Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site

2017 Update

Tim Jannik

Brooke Stagich

SRNL-STI-2016-00456,

Revision 0 - September 2016

Revision 1 - May 2017

DISCLAIMER

Printed in the United States of America

Prepared for
U.S. Department of Energy

SRNL-STI-2016-00456
Revision 1

Keywords: *Environmental Dosimetry*

Retention: *Permanent*

Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site

2017 Update

Tim Jannik
Brooke Stagich

May 2017

Savannah River National Laboratory™

OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

Prepared for the U.S. Department of Energy under contract number DE-AC09-08SR22470.

REVIEWS AND APPROVALS

AUTHORS:

____

Tim Jannik, Environmental Sciences & Biotechnology Date

____

Brooke Stagich, Environmental Sciences & Biotechnology Date

TECHNICAL REVIEW:

____

Kelsey Minter, Environmental Sciences & Biotechnology Date

APPROVAL:

____

Jack Mayer, Manager Date
Environmental Sciences & Biotechnology

EXECUTIVE SUMMARY

Operations at the Savannah River Site (SRS) result in releases of relatively small amounts of radioactive materials to the atmosphere and to the Savannah River. For regulatory compliance purposes, potential offsite radiological doses are estimated annually using computer models that follow U.S. Nuclear Regulatory Commission (NRC) regulatory guides. Within the regulatory guides, default values are provided for many of the dose model parameters, but the use of site-specific values is encouraged. Detailed surveys of land-use and water-use parameters were conducted in 1991, 2008, 2010, and 2016 and are being concurred with or updated in this report. These parameters include local characteristics of meat, milk, and vegetable production; river recreational activities; and meat, milk, and vegetable consumption rates, as well as other human usage parameters required in the SRS dosimetry models. In addition, the preferred elemental bioaccumulation factors and transfer factors (to be used in human health exposure calculations at SRS) are documented.

The intent of this report is to establish a standardized source for these parameters that is up to date with existing data, and that is maintained via review of future-issued national references (to evaluate the need for changes as new information is released). These reviews will continue to be added to this document by revision.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
MEI	Maximally Exposed Individual
NESHAP	National Emission Standards for Hazardous Air Pollutants
NRC	U.S. Nuclear Regulatory Commission
PA	Performance assessement
PNNL	Pacific Northwest National Laboratory
SRS	Savannah River Site
USDA	US Department of Agriculture

1.0 Introduction

1.1 Background

Operations at the Savannah River Site (SRS) result in releases of relatively small amounts of radioactive materials to the atmosphere and to the Savannah River. For regulatory compliance purposes, potential offsite radiological doses are estimated annually using computer models that follow U.S. Nuclear Regulatory Commission (NRC) regulatory guides (NRC 1977a and 1977b). Within the regulatory guides, default values are provided for many of the dose model parameters, but the use of site-specific values is encouraged (NRC 1977a).

Detailed surveys of land and water use parameters were conducted by Hamby (1991) and by Jannik et al. (2010 and 2016) and are being concurred with or updated here. These parameters include local characteristics of meat, milk, and vegetable production; river recreational activities; and meat, milk, and vegetable consumption rates, as well as other human usage parameters required in the SRS dosimetry models. In addition, the preferred elemental bioaccumulation factors and transfer factors (to be used in human health exposure calculations at SRS) are also documented.

In Lee and Coffield (2008), many of the SRS input parameters utilized in dosimetry calculations were compared to a number of other DOE facilities and generic national/global references to establish relevance of the parameters selected and/or to verify the regional differences of the U.S. Southeast. The parameters selected were applicable to SRS performance assessments (PAs) and were specifically chosen to be expected values (along with identifying a range for these values) versus the conservative specification of parameters for estimating an annual dose to the maximum exposed individual (MEI). However, because of its thoroughness and direct applicability to annual SRS dose compliance calculations, many of the parameters documented in Lee and Coffield (2008) are adopted in this report.

1.2 Purpose

The purpose of this report is to review, and update as needed, the input parameters and environmental bioaccumulation and transfer factors used in human health exposure calculations at SRS for determining compliance with applicable U.S. Department of Energy (DOE) Orders (DOE 1999 and 2013) and U.S. Environmental Protection Agency (EPA) National Emission Standards for Hazardous Air Pollutants' (NESHAP) regulations (EPA 2002). The reason for the update is to utilize more currently issued information, validate currently used information, and correct minor inconsistencies between other modeling efforts performed at SRS.

The intent of this report is to establish a standardized source for these parameters that is up to date with existing data, and maintained via review of future-issued national references (to evaluate the need for changes as new information is released). These reviews will continue to be added to this document by revision.

1.3 Major Changes Since the 2010 Assessment

1.3.1 Representative Person Concept

DOE O 458.1 (DOE 2013) states that compliance with the DOE annual dose limit of 100 mrem (1 mSv), regarding a member of the public, may be demonstrated by calculating dose to the MEI or to a representative person. Historically, the MEI concept was used for dose compliance at SRS, using adult dose coefficients and adult male usage parameters. Beginning in 2012, SRS now uses the representative person concept for dose compliance.

In DOE O 458.1, the representative person is defined as, "…an individual receiving a dose that is representative of the more highly exposed individuals in the population." This term is equivalent of, and replaces, "…average member of the critical group." However, in the *International Commission on Radiological Protection* (ICRP) *Report 101* (ICRP 2006), the definition is extended to include the, "…average value for the more highly exposed group OR the 95th percentile of appropriate national or regional data." The 'OR' is highlighted for emphasis. At SRS, the representative person concept (which is based on a reference person at the 95th percentile of national usage data) is now used as a replacement for the MEI concept.

The reference person is weighted, based on sex and age; and this weighting is based on the six age groups documented in Report 89 (ICRP 2002): Infant (0 years), 1 year, 5 years, 10 years, 15 years, and Adult. The various age- and gender-specific intake rates from EPA (2011) were proportioned to correspond with these respective age groupings. SRS also developed usage parameters at the 50th percentile, which are used in calculating dose to a "typical" person for determining collective doses.

The SRS-specific reference and typical-person usage parameters were developed by Stone and Jannik (2013) and are adopted in this report. The subsequent effect on SRS compliance dose results, due to changing from the MEI to the Representative Person concept, also are documented in Stone and Jannik (2013).

