Final Status Survey Plan (FSSP) describes the final status survey (FSS) and sample effort in support of 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 September 29, 2003, includes Revision 3 of facility Decommissioning Plan (Energy*Solutions* 2003). The current license will expire March 31, 2008. Revision 4 to the Decommissioning Plan (Energy*Solutions* 2006) has been submitted for NRC approval and contains information pertinent to license termination that is not repeated in this FSSP.

1.1 SITE DESCRIPTION

The Quehanna facility is located at 115 Reactor 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 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 Waste Water Treatment Building 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 as radioactive waste. The facility also includes other laboratories, production and storage areas, and offices formerly used by PermaGrain. On-site radioactive material consisted of fixed and removable strontium-90 contamination and discrete cobalt-60 sources. The layout of the original facility is provided in Figures 1-1 and 1-2.

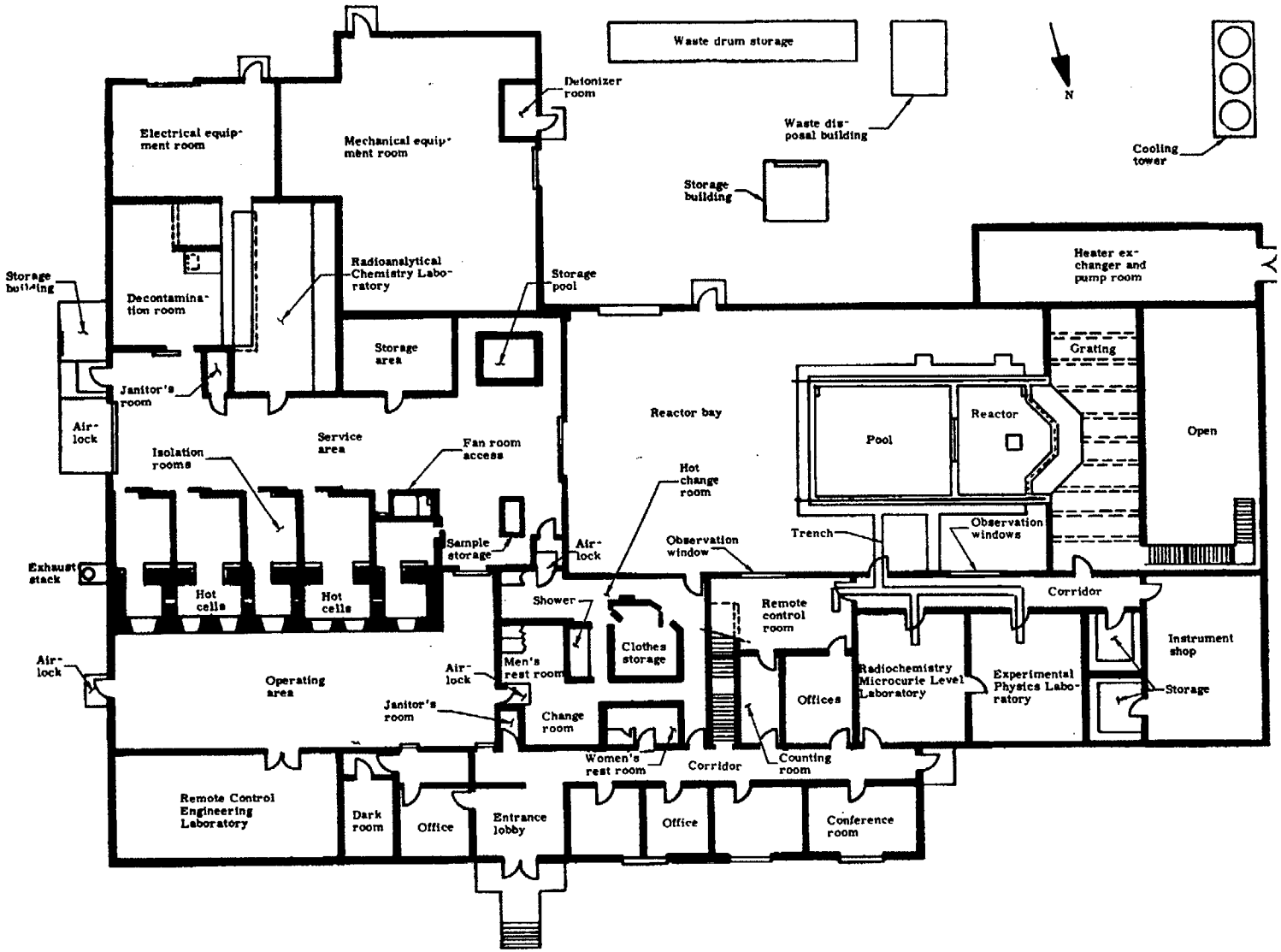
1.2 SUMMARY OF LICENSED ACTIVITIES

The 50,000-acre Quehanna Wild Area was originally state forest land 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 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.

