# Radiological Survey and Dose Assessment Report

# For the

# Western New York Nuclear Service Center and Off-Site Areas

# In Follow Up to

# Aerial Gamma Radiation Survey

# Conducted in 2014, Rev. 1

## Prepared For

## New York State Energy and Research Development Authority

## West Valley Site Management Program

9030-B Route 219 | West Valley, NY 14171

Agreement Number 61280

## Prepared By


## MJW Technical Services Inc.

243 Root Street, Suite 100, Olean, NY 14760


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243 Root Street, Suite 100
Olean, NY 14760-2436
Voice: (716) 372-5300  Fax: (716) 372-5307  Toll Free: (866) 300-3659 mjwts.com

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**List of Acronyms**

| | |
|---|---|
| Aerial Survey | 2014 Aerial Radiological Survey (Aerial Survey) |
| BGA | Background Area |
| cm | Centimeter |
| CPM | Counts per minute |
| DCF | Dose coefficients factor |
| DCGL | Derived Concentration Guideline Level |
| DOE | U.S. Department of Energy |
| ELAP | Environmental Laboratory Approval Program |
| EPA | U.S. Environmental Protection Agency |
| f1 | Fractional Absorption in the Gastrointestinal Tract Rate |
| FS&DP | Field Sampling and Dose Assessment Plan (“Plan”) |
| g | Gram |
| GPS | Global Positioning System |
| HASP | Health and Safety Plan |
| ICRP | International Commission on Radiological Protection |
| kCPM | Thousand counts per minute |
| kg | Kilogram |
| lbs | Pounds |
| m | Meter |
| MDL | Minimum Detectable Levels |
| MJWTS | MJW Technical Services Inc. |
| mrem | Millirem |
| NaI | Sodium Iodide |
| NIST | National Institute of Standards and Technology |
| NORM | Naturally Occurring Radioactive Material |
| NRC | Nuclear Regulatory Commission |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSDOH | New York State Department of Health |
| NYSERDA | New York State Energy Research and Development Authority |
| pCi | Pico Curie |
| PM | Project Manager |
| QAPP | Quality Assurance Project Plan |
| RESRAD | RESidual RADioactive Material |
| RSL | Remote Sensing Laboratory |
| SNI | Cattaraugus Territory of the Seneca Nation of Indians |
| WNYNSC | Western New York Nuclear Service Center |
| WVDP | West Valley Demonstration Project |

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## Executive Summary

### Purpose

The purpose of the radiological survey and dose assessment project was to determine if the elevated levels of radioactivity identified in the 2014 Aerial Radiological Survey (Aerial Survey) of the Western New York Nuclear Service Center (WNYNSC) (Ref. 1) were present in the radionuclide concentrations in the soil. If elevated soil concentrations were identified, a dose assessment (based on current and reasonably foreseeable future land use) was conducted to confirm that there were no health and safety concerns for the identified area. Because the areas sampled are off site and the land use is unrestricted, the dose assessment results were compared to 10 C.F.R. § 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 2).

In addition, the U.S. Nuclear Regulatory Commission (NRC) requested that a comparison of the soil sampling results to the Derived Concentration Guidelines in the WVDP Phase 1 Decommissioning Plan (Ref. 3) be completed as an independent check against a conservative exposure scenario.

The results from this soil sampling and dose assessment project show that radiation exposure to the public for each of the areas evaluated is substantially below the NRC-regulatory unrestricted use requirement of 25 millirem (mrem) per year (in accordance with 10 C.F.R. § 20.1402). Therefore, no public health and safety concerns were identified through this analysis.

### Radiological Survey and Sampling Actions

Specific areas were identified in the project Field Sampling and Dose Assessment Plan ("Plan") (Ref. 4, Appendix A) for study based upon the Aerial Survey and other historic knowledge (e.g., Cesium Prong). The Plan further specified the specific survey and sampling parameters for each area including the location and shape of the area, the number of locations within the area to be surveyed and sampled, and radiochemical analyses to be performed. Field Guides (Appendix B) provided additional detail and instructions on surveys and sampling.

The number of locations to be surveyed and sampled in each survey area was based upon the size of the area.

- For areas 0 – 2,000 m2 in area, a minimum of four locations were surveyed and sampled.
- For areas 2,001 to 10,000 m2 in area, a minimum of 15 locations were surveyed and sampled.
- For areas > than 10,000 m2 in area, a minimum of 24 locations were surveyed and sampled.

The following is an overview of radiological survey and sampling actions taken. Additional detail is provided for each area surveyed in Sections 5.1 through 5.6 of this report.

Radiological survey and sampling activities included three components:

- Global Positioning System (GPS) Walkover Gamma Surveys

GPS walkover gamma surveys were conducted over designated survey areas using a Ludlum Model 2241-2 Scaler Rate Meter and a Ludlum Model 44-10 2"x2" Sodium Iodide (NaI) gamma detector, coupled with a GPS unit. Radiation count rates in counts per minute (CPM) were collected as the survey team walked designated grid patterns while the GPS position was simultaneously logged. The purpose of this survey was to determine if any sub-regions within the designated survey area were elevated compared to the rest of that survey area. The results were displayed graphically, and if elevated sub-regions were identified, samples were collected in the elevated sub-regions, along with random samples.

- Collection of Soil Samples

  Within each survey area, soil samples were collected from the number of locations and at the depth intervals specified in the plan. Specifically, based on a review of historical information, areas where potential contamination was more likely a result of airborne deposition, initial surface layer samples were analyzed from the first five centimeters (cm) of soil. Similarly, based on a review of historical information, areas where potential contamination was more likely the result of water deposition, initial samples were analyzed from the first 15 cm of soil.

- Static Direct Radiation Measurements

  At each location where soil samples were collected, static direct radiation measurements were collected using both a Bicron microRem survey meter, which employs a tissue equivalent gamma detector, and a Ludlum Model 2241-2 Scaler Ratemeter with the Model 44-10 2"x2" NaI gamma detector. Readings were collected at 1 and 100 cm above the ground.

**Sample Radiochemical Analysis**

As specified in the Plan, a percentage of the samples collected were submitted for radiochemical analysis. All samples submitted were analyzed by a New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP)-laboratory for gamma spectroscopy (which includes analysis for Cesium-137 [Cs-137]), gross beta, and gross alpha analysis. Some samples were also analyzed for additional isotopic information. Where surface samples statistically exceeded Cs-137 background concentrations plus two standard deviations, the next deeper depth increment samples were analyzed. All analytical data received Level IV data validation per (Evaluation of Radiochemical Data Usability (es/er/ms-5), 1997 (Ref. 5) and were found to be usable. Additional detail is provided in Sections 6.1 through 6.6 and the appendices.

**Summary of Dose Assessment Results**

For each area studied, a dose assessment was conducted as specified in the Plan or as subsequently determined to be the appropriate methodology. For Areas 1, 2, and 3, this was based upon property-specific land use, and the size and physical characteristics of the area such as terrain and tree cover. For Areas 4 and 5, which are located on the Cattaraugus Territory of the Seneca Nation of Indians (SNI), culturally specific land use information was used. Additional detail is provided for each area in Sections 7.1 through 7.6 and the appendices to this report.

The radiation doses were assessed using the following approach:

- Annual radiation doses were estimated based upon the results of the 2014 Aerial Survey. The Aerial Survey Report did not provide background levels for the specific areas identified this report; therefore, background levels were interpolated from the aerial survey data.
- Annual radiation doses were estimated based on readings collected using the tissue equivalent dose rate survey meters.
- The average soil concentrations for all areas, even those that were determined to be slightly above background levels, have gross alpha and gross beta activity levels that can be attributed to NORM radioisotopes and are more likely the result of the natural fluctuation in background.
- Annual radiation doses, for current land use, were estimated by performing RESidual RADioactive (RESRAD) OFFSITE 3.1 computer code (Ref. 6) of measured gross alpha, gross beta, and Cs-137 soil concentrations in excess of background. The assessment of the gross alpha was based on the most conservative isotopes (Americium-241 [Am-241] or Plutonium-239 [Pu-239]) and the beta was based on Strontium-90 (Sr-90).
    1. Of the alpha emitters that are of dosimetric concern, Pu-239 and Am-241 were selected as the two alpha-emitting isotopes based on the predominant concentrations of these two radionuclides in the West Valley waste stream (i.e., they were greater than 10,000 times other alpha-emitting radionuclide concentrations for the historical operations). In addition, due to the longer half-lives of these isotopes, Pu-239 and Am-241 would continue to be dosimetrically important in the dose assessments for future land users.
    2. Of the beta emitters that are of dosimetric concern, Sr-90 was selected as the beta emitting isotope based on the concentrations in the West Valley waste stream, and the fact that Sr-90 is longer-lived than the majority of beta-emitters that would have been generated during historical operations. Sr-90 is a waste product of reprocessing and thus it would likely be a key contributor to the beta dose from the site.
- For purposes of this study, background concentrations were determined from two locations within the WNYNSC and from 10 locations within the SNI, five of which are in the Cattaraugus Creek floodplain and five of which are not in the floodplain.
- These sample results were compared to the Derived Concentration Guideline Level ($DCGL_w$) concentrations established in the Phase 1 Decommissioning Plan for the West Valley Demonstration Project (WVDP). This comparison of the gross alpha and beta was based on the most conservative isotopes (Am-241, Pu-239 and Sr-90, respectively) and accounted for all of the anthropogenic nuclides except Carbon-14 (C-14), Iodine-129 (I-129), and Technetium-99 (Tc-99). For these radionuclides, a qualitative analysis was performed. In all cases for these three radionuclides, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the radionuclides that account for most of the gross alpha and gross beta soil concentrations are radionuclides that are considered Naturally Occurring Radioactive Material (e.g., natural uranium, natural thorium, and potassium-40). The DCGLs used for this comparison were based on a Resident Farmer scenario.
- For Areas 1-3, annual radiation doses for reasonably foreseeable future land use were also estimated using the RESidual RADioactive (RESRAD) 7.0 computer code (Ref. 7) to assess gross

alpha, gross beta, and Cs-137 soil concentrations in excess of background. The assessment of the gross alpha was based on the most conservative isotopes between Am-241 and Pu-239, and the beta was based on Sr-90.

- For Areas 4 and 5, culturally specific land use scenarios were developed. The SNI indicated that there was no expected change in the current land use for the foreseeable future.
- Annual radiation doses from the consumption of fish were also estimated. Calculations were performed using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the 2012 WVDP Annual Site Environmental Report (ASER) (Ref. 8). Annual exposures were calculated based on ingestion dose coefficients from the International Commission on Radiological Protection (ICRP) ICRP Publication 68 (Ref. 9).

**Conclusion**

The assessed doses in Areas 1, 2, and 3, based upon multiple approaches and covering current and reasonably foreseeable future land use scenarios, were determined to be significantly less than the 25 mrem per year requirement identified in 10 C.F.R. § 20.1402, and there are no health and safety concerns identified for these locations.

For Areas 4 and 5, the assessed doses, based upon current land use scenarios and considering culturally specific SNI land use, were determined to be significantly less than the 25 mrem per year requirement identified in 10 C.F.R. § 20.1402, and there are no health and safety concerns identified for these locations.

# 1.0 Introduction

## 1.1 Background

The New York State Energy Research and Development Authority (NYSERDA) owns the 3,300-acre Western New York Nuclear Service Center (WNYNSC) in the town of Ashford, New York. Since 1982, NYSERDA and the U.S. Department of Energy (DOE) have been working at the WNYNSC ("Center") to conduct the West Valley Demonstration Project (WVDP), a high-level radioactive waste solidification and cleanup project.

In September 2014, DOE and NYSERDA jointly initiated an aerial radiological survey (Ref. 1) to examine the radiological conditions of the Center and adjacent areas, as well as Cattaraugus Creek from the Center to Lake Erie in Western New York. This Aerial Survey was conducted by the National Nuclear Security Administration's Remote Sensing Laboratory (RSL).

Previous aerial, soil sampling, and radiological survey studies had identified areas of contamination both on the WNYNSC property, and in nearby off-site locations resulting from routine permitted discharges and inadvertent releases of radioactivity from the site (1995 Western New York Nuclear Service Center Off-Site Radiation Investigation Summary Report, Dames & Moore) (Ref. 10). Of note was the identification and analysis of areas referred to as the "Cesium Prong." The Cesium Prong comprises an irregularly shaped area on the Center property that extends outward and generally to the northwest, onto off-Center properties. This contamination is believed to be the result of unintentional airborne releases from the Center in 1968. Historic soil sample data from the Cesium Prong is consistent with airborne surface deposition of Cs-137. In addition to the Cesium Prong, the Aerial Survey showed slightly elevated areas of radioactivity in the on-site creeks including Buttermilk Creek, and possibly Cattaraugus Creek. A summary of liquid effluent discharges from the WVDP is provided in Appendix I.

Based on the Aerial Survey, five areas outside the Center property were identified for further evaluation based on information provided by RSL that showed that radiation levels at these locations were slightly above the "background" radiation levels seen throughout Western New York[1]. Two of these areas were identified during previous aerial surveys, and the three other locations were newly identified during the 2014 Aerial Survey. The identification of the three new areas is likely due to improvements in detection sensitivity and precision, and the survey extending into areas that had not been previously surveyed.

MJW Technical Services Inc. (MJWTS) was retained by NYSERDA to conduct a survey, sampling, and dose assessment study to "ground truth" the 2014 Aerial Survey results, and to confirm that credible potential radiation exposures to members of the public in unrestricted areas do not exceed the applicable NRC limits per 10 C.F.R. § 20.1402. The survey and sampling operations were extensive, and examined areas in proximity to the Center, as well as the areas further to the west, located on the SNI.

[1] Background radiation is caused by naturally occurring radioactive materials like radon and from certain man-made radioactive materials that are found throughout the environment today.

The scope of the activities conducted by MJWTS included development and execution of the Plan (Ref. 4), a project Quality Assurance Project Plan (QAPP) (Ref. 11), a project Health and Safety Plan (HASP) (Ref. 12), Field Guides (Appendix B), and procedures.

## 2.0 Project Components and Organization

### 2.1 Field Sampling and Dose Assessment Plan

The Plan describes the purpose and objectives of the project; defines the project organization and structure; establishes the approach for field survey, sample collection, analysis, data validation, and defines the requirements and approach to dose assessment. An initial draft of the Plan was shared with the NRC, the Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), NYSDOH, and the SNI. Comments provided by these agencies were used to develop the Plan, which was issued on October 1, 2015. Minor revisions in the sampling areas identified in the Plan were implemented after further discussion between NYSERDA and RSL when the final version of the 2014 Aerial Survey was issued. The changes are summarized in Appendix A.

### 2.2 Quality Assurance Project Plan (QAPP)

The QAPP provides the project-specific details on how the surveys and samples were to be collected to ensure representativeness, traceability and reproducibility. The data quality objectives are defined in the QAPP, along with information detailing data quality and validation processes. Appendix E, Data Quality Objectives, provides additional detail on field and laboratory data quality indicators.

### 2.3 Project Health and Safety Plan (HASP)

The HASP provides the project-specific details on how the project activities would be conducted in a safe manner and in compliance with applicable safety requirements.

### 2.4 Participants, Roles, and Responsibilities

The key project staff and their primary roles and responsibilities were:

#### 2.4.1 NYSERDA Project Manager

The NYSERDA Project Manager was the primary point of contact and coordination with the MJWTS Project Manager, and ensured that the MJWTS Project Manager was cognizant of relevant information, issues, objectives, requirements, and potential concerns or deficiencies.

#### 2.4.2 Project Manager

The Project Manager (PM) was responsible for execution of the survey, sampling, and dose assessment activities and was responsible for the health physics aspects for all field activities. The PM was also responsible for ensuring that work was executed in a timely manner, in accordance with the Plan, and in conformance with all applicable regulatory requirements.

### 2.4.3 Project Certified Health Physicist

The Project Certified Health Physicist ensured that the collection and analysis of survey data and the derived dose assessments were conducted properly and in accordance with the Plan, and appropriate professional and regulatory standards and practices to ensure that results are accurate and defensible.

### 2.4.4 Project Health Physicist

The Project Health Physicist was responsible for the evaluation of survey and laboratory data, and for the performance of the dose assessments.

### 2.4.5 Project Quality Assurance and Control Manager

The Project Quality Assurance and Control Manager was responsible for all aspects of project Quality Assurance and Quality Control including field surveying, sampling activities and laboratory analysis.

### 2.4.6 Project Data Validation Specialist

The Project Data Validation Specialist was responsible for Level IV validation of data as required by accepted professional practices and standards in accordance with the QAPP.

### 2.4.7 Project Information Technology/Geographic Information System Specialist

The Project Information Technology/Geographic Information System Specialist was responsible for oversight of data file storage and the processing of acquired data, in particular, GPS-driven radiation survey data.

## 3.0 Summary of 2014 Aerial Survey Results and Areas Selected for Analysis

The 2014 Aerial Survey was conducted by RSL. It encompassed areas in proximity to the WNYNSC as well as a corridor following Cattaraugus Creek westward to Lake Erie. The detection capabilities of this survey were considerably better than those of previous aerial surveys due to improved technology. The aerial survey data was spectroscopic in nature, thus allowing RSL to extract information specific to anthropogenic isotopes including Cs-137 and Cobalt-60 (Co-60). Cobalt-60 was not identified outside of the WNYNSC.

## 3.1 Method to Select Off-Site Survey Areas Based Upon the Results of the Aerial Survey Data and Reduce Uncertainty in the Location and Extent of Contaminated Areas

NYSERDA consulted extensively with RSL personnel on the identification of specific areas that warranted follow-up measurements based upon the results of the aerial survey. Based on RSL's expert knowledge of this particular dataset and their vast experience with aerial survey methods and results of similar surveys, RSL suggested a methodology that they believed was conservative and would capture the pertinent features and support the identification of areas for follow-up measurements. RSL identified four criteria that when considered in combination (i.e., an area must meet all criteria concurrently),

resulted in delineation of specific areas that were meaningful to NYSERDA's ground-level measurements of ambient radiation and collection of soil samples. These criteria included:

1. Data from the Cs-137 spectral signature are greater than two standard deviations above background. This threshold (30 counts per second) is only slightly above background and is thus coincidental with statistical noise in the dataset. This particular measure on its own could result in false negatives. That is, given the relatively small variance in the extraction algorithm, Cs-137 may be indicated in the spectral data though not strongly within the photopeak.
2. Data from the anthropogenic-sources spectral signature are greater than two standard deviations above background. This threshold (1000 counts per second) is only slightly above background and is thus coincidental with statistical noise in the dataset. This particular measure on its own could result in false positives. That is, because the anthropogenic extraction has a relatively large variance, it can produce false positives if used to look for a specific isotope (Cs-137).
3. Both Criteria 1 and 2 are met, and they are both met over the same area (co-located), or both met over areas in close proximity to one another. Given that aerial survey methods result in somewhat "coarse" data, it is difficult to define exact spatial "boundaries" of areas meeting thresholds 1 and 2 strictly from the aerial data. As such, consideration is given to areas that are not only co-located (overlapping), but also to those areas located relatively near one another (less than or equal to 300 feet).
4. Both Criteria 1 and 2 are met, areas are co-located or located in close proximity (Criteria 3), and these areas appear clustered or extended in the area. Given that Criteria 1 and 2 are very close to background, the first three criteria produce a dataset that still contains statistical noise, identifying very small randomly located spots across the entire aerial survey area. Having examined the detailed spectral data, RSL was confident these small random areas represent statistical noise. Where these areas appeared clustered and/or extended in area, RSL believed they are more suggestive of areas that may contain slightly elevated levels of radiation. As such, these four criteria, in combination, provide a reasonable delineation of areas that warrant follow-up measurements of ambient radiation at ground level and soil sample collection.

Based on the criteria identified above, five areas were selected for survey, sampling and dose assessment. These areas were designated Areas 1, 2, 3, 4, and 5 (Figures 1 through 5). Areas 2, 3, 4, and 5 were further broken down into sub-areas. Area 2 had two sub-areas, Area 3 had two sub-areas, Area 4 had five sub-areas, and Area 5 had six sub-areas. In order to reduce uncertainty in the location and aerial extent of the potentially elevated regions, when GPS or manual survey grids were surveyed using the Ludlum 2241-2 survey meter and 2”x2” NaI gamma detector, the boundaries of the survey areas were extended outside of the boundaries identified by the aerial survey data. These meter readings therefore achieved two things:

1. The identification of any comparatively elevated regions within the areas identified by the RSL data.

2. The identification of any elevated regions, within the survey area, but outside the areas identified by the RSL data.

For the Area 2, rectangular survey boxes (associated with the 2"x2" meter readings) encompassed an area at least three times the area of the investigation lines derived from the RSL data.

For Areas 3.1, the shape of the 2"x2" survey readings boundaries were based on configuration of the terrain and other physical features surrounding the investigation areas derived from the RSL data.

For Areas 4 and 5, the sub-areas (e.g., 4.1, 4.2, etc.) were identified by constructing polygons that surrounded the clusters of investigation areas (e.g., 4.1A, 4.1 B, etc.) based upon the RSL criteria. These polygons determined the boundaries of the GPS walkover survey traverses.

In addition to these five areas, "confirmatory" locations were also sampled on the WNYNSC to compare Aerial Survey results to areas known or suspected to contain contamination.

The five survey areas and their current land characteristics (as determined through aerial photos and land use surveys) (Appendix D) and the on-center confirmatory location are summarized in Table 1.

**Table 1. Locations Selected for Further Evaluation**

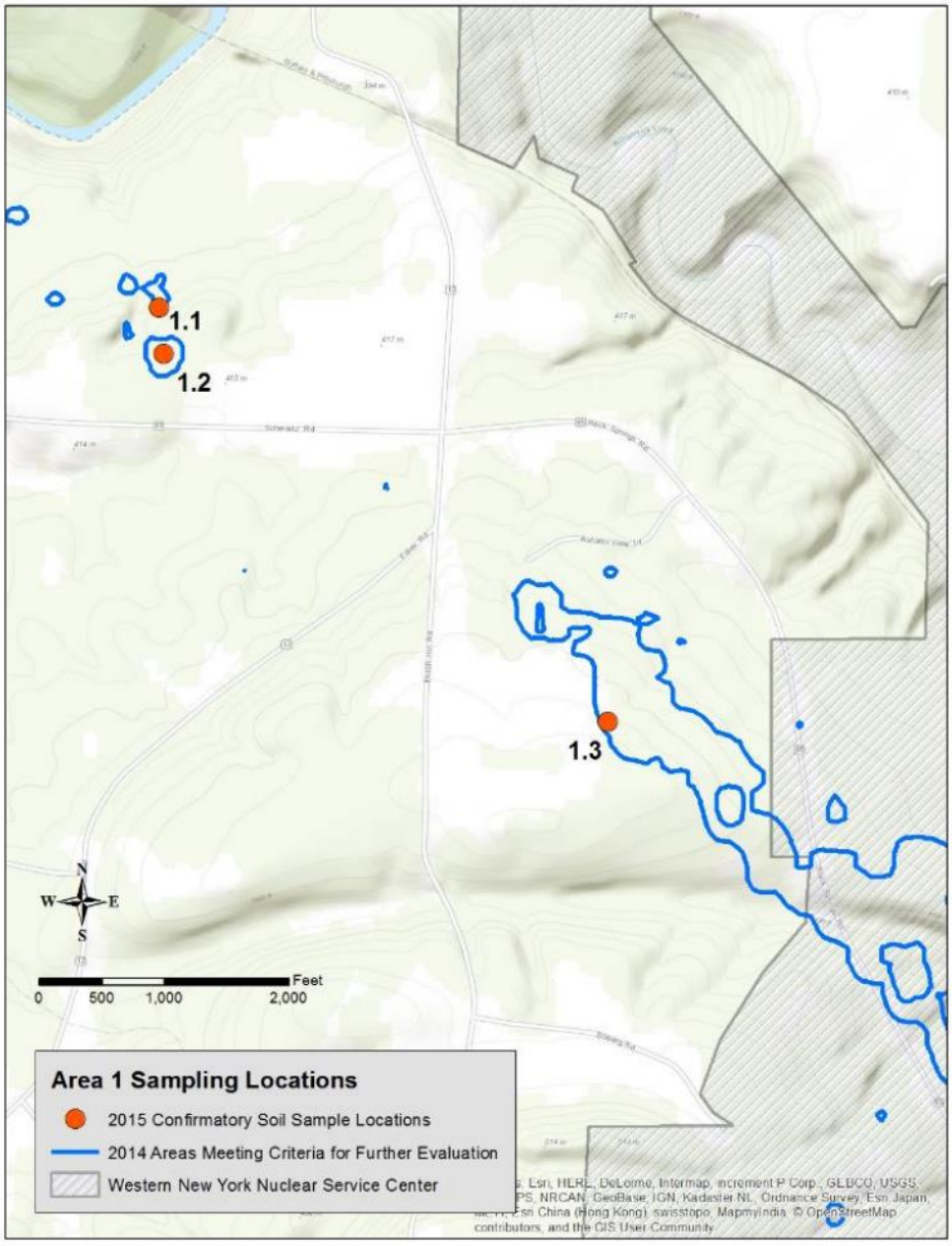
| Area No. | Location | Current Land Characteristic | GPS Coordinates (centroid location) | |
|---|---|---|---|---|
| 1 | Cesium Prong (Off–Site) | Residential properties, with cleared and tree covered areas. | 42°27'46.97" N | 78°40'13.53" W |
| 2 | Near Springville Dam (new location likely an extension of the Cesium Prong) (Sub-Areas 2.1 and 2.2) | Varying in terrain and tree cover. These areas are not residential. | 42°28'25.66" N | 78°41'18.84" W |
| 3 | Near confluence of Buttermilk and Cattaraugus Creeks (Sub-Areas 3.1 and 3.2) | Active agriculture area. | 42°28'56.20" N | 78°40'42.19" W |
| 4 | Cattaraugus Territory of the Seneca Nation of Indians | Wooded area that does not include residences on the floodplain of Cattaraugus Creek | 42°32'23.84" N | 79°02'13.07" W |
| 5 | Cattaraugus Territory of the Seneca Nation of Indians | Wooded area near residential property not on the floodplain of Cattaraugus Creek | 42°31'12.94" N | 78°58'25.11" W |
| WNYNSC | WNYNSC Confirmatory | On-Center | N/A | N/A |

Details on these areas and the discrete locations selected for study on, or in proximity to, the WNYNSC are provided in Figures 1 through 6.

### 3.1.1 Area 1

Area 1 (Cesium Prong, outside the WNYNSC property) includes three specific locations within the Cesium Prong, but outside of the WNYNSC property. Because the Cesium Prong was extensively sampled and analyzed in the 1990s, these samples were collected to compare currently measured concentrations to previously measured concentrations decay corrected to current day. Figure 1 below provides a map of these locations.

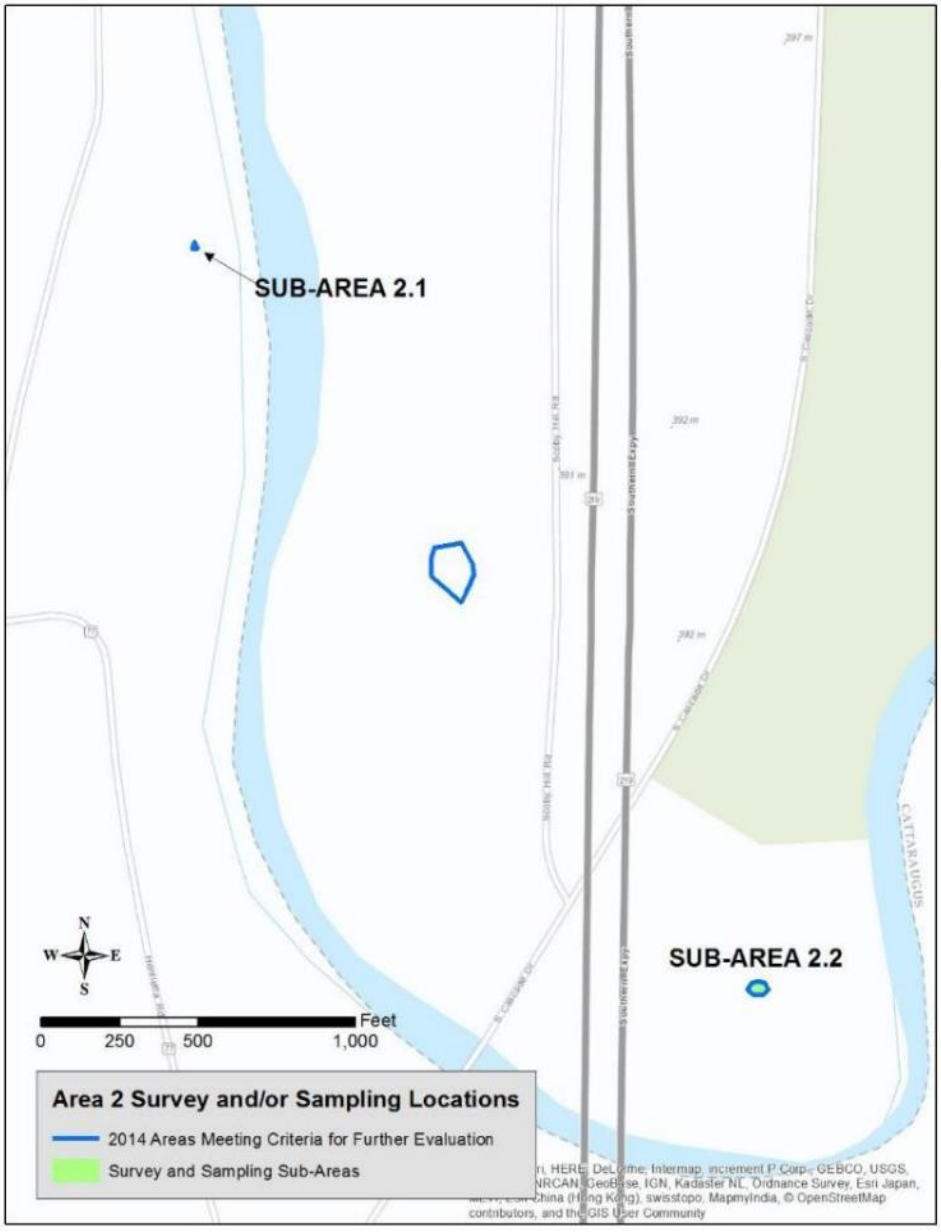
**Figure 1. Area 1 Sampling Locations**



### 3.1.2 Area 2

Area 2 consists of two separate sub-areas northwest of Area 1 in a region transected by the Route 219 Expressway in proximity to Cattaraugus Creek. Figure 2 provides a map of these locations.

**Figure 2. Area 2 Survey and Sampling Locations**

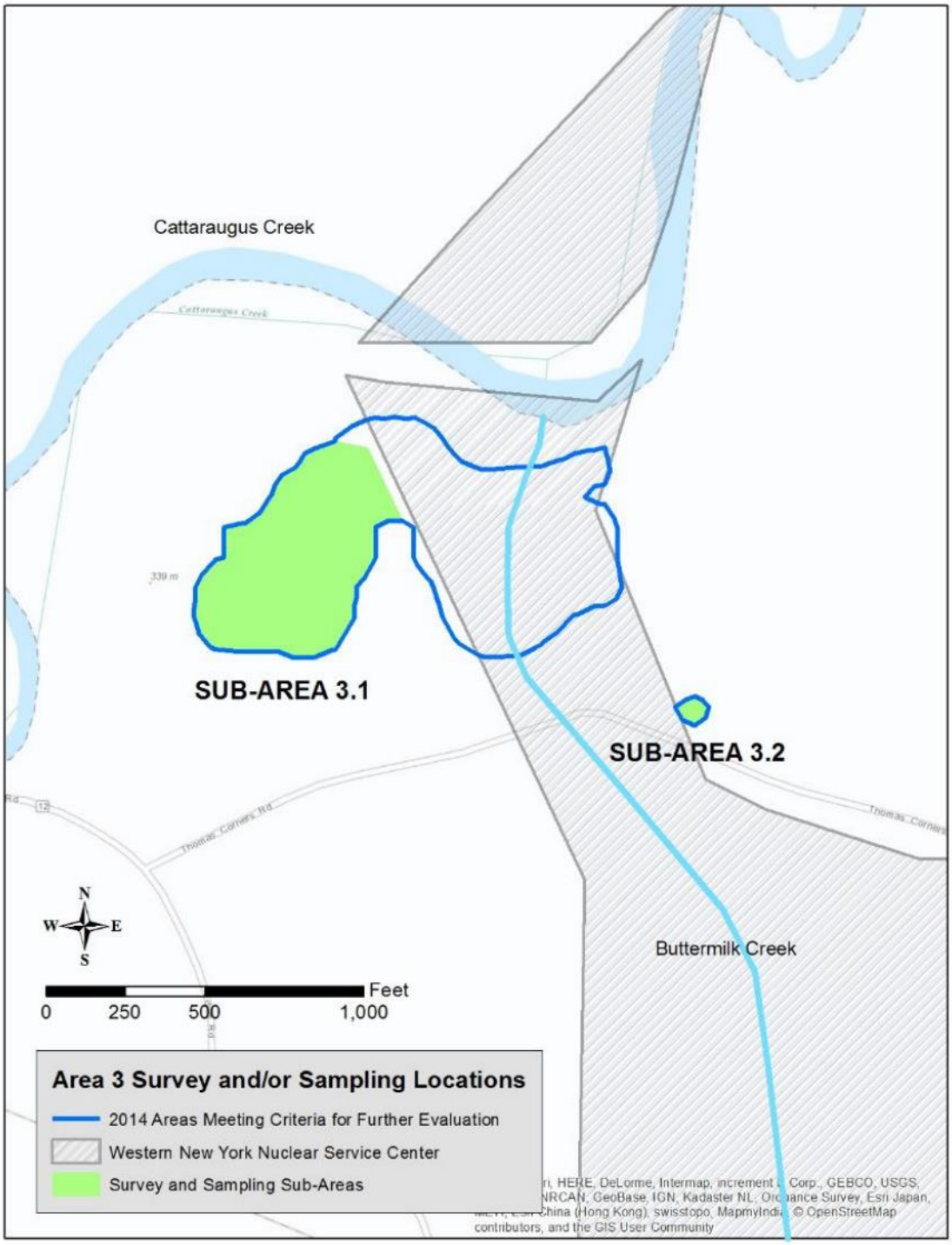



Note: The area near the center of the map was identified as meeting criteria for further evaluation; however, the landowner declined permission to survey and sample.

### 3.1.3 Area 3

Area 3 consists of two separate sub-areas adjacent to the northern section of the WNYNSC on a farm located at the confluence of Buttermilk and Cattaraugus Creeks. Figure 3 provides a map of these locations.

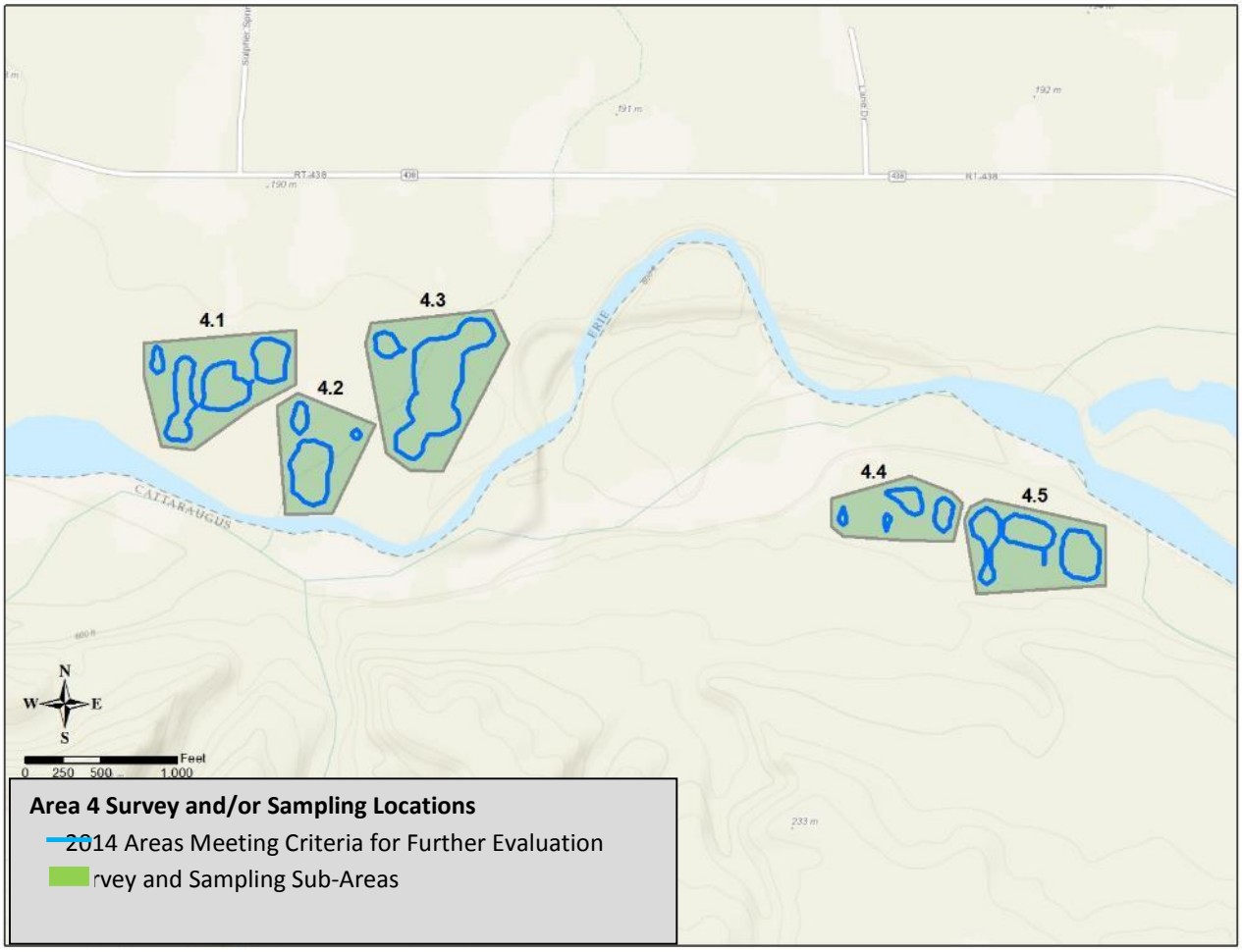
**Figure 3. Area 3 Survey and Sampling Locations**



### 3.1.4 Area 4

Area 4 consists of five separate sub-areas spanning Cattaraugus Creek, located approximately 20 miles to the west of the WNYNSC and on the Seneca Nation of Indians Cattaraugus Territory. Figure 4 below provides a map of these locations.

