

Appendix H64

Dose Assessment Report For the Homeowners and Reach Areas

Table of Contents

1.0	Purpose.....	4
2.0	Soil Samples.....	4
3.0	Background.....	4
4.0	Dose Assessment Approach	5
5.0	Survey, Sampling and Dose Assessment Results.....	6
5.1	Homeowners Areas.....	6
5.1.1	Description of Area Homeowner Areas	6
5.1.2	Soil Concentration Data	7
5.1.3	Dose Assessment Approach for Homeowners	8
5.1.4	Dose Assessment Results for the Homeowner Areas.....	8
5.1.5	Conclusions for Homeowner Area	13
6.0	Description and Results for Reach Areas	14
6.1	Reach Areas	14
6.1.1	Description of Reach Areas.....	14
6.1.2	Soil Concentration Data	16
6.1.3	Dose Assessment Approach for Reach Areas	17
6.1.4	Dose Assessment Results for the Reach Areas.....	17
6.1.5	Conclusions for Reach Area	20
7.0	Final Summary	21
7.1	Homeowners Calculated Annual Dose	21
7.2	Reach Calculated Annual Dose	21
8.0	References.....	21

List of Figures

Figure 1: Homeowners Locations6
 Figure 2: Homeowner RESRAD Modeled Exposure Layout10
 Figure 3: Reach 7 RESRAD Modeled Exposure Layout14
 Figure 4: Reach 21 RESRAD Modeled Exposure Layout15

List of Tables

Table 1: SNI Floodplain Background5
 Table 2: SNI Non-Floodplain Background5
 Table 3: Culturally Specific Homeowner Land Use7
 Table 4: Homeowner Weighted Average Soil Concentrations7
 Table 5: Homeowner Weighted Net Soil Concentrations for 0-100 cm8
 Table 6: Homeowner 3 Pathway Doses11
 Table 7: Homeowner 4 Pathway Doses11
 Table 8: Homeowner 5 Pathway Doses11
 Table 9: Homeowner Area Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w12
 Table 10: Concentrations in Edible Portions of Fish around Springville Dam12
 Table 11: Background Concentrations in Edible Portions of Fish13
 Table 12: Ingestion dose coefficients (mrem/μCi) from ICRP 6813
 Table 13: Culturally Specific Land Use Information for Reach 7 Locations15
 Table 14: Culturally Specific Land Use Information for Reach 21 Locations16
 Table 15: Reach Area Weighted Average Soil Concentrations16
 Table 16: Reach Weighted Net Soil Concentrations for 0-100 cm17
 Table 17: Calculated Doses Based on Tissue Equivalent Survey Meter Readings for Reach 2118
 Table 18: Reach 7 Collector Pathway Doses18
 Table 19: Reach 7 Hunter/Fisher Pathway Doses18
 Table 20: Reach 21 Collector Pathway Doses19
 Table 21: Reach 21 Hunter/Fisher Pathway Doses19
 Table 22: Reach Area Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w19
 Table 23: Concentrations in Edible Portions of Fish around Springville Dam20
 Table 24: Background Concentrations in Edible Portions of Fish20
 Table 25: Ingestion dose coefficients (mrem/μCi) from ICRP 6820
 Table 26: Homeowner Calculated Annual Dose (mrem/year)21
 Table 27: Reach Calculated Annual Dose (mrem/year)21

List of Acronyms

cm	Centimeter
DCF	Dose coefficients factor
DCGL	Derived Concentration Guideline Level
ELAP	Environmental Laboratory Approval Program
f1	Fractional Absorption in the Gastrointestinal Tract Rate
g	Gram
HO	Homeowner
ICRP	International Commission on Radiological Protection
m	Meter
MDL	Minimum Detectable Levels
mrem	Millirem
NORM	Naturally Occurring Radioactive Material
NRC	Nuclear Regulatory Commission
NYSDOH	New York State Department of Health
pCi	Pico Curie
RESRAD	RESidual RADioactive Material
SNI	Cattaraugus Territory of the Seneca Nation of Indians
WVDP	West Valley Demonstration Project

1.0 Purpose

The purpose of the radiological survey and dose assessment project was to determine if areas identified by the Cattaraugus Territory of the Seneca Nation of Indians (SNI) have elevated radionuclide concentrations in the soil. If elevated soil concentrations were identified, a dose assessment, based on current 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 CFR § 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 1), requirement of 25 millirem (mrem) per year.