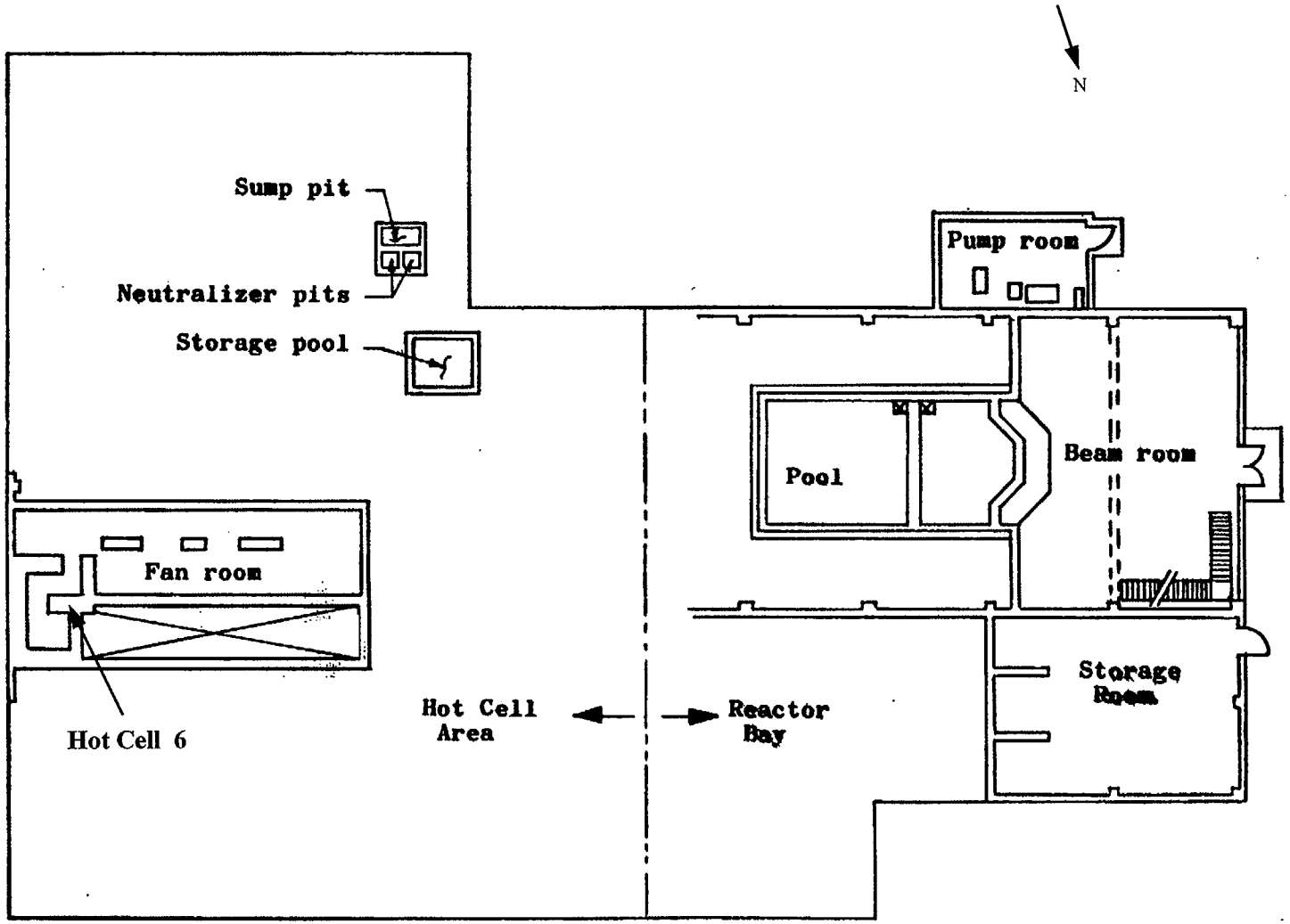
Martin Marietta terminated its lease with Penn State in 1967 and vacated the facility after partially decontaminating portions of the facility and Penn State released its interest in the Quehanna facility back to the Commonwealth of Pennsylvania (Commonwealth). The Commonwealth then leased the facility 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: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process Martin Marietta, May 1966

FIGURE 1-1
ORIGINAL MAIN FLOOR PLAN
QUEHANNA FACILITY



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

FIGURE 1-2
ORIGINAL BASEMENT LEVEL FLOOR PLAN
QUEHANNA FACILITY

1.3 SUMMARY OF DECOMMISSIONING OPERATIONS

Energy*Solutions* (formerly D&D Division of Scientech, LLC) mobilized to the Quehanna site in May 1998 and began extensive decontamination and dismantling activities to reduce contamination levels to free-release limits. The following information summarizes the primary D&D activities.

- The Waste Water Treatment Building (WWTB) was decontaminated and included the excavation of contaminated tanks, pipes, and soil to about 9 feet (3 meters) in depth.

- Using upgraded manipulator arms, about 2,000 curies of cobalt-60 from the hot cells was collected, packaged and was shipped for disposal.

- In the reactor pool, the cobalt-60 sources, irradiator handling equipment, water and sludge was removed. The cobalt-60 sources were removed by a U.S. Environmental Protection Agency (EPA) contractor under an emergency action contract.

- In the Service Area, most of the dividing walls, much of the floor, and all equipment, including the gantry crane, were removed. In addition, contaminated drain lines below the Service Area floor were excavated along with a limited amount of soil that was affected by line leakage.

- Using robotic dismantlement techniques, the Hot Cell 4 Process System, which contained the bulk of the strontium-90 radioactivity, was removed and packaged for disposal.

- The hot cell complex was removed entirely exposing the basement below (Pipe Chase and Fan Room). The only remaining remnants of the hot cells are two walls and the floor of hot cell six, which was located in the basement. The concrete floor in the basement was subjected to heavy decontamination to meet the release criteria. Some sections of the floor or walls were removed because further decontamination was not practical.

- Interior walls of the Administration Area and PPI support areas were removed and the areas were surveyed and decontaminated to levels below the release criteria. All woodworking equipment sold as part of the PPI bankruptcy was surveyed prior to release. Utilities, fixtures, piping, insulation and building systems were decontaminated as necessary to meet the release criteria.

- In December of 2004, the remediation and FSS of the Quehanna hot cell facility was deemed complete. During the verification survey performed in early May of 2005, however, evidence of recontamination above the NRC's Regulatory Guide 1.86 (AEC 1974, NRC 1987) criteria was found to be present.

1.4 RECONTAMINATION EVENTS

The previously unidentified contamination found in 2005 was found to be present in two distinct forms: (1) over one-hundred microscopic hot particles that appeared to have migrated randomly through the structure, and (2), wide-spread low-level spots of fixed contamination which appeared to have leached out of the surface of certain concrete floor areas.

The recontamination event affected the entire interior footprint of the structure with the heaviest concentration of contamination found on the floors of the former Decontamination Room and Radioanalytical Laboratory areas. Both of these rooms are part of the Service Area. To a much lesser degree, additional widespread contamination was found throughout the Administration Area, Service Area, Reactor Bay, and, Finishing Area. Most of the recontaminated areas ranged from just barely over the release criteria to several areas at the 50,000 to 150,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) level.

One isolated area measured 7.5 mRad/hr. This was a relatively isolated area in the floor of the Decontamination Room shower stall. Approximately one-half of a millicure was identified in the concrete joints that formed the edges of the shower pan in the Decontamination Room. The radioactive strontium particles apparently migrated closer to the joint surfaces after decontamination and survey activities had ceased. This area was subsequently remediated.

After remediation of the Decontamination Room shower stall, the Administration Area, Reactor Bay, Finishing Area, and Boiler Room floor were completely surveyed twice. Several dozen small spots (less than 100 cm^2) of activity just above the release criteria were identified during the survey work and were removed utilizing light decontamination techniques. Overhead and walls in all areas were subjected to broad scoping surveys that identified very little contamination above the release criteria in the Service Area. These surfaces were decontaminated as the survey was performed.

1.4.1 Source of Recontamination

The source of the recontamination appears to be multifaceted. Despite attempts to sample and monitor for leaching, some near-surface radioactivity did migrate to surfaces where it was later detected. The migration of strontium-90 in concrete has been studied and is a known phenomenon. The concrete core samples that were previously taken either were free of subsurface contamination or contained subsurface contamination that, when diluted over the entire sample, was present in insufficient quantities to detect.