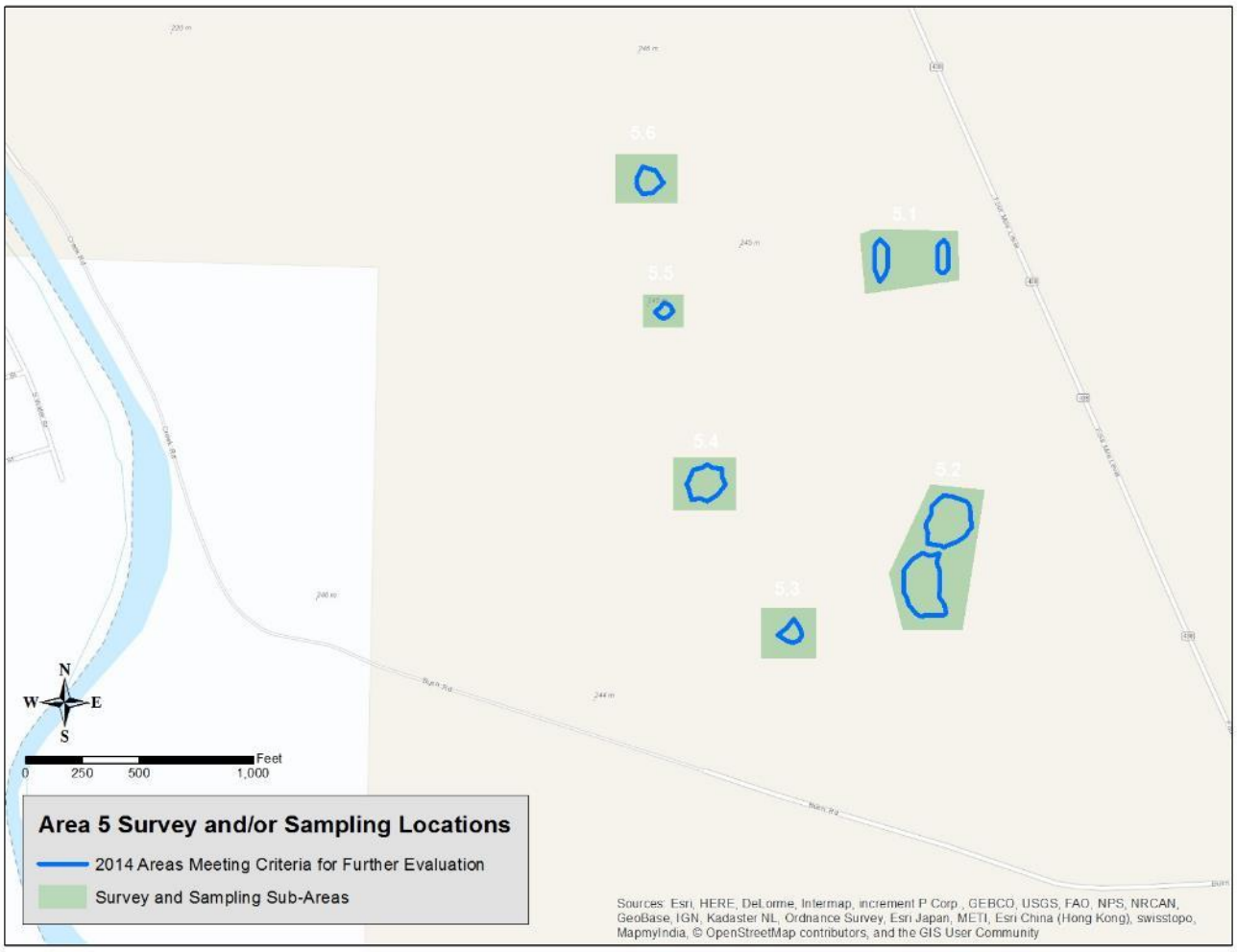
**Figure 4. Area 4 Survey and Sampling Locations**



### 3.1.5 Area 5

Area 5 consists of six separate sub-areas north of Cattaraugus Creek, located approximately 17 miles to the west of the WNYNSC and on the SNI. Figure 5 below provides a map of these locations.

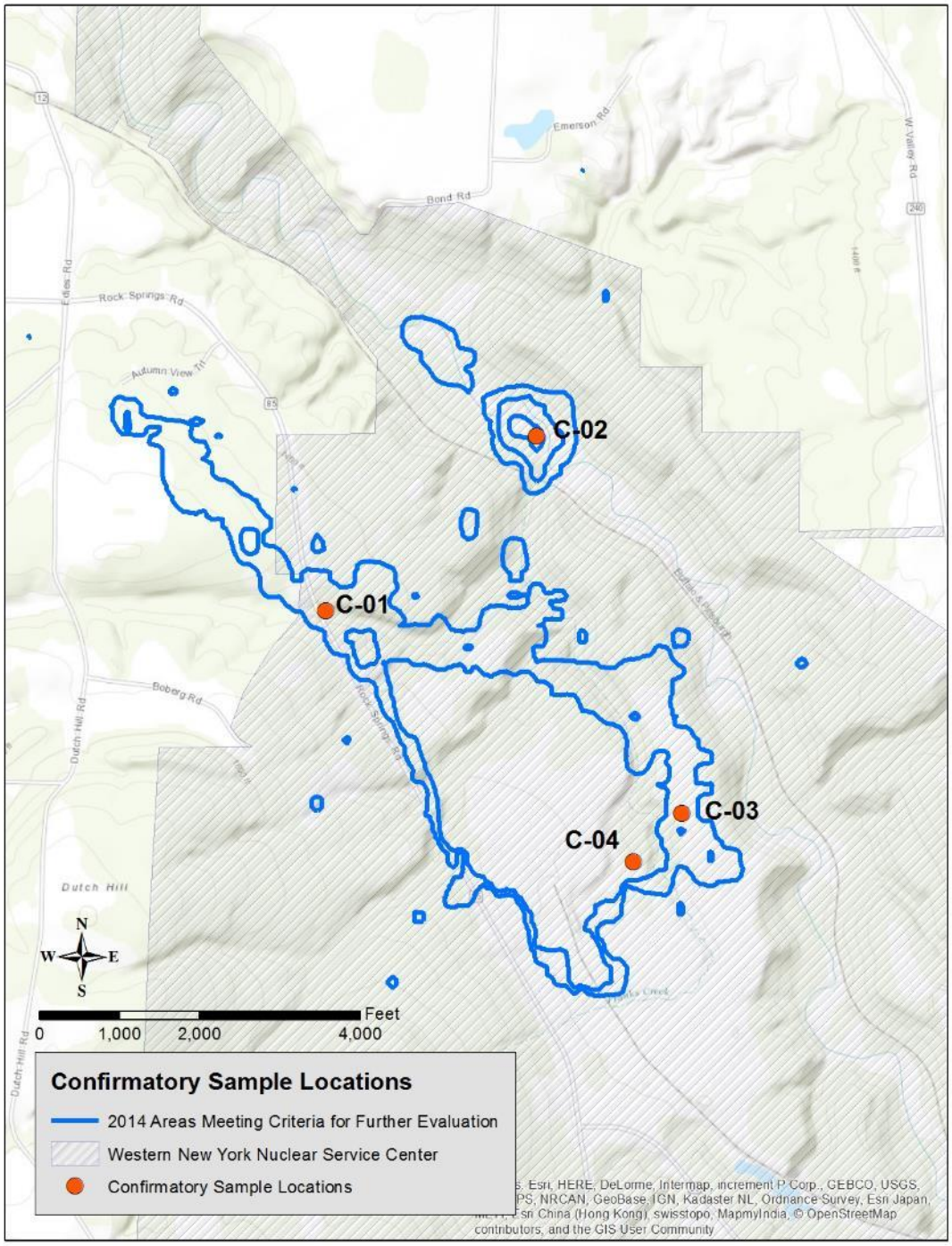
**Figure 5. Area 5 Survey and Sampling Locations**



### 3.1.6 WNYNSC Confirmatory

Four selected locations on the WNYNSC property were identified for survey and sampling. These were considered "confirmatory" locations to compare Aerial Survey results to areas known or suspected to be contaminated. Figure 6 below provides a map of these locations.

**Figure 6. WNYNSC Confirmatory Sampling Locations**



## 4.0 Data Quality Objectives

This soil sampling and dose assessment study was completed using the Plan (Ref. 4). Within the context of the Environmental Protection Agency's guidance for identifying data quality objectives (EPA QA/G-4 Guidance for the Data Quality Objectives Process, 2000), (Ref. 13) and (EPA QA R-5 EPA Requirements for Quality Assurance Planning, 2001) (Ref. 14) the rationale for the sampling approach is as follows:

1. State the problem – This soil and dose assessment effort was completed as a follow-up activity to the 2014 Aerial Survey of the WNYNSC. Specifically, the 2014 Aerial Survey identified five areas potentially having elevated levels of radioactivity above background. An aerial radiation survey does not, however, provide the data to confirm that all of the areas identified are below public health and safety standards, for example the criteria in 10 CFR 20.1402, Radiological Criteria for Unrestricted Use.

2. Identify the goals of the study - The key goal for this activity was to evaluate each of the five areas to determine if these areas do in fact contain elevated radionuclide concentrations in the soils. For those with elevated concentrations, to complete a dose assessment that evaluates the current and reasonably foreseeable future land use scenarios to determine if there are any health and safety issues for the property.

   The criteria used to evaluate each area are the NRC Radiological Criteria for Unrestricted Use (10 CFR 20.1402), which establishes the requirements that exposure for the public must be less than 25 mrem per year for license termination with unrestricted use.

3. Identify the inputs to the decision – The input to the decision of whether the decision criteria were met include:
   - The dose rate data collected during the 2014 Aerial Survey,
   - The field dose rate measurements collected for each area,
   - The soil samples collected and analyzed for specific alpha, beta and gamma-emitting radionuclides,
   - A comparison to the WVDP Phase 1 Decommissioning Plan Derived Concentration Guidelines
   - A dose assessment completed for the current land use, and
   - A conservative dose assessment using a reasonably foreseeable future land use scenario.

4. Define the boundaries of the study – The study focused on five areas identified through the aerial radiation survey, and land use information.

5. Develop the analytic approach - If the soil sampling data for cesium, gross alpha or gross beta are greater than two standard deviations above background, then a dose assessment is conducted.

   If the dose assessment information from the various evaluation methods are below 25 mrem/year, then the 10 CFR 20.1402 criteria used for comparison purposes are met.

6. Specify performance or acceptance criteria
   - Acceptance criteria developed for the aerial survey data are discussed in Section 3.1.
   - The acceptance criteria developed for the field and soil sampling data are listed below.

1. Field Survey and Soil Sampling Data Acceptance Criteria

The field survey and soil sampling acceptance criteria identified in the plan include:

a) Use of certified standards (e.g., National Institute of Standards and Technology [NIST]) to calibrate and daily evaluate the operability of instrumentation. The acceptance criteria for the instrumentation is specified in the applicable quality assurance documents for the field and laboratory instrumentation.

b) Quality control standards to ensure that the laboratory instrumentation maintained calibration during the sample analysis period. The frequency and acceptance criteria for the laboratory analyses is specified in the GEL Quality Assurance Plan, Rev. 29 (Ref. 15).

c) Field and laboratory duplicates were collected and analyzed at a frequency of 20 percent to ensure that the soil sampling and laboratory analysis methodologies were consistent with the quality control parameters defined by the laboratory.

d) Multiple sample locations and soil depths sent for analysis to ensure that the soil concentration data was representative of the area

7. Optimizing the design for obtaining data – In order to optimize the design and obtain survey data that addresses the goal of this effort, sampling was conducted using multiple survey methods and data collection efforts in order to compare the dose values calculated for each area. These multiple survey and data collection efforts included:

a) Aerial radiation survey data of the entire area identified the five locations where follow-up activities were warranted.

b) Follow-up gamma walkovers and tissue equivalent surveys were completed for each area to determine if any elevated locations were within an area, and the dose rates at each location.

c) If any elevated locations were identified they were sampled and the remainder of the random sampling was conducted based on the size of the areas. Soil samples were collected from 0-100 cm, with at least two at-depth samples collected from each area.

d) All surface soil samples were sent for gross alpha, gross beta and gamma spectroscopy.

e) Next depth interval soil sample analysis was completed if the initial surface analysis were greater than background mean plus two standard deviations.

f) Detailed radionuclide analysis was completed for a minimum of 20 percent of each area.

g) Finally, dose assessments were conducted for all areas with dose rate readings or soil sample results greater than two standard deviations above background. These assessments were compared to the 10 CFR20.1402 dose standard (25 mrem/year).

## 5.0 Field Survey and Sampling Strategy

The following is a description of the equipment and general methods used to conduct field survey and sampling operations.

### 5.1 Instrumentation and Equipment Used

Instrumentation and equipment used to collect direct radiation level measurements included:

- Bicron "microRem" Survey Meters – These instruments measure gamma radiation exposure rates using a tissue equivalent detector. The manufacturer-stated accuracy for the Bicron instruments is 10 percent (for Cs-137) across the operating ranges that were used. The internal scintillation detector is tissue equivalent and provides a flat energy response over a broad gamma energy range.
- Ludlum Model 2241-2 Scaler Ratemeter connected to a Ludlum Model 44-10 2"x2" NaI gamma detector - This instrument can collect count rates in counts per minute (CPM) or can collect scaler (static) counts (the total number of counts in a designated counting time such as one minute). The 44-10 NaI detector is nominally nine percent efficient for Cs-137, and exhibits a nonlinear energy response (the Am-241 response, for example, is typically 30-40 times higher than the response to Cs-137).
- Ludlum Model 2241-2 Scaler Ratemeter connected to a Ludlum Model 44-10 2"x2" NaI gamma detector coupled to a Trimble GeoXT-GeoExplorer GPS instrument - This system allowed for the simultaneous collection and logging of CPM and GPS location. Under ideal conditions, the GPS unit can achieve sub-meter location precision. The actual precision varied depending on the number of available satellite signals and the slope of the terrain being surveyed.
- Garmin GPSMAP 64s GPS - This GPS was used to determine the sample locations. This instrument can achieve a nominal five-meter (m) precision. The actual precision varied depending on the number of available satellite signals and the slope of the terrain being surveyed.
- NIST Traceable Thermometers – These thermometers were used to log temperatures at the beginning of a day's field operations, nominally at lunch time, and again at the conclusion of the day's operations when instrument operability and source checks (see Appendix E) were performed to verify that no substantive changes in instrument response occurred due to temperature changes. Checks were performed using both a NIST traceable Cs-137 source and a thorium check source.

All radiological detection equipment was calibrated within the last 12 months by an MJW Technical Services' NYSDOH-licensed calibration facility (Ref. 16), using NIST traceable Cs-137 calibration sources. In addition, the field operability checks were performed typically three times per day as described above (see Appendix E).

### 5.2 Overland GPS Walkover Gamma Surveys

The first step taken by the survey team was to perform a GPS walkover gamma survey of the designated survey area. The survey team walked grid patterns across the survey area with the detector suspended close to the ground. To the extent practicable, the grid pattern extended slightly beyond the borders of the designated survey area. In some locations this was not possible because of unsafe terrain or obstructions.

After the data was collected, it was downloaded and transferred to a computer. The data consisted of the measured CPM and the GPS Coordinates. The data was overlaid onto maps as color-coded dots. The color of the dots corresponded with increments of CPM. For example, the count rate increments could be 0-5000 CPM, 5000-10,000 CPM, 10,000 to 15,000 CPM, etc. The count rate color coding increments were specific to each survey area. This allowed for the most sensitive graphic analysis for each particular area.

Once displayed graphically, the data was evaluated by the PM to determine if any locations in the map showed count rates that were higher than the rest of the map (elevated locations). If elevated locations were discerned in a survey area, the PM would direct the sampling and survey team to collect at the elevated locations in addition to the random sample locations.

GPS walkover gamma surveys with the Ludlum/GPS units were not conducted in Area 1 or in the confirmatory locations in the Cesium Prong inside the WNYNSC property boundary since the objective was to measure radiation levels and collect data at specific preselected locations.

### 5.3 Direct Radiation Measurements

After the GPS Survey was completed and all sampling locations were identified, the survey team collected static direct radiation measurements at each sampling location before collecting samples.

Static radiation measurements consisted of:

- Dose rate measurements using the Tissue Equivalent Bicron survey meter at elevations of one cm and 100 cm above the ground.
- Two consecutive one-minute scaler counts using the Ludlum Scaler Ratemeter and 2”x2” NaI gamma detector, at the one and 100 cm elevations. No dose assessment was performed based on these readings.

### 5.4 Sample Collection Activities

After the direct radiation measurements were completed, soil samples were collected in accordance with the Plan and associated Field Guides.

For each sampling location, the number of samples to be collected and the increments of depth (e.g., 0-15 cm depth sample or a 15-30 cm depth sample) were predetermined in accordance with the Plan. Excavation was performed and samples were collected using hand tools in order to carefully sample from the correct depths. Sampling equipment was thoroughly cleaned in between each depth to ensure against cross-contamination of samples. Field (split) duplicates were collected in accordance with the

QAPP. Samples were placed in plastic sample bottles and labeled. Sample information was recorded on the sample bottles and on the field Chain-of-Custody Forms for transfer to a secure sample storage area to await shipment to the analytical laboratory. Equipment blanks and a sample of the deionized water used for instrument cleaning were also sent to the laboratory for quality control analysis. Appendix F provides a summary of all soil samples collected, including locations, depths, and type of laboratory analysis.

### 5.5 Radiochemical Analysis

Most of the samples collected from each area were submitted for radiochemical analysis, while others were archived as specified in the Plan. A total of 641 samples were collected in the field, and 532 were submitted for analysis to GEL Laboratories, a NYSDOH-ELAP analytical laboratory.

All samples submitted for analysis were analyzed for gross alpha activity, beta activity and by gamma spectroscopy. Some samples also underwent additional isotopic analysis. Appendix C provides further detail regarding the analyses including the isotopes, analytical method, and minimum detectable concentrations. As noted above, quality control samples, including field duplicates, equipment (rinsate) blanks, and deionized water were also collected and analyzed.

Analytical data was provided by the laboratory with two standard deviation precision. All analytical data underwent Level IV data validation in accordance with the Evaluation of Radiochemical Data Usability (Ref. 5) and all data were determined to be usable. Appendix G provides the laboratory Certificates of Analysis.

In Areas 1, 2, 3, 4, and 5 the surface samples were all analyzed and the gross alpha, gross beta and Cs-137 concentrations were compared to the background concentrations (refer to Section 6.1 for information related to determination of background). For each surface sample, the gross alpha, gross beta and Cs-137 concentration was compared to the background screening level (background plus two standard deviations); and if it exceeded the screening level, the next depth sample from that location was submitted for analysis.

## 6.0 Dose Assessment Approach

The strategy and approach to assess potential radiation doses included the following elements:

- Assessment of dose based upon the Aerial Survey data.
- Assessment of dose based on the tissue equivalent dose rate measurements.
- Assessment of dose based on soil concentrations using the RESRAD OFFSITE 3.1 computer code (Ref. 6) with input parameters adjusted to meet current land use based on land use survey forms (i.e., Recreational Hiker/Hunter, Resident Homemaker, Resident Farmer, SNI Collector, and SNI Hunter/Fisher). Appendix H provides key RESRAD information and data.
- Comparison of the surface soil concentrations to the surface soil decay-corrected $DCGL_w$ peak-of-the-mean values of the WVDP Phase 1 Decommissioning Plan. The peak-of-the mean values

are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.

**Table 2. $DCGL_w$ Peak-of-the-Mean Values, Rev. 2 for 25 mrem/year (pCi/g)**

| Nuclide | Surface Soil[(a)] |
|---|---|
| Am-241 | 2.9E+01 |
| C-14 | 1.6E+01 |
| Cm-243 | 3.5E+01 |
| Cm-244 | 6.5E+01 |
| Cs-137[(b)] | 1.5E+01 |
| I-129 | 3.3E-01 |
| Np-237 | 2.6E-01 |
| Pu-238 | 4.0E+01 |
| Pu-239 | 2.5E+01 |
| Pu-240 | 2.6E+01 |
| Pu-241 | 1.2E+03 |
| Sr-90[(b)] | 4.1E+00 |
| Tc-99 | 2.1E+01 |
| U-232 | 1.5E+00 |
| U-233 | 8.3E+00 |
| U-234 | 8.4E+00 |
| U-235 | 3.5E+00 |
| U-238 | 9.8E+00 |

[a] The $DCGL_W$ is the DCGL applicable to the average concentration over the survey unit.

[b] WVDP Phase 1 DP DCGLs for Sr-90 and Cs-137 are based on an assumption of immediate free release with no hold time for decay.

- For Areas 1-3, assessment of dose based on soil concentrations using the RESRAD 7.0 computer code (Ref. 7, Appendix H) with input parameters adjusted to account for potential future use scenarios. Appendix H provides key RESRAD information and data.
- Assessment of dose associated with the consumption of fish. Calculations were performed using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the ASER (Ref. 8). Annual exposures were calculated based on ingestion dose coefficients from the ICRP (Ref. 9).

For the current land use RESRAD calculations, Area 1 was assessed using a “Resident Homemaker” scenario; Area 2 was assessed using a “Recreational Hiker” scenario (with hunting); and Area 3 was assessed using a “Resident Farmer” scenario (for Area 3 livestock grazing and feed corn crop cultivation was assumed). Areas 4 and 5, which are located on the Cattaraugus Territory of SNI, were assessed based on culturally specific land use information for a “Collector” and a “Hunter/Fisher” scenario.

For the conservative reasonably foreseeable land use evaluation, Areas 1-3 were assessed using a “Resident Farmer” scenario with livestock and crop cultivation for consumption. The only exception was Area 2.1, where the deeply sloped terrain and extremely small size are not suitable to support a Resident Farmer land use scenario. As such, the only reasonably foreseeable land use for Area 2.1 was a

"Recreational Hiker" (with hunting), which is the same scenario as the current land use. For Areas 4 and 5, the SNI indicated that there is no expected change to the current land use for the foreseeable future.

Dose Assessments based upon soil concentrations were performed using the conservative assumptions that gross beta activity in excess of background was attributable to Sr-90, and that gross alpha concentrations, in excess of background, was attributable to either Am-241 or Pu-239 (separate calculations).

### 6.1 Background Radiation and Radionuclide Determinations

In order to assess potential radiation exposures in excess of background, it was necessary to determine background levels for all locations surveyed. This included background soil concentrations for Cs-137, gross beta and gross alpha activity. In addition, it was necessary to determine instrument backgrounds for the tissue equivalent survey meters that were used to measure direct exposure rates. Two separate background data sets were developed:

- One set of background measurements was conducted for comparison to dose rates and soil concentrations from Areas 1, 2, and 3, and the confirmatory locations on the WNYNSC property. This location is designated as "WNYNSC Background." The initial intent as specified in the Plan was to use the existing background determinations from a 2014 WVDP Terrestrial Background Study (Ref. 17). However, the DOE Background Study did not include gross alpha or gross beta soil concentrations, so it was necessary to obtain new background data as part of the current study. Ten locations were surveyed and sampled from within the two reference background areas identified in the 2014 DOE Background Study.
- A second background data set obtained for Areas 4 and 5 (SNI Background). Within this data set, two subsets of data were developed: one using data collected from the floodplain of Cattaraugus Creek for application to Area 4, and one using data collected from areas not on the floodplain for application to Area 5.

In order to account for the measurements uncertainty in a calculated average, a weighted mean was used to combine any set of similar data into a single average and its combined uncertainty. A weighted mean is used instead of standard average when the data do not all have the same level of precision. Therefore, a weighted mean was used to calculate the average external dose rates taken at a given distance and the average soil concentrations for the given depth. The equations to calculate a weighted mean for a given depth and its associated standard deviation (one sigma) are shown below:

$$Weighted\ mean\ for\ a\ given\ depth = \frac{\sum_{i=1}^{\infty} weight_i\ x\ concentration_i}{\sum_{i=1}^{\infty} weight_i}$$

$$weight_i = \frac{1}{(standard\ deviation, 1\ sigma, of\ the\ concentration)_i^2}$$

$$Standard\ deviation\ of\ the\ weighted\ mean = \sqrt{\frac{1}{\sum_{i=1}^{\infty} weight_i}}$$

### 6.1.1 WNYNSC Background Determination

Two areas on the WNYNSC property that had previously been established as reference background areas in the 2014 DOE Background Study were sampled and surveyed. For purposes of this study, they are referred to as Background Area 1 and Background Area 2. Instrument readings and soil samples were collected from five locations in each of the two areas. Instrument readings were collected in a manner identical to the field readings *collected* in each survey area (i.e., readings using the tissue equivalent Bicron Instrument and the Ludlum Instrument with 2"x2" NaI detector at elevations of one cm and one m). Sample depth increments were 0-15 cm, 15-30 cm, 30-60 m, and 60-100 cm. In each of the two areas a total of 12 samples were collected and analyzed including five samples from 0-15 cm, 5 samples from 15-30 cm, one sample from 30-60 cm, and one sample from 60-100 cm.

Figure 7 shows the location of the two background areas designated Background Area 1 (BGA1) and Background Area 2 (BGA1).

**Figure 7. General Locations of Background Areas**

Figures 8 and 9 provide closer views of each area including sample location points.

**Figure 8. Background Area 1 Sample Locations**

**Figure 9. Background Area 2 Sample Locations**


### *WNYNSC Aerial Survey Background Readings*

Figures 10 and 11 below are maps extracted from the Aerial Survey data to which the locations for Background Areas 1 and 2 have been added. The dose rates at an elevation of one m as derived from the map are presented in Table 3. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hour.

**Figure 10. WNYNSC Background Area 1 Location on the 2014 Aerial Radiological Survey**

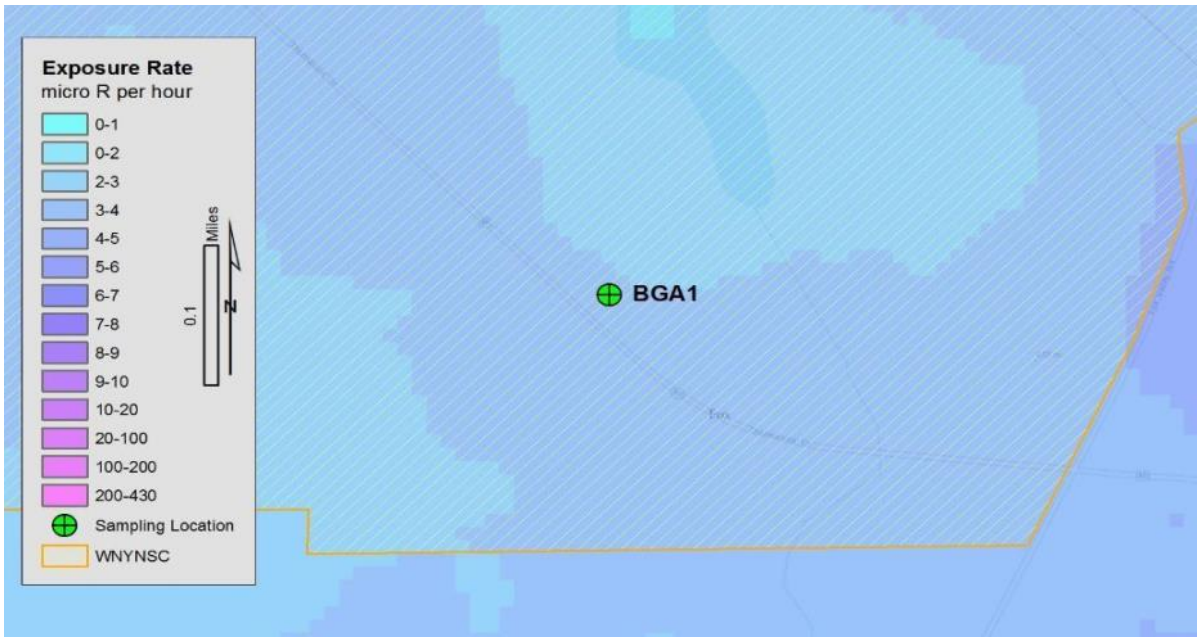



**Figure 11. WNYNSC Background Area 2 Location on the 2014 Aerial Radiological Survey**

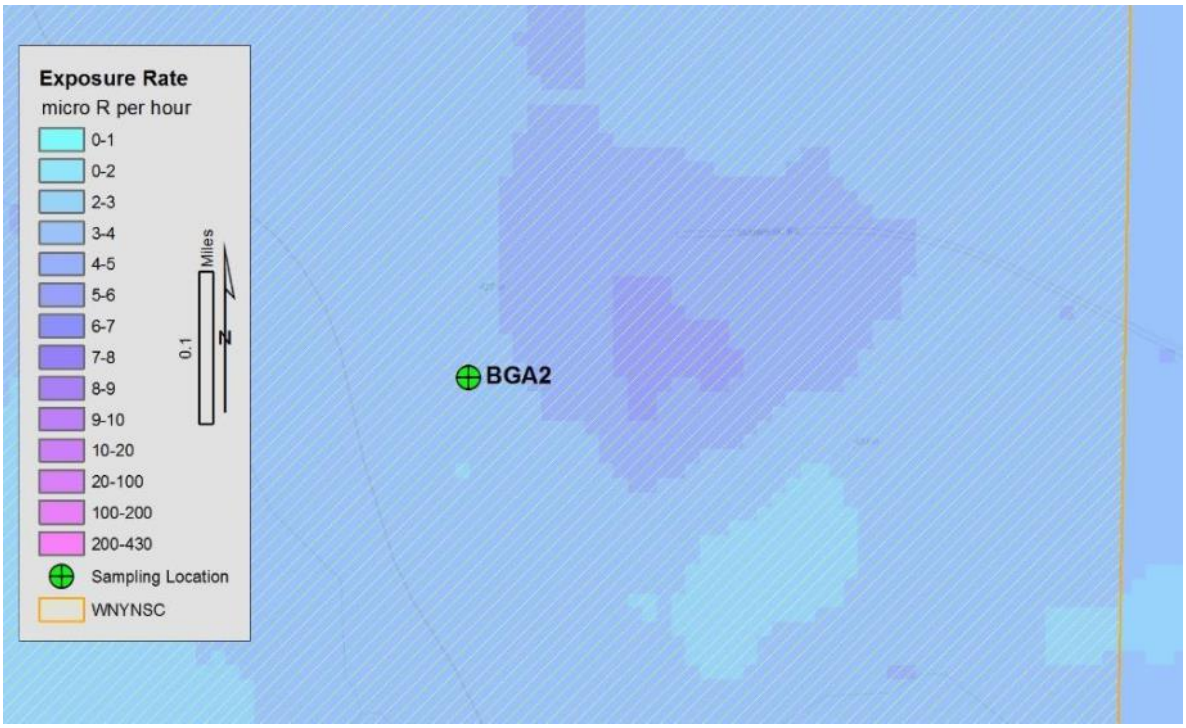


**Table 3. WNYNSC Background Area Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) | Average Dose Rate (μR/hour) |
|---|---|---|---|---|---|
| Area 1 | 3-4 | 3.5 | 4.8 | 8.3 | 8.3 |
| Area 2 | 3-4 | 3.5 | 4.8 | 8.3 | |

### *WNYNSC NaI Detector Background Readings*

The background area static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 6146 CPM to 6781 CPM at the 100 cm elevation. The average across all locations was 6333 CPM.

All background area NaI detector data is provided in Appendix H32.

### *WNYNSC Bicron Instrument Background Calculation*

The average dose rates measured using the Bicron tissue equivalent survey meters were calculated at one and 100 cm elevations. A "screening" value for comparison to the data from Areas 1, 2 and 3, and the confirmatory locations on the WNYNSC property was calculated based on the average of the readings plus two standard deviations. The results were as follows:

Average Background Bicron Instrument Reading (± 1 sigma)

- 3.69 ± 0.12 μrem/hour at the 100 cm elevation

Background Bicron Reading Based Screening Level (Average + 2 sigma)

- 3.93 μrem/hour at the 100 cm elevation

### *WNYNSC Background Soil Concentrations*

Table 4 below provides the average WNYNSC background soil concentrations at each depth:

**Table 4. WNYNSC Background Soil Concentrations**

| Depth (cm) | Alpha[a] (pCi/g) | Beta[a] (pCi/g) | Cesium[a] (pCi/g) |
|---|---|---|---|
| 0-15 | 1.2E+01 ± 5.6E-01 | 2.3E+01 ± 4.9E-01 | 2.9E-01 ± 1.3E-02 |
| 15-30 | 1.1E+01 ± 5.3E-01 | 2.0E+01 ± 4.5E-01 | 1.1E-01 ± 1.0E-02 |
| 30-60 | 1.4E+01 ± 1.2E+00 | 2.4E+01 ± 1.0E+00 | 0.0E-00 ± 1.7E-02 |
| 60-100 | 1.4E+01 ± 1.2E+00 | 2.8E+01 ± 1.1E+00 | 1.1E-01 ± 1.9E-02 |

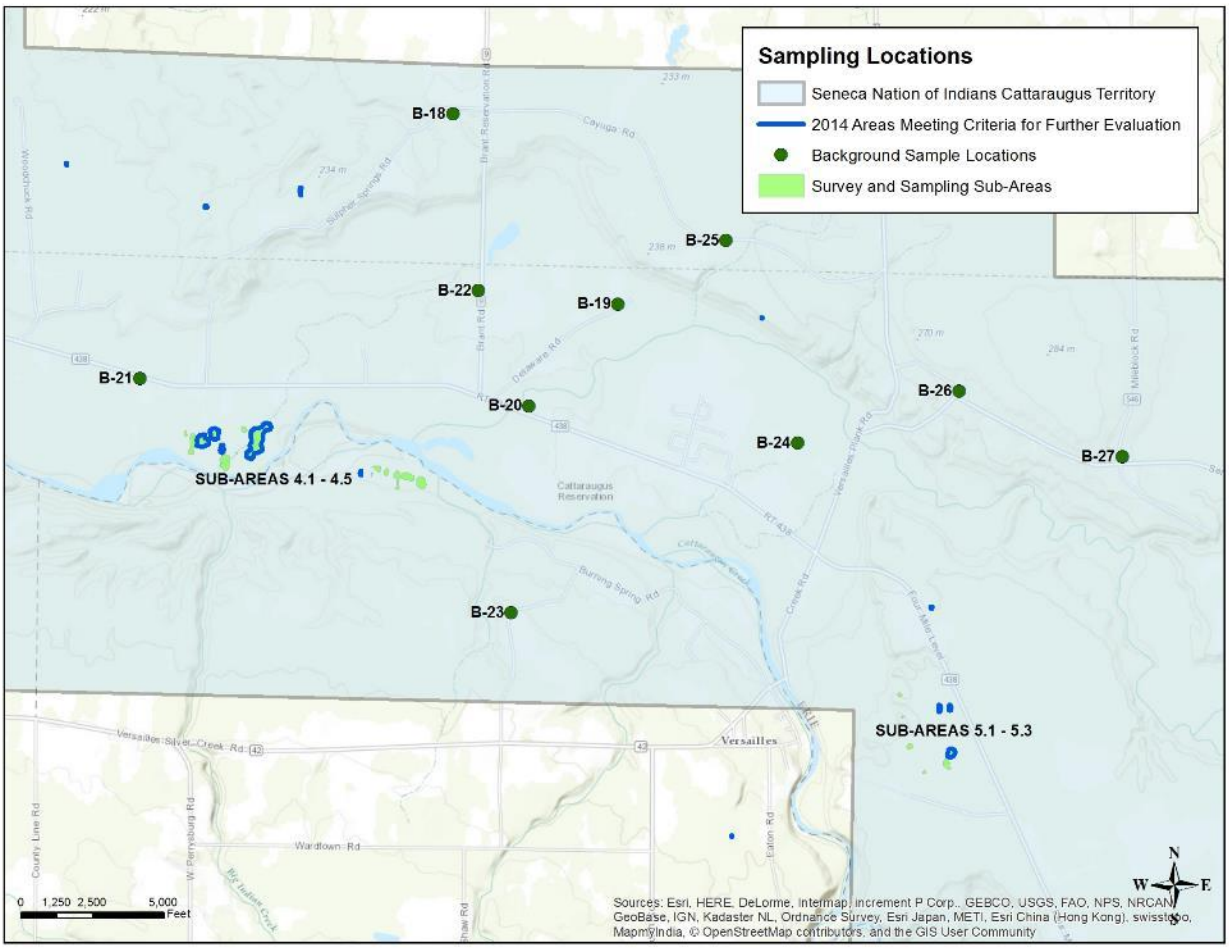
[a] Uncertainty is reported ± 1 sigma.

### 6.1.2 Seneca Nation of Indians (SNI) Background Determination

Ten background locations on the Cattaraugus Territory of the Seneca Nation of Indians were surveyed and sampled. Five locations were in the floodplain of Cattaraugus Creek (Locations 19, 20, 21, 22, and 24), while the remaining locations (18, 23, 25, 26, and 27) were not in the floodplain. Figure 12 provides a map of these locations.

Instrument readings and soil samples were collected from the 10 specified locations. Instrument readings were collected in the same manner as performed in all other areas (i.e., readings using the Bicron tissue equivalent survey meter, and the Ludlum Instrument with 2"x2" NaI detector, at elevations of 1 and 100 cm). Sample depth increments were 0-15 cm, 15-30 cm, 30-60 cm, and 60-100 cm.

**Figure 12. SNI Background Locations**




### *SNI Aerial Survey Background Readings*

Figures 13 and 14 below are maps extracted from the Aerial Survey data to which the Floodplain and Non-Floodplain locations have been added. The dose rates at an elevation of one m derived from the map are presented in Table 5 and Table 6. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hour.