2.0 Soil Samples

- Within each survey area, soil samples were collected from one location at two different depth intervals.
- 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 Cs-137), gross beta, and gross alpha analysis. Samples were also analyzed for additional isotopic information.

3.0 Background

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.

Two background data set obtained for SNI Background were developed:

- One using data collected from the floodplain of Cattaraugus Creek.
- One using data collected from areas not on the floodplain.

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:

$$\text{Weighted mean for a given depth} = \frac{\sum_{i=1}^{\infty} \text{weight}_i \times \text{concentration}_i}{\sum_{i=1}^{\infty} \text{weight}_i}$$

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

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

Ten background locations on the SNI were 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. Soil samples were collected from the 10 specified locations. Sample depth increments were 0-15 centimeter (cm), 15-30 cm, 30-60 cm, and 60-100 cm. Table 1 and Table 2 provide the average background concentrations by depth for the floodplain and non-floodplain background areas.

Table 1: SNI Floodplain Background

Floodplain Background Soil Concentrations				
Depth (cm)	Alpha* (pCi/g)	Beta* (pCi/g)	Cesium-137* (pCi/g)	Tissue Equivalent Survey Meter Reading (Bicron) (µrem/hour)
0-15	1.5E+01 ± 8.9E-01	2.2E+01 ± 7.3E-01	7.8E-02 ± 1.2E-02	5.0E-00 ± 2.2E-01
15-30	1.4E+01 ± 7.0E-01	2.5E+01 ± 6.2E-01	7.5E-02 ± 1.4E-02	

*Uncertainty is reported ± 1 sigma

Table 2: SNI Non-Floodplain Background

Non-Floodplain Background				
Depth (cm)	Alpha* (pCi/g)	Beta* (pCi/g)	Cesium-137* (pCi/g)	Tissue Equivalent Survey Meter Reading (Bicron) (µrem/hour)
0-15	1.2E+01 ± 7.8E-01	2.0E+01 ± 6.2E-01	1.6E-01 ± 1.9E-02	4.4E-00 ± 2.1E-01
15-30	1.4E+01 ± 7.7E-01	2.6E+01 ± 6.9E-01	9.4E-02 ± 1.3E-02	

*Uncertainty is reported ± 1 sigma

4.0 Dose Assessment Approach

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

- Assessment of tissue equivalent dose rate survey meter (m) readings (Bicron).
- Assessment of dose based on soil concentrations using the RESRAD OFFSITE 3.1 computer code (Ref. 2) with input parameters adjusted to meet current land use based on cultural land use information provided by the SNI (i.e., SNI Collector, and SNI Hunter/Fisher).
- Assessment of dose associated with the consumption of fish. Calculations were performed by two different methods: 1) using the average concentration of Sr-90 and Cs-137 in the edible portion of fish above background from the ASER (Ref. 3). Annual exposures were calculated based on ingestion

dose coefficients from the ICRP (Ref. 4); and 2) using the RESRAD Offsite 3.1 computer code for the specific length of the creek identified by the SNI.

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, were attributable to either Am-241 or Pu-239 (separate calculations).