1.4 Major Changes Since the 2016 Assessment

1.4.1 Agricultural Production

The total production of vegetables, meat, and milk were revised upward based on the U. S. Department of Agriculture (USDA 2014) agricultural statistics. Also, production maps for the counties within the 50-mile radius surrounding SRS are included in the Appendix.

2.0 Discussion

2.1 Physical Parameters

Physical parameters are defined as those whose value would not change, if a different group of receptors were considered. For the purposes of this report, these parameters include agricultural production factors and aquatic food harvest factors. The other physical input parameters are determined by SRS's geographical location, the geophysical characteristics of the site, and the element-specific transfer and bioaccumulation factors. After review of applicable states (Georgia and South Carolina) and federal (USDA) data, all SRS agricultural and river transport physical parameters remained unchanged from the 2016 values. Therefore, the current agricultural productivity and Savannah River transport physical parameters (to be used in SRS dose assessments) remained unchanged and are listed in the column labeled "2010/2016 Values" in Table 1.

The International Atomic Energy Agency (IAEA) published (in Technical Reports Series No. 472) updated recommended transfer factors for a limited number of elements (IAEA 2010). With only a few exceptions (noted in the discussions to follow), these element-specific transfer values were used in the 2010 version of this report and remain unchanged in this report. For the elements not included in IAEA No. 472, the values documented in Lee and Coffield (2008) are used. The soil-to-vegetable, feed-to-milk, and feed-to-meat transfer factors are provided in Table 2, Table 3, and Table 4, respectively. The water-to-fish bioaccumulation factors and water-to-saltwater invertebrates' bioaccumulation factors are provided in Table 5 and Table 6, respectively.

During this updated study, the physical parameters that were determined to differ from Hamby (1991) or

Lee and Coffield (2008) are discussed below. The parameters that remained the same are also documented in Table 1 through Table 6, but without additional comment.

2.1.1 Agricultural Productivity and Production

The agricultural productivity factors for vegetables, meat, and milk are weighted averages based on the 2012 USDA National Agricultural Statistics (USDA 2014). These annual production rates that occur within a 50-mile radius of SRS and are used for SRS dose assessments have been verified and provided in Table 1 under "2010/2016 Values". The 2007 USDA agricultural statistics were also considered to confirm agricultural production trends (USDA 2009).

2.1.1.1 Vegetable Productivity and Production

The South Carolina and Georgia weighted average vegetable productivity was determined to be 2.2 kg/m^2 (USDA 2014). This value, which includes leafy and non-leafy vegetables, is over 200 percent more than the Hamby (1991) and Lee and Coffield (2008) reported value of 0.7 kg/m^2. However, it is comparable to the NRC (1977a,b) default value of 2.0 kg/m^2, and it is the same as the USDA (2009) dataset.

Based on USDA (2014), the combined leafy and non-leafy vegetable commercial production (within 50 miles of SRS) was estimated to be 1.1E+06 kg/yr (9.5E+04 kg/yr for leafy vegetables and 9.9E+05 kg/yr for non-leafy vegetables). For the purposes of this report, the total combined vegetable production value was increased by a factor of 10 (revised up to 1.1E+07 kg/yr) to account for unreported and non-commercial (individual use) production of vegetables in the area. This conservative factor is based on professional judgment and on personal discussions with county agents and other professionals in the field. The updated production value of 1.1E+07 kg/yr is about 80 percent less than the Hamby (1991) estimated value of 4.7E+07 kg/yr. The USDA (2009) estimated combined total was 6.7E+06 kg/yr (including the factor of 10 for unreported production), which indicates an upward trend in vegetable production in the SRS area. The combined leafy and non-leafy vegetable production, as a function of distance and sector from the center of SRS, is provided in
Table 7. These data are shown graphically, for the counties surrounding SRS, in Figure 1.

The vegetable production in the SRS area has increased from the previous census; therefore, does not follow the decreasing trend stated in the past. This is due largely in part to improvements in the farming methods (better plant resistance to disease, irrigation methods, pesticides, etc.) in the last decade which have led to higher vegetable yields. This increase is a result of programs raising awareness about the benefits of eating more fruits and vegetables (USDA 2017a).

2.1.1.2 Pasture Grass Productivity

The South Carolina and Georgia weighted average pasture grass productivity was determined to be 0.7 kg/m^2 (USDA 2014). This value is about 60 percent less than the Hamby (1991) and Lee and Coffield (2008) reported value of 1.8 kg/m^2. However, it is the same as the NRC (1977a,b) default value and the value estimated using the USDA (2009) dataset.

2.1.1.3 Meat (Beef) Productivity and Production

Because commercial poultry and pork production are almost exclusively indoor operations, only beef production is considered for the meat pathway. Based on USDA (2014), the South Carolina and Georgia weighted average meat productivity was determined to be 0.01 kg/m^2. This value was not considered in the Hamby (1991) and Lee and Coffield (2008) reports. However, it is used in the LADTAP XL© IRRIDOSE spreadsheet for population dose assessments to determine the amount of beef production on a given irrigated area of land. The 0.01 kg/m^2 value was determined based on the daily consumption rate of forage by beef cattle (36 kg/d), the current pasture grass productivity (0.7 kg/m^2), and an assumed edible meat amount per beef cow (200 kg). The following equation details the calculation:

$$\frac{\dfrac{200\ \text{kg/yr}}{36\ \text{kg/d} * 365.25\ \text{d/yr}}}{\dfrac{1\ \text{m}^2}{0.7\ \text{kg}}} = 0.01\ \ \text{kg/m}^2 \qquad (1)$$

Based on USDA (2014), the commercial beef production (within 50 miles of SRS) was estimated to be 5.8E+06 kg/yr. For the purposes of this report, the commercial beef production value was increased by a factor of 1.25 (revised up to 7.2E+06 kg/yr) to account for unreported and non-commercial (individual use) production of beef in the area. Again, this factor is based on professional judgment and on personal discussions with county agents and other professionals in the field. The beef production value of 7.2E+06 kg/yr is about 50 percent less than the Hamby (1991) estimated value of 1.5E+07 kg/yr. The USDA (2009) estimated total was 7.6E+06 kg/yr (including the factor of 1.25 for unreported production), which indicates a continuing downward trend in beef production in the SRS area. The beef production, as a function of distance and sector, is provided in Table 8. These data are shown graphically, for the counties surrounding SRS, in Figure 2.