**Figure 13. SNI Background Floodplain Locations on the 2014 Aerial Radiological Survey**

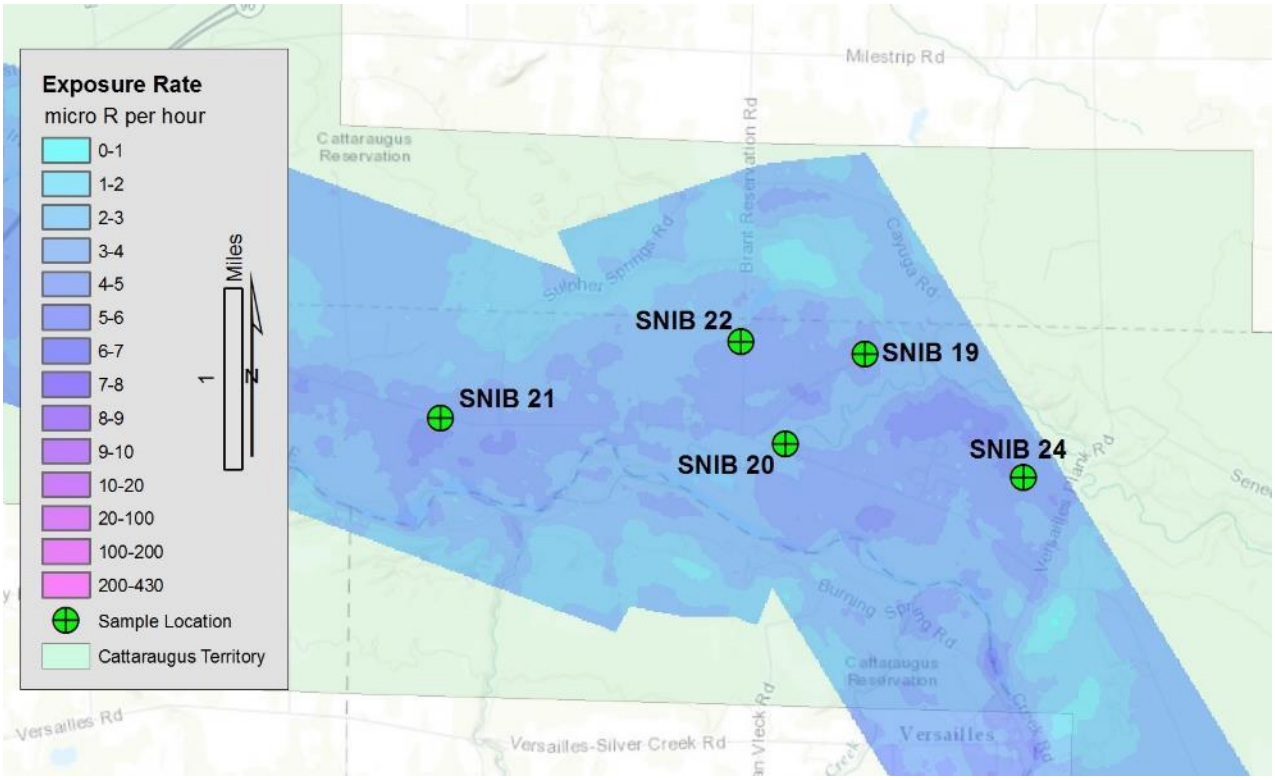



**Table 5. SNI Background Floodplain Area Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (µR/hour) | Average Dose Rate (µR/hour) | Cosmic + Radon Dose Rate (µR/hour) | Total Dose Rate (µR/hour) | Average Dose Rate (µR/hour) |
|---|---|---|---|---|---|
| SNIB 19 | 4-5 | 4.5 | 4.8 | 9.3 | 8.9 |
| SNIB 20 | 3-4 | 3.5 | 4.8 | 8.3 | |
| SNIB 21 | 4-5 | 4.5 | 4.8 | 9.3 | |
| SNIB 22 | 4-5 | 4.5 | 4.8 | 9.3 | |
| SNIB 24 | 3-4 | 3.5 | 4.8 | 8.3 | |

**Figure 14. SNI Background Non-Floodplain Locations on the 2014 Aerial Radiological Survey**

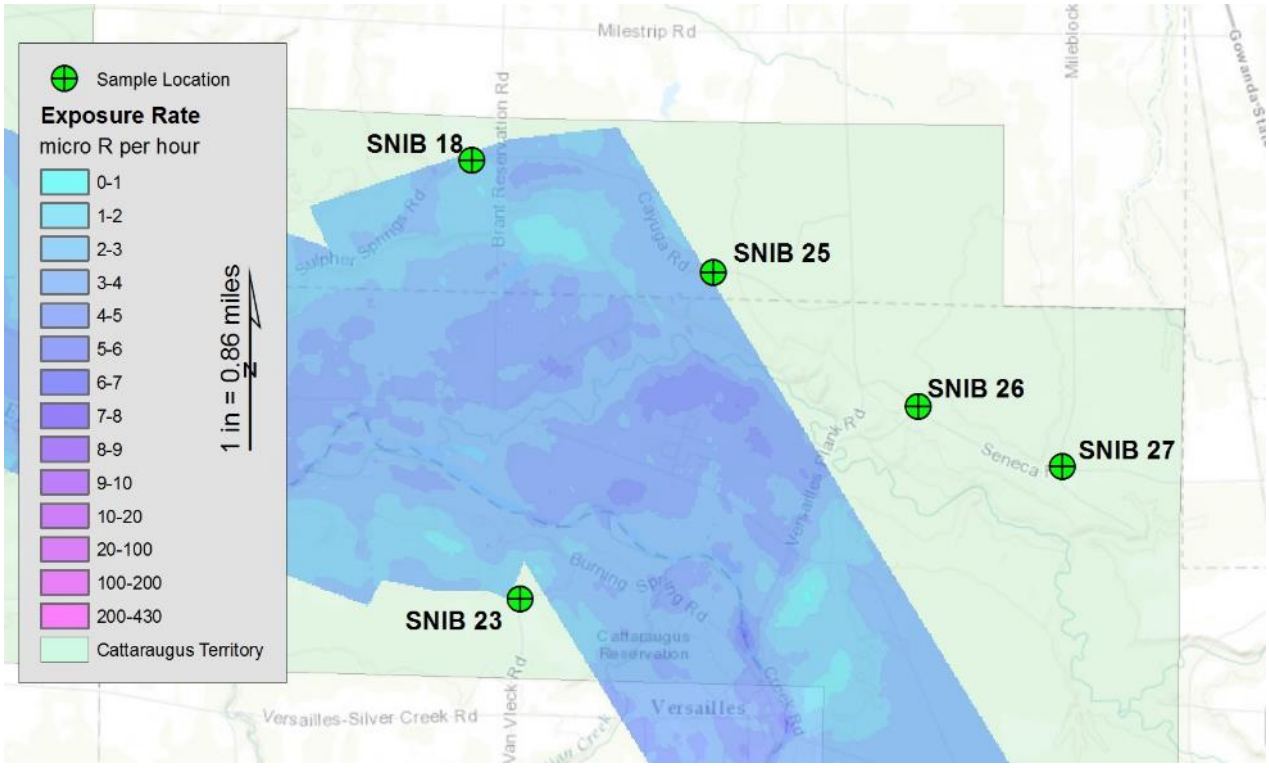



**Table 6. SNI Background Non-Floodplain Area Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) | Average Dose Rate (μR/hour) |
|---|---|---|---|---|---|
| SNIB 18 | 3-4 | 3.5 | 4.8 | 8.3 | 7.8 |
| SNIB 23 | 2-3 | 2.5 | 4.8 | 7.3 | |
| SNIB 25[a] | n/a | n/a | n/a | n/a | |
| SNIB 26[a] | n/a | n/a | n/a | n/a | |
| SNIB 27[a] | n/a | n/a | n/a | n/a | |

[a] Locations outside of aerial survey.

### *SNI NaI Detector Background Readings*

The background readings in the SNI Background floodplain locations at the 100 cm elevation ranged from 6512 CPM to 8864 CPM and averaged 7943 CPM. This background is applicable to the Areas 4.1 through 4.5.

The background readings in the SNI Background non-floodplain locations at the 100 cm elevation ranged from 7022 CPM to 12270 CPM and averaged 8745 CPM. This background is applicable to Areas 5.1 through 5.6.

### *SNI Bicron Instrument Background Calculation*

The average dose rates measured using the tissue equivalent survey meters were calculated at the one and 100 cm elevations. A "screening" value for comparison to the data from Areas 4 and 5 was calculated based on the average of the readings plus two standard deviations. The results were as follows:

SNI Average Background Bicron Instrument Readings

Floodplain Locations (± 1 sigma):

- 4.96 ± 0.22 μrem/hour at the 100 cm elevation

Non–Floodplain Locations (± 1 sigma):

- 4.40 ± 0.21 μrem/hour at the 100 cm elevation

SNI Background Bicron Reading Based Screening Level (Avg+2 sigma)

Floodplain Locations:

- 5.41 μrem/hour at the 100 cm elevation

Non-Floodplain Locations:

- 4.81 μrem/hour at the 100 cm elevation

### *SNI Background Soil Concentration Calculations*

Thirty-nine samples from 10 locations were collected to determine background for Areas 4 and 5, which are located on the SNI. Table 7 and Table 8 provide the average background concentrations by depth for the floodplain and non-floodplain background areas.

**Table 7. SNI Floodplain Background Soil Concentrations**

| Floodplain Background Soil Concentrations | | | |
|---|---|---|---|
| **Depth (cm)** | **Alpha[a] (pCi/g)** | **Beta[a] (pCi/g)** | **Cesium-137[a] (pCi/g)** |
| 0-15 | 1.5E+01 ± 8.9E-01 | 2.2E+01 ± 7.3E-01 | 7.8E-02 ± 1.2E-02 |
| 15-30 | 1.4E+01 ± 7.0E-01 | 2.5E+01 ± 6.2E-01 | 7.5E-02 ± 1.4E-02 |
| 30-60 | 1.5E+01 ± 8.7E-01 | 2.4E+01 ± 7.5E-01 | 3.5E-02 ± 1.3E-02 |
| 60-100 | 1.5E+01 ± 2.0E+00 | 2.2E+01 ± 1.5E+00 | -3.0E-03 ± 2E-02 |

[a] Uncertainty is report as ± 1 sigma.

**Table 8. SNI Non-Floodplain Background Soil Concentrations**

| Non-Floodplain Background Soil Concentrations | | | |
|---|---|---|---|
| **Depth (cm)** | **Alpha[a] (pCi/g)** | **Beta[a] (pCi/g)** | **Cesium-137[a] (pCi/g)** |
| 0-15 | 1.3E+01 ± 7.8E-01 | 2.0E+01 ± 6.2E-01 | 1.6E-01 ± 1.9E-02 |
| 15-30 | 1.4E+01 ± 7.7E-01 | 2.6E+01 ± 6.9E-01 | 9.4E-02 ± 1.3E-02 |
| 30-60 | 1.3E+01 ± 7.7E-01 | 2.6E+01 ± 7.1E-01 | 1.3E-02 ± 1.5E-02 |
| 60-100 | 2.2E+00 ± 1.8E+00 | 3.7E+01 ± 1.5E+00 | 1.0E-03 ± 1.3E-02 |

[a] Uncertainty is report as ± 1 sigma.

## 7.0 Survey, Sampling and Dose Assessment Results

### 7.1 Area 1

#### 7.1.1 Description of Area 1

Area 1 encompasses an area outside the boundaries of the WNYNSC that has been previously characterized as the "Cesium Prong." It largely consists of residential properties to the north and west of the Center boundary (see pg. 6, Figure 1).

Three locations were surveyed and sampled for comparison to data from the Off-Site Investigation Report (Ref. 10). Sample Locations 1.1 and 1.2 are in a residential area and located within 350 feet of each other in a wooded lot behind a residence. Sample Location 1.3 was located on the edge of an open field along a tree line. This area is not currently being used for farming or industrial purposes but could be used for recreation including hunting.

#### 7.1.2 Survey and Sampling Methodology for Area 1

No GPS survey was performed in Area 1 since the objective was to survey and sample at three predetermined locations in order to compare current soil radioactivity concentrations to those measured in the 1995 investigation.

To allow comparison, the survey and sampling locations were selected to coincide with locations previously sampled. Locations 1.1 and 1.2 were in proximity to the location identified as "L12" in the 1995 report (note the sample data presented in the 1995 Report were for samples collected in 1994). Location 1.3 was in proximity to the location identified as "L23" in the 1995 report. Since GPS locations for the L12 and L23 locations are not precisely known (due to technology limitations at the time), the correlation between current and former locations was only approximate.

Direct radiation readings and soil samples were collected in the three locations as described above and in Table 3 of the Plan.

Each location was surveyed and sampled as follows:

- Dose rate readings were collected at one and 100 cm from the ground surface using the tissue equivalent dose rate meter.
- Static 2" x 2" NaI detector readings were collected at one and 100 cm from the ground surface using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two, one-minute scaler counts were collected at one and 100 cm elevations.
- A total of nine soil samples were collected at each of the three soil depth intervals; 0 to 5 cm, 5-15 cm and 15-30 cm.

### 7.1.3 Survey and Sampling Results for Area 1

As noted above, no GPS survey was required for Area 1 since the goal was to compare current to past soil concentration data.

#### *Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation*

- The Area 1 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7607 CPM to 8361 CPM. The average across all locations was 7876 CPM.
- The applicable background count rate for Area 1 was determined to be 6333 CPM.

A tabulation of the static count rates is provided in Appendix H32.

#### *Tissue Equivalent Survey Meter Readings*

Table 9 provides the tissue equivalent dose rate readings (including background) for each sample location.

**Table 9. Area 1 Tissue Equivalent Dose Rate Instrument Gross Readings**

| Sample Location | Dose Rate at 100 cm (μrem/hour) |
|---|---|
| 1.1 | 4 |
| 1.2 | 5 |
| 1.3 | 6 |

#### *Soil Sample Comparison to Background*

Six soil samples from the 0-5 and 5-15 cm depths were analyzed by gamma spectroscopy and for gross alpha and gross beta activity. Due to the proximity in geographic location, the soil concentration values for Locations 1.1 and 1.2 were averaged together for data comparison and dose assessment purposes.

The weighted average soil concentrations for gross alpha, gross beta and Cs-137 results associated with the 0-15 cm depth are summarized in Table 10. In this study, the Area 1 samples were collected at depths of 0-5 cm and 5-15 cm, while the background samples were collected at 0-15 cm and 15-30 cm depths. Therefore, a weighted average for the 0-15 cm Area 1 depth was calculated as follows in order to compare the soil concentration to an equivalent background depth.

The individual soil concentrations including background for Area 1, associated with multiple independent depths were combined into a single average soil concentration over a single depth. The weight given to any single layer was based on the thickness of each individual soil depth as compared to the overall thickness of the combined layer. This is shown in the following equations below:

$$weight_i = \frac{thickness_i}{\sum_{j=1}^{\infty} thickness_j}$$

$$Weighted\ average\ over\ multiple\ depths = \sum_{i=1}^{\infty} weight_i\ x\ concentration_i$$

**Table 10. Area 1 Weighted Average Soil Concentrations**

| Location | Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|---|
| 1.1/1.2(L12[b]) | 0-15 | 8.6E+00 ± 7.9E-01 | 1.9E+01 ± 7.7E-01 | 1.1E+00 ± 4.1E-02 |
| 1.3(L23[c]) | 0-15 | 1.0E+01 ± 1.3E+00 | 2.3E+01 ± 1.2E+00 | 4.6E-01 ± 5.6E-02 |

a. Uncertainty is reported ± 1 sigma.

b. Locations 1.1 and 1.2 were combined and compared to the sample collected at the location associated with the L12 described in the 1995 Report.

c. Location 1.3 was compared to the sample collected at the location associated with the L23 described in the 1995 Report.

The weighted average gross alpha and gross beta concentrations were less than background soil concentrations provided in Section 6.1 and therefore no further analysis was performed related to the gross alpha and gross beta data. The Cs-137 soil concentrations were above the background soil concentrations provided in Section 6.1; therefore, they were compared to the decay corrected 1995 data as described below.

### *Comparison of Soil Sample Concentrations to Decay Corrected 1995 Report Concentrations*

The Cs-137 soil concentrations values from the 1995 report, plus 10 percent were adjusted for decay (activity on the date of the sample analysis would be 61.8 percent of the 1994 activity), and compared to the two standard deviation concentration range for the corresponding 2014 samples as shown in Table 10. The samples collected in 1994 were collected at a depth of 0-10 cm and therefore, the weighted averages in Table 10 were recalculated (using the same formula as above) for a depth of 0-10 cm in order to make a comparison at equivalent depths (see Table 11).

**Table 11. Area 1 Cesium-137 Soil Concentrations Comparison**

| 1994 Location | 2015 Location | Depth (cm) | 1994 Sample Result (pCi/g) | 1994 Sample Result Decay Corrected Plus 10% (pCi/g) | 2015 Sample Result (pCi/g) |
|---|---|---|---|---|---|
| L12 | 1.1 / 1.2 | 0-10 | 1.6E+00±2.0E-01 | 1.1E+00 | 1.5E+00±5.0E-02 |
| L23 | 1.3 | 0-10 | 3.4E-01±4.0E-02 | 2.3E-01 | 4.4E-01±6.0E-02 |

The current soil concentrations were not less than the decay corrected data plus 10 percent. Some possible factors that could explain this difference include:

- Changes in soil depth sampling intervals from the 1995 sampling activities. Specifically, the 2015 samples were collected at 0-5 cm, 5-15 cm, and 15-30 cm, while the 1995 soil samples were collected at 0-4 inches (0-10 cm) and 4-10 inches (10-25 cm). In order to compare these results, a weighted average was calculated for the 1995 and 2015 samples. In both sampling activities, the shallow soil samples contained the highest concentrations and largest degree of variability, thereby providing these decay corrected differences.
- GPS did not exist and the current sampling locations are only approximate to the previous sample locations. This slight difference in location could result in differences in surficial soil sample locations and results.
- Possible migration of activity from natural environmental factors (e.g., wind, rain and snow).

Since the current results were not less than the 1994 values plus 10 percent corrected for decay, the current soil concentrations, net of background, were used to perform a dose assessment for Area 1 as described in Section 7.1.4 (see Table 12).

**Table 12. Area 1 Net Average Soil Concentrations**

| Location | Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|---|
| 1.1/1.2(L12[a]) | 0-100 | 0.0E+00 | 0.0E+00 | 7.9E-01 |
| 1.3(L23[b]) | 0-100 | 0.0E+00 | 7.0E-03 | 1.7E-01 |

a. Locations 1.1 and 1.2 were combined and compared to the sample collected at the location associated with the L12 described in the 1995 Report.

b. Location 1.3 was compared to the sample collected at the location associated with the L23 described in the 1995 Report.

The individual sample numbers, depths, concentrations, uncertainties, and minimum detectable levels (MDLs) are provided in Appendix H2.

### 7.1.4 Dose Assessment Approach for Area 1

The dose assessment approach for Area 1 was to:

- Develop an estimate of annual exposure based upon the 2014 Aerial Survey.
- Develop an estimate of annual exposure based upon the tissue equivalent meter readings.
- Perform an assessment based on the current land use Resident Homemaker scenario to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed.

Dose assessments associated with soil data were performed using the RESRAD-OFFSITE 3.1 computer code. Hydrology data for the contaminated, unsaturated, and saturated zones were based on Revision 2 of the Phase 1 Decommissioning Plan for the West Valley Demonstration Project. The

RESRAD input parameters used that differed from the RESRAD defaults are summarized in Appendix H3. In cases where area specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modifications are described below and in Appendix H3. This would include, but are not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where there were no site-specific data or there was no corresponding Decommissioning Plan value, the RESRAD-OFFSITE default parameters were used.

The Area 1 dose assessment was based on a Resident Homemaker. The resident is assumed to spend eight hours sleeping and another eight hours working inside the dwelling. Of the remaining eight hours, 50 percent is assumed to be spent inside the dwelling (bringing total time in the dwelling to 20 hours) and 50 percent is assumed to be spent outside in the elevated area (bringing the total time spent outside the dwelling to four hours). It is assumed that this Resident Homemaker also hunts deer and consumes the deer meat. No plant, fish, or dairy cattle milk is consumed from this area. The Resident Homemaker's dwelling is located on-site and within the area assessed.

In addition, no irrigation was assumed for any part of Area 1. The evapotranspiration coefficient provided in the Decommissioning Plan was recalculated to maintain the same infiltration rate of 0.26 m per year. The soil erodibility factor, which is used to calculate the erosion rate, was set to the maximum value of the default range (0 to 0.5) in the User Manual for RESRAD-OFFSITE 3.1 (Ref. 6). This will allow transport of elevated concentrations from these areas to the surface water and subsequently ingested by the deer, which is then consumed by the Resident Homemaker.

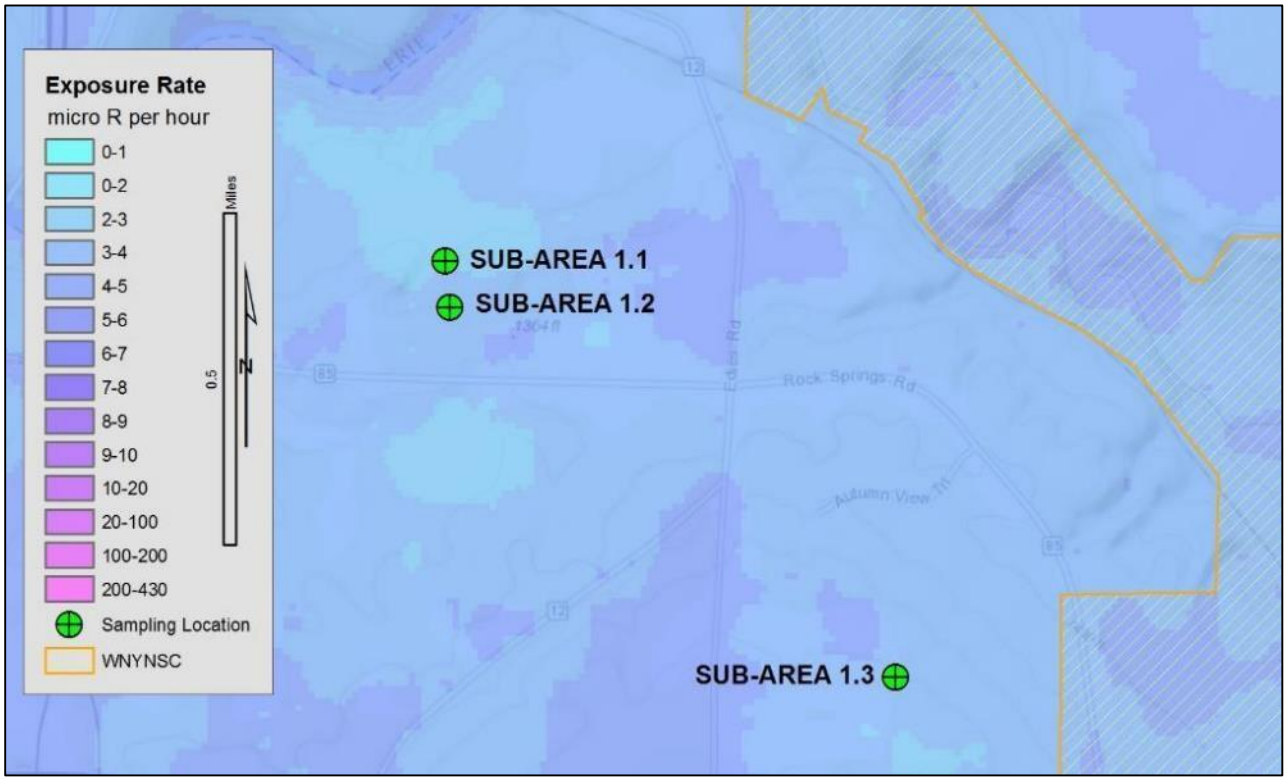
- The sample results were compared to the $DCGL_w$ concentrations established in the Phase 1 Decommissioning Plan for the WVDP. The peak-of-the-mean values are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.
- Perform an assessment based on a conservative potential use scenario of a Resident Farmer's exposure to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed. Dose assessments associated with soil data were performed using the RESRAD 7.0 computer code. RESRAD input parameters were based on Revision 2 of the Phase 1 Decommissioning Plan for the West Valley Demonstration Project Appendix C. The RESRAD input parameters are summarized in Appendix H33.
- Perform an assessment based on consumption of fish caught from the Cattaraugus Creek. Current land use surveys indicate that in Areas 1, 2, and 3, no consumption of fish occurs. Calculations were performed using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the ASER (Ref. 8). Annual exposures were calculated based on ingestion dose coefficients from the ICRP (Ref. 9).

### 7.1.5 Dose Assessment Results for Area 1

### *Dose estimate based upon 2014 WNYNSC Aerial Survey Data*

Figure 15 below is an aerial radiological survey map extracted from the Aerial Survey data to which the locations for Areas 1.1, 1.2, and 1.3 have been added. The dose rates at an elevation of 100 cm as derived from the map were determined to be 2-3 (μR/hour) for Area 1.1 and 3-4 (μR/hour) for Areas 1.2 and 1.3. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hour.

**Figure 15. Area 1 Locations on the 2014 WNYNSC Aerial Radiological Survey**




Based on this aerial map and the assumed cosmic and airborne radon contribution, the dose rates were determined for Area 1 as shown in Table 13. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings derived from Figure 15 to account for the contribution to background from cosmic radiation and airborne radon.

**Table 13. Area 1 Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| Sub-Area L12 (1.1+1.2) | 2-3 | 2.5 | 4.8 | 7.3 |
| | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area L23 (1.3) | 3-4 | 3.5 | 4.8 | 8.3 |

The average background dose rate based on the WNYNSC Aerial Survey was 8.3 μR/hour at 100 cm above the ground. This was subtracted from the total doses rate in Table 13, and based on an average occupancy time of 365 days per year, the calculated doses for Area 1 are provided in Table 14.

**Table 14. Area 1 Calculated Doses Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Total Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Annual Occupancy Time[a] (hours/year) | Annual Dose Rate[b] (mrem/year) |
|---|---|---|---|---|
| Sub-Area L12 | 7.8[c] | 8.3 | 8670 | 0.0 |
| Sub-Area L23 | 8.3 | 8.3 | 8670 | 0.0 |

a. Occupancy hours are divided into 83.3 percent indoors and 16.7 percent outdoors; a 0.273 gamma shielding fraction is applied to the time indoors.

b. The aerial survey dose rates were recorded in units of Roentgen. The quality factors for photons and electrons are both one; therefore, 1 R equals 0.877 rem.

c. Average of Sub-Areas 1.1 and 1.2.

### *Dose Estimate Based on Tissue Equivalent Survey Meter Readings*

All three survey locations exhibited dose rates in excess of background at the 100 cm elevation. The average dose rate for Sub-Area L12 was 4.4 ± 0.3 μrem/hour at 100 cm (± 1 sigma). The average dose rate for Sub-Area L23 was 6 ± 0.6 μrem/hour at 100 cm (± 1 sigma). The dose rate net of background in Sub-Area L12 and L23 respectively was 0.7 and 2.3 μrem/hour at 100 cm. As a result, the annual estimated dose at these locations based on 8760 hours (the occupancy hours derived from the RESRAD Scenario for Area 1) of which 83.3 percent of the time is spent indoors (with a 0.273 gamma shielding fraction) and 16.7 percent of the time is spent outdoors, is 2.4 mrem and 8.0 mrem per year, respectively.

### *Current Use RESRAD Dose Assessment Based Upon Soil Concentrations Assuming a Resident Homemaker Scenario*

#### Sub-Area L12

Sub-Area L12 was defined as a 69,600-square-m piece of property (see Figure 16). The deer associated with Sub-Area L12 are assumed to stay within the boundaries of the road. This results in a deer pasture area of about 1,062,100 square meters. In addition, the creek bed to the north of the elevated area is assumed to provide the drinking water resources for the deer. The creek is assumed to be about 50 meters wide and averages about one-m deep over the course of the year.

**Figure 16. Sub-Area L12**


Soil samples for Sub-Area L12 from Locations 1.1 and 1.2 were analyzed for the first 15 cm of soil. Therefore, the assumption was made that the entire first meter of soil was the same average soil concentrations as the first 15 cm.

The exposure to a Resident Homemaker in Sub-Area L12 that also consumed deer meat is provided in Table 15. The RESRAD input parameters are provided in Appendix H3.

**Table 15. Sub-Area L23 Current Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|
| 1.02E-00 | 6.34E-07 | 2.94E-03 | 7.14E-04 | 1.02E-00 |

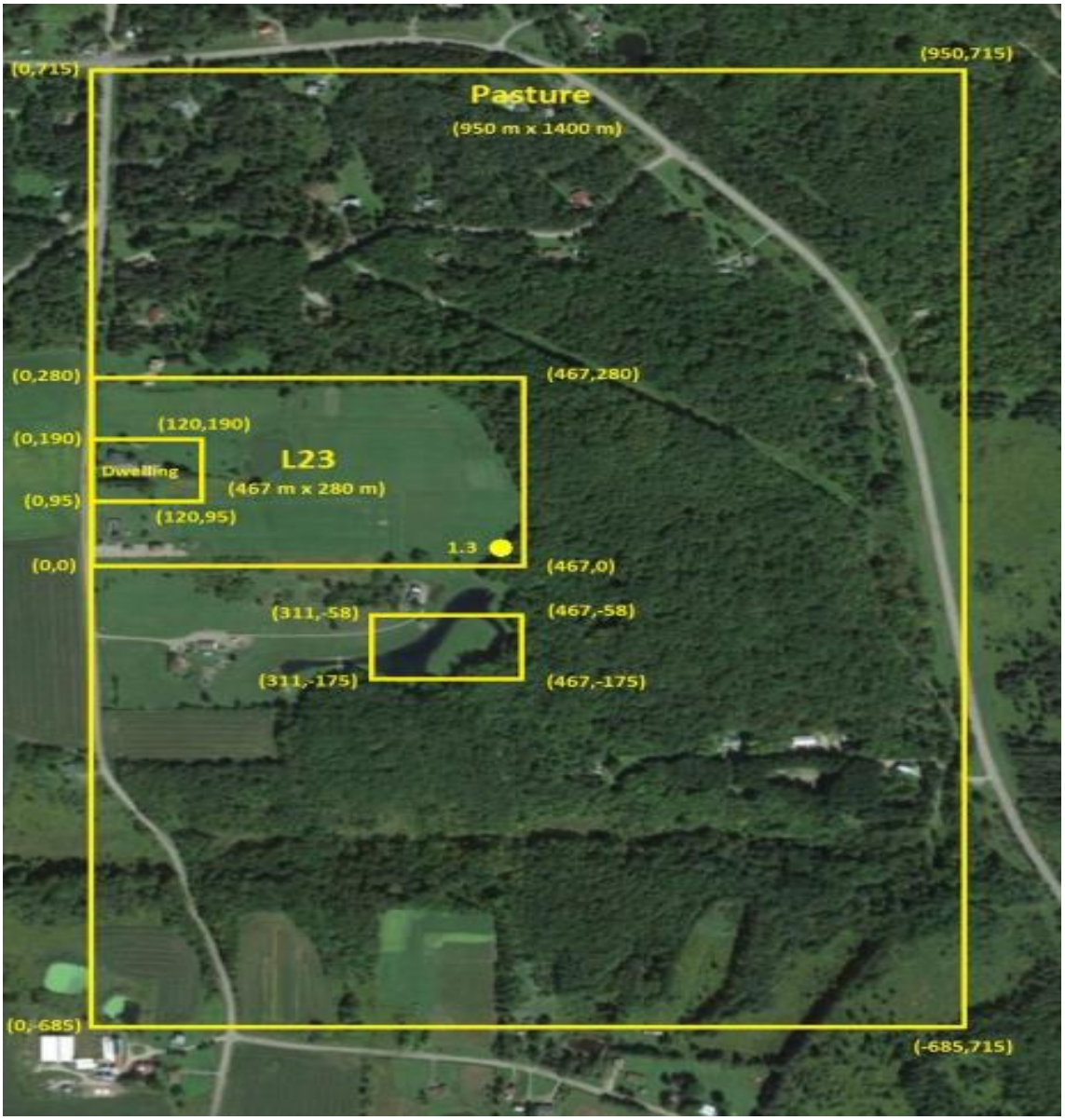
The main source of exposure is direct external from the ground. This accounted for over 99 percent of the overall exposure. The full RESRAD output file is provided in Appendix H8.

### Sub-Area L23

Sub-Area L23 was defined as a 130,760-square-m piece of property (Figure 17). The deer associated with Sub-Area L23 are assumed to stay within the boundaries of the creek and the road. This results in a deer pasture area of about 1,330,000 square meters. In addition, the pond area to the south of the elevated

area is assumed to provide the drinking water resources for the deer. The pond is estimated to be about 18,252 square meters and averages about one-m deep over the course of the year.

**Figure 17. Sub-Area L23**




Soil sample for Sub-Area L23 from Locations 1.3 was analyzed for the first 15 cm of soil. Therefore, the assumption was made that the entire first m of soil was the same average soil concentrations as the first 15 cm.

The exposure to a Resident Homemaker in Sub-Area L23 that also consumed deer meat is provided in Table 16. The RESRAD input parameters are provided in Appendix H3.

**Table 16. Sub-Area L23 Current Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|
| 2.19E-01 | 3.86E-07 | 1.34E-03 | 1.72E-04 | 2.21E-01 |

The main source of exposure is direct external from the ground. This accounted for over 99 percent of the overall exposure. The full RESRAD output file is provided in Appendix H9.

### *Comparison to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values for Area 1*

Table 17 provides a comparison of the Area 1 soil concentrations to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values.

**Table 17. Area 1 Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$**

| Measurement Type | Nuclide Used | WVDP DCGL (pCi/g) | Net Soil Concentrations (pCi/g) | | Comparison | |
|---|---|---|---|---|---|---|
| | | | L12 | L23 | L12 | L23 |
| Alpha | Pu-239 | 2.50E+01 | 0.0E+00 | 0.0E+00 | Below | Below |
| Beta | Sr-90 | 4.10E+00 | 0.0E+00 | 7.0E-03 | Below | Below |
| Cesium | Cs-137 | 1.50E+01 | 1.7E+00 | 1.7E-01 | Below | Below |
| | | | | Sum of the Fractions: | Below | Below |

The assessment of the gross alpha and beta based on the most conservative isotopes (Pu-239 and Sr-90, respectively) will account for all of the anthropogenic nuclides listed in Table 2 except for C-14, I-129, and Tc-99. For these radionuclides, a qualitative analysis was performed. In all cases for these three radionuclides, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the radionuclides that account for most of the gross alpha and beta soil concentrations are radionuclides that are considered naturally occurring radioactive material (NORM) (e.g., natural uranium, natural thorium, and potassium-40).

Therefore, the use of the $DCGLs_w$ based on the WVDP Phase 1 Decommissioning Plan Resident Farmer scenario and gross results assuming the most conservative nuclides result in a highly conservative comparison.

### *Conservative Potential Use RESRAD Dose Assessment Based Upon Soil Concentrations Assuming a Resident Farmer Scenario*

#### Sub-Area L12

Sub-Area L12 was defined as a 69,600-square-m piece of property (see Figure 16). This assessment is based on a Resident Farmer scenario. It is assumed that the farmer's dwelling, crop fields, and pasture lands resides in the elevated area. In addition, the crop that is grown is consumed by the farmer. The farmer also maintains and consumes both dairy and meat from the cattle. The annual exposure for Sub-Area L12 is provided in Table 18. The RESRAD input parameters are provided in Appendix H33.

**Table 18. Sub-Area L12 Potential Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Milk (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.11E+00 | 5.55E-07 | 2.08E-01 | 1.21E-01 | 2.23E-01 | 6.50E-04 | 1.66E+00 |

The full RESRAD output file is provided in Appendix H34.

### Sub-Area L23

Sub-Area L23 was defined as a 130,760-square-m piece of property (Figure 17). This assessment is based on a Resident Farmer scenario. It is assumed that the farmer's dwelling, crop fields, and pasture lands resides in the elevated area. In addition, the crop that is grown is consumed by the farmer. The farmer also maintains and consumes both dairy and meat from the cattle. The annual exposure for Sub-Area L23 is provided in Table 19. The RESRAD input parameters are provided in Appendix H33.

**Table 19. Sub-Area L23 Potential Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Milk (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 2.40E-01 | 3.38E-07 | 8.60E-02 | 3.07E-02 | 5.74E-02 | 1.56E-04 | 4.14E-01 |

The full RESRAD output file is provided in Appendix H35.

### *Dose Assessment for Consumption of Fish Based Upon 2012 WVDP Annual Site Environmental Report*

The ASER (Ref. 8) provides radiological concentrations of strontium and cesium in the edible portion of the fish in Cattaraugus Creek. Biological data from these locations are provided. Hog-nosed Sucker and White Sucker are sampled from above the Springville Dam, and Steelhead Trout are sampled from below the Springville Dam. Brown Trout, White Sucker, Bullhead, and Hog-nosed Sucker were also sampled at a background location. This data is provided in Appendix H41. The average radiological concentrations of strontium and cesium in the edible portion of the fish for the two areas around Springville Dam and the background area are provided in Table 20 and Table 21 below.

**Table 20. Concentrations in Edible Portions of Fish around Springville Dam**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.40E-08 | 1.16E-09 | µCi/g - wet |
| Cs-137 | 5.46E-08 | 1.31E-08 | µCi/g - wet |

**Table 21. Background Concentrations in Edible Portions of Fish**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.02E-08 | 1.77E-09 | µCi/g - wet |
| Cs-137 | 4.75E-08 | 4.00E-08 | µCi/g - wet |

This results in a net above background concentration in the edible portions of the fish of 3.74E-09 µCi Sr-90 per gram of fish flesh and 7.08E-09 µCi Cs-137 per gram of fish flesh. The ingestion dose coefficients factor (DCF) and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 22.

**Table 22. Ingestion dose coefficients (mrem / µCi) from ICRP 68**

| Isotope | f1* | DCF | Units |
|---|---|---|---|
| Sr-90 | 0.3 | 1.04E+02 | mrem/µCi Ingestion |
| Sr-90 | 0.01 | 1.00E+01 | mrem/µCi Ingestion |
| Cs-137 | 1 | 4.81E+01 | mrem/µCi Ingestion |

* f1 – Fractional absorption in the gastrointestinal tract rate.

EPA's Exposure Factors Handbook (Ref. 18) indicates that the 95$^{th}$ percentile of fish consumption by recreational anglers is about nine kilogram (kg) of fish per year. This results in an annual exposure rate of less than 0.1 mrem per year.

### 7.1.6 Conclusions for Area 1

Annual doses based on the Aerial Survey, tissue equivalent survey meter readings, and RESRAD analysis ranged from 0.0 to 8.0 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that Area 1 is well below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 C.F.R. § 20.1402.

## 7.2 Area 2

### 7.2.1 Description of Area 2

Area 2 consisted of two sub-areas (Area 2.1 and Area 2.2). These areas lie in a region nominally three miles to the northwest of the WVDP that is transected by the Route 219 Expressway. Area 2.1 is to the north and on the west side of the expressway, while Area 2.2 is to the south on the east side of the Expressway (see pg. 7, Figure 2). Area 2.1 and Area 2.2 are both sloped, and tree covered.

### 7.2.2 Survey and Sampling Methodology for Area 2

#### *GPS Walkover Gamma Surveys of Area 2*

Because both areas were steeply sloped, making footing in some places treacherous, coupled with the heavy tree cover interfering with GPS satellite signal reception, it was not possible to utilize the GPS and automated data logging system. As specified in the Plan, the contingency method of laying out a grid system and collecting data by hand in discrete locations was employed.

The 2"x 2" gamma detector survey grid readings in Area 2.1 were on average lower than the readings in Area 2.2. An evaluation of the readings for each individual sub-area however did not identify zones within either sub-area that were elevated compared to the rest of the readings from that particular sub-

area. Consequently, the random sampling locations and survey locations were used. Figures 18 and 19 show the sampling locations in Sub-Areas 2.1 and 2.2, respectively.