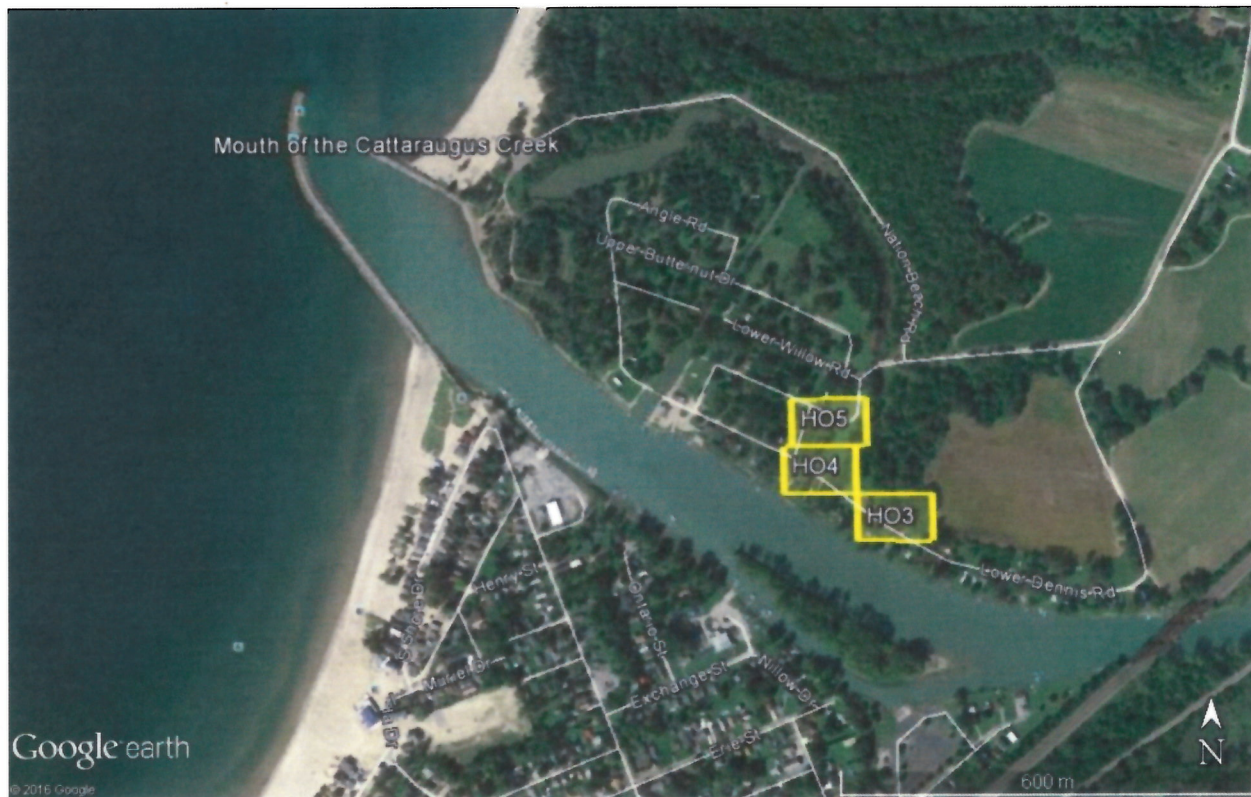
5.0 Survey, Sampling and Dose Assessment Results

5.1 Homeowners Areas

5.1.1 Description of Area Homeowner Areas

The Homeowner (HO) areas lie approximately 0.5 miles to the southeast of the mouth of the Cattaraugus Creek (Figure 1). They include three areas designated HO3, HO4 and HO5.

Figure 1: Homeowners Locations



These areas are a residential area with some farming terrain to the east. They lie within the historic floodplain. They were assessed based on cultural land use information provided by the SNI, summarized in Table 3 below.

Table 3: Culturally Specific Homeowner Land Use

Parameter	Homeowner Scenario Value
Well water	Wells not utilized due to sediment buildup
Surface Water	None
Fish Consumption	36 pounds per year
Meat Consumption	None
Non-Leafy Vegetation	364 pounds per year
Leafy Vegetation	260 pounds per year
Onsite inside a dwelling	4,380 hours per day
Onsite outdoors	1,370 hours per year
Collecting Non-Leafy Vegetation	365 hours per year
Collecting Leafy Vegetation	550 hours per year

5.1.2 Soil Concentration Data

The weighted mean soil concentrations for gross alpha, gross beta, and cesium results associated with each soil depth for Homeowner 3 through 5 were calculated and are summarized in Table 4 below:

Table 4: Homeowner Weighted Average Soil Concentrations

Homeowner 3			
Depth (cm)	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
0-15	1.3E+01 ± 1.1E+00	9.9E+00 ± 0.6E-01	2.2E-01 ± 2.0E-02
15-30	1.3E+01 ± 1.1E+00	2.0E+01 ± 9.3E-01	2.2E-01 ± 2.0E-02

* Uncertainty is 1 sigma.