The other predominant source of activity during the recontamination event was a string of highly mobile, high-activity particles. Although over 100 particles were identified and easily remediated, the source of the particles remains unclear. It is theorized that a particle emission "event" could have occurred as the facility and environs experienced a freeze-thaw cycle at the end of winter.

1.4.2 Revised Approach to Site Closure

Although the levels identified in the spring of 2005 could be detected, they did not present a public health concern. Based on this fact, the PADEP has reconsidered its approach to final site closure. Under Title 10 of the Code of Federal Regulations, Part 20, Subpart E, the unrestricted release of a site is to be completed in such a way that the average member of the critical exposure group, which would be exposed to residual radioactivity remaining at the site, receive no more than 25 millirem per year after the site has been closed and the license terminated. In addition, this dose should be as low as reasonably achievable.

PADEP now intends to depart from the NRC's Regulatory Guide 1.86-based approach and adopt the contemporary framework for site closure under 10 CFR 20 (10 CFR 20), Subpart E. Having not been maintained for years, the above-grade structures at the site are decrepit and are believed to be in danger of collapsing. As such, the PADEP intends to remove the above grade structures in a timely manner. Debris from the above-grade structures, if found suitable for release, will be placed in a suitable construction landfill. PADEP will fill the subgrade voids primarily using at-grade concrete.

Revision 4 of the Decommissioning Plan (Energy*Solutions* 2006), encompasses the dose-based approach to Quehanna Site closure. Dose assessments are conducted in the Decommissioning Plan, to provide for derived concentration guideline levels (DCGL) for debris that will be placed in a landfill, concrete that will be remain at the site, and affected soil that will remain at the site.

2.0 FINAL STATUS SURVEY PROCESS

2.1 RELEASE CRITERIA

Revision 4 of the Decommissioning Plan (Energy*Solutions* 2006) provides the general approach proposed for final site closure at Quehanna and the basis for the site release criteria, these include site-specific DCGLs and NRC established release criteria. Table 2-1 summarizes the criteria that will be used. The first release criteria for total and removable surface contamination will be used to release non-concrete demolition debris that will be disposed of at an off-site landfill. The second criterion will be used for the on-site disposal of concrete, and the third criteria will be used for on-site soils.

TABLE 2-1
RELEASE CRTITERIA

	Media	Release Criteria	Notes
1	Non-concrete building materials	250,000 dpm/100cm^2 total surface contamination[a]	Removable contamination will be controlled to Reg. Guide 1.86 levels – 200 dpm/100cm^2
2	Concrete/Cinder Blocks	30,000 pCi/g[a]	Concrete includes any remaining cinder blocks that will be used as fill
3	Site Soils	5 pCi/g[b]	Maximum allowable level 15 pCi/g will NOT be applied in this FSS.

Notes:
[a] DCGL based on site-specific dose model presented in the Decommissioning Plan.
[b] "Current Guidelines on Acceptable Levels of Contamination in Soil and Groundwater in Property to be Released for Unrestricted Use" (NRC 1992).

2.2 DATA QUALITY OBJECTIVES

The following data quality objectives (DQO) are quantitative and qualitative statements derived from the output of the DQO process. More information on DQOs is provided in Energy*Solutions* Document No. 82A9149 "Quehanna Decommissioning Project Quality Assurance Project Plan (QAPP)."

- The objective of the FSS is to prove that the residual radioactivity levels in the survey units within the facility are at or below the release criteria.
- The background reference area will be located in an area that has similar construction materials to those located in the facility e.g. the northeast section of the Finishing Area.
- The null hypothesis (H_o) will be: the residual radioactivity in the survey unit exceeds the release criteria.
- A decision error occurs when the decision maker rejects the null hypothesis when it is true, or accepts the null hypothesis when it is false, these two types of decision errors are classified as Type I and Type II decision errors respectively.

- The Type I and Type II decision error probabilities will both be 5%. Type II may be adjusted by the Energy*Solutions* Project HP since this type of error leads to the labeling of a survey unit as being contaminated when it is not.
- The upper bound of the gray region is defined as the release criteria and the lower bound of the gray region (LBGR) is defined initially as the mean concentration of the survey unit. The LBGR may be adjusted for an acceptable relative shift as described in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000).
- For the non-concrete building materials and Reference Areas, all fixed-point measurement locations will be determined for the survey units using a random selection method.
- For Class 1 and 2 soil areas, all sampling locations will be established on a random start triangular grid. Locations for Reference Area soil samples will be determined using a random selection method.
- For concrete and soil samples, instrument MDCs will be less than 50% of the respective activity/mass release criteria.
- For fixed-point measurements, instrument MDCs will be less than 10% of the total surface activity release criteria.
- For smear measurements, instrument MDCs will be less than 100% of the removable activity release criteria.
- Scanning MDCs (ScanMDC) will be ≤10% of the total surface activity (fixed plus removable) release criteria.
- Detectors with areas less than 100 cm^2 should only be used in areas too small for the larger area detectors.
- Quality control (QC) measurements will be made to evaluate instrument and operator precision (methods described in Section 3.2.3)
- Survey measurements will be documented and controlled as described in Section 3 of this document.
- The investigation level (IL) will be 25,000 dpm/100 cm^2 for fixed-point measurements and for scanning measurements.
- A response check form or instrument control log will be used to keep track of background counts and response checks.

The DQOs may be adjusted during the course of the project if found to be necessary using the Energy*Solutions* change request authorization (CRA) process.

2.3 RELEASE OF BUILDING STRUCTURES (EXCEPT CONCRETE)

All non-concrete building materials will be released according to the criteria in Table 2-1. To release these materials, pre-demolitions surveys will be conducted according to the protocols established in MARSSIM (NRC 2000). MARSSIM suggests that if the difference between maximum survey unit measurement and minimum reference area measurement is less than DCGLw, then the survey unit meets the release criterion. The WRS test and elevated measurement comparison test is to be applied when the difference

between any survey unit and any reference measurement is greater than DCGLw and the difference of survey unit average and reference area average is less than the DCGLw.

Contamination surveys conducted as part of the original FSS conducted in 2005 indicated that all residual radioactivity levels (fixed plus removable) were less than 1,000 dpm/100cm^2. After the recontamination event, a few horizontal structures exceeded this value; however, they were far below the current release criteria. In addition, all identified areas that were greater than 1,000 dpm/100cm^2 were decontaminated. Extensive surveys have not shown any removable contamination greater than the NRC's Regulatory Guide 1.86 criteria for strontium-90, which is 200 dpm/100cm^2.