The general orientation of the Cesium Prong as it projects outward from the WNYNSC is in a northwest direction on an axis, which roughly transects Area 2.1 and 2.2 on the map. In light of the elevations of the areas and their alignment with the direction of the Cesium Prong, there is supposition that any anthropogenic contamination on these sites could be from an airborne deposition pathway. As a result, the surface samples in Area 2 were collected in a 0-5 cm increment, which is where most contamination was predicted from an air deposition pathway.

**Figure 18. Sub-Area 2.1 Survey and Sampling Locations**

**Figure 19. Sub-Area 2.2 Survey and Sampling Locations**


Direct radiation readings and soil samples were collected in four locations in each sub-area as described below.

- Dose rate readings were collected at one and 100 cm from the ground surface using the tissue equivalent dose rate meter.
- Static 2" x 2" NaI detector readings were collected at one and 100 cm from the ground surface using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two, one- minute counts were collected at each location at both elevations.
- Soil samples were collected in depth increments of 0-5 cm, 5-15 cm, and 15-100 cm. Four locations were sampled in each of Sub-Areas 2.1 and 2.2. Samples were collected from the first two depths at all locations. Samples were collected from the 15-100 cm depth at all locations in Sub-Area 2.2. Due to the difficult terrain and soil conditions, a 15-100 cm sample was only collected in one location in Sub-Area 2.1.

### 7.2.3 Survey and Sampling Results for Area 2

#### *GPS Survey Results Area 2*

Figure 20 shows the location of the manual grid for Area 2.1. The manual survey box for Area 2.1 was roughly 19 meters east to west, and 17 meters north to south (Figure 22).

**Figure 20. Sub-Area 2.1 Manual Grid Survey Box**


Figure 21 (on the following page) shows the location of the manual grid for Area 2.2. The manual survey box for Area 2.2 was approximately 37 meters east to west and 27 meters north to south (Figure 23).

**Figure 21. Sub-Area 2.2 Manual Grid Box**


### *Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation*

- The Area 2.1 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 9426 CPM to 10117 CPM. The average across all locations was 9736 CPM.
- The Area 2.2 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 5690 CPM to 6052 CPM. The average across all locations was 5917 CPM.
- The applicable background count rate for Area 2 was determined to be 6333 CPM.
- A tabulation of the static count rates is provided in Appendix H32.

**Figure 22. Sub-Area 2.1 Gamma Walkover Survey Data**

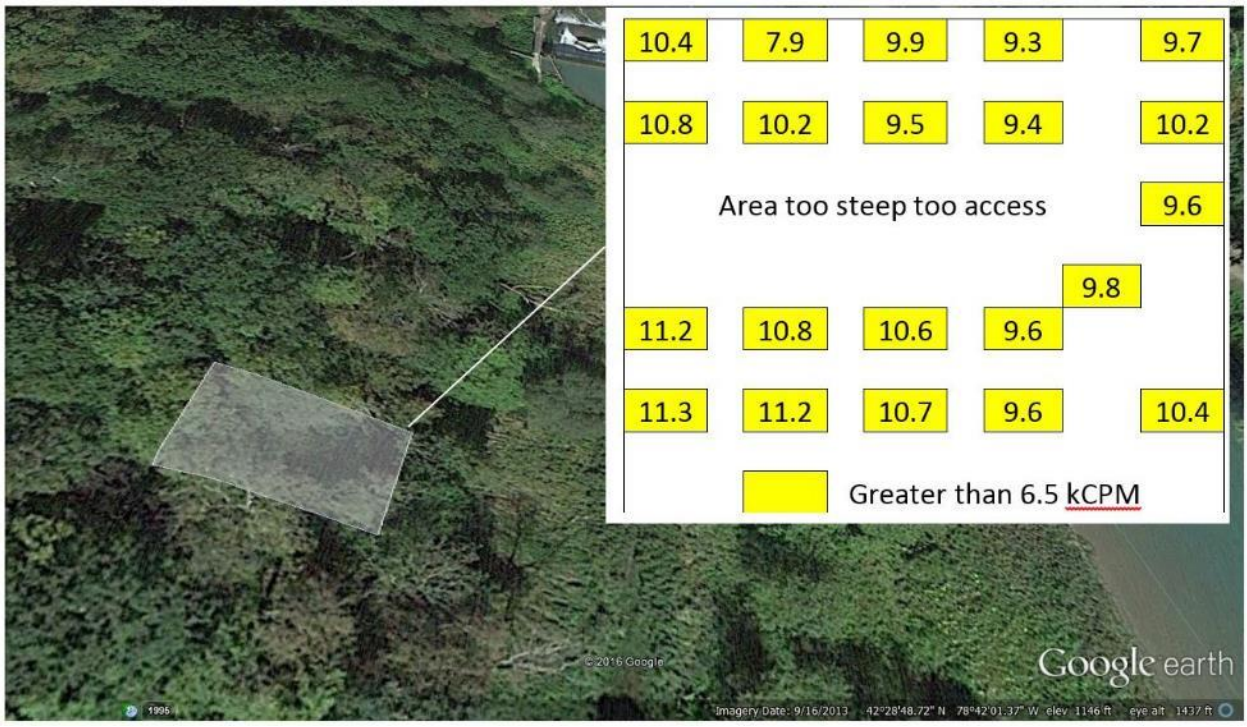
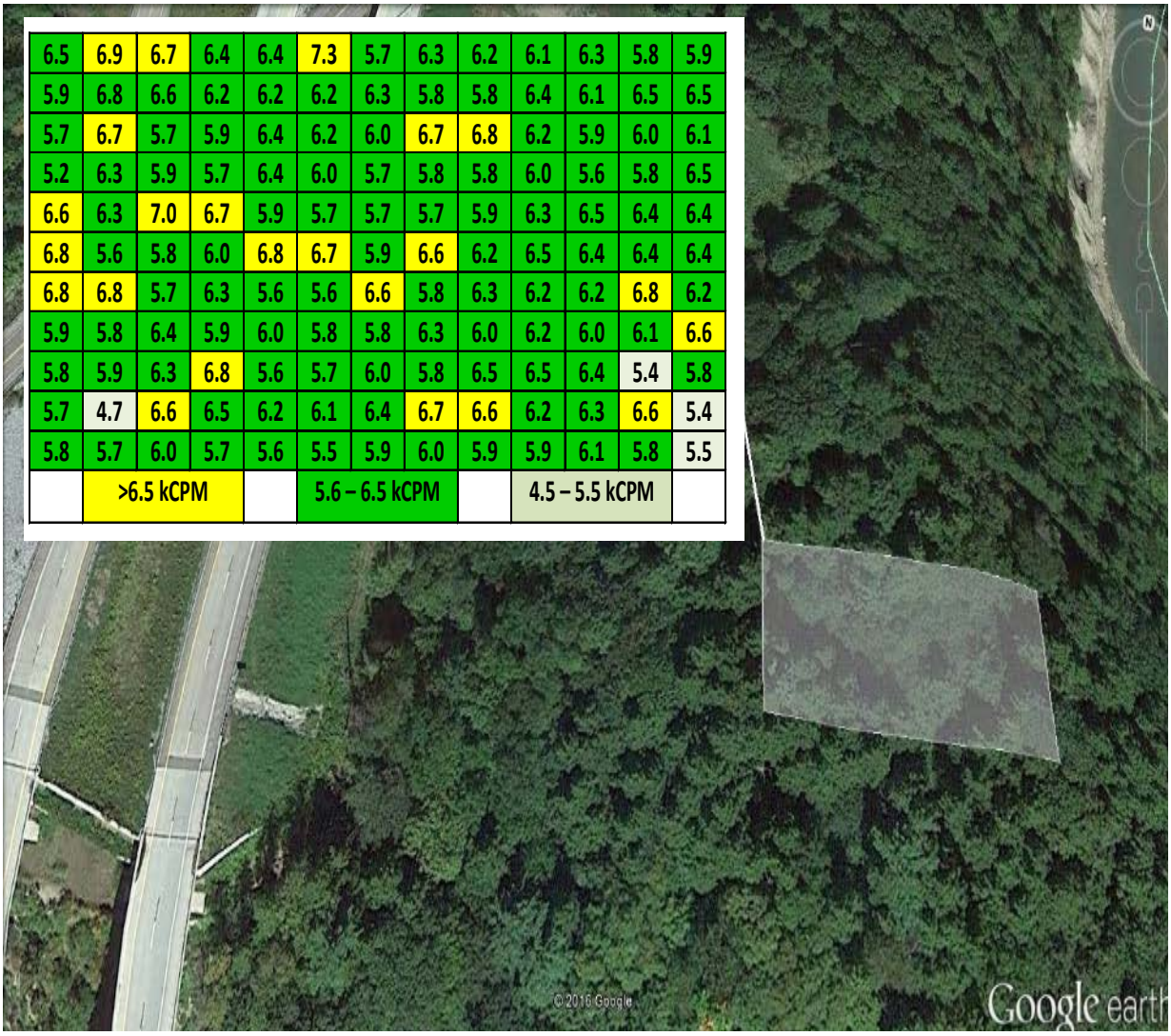


**Figure 23. Gamma Walkover Survey Data**




***Tissue Equivalent Dose Rate Survey Meter Readings.***

Table 23 provides the tissue equivalent dose rate readings (including background) for the Area 2 survey and sample locations:

**Table 23. Area 2 Tissue Equivalent Dose Rate Instrument Gross Readings**

| Sample Location | Dose Rate at 100 cm (µrem/hour) |
|---|---|
| 2.1.1 | 7 |
| 2.1.2 | 9 |
| 2.1.3 | 8 |
| 2.1.4 | 7 |
| 2.2.1 | 3 |
| 2.2.2 | 4 |
| 2.2.3 | 5 |
| 2.2.4 | 4 |

### *Soil Sampling Results Area 2*

#### Sub-Area 2.1

Six soil samples were analyzed in Sub-Area 2.1. The weighted average soil concentrations for gross alpha, gross beta, and cesium results associated with each soil depth sampled are summarized in Table 24.

**Table 24. Sub-Area 2.1 Weighted Average Soil Concentrations**

| Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|
| 0-15 | 1.0E+01 ± 9.4E-01 | 2.4E+01 ± 7.1E-01 | 4.8E-01 ± 3.2E-02 |

[a] Uncertainty is reported ± 1 sigma.

The gross alpha soil concentration was less than background levels. For gross beta and cesium, the soil concentrations were above background levels. The net soil concentrations were used to assess potential exposure to a Recreational Hiker. As only the first 15 cm of soil was sampled, the concentration for the first m of soil was assumed to be represented by this depth interval. The net soil concentrations used in the dose assessment are provided in Table 25.

**Table 25. Sub-Area 2.1 Net Average Soil Concentrations**

| Depth (cm) | Gross Alpha (pCi/g) | Gross Beta (pCi/g) | Cesium-137 (pCi/g) |
|---|---|---|---|
| 0-100 | 0.0E+00 | 1.3E+00 | 1.9E-01 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

#### Sub-Area 2.2

Nine soil samples were analyzed in Sub-Area 2.2. The weighted average soil concentrations for gross alpha, gross beta, and cesium results associated with each soil depth analyzed are summarized in Table 26 below.

**Table 26. Sub-Area 2.2 Weighted Average Soil Concentrations**

| Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|
| 0-15 | 9.8E+00 ± 1.2E+00 | 1.8E+01 ± 1.1E-00 | 7.3E-01 ± 4.4E-02 |
| 15-100 | 1.3E+01 ± 1.0E+00 | 1.8E+01 ± 6.7E-01 | 0.0E-00 ± 2.2E-02 |

a Uncertainty is reported ± 1 sigma.

The gross alpha and gross beta soil concentrations were less than background levels. For cesium, the soil concentration was above background levels. The net soil concentration was used to assess potential exposure to a Recreational Hiker. The calculated weighted net average soil concentrations used in the dose assessment are provided in Table 27.

**Table 27. Sub-Area 2.2 Net Average Soil Concentrations**

| Depth (cm) | Gross Alpha (pCi/g) | Gross Beta (pCi/g) | Cesium-137 (pCi/g) |
|---|---|---|---|
| 0-100 | 0.0E+00 | 0.0E+00 | 6.6E-02 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### 7.2.4 Dose Assessment Approach for Area 2

The dose assessment approach for Area 2 was to:

- Develop an estimate of annual exposure based on the Aerial Survey data.
- Develop an estimate of annual exposure based upon the tissue equivalent dose rate survey meter readings.
- Perform an assessment based on the current land use Recreational Hiker scenario to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed.

  Dose assessments associated with soil data were performed using the RESRAD-OFFSITE 3.1 computer code. Hydrology data for the contaminated, unsaturated, and saturated zones were based on Revision 2 of the Phase 1 Decommissioning Plan for the WVDP. The RESRAD input parameters used that differed from the RESRAD defaults are summarized in Appendix H4. In cases where area specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modification are described below and in Appendix H4. This would include, but are not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where there were no site-specific data or there was no corresponding Decommissioning Plan value, the RESRAD-OFFSITE default parameters were used.

  The Area 2 dose assessment was based on a Recreational Hiker that spends 100 hours per year in the elevated area. It is assumed that this Recreational Hiker also hunts deer and consumes the deer meat. No plant, fish or dairy cattle milk is consumed from this area. The Recreational Hiker's dwelling is located off-site and not within the area assessed.

  In addition, no irrigation was assumed for any part of Area 2, as the entire area contains undeveloped land. The evapotranspiration coefficient provided in the Decommissioning Plan was recalculated to maintain the same infiltration rate of 0.26 meters per year. The soil erodibility factor, which is used to calculate the erosion rate, was set to the maximum value of the default range (0 to 0.5) in the User Manual for (Ref. 6). This will allow transport of contamination from the contamination zone to the surface water and subsequently ingested by the deer, which is then consumed by the Recreational Hiker.

- The sample results were compared to the $DCGL_w$ concentrations established in the Phase 1 Decommissioning Plan for the WVDP. The peak-of-the mean values are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.
- Perform an assessment based on a conservative potential land use scenario of a Resident Farmer's exposure in Area 2.2 to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). As stated earlier, the small size and steep terrain of Area 2.1 preclude current or future use for farming. Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed. Dose assessments associated with soil data were performed using the RESRAD 7.0 computer code. RESRAD input parameters were based on Revision 2 of the Phase 1 Decommissioning Plan for the West Valley Demonstration Project Appendix C. The RESRAD input parameters are summarized in Appendix H33.
- Perform an assessment based on consumption of fish caught from the Cattaraugus Creek. Current land use surveys indicate that in Areas 1, 2, and 3, no consumption of fish occurs. Calculations were performed using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the ASER (Ref. 8). Annual exposures were calculated based on ingestion dose coefficients from ICRP (Ref. 9)

### 7.2.5 Dose Assessment Results for Area 2

#### *Dose Based Upon 2014 Aerial Survey Data*

Figure 24 is an aerial radiological survey map extracted from the Aerial Survey data onto which the locations for Area 2 have been placed. The dose rates at an elevation of one m as derived from the map were determined to be 4-5 (μR/hour) for Area 2.1 and 4-5 (μR/hour) for Area 2.2. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hr.

Based on this aerial map and the assumed cosmic and airborne radon contribution, the dose rates were determined for Area 2 as shown in Table 28. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings derived from Figure 24 to account for the contribution to background from cosmic radiation and airborne radon.

**Figure 24. Area 2 Locations on the 2014 WNYNSC Aerial Radiological Survey**

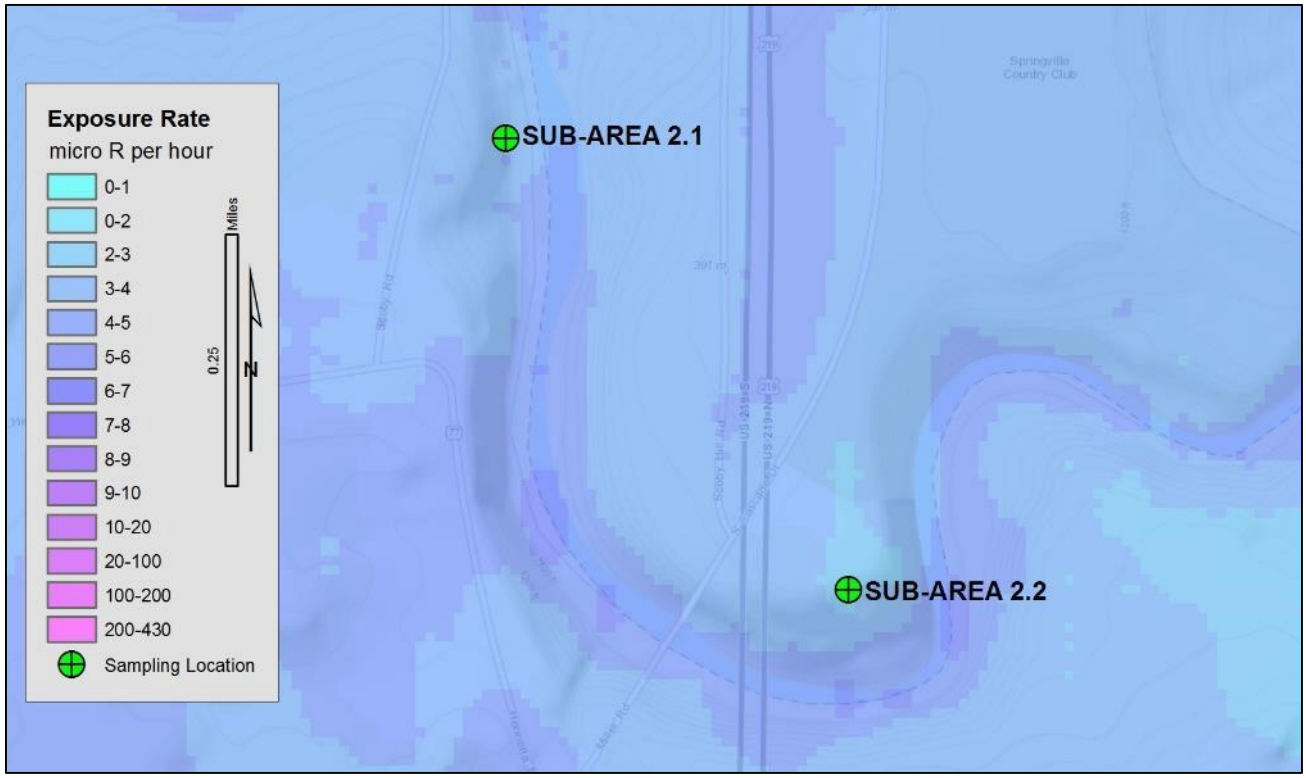



**Table 28. Area 2 Dose Rates Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| Sub-Area 2.1 | 4-5 | 4.5 | 4.8 | 9.3 |
| Sub-Area 2.2 | 4-5 | 4.5 | 4.8 | 9.3 |

The average background dose rate based on the WNYNSC Aerial Survey was 8.3 μR/hour at one m above the ground. This was subtracted from the total doses rate in Table 28, and based on occupancy time of 100 hours per year, the calculated doses for Area 2 are provided in Table 29.

**Table 29. Area 2 Calculated Doses Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Total Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Annual Occupancy Time (hours/year) | Annual Dose Rate[a] (mrem/year) |
|---|---|---|---|---|
| Sub-Area 2.1 | 9.3 | 8.3 | 100 | 0.1 |
| Sub-Area 2.2 | 9.3 | 8.3 | 100 | 0.1 |

[a] The aerial survey dose rates were recorded in units of Roentgen. The quality factors for photons and electrons are both one; therefore, 1 R equals 0.877 rem.

### *Dose Assessment Based Upon Tissue Equivalent Survey Meter Readings*

#### Sub-Area 2.1

Sub-Area 2.1 indicated external dose rates higher than the background screening level calculated in Section 5.1. The average dose rate for Sub-Area 2.1 was 7.59 ± 0.38 μrem/hour at 100 cm (± 1 sigma). The average dose rate minus background for Sub-Area 2.1 was 3.9 μrem/hour at 100 cm; therefore, a Recreational Hiker that spends 100 hours per year in the elevated area would receive 0.4 mrem per year.

#### Sub-Area 2.2

Sub-Area 2.2 indicated external dose rates slightly higher than the background screening level calculated in Section 5.1. The average dose rate for Sub-Area 2.2 was 3.74 ± 0.19 μrem/hour at 100 cm (± 1 sigma).

The average dose rate minus background was 0.05 μrem/hour at 100 cm. Therefore, a Recreational Hiker that spends 100 hours per year in the elevated area would receive a dose of less than 0.1 mrem per year.

### *Current Use RESRAD Dose Assessment Based Upon Soil Concentrations Assuming a Recreational Hiker Scenario*

#### Sub-Area 2.1

Sub-Area 2.1 is a small 42-square-m area of undeveloped land (see red marker in Figure 25). The deer associated with Sub-Area 2.1 are assumed to stay within the boundaries of the creek and the road. This results in a deer pasture area (white box in Figure 25 below) of about 55,800 square meters. In addition, the creek bed next to the elevated area is assumed to provide the drinking water resources for the deer. The creek is assumed to be about 50 meters wide and averages about one-m deep over the course of the year.

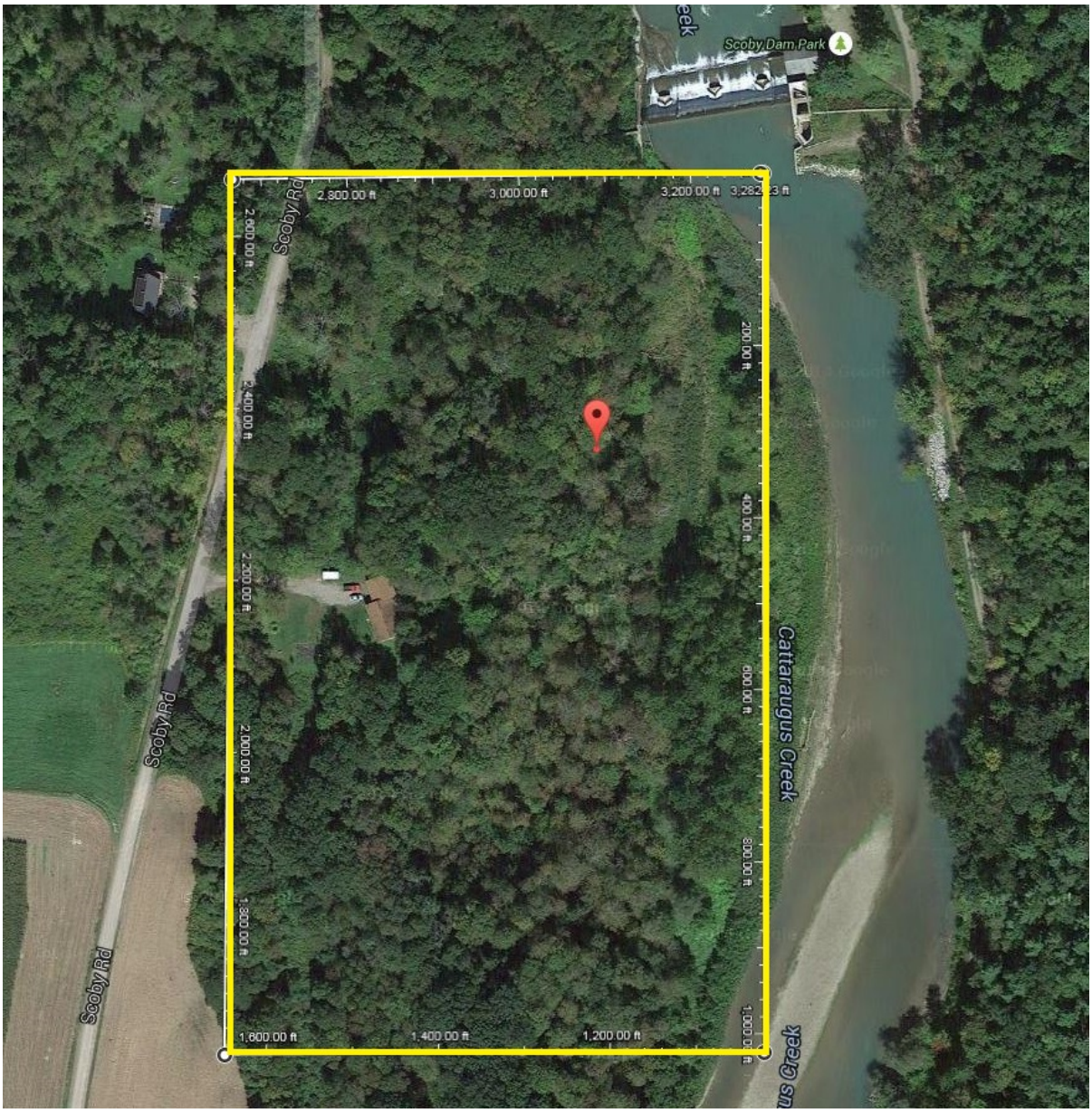
The exposure to a Recreational Hiker in Sub-Area 2.1 that also consumed deer meat is provided in Table 30. The RESRAD input parameters are provided in Appendix H4.

**Table 30. Sub-Area 2.1 Current Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|
| 4.71E-03 | 2.17E-07 | 9.47E-05 | 1.73E-06 | 4.81E-03 |

The main source of exposure is direct external from the ground. This accounted for over 97 percent of the overall exposure. The full RESRAD output file is provided in Appendix H10.

**Figure 25. Sub-Area 2.1 and Deer Pasture Area**




## Sub-Area 2.2

Sub-Area 2.2 is a small 350-square-meter area of undeveloped land (red marker in Figure 26) located between Cattaraugus Creek, Route 219 Expressway and Cascade Road. The deer associated with Sub-Area 2.2 are assumed to stay within the boundaries of the creek and the road. This results in a deer pasture area of about 76,000 square meters. In addition, the creek bed next to the elevated area is assumed to provide the drinking water resources for the deer. The creek is assumed to be about 50 meters wide, runs the entire 329.4 m length of the elevated area, and averages about one-m deep over the course of the year.

The exposure to a Recreational Hiker in Sub-Area 2.2 that also consumed deer meat is provided in Table 31. The RESRAD input parameters are provided in Appendix H4.

**Figure 26. Sub-Area 2.2 and Deer Pasture Area**

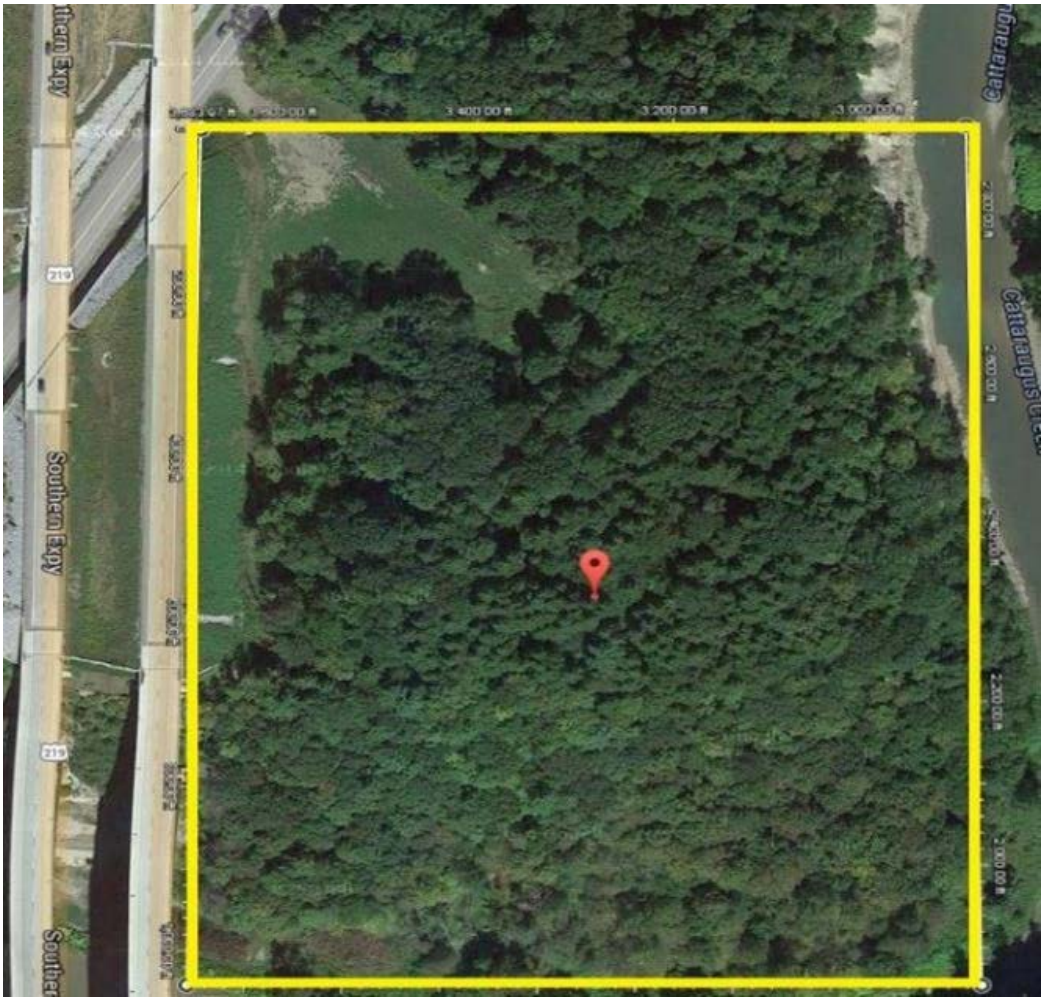



**Table 31. Sub-Area 2.2 Current Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|
| 2.16E-03 | 3.50E-10 | 1.73E-05 | 2.38E-07 | 2.18E-03 |

The main source of exposure is direct external from the ground. This accounted for over 99 percent of the overall exposure. The full RESRAD output file is provided in Appendix H11.

### *Comparison to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values for Area 2*

Table 32 provides a comparison of the Area 2 soil concentrations to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values.

**Table 32. Area 2 Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$**

| Measurement Type | Nuclide Used | WVDP DCGL (pCi/g) | Net Soil Concentration (pCi/g) | | Comparison | |
|---|---|---|---|---|---|---|
| | | | 2.1 | 2.2 | 2.1 | 2.2 |
| Alpha | Pu-239 | 2.50E+01 | 0.0E+00 | 0.0E+00 | Below | Below |
| Beta | Sr-90 | 4.10E+00 | 1.3E+00 | 0.0E+00 | Below | Below |
| Cesium | Cs-137 | 1.50E+01 | 1.9E-01 | 6.6E-02 | Below | Below |
| | | | | Sum of the Fractions: | Below | Below |

The assessment of the gross alpha and beta based on the most conservative isotopes (Am-241, Pu-239 and Sr-90, respectively) will account for all of the anthropogenic nuclides listed in Table 2 except C-14, I-129, and Tc-99. For these radionuclides, a qualitative analysis was performed. In all cases for these three radionuclides, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the radionuclides that account for most of the gross alpha and beta soil concentrations are radionuclides that are considered NORM (e.g., natural uranium, natural thorium, and potassium-40).

Therefore, the use of the DCGLs based on the WVDP Phase 1 Decommissioning Plan Resident Farmer scenario and gross results assuming the most conservative nuclide results in a highly conservative comparison.

### *Conservative Potential Use Dose Assessment Based Upon Soil Concentrations Assuming a Resident Farmer Scenario*

#### Sub-Area 2.1

Sub-Area 2.1 is a small 42-square-meter area of undeveloped land (see red marker in Figure 25). Based on its small size and steep terrain, it was determined that a Resident Farmer scenario was not a viable scenario for this sub-area. The current use scenario of a Recreational Hiker that also consumed deer meat is considered to be the bounding scenario for any future use of this parcel of land. Therefore, the future use dose is the same as presented in Table 30.

#### Sub-Area 2.2

Sub-Area 2.2 is a small 350-square-meter area of undeveloped land (see red marker in Figure 26) located between Cattaraugus Creek, Route 219 Expressway, and Cascade Road. The future land use scenario is a Resident Farmer scenario. It is assumed that the farmer's dwelling, crop fields, and pasture lands resides in the elevated area. In addition, the crop that is grown is consumed by the farmer. The farmer also maintains and consumes both dairy and meat from the cattle. The annual exposure for Sub-Area 2.2 is provided in Table 33. The RESRAD input parameters are provided in Appendix H33.

**Table 33. Sub-Area 2.2 Potential Use Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Milk (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 8.17E-02 | 2.69E-08 | 1.74E-02 | 1.01E-02 | 1.87E-02 | 1.90E-05 | 1.28E-01 |

The full RESRAD output file is provided in Appendix H36.

### *Dose Assessment for Consumption of Fish Based Upon 2012 WVDP Annual Site Environmental Report*

The ASER (Ref. 8) provides radiological concentrations of strontium and cesium in the edible portion of the fish in Cattaraugus Creek. Biological data from there locations are provided. Hog-nosed Sucker and White Sucker are sampled from above the Springville Dam and Steelhead Trout are sampled from below the Springville Dam. Brown Trout, White Sucker, Bullhead, and Hog-nosed Sucker were also sampled at a background location. This data is provided in Appendix H41. The average radiological concentrations of strontium and cesium in the edible portion of the fish for the two areas around Springville Dam and the background area are provided in Table 34 and Table 35 below.

**Table 34. Concentrations in Edible Portions of Fish around Springville Dam**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.40E-08 | 1.16E-09 | µCi/g - wet |
| Cs-137 | 5.46E-08 | 1.31E-08 | µCi/g - wet |

**Table 35. Background Concentrations in Edible Portions of Fish**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.02E-08 | 1.77E-09 | µCi/g - wet |
| Cs-137 | 4.75E-08 | 4.00E-08 | µCi/g - wet |

This results in a net above background concentration in the edible portions of the fish of 3.74E-09 µCi Sr-90 per gram of fish flesh and 7.08E-09 µCi Cs-137 per gram of fish flesh. The ingestion dose coefficients factors (DCF) and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 36.

**Table 36. Ingestion dose coefficients (mrem / µCi) from ICRP 68**

| Isotope | f1* | DCF | Units |
|---|---|---|---|
| Sr-90 | 0.3 | 1.04E+02 | mrem/µCi Ingestion |
| Sr-90 | 0.01 | 1.00E+01 | mrem/µCi Ingestion |
| Cs-137 | 1 | 4.81E+01 | mrem/µCi Ingestion |

* f1 – Fractional absorption in the Gastrointestinal tract rate.

The Exposure Factors Handbook (Ref. 18) indicates that the 95$^{th}$ percentile of fish consumption by recreational anglers is about nine kg of fish per year. This results in an annual exposure rate of less than 0.1 mrem per year.

### 7.2.6 Conclusions for Area 2

Annual doses based on the Aerial Survey, tissue equivalent survey meter readings, and RESRAD analysis ranged from 0.0 to 0.4 mrem per year. Soil concentrations were all below the DCGL values. This

demonstrates that Area 2 is well below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 CFR § 20.1402.

## 7.3 Area 3

### 7.3.1 Description of Area 3

Area 3 is located at the confluence of Buttermilk and Cattaraugus Creeks (pg. 8, Figure 3), and also consisted of two sub-areas designated 3.1 and 3.2. Both areas are located on an active farm. Sub-Area 3.1 is a large, slightly sloped area, the majority of which is currently utilized to grow corn for livestock consumption. Sub-Area 3.2 is a smaller area located just north of Thomas Corners Road. This area sloped upward from the roadway towards the farm dwelling, and was transected by a gravel driveway.

### 7.3.2 Survey and Sampling Methodology for Area 3

#### *GPS Walkover Gamma Surveys of Area 3*

GPS walkover gamma surveys were conducted in both sub-areas using a nominal grid spacing of 20 meters or less. Some portions of Sub-Area 3.1 were heavily wooded and overgrown. As a result, it was not possible to completely survey the designated survey box. However, the cultivated areas within the designated survey area and immediately adjacent areas were surveyed. Some sections of Sub-Area 3.2 were obstructed by trees, shrubs, and a debris pile, and therefore the path walked by the survey team could not traverse these obstructed areas.

In Sub-Area 3.1, a pattern of elevated readings was identified by the GPS walkover gamma data (Figure 29) immediately to the southwest and down slope of the sub-area. As a result, samples were collected from seven elevated locations, and random locations were used for 17 other locations.

In Sub-Area 3.2, no elevated locations were identified by the GPS walkover gamma data (Figure 30). As a result, samples were collected from four random locations. One planned sample location was relocated slightly west to avoid an existing driveway on the property.

Direct radiation readings and soil samples were collected in the 24 locations in Sub-Area 3.1 and from four locations in Sub-Area 3.2 as described in Table 4 of the Plan (Ref. 4).

Each location was surveyed and sampled as follows:

- Dose rate readings were collected at one and 100 cm from the ground surface using the tissue equivalent dose rate meter.
- Static 2” x 2” NaI detector readings were collected at one and 100 cm from the ground surface using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two, one-minute counts were collected at each location at both elevations.
- Soil samples were collected in depth increments of 0-15 cm, 15-30 cm, 30-60 cm and 60-100 cm.
- In Area 3.1 a total of 24 locations were sampled, 17 random and seven elevated.
- In Area 3.2 a total of four locations were sampled.

Figures 27 and 28 show the sampling locations of Area 3.1 and 3.2, respectively.

**Figure 27. Sub-Area 3.1 Sampling Locations**

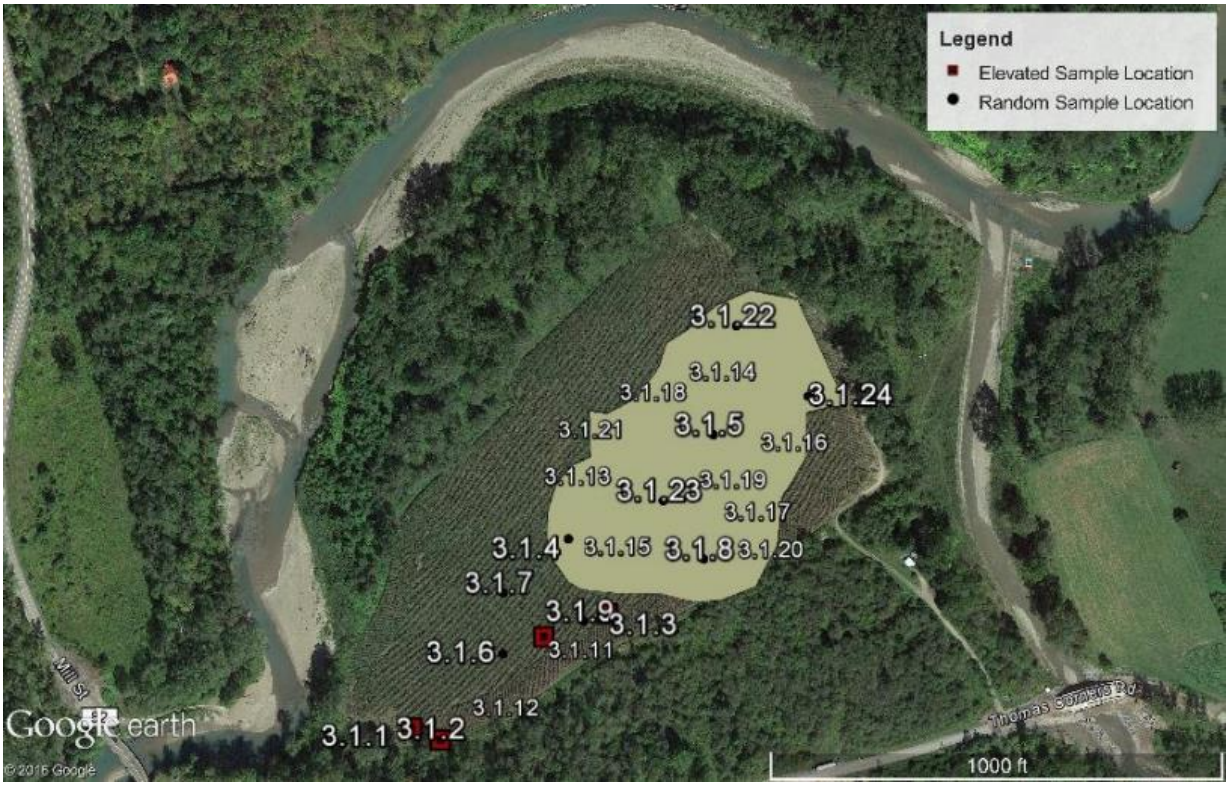


**Figure 28. Sub-Area 3.2 Sampling Locations**


### 7.3.3 Survey and Sampling Results for Area 3

#### *GPS Survey Results*

Figures 29 and 30 provide the graphical display of the GPS survey data for Sub-Areas 3.1 and 3.2.