Homeowner 4			
Depth (cm)	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
0-15	1.0E+01 ± 9.8E-01	1.9E+01 ± 7.7E-01	2.4E-01 ± 2.2E-02
15-30	1.3E+01 ± 1.0E-01	1.6E+01 ± 7.4E-01	2.7E-01 ± 2.0E-02

* Uncertainty is 1 sigma.

Homeowner 5			
Depth (cm)	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
0-15	1.5E+01 ± 1.2E+00	1.9E+01 ± 8.9E-01	3.8E-01 ± 3.1E-02
15-30	1.0E+01 ± 9.7E-01	2.1E+01 ± 8.6E-01	6.9E-01 ± 3.0E-02

* Uncertainty is 1 sigma.

The corresponding background gross alpha, gross beta, and cesium soil concentrations were subtracted the average soil concentrations to determine the net soil concentrations above background. The net soil concentrations were used to assess the potential exposure to each of the three Homeowners. Table 5 provides the calculated weighted net average soil concentrations used in the dose assessment.

Table 5: Homeowner Weighted Net Soil Concentrations for 0-100 cm

Sub-Area	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
HO3	0.0E-00	0.0E-00	1.4E-01
HO4	0.0E-00	0.0E-00	1.8E-01
HO5	2.1E-01	0.0E-00	4.6E-01

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

5.1.3 Dose Assessment Approach for Homeowners

The dose assessment approach for the homeowner areas was based upon the tissue equivalent dose rate survey meter readings (Bicron) and a site-specific RESRAD scenario calculation using input from cultural land use information provided by the SNI to assess exposures in excess of background, using the appropriate parameters (e.g., hydrology, occupancy and consumption) in order to estimate the homeowner’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 (Ref. 5). The RESRAD input parameters that differed from the RESRAD defaults are summarized in Appendix H65. In cases where area-specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modifications are described below and in Appendix H65. This would include, but are not limited to, exposure pathways, irrigation, consumption, erosion rates, and occupancy times. For parameters where no site-specific data or corresponding Decommissioning Plan value were available, the RESRAD-OFFSITE default parameters were used.

Comparison of the sample results to the Dose coefficient factor (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.

5.1.4 Dose Assessment Results for the Homeowner Areas

Dose Assessment Based upon Tissue Equivalent Survey Meter Readings

For the homeowner areas, the dose rate measured using the tissue equivalent survey meter reading (Bicron) did not exceed the background plus 2-sigma; therefore, no dose above background was measured.

Dose Assessment Based upon RESRAD Analysis of Soil Concentrations

The exposure scenario for the Homeowner areas is based on the cultural land use information provided by the SNI. The SNI indicated the area that represents each homeowner. Each homeowner location is represented by a yellow box in Figure 2 below. The source of the fish caught for consumption is represented by the blue box.

Figure 2: Homeowner RESRAD Modeled Exposure Layout



Homeowner 3

Homeowner 3 was modeled as a 7,700 square meter (110 m x 70 m) area. This modeled elevated area contains the dwelling and source of vegetation. There are no surface water features within the 7,700 square meter area of land. However, there is a creek, due south, of the area that provides a source of fish for consumption. The creek is modeled as a 120,000 square meter (600 m x 200 m) area. No water or milk consumption was assessed based on the culturally specific land use information. The exposures associated with this scenario are provided in Table 6. The RESRAD input parameters are in Appendix H65.