2.1.1.4 Milk Productivity and Production

The South Carolina and Georgia weighted average milk productivity was determined to be 0.34 L/m^2 (USDA 2014). This value was not considered in the Hamby (1991) and Lee and Coffield (2008) reports. However, it is used in the LADTAP XL© IRRIDOSE spreadsheet for population dose assessments, to determine the amount of milk production on a given irrigated area of land. The 0.34 kg/m^2 value was determined based on the daily consumption rate of forage by milk cows (52 kg/d), the current pasture grass productivity (0.7 kg/m^2), and an assumed daily milk production amount per milk cow (25 L/d). The following equation details the calculation:

$$\frac{\dfrac{25\ \text{L/d}}{52\ \text{kg/d}}}{\dfrac{1\ \text{m}^2}{0.7\ \text{kg}}} = 0.34\ \text{L/m}^2 \qquad (2)$$

The commercial milk production (within 50 miles of SRS) was estimated to be 1.0E+08 L/yr (USDA 2014). For the purposes of this report, the commercial milk production value was increased by a factor of 1.25 (revised up to 1.3E+08 L/yr) to account for unreported and non-commercial (individual use) production of milk in the area. Again, this factor is based on professional judgment and on personal discussions with county agents and other professionals in the field. The updated milk production value of 1.3E+08 L/yr is about 20 percent more than the Hamby (1991) estimated value of 1.1E+08 L/yr. The USDA (2009) estimated total was 8.5E+07 L/yr (including the factor of 1.25 for unreported production), which indicates an upward trend in milk production in the SRS area. The milk production, as a function of distance and sector, is provided in Table 9. These data are shown graphically, for the counties surrounding SRS, in Figure 3.

The recent upward trend in the production of milk is due to an increase in the number of cows per farm rather than in the number of farms (USDA 2017b).

2.1.2 Soil to Vegetable Transfer Factors

In IAEA (2010), a selection of element-specific, soil-to-plant (vegetable) transfer factors are provided for a variety of plant groups. Based on USDA (2014), the estimated percentage breakdown of the major plant groups that are commercially produced in the SRS area is as follows:

- Leafy vegetables 20%
- Legumes 15%
- Tubers and Roots 10%
- Non-leafy 55%

These percentages were used to calculate a weighted-average, element-specific transfer factor which is documented in Table 2. For the elements not included in IAEA (2010), the values documented in Lee and Coffield (2008) were used. The soil-to-vegetable transfer factors remain unchanged in this report and are provided in the Table 2 column labeled "2010/2016 Values."

2.1.3 Feed to Milk Transfer Factors

In IAEA (2010), a selection of element-specific transfer coefficients to cow's milk (feed-to-milk) are provided. For the elements not included in IAEA (2010), the values documented in Lee and Coffield (2008) were used. The milk transfer coefficients remain unchanged in this report and are provided in the Table 3 column labeled "2010/2016 Values."

2.1.4 Feed to Meat Transfer Factors

In IAEA (2010), a selection of element-specific transfer coefficients to beef (feed-to-meat) are provided. For the elements not included in IAEA (2010), the values documented in Lee and Coffield (2008) were used. The meat transfer coefficients remain unchanged in this report and are provided in the Table 4 column labeled "2010/2016 Values."

2.1.5 Water to Fish Bioaccumulation Factors

In IAEA (2010), a selection of element-specific concentrations ratios (bioaccumulation factors) for freshwater fish tissue are provided. For the elements not included in IAEA (2010), the values documented in Lee and Coffield (2008) were used, as discussed below. Exceptions to this rule, which are described below, are plutonium, cesium, and carbon. The fish bioaccumulation factors remain unchanged in this report and are provided in the Table 5 column labeled "2010/2016 Values."

As discussed in section 3.0 (Summary), the plutonium bioaccumulation factor recommended in IAEA (2010) is 21,000 L/kg. This is several orders of magnitude greater than the previous IAEA value, which (as documented in Lee and Coffield (2008)) is 30 L/kg. The 21,000 L/kg bioaccumulation value for plutonium seems unreasonable, based on the professional judgement of the authors and other national experts. Therefore, the Lee and Coffield (2008) value of 30 L/kg will continue to be used, until the IAEA (2010) value is verified or changed.

The SRS site-specific bioaccumulation factor for cesium of 3,000 L/kg (Jannik 2003) is used in this update, in lieu of the IAEA (2010) value of 2,500 L/kg. The site-specific value is slightly more conservative than the IAEA (2010) value and is considered the best available data for SRS.

Also, the SRS-determined bioaccumulation factor for carbon of 3 L/kg (Hinton et al. 2009) is used in lieu of the IAEA (2010) value of 400,000 L/kg. Hinton et al. (2009) used a systems-model approach to study the carbon mass balance in an SRS stream. This study showed that most of the carbon in fish does not come from the water in which they live; the assumption on which the IAEA-referenced elemental bioaccumulation factors are based.

2.1.6 Water to Saltwater Invertebrates Bioaccumulation Factors

Recommended concentration ratios for saltwater invertebrates were not addressed in IAEA (2010). Also, because the saltwater invertebrate pathway is not applicable to Performance Assessments at SRS, they were not addressed in Lee and Coffield (2008). Therefore, the values presented in Pacific Northwest National Laboratory (PNNL) (2003) continue to be used in this report and are provided in the Table 6 column labeled "2010/2016 Values." In PNNL (2003), saltwater bioaccumulation factors are provided for crustaceans and mollusks. To be conservative, the larger of the two values was used.

2.2 Behavioral Parameters

Behavioral parameters are defined as those whose value depends on the receptor's behavior and the defined exposure scenario. For the purposes of this report, these parameters include the metabolic characteristics of the receptor. As discussed, in 2013 SRS changed to using the Representative Person concept for DOE (2013) compliance dose calculations. The 2010 MEI usage parameters have been updated to reference person usage parameters at the 95th percentile, and the average individual usage parameters have been updated to the typical person usage parameters at the 50th percentile. A complete description of these changes is provided in Stone and Jannik (2013).

2.2.1 Typical Person, Reference Person, and Population Usage Parameters

A summary of the current and updated behavioral and metabolic parameters for the typical person and general population are listed in Table 10, and a summary for the reference person is in Table 11. The parameters that remained the same are also documented in Table 10 and Table 11, but without additional comment.