2.3.1 Number of Survey Points

For building surfaces, Energy*Solutions* intends to use the Wilcoxon Rank Sum (WRS) test to test the null hypothesis described in Section 2.2. Sections 11.2 and 11.3 of MARSSIM describe the process for determining the number of survey measurements necessary to ensure a data set sufficient for statistical analysis. The method for determining the combined number of data points (N) for the survey unit and reference area is based on the expected contaminant variability and the predetermined acceptable Type I and Type II error rates. The equation for calculating N is as follows:

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{3\left(P_r - 0.5\right)^2}$$

The project DQOs provided in Section 2.2 established the Type I and Type II error rates (α and β respectively) at 0.05. For α and β = 0.05, the Z-statistics $Z_{(1-\alpha)}$ and $Z_{(1-\beta)}$ are both equal to 1.645 (Table 5.2 in MARSSIM).

The other variable in the equation above, P_r, is based on a factor called the "relative shift" and is obtained from a Table 5.1 in MARSSIM. The "relative shift" (Δ/σ) is the ratio involving the concentration to be measured relative to the expected variability in that concentration sigma (σ), and can be thought of as an expression of the resolution of the measurements. The sigma (σ) is selected from the larger of that found in the survey unit or the reference area. The shift (Δ) is the width of the statistical gray region or difference in the release criterion (250,000 dpm/100cm^2 for strontium-90) and the lower bound of the gray region (LBGR). The gray region is the area where the impact of making an incorrect error decision (Type I or Type II error) is small.

Because the release criterion for surface contamination is much higher than the expected concentrations (250,000 compared to 1,000) and the expected standard deviation is < 1,000, the "relative shift" (Δ/σ) is very large (>100). In MARSSIM Table 5.1, the largest value for Δ/σ is 4.0 and since the expected (Δ/σ) is >100, the number of sample points is minimized by using a value of 1 for P_r.

Therefore,

$$N = \frac{(1.645 + 1.645)^2}{3(1 - 0.5)^2} = 14.4$$

To determine the actual number of data points needed in each survey unit and reference area, N is increased by 20% to allow for extra measurements. The extra measurements are necessary to ensure adequate statistical power for the survey in the event the assumed conditions differ than the actual, as found conditions. The resulting number is 18. This is the combined total number of data points needed in the reference area and in each interior survey unit. Therefore, each interior survey unit and the reference area were required to have a minimum of 9 survey points. This is the same value obtained if using MARSSIM Table 5.3, *Values of N/2 for a Given Relative Shift (Δ/σ), α and β When the Contaminant is Present in Background.*

2.3.2 Survey Units

A survey unit is a physical area consisting of structures or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release limits. As a result, the survey unit is the primary entity for demonstrating compliance with the release limits.

For this FSS, the release criterion for surface contamination, 250,000 dpm/100cm^2, is very high compared to the expected strontium-90 concentrations (< 1,000 dpm/100cm^2). As such, the non-concrete building materials will be surveyed as Class 3 survey units. MARSSIM defines a Class 3 area as: "Any impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity as a small fraction of the DCGL, based on operating history and previous radiological surveys."

MARSSIM allows for Class 3 survey units to be unlimited in size. However, Energy*Solutions* has divided the facility into multiple survey units based on the type of building material and the location of the material. The survey units are specifically identified in Table 2-2. If any areas demonstrate removable radioactivity greater than the removable criteria, these areas will be decontaminated or controlled (e.g., fixed) to prevent the spread of radioactivity.

TABLE 2-2
CLASS 3 NON-CONCRETE BUILDING STRUCTURES

Class 3 Building Structures	Survey Units
Administration Area	North and East wall
	South and West wall
	Ceiling – East half
	Ceiling – West half
Reactor Bay	North wall
	South wall
	West wall
	Ceiling
Beam Room	Walls and fixed equipment
Finishing Area	North wall
	Associated rooms (Electrical Room, Electrician's Office, Finishing Area Bunker, Office, Tool Crib)
	South wall
	East wall and east half of ceiling
	West wall and west half of ceiling
Service Area	West wall
	North wall
	South wall
	East wall and vestibule
	Chem Lab and Decon Room walls and ceiling
	Ceiling – East half
	Ceiling – West half
Office Mezzanine	Floor, walls, ceiling
Area Between Reactor Bay and Finishing Area	Mechanical room and fixed equipment, HydroBlast Area, associated hallway
Storage Shed	Walls and ceilings
Tank 411 (decay tank)	All surfaces
Waste Water Treatment Building (WWTB)	Wall and Ceilings and fixed equipment, also includes Sawdust shed remains

2.3.3 Daily Background Measurements and Reference Area Measurements

Daily background measurements are taken to ensure proper instrument operation while average values from reference areas are used in calculating net radioactivity values in the survey units. The net radioactivity values are immediately compared with the release criterion for strontium-90 to determine if an IL or criteria are exceeded.

The reference area measurements are only taken once (not daily). Nine reference area measurements will be collected for each type of material included in the FSS if "background" values or intrinsic radioactivity values differ. This would include separate reference area sets for sheet metal, roofing materials, etc. Reference area measurements can be used for multiple survey units as long as the material being surveyed in the survey unit is similar to that of the reference area.

2.3.4 Contamination Surveys

The FSS requires that nine fixed-point measurements be taken in each survey unit at predetermined locations based on randomly generated coordinate numbers per MARSSIM paragraph 5.5.2.5.

The fixed-point measurement DQO requires that the MDC be less than 10% of the release criteria, or 25,000 dpm/100cm^2. A one-minute count time for all standard beta-gamma survey instruments will be sufficient to meet this DQO.

At each fixed-point survey measurement location, one 100 cm^2 smear sample will be collected to assess the level of removable contamination. The smear sample results will be manually recorded on a survey sheet.

MARSSIM recommends that Class 3 survey units receive judgmental scans. These are scans in areas identified by the health physics technicians or Project Health Physicists that may have a higher likelihood of containing residual radioactivity. For the FSS, Energy*Solutions* will scan a minimum of 5% of the surface area of a survey unit in addition to judgmental scans. These scans will surround each direct measurement survey point. The size of the area scanned around each point will be equal to:

$$ScanArea = \frac{SU_Total_Area * 0.05}{N/2}$$

2.3.5 Instruments

The FSS for structures will consist of scans, fixed-point measurements (total surface contamination measurements), and smears (removable contamination measurements). The instruments proposed for use during the FSS and their applications are provided in Table 2-3. If necessary, Energy*Solutions* may substitute comparable instruments should those provided in Table 2-3 not be available.