Table 6: Homeowner 3 Pathway Doses

Ground (mrem/year)	Inhalation (mrem/year)	Fish ^a (mrem/year)	Plant (mrem/year)	Soil (mrem/year)	Total (mrem/year)
1.74E-01	5.84E-08	1.52E-09	7.12E-02	8.31E-05	2.45E-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 H67.

Homeowner 4

Homeowner 4 was modeled as a 7,700 square meter (110 m x 70 m) area. This modeled elevated area contains the dwelling and source of vegetation. There are no surface water features within the 7,700 square meter area of land. However, there is a creek, due south, of the area that provides a source of fish for consumption. The creek is modeled as a 120,000 square meter (600 m x 200 m) area. No water or milk consumption was assessed based on the culturally specific land use information. The exposures associated with this scenario are provided in Table 7. The RESRAD input parameters are provided in Appendix H65.

Table 7: Homeowner 4 Pathway Doses

Ground (mrem/year)	Inhalation (mrem/year)	Fish ^a (mrem/year)	Plant (mrem/year)	Soil (mrem/year)	Total (mrem/year)
2.20E-01	7.46E-08	1.17E-09	9.90E-02	1.05E-04	3.19E-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 H68.

Homeowner 5

Homeowner 5 was modeled as a 7,700 square meter (110 m x 70 m) area. This modeled elevated area contains the dwelling and source of vegetation. There are no surface water features within the 7,700 square meter area of land. However, there is a creek, due south, of the area that provides a source of fish for consumption. The creek is modeled as a 120,000 square meter (600 m x 200 m) area. No water or milk consumption was assessed based on the culturally specific land use information. The exposures associated with this scenario are Table 8. The RESRAD input parameters are provided in Appendix H65.

Table 8: Homeowner 5 Pathway Doses

Ground (mrem/year)	Inhalation (mrem/year)	Fish ^a (mrem/year)	Plant (mrem/year)	Soil (mrem/year)	Total (mrem/year)
5.76E-01	1.25E-03	4.61E-09	4.74E-01	9.45E-03	1.06E+00

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 files are provided in Appendix H69 and H70.

Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w Values for Homeowners

Table 9 provides a comparison of the Homeowner areas soil concentrations to the WVDP Phase 1 Decommissioning Plan DCGL_w Values.

Table 9: Homeowner Area Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w

Measurement Type	Nuclide Used	WVDP DCGL (pCi/g)	Soil Concentrations (pCi/g)		
			HO3	HO4	HO5
Alpha	Pu-239 ^a	2.50E+01	0.000	0.000	0.210
Beta	Sr-90	4.10E+00	0.000	0.000	0.000
Cesium	Cs-137	1.50E+01	0.140	0.177	0.461
Sum of Fractions:			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 with the exception of 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 Naturally Occurring Radioactive Material (NORM) (e.g., natural uranium, natural thorium, and potassium-40).

Therefore, the use of the DCGLs based on the WVDP Phase 1 Decommissioning Plan (Ref. 5) 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. 3) 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 10 and Table 11 below.

Table 10: 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 11: 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 (g) of fish flesh and 7.08E-09 μCi Cs-137 per gram of fish flesh. The ingestion DCF and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 12.

Table 12: 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 the culturally specific land use information, a Homeowner (HO) consumes about 36 pounds of fish flesh per year. These consumption rates result in a calculated annual dose of about 0.2 mrem per year.

5.1.5 Conclusions for Homeowner Area

Annual doses based on the RESRAD analysis and the ASER fish data ranged from 0.2 to 1.1 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that the Homeowner area is well below the Nuclear Regulatory Commission (NRC) regulatory release requirement of less than 25 mrem per year in accordance with 10 CFR § 20.1402.

6.0 Description and Results for Reach Areas

6.1 Reach Areas

6.1.1 Description of Reach Areas

The Reach 7 area lies approximately two miles to the southeast of Area 5 along the Cattaraugus Creek (Figure 3). The Reach 21 area lies approximately 1.5 miles to the west of Area 4 along the Cattaraugus Creek (Figure 4).