2.2.1.1 Shoreline, Swimming, and Boating Exposure Time

After review of applicable state (Georgia and South Carolina) recreation data, the average individual recreational exposure usage rates for shoreline usage, swimming, and boating in the SRS area remained unchanged. As shown in Table 12, these exposure times were estimated to be 10 hr/yr, 7 hr/yr, and 22 hr/yr, respectively. These values are based on 2005 data from the Georgia Department of Natural Resources (GDNR 2005), the South Carolina Department of Parks and Recreation (SCDPR 2005), and on the estimated hours per occasion from Hamby (1991). The reference person recreation exposure times were conservatively set at twice the per capita values.

Based on these recreational usage rates, the weighted population exposure times for shoreline usage, swimming, and boating were determined. These are provided in Table 13. These values are based on the SC and GA state usage available fractions from Hamby (1991), the 2000 census population fraction in the SC (0.6) and GA (0.4) counties within 50 miles of SRS, and on the projected 2010 total population (1.4E+06 people) in those counties. Because the projected 2010 census data was within 15 percent of the actual 2010 data, in this assessment, these values remain unchanged.

2.2.1.2 Population Served by Downriver Drinking Water Plants

In 2016 the operators of the three public drinking water plants (located downriver of SRS) estimated that the following populations were served:

- Beaufort-Jasper Water and Sewer Authority (Chelsea Plant) 83,700 people
- Beaufort-Jasper Water and Sewer Authority (Purrysburg Plant) 64,800 people
- City of Savannah Industrial and Domestic Water Supply Plant 35,000 people

These totals will be updated annually for use in the SRS Annual Site Environmental Report.

3.0 Summary

Detailed surveys of land-use and water-use parameters in the SRS area were conducted by Hamby (1991), Lee and Coffield (2008), and Jannik et al. (2010 and 2016). The updated parameters include local characteristics of meat, milk, and vegetable production; river recreational activities; and meat, milk, and vegetable consumption rates, as well as other human usage parameters required in the SRS dosimetry models. In addition, the preferred elemental bioaccumulation factors and transfer factors (to be used in human health exposure calculations at SRS) have been documented in this report.

4.0 References

DOE 1999, *Radioactive Waste Management,* DOE Order 435.1, U.S. Department of Energy, Washington, DC; 1999.

DOE 2013. U.S. Department of Energy, *Radiation protection of the public and the environment, Change #3*, Washington, DC: U.S. DOE O 458.1; 2013.

EPA 2002. U.S. Environmental Protection Agency, *National Emission Standard for Hazardous Air Pollutants,* Title 40 Code of Federal Regulations, Part 61, Subpart H, Washington, D.C., 2002.

EPA 2011. U.S. Environmental Protection Agency. Exposure factors handbook. Washington, DC: U.S. Environmental Protection Agency; EPA/600/R-90/052F; 2011.

GDNR (2005). Personal conversations with Elizabeth Cheney, Georgia Department of Natural Resources website: http://crd.dnr.state.ga.us/

Hamby 1991. D.M. Hamby, *Land and Water Use Characteristics in the Vicinity of the Savannah River Site*, Westinghouse Savannah River Company Report: WSRC-RP-91-17, Aiken, SC, March 1991.

Hinton et al. 2009. Hinton, T., Kaplan, D., Fletcher, D., McArthur, J., and Romanek, C., *"Systems Model of Carbon Dynamics in Four Mile Branch on the Savannah River Site",* SRNS-TR-2009-00178, Rev. 1, March 25, 2009.

IAEA 2010. International Atomic Energy Agency, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments, IAEA Technical Reports Series No. 472, Vienna, Austria, 2010.

ICRP 2002. International Commission on Radiological Protection. Basic anatomical physiological data for use in radiological protection reference values. Oxford: ICRP; Publication 89, Ann. ICRP 32 (3-4); 2002.

ICRP 2006. International Commission on Radiological Protection. Assessing dose of the representative person for the purpose of the radiation protection of the public. Oxford: ICRP; Publication 101a, Ann. ICRP 36 (3); 2006.

Jannik 2003. Jannik, G.T., Cesium-137 Bioconcentration Factor for Freshwater Fish in the SRS Environment, SRT-EST-2003-00134, Savannah River Site, Aiken, SC, 2003.

Jannik 2010. Jannik, G.T., Karapatakis, D.J., and Lee, P.L., Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site, SRNL-STI-2010-00447 Revision 0, Savannah River Site, Aiken, SC, 2010.

Jannik 2016. Jannik, G.T., Stagich, B.H., and Hartman, L., Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site, SRNL-STI-2016-00456 Revision 0, Savannah River Site, Aiken, SC, 2016.

Lee and Coffield 2008. P.L. Lee and T.W. Coffield, Baseline Parameter Update for Human Health Input and Transfer Factors for Radiological Performance Assessments at the Savannah River Site, Westinghouse Savannah River Company Report: WSRC-STI-2007-00004, Rev. 4, Aiken, SC, June 2008.

NRC 1977a. U.S. Nuclear Regulatory Commission, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I, Regulatory Guide 1.109, Washington, D.C., 1977.

NRC 1977b. U.S. Nuclear Regulatory Commission, Estimating Aquatic Dispersion of Effluents from Accidental and Routine Releases for the Purpose of Implementing Appendix I, Regulatory Guide 1.113 (Rev. 1), Washington, D.C., 1977.

PNNL 2003. Pacific Northwest National Laboratory, *A Compendium of Transfer Factors for Agricultural and Animal Products,* PNNL-13421, Hanford, WA, 2003.

SCDPR (2005). *SC 2005 Recreation Participation and Preference Study*, South Carolina Department of Parks and Recreation website: http://www.scprt.com/our-partners/tourismstatistics/researchreports.aspx

Stone and Jannik 2013. Stone, D. K., Jannik, G. T. Site Specific Reference Person Parameters and Derived Concentration Standards for the Savannah River Site. SRNL-STI-2013-00115. Savannah River National Laboratory. Aiken, SC: 2013.

USDA 2009. U.S. Department of Agriculture, *2007 Census of Agriculture, U.S. Summary and State Data,* National Agricultural Statistics Service Report AC-07-A-51, Washington, D.C., 2009.

USDA 2014. U.S. Department of Agriculture, *2012 Census of Agriculture, U.S. Summary and State Data,* National Agricultural Statistics Service Report AC-07-A-51, Washington, D.C., 2012.