All Instruments will be calibrated using NIST-traceable standards according to Energy*Solutions* Document No. 82A8008. Instruments will be response checked daily to ensure they are operating properly.

Instrument records, including dates of use, efficiencies, probe areas, calibration due dates and source traceability will be maintained in accordance with Energy*Solutions* Document No. 82A8030 "Radioactive Check Source Accountability Procedure" and 82A8041 "Radiological Control, Safety and Quality Assurance Program Manual."

The formulas for the ScanMDC and fixed-point/smear measurement MDC calculations are provided in Table 2-4. For field applications, it is also important to know the value of the MDC, IL and release limit, which are provided in dpm/100cm^2, in gross cpm so that the surveyor can make an immediate judgment based on instrument response (in cpm).

An instrument's intrinsic efficiency (ε_i) is the ratio of the instrument's net count rate [in counts per minute (cpm)] to the surface emission rate of the source [in disintegrations per minute (dpm)]. The surface emission rate is the 2π fluence that includes absorption and scattering processes that affect the radiation emitted from the source.

At the beginning of the project, Energy*Solutions* will use a strontium-90 check source of known activity to determine the counting efficiency of each survey instrument used that does not have a documented efficiency for strontium-90 determined at a calibration facility. This will be done by collecting ten one-minute counts with the check source placed in the center of the detector. After each one-minute count, the detector will be picked up and replaced on the source before collecting the next one-minute count. The average net count rate of the ten one-minute counts (subtracting background) will be divided by the source's 2π emission rate in dpm. This will approximate the detector's intrinsic efficiency for use in MDC and activity calculations.

The Energy*Solutions* Project Health Physicist (HP) must approve use of any source other than strontium-90 for efficiency and MDC evaluations. The efficiency needs to only be determined once during the course of the project unless the instrument is recalibrated.

Before proceeding, the Energy*Solutions* Project HP will compare the calculated efficiency with the instrument's calibration records to ensure that the efficiency is within the expected range for strontium-90.

The Ludlum Model 2929 sample counter with a Model 43-10-1 ZnS(Ag) detector (or equivalent) will be used for smear counting and analysis of roofing material. Sample analysis time to meet MDC requirements with background count times will be established by the Energy*Solutions* Project HP.

TABLE 2-3
FSS INSTRUMENTS

Application	Primary Instrument	Probe Physical Area
Fixed-point measurements	Ludlum 2360 with a Ludlum 43-93 100-cm^2 dual phosphor alpha/beta scintillator (*alpha and beta measurement logging)*	100 cm^2
Roofing Material and Smears	Ludlum Model 2929 sample counter with a Model 43-10-1 ZnS(Ag) detector	20.3 cm^2
Wall and ceiling	1) Ludlum 2360 with a Ludlum 43-93 dual phosphor alpha/beta scintillator (phoswich detector); 2) Ludlum 2220 with a Ludlum 239-1F floor monitor (large-area gas flow proportional detector); 3) Ludlum 2221 with a Ludlum 44-9 GM detector	1) 100 cm^2 2) 697 cm^2 3) 15 cm^2
Exposure/dose rates	Ludlum Model 19 mircoR meter or Bicron/Victoreen microRem meter	N/A

Equations from Energy*Solutions* Document No. 82A8008 for calculating the MDC for smear, fixed-point and scan measurements are given in Table 2-4. The FSS personnel will be provided with an Excel sheet that calculates the MDC; however, the equations given in Table 2-4 may be used in its place.

TABLE 2-4
EQUATIONS

Survey Type	MDC Equation	Variables
MDC for Scans	$ScanMDC = \dfrac{1.38 * 60\sqrt{\dfrac{R_B}{60}}}{\sqrt{0.5}\varepsilon_s(\varepsilon_i)\left(\dfrac{a}{100cm^2}\right)}$ **Only applicable for a 1 detector-width per second scanning rate.**	R_B = Background count rate $\sqrt{0.5}$ = Surveyor efficiency factor ε_i = Intrinsic instrument efficiency* ε_s = Surface efficiency (0.5for beta only) a = probe area in cm^2
MDC for Fixed-Point And Removable Contamination Measurements	$MDC = \dfrac{3 + 3.29\sqrt{R_B t_S\left(1 + \dfrac{t_S}{t_B}\right)}}{\varepsilon_s(\varepsilon_i)(t_S)\left(\dfrac{a}{100cm^2}\right)}$	R_B = Background count rate (cpm) t_S = Sample counting time t_B = Background counting time ε_i = Intrinsic instrument efficiency* ε_s = Surface efficiency (0.5 for beta only) a = probe area in cm^2 = area of surface smear in cm^2
MDC for Scalers (Embedded Tennelec Software)	$MDC = \dfrac{3 + 4.65\sqrt{R_B}}{(\varepsilon_{total})(Q)(t_S)}$	R_B = Background count rate (cpm) t_S = Sample counting time ε_{total}= Instrument total efficiency; cpm/pCi Q= mass of sample in grams
Conversion from dpm/100cm^2 to gross cpm	gross cpm = $dpm/100cm^2 \times \varepsilon_s(\varepsilon_i)\left(\dfrac{a}{100cm^2}\right)$ + background(cpm) (see variable definitions above)	

2.3.6 Investigation Levels

ILs are levels of radioactivity used to indicate when additional investigations may be necessary. For this survey, an investigation will begin when any individual fixed point or scan measurement exceeds 10% of the DCGLw (25,000 dpm/100 cm^2). ILs also serve as a quality control check to determine when a measurement process begins to depart from expected conditions stated in this FSSP.

When an IL is exceeded, the first step is to confirm that the initial measurement/sample actually exceeds the particular IL. This may involve taking further measurements to determine the level and extent of any potential radioactivity. Depending on the results of the investigation actions, the survey unit or a portion of the survey unit may require remediation to support proper radiation controls during demolition.

2.3.7 Roofing Material Sampling and Analysis

In addition to being surveyed as described above, the roofing material will be cored and analyzed prior to demolition according to the Table 2-4. Cores that are approximately 2″ in diameter will be taken of the composite roof layers. Each core will be removed and the layers will be separated to the extent practical. Each layer will then be surveyed, using hand-held instruments. The results of the survey will be documented. No contamination is expected; however, if it is identified, appropriate precautions will be taken during and after the demolition to maintain positive control of any radioactive material.

TABLE 2-5
ROOF SAMPLING

Area	Quantity
Admin. Area and Finishing Area	3 cores in each (systematic*)
Reactor Bay	3 cores near Service Area, 1 core in approximate center of structure
Service Area	9 cores (systematic*)

* A systematic approach would include collecting samples on a grid system such as a 1x3 or 3x3 grid with samples taken at evenly spaced intervals.