Figure 3: Reach 7 RESRAD Modeled Exposure Layout



Figure 4: Reach 21 RESRAD Modeled Exposure Layout



These areas are generally rural areas comprised of some forested and farming terrain. Reach 7 lies within the historic floodplain, while Reach 21 is not considered within the historic floodplain. The source of the vegetation (yellow box) and fish (blue box) are shown in Figures 3 and 4. These areas were chosen based on the cultural land use information provided by the SNI. The SNI also provided the consumption and occupancy times, which are summarized in Tables 13 and 14.

Table 13: Culturally Specific Land Use Information for Reach 7 Locations

Parameter	Collector Scenario Value	Hunter/Fisher Scenario Value
Well water	No well in area	No well in area
Surface Water	Field irrigation only	Field irrigation only
Fish Consumption	21.6 pounds per year	21.6 pounds per year
Meat Consumption	5.8 pounds per year	5.8 pounds per year
Non-Leafy Vegetation	18.2 pounds per year	18.2 pounds per year
Leafy Vegetation	13 pounds per year	13 pounds per year
Onsite inside a dwelling	None	None
Onsite outdoors	1,100 hours per year	2,920 hours per year
Collecting Non-Leafy Vegetation	46 hours per year	46 hours per year
Collecting Leafy Vegetation	37 hours per year	37 hours per year

- Based on a telephone conference call with SNI on October 19, 2016, the original consumption rates provided by SNI for the Reach Areas were adjusted using Area 4.1/4.2/4.3 yield rate for the vegetation and surface water areas basis for crop and

fish yield for an undeveloped area. The fish yield rate is the ratio of 4.1 fish consumption rate (108 pounds/year) to surface water area (110,000 m²). The vegetation is the ratio of the non-leafy consumption rate (365 pounds/year) and leafy consumption rate (260 pounds/year) to vegetation area (450,000 m²). These yield rates (pounds/ m²) were then applied the to Reach 7 vegetation and surface water areas. Based on the adjustment to the consumption rates, the collection times for non-leafy and leafy vegetation were adjusted to account for the reduction in consumption rates. The recreational occupancy time was not adjusted.

Table 14: Culturally Specific Land Use Information for Reach 21 Locations

Parameter	Collector Scenario Value	Hunter/Fisher Scenario Value
Well water	No well in area	No well in area
Surface Water	Field irrigation only	Field irrigation only
Fish Consumption	36.0 pounds per year	36.0 pounds per year
Meat Consumption	19.3 pounds per year	19.3 pounds per year
Non-Leafy Vegetation	61.2 pounds per year	61.2 pounds per year
Leafy Vegetation	43.7 pounds per year	43.7 pounds per year
Onsite inside a dwelling	None	None
Onsite outdoors	1,100 hours per year	2,920 hours per year
Collecting Non-Leafy Vegetation	154 hours per year	61 hours per year
Collecting Leafy Vegetation	123 hours per year	92 hours per year

* Based on a telephone conference call on October 19, 2016 with SNI, the original consumption rates provided by SNI for the Reach Areas were adjusted using Area 4.1/4.2/4.3 yield rate for the vegetation and surface water areas basis for crop and fish yield for an undeveloped area. The fish yield rate is the ratio of 4.1 fish consumption rate (108 pounds/year) to surface water area (110,000 m²). The vegetation is the ratio of the non-leafy consumption rate (365 pounds/year) and leafy consumption rate (260 pounds/year) to vegetation area (450,000 m²). These yield rates (pounds/ m²) was then applied the to Reach 21 vegetation and surface water areas. Based on the adjustment to the consumption rates, the collection times for non-leafy and leafy vegetation were adjusted to account for the reduction in consumption rates. The recreational occupancy time was not adjusted.