**Figure 29. Sub-Area 3.1 Gamma Walkover Survey Data**

**Figure 30. Sub-Area 3.2 Gamma Walkover Survey Data**


***Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation***

- The Area 3.1 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 8360 CPM to 10980 CPM. The average across all locations was 9939 CPM.

- The Area 3.2 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7074 CPM to 7760 CPM. The average across all locations was 7760 CPM.
- The applicable background count rate for Area 3 was determined to be 6333 CPM.

A tabulation of the static count rates is provided in Appendix H32.

### *Tissue Equivalent Dose Rate Survey Meter Readings*

Tissue equivalent survey meter readings were collected at 24 locations in Area 3.1 and at four locations in Area 3.2.

The average of the readings in Area 3.1 was 7.55 ± 0.16 μrem/hour at 100 cm (± 1 sigma). This reading exceeded the background screening level.

The average of the readings in Area 3.2 was 4.11 ± 0.21 μrem/hour at 100 cm (± 1 sigma). This reading also exceeded the background screening level.

A tabulation of the individual readings in Area 3 is provided in Appendix H1.

### *Soil Sampling Results for Area 3*

#### Sub-Area 3.1

Fifty-three soil samples were analyzed in Sub-Area 3.1. The average soil concentrations for gross alpha, gross beta and cesium results associated with each soil depth sampled are summarized in Table 37.

**Table 37. Sub-Area 3.1 Average Soil Concentrations**

| Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|
| 0-15 | 1.3E+01 ± 2.9E-01 | 2.2E+01 ± 2.5E-01 | 1.1E+00 ± 1.3E-02 |
| 15-30 | 1.4E+01 ± 3.5E-01 | 2.4E+01 ± 2.8E-01 | 1.4E+00 ± 1.5E-02 |
| 30-60 | 1.6E+01 ± 1.1E+00 | 2.3E+01 ± 7.7E-01 | 2.2E+00 ± 8.7E-02 |
| 60-100 | 1.4E+01 ± 5.3E-01 | 2.3E+01 ± 4.5E-01 | 2.5E-01 ± 2.1E-02 |

[a] Uncertainty is reported as ± 1 sigma.

The gross alpha, gross beta and cesium soil concentrations were above background levels. The net soil concentrations were used to assess potential exposure to a Resident Farmer. The calculated weighted net average soil concentrations used in the dose assessment are provided in Table 38.

**Table 38. Sub-Area 3.1 Net Average Soil Concentrations**

| Depth (cm) | Gross Alpha (pCi/g) | Gross Beta (pCi/g) | Cesium-137 (pCi/g) |
|---|---|---|---|
| 0-100 | 1.1E+00 | 5.6E-01 | 1.0E+00 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### Sub-Area 3.2

Six soil samples were analyzed in Sub-Area 3.2. The average soil concentrations for gross alpha, gross beta, and cesium results associated with each soil depth sampled are summarized in Table 39.

**Table 39. Sub-Area 3.2 Average Soil Concentrations**

| Depth (cm) | Gross Alpha[a] (pCi/g) | Gross Beta[a] (pCi/g) | Cesium-137[a] (pCi/g) |
|---|---|---|---|
| 0-15 | 1.3E+01 ± 9.9E-01 | 1.9E+01 ± 8.2E-01 | 5.5E-01 ± 2.4E-02 |
| 15-30[b] | 1.2E+01 ± 1.4E+00 | 1.9E+01 ± 1.2E+00 | 3.4E-01 ± 3.3E-02 |
| 30-60 | 1.2E+01 ± 1.8E+00 | 1.9E+01 ± 1.6E+00 | 1.3E-01 ± 4.2E-02 |
| 60-100 | 7.8E+00 ± 1.6E+00 | 2.2E+01 ± 1.6E+00 | 8.1E-02 ± 2.6E-02 |

[a] Uncertainty is reported as ± 1 sigma.

[b] No samples were analyzed at this depth, the average of 0-15 and 30-60 were calculated and used for this depth.

The gross beta soil concentration was less than background levels. The gross alpha and cesium soil concentrations were above background levels. The net soil concentrations were used to assess potential exposure to a Resident Farmer. The calculated weighted net average soil concentrations used in the dose assessment are provided in Table 40.

**Table 40. Sub-Area 3.2 Net Soil Concentrations**

| Depth (cm) | Gross Alpha (pCi/g) | Gross Beta (pCi/g) | Cesium-137 (pCi/g) |
|---|---|---|---|
| 0-100 | 1.9E-01 | 0.0E-00 | 1.1E-01 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### 7.3.4 Dose Assessment Approach for Area 3

The dose assessment approach for Area 3 was to:

- Develop an estimate of annual exposure based on the Aerial Survey data.
- Develop an estimate of annual exposure based upon the tissue equivalent dose rate survey meter readings.
- Perform an assessment based on the current land use Resident Farmer scenario to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed.
  Dose assessments associated with soil data were performed using the RESRAD-OFFSITE 3.1 computer code. Hydrology data for the contaminated, unsaturated, and saturated zones were

based on Revision 2 of the Phase 1 Decommissioning Plan for the WVDP. The RESRAD input parameters used that differed from the RESRAD defaults are summarized in Appendix H5. In cases where area-specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modifications are described below and in Appendix H5. This would include, but are not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where there were no site-specific data or there was no corresponding Decommissioning Plan value, the RESRAD-OFFSITE default parameters were used.

The Area 3 dose assessment was based on a Resident Farmer that spends 1,000 hours per year tending feed crops in Sub-Area 3.1 and 1,000 hours per year tending livestock. It is assumed that this Resident Farmer consumes the cattle meat. No plant, milk, or fish is consumed from this area. The Resident Farmer's dwelling is located off-site, but within the general area and therefore is included in this assessment. It is assumed that 100 hours was spent traversing Sub-Area 3.2.

In addition, irrigation was only assumed for crop fields in Area 3. The evapotranspiration coefficient provided in the Decommissioning Plan was recalculated to maintain the same infiltration rate of 0.26 meters per year.

- The sample results were compared to the $DCGL_w$ concentrations established in the Phase 1 Decommissioning Plan for the WVDP. The peak-of-the-mean values are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.
- Perform an assessment based on a conservative potential land use scenario of a Resident Farmer's exposure to determine the exposure in excess of background using current and appropriate parameters (e.g., hydrology, occupancy and consumption). Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed. Dose assessments associated with soil data were performed using the RESRAD 7.0 computer code. RESRAD input parameters were based on Revision 2 of the Phase 1 Decommissioning Plan for the West Valley Demonstration Project Appendix C. The RESRAD input parameters are summarized in Appendix H33.
- Perform an assessment based on consumption of fish caught from the Cattaraugus Creek. Current land use surveys indicate that in Areas 1, 2, and 3, no consumption of fish occurs. Calculations were performed using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the ASER (Ref. 8). Annual exposures were calculated based on ingestion dose coefficients from ICRP (Ref. 9).

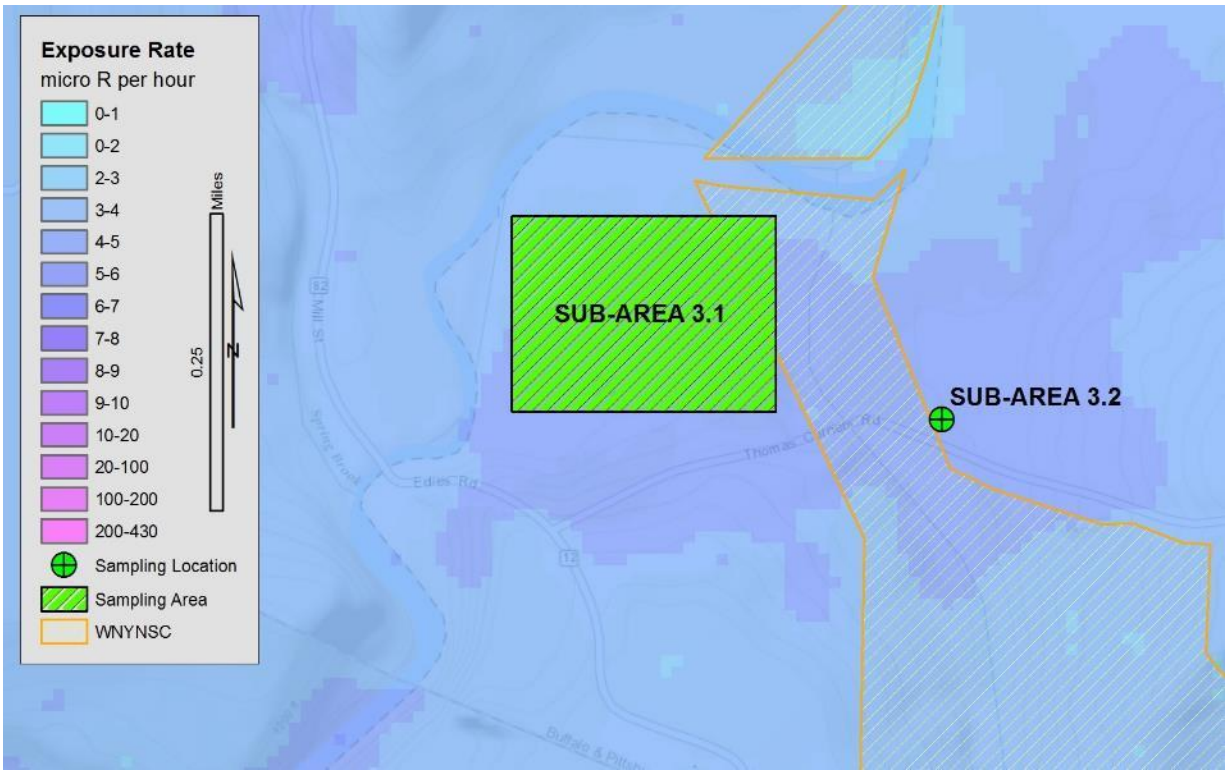
### 7.3.5 Dose Assessment Results for Area 3

#### *Dose Based Upon 2014 Aerial Survey Data*

Figure 31 is an aerial radiological survey map extracted from the Aerial Survey data onto which the locations for Area 3 have been placed. The dose rates at an elevation of one m as derived from the map

were determined to be 5-6 (μR/hour) for Area 3.1 and 5-6 (μR/hour) for Areas 3.2. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hour.

**Figure 31. Area 3 Locations on the 2014 WNYNSC Aerial Radiological Survey**




Based on this aerial map and the assumed cosmic and airborne radon contribution, the dose rates were determined for Area 3 as shown in Table 41. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings derived from Figure 31 to account for the contribution to background from cosmic radiation and airborne radon.

**Table 41. Area 3 Dose Rates Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| Sub-Area 3.1 | 5-6 | 5.5 | 4.8 | 10.3 |
| Sub-Area 3.2 | 5-6 | 5.5 | 4.8 | 10.3 |

The average background dose rate based on the WNYNSC Aerial Survey was 8.3 μR/hour at one m above the ground. This was subtracted from the total doses rate in Table 41, and based on occupancy time of 1,000 hours per year in Area 3.1 and 100 hours per year in Area 3.2, the calculated doses for Area 3 are provided in Table 42.

**Table 42. Area 3 Calculated Doses Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Total Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Annual Occupancy Time (hours/year) | Annual Dose Rate[a] (mrem/year) |
|---|---|---|---|---|
| Sub-Area 3.1 | 10.3 | 8.3 | 1000 | 1.8 |
| Sub-Area 3.2 | 10.3 | 8.3 | 100 | 0.2 |

[a] The aerial survey dose rates were recorded in units of Roentgen. The quality factors for photons and electrons are both one; therefore, 1 R equals 0.877 rem.

### *Dose Assessment Based Upon Tissue Equivalent Survey Meter Readings*

#### Sub-Area 3.1

Dose rate readings in Sub-Area 3.1 demonstrated external dose rates higher than the background screening level. The average dose rate for Sub-Area 3.1 was 7.55 ± 0.16 μrem/hour at 100 cm (± 1 sigma). The dose rate net of background in Sub-Area 3.1 was 3.86 μrem/hour at 100 cm. Based on the annual occupancy derived from the Resident Farmer scenario of 1,000 hours per year in Area 3.1, the net dose to the farmer based upon the tissue equivalent survey meter readings is 3.9 mrem per year.

#### Sub-Area 3.2

Readings in Sub-Area 3.2 demonstrated dose rates lower than the background screening level and therefore the assessed dose for Sub-Area 3.2 based on tissue equivalent tissue equivalent survey meter readings is 0.0 mrem per year.

### *Current Use RESRAD Dose Assessment Based Upon Soil Concentrations Assuming a Resident Farmer Scenario*

RESRAD dose assessments were based on a Resident Farmer that spends 11.42 percent (1,000 hours per year) working in the elevated area where feed grain is grown. The Resident Farmer also spends 11.42 percent (1,000 hours per year) maintaining their livestock in a pasture just north of the dwelling. Sixty-six percent of the year is assumed to be spent inside the dwelling and the remaining time (11.16 percent) outdoors, but not associated with farming or maintaining their livestock. No edible vegetation is grown for human consumption. Cattle are assumed to graze in the pasture and are assumed to consume grain grown in the elevated area. The number of livestock consumed is assumed to be 10. No livestock are directly located within the elevated area. The dwelling is assumed to house four individuals. The consumption of milk or fish is not considered for this area.

Irrigation was only assumed for feed grain crop field. For all other areas, the evapotranspiration coefficient was recalculated to maintain the same infiltration rate in the Decommissioning Plan of 0.26 meters per year. All water used is assumed to be pumped from a well. The total well pump rate was calculated 32,100 cubic meters per year based on the water usage for irrigation, livestock, dwelling, and human consumption.

### Sub-Area 3.1

Sub-Area 3.1 is a 64,500-square-m crop field, located about 300 meters west of the dwelling. For purposes of the analysis, the size was increased to include the entire field. Feed grain is grown as a crop in this field. See Figure 32 below.

The exposure to a Resident Farmer in Sub-Area 3.1 that also consumed cattle meat is provided in Table 43. The RESRAD input parameters are provided in Appendix H5.

**Figure 32. Sub-Areas 3.1 and 3.2**

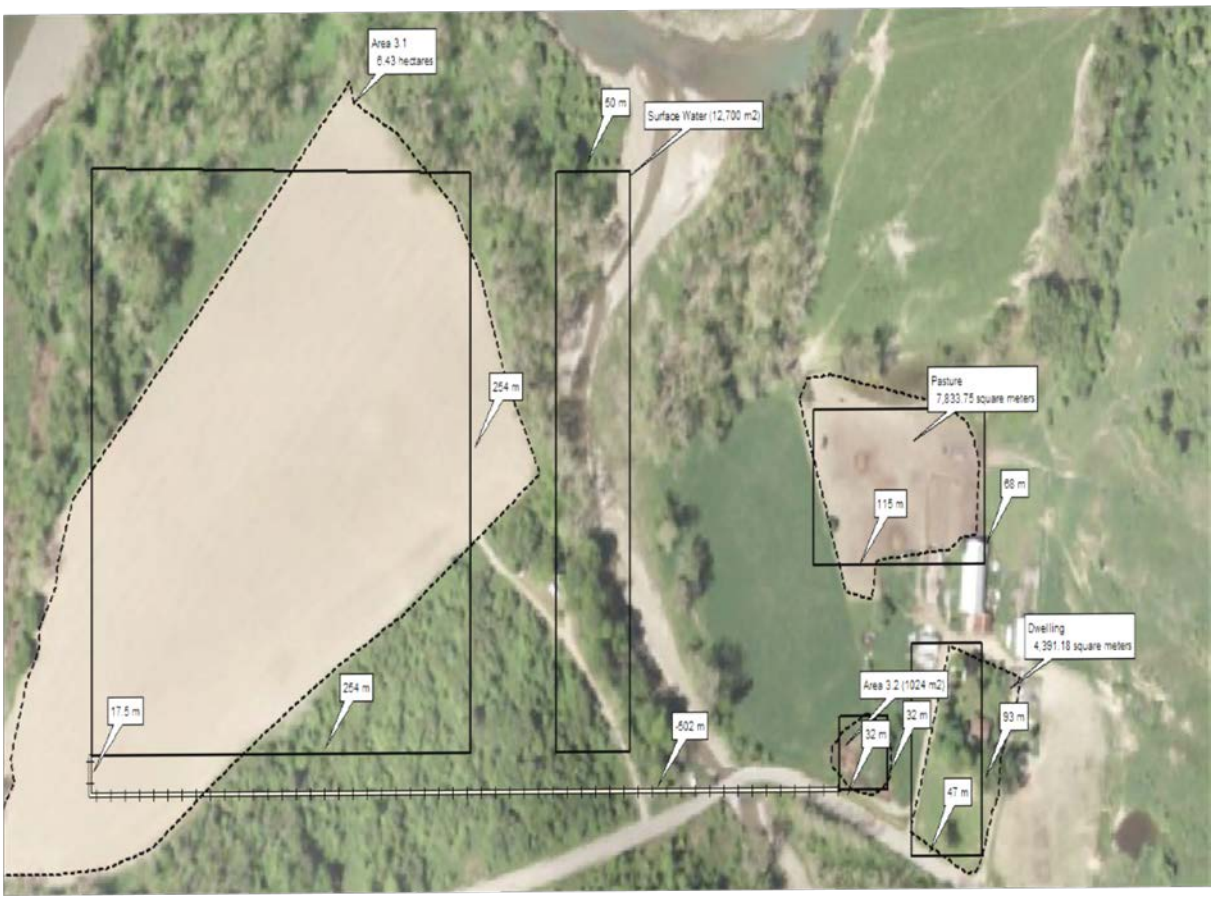



**Table 43. Sub-Area 3.1 Pathway Doses**

| Ground[a] (mrem/year) | Inhalation[a] (mrem/year) | Meat[a] (mrem/year) | Soil[a] (mrem/year) | Total[a] (mrem/year) |
|---|---|---|---|---|
| 3.87E-01 | 4.23E-05 | 4.31E-01 | 4.81E-11 | 8.18E-01 |

[a] The gross alpha was assessed as Am-241, as this provided the more conservative dose estimate.

The main sources of exposure were direct external from the ground and consumption of cattle meat. These accounted for over 47 and 52 percent, respectively, of the overall exposure. The full RESRAD output files are provided in Appendix H12 and H13.

### Sub-Area 3.2

Sub-Area 3.2 is a 1,000-square-m section of overgrowth (Figure 32 on the previous page) located about 15 meters west of the dwelling. No crop or livestock are located in this area.

The exposure to a Resident Farmer in Sub-Area 3.2 that also consumed cattle meat is provided in Table 44. The RESRAD input parameters are provided in Appendix H5.

**Table 44. Sub-Area 3.2 Pathway Doses**

| Ground[a] (mrem/year) | Inhalation[a] (mrem/year) | Meat[a] (mrem/year) | Soil[a] (mrem/year) | Total[a] (mrem/year) |
|---|---|---|---|---|
| 4.08E-03 | 2.07E-05 | 9.21E-11 | 1.45E-04 | 4.25E-03 |

* The gross alpha was assessed as Am-241, as this provided the more conservative dose estimate.

The main source of exposure is direct external from the ground. This accounted for over 96 percent of the overall exposure. The full RESRAD output files are provided in Appendix H14 and H15.

### *Comparison to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values for Area 3*

Table 45 provides a comparison of the Area 3 soil concentrations to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values.

**Table 45. Area 3 Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$**

| Measurement Type | Nuclide Used | WVDP DCGL (pCi/g) | Net Soil Concentration (pCi/g) | | Comparison | |
|---|---|---|---|---|---|---|
| | | | 3.1 | 3.2 | Sub-Area 3.1 | Sub-Area 3.2 |
| Alpha | Pu-239 | 2.50E+01 | 1.1E+00 | 1.9E-01 | Below | Below |
| Beta | Sr-90 | 4.10E+00 | 5.6E-01 | 0.0E+00 | Below | Below |
| Cesium | Cs-137 | 1.50E+01 | 1.0E+00 | 1.1E-01 | Below | Below |
| | | | | Sum of the Fractions: | Below | Below |

The assessment of the gross alpha and beta based on the most conservative isotopes (Pu-239 and Sr-90, respectively) will account for all of the anthropogenic nuclides listed in Table 2 except C-14, I-129, and Tc-99. For these radionuclides, a qualitative analysis was performed. In all cases for these three radionuclides, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the radionuclides that account for most of the gross alpha and beta soil concentrations are radionuclides that are considered NORM (e.g., natural uranium, natural thorium, and potassium-40).

These DCGLs are based on a Resident Farmer scenario used in the WVDP Phase 1 Decommissioning Plan, which is different than the current land use Resident Farmer described above. One of the key differences is that RESRAD (onsite) was used to do the calculations versus RESRAD-OFFSITE. This resulted in all farming activities to be assumed to occur in the contamination zone. In addition, the Resident Farmer scenario used in the WVDP Phase 1 Decommissioning Plan assumes the consumption of plant vegetation grown by the farmer. These two items account for most of the difference in the

estimated doses. Therefore, the Resident Farmer scenario used in the WVDP Phase 1 Decommissioning Plan is a conservative comparison.

### *Conservative Potential Use Dose Assessment Based Upon Soil Concentrations Assuming a Resident Farmer Scenario*

#### Sub-Area 3.1

Sub-Area 3.1 is a 64,500-square-m crop field, located about 300 meters west of the dwelling. This assessment is based on a Resident Farmer scenario. It is assumed that the farmer's dwelling, crop fields, and pasture lands resides in the elevated area. In addition, the crop that is grown is consumed by the farmer. The farmer also maintains and consumes both dairy and meat from the cattle. The annual exposure for Sub-Area 3.1 is provided in Table 46. The RESRAD input parameters are provided in Appendix H33.

**Table 46. Sub-Area 3.1 Potential Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Milk (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.45E+00 | 1.07E-02 | 4.14E+00 | 5.42E-01 | 1.06E+00 | 6.83E-02 | 7.27E+00 |

The full RESRAD output file is provided in Appendix H37 and H38.

#### Sub-Area 3.2

Sub-Area 3.2 is a 1,000-square-m section of overgrowth located about 15 meters west of the dwelling. This assessment is based on a Resident Farmer scenario. It is assumed that the farmer's dwelling, crop fields, and pasture lands resides in the elevated area. In addition, the crop that is grown is consumed by the farmer. The farmer also maintains and consumes both dairy and meat from the cattle. The annual exposure for Sub-Area 3.2 is provided in Table 47. The RESRAD input parameters are provided in Appendix H33.

**Table 47. Sub-Area 3.2 Potential Use Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Milk (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.46E-01 | 1.21E-03 | 1.21E-01 | 1.82E-02 | 3.16E-02 | 1.15E-02 | 3.29E-01 |

The full RESRAD output file is provided in Appendix H39 and H40.

### *Dose Assessment for Consumption of Fish Based Upon 2012 WVDP Annual Site Environmental Report*

The ASER (Ref. 8) provides radiological concentrations of strontium and cesium in the edible portion of the fish in Cattaraugus Creek. Biological data from their locations are provided. Hog-nosed Sucker and White Sucker are sampled from above the Springville Dam and Steelhead Trout are sampled from below the Springville Dam. Brown Trout, White Sucker, Bullhead, and Hog-nosed Sucker were also sampled at a background location. This data is provided in Appendix H41. The average radiological concentrations of

strontium and cesium in the edible portion of the fish for the two areas around Springville Dam and the background area are provided in Table 48 and Table 49 below.

**Table 48. Concentrations in Edible Portions of Fish around Springville Dam**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.40E-08 | 1.16E-09 | µCi/g - wet |
| Cs-137 | 5.46E-08 | 1.31E-08 | µCi/g - wet |

**Table 49. Background Concentrations in Edible Portions of Fish**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.02E-08 | 1.77E-09 | µCi/g - wet |
| Cs-137 | 4.75E-08 | 4.00E-08 | µCi/g - wet |

This results in a net above background concentration in the edible portions of the fish of 3.74E-09 µCi Sr-90 per gram of fish flesh and 7.08E-09 µCi Cs-137 per gram of fish flesh. The ingestion dose coefficients factors (DCF) and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 50.

**Table 50. Ingestion dose coefficients (mrem/µCi) from ICRP 68**

| Isotope | f1* | DCF | Units |
|---|---|---|---|
| Sr-90 | 0.3 | 1.04E+02 | mrem/µCi Ingestion |
| Sr-90 | 0.01 | 1.00E+01 | mrem/µCi Ingestion |
| Cs-137 | 1 | 4.81E+01 | mrem/µCi Ingestion |

* f1 – Fractional absorption in the Gastrointestinal tract rate.

The Exposure Factors Handbook (Ref. 18) indicates that the 95$^{th}$ percentile of fish consumption by recreational anglers is about nine kg of fish per year. This results in an annual exposure rate of less than 0.1 mrem per year.

### 7.3.6 Conclusions for Area 3

Annual doses based on the Aerial Survey, tissue equivalent survey meter readings, and RESRAD analysis ranged from 0 to 7.2 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that Area 3 is well below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 C.F.R. § 20.1402.

## 7.4 Area 4

### 7.4.1 Description of Area 4

Area 4 lies approximately 20 miles to the west of the WNYNSC on the SNI and spans Cattaraugus Creek (Figure 4). It includes five sub-areas designated 4.1, 4.2, 4.3, 4.4, and 4.5. As can be seen in Figures 33

and 34, multiple irregularly shaped sub-regions, derived from the Aerial Survey, were combined into five sub-areas as follows:

- Sub-Area 4.1 – four sub regions designated 4.1A, 4.1B, 4.1C, and 4.1D
- Sub-Area 4.2 - three sub regions designated 4.2A, 4.2B, and 4.2C
- Sub-Area 4.3 – two sub region designated 4.3A and 4.3B
- Sub-Area 4.4 - four sub regions designated 4.4A, 4.4B, 4.4C, and 4.4D
- Sub-Area 4.5 - three sub regions designated 4.5A. 4.5B, and 4.5C

Area 4 is a wooded area with varying terrain that lies within the historic floodplain. There are no residences located in the area. Area 4, which is located on the SNI, was assessed using culturally specific land use scenarios provided by the SNI for a "Collector" and a "Hunter/Fisher."

### 7.4.2 Survey and Sampling Methodology for Area 4

#### *GPS Walkover Gamma Surveys of Area 4*

GPS walkover gamma surveys were conducted in all sub-areas using a nominal grid spacing of 30 meters (see Figures 35-39). The areas were generally heavily wooded and GPS precision varied; however, sufficient data was collected and analyzed to determine if any elevated locations would be sampled or if all samples would be from random sampling locations. There were no elevated areas identified.

#### *Static Survey and Sample Collection in Area 4*

Direct radiation readings and soil samples were collected in each sub-region as follows:

Sub-Area 4.1

- Sub Region 4.1A - one location
- Sub Region 4.1B – eight locations
- Sub Region 4.1C – nine locations
- Sub Region 4.1D – six locations

Sub-Area 4.2

- Sub Region 4.2A – four locations
- Sub Region 4.2B - eighteen locations
- Sub Region 4.2C – two locations

Sub-Area 4.3

- Sub Region 4.3A – four locations
- Sub Region 4.3B – twenty locations

Sub-Area 4.4

- Sub Region 4.4A – one location

- Sub Region 4.4B – one location
- Sub Region 4.4C – seven locations
- Sub Region 4.4D – six locations

Sub-Area 4.5

- Sub Region 4.5A – seven locations
- Sub Region 4.5B – eight Locations
- Sub Region 4.5C – nine locations

Figure 33 shows the sampling locations in Sub-Areas 4.1, 4.2, and 4.3; and Figure 34 shows the sampling locations in Sub-Areas 4.4 and 4.5.

**Figure 33. Sampling Locations in Sub-Areas 4.1, 4.2, and 4.3**

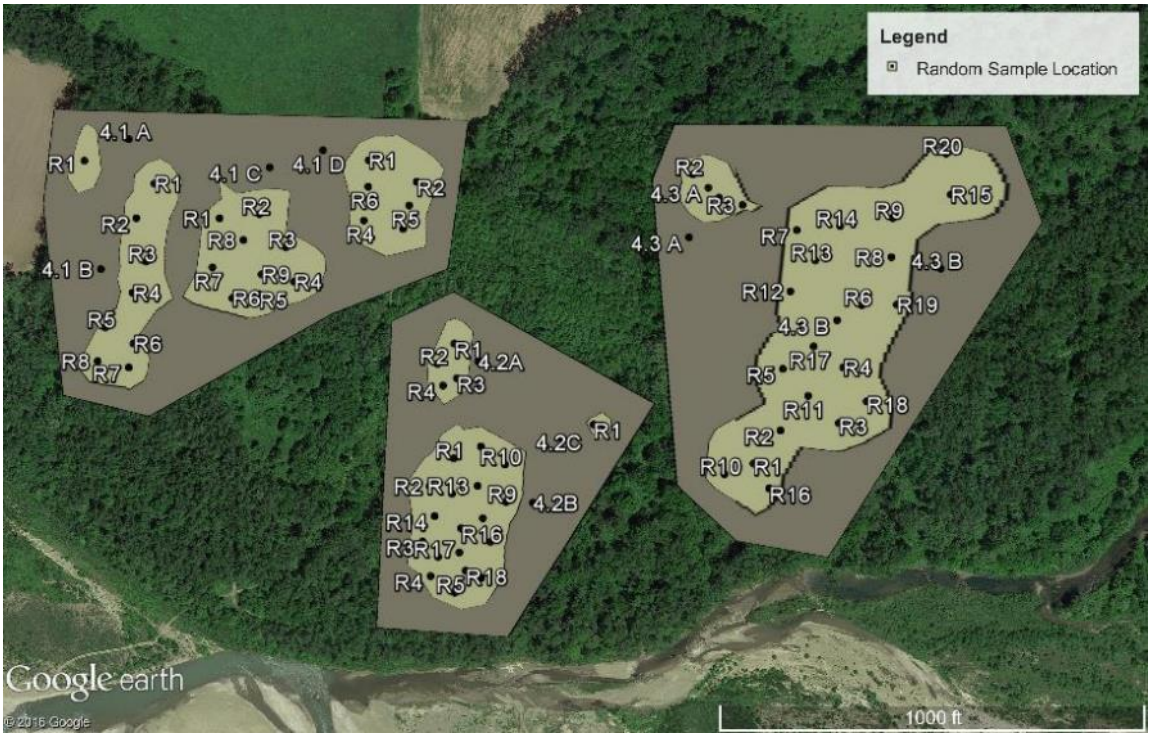
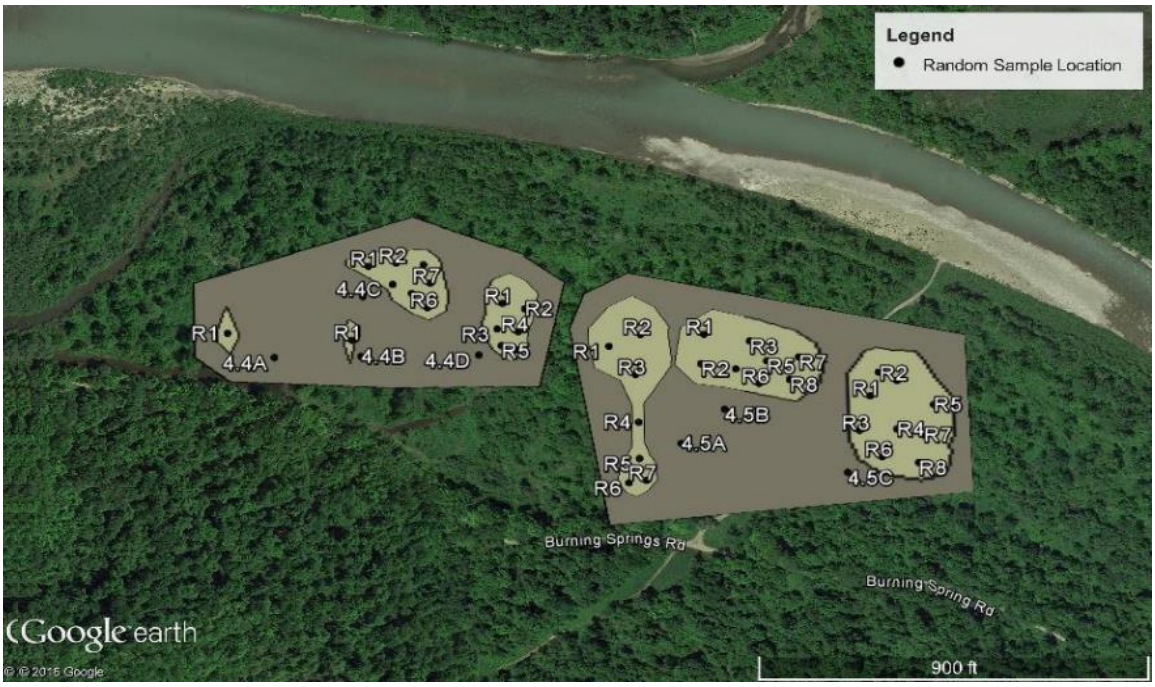


**Figure 34. Sampling Locations in Sub-Areas 4.4 and 4.5**




Each location was surveyed and sampled as follows:

- Dose rate readings were collected at one and 100 cm from the ground surface using the tissue equivalent dose rate meter.
- Static 2" x 2" NaI detector readings were collected at one and 100 cm from the ground surface using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two, one-minute counts were collected at each location at both elevations.
- Soil samples were collected in depth increments of 0-15 cm, 15-30 cm, 30-60 cm, and 60-100 cm.

### 7.4.3 Survey and Sampling Results for Area 4

#### *GPS Survey Results*

Figures 35 through 39 provide the GPS walkover gamma survey results for Area 4. No pattern of elevated locations was discerned in the GPS maps and therefore only random samples were collected.