USDA 2017a. U.S. Department of Agriculture, *Vegetables & Pulses Overview,* Economic Research Service website: https://www.ers.usda.gov/topics/crops/vegetables-pulses/

USDA 2017b. U.S. Department of Agriculture, *Dairy Background,* Economic Research Service website: https://www.ers.usda.gov/topics/animal-products/dairy/background/

Appendix A. Usage Parameters, Transfer Factors, and Bioaccumulation Factors
(Tables 1 – 13)

Table 1. SRS Agricultural and River Transport Physical Parameters for Dose Calculations

Parameter	Units	1977 NRC Default	1991 Hamby	2008 Lee and Coffield	2010/2016 Jannik et al.
Beef-cow forage consumption (wet)	kg/d	50	36	36	36
Milk-cow forage consumption (wet)	kg/d	50	52	52	52
Pasture-grass exposure time to irrigation	d	30	30	30	30
Vegetable crop exposure time to irrigation	d	60	70	70	70
Vegetable garden productivity	kg/m^2	2	0.7	0.7	2.2
Agricultural productivity (produce/veg.)	kg/m^2	2	0.7	0.7	2.2
Agricultural productivity (pasture grass)	kg/m^2	0.7	1.8	1.8	0.7
Agricultural productivity (edible beef.)	kg/m^2	-	-	-	0.01
Agricultural productivity (milk)	L/m^2	-	-	-	0.34
Irrigation rate	$L/d/m^2$		3.4	3.6	3.6
Transport time (feed-milk-man)	d	4	3	3	3
Transport time (produce for avg/pop)	d	14	14	6	6
Transport time (produce for MEI)	d	1	1	N/A	1
Time from slaughter to consumption	d	20	6	6	6
Holdup time (pasture grass, forage)	d	0	0	0	0
Holdup time (stored feed)	d	90	90	N/A	90
Fraction of time milk-cow on pasture	-	0.75	1	1	1
Fraction of time beef-cow on pasture	-	0.75	1	1	1
Fraction of intake from pasture (milk cow)	-	1 (b)	0.56	0.56	0.56
Fraction of intake from pasture (beef-cow)	-	1 (b)	0.75	0.75	0.75
Fraction of veg. from local farm (avg/pop)	-	1	1	0.308	0.308
Fraction of meat from local farm (avg/pop)	-	1	1	0.319	0.319
Fraction of milk from local farm (avg/pop)	-	1	1	0.254	0.254
Fraction of veg. from local farm (MEI)	-	1	1	N/A	1
Fraction of meat from local farm (MEI)	-	1	1	N/A	1

Table 1. SRS Agricultural and River Transport Physical Parameters for Dose Calculations ***(continued)***

Parameter	Units	1977	1991	2008	2010/2016
		NRC Default	Hamby	Lee and Coffield	Jannik et al.
Fraction of milk from local farm (MEI)	-	1	1	N/A	1
Fraction of intake from contaminated water	-	1	1	1	1
Cattle consumption rate of water (meat)	L/d	50	50	28	28
Cattle consumption rate of water (milk)	L/d	60	60	50	50
Buildup time in soil	d	5475	7300	183	9125
Areal density of soil	kg/m^2	240	240	240	240
Soil density	kg/m^3	N/A	N/A	1600	1600
Weathering removal constant	1/d	0.0495	0.0495	0.0495	0.0495
Fractional retention of leaves	-	0.25	0.25	0.25	0.25
Depth of garden	cm	-	-	15	15
Edible sport fish harvest	kg/yr	-	3.50E+04	N/A	8.22E+03
Edible commercial fish harvest	kg/yr	-	2.70E+03	N/A	5.70E+04
Edible commercial invertebrate harvest	kg/yr	-	2.45E+05	N/A	3.80E+05
Edible fraction of harvest - fish (whole)	-	-	0.5	N/A	0.5
Edible fraction of harvest - crab (whole)	-	-	0.14	N/A	0.14
Edible fraction of harvest - shrimp (tail only)	-	-	0.9	N/A	0.9
Edible fraction of harvest - oysters (meat)	-	-	1	N/A	1
Edible fraction of harvest - clams (meat)	-	-	1	N/A	1
River dilution in estuary	-	-	3	N/A	3
River Transport Time for Recreation	d	-	1	N/A	1
River Transport Time for MEI (RM 118.8)	d	-	1.5	N/A	1.5
River Transport Time for Fish	d	-	2	N/A	2
River Transport Time for Irrigation	d	-	2	N/A	2
River Transport Time for Drinking Water	d	-	4	N/A	4
River Transport Time for Sport Fish	d	-	10	N/A	10
River Transport Time for Commercial Fish	d	-	13	N/A	13
River Transport Time for Invertibrates	d	-	13	N/A	13
Shoreline width factor	-	0.2	0.2	N/A	0.2

Table 2. Soil-to-Vegetable Transfer Factors

Element	Z	Prior to 2010 Value SRS	2008 Value Lee and Coffield	2010 Weighted Value IAEA #472	2003 Weighted Value PNNL-13421	2010/2016 Values Jannik, et al.
Ac	89	2.5E-03	6.83E-05		6.11E-05	6.11E-05
Ag	47	1.5E-01	1.18E-02	1.19E-04		1.19E-04
Al	13	4.0E-03	1.27E-04			1.27E-04
Am	95	2.5E-04	6.83E-05	7.3E-05		7.33E-05
Ar	18		1.00E-20			1.00E-20
As	33		1.17E-03		2.73E-03	2.73E-03
At	85		2.93E-02			2.93E-02
Au	79		3.51E-03		2.64E-03	2.64E-03
B	5		3.90E-01			3.90E-01
Ba	56	5.0E-03	2.93E-03	9.75E-04		9.75E-04
Be	4	4.0E-03	2.93E-04		6.83E-04	6.83E-04
Bi	83	1.0E-01	9.75E-02		9.75E-02	9.75E-02
Bk	97	5.9E-05	1.00E-03			1.00E-03
Br	35		2.93E-01		2.93E-01	2.93E-01
C	6	5.5E+00	1.37E-01		1.37E-01	1.37E-01
Ca	20	5.0E-01	6.83E-02	3.9E+00		3.90E+00
Cd	48	3.0E-01	2.93E-02	1.5E-01		1.49E-01
Ce	58	2.5E-03	3.90E-03	1.6E-03		1.63E-03
Cf	98	1.0E-03	6.83E-05		6.11E-05	6.11E-05
Cl	17	2.0E+01	1.37E+01	3.5E+00		3.49E+00
Cm	96	2.5E-03	8.39E-05	1.3E-04		1.27E-04
Co	27	9.4E-03	1.31E-02	2.5E-02		2.48E-02
Cr	24	2.5E-04	8.78E-04	2.0E-04		1.95E-04
Cs	55	1.0E-02	9.00E-01	6.9E-03		6.85E-03
Cu	29	1.2E-01	4.88E-02	1.6E-01		1.56E-01
Dy	66		3.90E-03		3.90E-03	3.90E-03
Er	68		3.90E-03		3.90E-03	3.90E-03
Es	99	5.9E-05	1.00E-03			1.00E-03

Note: 1.00E-20 is equivalent to 0.00.