6.1.2 Soil Concentration Data

The weighted mean soil concentrations for gross alpha, gross beta, and cesium results associated with each depth for Reach 7 and 21 were calculated and are summarized in Table 15 below:

Table 15: Reach Area Weighted Average Soil Concentrations

Reach 7			
Depth (cm)	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
0-15	1.4E+01 ± 1.1E+00	2.2E+01 ± 8.4E-01	5.8E-02 ± 1.7E-02
15-30	1.4E+01 ± 1.1E+00	2.1E+01 ± 8.0E-01	1.5 E-01 ± 1.7E-02

* Uncertainty is 1 sigma.

Reach 21			
Depth (cm)	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
0-15	1.3E+01 ± 1.1E+00	2.0E+01 ± 8.2E-01	2.9E-01 ± 3.0E-02
15-30	1.2E+01 ± 1.4E+00	2.3E+01 ± 1.1E+00	1.1E-01 ± 2.3E-02

* Uncertainty is 1 sigma.

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 each of the three Homeowners. Table 16 provides the calculated weighted net average soil concentrations used in the dose assessment.

Table 16: Reach Weighted Net Soil Concentrations for 0-100 cm

Sub-Area	Alpha (pCi/g)	Beta (pCi/g)	Cesium-137 (pCi/g)
Reach 7	0.0E+00	8.7E-02	3.6E-02
Reach 21	3.0E-01	1.9E-01	7.1E-02

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

6.1.3 Dose Assessment Approach for Reach Areas

The dose assessment approach for the Reach areas will be based upon the tissue equivalent dose rate survey meter readings (Bicron) and a site-specific RESRAD scenario calculation utilizing input from the cultural 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 the Collector's and Hunter'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 (Ref. 5). The RESRAD input parameters used that differed from the RESRAD defaults are summarized in Appendix H66. In cases where area specific scenarios were not consistent with assumptions used in the Decommissioning Plan, modifications are described below and in Appendix H66. 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.

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.

6.1.4 Dose Assessment Results for the Reach Areas

Dose Assessment Based upon Tissue Equivalent Survey Meter Readings for Reach Areas

For Reach 7, the dose rate measured using the tissue equivalent survey meter readings did not exceed the background plus 2 sigma; therefore, no dose above background was measured.

For Reach 21, the tissue equivalent survey meter readings and calculated annual dose are provided in Table 17.

Table 17. Calculated Doses Based on Tissue Equivalent Survey Meter Readings for Reach 21

Location	Dose Rate (μR/hour)	Non-Floodplain Background Dose Rate (μR/hour)	Collector Annual Dose Rate (mrem/year)	Hunter/Fisher Annual Dose Rate (mrem/year)
Reach 21	7	4.4	7.1	10.0

Dose Assessment Based upon RESRAD Analysis of Soil Concentrations for Reach Areas

The exposure scenario for the Reach areas are based on the culturally specific land use information.

Reach 7

Reach 7 was modeled as an area of land totaling 22,500 square meters (150 m x 150 m). The layout is setup with the y-axis 15 degrees west of north. This modeled elevated area contains the source of wild vegetation. There are no surface water features within the 22,500 square meter area of land. However, there is a creek west of the area that provides a source of fish for consumption. The creek is modeled as an area that covers 22,000 square meters (80 m x 275 m). See Figure 3 for a representation of this area. No water or milk consumption was assessed based on the culturally specific land use information. The exposures associated with these two scenarios are provided in Table 18 and Table 19. The RESRAD input parameters are provided in Appendix H66.

Table 18. Reach 7 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)
1.58E-02	3.20E-07	3.72E-09	1.12E-01	3.99E-04	3.38E-05	1.29E-01

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

Table 19. Reach 7 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)
3.95E-02	8.48E-07	3.72E-09	1.12E-01	3.99E-04	8.98E-05	1.52E-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 from vegetation consumption. The full RESRAD output files are provided in Appendix H71 and 72.