**Figure 35. Sub-Area 4.1 GPS Walkover Gamma Survey Data**

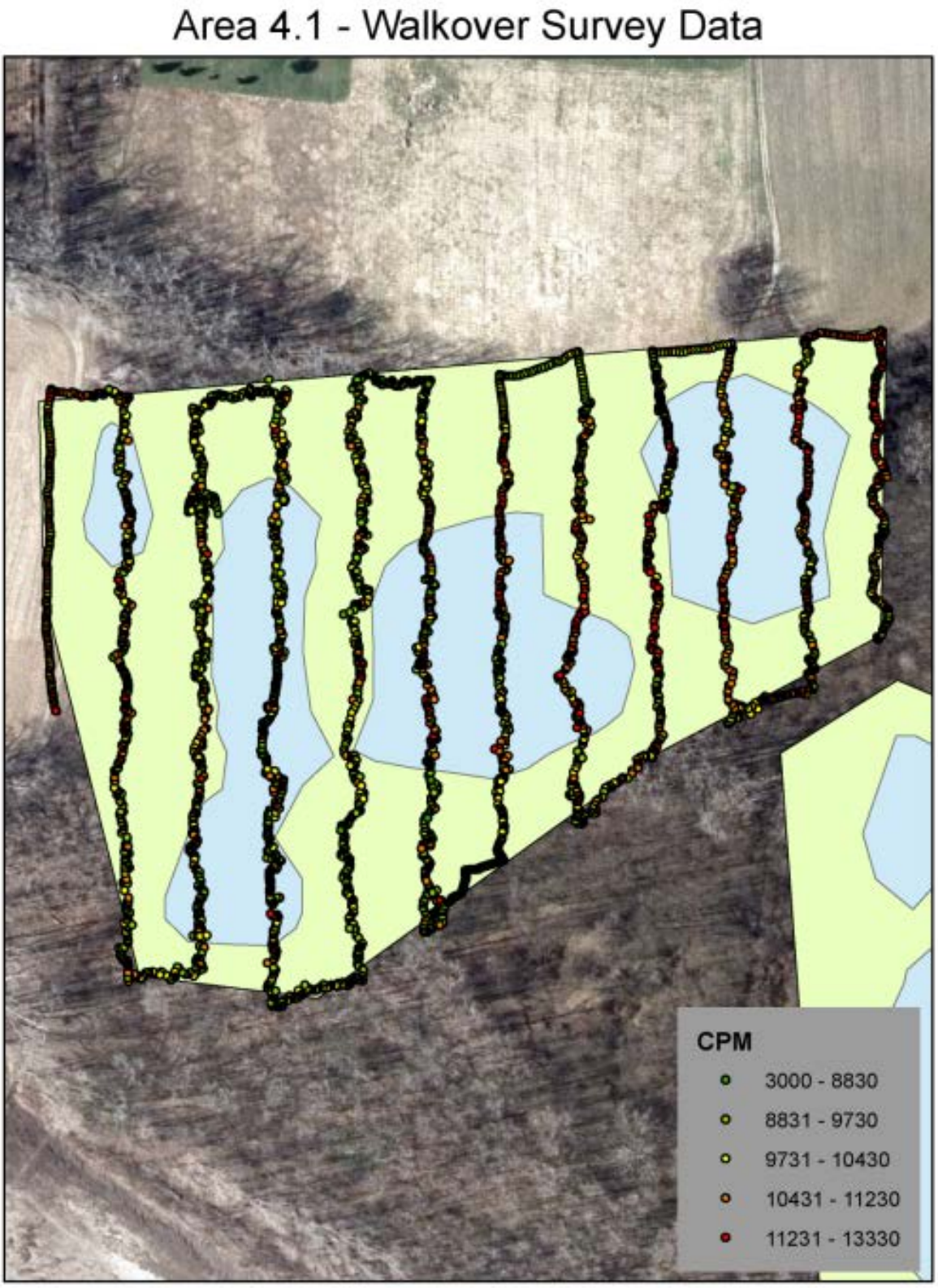


**Figure 36. Sub-Area 4.2 GPS Walkover Gamma Survey Data**

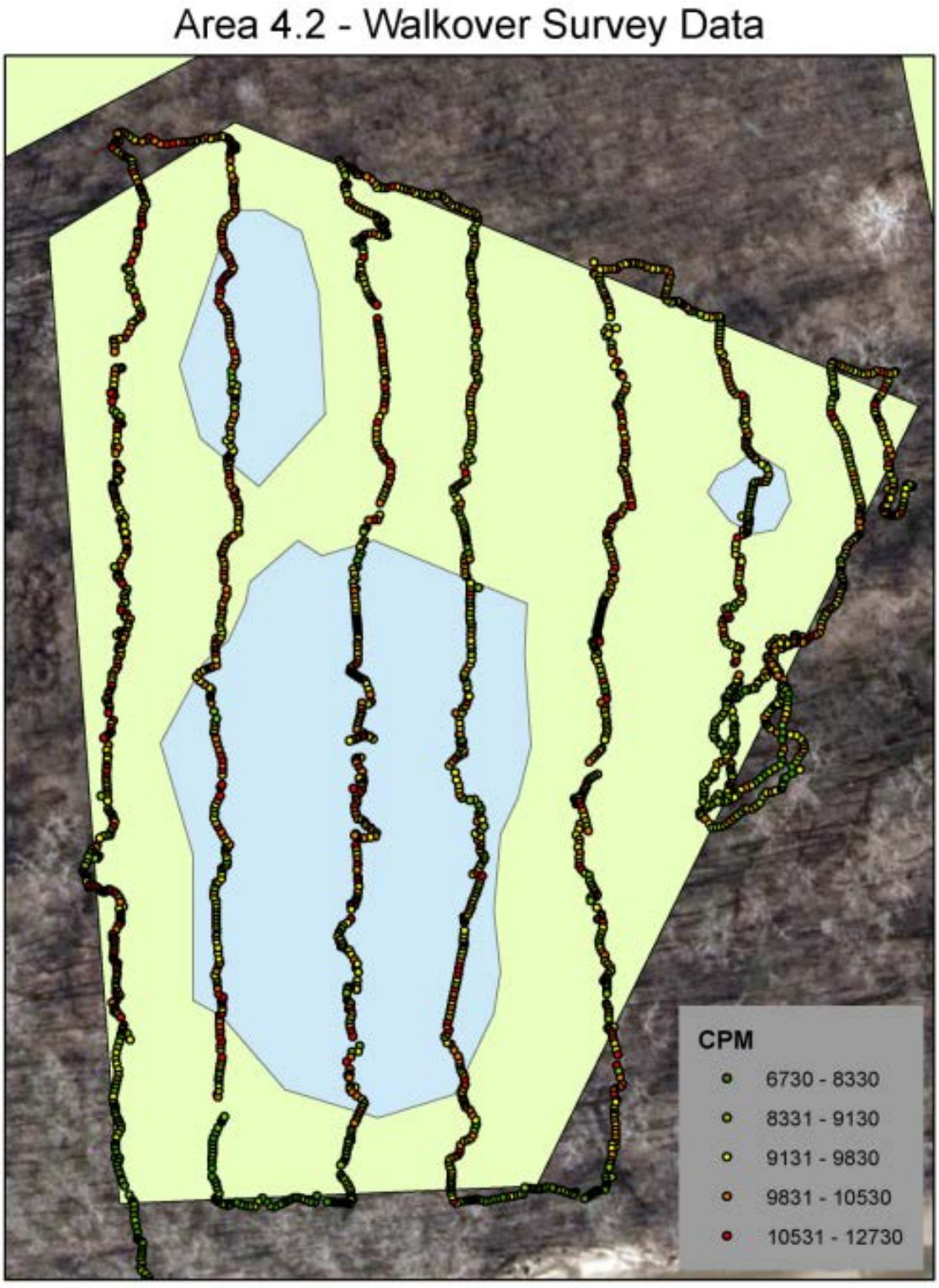


**Figure 37. Sub-Area 4.3 GPS Walkover Gamma Survey Data**

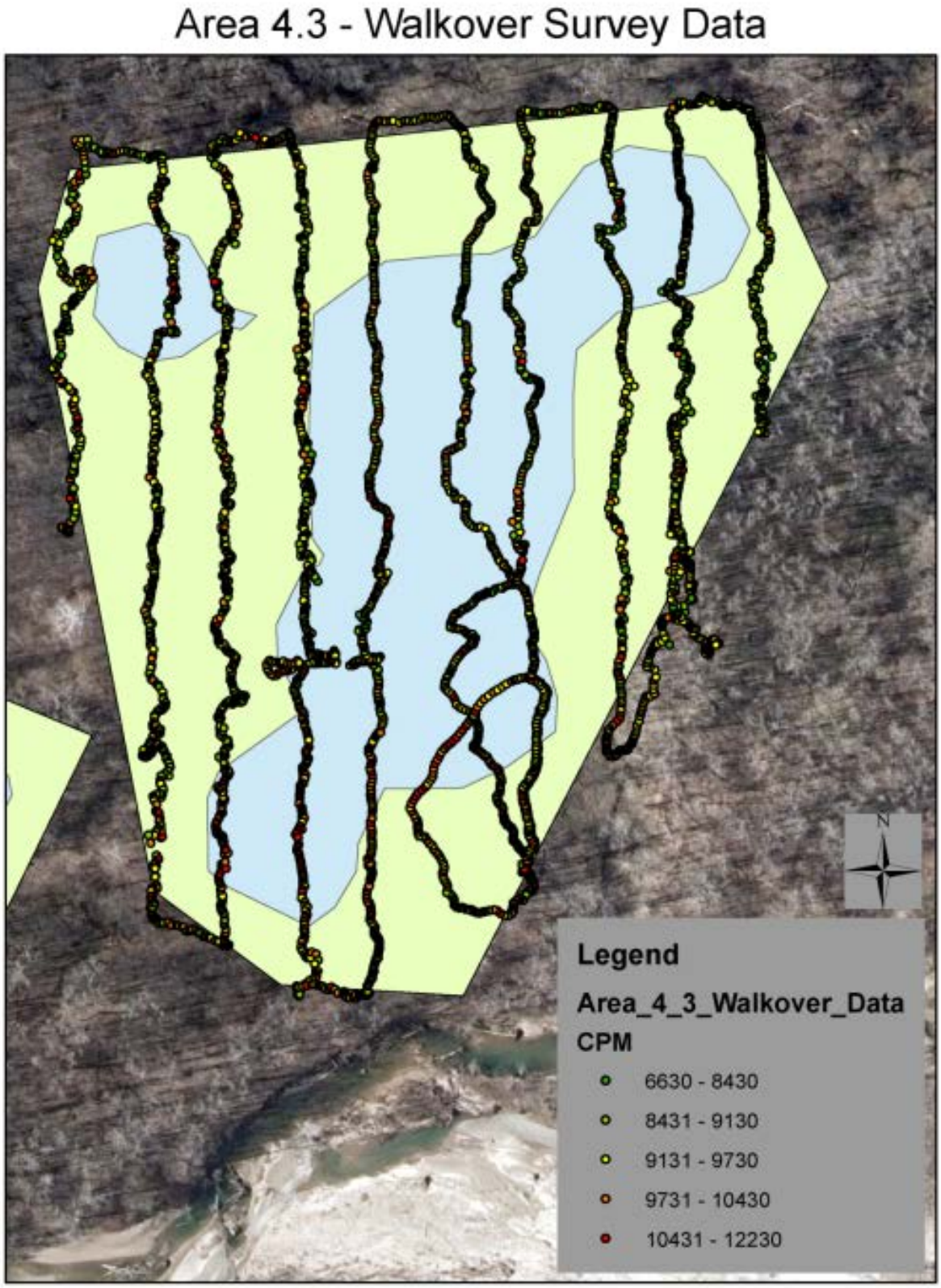


**Figure 38. Sub-Area 4.4 GPS Walkover Gamma Survey Data**

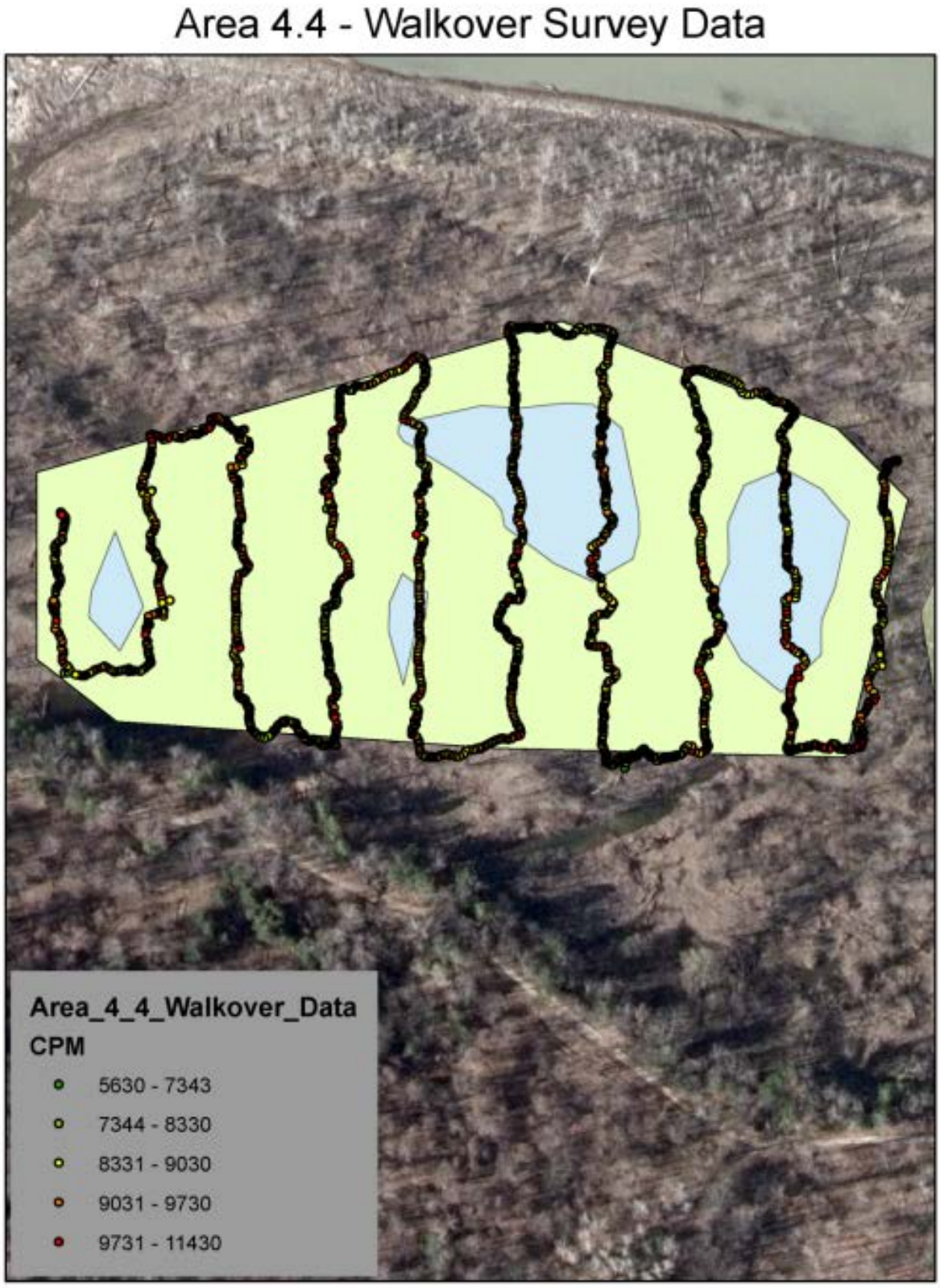
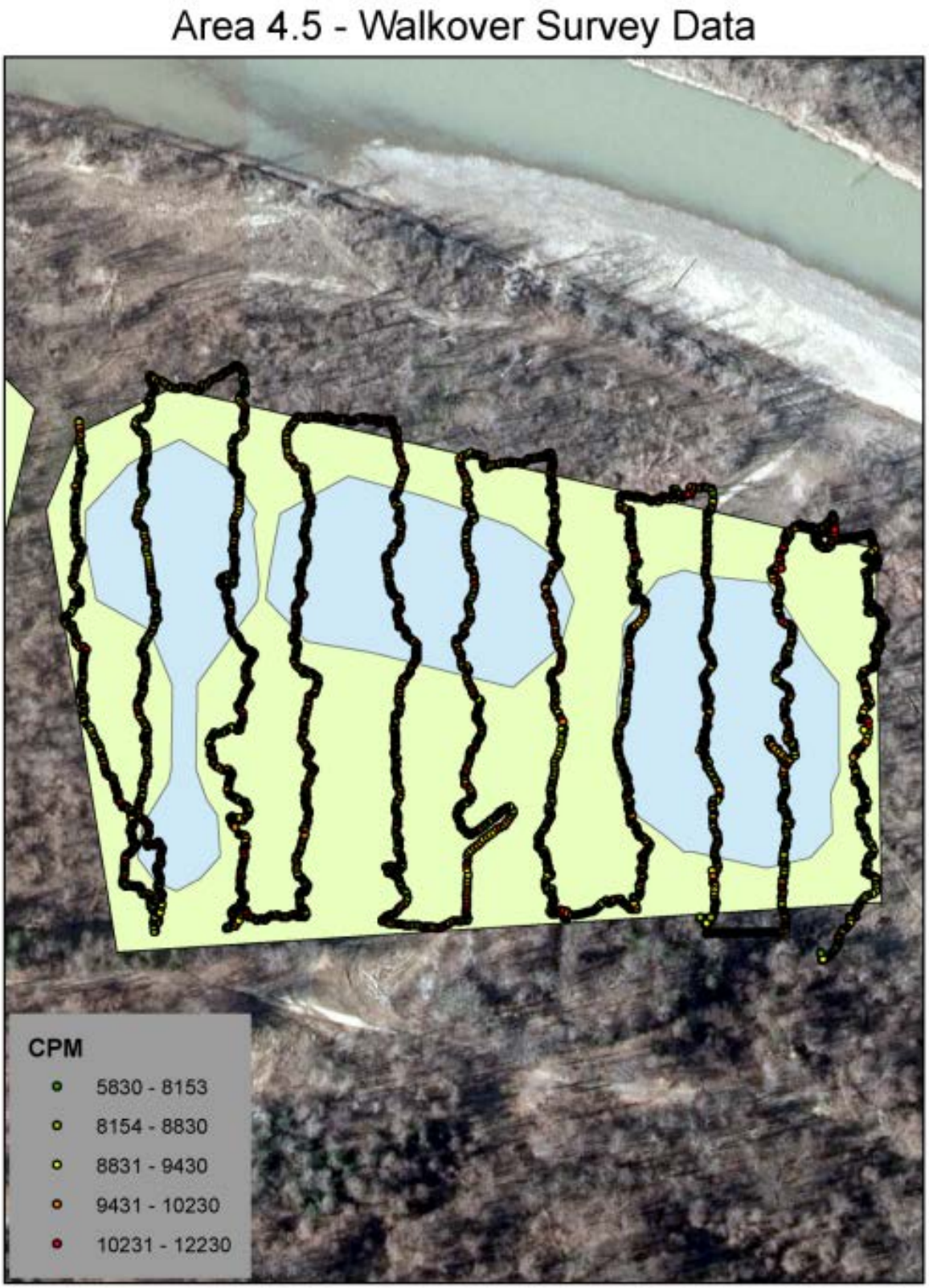


**Figure 39. Sub-Area 4.5 GPS Walkover Gamma Survey Data**



### *Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation*

- The Area 4.1 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7871 CPM to 10299 CPM. The average across all locations was 9030 CPM.
- The Area 4.2 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7723 CPM to 10383 CPM. The average across all locations was 8704 CPM.
- The Area 4.3 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7225 CPM to 9804 CPM. The average across all locations was 7966 CPM.
- The Area 4.4 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7130 CPM to 9210 CPM. The average across all locations was 7799 CPM.
- The Area 4.5 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7263 CPM to 9367 CPM. The average across all locations was 8205 CPM.
- The applicable background count rate for Area 4 was determined to be 7943 CPM.

A tabulation of the static count rates is provided in Appendix H32.

### *Tissue Equivalent Dose Rate Survey Meter Readings*

The tissue equivalent survey meter readings for Area 4 are provided in Appendix H1.

The average dose rates for each sub-area are provided below (Table 51).

**Table 51. Area 4 Tissue Equivalent Dose Rates**

| Area | Average Dose Rate[a] at 100 cm (µrem/hour) | Maximum Dose Rate at 100 cm (µrem/hour) |
|---|---|---|
| Sub-Area 4.1 | 5.6 ± 0.1 | 7 |
| Sub-Area 4.2 | 4.9 ± 0.1 | 8 |
| Sub-Area 4.3 | 4.4 ± 0.1 | 8 |
| Sub-Area 4.4 | 4.5 ± 0.1 | 7 |
| Sub-Area 4.5 | 4.5 ± 0.1 | 7 |

[a] Uncertainty is reported as ± 1 sigma.

In Sub-Area 4.1, the average dose rate at the 100 cm elevation exceeded the background screening level. In all other sub-areas, the average dose rate at 100 cm was less than the background screening level.

### *Soil Concentration Data*

The weighted mean soil concentrations for gross alpha, gross beta, and cesium results associated with each depth for Areas 4.1 through 4.5 were calculated and are summarized in Table 52 below:

**Table 52. Area 4 Weighted Average Soil Concentrations (pCi/g)**

| Sub-Area 4.1 | | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Alpha | | Beta | | Cesium-137 | |
| | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.5E+01 | 4.2E-01 | 2.0E+01 | 3.2E-01 | 7.8E-01 | 1.2E-02 |
| 15-30 | 1.5E+01 | 4.0E-01 | 2.4E+01 | 3.1E-01 | 8.3E-01 | 1.2E-02 |
| 30-60 | 1.5E+01 | 7.1E-01 | 2.1E+01 | 5.0E-01 | 2.7E-01 | 1.7E-02 |
| 60-100 | 1.3E+01 | 7.4E-01 | 2.3E+01 | 5.5E-01 | 7.3E-02 | 1.2E-02 |

| Sub-Area 4.2 | | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Alpha | | Beta | | Cesium-137 | |
| | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.5E+01 | 4.1E-01 | 2.4E+01 | 3.2E-01 | 1.1E+00 | 1.2E-02 |
| 15-30 | 1.5E+01 | 4.1E-01 | 2.4E+01 | 3.1E-01 | 1.6E+00 | 1.6E-02 |
| 30-60 | 1.2E+01 | 7.3E-01 | 1.9E+01 | 5.3E-01 | 2.3E-01 | 1.4E-02 |
| 60-100 | 1.4E+01 | 7.8E-01 | 2.0E+01 | 5.5E-01 | 3.9E-02 | 1.1E-02 |

| Sub-Area 4.3 | | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Alpha | | Beta | | Cesium-137 | |
| | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.5E+01 | 4.0E-01 | 2.3E+01 | 3.1E-01 | 9.0E-01 | 1.3E-02 |
| 15-30 | 1.3E+01 | 3.7E-01 | 2.2E+01 | 3.1E-01 | 6.3E-01 | 1.0E-02 |
| 30-60 | 1.4E+01 | 6.5E-01 | 1.7E+01 | 4.2E-01 | 1.7E-01 | 1.5E-02 |
| 60-100 | 1.2E+01 | 7.9E-01 | 1.9E+01 | 6.0E-01 | 6.9E-02 | 1.1E-02 |

| Sub-Area 4.4 | | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Alpha | | Beta | | Cesium-137 | |
| | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.3E+01 | 4.9E-01 | 2.1E+01 | 3.9E-01 | 5.2E-01 | 1.3E-02 |
| 15-30 | 1.4E+01 | 5.1E-01 | 2.1E+01 | 3.9E-01 | 6.7E-01 | 1.4E-02 |
| 30-60 | 1.2E+01 | 8.9E-01 | 1.7E+01 | 6.4E-01 | 1.4E-01 | 1.8E-02 |
| 60-100 | 1.1E+01 | 9.5E-01 | 1.8E+01 | 6.8E-01 | 1.4E-02 | 1.0E-02 |

| Sub-Area 4.5 | | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Alpha | | Beta | | Cesium-137 | |
| | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.4E+01 | 3.6E-01 | 2.3E+01 | 3.0E-01 | 6.9E-01 | 1.0E-02 |
| 15-30 | 1.5E+01 | 3.9E-01 | 2.5E+01 | 3.2E-01 | 4.7E-01 | 1.0E-02 |
| 30-60 | 1.7E+01 | 8.5E-01 | 2.2E+01 | 5.7E-01 | 1.1E-01 | 1.2E-02 |
| 60-100 | 1.7E+01 | 8.1E-01 | 2.0E+01 | 5.5E-01 | 3.0E-02 | 9.0E-03 |

The corresponding background gross alpha, gross beta, and cesium soil concentrations were subtracted from the average soil concentrations to determine the net soil concentrations above background. The net soil concentrations were used to assess the potential exposure to a "Collector" and a "Hunter/Fisher." Table 53 provides the calculated weighted net average soil concentrations, for the 0-100 cm depth, used in the dose assessment.

**Table 53. Area 4 Weighted Net Soil Concentrations (pCi/g) for 0-100 cm**

| Sub-Area | Alpha | Beta | Cesium-137 |
|---|---|---|---|
| 4.1E+00 | 1.7E-01 | 2.8E-01 | 3.2E-01 |
| 4.2E+00 | 3.1E-01 | 2.3E-01 | 4.5E-01 |
| 4.3E+00 | 2.3E-02 | 1.5E-01 | 2.8E-01 |
| 4.4E+00 | 6.9E-02 | 0.0E+00 | 1.9E-01 |
| 4.5E+00 | 1.5E+00 | 1.7E-01 | 1.9E-01 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### 7.4.4 Dose Assessment Approach for Area 4

The dose assessment approach for Area 4 was to:

- Develop an estimate of annual exposure based on the Aerial Survey data.
- Develop an estimate of annual exposure based upon the tissue equivalent dose rate survey meter readings.
- Perform a site-specific "Collector" and a "Hunter/Fisher" RESRAD scenario calculation culturally specific land use information to assess exposures in excess of background using appropriate parameters (e.g., hydrology, occupancy and consumption) in order to estimate the Collector's and Hunter/Fisher's exposure. Parameters were adjusted based on published references for the region or historical site specific data. Calculations were performed using the weighted mean above background for the data analyzed.

  Dose assessments associated with soil data were performed using RESRAD-OFFSITE 3.1. Hydrology data for the elevated, unsaturated, and saturated zones were based on Revision 2 of the Phase 1 Decommissioning Plan for the WVDP. The RESRAD input parameters used that

differed from the RESRAD defaults are summarized in Appendix H6. In cases where area specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modification are described below and in Appendix H6. This would include, but is not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where there were no site-specific data or there was no corresponding Decommissioning Plan value, the RESRAD-OFFSITE default parameters were used.

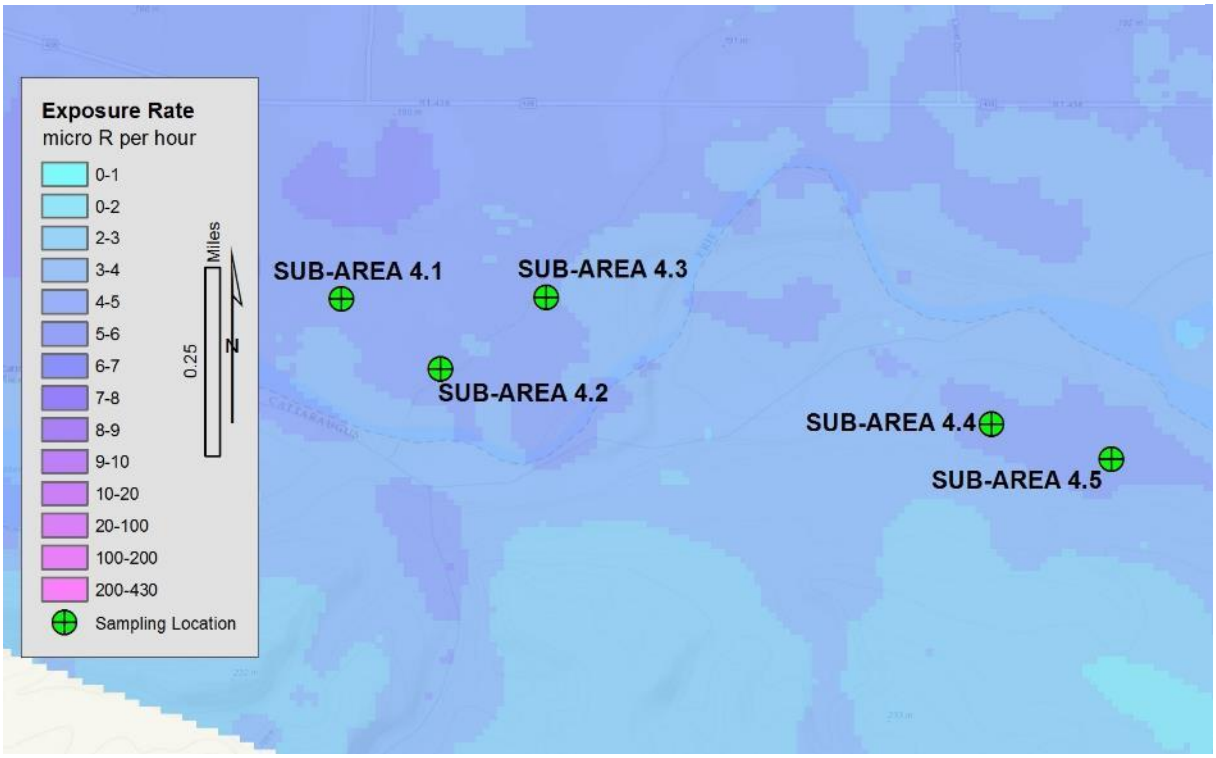
- The Area 4 dose assessment was based on culturally specific land for the Collector and Hunter/Fisher as provided by the SNI (see Appendix D).
- The evapotranspiration coefficient provided in the Decommissioning Plan was recalculated to maintain the same infiltration rate of 0.26 meters per year.
- Comparison of the sample results to the $DCGL_w$ concentrations established in the Phase 1 Decommissioning Plan for the WVDP. The peak-of-the-mean values are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.

### 7.4.5 Dose Assessment Results for Area 4 Dose

#### *Dose Assessment Based on Aerial Survey Data for Area 4*

Figure 40 is an aerial radiological survey map extracted from the Aerial Survey data onto which the location of Area 4 has been placed. The dose rates at an elevation of one m as derived from the map were determined to be 5-6 (μR/hour) for Sub-Area 4.1 and 3-4 (μR/hour) for all other sub-areas. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 (μR/hour).

**Figure 40. Area 4 Locations on the 2014 WNYNSC Aerial Radiological Survey**



Based on this aerial map and the assumed cosmic and airborne radon contribution, the dose rates were determined for Area 4 as shown in Table 54. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings to account for the contribution to background from cosmic radiation and airborne radon.

**Table 54. Area 4 Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| Sub-Area 4.1 | 5-6 | 5.5 | 4.8 | 10.3 |
| Sub-Area 4.2 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 4.3 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 4.4 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 4.5 | 3-4 | 3.5 | 4.8 | 8.3 |

The average SNI Floodplain background dose rate based on the WNYNSC Aerial Survey was 8.9 μR/hour at one meter above the ground. This was subtracted from the total dose rate in Table 54, and the calculated doses for Area 4 are provided in Table 55. The occupancy time was based on culturally specific land use information provided by the SNI.

**Table 55. Area 4 Calculated Doses Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Total Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate[a] (mrem/year) | Hunter/Fisher Annual Dose Rate[a] (mrem/year) |
|---|---|---|---|---|
| Sub-Area 4.1 | 10.3 | 8.9 | 1.5 | 3.7 |
| Sub-Area 4.2 | 8.3 | 8.9 | 0.0 | 0.0 |
| Sub-Area 4.3 | 8.3 | 8.9 | 0.0 | 0.0 |
| Sub-Area 4.4 | 8.3 | 8.9 | 0.0 | 0.0 |
| Sub-Area 4.5 | 8.3 | 8.9 | 0.0 | 0.0 |

[a] The aerial survey dose rates were recorded in units of Roentgen. The quality factors for photons and electrons are both one; therefore, 1 R equals 0.877 rem.

### *Dose Assessment Based Upon Tissue Equivalent Survey Meter Readings for Area 4*

For Sub-Area 4.1, the average dose rate slightly exceeded the background screening level. The occupancy time was based on culturally specific land use information provided by the SNI.

For Sub-Areas 4.2-4.5, the tissue equivalent survey meter readings were all below the background dose rates. The calculated doses for Area 4 are provided in Table 56.

**Table 56. Area 4 Calculated Doses Based on Tissue Equivalent Survey Meter Readings**

| Location | Average Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate (mrem/year) | Hunter/Fisher Annual Dose Rate (mrem/year) |
|---|---|---|---|---|
| Sub-Area 4.1 | 5.6 | 5.0 | 0.8 | 1.9 |
| Sub-Area 4.2 | 4.9 | 5.0 | 0.0 | 0.0 |
| Sub-Area 4.3 | 4.4 | 5.0 | 0.0 | 0.0 |
| Sub-Area 4.4 | 4.5 | 5.0 | 0.0 | 0.0 |
| Sub-Area 4.5 | 4.5 | 5.0 | 0.0 | 0.0 |

In addition, per an SNI request, a maximum dose was assessed, based on the highest tissue equivalent survey meter readings. This assumes that an individual performed all the activities (gathering, camping, hunting, etc.) at a single location that corresponds to the highest exposure rate for the entire occupancy time provided in the culturally specific land use information. This scenario provides an upper bound estimate of the potential exposure to an individual as it is not likely that all the non-leafy and leafy vegetation, wild game, and camping sites reside in the same single isolated location, year round. Table 57 provides the maximum calculated doses based on the Tissue Equivalent Survey Meter.

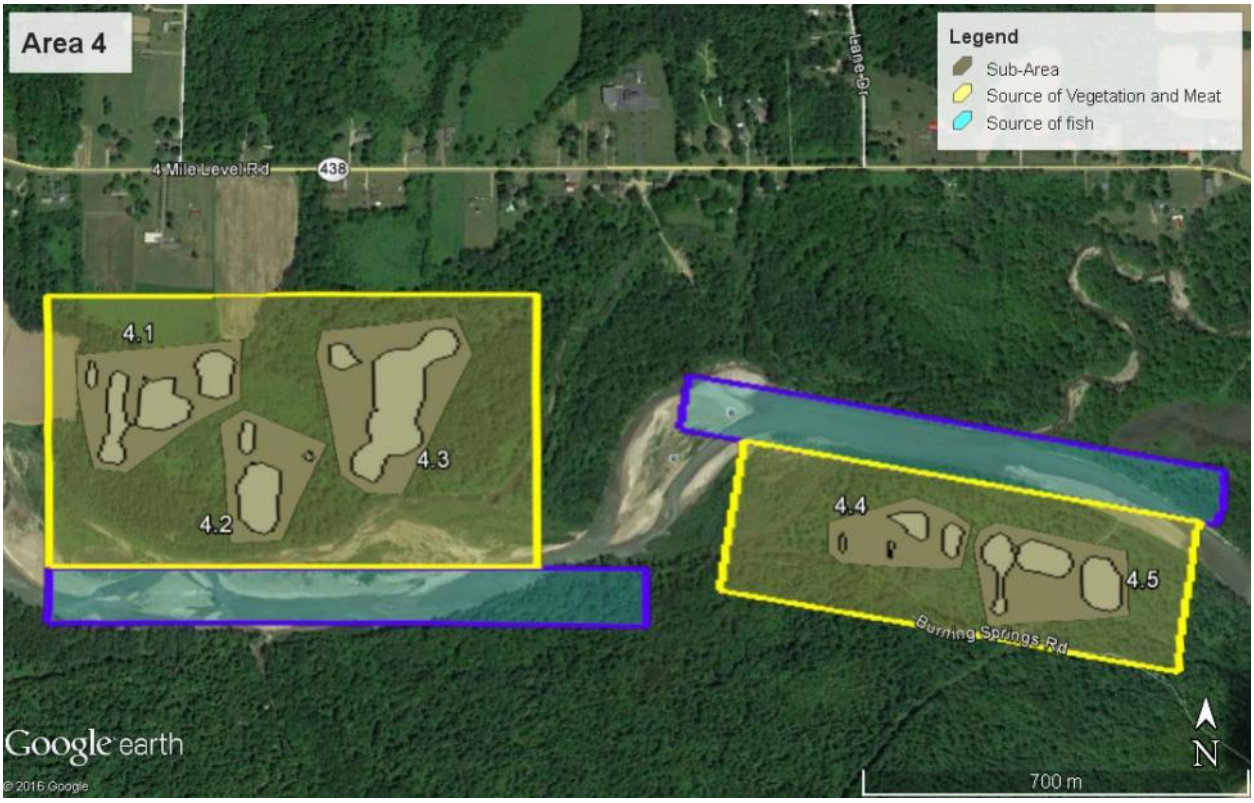
**Table 57. Area 4 Calculated Doses Based on the Maximum Tissue Equivalent Survey Meter Readings**

| Location | Maximum Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate (mrem/year) | Hunter/Fisher Annual Dose Rate (mrem/year) |
|---|---|---|---|---|
| Sub-Area 4.1 | 7 | 5.0 | 5.8 | 8.0 |
| Sub-Area 4.2 | 8 | 5.0 | 8.6 | 11.9 |
| Sub-Area 4.3 | 8 | 5.0 | 8.6 | 11.9 |
| Sub-Area 4.4 | 7 | 5.0 | 5.2 | 7.8 |
| Sub-Area 4.5 | 7 | 5.0 | 5.2 | 7.8 |

### *Dose Assessment Based upon RESRAD Analysis of Soil Concentrations for Area 4*

The exposure scenario for Area 4 is based on the culturally specific land use information for a "Collector" and a "Hunter/Fisher" scenario. The elevated areas are a series of smaller irregularly shaped areas (listed as a, b, c, etc.) within the boundaries of each irregularly shaped Sub-Area (4.1, 4.2, 4.3, etc.). In order to model these irregularly shaped areas, the total elevated surface area within each sub-area was converted into a single rectangle of equivalent surface area located at the center of the Sub-Area. Each sub-area was also converted into a single rectangle of equivalent surface area with its center located at the center of the sub-area; Figure 41 provides a demonstration of this (see following page).

**Figure 41. Area 4 RESRAD Modeled Exposure Layout**




## Sub-Area 4.1

There were four elevated areas within Sub-Area 4.1. These areas were combined into an equivalent modeled area, totaling 18,513 square meters (153 m x 121 m). This modeled elevated area is contained within a larger 450,000 square meter (900 m x 500 m) undeveloped area based on the cultural land use information provided by the SNI. The SNI indicated the areas where wild vegetation and wild game are collected for consumption (yellow box). Therefore, the forested area north of the creek was used as the source of the wild vegetation and wild game. There are no surface water features within the 450,000 square meter area of land. However, there is a creek (blue box), due south, of the area that provides a source of water for irrigation and fish for consumption. The creek is modeled as an area that covers 110,000 square meters (1100 m x 100 m) south of the source of wild vegetation and wild game. See Figure 41 for a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game, fish, and wild vegetation. No water or milk consumption was assessed based on the culturally specific land use information. However, both well and surface water were included as sources for irrigation. The exposures associated with these two scenarios are provided in Table 58 and Table 59. The RESRAD input parameters are provided in Appendix H6.

**Table 58. Sub-Area 4.1 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.39E-01 | 2.29E-04 | 3.44E-09 | 1.58E-01 | 1.46E-03 | 1.68E-03 | 3.01E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

**Table 59. Sub-Area 4.1 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 3.52E-01 | 5.80E-04 | 1.03E-08 | 1.58E-01 | 1.46E-03 | 4.24E-03 | 5.16E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

The main source of exposure is direct external from the ground and vegetation consumption. The full RESRAD output file is provided in Appendix H16, H17, H18, and H19.

### Sub-Area 4.2

There were three areas within Sub-Area 4.2. These areas were combined into an equivalent modeled area, totaling 10,080 square meters (90 m x 112 m). This modeled elevated area is contained within a larger 450,000 square meter (900 m x 500 m) undeveloped area based on the cultural land use information provided by the SNI. The SNI indicated the areas where wild vegetation and wild game are collected for consumption (yellow box). Therefore, the forested area north of the creek was used as the source of the wild vegetation and wild game. There are no surface water features within the 450,000 square meter area of land. However, there is a creek (blue box), due south, of the area that provides a source of water for irrigation and fish for consumption. The creek is modeled as an area that covers 110,000 square meters (1100 m x 100 m) south of the source of wild vegetation and wild game. See Figure 41 for a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game, fish and wild vegetation. No water or milk consumption was assessed based on the culturally specific land use information. However, both well and surface water were included as sources for irrigation. The exposures associated with these two scenarios are provided in Table 60 and Table 61. The RESRAD input parameters are provided in Appendix H6.

**Table 60. Sub-Area 4.2 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.96E-01 | 3.88E-04 | 4.87E-09 | 7.64E-02 | 8.58E-04 | 2.91E-03 | 2.77E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

**Table 61. Sub-Area 4.2 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 4.91E-01 | 9.82E-04 | 1.46E-08 | 7.64E-02 | 8.58E-04 | 7.37E-03 | 5.77E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

The main source of exposure is direct external from the ground and vegetation consumption. The full RESRAD output file is provided in Appendix H20, H21, H22, and H23.

### Sub-Area 4.3

There were three areas within Sub-Area 4.3. These areas were combined into an equivalent modeled area, totaling 25,650 square meters (150 m x 171 m). This modeled elevated area is contained within a larger 450,000 square meter (900 m x 500 m) undeveloped area based on the cultural land use information provided by the SNI. The SNI indicated the areas where wild vegetation and wild game are collected for consumption (yellow box). Therefore, the forested area north of the creek was used as the source of the wild vegetation and wild game. There are no surface water features within the 450,000 square meter area of land. However, there is a creek (blue box), due south, of the area that provides a source of water for irrigation and fish for consumption. The creek is modeled as an area that covers 110,000 square meters (1100 m x 100 m) south of the source of wild vegetation and wild game. See Figure 41 for a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on culturally specific land use information. In both cases, the individual consumes wild game, fish and wild vegetation. No water or milk consumption was assessed based on the culturally specific land use information. However, both well and surface water were included as sources for irrigation. The exposures associated with these two scenarios are provided in Table 62 and Table 63. The RESRAD input parameters are provided in Appendix H6.