Table 2. Soil-to-Vegetable Transfer Factors ***(continued)***

Element	Z	Prior to 2010 Value	2008 Value	2010 Weighted Value	2003 Weighted Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	PNNL-13421	Jannik, et al.
Eu	63	2.5E-03	3.90E-03		3.90E-03	3.90E-03
F	9		1.17E-03		3.65E-03	3.65E-03
Fe	26	6.6E-04	9.75E-03	1.10E-02		1.10E-02
Fm	100		2.00E-03			2.00E-03
Fr	87		5.85E-03			5.85E-03
Ga	31		7.80E-05		2.43E-04	2.43E-04
Gd	64	2.0E-03	3.90E-03		3.90E-03	3.90E-03
Ge	32	1.0E-01	1.56E-02			1.56E-02
H	1	not used	4.80E+00			4.80E+00
Ha	108		2.00E-03			2.00E-03
He	2		1.00E-20			1.00E-20
Hf	72	1.0E-04	1.95E-04		1.95E-04	1.95E-04
Hg	80	3.8E-01	3.90E-02		9.03E-02	9.03E-02
Ho	67	2.5E-03	3.90E-03		3.90E-03	3.90E-03
I	53	2.0E-02	7.80E-03	1.3E-02		1.32E-02
In	49	3.0E-03	7.80E-05		2.43E-04	2.43E-04
Ir	77	3.0E-02	2.93E-03		4.76E-03	4.76E-03
K	19	3.0E-01	1.07E-01	2.5E-01		2.54E-01
Kr	36		1.00E-20			1.00E-20
La	57	2.5E-03	6.83E-05	9.09E-04		9.09E-04
Li	3		7.80E-04			7.80E-04
Lr	103		2.00E-03			2.00E-03
Lu	71	2.5E-03	7.80E-04			7.80E-04
Md	101		2.00E-03			2.00E-03
Mg	12		1.07E-01		1.28E-01	1.28E-01
Mn	25	2.9E-02	3.90E-02	6.39E-02		6.39E-02
Mo	42	1.2E-01	1.56E-01	8.7E-02		8.71E-02
N	7		3.50E-01		7.43E-03	7.43E-03
Na	11	5.0E-02	5.85E-02	5.85E-03		5.85E-03

Note: 1.00E-20 is equivalent to 0.00.

Table 2. Soil-to-Vegetable Transfer Factors *(continued)*

Element	Z	Prior to 2010 Value	2008 Value	2010 Weighted Value	2003 Weighted Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	PNNL-13421	Jannik, et al.
Nb	41	9.4E-03	4.88E-03	2.2E-03		2.18E-03
Nd	60		3.90E-03	3.9E-03		3.90E-03
Ne	10		1.00E-20			1.00E-20
Ni	28	1.9E-02	1.17E-02		2.18E-02	2.18E-02
No	102		2.00E-03			2.00E-03
Np	93	2.5E-03	2.54E-03	3.91E-03		3.91E-03
O	8		6.00E-01			6.00E-01
Os	76		6.83E-04		6.45E-03	6.45E-03
P	15	1.1E+00	6.83E-01	1.95E-01		1.95E-01
Pa	91	1.0E-02	4.18E-04		6.11E-05	6.11E-05
Pb	82	1.0E-02	1.17E-03	5.2E-03		5.18E-03
Pd	46	1.0E-01	7.80E-03		1.28E-02	1.28E-02
Pm	61	2.5E-03	3.90E-03	2.3E-02		2.32E-02
Po	84	1.0E-03	1.37E-03	4.3E-04		4.30E-04
Pr	59		3.90E-03	3.9E-03		3.90E-03
Pt	78	2.4E-02	4.88E-03			4.88E-03
Pu	94	2.5E-04	2.15E-04	2.0E-05		1.97E-05
Ra	88	4.0E-02	4.64E-03	1.2E-02		1.19E-02
Rb	37	1.3E-01	1.76E-01	1.4E-01		1.39E-01
Re	75	2.1E+02	1.29E+00		1.21E-01	1.21E-01
Rf	104		3.00E-03			3.00E-03
Rh	45		7.80E-03	1.76E-01		1.76E-01
Rn	86		1.00E-20			1.00E-20
Ru	44	5.0E-02	7.80E-03	6.29E-03		6.29E-03
S	16	5.9E-01	2.93E-01		2.93E-01	2.93E-01
Sb	51	1.1E-02	2.49E-03	2.6E-04		2.61E-04
Sc	21		1.95E-04		4.24E-04	4.24E-04

Note: 1.00E-20 is equivalent to 0.00.

Table 2. Soil-to-Vegetable Transfer Factors *(continued)*

Element	Z	Prior to 2010 Value	2008 Value	2010 Weighted Value	2003 Weighted Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	PNNL-13421	Jannik, et al.
Se	34	1.3E+00	5.14E-02		1.89E-02	1.89E-02
Si	14	8.8E-02	1.37E-02		2.65E-02	2.65E-02
Sm	62	2.5E-03	3.90E-03		3.90E-03	3.90E-03
Sn	50	2.5E-03	1.17E-03		2.27E-03	2.27E-03
Sr	38	1.7E-02	9.75E-02	1.2E-01		1.23E-01
Ta	73	2.5E-03	4.88E-03		4.88E-03	4.88E-03
Tb	65		3.90E-03		3.90E-03	3.90E-03
Tc	43	2.5E-01	4.68E-02	1.79E+01		1.79E+01
Te	52	1.3E+00	1.20E-02	5.9E-02		5.85E-02
Th	90	4.2E-03	6.44E-05	3.1E-04		3.14E-04
Ti	22	1.0E-04	5.85E-04			5.85E-04
Tl	81		7.80E-05		2.43E-04	2.43E-04
Tm	69		7.80E-04			7.80E-04
U	92	2.5E-03	2.34E-03	6.69E-03		6.69E-03
V	23	1.4E-03	5.85E-04			5.85E-04
W	74		5.00E-02	2.0E-02		1.95E-02
Xe	54		1.00E-20			1.00E-20
Y	39	2.6E-03	1.95E-03	3.90E-04		3.90E-04
Yb	70		7.80E-04			7.80E-04
Zn	30	4.0E-01	6.83E-02	1.71E-01		1.71E-01
Zr	40	1.7E-04	1.95E-04	7.8E-04		7.80E-04

Note: 1.00E-20 is equivalent to 0.00.