Reach 21

Reach 21 was modeled as an area of land totaling 75,625 square meters (275 m x 275 m). The layout is setup with the y-axis 30 degrees west of north. This modeled elevated area contains the source of wild vegetation. There are no surface water features within the 75,625 square meter area of land. However,

there is a creek southwest of the area that provides a source of fish for consumption. The creek is modeled as an area that covers 220,000 square meters (1100 m x 200 m). See Figure 4 for a representation of this area. No water or milk consumption was assessed based on the culturally specific land use information. The exposures associated with these two scenarios are provided in Table 20 and Table 21. The RESRAD input parameters are provided in Appendix H66.

Table 20: Reach 21 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)
3.92E-02	4.24E-04	1.42E-08	9.22E-01	3.13E-03	2.55E-03	9.67E-01

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

Table 21: Reach 21 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)
8.76E-02	1.13E-03	1.42E-08	9.22E-01	3.13E-03	6.76E-03	1.02E+00

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 from vegetation consumption. The full RESRAD output files are provided in Appendix H73, H74, H75, and H76.

Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w Values for Reach Areas

Table 22 provides a comparison of the Reach area soil concentrations to the WVDP Phase 1 Decommissioning Plan DCGL_w Values.

Table 22: Reach Area Comparison to WVDP Phase 1 Decommissioning Plan DCGL_w

Measurement Type	Nuclide Used	WVDP DCGL (pCi/g)	Soil Concentrations (pCi/g)	
			Reach 7	Reach 21
Alpha	Pu-239 ^a	2.50E+01	0.000	0.296
Beta	Sr-90	4.10E+00	0.087	0.190
Cesium	Cs-137	1.50E+01	0.036	0.071
Sum of Fractions:			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 except for 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. 3) 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 23 and Table 24 below.

Table 23. 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 24. 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 DCF and the fraction of an ingested element directly absorbed to body fluids (f1) from ICRP 68 are provided in Table 25.

Table 25: 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, both the Collector and Hunter/Fisher consume about 36 pounds of fish flesh per year. These consumption rates result in a calculated annual dose of about 0.2 mrem per year.

6.1.5 Conclusions for Reach Area

Annual doses based on the RESRAD analysis and the ASER fish data ranged from 0.1 to 10.0 mrem per year. Soil concentrations were all below the DCGL values. This demonstrates that Reach areas are well

below the NRC regulatory release requirement of less than 25 mrem per year in accordance with 10 CFR § 20.1402.

7.0 Final Summary

The doses calculated for the Homeowner and Reach areas, summarized in Table 26 and Table 27 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.

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 a result of the natural fluctuation in background.

7.1 Homeowners Calculated Annual Dose

Table 26: Homeowner Calculated Annual Dose (mrem/year)

Dose Assessment Method	HO3	HO4	HO5	Model
Tissue Equivalent Survey Meter Readings	0.0	0.0	0.0	
RESRAD Calculation	0.2	0.3	1.1	Hunter
DCGL Comparison	Below	Below	Below	Hunter
Fish Consumption	0.2	0.2	0.2	Hunter

* 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.

7.2 Reach Calculated Annual Dose

Table 27: Reach Calculated Annual Dose (mrem/year)

Dose Assessment Method	Reach 7	Reach 21	Model
Tissue Equivalent Survey Meter Readings	0.0	10.0	
RESRAD Calculation	0.2	1.0	Hunter
DCGL Comparison	Below	Below	Hunter
Fish Consumption	0.2	0.2	Hunter

* 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.

8.0 References

- 1 U.S. Nuclear Regulatory Commission, Standards for Protection against Radiation, 10 CFR Part 20.1402, *Radiological Criteria for Unrestricted Use*
- 2 RESRAD-OFFSITE 3.1, July 2013, Argonne National Laboratory and User Manual for RESRAD-OFFSITE (NUREG/CR-6937)
- 3 West Valley Demonstration Project Annual Site Environmental Report for Calendar Year 2012, (ASER), September 2013.

- 4 International Commission on Radiological Protection (ICRP) Publication 68, Dose Coefficients for Intakes by Workers, 1994.
- 5 Phase 1 Decommissioning Plan for the West Valley Demonstration Project, Rev. 2, December 2009.