**Table 62. Sub-Area 4.3 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.21E-01 | 3.25E-05 | 2.19E-09 | 1.21E-01 | 1.37E-03 | 2.99E-04 | 2.44E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

**Table 63. Sub-Area 4.3 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 3.05E-01 | 8.23E-05 | 6.59E-09 | 1.21E-01 | 1.37E-03 | 7.56E-04 | 4.28E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

The main source of exposure is direct external from the ground and vegetation consumption. The full RESRAD output file is provided in Appendix H24, H25, H26, and H27.

### Sub-Area 4.4

There were four areas within Sub-Area 4.4. These areas were combined into an equivalent modeled area, totaling 4,746 square meters (113 m x 42 m). This modeled elevated area is contained within a larger 233,750 square meter (850 m x 275 m) undeveloped area based on the cultural land use information provided by the SNI. The SNI indicated the areas where wild vegetation and wild game are collected for consumption (yellow box). Therefore, the forested area north of the creek was used as the source of the wild vegetation and wild game. There are no surface water features within the 233,750 square meter area of land. However, there is a creek (blue box), due south, of the area that provides a

source of water for irrigation and fish for consumption. The creek is modeled as an area that covers 100,000 square meters (1000 m x 100 m) south of the source of vegetation and wild game. See Figure 41 for a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on culturally specific land use information. In both cases, the individual consumes wild game, fish and vegetation. No water or milk consumption was assessed based on the culturally specific land use information. However, both well and surface water were included as sources for irrigation. The exposures associated with these two scenarios are provided in Table 64 and Table 65. The RESRAD input parameters are provided in Appendix H6.

**Table 64. Sub-Area 4.4 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 7.47E-02 | 7.45E-05 | 2.56E-09 | 3.62E-03 | 2.53E-04 | 5.99E-04 | 7.92E-02 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

**Table 65. Sub-Area 4.4 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 1.98E-01 | 1.98E-04 | 7.68E-09 | 3.62E-03 | 2.57E-04 | 1.59E-03 | 2.04E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

The main source of exposure is direct external from the ground and vegetation consumption. The full RESRAD output file is provided in Appendix H28, H29, H30, and H31.

### Sub-Area 4.5

There were three areas within Sub-Area 4.5. These areas were combined into an equivalent modeled area, totaling 15,708 square meters (154 m x 102 m). This modeled elevated area is contained within a larger 233,750 square meter (850 m x 275 m) undeveloped area based on the cultural land use information provided by the SNI. The SNI indicated the areas where wild vegetation and wild game are collected for consumption (yellow box). Therefore, the forested area north of the creek was used as the source of the wild vegetation and wild game. There are no surface water features within the 233,750 square meter area of land. However, there is a creek (blue box), due south, of the area that provides a source of water for irrigation and fish for consumption. The creek is modeled as an area that covers 100,000 square meters (1000 m x 100 m) south of the source of vegetation and wild game. See Figure 41 for a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on culturally specific land use information. In both cases, the individual consumes wild game, fish and vegetation. No water or milk consumption was assessed based on the culturally specific land use information. However, both well and surface water were included as sources for irrigation. The exposures associated with these two scenarios are provided in Table 66 and Table 67. The RESRAD input parameters are provided in Appendix H6.

**Table 66. Sub-Area 4.5 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 8.29E-02 | 1.88E-03 | 4.93E-08 | 2.56E-01 | 2.57E-03 | 1.30E-02 | 3.56E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

**Table 67. Sub-Area 4.5 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Fish[a] (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|---|
| 2.19E-01 | 4.99E-03 | 1.48E-07 | 2.56E-01 | 2.62E-03 | 3.44E-02 | 5.17E-01 |

a. Fish dose was increased by a factor of 28.65 to include the consumption of fish bones (see Appendix H77).

The main source of exposure is direct external from the ground and vegetation consumption. The full RESRAD output file is provided in Appendix H42, H43, H44, and H45.

### *Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values for Area 4*

Table 68 provides a comparison of the Area 4 soil concentrations to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values.

**Table 68. Area 4 Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$**

| Measurement Type | Nuclide Used | WVDP DCGL (pCi/g) | Soil Concentrations (pCi/g) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sub-Area 4.1 | Sub-Area 4.2 | Sub-Area 4.3 | Sub-Area 4.4 | Sub-Area 4.5 |
| Alpha | Pu-239[a] | 2.50E+01 | 0.170 | 0.307 | 0.023 | 0.069 | 1.541 |
| Beta | Sr-90 | 4.10E+00 | 0.276 | 0.225 | 0.154 | 0.000 | 0.167 |
| Cesium | Cs-137 | 1.50E+01 | 0.318 | 0.447 | 0.276 | 0.192 | 0.185 |
| Sum of Fractions: | | | Below | Below | Below | Below | Below |

a. The more conservative $DCGL_w$ between Am-241 and Pu-239 was used.

The assessment of the gross alpha and beta based on the most conservative isotopes (Pu-239 and Sr-90, respectively) accounts for all of the anthropogenic nuclides listed in Table 2 except C-14, I-129, and Tc-99. For these nuclides, a qualitative analysis was performed. In all cases, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the nuclides that account for most of the gross alpha and beta soil concentrations are radionuclides that are considered NORM (e.g., natural uranium, natural thorium, and potassium-40).

Therefore, the use of the DCGLs based on the WVDP Phase 1 Decommissioning Plan Resident Farmer scenario and gross results assuming the most conservative nuclide results in a highly conservative comparison.

### *Dose Assessment for Consumption of Fish Based Upon 2012 WVDP Annual Site Environmental Report*

The ASER (Ref. 8) provides radiological concentrations of strontium and cesium in the edible portion of the fish in Cattaraugus Creek. Biological data from their locations are provided. Hog-nosed Sucker and White Sucker are sampled from above the Springville Dam and Steelhead Trout are sampled from below the Springville Dam. Brown Trout, White Sucker, Bullhead, and Hog-nosed Sucker were also sampled at a background location. This data is provided in Appendix H41. The average radiological concentrations of strontium and cesium in the edible portion of the fish for the two areas around Springville Dam and the background area are provided in Table 69 and Table 70 below.

**Table 69. Concentrations in Edible Portions of Fish around Springville Dam**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.40E-08 | 1.16E-09 | µCi/g - wet |
| Cs-137 | 5.46E-08 | 1.31E-08 | µCi/g - wet |

**Table 70. Background Concentrations in Edible Portions of Fish**

| Isotope | Average | 1 Sigma | Units |
|---|---|---|---|
| Sr-90 | 1.02E-08 | 1.77E-09 | µCi/g - wet |
| Cs-137 | 4.75E-08 | 4.00E-08 | µCi/g - wet |

This results in a net above background concentration in the edible portions of the fish of 3.74E-09 µCi Sr-90 per gram of fish flesh and 7.08E-09 µCi Cs-137 per gram of fish flesh. The ingestion dose coefficients factors (DCF) and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 71.

**Table 71. Ingestion dose coefficients (mrem/µCi) from ICRP 68**

| Isotope | f1* | DCF | Units |
|---|---|---|---|
| Sr-90 | 0.3 | 1.04E+02 | mrem/µCi Ingestion |
| Sr-90 | 0.01 | 1.00E+01 | mrem/µCi Ingestion |
| Cs-137 | 1 | 4.81E+01 | mrem/µCi Ingestion |

* f1 – Fractional absorption in the gastrointestinal tract rate.

Based on culturally specific land use information, a Collector consumes about 36 pounds (lbs) of fish flesh per year and a Hunter/Fisher consumes about 108 lbs per year. These consumption rates result in a calculated annual dose of about 0.2 and 0.6 mrem per year, respectively.

### 7.4.6 Conclusions for Area 4

Annual doses based on the Aerial Survey, tissue equivalent survey meter readings, and RESRAD analysis ranged from 0 to 3.7 mrem per year. At the request of the SNI, a bounding estimate was performed for an individual located in the same area as the highest tissue equivalent survey meter reading. This assumes that an individual performed all the activities (e.g., gathering, camping, hunting, etc.) at a single

location that corresponds to the highest exposure rate for the entire occupancy time provided in the culturally specific land use information. This resulted in a maximum annual dose rate of 11.9 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that Area 4 is well below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 C.F.R. § 20.1402.

## 7.5 Area 5

### 7.5.1 Description of Area 5

Area 5 lies approximately 17 miles to the west of the WNYNSC, and 0.6 miles east of Cattaraugus Creek (pg. 10, Figure 5). It includes six sub-areas designated 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6. Each sub-area was defined by a polygon as can be seen in Figures 41, 42, and 43. Also seen in these figures, within each sub-area polygon, are one or two irregularly shaped sub-regions that were defined as derived from the Aerial Survey as follows:

- Sub-Area 5.1 – two sub regions designated 5.1A, and 5.1B.
- Sub-Area 5.2 – two sub regions designated 5.2A, and 5.2B
- Sub-Area 5.3 – one sub region designated 5.3A
- Sub-Area 5.4 - one sub region designated 5.4A
- Sub-Area 5.5 – one sub region designated 5.5A
- Sub-Area 5.6 – one sub region designated 5.6A

Area 5 is a relatively undisturbed old growth wooded area with varying terrain that lies outside the floodplain. There are no residences located in Area 5. For Area 5, culturally specific land use surveys were developed.

### 7.5.2 Survey and Sampling Methodology for Area 5

#### *GPS walkover surveys of Area 5*

GPS walkover surveys were conducted in all sub-areas using a nominal grid spacing of 30 meters. The areas were generally heavily wooded and GPS precision varied; however, sufficient data was collected and analyzed to determine if any random sampling locations needed to be redirected to elevated areas. No elevated areas were identified in Area 5.

#### *Static Survey and Sample Collection in Area 5*

Direct radiation readings and soil samples were collected in each sub-region as follows:

Sub-Area 5.1

- Sub Region 5.1A - two locations
- Sub Region 5.1B – two locations

Sub-Area 5.2

- Sub Region 5.2A – seven locations
- Sub Region 5.2B – eight locations

Sub-Area 5.3

- Sub Region 5.3A – four locations

Sub-Area 5.4

- Sub Region 5.4A – four locations

Sub-Area 5.5

- Sub Region 5.5A – four locations

Sub-Area 5.6

- Sub Region 5.6 A – four locations

Figures 42 to 44 show the sampling locations in Area 5.1

**Figure 42. Sub-Area 5.1 Sampling Locations**

**Figure 43. Sub-Areas 5.2, 5.3 and 5.4 Sampling Locations**

**Figure 44. Sub-Areas 5.5 and 5.6 Sampling Locations**


Each location was surveyed and sampled as follows:

- Dose rate readings were collected at one and 100 cm from the ground surface using the tissue equivalent dose rate meter.
- Static 2" x 2" NaI detector readings were collected at one and 100 cm from the ground surface using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two, one-minute counts were collected at each location at both elevations.
- Soil samples were collected in depth increments of 0-15 cm, 15-30 cm, 30-60 cm, and 60-100 cm.

### 7.5.3 Survey and Sampling Results for Area 5

#### *GPS Survey Results*

Figures 45 to 50 represent the graphical results of the GPS walkover surveys conducted in Area 5. No pattern of elevated locations was discerned in the GPS maps and therefore no elevated locations were sampled.

**Figure 45. Sub-Area 5.1 GPS Walkover Survey Data**

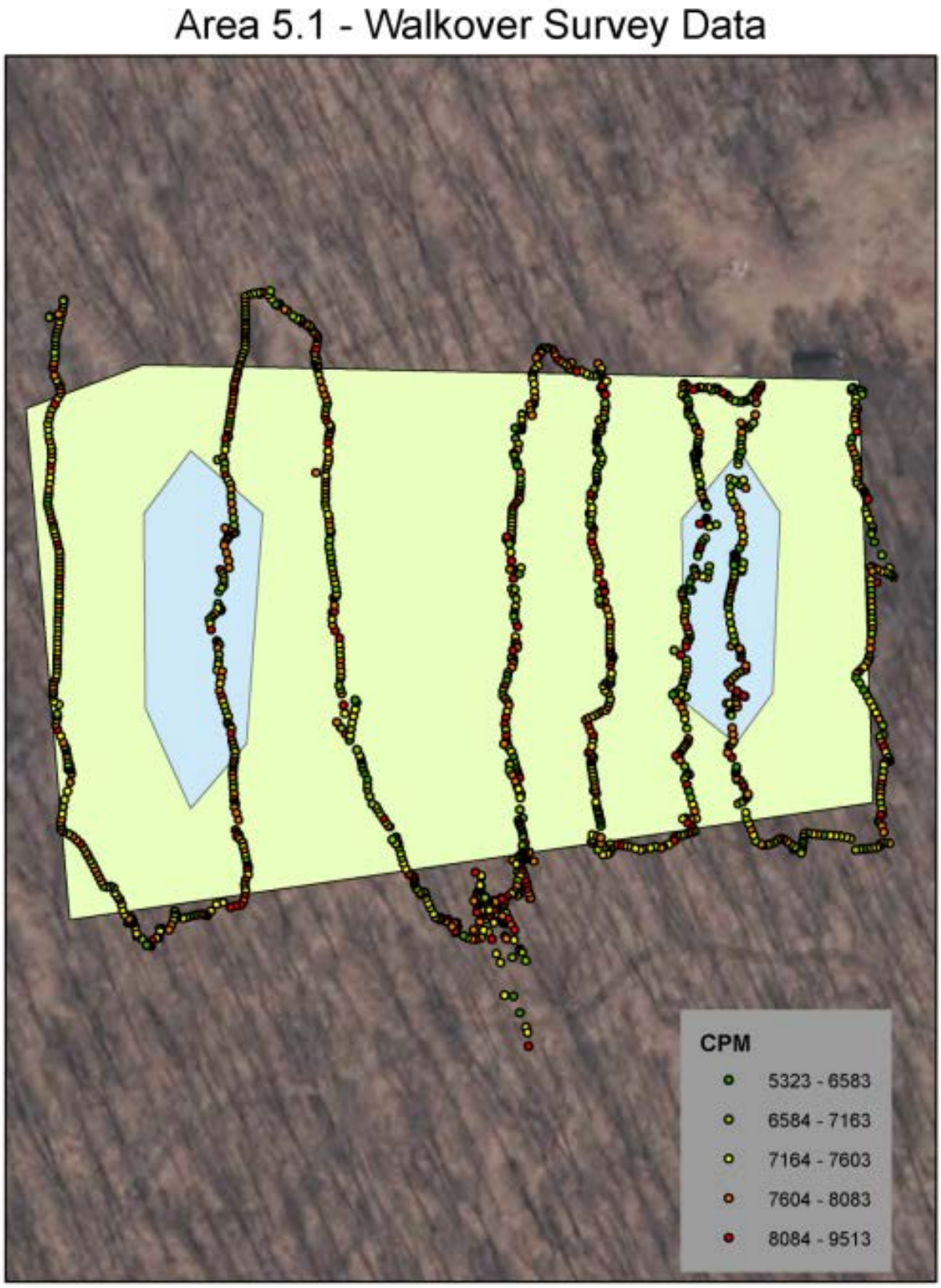


**Figure 46. Sub-Area 5.2 GPS Walkover Gamma Survey Data**

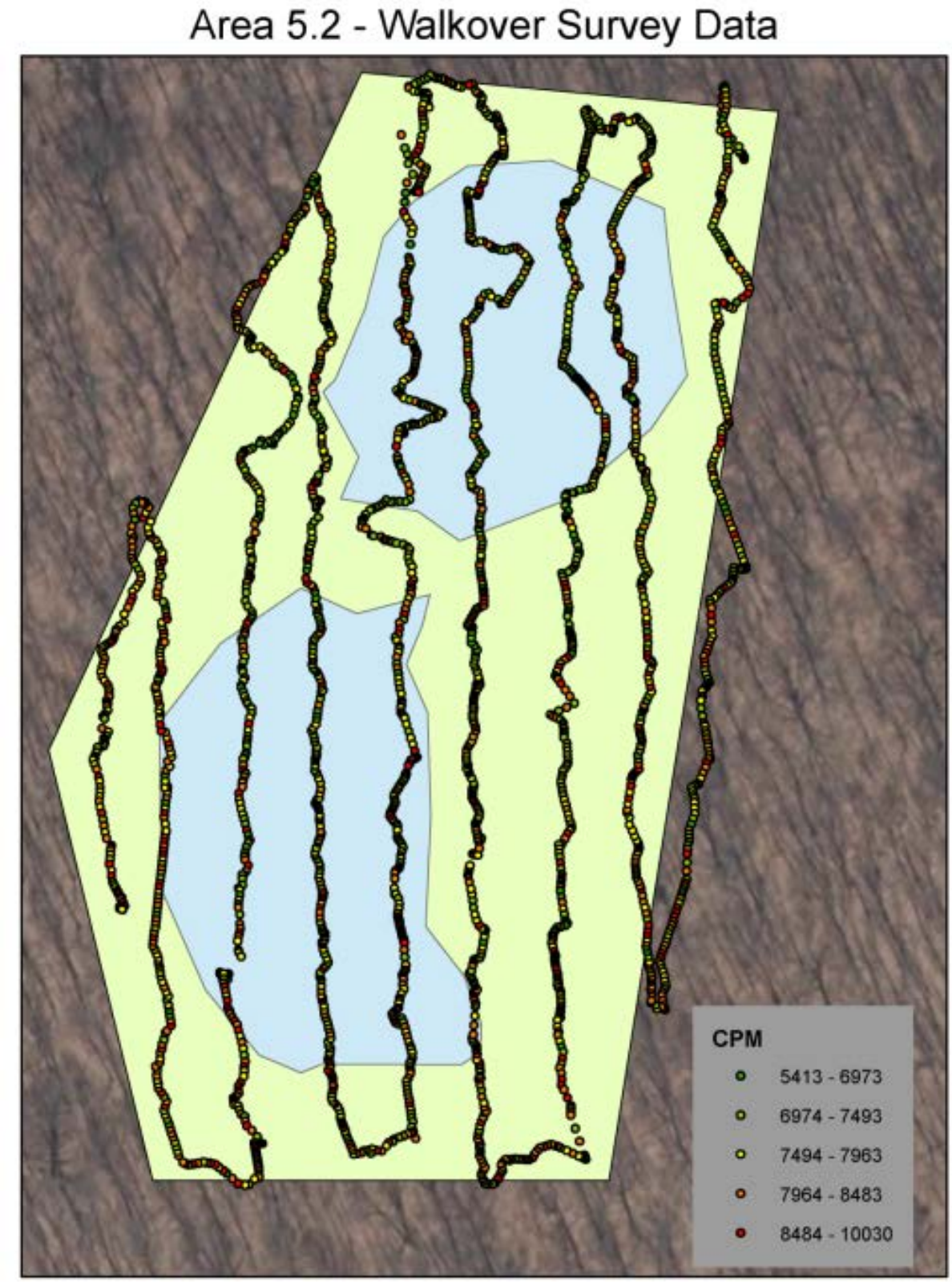


**Figure 47. Sub-Area 5.3 GPS Walkover Gamma Survey Data**

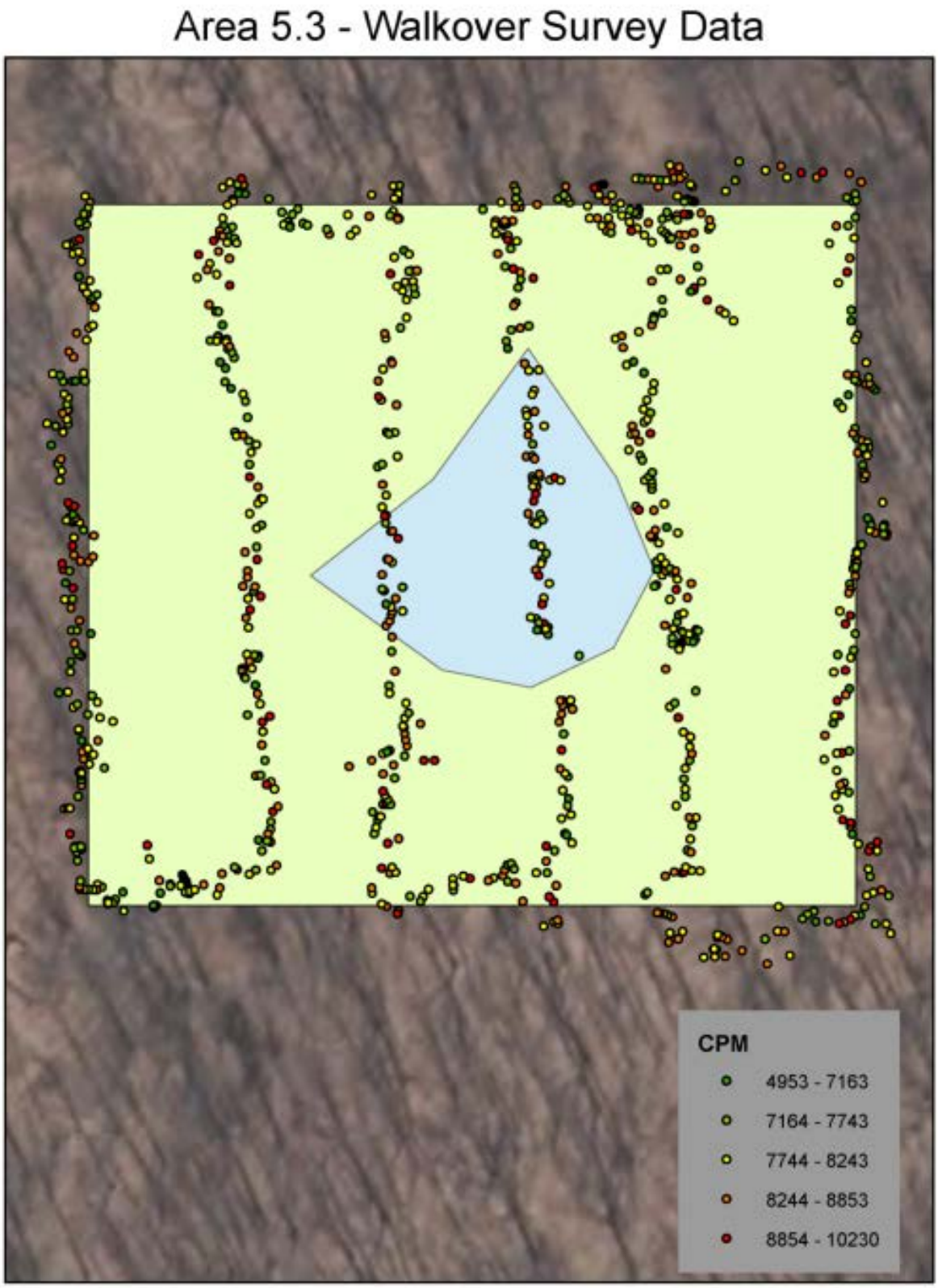


**Figure 48. Sub-Area 5.4 GPS Walkover Gamma Survey Data**

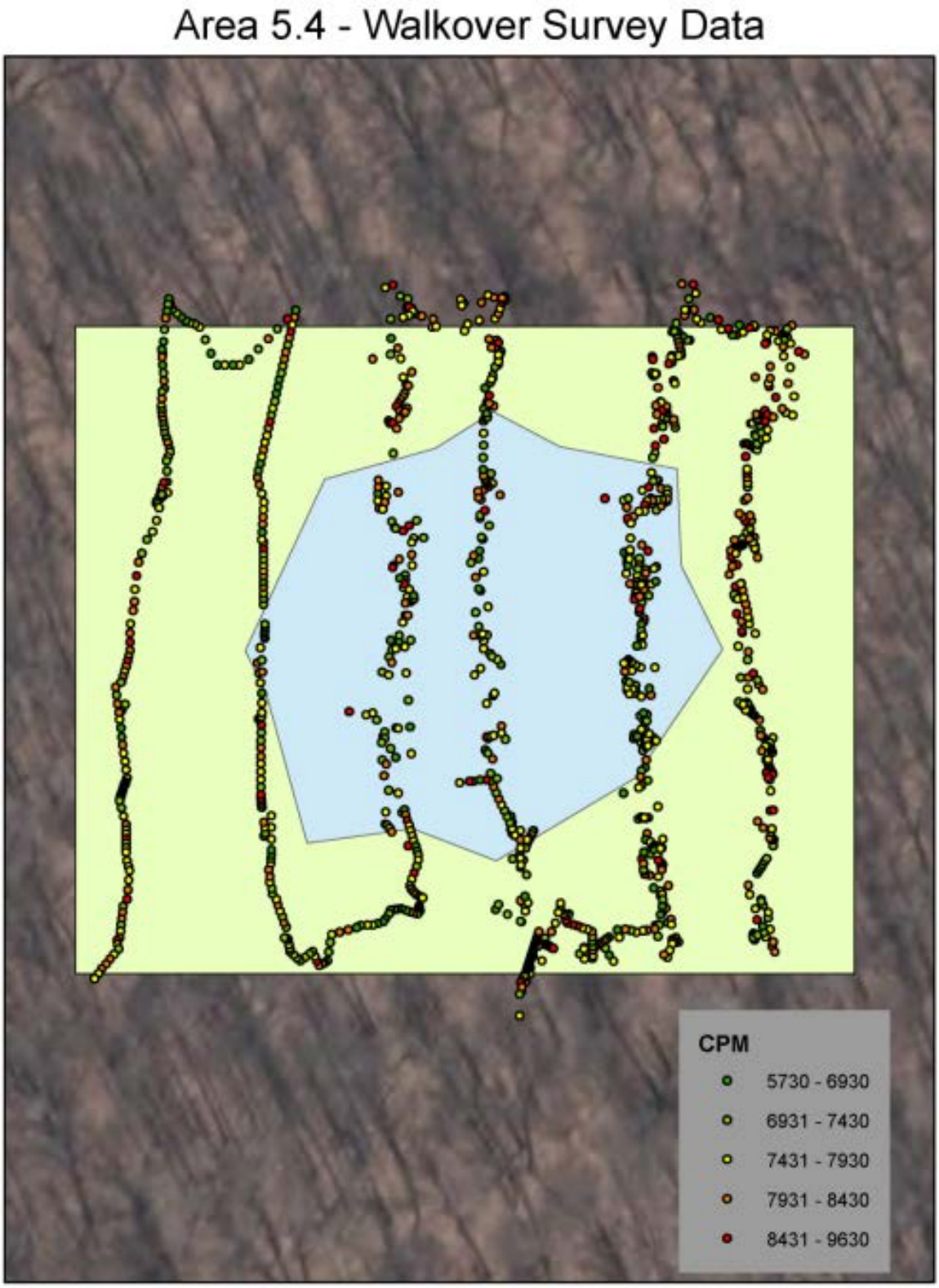


**Figure 49. Sub-Area 5.5 GPS Walkover Gamma Survey Data**

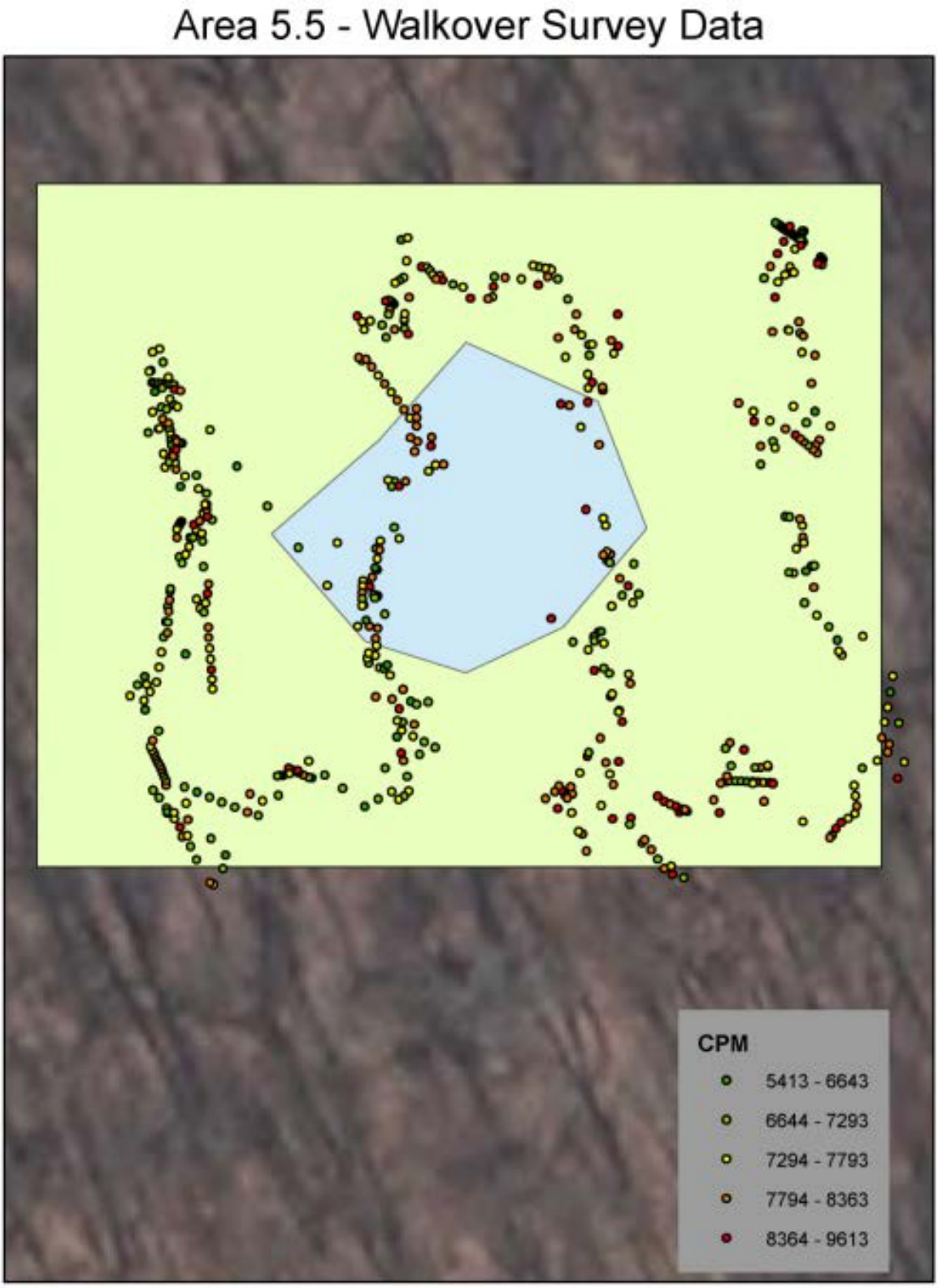
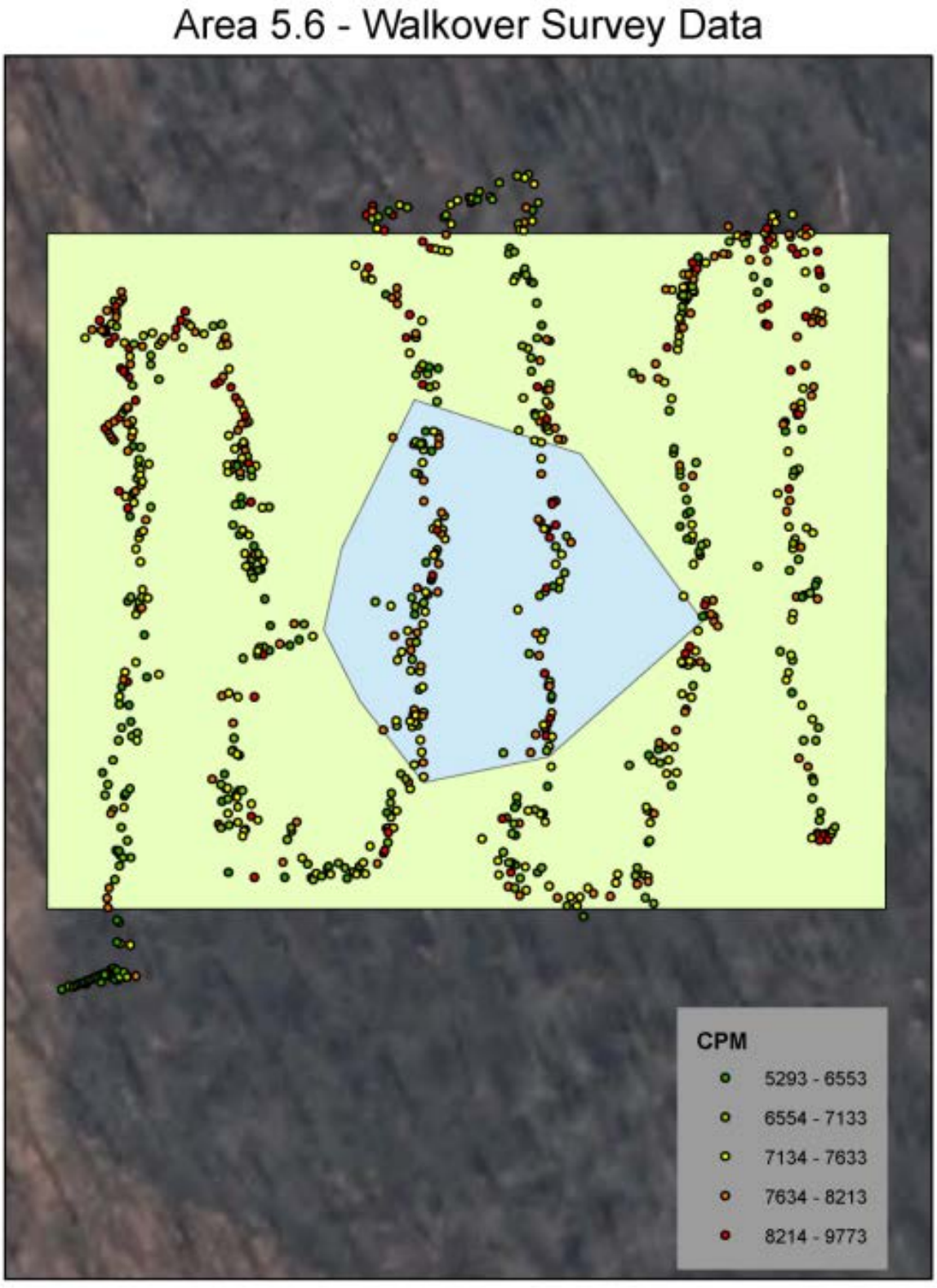


**Figure 50. Sub-Area 5.6 Walkover Gamma Survey Data**



### *Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation*

- The Area 5.1 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 6108 CPM to 6464 CPM. The average across all locations was 6295 CPM.
- The Area 5.2 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 6348 CPM to 8984 CPM. The average across all locations was 7266 CPM.
- The Area 5.3 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 6839 CPM to 8614 CPM. The average across all locations was 7499 CPM.
- The Area 5.4 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 5878 CPM to 6126 CPM. The average across all locations was 5992 CPM.
- The Area 5.5 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 5933 CPM to 7211 CPM. The average across all locations was 6288 CPM.
- The Area 5.6 static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 5724 CPM to 7525 CPM. The average across all locations was 6408 CPM.
- The applicable background count rate for Area 5 was determined to be 8745 CPM.

A tabulation of the static count rates is provided in Appendix H32.

### *Tissue Equivalent Dose Rate Survey Meter Readings*

The tissue equivalent survey meter readings for Area 5 are provided in Appendix H1.

The average dose rates for each sub-area are provided in Table 72.

**Table 72. Area 5 Tissue Equivalent Dose Rates**

| Area | Average Dose Rate[a] at 100 cm (μrem/hour) |
|---|---|
| Sub-Area 5.1 | 6.2 ± 0.3 |
| Sub-Area 5.2 | 4.6 ± 0.1 |
| Sub-Area 5.3 | 4.7 ± 0.2 |
| Sub-Area 5.4 | 5.0 ± 0.3 |
| Sub-Area 5.5 | 5.5 ± 0.3 |
| Sub-Area 5.6 | 4.5 ± 0.2 |

[a]. Uncertainty is reported as ± 1 sigma.

In Sub-Areas 5.1 – 5.6, the dose rate at the 100 cm elevation exceeded the background screening level.

### *Soil Concentration Data*

The weighted mean soil concentrations for gross alpha, gross beta, and cesium results associated with each soil depth for Areas 5.1 through 5.6 were calculated and are summarized in Table 73 below:

**Table 73. Area 5 Weighted Soil Concentrations (pCi/g)**

| Depth | Alpha | | Beta | | Cesium-137 | |
|---|---|---|---|---|---|---|
| (cm) | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 9.1E+00 | 3.9E-01 | 1.4E+01 | 3.4E-01 | 4.4E-01 | 1.2E-02 |
| 15-30 | 1.2E+01 | 4.4E-01 | 2.2E+01 | 3.7E-01 | 6.0E-02 | 7.0E-03 |
| 30-60 | 1.1E+01 | 6.2E-01 | 2.0E+01 | 5.4E-01 | 5.2E-02 | 1.1E-02 |
| 60-100 | 2.0E+01 | 1.2E+00 | 2.5E+01 | 8.0E-01 | 5.0E-03 | 8.0E-03 |

| Sub-Area 5.3 | | | | | | |
|---|---|---|---|---|---|---|
| Depth | Alpha | | Beta | | Cesium-137 | |
| (cm) | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 9.0E+00 | 7.0E-01 | 2.1E+01 | 6.9E-01 | 6.2E-01 | 2.6E-02 |
| 15-30 | 1.2E+01 | 8.0E-01 | 1.7E+01 | 6.5E-01 | 5.7E-02 | 1.1E-02 |
| 30-60 | 1.5E+01 | 1.9E+00 | 1.9E+01 | 1.2E+00 | 4.0E-03 | 1.6E-02 |
| 60-100 | 1.0E+01 | 9.9E-01 | 1.9E+01 | 9.3E-01 | -1.6E-02 | 1.6E-02 |

| Sub-Area 5.4 | | | | | | |
|---|---|---|---|---|---|---|
| Depth | Alpha | | Beta | | Cesium-137 | |
| (cm) | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 9.9E+00 | 8.4E-01 | 1.8E+01 | 7.2E-01 | 4.5E-01 | 2.5E-02 |
| 15-30 | 1.1E+01 | 8.2E-01 | 1.5E+01 | 6.5E-01 | 1.0E-02 | 1.2E-02 |
| 30-60 | 9.5E+00 | 2.1E+00 | 1.8E+01 | 1.9E+00 | 3.0E-03 | 1.3E-02 |
| 60-100 | 1.3E+01 | 2.0E+00 | 1.7E+01 | 1.5E+00 | 0.0E+00 | 1.5E-02 |

| Sub-Area 5.5 | | | | | | |
|---|---|---|---|---|---|---|
| Depth | Alpha | | Beta | | Cesium-137 | |
| (cm) | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 1.0E+01 | 8.6E-01 | 1.6E+01 | 8.0E-01 | 5.1E-01 | 2.1E-02 |
| 15-30 | 7.9E+00 | 7.4E-01 | 1.4E+01 | 6.8E-01 | 1.3E-02 | 9.0E-03 |
| 30-60 | 1.7E+01 | 2.9E+00 | 1.7E+01 | 1.8E+00 | -9.0E-03 | 1.4E-02 |
| 60-100 | 9.1E+00 | 1.8E+00 | 1.8E+01 | 1.6E+00 | 1.0E-03 | 1.8E-02 |

| Sub-Area 5.6 | | | | | | |
|---|---|---|---|---|---|---|
| Depth | Alpha | | Beta | | Cesium-137 | |
| (cm) | Average | 1 Sigma | Average | 1 Sigma | Average | 1 Sigma |
| 0-15 | 6.8E+00 | 7.4E-01 | 1.6E+01 | 7.2E-01 | 6.6E-01 | 2.3E-02 |
| 15-30 | 8.2E+00 | 7.5E-01 | 1.6E+01 | 7.0E-01 | 7.4E-02 | 1.6E-02 |
| 30-60 | 8.2E+00 | 7.5E-01 | 1.6E+01 | 7.0E-01 | 7.4E-02 | 1.6E-02 |
| 60-100 | 4.8E+00 | 1.4E+00 | 1.4E+01 | 1.5E+00 | 5.0E-03 | 1.9E-02 |

The corresponding background gross alpha, gross beta, and cesium soil concentrations were subtracted from the average soil concentrations to determine the net soil concentrations above background. The net soil concentrations were then used to assess potential exposure to a Collector and a Hunter/Fisher. The calculated weighted net average soil concentrations used in the dose assessment is provided in Table 74.