.

Table 3. Feed-to-Milk Transfer Factors (d/L)

Element	Z	Prior to 2010 Value	2008 Value	2010 Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	Jannik et al.
Ac	89	2.0E-05	2.00E-05		2.00E-05
Ag	47	5.0E-02	1.58E-03		1.58E-03
Al	13	2.0E-04	2.06E-04		2.06E-04
Am	95	5.0E-06	1.50E-06	4.20E-07	4.20E-07
As	33		6.00E-05		6.00E-05
At	85		1.03E-02		1.03E-02
Au	79		5.50E-06		5.50E-06
B	5		1.55E-03		1.55E-03
Ba	56	4.0E-04	4.80E-04	1.60E-04	1.60E-04
Be	4	2.0E-06	9.00E-07	8.30E-07	8.30E-07
Bi	83	5.0E-04	5.00E-04		5.00E-04
Bk	97	4.0E-07	2.00E-06		2.00E-06
Br	35		2.00E-02		2.00E-02
C	6	1.2E-02	1.20E-02		1.20E-02
Ca	20	3.0E-03	3.00E-03	1.00E-02	1.00E-02
Cd	48	1.2E-04	1.00E-03	1.90E-04	1.90E-04
Ce	58	6.0E-04	3.00E-05	2.00E-05	2.00E-05
Cf	98	7.5E-07	1.50E-06		1.50E-06
Cl	17	2.0E-02	1.70E-02		1.70E-02
Cm	96	5.0E-06	2.00E-05		2.00E-05
Co	27	1.0E-03	3.00E-04	1.10E-04	1.10E-04
Cr	24	2.2E-03	1.00E-05	4.30E-04	4.30E-04
Cs	55	1.2E-02	7.90E-03	4.60E-03	4.60E-03
Cu	29	1.4E-02	2.00E-03		2.00E-03
Dy	66		3.00E-05		3.00E-05
Er	68		3.00E-05		3.00E-05
Es	99	4.0E-07	2.00E-06		2.00E-06
Eu	63	5.0E-06	3.00E-05		3.00E-05
F	9		1.00E-03		1.00E-03
Fe	26	1.2E-03	3.00E-05	3.50E-05	3.50E-05
Fr	87		2.06E-02		2.06E-02
Ga	31		5.00E-05		5.00E-05
Gd	64	6.0E-05	3.00E-05		3.00E-05
Ge	32	7.0E-02	7.21E-02		7.21E-02
H	1	not used	1.50E-02		1.50E-02
Ha	105		5.00E-06		5.00E-06
He	2		1.00E-20		1.00E-20
Hf	72	5.5E-07	5.50E-07		5.50E-07
Hg	80	5.0E-04	4.70E-04		4.70E-04
Ho	67	2.0E-05	3.00E-05		3.00E-05
I	53	6.0E-03	9.00E-03	5.40E-03	5.40E-03
In	49	2.0E-04	2.00E-04		2.00E-04
Ir	77	2.0E-06	2.00E-06		2.00E-06
K	19	7.0E-03	7.20E-03		7.20E-03
La	57	5.0E-06	2.00E-05		2.00E-05
Li	3		2.06E-02		2.06E-02
Lr	103		5.00E-06		5.00E-06
Lu	71	2.0E-05	2.06E-05		2.06E-05
Md	101		5.00E-06		5.00E-06

Table 3. Feed-to-Milk Transfer Factors (d/L) ***(continued)***

Element	Z	Prior to 2010 Value	2008 Value	2010 Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	Jannik et al.
Mg	12		3.90E-03		3.90E-03
Mn	25	2.5E-04	3.00E-05	4.10E-05	4.10E-05
Mo	42	7.5E-03	1.70E-03	1.10E-03	1.10E-03
N	7		2.50E-02		2.50E-02
Na	11	4.0E-02	1.60E-02	1.30E-02	1.30E-02
Nb	41	2.5E-03	3.20E-05	4.10E-07	4.10E-07
Nd	60		3.00E-05		3.00E-05
Ni	28	6.7E-03	1.60E-02	9.50E-04	9.50E-04
No	102		5.00E-06		5.00E-06
Np	93	5.0E-06	5.00E-06		5.00E-06
Os	76		5.00E-03		5.00E-03
P	15	2.5E-02	1.60E-02	2.00E-02	2.00E-02
Pa	91	5.0E-06	5.00E-06		5.00E-06
Pb	82	3.0E-04	2.60E-04	1.90E-04	1.90E-04
Pd	46	5.0E-03	1.00E-02		1.00E-02
Pm	61	5.0E-06	3.00E-05		3.00E-05
Po	84	3.4E-04	3.40E-04	2.10E-04	2.10E-04
Pr	59		3.00E-05		3.00E-05
Pt	78	5.0E-03	5.15E-03		5.15E-03
Pu	94	2.0E-06	1.10E-06	1.00E-05	1.00E-05
Ra	88	1.0E-03	1.30E-03	3.80E-04	3.80E-04
Rb	37	3.0E-02	1.20E-02		1.20E-02
Re	75	1.4E-04	1.50E-03		1.50E-03
Rf	104		2.00E-05		2.00E-05
Rh	45		1.00E-02		1.00E-02
Rn	86		1.00E-20		1.00E-20
Ru	44	1.0E-06	3.30E-06	9.40E-06	9.40E-06
S	16	1.8E-02	1.60E-02	7.90E-03	7.90E-03
Sb	51	1.5E-03	2.50E-05	3.80E-05	3.80E-05
Sc	21		5.00E-06		5.00E-06
Se	34	4.5E-02	4.00E-03	4.00E-03	4.00E-03
Si	14	2.0E-05	2.00E-05		2.00E-05
Sm	62	5.0E-06	3.00E-05		3.00E-05
Sn	50	2.5E-03	1.00E-03		1.00E-03
Sr	38	8.0E-04	2.80E-03	1.30E-03	1.30E-03
Ta	73	3.0E-06	4.10E-07		4.10E-07
Tb	65		3.00E-05		3.00E-05
Tc	43	2.5E-02	1.87E-03		1.87E-03
Te	52	1.0E-03	4.50E-04	3.40E-04	3.40E-04
Th	90	5.0E-06	5.00E-06		5.00E-06
Ti	22	5.5E-07	7.53E-05		7.53E-05
Tl	81		2.00E-03		2.00E-03
Tm	69		2.06E-05		2.06E-05
U	92	5.0E-04	4.00E-04	1.80E-03	1.80E-03
V	23	2.0E-05	2.06E-05		2.06E-05
W	74		3.00E-04	1.90E-04	1.90E-04
Y	39	1.0E-05	2.00E-05		2.00E-05
Yb	70		2.06E-05		2.06E-05
Zn	30	3.9E-02	1.00E-02	2.70E-03	2.70E-03
Zr	40	5.0E-06	5.50E-07	3.60E-06	3.60E-06