2.4 RELEASE OF CONCRETE

Since there will be no exposure pathway to the surfaces of the affected concrete under the current disposal option, surface contamination surveys will provide little useful information. Potential exposure information will be obtained through the volumetric sampling. As such, surface surveys on the concrete surfaces except as necessary to maintain control and radiological safety over any remaining residual radioactivity during the demolition and site closure work.

2.4.1 Concrete Sampling

Energy*Solutions* will collect concrete samples using a hammer drill or other method that will generate concrete powder and/or small chips. Sampling equipment shall be cleaned between sample locations. Each sample will consist of only the first two to three inches of concrete and will be placed in a sample container; clearly labeled with a unique identification number that corresponds to its location. Samples will remain in control of Energy*Solutions* until either relinquished to an offsite laboratory or to the PADEP.

2.4.2 Concrete Analysis

Energy*Solutions* will verify that all concrete that will be used to fill the ground voids meets the release criterion in Table 2-1. The sampling rate for the concrete will be as shown in Table 2-6.

Concrete samples will first be screened onsite using field instrumentation such as a GM detector to determine if there are high levels of activity in any of the samples. The screening method is intended to be only a qualitative analytical method. All samples will then be sent off-site for quantitative analysis of strontium-90. The laboratory method, which will use wet chemistry to extract and quantify residual strontium activity, is expected to have a minimum detectable activity of 5 pCi/g. As many as 5 samples may be combined to form a composite sample for the laboratory analysis.

TABLE 2-6
CONCRETE SAMPLING PROTOCOL

Concrete Item	Sampling Protocol	Estimated # Samples
Concrete Floor Slabs	One sample per 64 square meters in areas. For a 5-inch think concrete slab, this correlates to one sample per 8 cubic meters (m^3).[1]	56
Reactor Pool	Four samples will be collected of the Reactor Pool base. Previous survey results indicate the Reactor Pool contains no volumetric residual radioactivity.	4
Service Area Shield Wall	This shield wall is approximately 2-feet thick. Two samples will be taken of this wall. This correlates to approximately one sample per 8 m^3.	2
Gamma Pool	One sample will be taken in the base of the Gamma Pool. One additional sample will be taken randomly on a wall.	2
Hot Cell Basement	5 Samples will be taken from the base; 10 samples will be taken of the walls; and 5 samples will be taken of the center wall. This correlates to approximately one sample per 8 m^3.	20
Concrete Blocks in Parking Lot	The removed and stored concrete blocks are estimated at 2,000 ft^3. A sample rate of one sample per 8 m^3 equates to approximately 7 samples.	7
Cinder Blocks	Cinder block used as part of the facility construction that will be used to fill ground voids.	5
Total number of concrete samples		**96**

2.5 SOIL SAMPLING

Allowable residual levels of contamination in surface and subsurface soils (Table 2-1) are described in the Revision 4 of the Decommissioning Plan (Energy*Solutions* 2006).

As part of the previous FSS effort in 2004 (Energy*Solutions* 2005), Energy*Solutions* collected a total of 194 soil samples from locations around the Quehanna site (149 surface samples and 45 subsurface samples). Much of the original FSS's soil assessment was patterned to show that soil contamination did not spread from the areas of known soil contamination and the hot cell basement area, which was considered the most likely source of subsurface contamination if unidentified breeches were present. From the 149 surface soil samples, there were 45 composite samples analyzed consisting of 2 or 3 individual samples from different sample locations within the same survey unit. These samples were from Class 2 and Class 3 outside survey units. There were 16 samples from the Class 1 outside survey unit that were analyzed individually (not composite samples). None of the 45 subsurface samples were composite samples.

[1] Note: This sampling density is deemed to be sufficient because of the large difference between the DCGL and actual conditions but is not based on any standard or guidance.

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, the samples were sent off-site for analysis for strontium-90 using EPA Method 905.0/SM704. The surface sample with the highest strontium-90 concentration, 0.45 pCi/g (MDA = 0.57 pCi/g), was collected on the east side of the WWTB. The subsurface sample with the highest strontium-90 concentration, 0.86 pCi/g (MDA = 0.67 pCi/g), was collected below the Service Area.

Limited contamination was found as part of the previous FSS on the Loading Zone pavement, which is between the main building and the pond. This area was used during decommissioning operations as a radioactive waste loading and storage area. The localized areas of low-level contamination in this area were easily remediated. No other contaminated areas outside of the facility structures were found.

All previous FSS soil data will be presented in the final FSS Report to support license termination. However, this data included only a few samples from below the concrete slabs which are going to be removed during the site demolition work. Therefore, the following sections direct soil sampling of the areas where concrete slabs are removed as well as areas that may have been potentially impacted by site demolition activities, such as the lay down areas for the building materials.

2.5.1 Soil Survey Units

The sampling procedures that will be applied during the FSS are addressed in the following sections. Energy*Solutions* documents 82A8008 "General Radiological Survey and Air Sampling Procedure," 82A9375 "Preliminary Environmental Sampling and Analysis Plan for the Quehanna, Pennsylvania Site," 82A8016 "Radiological Environmental Sample Collection Procedure," and other applicable documents should be used when conducting these sampling activities.

Previous laboratory gamma spectrum analysis testing showed little or no levels of gamma emitting radionuclides, which were not naturally occurring. However, during the original FSS, soil samples screened for cobalt-60 on-site using gamma spectroscopy and no gamma-emitting contamination was identified. Therefore, soil samples collected as part of this FSS will not be analyzed using gamma spectroscopy.

Based on discussions with the NRC, split soil sampling may be necessary to support the NRC's verification and auditing efforts. The PADEP License RSO will determine any split sampling requirements.

2.5.2 Surface Soil Sampling

Energy*Solutions* collected 154 surface soil samples at a rate of approximately 1 sample per 50 m^2 as part of the original FSS. Surface samples were generally taken at a depth of approximately 6 inches. Samples were subjected to strontium-90 analysis and gamma spectroscopy for cobalt-60. Exposure/dose rates were taken at 3 feet (1 meter) above

each soil sampling location. Surface soil samples were often blended to limit the analytical costs. Up to three samples could be blended to form one composite sample. If one of the three samples were 5 pCi/g or more, the resultant composite sample results would be at least 1.7 pCi/g. All of the samples were well below 1 pCi/g. As a result, there is high level of confidence that no single soil sample exceeded the release criteria.