**Table 74. Area 5 Weighted Net Soil Concentrations (pCi/g) for 0-100 cm**

| Sub-Area | Alpha | Beta | Cesium-137 |
|---|---|---|---|
| 5.1E+00 | 1.6E+00 | 0.0E+00 | 6.0E-02 |
| 5.2E+00 | 0.0E+00 | 0.0E+00 | 5.7E-02 |
| 5.3E+00 | 7.5E-01 | 2.2E-01 | 6.8E-02 |
| 5.4E+00 | 0.0E+00 | 0.0E+00 | 4.3E-02 |
| 5.5E+00 | 1.4E+00 | 0.0E+00 | 5.2E-02 |
| 5.6E+00 | 0.0E+00 | 0.0E+00 | 9.5E-02 |

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### 7.5.4 Dose Assessment Approach for Area 5

The dose assessment approach for Area 5 was to:

- Develop an estimate of annual exposure based on the Aerial Survey data.
- Develop an estimate of annual exposure based upon the tissue equivalent dose rate survey meter readings.
- Perform a site-specific Collector and Hunter/Fisher RESRAD scenario calculation utilizing input from the culturally specific land use information provided by the SNI to assess exposures in excess of background using appropriate parameters (e.g., hydrology, occupancy and consumption) in order to estimate a Collector's and Hunter/Fisher's exposure. Parameters were adjusted based on published references for the region, historical site specific data, and/or the land use survey. Calculations were performed using the weighted mean above background for the data analyzed.

  Dose assessments associated with soil data were performed using RESRAD-OFFSITE 3.1. Hydrology data for the contaminated, unsaturated, and saturated zones were based on Revision

2 of the Phase 1 Decommissioning Plan for the West Valley Demonstration Project. The RESRAD input parameters used that differed from the RESRAD defaults are summarized in Appendix H7. In cases where area-specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modification are described below and in Appendix H7. This would include, but are not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where there were no site-specific data or no corresponding Decommissioning Plan value, the RESRAD-OFFSITE default parameters were used.

The Area 5 dose assessment was based on a culturally specific Collector and Hunter/Fisher land use provided by the SNI surveys (see Appendix D).

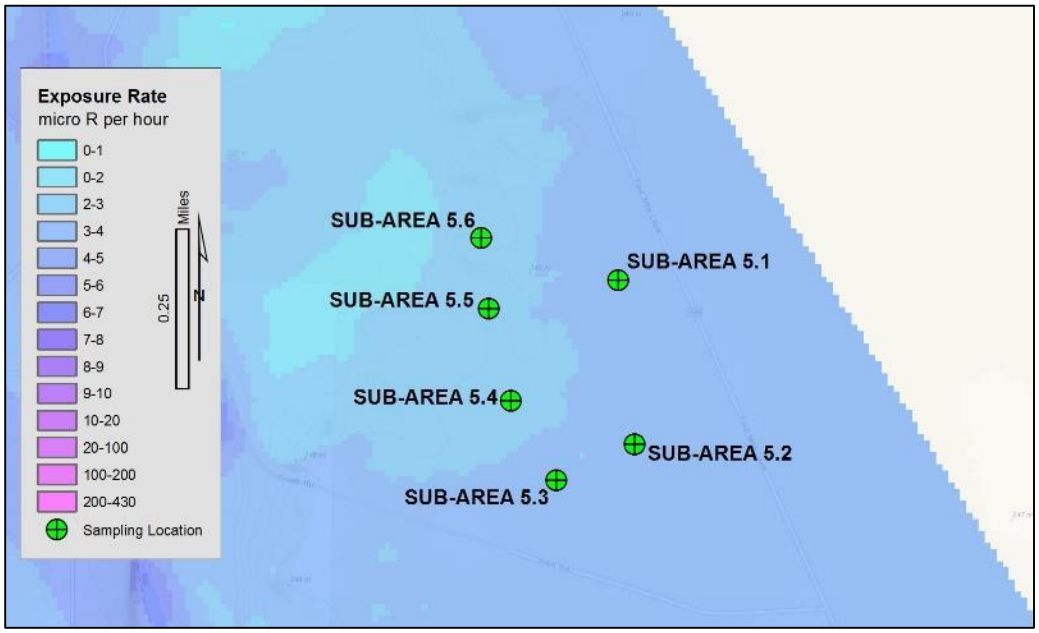
- The evapotranspiration coefficient provided in the Decommissioning Plan was recalculated to maintain the same infiltration rate of 0.26 meters per year.
- Comparison of the sample results to the $DCGL_w$ concentrations established in the Phase 1 Decommissioning Plan for the WVDP. The peak-of-the-mean values are the most conservative $DCGL_w$ values provided in the Phase 1 WVDP Decommissioning Plan and are for a Resident Farmer scenario.

### 7.5.5 Dose Assessment Results for Area 5

#### *Dose Assessment Based on Aerial Survey Data for Area 5*

Figure 51 is an aerial radiological survey map extracted from the Aerial Survey onto which the location of Area 5 has been placed. The dose rates at an elevation of one meter as derived from the map were determined to be 3-4 μR/hour for all sub-areas. The Aerial Survey states that the contribution to dose from cosmic rays and airborne radon across the entire map is 4.8 μR/hour.

**Figure 51. Area 5 Locations on the 2014 WNYNSC Aerial Radiological Survey**



Based on this aerial map and the assumed cosmic and airborne radon contribution, the dose rates were determined for Area 5 as shown in Table 75. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings to account for the contribution to background from cosmic radiation and airborne radon.

**Table 75. Area 5 Dose Rates Based Upon 2014 Aerial Survey Data**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| Sub-Area 5.1 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 5.2 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 5.3 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 5.4 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 5.5 | 3-4 | 3.5 | 4.8 | 8.3 |
| Sub-Area 5.6 | 3-4 | 3.5 | 4.8 | 8.3 |

The average SNI non-floodplain background dose rate based on the WNYNSC Aerial Survey was 7.8 μR/hour at one meter above the ground. This was subtracted from the total dose rate in Table 75, and the calculated doses for Area 5 are provided in Table 76. The occupancy time was based on culturally specific of land use information.

**Table 76. Area 5 Calculated Doses Based on 2014 WNYNSC Aerial Radiological Survey Data**

| Location | Total Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate[a] (mrem/year) | Hunter/Fisher Annual Dose Rate[a] (mrem/year) |
|---|---|---|---|---|
| Sub-Area 5.1 | 8.3 | 7.8 | 0.6 | 1.3 |
| Sub-Area 5.2 | 8.3 | 7.8 | 0.6 | 1.3 |
| Sub-Area 5.3 | 8.3 | 7.8 | 0.6 | 1.3 |
| Sub-Area 5.4 | 8.3 | 7.8 | 0.6 | 1.3 |
| Sub-Area 5.5 | 8.3 | 7.8 | 0.6 | 1.3 |
| Sub-Area 5.6 | 8.3 | 7.8 | 0.6 | 1.3 |

[a]. The aerial survey dose rates were recorded in units of Roentgen. The quality factors for photons and electrons are both one; therefore, 1 R equals 0.877 rem.

### *Dose Assessment Base Upon Tissue Equivalent Survey Meter Readings for Area 5*

The average dose rate for all Sub-Area 5 locations slightly exceeded the background screening level, the calculated doses for Area 5 are provided in Table 77. The occupancy time was based on culturally specific land use information.

**Table 77. Area 5 Calculated Average Doses Based on Tissue Equivalent Survey Meter Readings**

| Location | Average Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate (mrem/year) | Hunter/Fisher Annual Dose Rate (mrem/year) |
|---|---|---|---|---|
| Sub-Area 5.1 | 6.2 | 4.4 | 2.0 | 4.6 |
| Sub-Area 5.2 | 4.6 | 4.4 | [a] | [a] |
| Sub-Area 5.3 | 4.7 | 4.4 | [a] | [a] |
| Sub-Area 5.4 | 5.0 | 4.4 | 0.6 | 1.4 |
| Sub-Area 5.5 | 5.5 | 4.4 | 1.2 | 2.9 |
| Sub-Area 5.6 | 4.5 | 4.4 | [a] | [a] |

[a.] Reading was below screening level (background plus 2 sigma); therefore, no dose was calculated.

In addition, per the request from the SNI, a maximum dose was assessed, based on the highest tissue equivalent survey meter readings. This assumes that an individual performed all the activities (gathering, camping, hunting, etc.) at a single location that corresponds to the highest exposure rate for the entire occupancy time provided in the culturally specific land use information. This scenario provides an upper bound estimate of the potential exposure to an individual as it is not likely that all the non-leafy and leafy vegetation, wild game, and camping sites reside in the same single isolated location, year round. Table 78 provides the maximum calculated doses based on the Tissue Equivalent Survey Meter.

**Table 78. Area 5 Calculated Doses Based on the Maximum Tissue Equivalent Survey Meter Readings**

| Location | Maximum Dose Rate (μR/hour) | Background Dose Rate (μR/hour) | Collector Annual Dose Rate* (mrem/year) | Hunter/Fisher Annual Dose Rate* (mrem/year) |
|---|---|---|---|---|
| Sub-Area 5.1 | 7 | 4.4 | 6.4 | 8.5 |
| Sub-Area 5.2 | 6 | 4.4 | 4.0 | 5.3 |
| Sub-Area 5.3 | 5 | 4.4 | 1.5 | 2.0 |
| Sub-Area 5.4 | 6 | 4.4 | 4.0 | 5.3 |
| Sub-Area 5.5 | 7 | 4.4 | 6.4 | 8.5 |
| Sub-Area 5.6 | 6 | 4.4 | 4.0 | 5.3 |

### *Dose Assessment Based upon RESRAD Analysis of Soil Concentrations for Area 5*

The exposure scenario for Area 5 is based on the culturally specific land use information for a "Collector" and a "Hunter/Fisher" scenario. The elevated areas are series of smaller irregularly shaped areas (listed as a, b, c, etc.) within the boundaries of each irregularly shaped subarea (5.1, 5.2, 5.3, etc.). In order to model these irregularly shaped areas, the total elevated surface area within each sub-area was converted into a single rectangle of equivalent surface area located at the center of the sub-area. Figure 52 provides a demonstration of this (see below).

**Figure 52. Area 5 RESRAD Modeled Exposure Layout**


## Sub-Area 5.1

There were two elevated areas within Sub-Area 5.1. These areas were combined into an equivalent modeled area, totaling 1,334 square meters (46 m x 29 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) undeveloped area based on the cultural land use information provided by the SNI. The source of wild vegetation and wild game associated with Sub-Area 5.1 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square m area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 79 and Table 80. The RESRAD input parameters are provided in Appendix H7.

**Table 79. Sub-Area 5.1 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 2.85E-02 | 1.49E-03 | 2.04E-03 | 1.27E-05 | 1.32E-02 | 4.52E-02 |

**Table 80. Sub-Area 5.1 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 6.62E-02 | 3.47E-03 | 2.04E-03 | 1.27E-05 | 3.07E-02 | 1.02E-01 |

The main source of exposure is direct external from the ground and soil consumption. The full RESRAD output file is provided in Appendix H46, H47, H48, and H49.

### Sub-Area 5.2

There were two elevated areas within Sub-Area 5.2. These areas were combined into an equivalent modeled area, totaling 6,600 square meters (66 m x 100 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) area of undeveloped land. The source of wild vegetation and wild game associated with Sub-Area 5.2 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square meter area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 81 and Table 82. The RESRAD input parameters are provided in Appendix H7.

**Table 81. Sub-Area 5.2 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 2.23E-02 | 4.52E-09 | 1.95E-04 | 1.59E-05 | 6.47E-06 | 2.25E-02 |

**Table 82. Sub-Area 5.2 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 5.18E-02 | 1.05E-08 | 1.95E-04 | 1.59E-05 | 1.50E-05 | 5.20E-02 |

The main source of exposure is direct external from the ground. The full RESRAD output file is provided in Appendix H50 and H51.

### Sub-Area 5.3

There were two elevated areas within Sub-Area 5.3. These areas were combined into an equivalent modeled area, totaling 575 square meters (25 m x 23 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) area of undeveloped land. The source of the wild vegetation and wild game associated with Sub-Area 5.3 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square meter area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 83 and Table 84. The RESRAD input parameters are provided in Appendix H7.

**Table 83. Sub-Area 5.3 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 2.91E-02 | 6.53E-04 | 1.92E-03 | 1.22E-05 | 3.67E-03 | 3.54E-02 |

**Table 84. Sub-Area 5.3 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 6.75E-02 | 1.52E-03 | 1.92E-03 | 1.22E-05 | 8.52E-03 | 7.95E-02 |

The main source of exposure is direct external from the ground and soil consumption. The full RESRAD output file is provided in Appendix H52, H53, H54, and H55.

### Sub-Area 5.4

There were two elevated areas within Sub-Area 5.4. These areas were combined into an equivalent modeled area, totaling 1,786 square meters (47 m x 38 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) area of undeveloped land. The source of wild vegetation and wild game associated with Sub-Area 5.4 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square meter area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 85 and Table 86. The RESRAD input parameters are provided in Appendix H7.

**Table 85. Sub-Area 5.4 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 1.63E-02 | 2.98E-09 | 3.98E-05 | 3.24E-06 | 4.88E-06 | 1.63E-02 |

**Table 86. Sub-Area 5.4 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 3.79E-02 | 6.92E-09 | 3.98E-05 | 3.24E-06 | 1.13E-05 | 3.80E-02 |

The main source of exposure is direct external from the ground. The full RESRAD output file is provided in Appendix H56 and H57.

## Sub-Area 5.5

There were two elevated areas within Sub-Area 5.5. These areas were combined into an equivalent modeled area, totaling 320 square meters (20 m x 16 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) area of undeveloped land. The source of the wild vegetation and wild game associated with Sub-Area 5.5 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square meter area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 87 and Table 88. The RESRAD input parameters are provided in Appendix H7.

**Table 87. Sub-Area 5.5 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 2.56E-02 | 1.15E-03 | 4.40E-04 | 2.70E-06 | 3.78E-03 | 3.10E-02 |

**Table 88. Sub-Area 5.5 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 5.93E-02 | 2.67E-03 | 4.40E-04 | 2.70E-06 | 8.78E-03 | 7.12E-02 |

The main source of exposure is direct external from the ground and soil consumption. The full RESRAD output file is provided in Appendix H58, H59, H60, and H61.

### Sub-Area 5.6

There were two elevated areas within Sub-Area 5.6. These areas were combined into an equivalent modeled area, totaling 891 square meters (33 m x 27 m). This modeled elevated area is contained within a larger 1,080,000 square meter (1,000 m x 1,080 m) area of undeveloped land. The source of the wild vegetation and wild game associated with Sub-Area 5.6 are assumed to stay within the 1,080,000 square meter area of land (yellow box). There are no surface water features within the 1,080,000 square meter area of land. Figure 52 provides a representation of these areas.

Two exposure scenarios were assessed, a Collector and a Hunter/Fisher, based on the culturally specific land use information. In both cases, the individual consumes wild game and wild vegetation. No consumption of water, milk, or fish were assessed, based on the culturally specific land use information. In addition, there is no irrigation of the vegetation. The exposures associated with these two scenarios are provided in Table 89 and Table 90. The RESRAD input parameters are provided in Appendix H7.

**Table 89. Sub-Area 5.6 Collector Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 3.54E-02 | 6.12E-09 | 4.38E-05 | 3.57E-06 | 9.61E-06 | 3.55E-02 |

**Table 90. Sub-Area 5.6 Hunter/Fisher Pathway Doses**

| Ground (mrem/year) | Inhalation (mrem/year) | Plant (mrem/year) | Meat (mrem/year) | Soil (mrem/year) | Total (mrem/year) |
|---|---|---|---|---|---|
| 8.23E-02 | 1.42E-08 | 4.38E-05 | 3.57E-06 | 2.23E-05 | 8.24E-02 |

The main source of exposure is direct external from the ground. The full RESRAD output file is provided in Appendix H62 and H63.

### *Comparison to WVDP Phase 1 Decommissioning Plan DCGLw Values for Area 5*

Table 91 provides a comparison of the Area 5 soil concentrations to the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values.

**Table 91. Area 5 Comparison to WVDP Phase 1 Decommissioning Plan $DCGL_w$**

| Measurement Type | Nuclide Used | WVDP DCGL (pCi/g) | Soil Concentrations (pCi/g) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Sub-Area 5.1 | Sub-Area 5.2 | Sub-Area 5.3 | Sub-Area 5.4 | Sub-Area 5.5 | Sub-Area 5.6 |
| Alpha | Pu-239[a] | 2.50E+01 | 1.578 | 0.000 | 0.753 | 0.000 | 1.413 | 0.000 |
| Beta | Sr-90 | 4.10E+00 | 0.000 | 0.000 | 0.222 | 0.000 | 0.000 | 0.000 |
| Cesium | Cs-137 | 1.50E+01 | 0.060 | 0.057 | 0.068 | 0.043 | 0.052 | 0.095 |
| Sum of Fractions: | | | Below | Below | Below | Below | Below | Below |

[a] The more conservative DCGL between Am-241 and Pu-239 was used.

The assessment of the gross alpha and beta based on the most conservative isotopes (Pu-239 and Sr-90, respectively) will account for all of the anthropogenic nuclides listed in Table 2 except C-14, I-129, and Tc-99. For these nuclides, a qualitative analysis was performed. In all cases, either the soil concentration was below the detection limit or the soil concentration detected was significantly less than the WVDP Phase 1 Decommissioning Plan $DCGL_w$ Values. In addition, an analysis of the isotopic data indicates that the nuclides that account for most of the gross alpha and beta soil concentrations are radionuclides that are considered NORM (e.g. natural uranium, natural thorium, and potassium-40).

Therefore, the use of the DCGLs based on the WVDP Phase 1 Decommissioning Plan Resident Farmer scenario and gross results assuming the most conservative nuclide results in a highly conservative comparison.

### 7.5.6 Conclusions for Area 5

Annual doses based on the Aerial Survey, tissue equivalent survey meter readings, and RESRAD analysis ranged from 0 to 8.5 mrem per year. At the request of the SNI, a bounding estimate was performed for an individual located in the same area as the highest tissue equivalent survey meter readings. This assumes that an individual performed all the activities (gathering, camping, hunting, etc.) at a single location that corresponds to the highest exposure rate for the entire occupancy time provided in the culturally specific land use. This resulted in a maximum annual dose rate of 8.5 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that Area 5 is well below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 C.F.R. § 20.1402.

## 7.6 Confirmatory Locations Located on the WNYNSC Property

### 7.6.1 Description of Confirmatory Area

Selected locations within the property boundary of the WNYNSC were surveyed and sampled. Four sample locations were selected designated C1, C2, C3, and C4 (pg. 6, Figure 1).

### 7.6.2 Survey and Sampling Methodology for Confirmatory Area

No GPS survey was performed since the primary objective was to survey and sample predesignated locations.

Direct radiation readings and soil samples were collected in the four locations as described above and in Table 4 of the Plan.

Each location was surveyed and sampled as follows:

- Tissue equivalent dose rate readings were collected at 1 and 100 cm from the ground surface using the Bicron tissue equivalent survey meter.
- Static 2” x 2” NaI detector readings were collected at 1 and 100 cm elevations using the Ludlum Model 2241-2 survey meter coupled to a Ludlum Model 44-10 detector. Two consecutive counts were collected for each reading at each location and averaged.

- Soil samples were collected at depth intervals of 0 to 5, 5-15, 15-30, and 30-100 cm. A total of 13 samples were collected in accordance with Table 4 of the Plan. Samples were collected from the first three depths at all locations and an additional sample was collected from the 30-100 cm at location C.2.

### 7.6.3 Survey and Sampling Results for Confirmatory Area

As noted above, no GPS survey was required since the objective was to survey and sample at four predetermined locations. These areas were selected based on historical process knowledge (e.g., Cesium Prong, effluent liquid discharge) along with two locations that may be attributed to direct radiation shine from the WVDP.

#### *Static 2"x2" NaI Detector Gross Readings at the 100 cm Elevation*

- The WNYNSC Confirmatory Area static readings using the 2"x2" NaI detector were averaged between two counts at each location and ranged from 7812 CPM to 16586 CPM. The average across all locations was 11405 CPM.
- The applicable background count rate for WNYNSC Confirmatory Area was determined to be 6333 CPM.

These values are likely elevated in part due to the proximity of locations C1 and C2 to the WVDP.
A tabulation of the static count rates is provided in Appendix H32.

#### *Tissue Equivalent Survey Meter Readings*

Table 92 provides the dose rates based upon the tissue equivalent meter readings including background for each sample location.

**Table 92. WNYNSC On-Center Confirmatory Location Tissue Equivalent Dose Rate Readings**

| Sample Location | Dose Rate at 100 cm (μrem/hour) |
|---|---|
| C.1 | 10 |
| C.2 | 10 |
| C.3 | 6 |
| C.4 | 8 |

Readings are inclusive of background radiation

#### *Soil Sample Concentrations*

Four soil samples from the 0-5 cm depth and one sample from the 30-100 cm depth were analyzed by gamma spectroscopy, gross alpha, and gross beta activity. The data is summarized in Table 93.

**Table 93. WNYNSC On-Center Confirmatory Soil Concentrations Including Background**

| Sample Location | Depth (cm) | Alpha[a] (pCi/g) | Beta[a] (pCi/g) | Cesium[a] (pCi/g) |
|---|---|---|---|---|
| C.1 | 0-5 | 9.4E+00 ± 3.2E+00 | 2.9E+01 ± 2.82E+00 | 1.2E+00 ± 1.4E-01 |
| C.2 | 0-5 | 8.1E+00 ± 3.1E+00 | 2.0E+01 ± 3.40E+00 | 8.7E+00 ± 2.4E-01 |
| C.3 | 0-5 | 1.0E+01 ± 3.4E+00 | 8.7E+00 ± 2.27E+00 | 9.4E-01 ± 2.1E-01 |
| C.4 | 0-5 | 2.2E+01 ± 5.1E+00 | 4.0E+01 ± 4.42E+00 | 1.4E+00 ± 1.7E-01 |
| C.2 | 30-100 | 1.3E+01 ± 3.9E+00 | 4.7E+01 ± 4.09E+00 | 3.0E+01 ± 5.7E-01 |

a. Uncertainty is reported ± 1 sigma.

The individual sample numbers, depths, concentrations, uncertainties, and MDLs are provided in Appendix H2.

### 7.6.4 Estimation of Dose Rates Based Upon 2014 Aerial Survey Results

Figure 53 is an image extracted from Figure 15 of the 2014 Aerial Survey onto which the locations of the Confirmatory locations have been marked.

**Figure 53. WNYNSC Confirmatory Locations on the 2014 WNYNSC Aerial Radiological Survey**

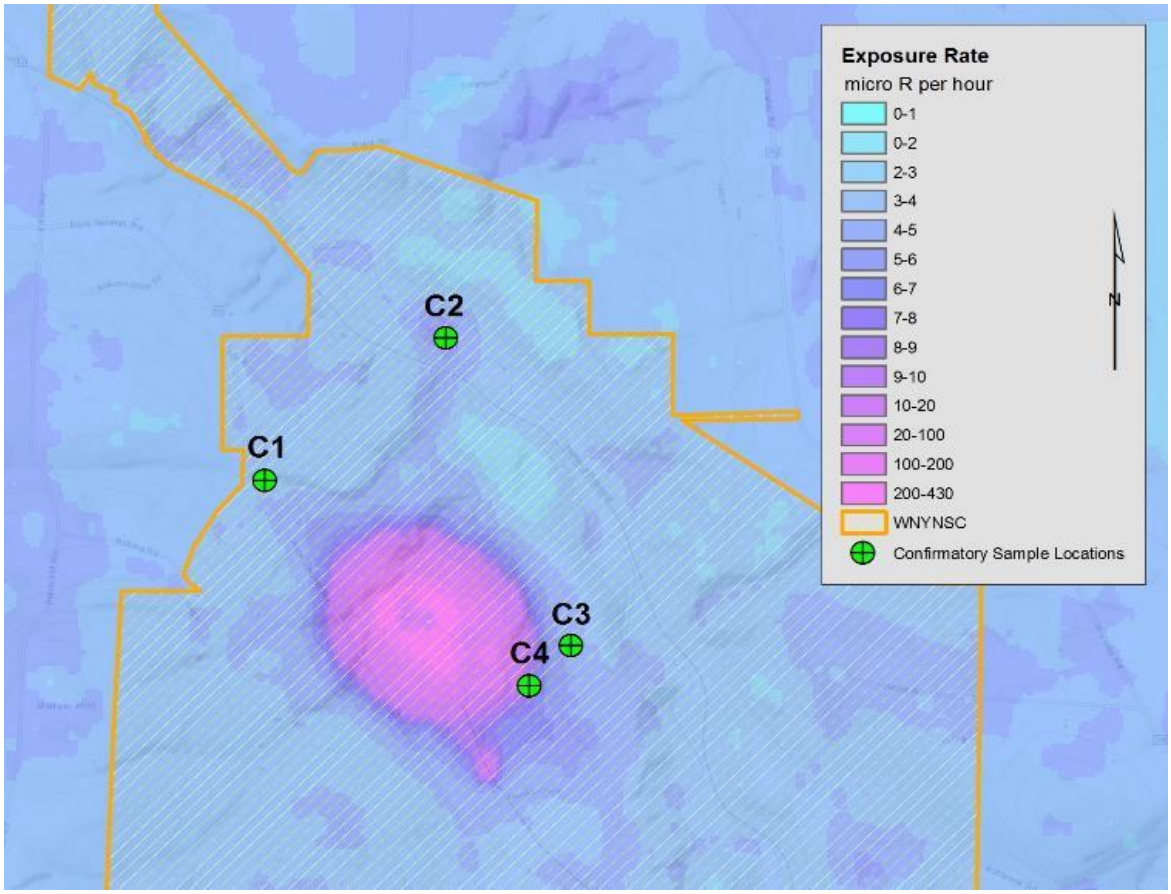


Table 94 presents the estimated dose rates based on the 2014 Aerial Survey inclusive of background. Consistent with the methodologies of the Aerial Survey, a value of 4.8 was added to all readings to account for the contribution to background from cosmic radiation and airborne radon.

**Table 94. Dose Rates Based on 2014 WNYNSC Aerial Radiological Survey Results**

| Location | Dose Rate Range from Map (μR/hour) | Average Dose Rate (μR/hour) | Cosmic + Radon Dose Rate (μR/hour) | Total Dose Rate (μR/hour) |
|---|---|---|---|---|
| C.1 | 3-4 | 3.5 | 4.8 | 8.3 |
| C.2 | 5-6 | 5.5 | 4.8 | 10.3 |
| C.3 | 5-6 | 5.5 | 4.8 | 10.3 |
| C.4 | 7-8 | 7.5 | 4.8 | 12.3 |

Because these confirmatory locations all reside within the NRC-Licensed area of the WNYNSC, a dose assessment using current land use and comparison to the NRC regulatory requirement of less than 25 mrem per year per 10 CFR § 20.1402 was not conducted.

### 7.6.5 Conclusions for Confirmatory Area

Four selected locations on the WNYNSC Property were identified for survey and sampling (Figure 6). These were considered “Confirmatory” locations to compare Aerial Survey results to areas known or suspected to be contaminated. Because these confirmatory locations all reside within the NRC-Licensed area of the WNYNSC and the subject of a future Decommissioning Plan, a dose assessment was not conducted.

## 8.0 Final Summary

Areas 1, 2, and 3 were assessed using the methods as described in this report, and all of the results indicate that the radiation exposures to the public are substantially below the NRC regulatory free release requirement of 25 mrem per year in accordance with 10 CFR § 20.1402.

Areas 4 and 5 were surveyed, sampled, and analysis of dose based upon soil concentrations was completed using culturally specific land use information provided by the SNI. The results indicate that the radiation exposures to the public are substantially below the NRC regulatory free release requirement of 25 mrem per year in accordance with 10 CFR § 20.1402.

It should be noted, that for many of the exposure pathways in Areas 1, 2, 3, 4 and 5, the dose was determined to be less than 10 percent of the applicable dose criteria (i.e., less than 2.5 mrem/year). In accordance with NRC NUREG-1757 (NRC Consolidated Decommissioning Guidance, Section 3.3 of Volume 2) (Ref. 19), the NRC considers these exposure pathways insignificant contributors. The average soil concentrations for all areas, even those that were determined to be slightly above background levels, have gross alpha and gross beta activity levels that can be attributed to NORM radioisotopes and are therefore more likely the result of the natural fluctuation in background.

The following is a more detailed summary of the dose assessment for each area. Additional detail is provided for each area in Sections 7.1 through 7.6, and Appendix H of this report. As can be seen in the tables below, the doses calculated for all areas were well below the 25 mrem per year limit imposed by 10 CFR § 20.1402.

### 8.1 Area 1

Area 1 consisted of three discrete locations within the Cesium Prong as it extends outward beyond the boundaries of the WNYNSC (Figure 1). The Cesium Prong is a large area northwest of the WVDP where surface soil became contaminated with Cs-137 when ventilation system filters failed in 1968. Because the Cesium Prong was extensively characterized in the 1990s (Ref. 10), the samples collected in this area were compared to decay-corrected results from the earlier investigation. The Plan specified that a dose assessment would be conducted if the comparison of the newly collected data varied by 10 percent.

Two designated locations (1.1 and 1.2) were in close proximity to each other and the data collected was compared to historic data from Location L12 in the 1995 Off-Site Investigation of the Cesium Prong. For dose assessment purposes, these two locations were averaged and assessed as "L-12." The third location designated (Location 1.3) was closer to the WNYNSC boundary, and it was compared to location "L-23" from the 1995 Report.

Doses were assessed for L12 and L23 using the methodologies described in Section 6. Table 95 below summarizes the assessed doses using the assessment methodologies.

**Table 95. Area 1 Calculated Annual Dose (mrem/year)**

| Dose Assessment Method | L12 | L23 | Model |
|---|---|---|---|
| Aerial Survey | 0.0 | 0.0 | Resident Homemaker |
| Tissue Equivalent Meter | 2.4 | 8.0 | Resident Homemaker |
| Current Use RESRAD Calculation | 1.0 | 0.2 | Resident Homemaker |
| DCGL Comparison | Below | Below | Resident Farmer |
| Potential Use Calculation | 1.7 | 0.4 | Resident Farmer |
| Fish Consumption | <0.1 | <0.1 | n/a |

### 8.2 Area 2

Area 2 consisted of two sub-areas designated 2.1 and 2.2 (Figure 2). The two sub-areas are located northwest of the WNYNSC in an area transected by Route 219, and in general proximity to Springville Dam. Both areas are small, sloped and heavily wooded. The suspected pathway of contamination for Area 2 is airborne deposition.

Doses were assessed for Sub-Area 2.1 and Sub-Area 2.2 using the methodologies described in Section 6. Table 96 summarizes the assessed doses using the assessment methodologies.

**Table 96. Area 2 Calculated Annual Dose (mrem/year)**

| Dose Assessment Method | 2.1 | 2.2 | Model |
|---|---|---|---|
| Aerial Survey | 0.0 | 0.0 | Recreational Hiker/Hunter |
| Tissue Equivalent Meter | 0.4 | 0.0 | Recreational Hiker/Hunter |
| Current Use RESRAD Calculation | 0.0 | 0.0 | Recreational Hiker/Hunter |
| DCGL Comparison | Below | Below | Resident Farmer |
| Potential Use Calculation | n/a | 0.1 | Resident Farmer |
| Fish Consumption | <0.1 | <0.1 | n/a |

### 8.3 Area 3

Area 3 is located on a farm at the confluence of Buttermilk and Cattaraugus Creeks (Figure 3). It consists of two sub-areas designated 3.1 and 3.2. Sub-Area 3.1 is a larger parcel on which corn for livestock feed is grown. Sub-Area 3.2 is a small, sloped parcel that lies between the road and the farmhouse.

Doses were assessed for Sub-Area 3.1 and Sub-Area 3.2 using the methodologies described in Section 6. Table 97 summarizes the assessed doses using the assessment methodologies.

**Table 97. Area 3 Calculated Annual Dose (mrem/year)**

| Dose Assessment Method | 3.1 | 3.2 | Model |
|---|---|---|---|
| Aerial Survey | 1.8 | 0.2 | Resident Farmer |
| Tissue Equivalent Meter | 3.9 | 0.0 | Resident Farmer |
| Current Use RESRAD Calculation | 0.8 | 0.0 | Resident Farmer |
| DCGL Comparison | Below | Below | Resident Farmer |
| Potential Use Calculation | 7.2 | 0.3 | Resident Farmer |
| Fish Consumption | <0.1 | <0.1 | n/a |

### 8.4 Area 4

Area 4 lies approximately 20 miles to the west of the WNYNSC in the floodplain of Cattaraugus Creek (Figure 4). It includes five sub-areas designated 4.1, 4.2, 4.3, 4.4, and 4.5. All of the sub-areas are wooded and no residences are located within the area.

Doses were assessed for each sub-area using the methodologies described in Section 6. Table 98 summarizes the assessed doses using the two assessment methodologies.

**Table 98. Area 4 Calculated Annual Dose (mrem/year)**

| Dose Assessment Method | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | Model |
|---|---|---|---|---|---|---|
| Aerial Survey | 3.7 | 0.0 | 0.0 | 0.0 | 0.0 | Hunter/Fisher[a] |
| Average Tissue Equivalent Meter | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | Hunter/Fisher[a] |
| Maximum Tissue Equivalent Meter | 8.0 | 11.9 | 11.9 | 7.8 | 7.8 | Hunter/Fisher[a] |
| RESRAD Calculation | 0.5 | 0.6 | 0.4 | 0.2 | 0.5 | Hunter/Fisher[a] |
| DCGL Comparison | Below | Below | Below | Below | Below | Hunter/Fisher[a] |
| Fish Consumption | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | Hunter/Fisher[a] |

a. In all cases, the Hunter/Fisher land use scenario was greater than the Collector; therefore, the dose for the Collector Scenario is lower than these values.

## 8.5 Area 5

Area 5 lies approximately 17 miles to the west of the WNYNSC on a plateau outside the floodplain of Cattaraugus Creek (Figure 5). It includes six sub-areas designated 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6. All of the sub-areas are wooded and no residences are located within the area.

Doses were assessed for each sub-area using the methodologies described in Section 6. Table 99 summarizes the assessed doses using the two assessment methodologies.

**Table 99. Area 5 Calculated Annual Dose (mrem/year)**

| Dose Assessment Method | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | Model |
|---|---|---|---|---|---|---|---|
| Aerial Survey | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | Hunter/Fisher[a] |
| Average Tissue Equivalent Meter | 4.6 | [b] | [b] | 1.4 | 2.9 | [b] | Hunter/Fisher[a] |
| Maximum Tissue Equivalent Meter | 8.5 | 5.3 | 2.0 | 5.3 | 8.5 | 5.3 | Hunter/Fisher[a] |
| RESRAD Calculation | 0.1 | 0.1 | 0.1 | <0.1 | 0.1 | 0.1 | Hunter/Fisher[a] |
| DCGL Comparison | Below | Below | Below | Below | Below | Below | Hunter/Fisher[a] |

a. In all cases, the Hunter/Fisher land use scenario was greater than the Collector; therefore, the dose for the Collector Scenario is lower than these values.

b. Reading was below screening level (background plus 2 sigma); therefore, no dose was calculated.

## 8.6 Confirmatory Area

Four selected locations on the WNYNSC Property were identified for survey and sampling (Figure 6). These were considered “Confirmatory” locations to compare Aerial Survey results to areas known or suspected to be contaminated. Because these confirmatory locations all reside within the NRC-Licensed area of the WNYNSC and the subject of a future Decommissioning Plan, a dose assessment was not conducted.

## 9.0 List of References


1 *An Aerial Radiological Survey of the Western New York Nuclear Service Center (Remote Sensing Laboratory*, National Securities Technologies, LLC) October 2015

2 U.S. Nuclear Regulatory Commission, Standards for Protection against Radiation, 10 CFR Part 20.1402, *Radiological Criteria for Unrestricted Use*

3 Phase 1 Decommissioning Plan for the West Valley Demonstration Project, Rev. 2, December 2009.

4 Project Field Sampling and Dose Assessment Plan

5 Evaluation of Radiochemical Data Usability (DOE, 1997).

6 RESRAD-OFFSITE 3.1, July 2013, Argonne National Laboratory and User Manual for RESRAD-OFFSITE (NUREG/CR-6937)

7 RESRAD 7.0, April 2014, Argonne National Laboratory

8 West Valley Demonstration Project Annual Site Environmental Report for Calendar Year 2012, (ASER), September 2013.

9 International Commission on Radiological Protection (ICRP) Publication 68, Dose Coefficients for Intakes by Workers, 1994.

10 1995 Western New York Nuclear Service Center Off-Site Radiation Investigation Summary Report (Dames and Moore)

11 Project Quality Assurance Project Plan (QAPP), MJW.

12 Project Health and Safety Plan, MJW.

13 U.S. EPA QA/G-4 Guidance for the Data Quality Objectives Process, 2006.

14 U.S. EPA QA R-5, EPA Requirements for Quality Assurance Project Plans, 2001.

15 GEL Quality Assurance Plan, Rev. 29 (Uncontrolled)

16 MJW Technical Services Radioactive Materials License – C3181.

17 WVDP Terrestrial Background Study, 2014.

18 U.S. Environmental Protection Agency's Exposure Factors Handbook, EPA 1997.

19 NUREG 1757, Volume 2, Rev. 1, Consolidated NMSS Decommissioning Guidance