Surface soil samples collected as part of this FSS will be taken at a depth of no greater than 6 inches; offsite laboratory wet chemistry analysis requires less than 100 grams of soil. Samples will be collected as described in Energy*Solutions* procedures and subjected to strontium-90 analysis at an off-site laboratory. Again to limit analytical cost, up to 3 samples may be blended to form composite samples but individual samples will be archived. If high results are detected which might fail the survey unit, archived samples will be analyzed and results of the archived samples will be used for survey unit pass/fail determinations.

There will be no broad land area scanning since traditional beta scanning techniques normally used on structures, which are necessary to identify the presence of strontium-90, would not be useful for surveying open land at the noted release criteria. The MARSSIM process to address the lack of scanning capabilities through the use of area factors is not applicable for this project because the release criteria for soil is not dose based. However, to compensate for the lack of scanning capabilities, the project will only use the average criterion which is three times less than the maximum release criteria (NRC 1992).

All areas where concrete slabs were removed will be classified as Class 1 land areas and areas potentially impacted by demolition activities (e.g., lay down areas, equipment areas, etc.) will be Classified as Class 2 areas. Class 1 areas would typically require extensive scanning and Class 2 areas would also require scanning to a lesser degree. However, since scanning will not be part of this FSS, the only difference will be in the allowable size of the survey unit.

Class 1 survey units will be limited to 2,000 m^2 while Class 2 survey units may be up to 10,000 m^2. The following Table 2-7 lists the anticipated survey units and their respective areas. This list may be expanded if needed to accommodate demolition activities.

TABLE 2-7
SOIL SURVEY UNITS

Class	Area	Cause	~Area (ft^2)	~Area (m^2)
1	Admin Area Dungeon Beam Room	Concrete Removal	~8,500	~800
1	East Service Area (including Chem Lab and Decon Room) &Vestibule	Concrete Removal	~ 2,100	~195
1	West Service Area	Concrete Removal	~ 2,100	~195
2	North of Administrative Offices and near Vestibule	Laydown Area	~ 2,500	~ 230
2	Loading Zone near Beam Room	Laydown Area	~ 1,500	~140
1	Hydroblast Area Mechanical Room West Portion of Finishing Area	Concrete Removal	~7,000	~650
1	East Portion of Finishing Area	Concrete Removal	~7,000	~650
2	South of Finishing Area	Laydown Area	~ 1,500	~ 140
1	WWTB, under Tank 411 & adjacent Loading Zone	Concrete Removal & Laydown Area	~ 2,000	~ 185

The number of required samples is based upon MARSSIM criteria. The number of samples was determined in the same manner as described in Section 2.3.2. Based upon a MARSSIM suggested LBGR of one-half of the DCGL, a Δ of 2.5 pCi/g was established. The standard deviation (σ) in the strontium-90 concentration used in the calculation for the number of samples was 0.74 pCi/g as provided in Table 4-1 of the Decommissioning Plan (Revision 4). The resulting Relative Shift (Δ/σ) of 3.4 yields a P_r is 0.983 from MARSSIM Table 5.1. Following the process in Section 2.3.2, each Class 1 and Class 2 survey unit will have a minimum of 10 samples with the sample locations established on a random-start triangular grid. Background sample results that were previously collected will be used in the evaluation process.

2.5.3 Subsurface Soil Sampling

The remediation and previous FSS effort used the same criteria as that noted in this FSSP. Thirty subsurface soil samples were taken throughout the area within the fence line, excluding the MMA Tank area, during the previous FSS. These samples were taken underneath the areas listed below, with the number of samples in parentheses.

- Service Area (5)
- Fan Room (3)
- Finishing Area (location of old Loading Dock) (4)
- WWTB Area (3)
- Loading Zone Area (7)
- Eastern land area of the complex (5)
- Reactor bay (2)
- Pond area near Loading Zone (1)
- Cell Operations (Cell Face) Area (3)
- Administrative Area Near Cell Face (2)

This subsurface sampling campaign did not show any contamination. As such, subsurface sampling will not be conducted as part of this FSS.

2.5.4 Sediment Samples

Sediment samples from the pond were collected at three locations in the previous FSS. One of the samples was taken directly at the facility discharge point. A split spoon was used to collect sediment from about the top 6 inches. Like soil samples, the collected sediment was subjected to gamma spectroscopy and strontium-90 analysis. All samples were less than 1 pCi/g. No additional sediment samples will be collected as part of this FSS.

3.0 ASSESSMENT

The following section provides a summary of how data will be collected, assessed, and recorded. It further addresses quality control and contents of the final report.

3.1 DATA MANAGEMENT

During the FSS, data will be properly documented so that aspects of the FSS can be referenced in the future if desired. The survey documentation should be of sufficient detail to allow for the recreation of the survey procedure, location, instrumentation used, and results.

All of the data taken including fixed measurements, scanning measurements, removable contamination, dose rates and soil contamination or other media contamination will be documented in detail.

Instrument measurements and analytical results will include the following data:

- Daily background measurements
- Location of the measurement or sample
- Date and time of the measurement or sample
- Gross or net instrument readings. Net instrument readings will often be negative since samples without any added radioactivity will often be below the background count. These numbers should be recorded since they may be necessary for statistical evaluation of the data. In instances where measured radioactivity is less than the MDC for the counting system, the final activity reading will also indicate "<MDC."
- Measured concentrations in pCi/g for soil samples and in dpm/100 cm^2 for surface contamination
- Name of surveyor, sampler, or analyst
- Instrument specifications and calibration date
- Minimum detectable concentrations or activity
- Name of person reviewing results
- Other relevant information

Any deviations from normal operating survey procedures or procedures specified in the FSSP including equipment selection and use should be documented for future reference with a complete explanation.

If any data is disregarded for any reason, the situation is to be documented with supporting reasons and necessary evidence. Examples of this would include detector malfunction/contamination, reclassification of a survey unit if cross contamination occurred between survey units after decontamination activities, and other such occurrences.

The following sections present the requirements for specific surveys and other data management activities.

3.1.1 Logging Measurements

The Ludlum 2360 detector, in conjunction with the Ludlum 43-93 probe (phoswich), will be used to log data at each direct measurement location. Along with each direct measurement at each survey point the data will be recorded on the final survey package.

- Logging instrument inputs (time, location, etc.) should be checked so that the correct data is logged.
- To mark the beginning and end of data logged in a single survey unit the first measurement logged before starting a survey unit and the last measurement logged after completing a survey unit should be taken with a check source. Multiple survey units may be surveyed before downloading the data file.
- The Ludlum 2360 will log up to 550 data points.
- The survey unit data file name should be written on the appropriate survey map. The surveyor should number the survey measurements sequentially in the order they were taken and indicate the location on the survey unit map. To account for all logged measurements that will appear in the data file, all duplicate or inadvertent measurements should also be numbered. If multiple survey units are surveyed before downloading the data, the measurement location number will continue from the previous survey unit. In addition, at the end of each workday, all log/spreadsheets should be backed-up.
- It is important to always note the survey start time on the survey map while logging fixed-point measurements. This helps in correlating the logged information to the survey package as well as account for the time spent in each survey unit.
- The Energy*Solutions* Project HP will convert the raw count rate data to net surface activity levels in dpm/100 cm^2 after receiving the data from the field or will review conversions made in the field. Gross surface activity measurements and net surface activity measurements data (corrected for background) will be recorded.

3.1.2 Scanning Surveys

- The number of scanning sections will be equal to the number of fixed measurement data points in the survey unit.
- Each scanning section within a survey unit should be approximately the same size.
- For each scanning section, the average and maximum count rates will be recorded in gross cpm on a survey sheet. The data will be labeled with a unique identification number corresponding to the survey unit and the scanning section.

3.1.3 Removable Contamination

- The smear samples will be counted on the smear counter. The Energy*Solutions* Project HP determines if any efficiency modifiers (e.g. surface efficiency) are needed if oil or excessive debris is on the smears.
- The smear sample results will be manually recorded survey sheets.

3.1.4 Exposure/Dose Rates

- Exposure rates will be reported in units of microroentgen per hour (μR/hr). Dose rates will be recorded in microrem per hour (μrem/hr).
- Exposure or dose rates should be recorded directly on the survey map.

3.1.5 Sample Handling and Record Keeping

- For soil/materials samples to be sent offsite, a sample tracking record (chain-of-custody record) accompanies each sample from the point of collection through obtaining the final results to ensure the validity of the sample data.
- Refer to Energy*Solutions* procedure for implementing the chain-of-custody record.

3.1.6 Data Assessment and Compliance

- An assessment will be performed on the FSS data to ensure that there is adequate data to support the determination to release the survey unit.
- Simple assessment methods such as comparing the survey data to the release criteria or comparing the mean value to the release criteria will first be performed.
- The statistical tests will then be applied to the final data set by the Energy*Solutions* Project HP and conclusions are made as to whether the survey unit meets the site release criteria.
- The data is also reviewed to identify any potential trends.

3.2 QUALITY ASSURANCE

All surveys will be conducted in accordance with the Quehanna QAPP, and Energy*Solutions* procedures with appropriately trained and qualified personnel and with properly calibrated instruments. Measures taken to assure survey quality will include a thorough review of the data, independent laboratory verification of samples, laboratory duplicates, precision measurements of instruments and operators, and daily operability checks. During the project, quality assurance measures will be assessed by the Energy*Solutions* Project HP to assure that the collected data remains valid.

3.2.1 Instrumentation

Instrument calibration records must be present on-site during all survey activities and will be provided as part of the FSS Report. While in use, each instrument will be source response checked daily. In addition the operability of the instrument and a background measurement will be assessed daily. As described in the DQO process and Section 2.2, control logs will be maintained for each instrument noting the results of the daily evaluations.

3.2.2 Off-site Laboratory Analyses

Laboratories used to assay FSS samples will be on the Energy*Solutions* Approved Vendors List. These laboratories will use proper calibration procedures, sample blanks, and sample duplicates to assure accurate results. In addition, for separations chemistry, tracers should be used to verify collection efficiency.

The primary laboratory selected to perform soil and concrete sample analysis is General Engineering Laboratories, Inc., Charleston, SC. The backup and quality control laboratory selected will be Severn Trent Laboratories (STL), St. Louis, MO. The laboratory selections may change based on performance and service. Additional laboratories that may be considered will be on the Energy*Solutions* qualified vendors list.

3.2.3 Instrument Precision

Site surveys will be performed in a manner that ensures results are accurate and sources of uncertainty are identified and controlled. As such, the survey team is required to collect QC samples to evaluate precision and systematic errors in the survey data. The precision is evaluated with the collection of replicate measurements.

To evaluate instrument precision, multiple instruments will be used to calculate the radioactivity of a standard beta source in a set geometry. If a source is used that is of different energy than the source used to calculate the instruments' efficiencies, the calculated "activity" may not equal the true source activity. This is acceptable since values are only used for comparative purposes. The same operator will be used for the evaluation. The following procedure for evaluating instrument precision is based on Section 4.9.2 of MARSSIM.

1. Collect sixteen (16) 1-minute counts of a beta emitting check source using every survey instrument that will be used for collecting fixed-point beta activity measurements.
2. Arbitrarily choose one of the instruments as the "standard."
3. Calculate and record each measurement of the "standard" instrument using the predetermined instrument-specific intrinsic efficiency and a surface efficiency of 0.5 (beta). Calculate the average activity.
4. Calculate and record each measurement of the other instruments. Calculate the average activity.
5. Compare the average activity of each instrument by calculating the percent difference from the average radioactivity of the "standard" instrument.

The above procedure should be performed for all survey instruments used for collecting FSS data. If more than one smear counter (Ludlum 2929 and PIC WPC-9550) is used on site, the above procedure should also be performed with each counter. An on-site health physics technician will complete steps 1 through 5 above. The Energy*Solutions* Project HP will evaluate the results.

3.2.4 Data Analysis

The Energy*Solutions* Project HP will carefully review collected data on a frequent basis to evaluate trends, identify potential instrument problems, identify potentially elevated areas, and to ensure that the assumptions used to classify the areas and develop the FSS Plan remain valid.

3.3 FINAL STATUS SURVEY REPORT

The FSSR should restate the intention of the Quehanna Decommissioning Plan and provide the results of the FSS. The FSSR should explain any deviations to the FSSP or the Quehanna Decommissioning Plan, as appropriated. It will also provide a summary of the survey results and the overall conclusions that demonstrate that the facility and site meet the radiological criteria for unrestricted use. Information such as the number and type of measurements, basic statistical quantities, and statistical analysis results are included in the report. The level of detail is sufficient to clearly describe the FSS program and to certify the results.

4.0 REFERENCES

EnergySolutions Document No. 82A9089, "Decommissioning Plan for the Quehanna, Pennsylvania Site." Revision 4. March 2006.

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EnergySolutions Document No. 82A9149, "Quehanna Decommissioning Project Quality Assurance Project Plan (QAPP). Revision 1. July 2002.

EnergySolutions Document No. 82A8030, "Radioactive Check Source Accountability Procedure." Revision 5. March 2006.

EnergySolutions Document No. 82A8041, "Radiological Control, Safety and Quality Assurance Program Manual." Revision 4. March 2006.

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