Table 4. Feed-to-Meat Transfer Factors (d/kg)

Element	Z	Prior to 2010 Value	2008 Value	2010 Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	Jannik et al.
Ac	89	2.0E-05	4.00E-04		4.00E-04
Ag	47	1.7E-02	3.00E-03		3.00E-03
Al	13	5.0E-04	1.50E-03		1.50E-03
Am	95	2.0E-04	4.00E-05	5.00E-04	5.00E-04
As	33		2.00E-03		2.00E-03
At	85		1.00E-02		1.00E-02
Au	79		5.00E-03		5.00E-03
B	5		8.00E-04		8.00E-04
Ba	56	3.2E-03	2.00E-04	1.40E-04	1.40E-04
Be	4	1.0E-03	1.00E-03		1.00E-03
Bi	83	2.0E-03	4.00E-04		4.00E-04
Bk	97	2.0E-05	2.50E-05		2.50E-05
Br	35		2.50E-02		2.50E-02
C	6	3.1E-02	3.10E-02		3.10E-02
Ca	20	1.6E-03	2.00E-03	1.30E-02	1.30E-02
Cd	48	5.3E-04	4.00E-04	5.80E-03	5.80E-03
Ce	58	1.2E-03	2.00E-05		2.00E-05
Cf	98	6.0E-05	4.00E-05		4.00E-05
Cl	17	6.0E-02	2.00E-02	1.70E-02	1.70E-02
Cm	96	2.0E-04	4.00E-05		4.00E-05
Co	27	1.3E-02	1.00E-02	4.30E-04	4.30E-04
Cr	24	2.4E-03	9.00E-03		9.00E-03
Cs	55	4.0E-03	5.00E-02	2.20E-02	2.20E-02
Cu	29	8.0E-03	9.00E-03		9.00E-03
Dy	66		2.00E-05		2.00E-05
Er	68		2.00E-05		2.00E-05
Es	99	2.0E-05	2.50E-05		2.50E-05
Eu	63	4.8E-03	2.00E-05		2.00E-05
F	9		1.50E-01		1.50E-01
Fe	26	4.0E-02	2.00E-02	1.40E-02	1.40E-02
Fm	100		2.00E-04		2.00E-04
Fr	87		2.50E-03		2.50E-03
Ga	31		5.00E-04		5.00E-04
Gd	64	2.0E-03	2.00E-05		2.00E-05
Ge	32	7.0E-01	7.00E-01		7.00E-01
H	1	not used	0.00E+00		0.00E+00
Ha	105		5.00E-06		5.00E-06
Hf	72	1.0E-06	3.16E-05		3.16E-05
Hg	80	1.0E-01	2.50E-01		2.50E-01
Ho	67	4.5E-03	3.00E-04		3.00E-04
I	53	2.9E-03	4.00E-02	6.70E-03	6.70E-03
In	49	4.0E-03	8.00E-03		8.00E-03
Ir	77	2.0E-03	1.50E-03		1.50E-03
K	19	2.0E-02	2.00E-02		2.00E-02
La	57	2.0E-04	2.00E-03	1.30E-04	1.30E-04
Li	3	4.5E-03	1.00E-02		1.00E-02
Lr	103		2.00E-04		2.00E-04
Lu	71		4.50E-03		4.50E-03
Mg	12		2.00E-02		2.00E-02
Mn	25	8.0E-04	5.00E-04	6.00E-04	6.00E-04

Table 4. Feed-to-Meat Transfer Factors *(continued)*

Element	Z	Prior to 2010 Value	2008 Value	2010 Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	Jannik et al.
Mo	42	8.0E-03	1.00E-03	1.00E-03	1.00E-03
N	7		7.50E-02		7.50E-02
Na	11	3.0E-02	8.00E-02	1.50E-02	1.50E-02
Nb	41	2.8E-01	2.90E-04	2.60E-07	2.60E-07
Nd	60		2.00E-05		2.00E-05
Ni	28	5.3E-03	5.00E-03		5.00E-03
No	102		2.00E-04		2.00E-04
Np	93	2.0E-04	1.00E-03		1.00E-03
Os	76		4.00E-01		4.00E-01
P	15	4.6E-02	5.00E-02	5.50E-02	5.50E-02
Pa	91	5.0E-03	4.47E-04		4.47E-04
Pb	82	8.0E-04	4.00E-04	7.00E-04	7.00E-04
Pd	46	1.0E-03	4.00E-03		4.00E-03
Pm	61	4.8E-03	2.00E-05		2.00E-05
Po	84	5.0E-03	5.00E-03		5.00E-03
Pr	59		2.00E-05		2.00E-05
Pt	78	4.0E-03	4.00E-03		4.00E-03
Pu	94	1.4E-05	1.00E-05	1.10E-06	1.10E-06
Ra	88	1.0E-03	9.00E-04	1.70E-03	1.70E-03
Rb	37	3.1E-02	1.00E-02		1.00E-02
Re	75	1.0E-04	8.00E-03		8.00E-03
Rh	45		2.00E-03		2.00E-03
Rn	86		1.00E-20		1.00E-20
Ru	44	4.0E-01	5.00E-02	3.30E-03	3.30E-03
S	16	1.0E-01	2.00E-01		2.00E-01
Sb	51	4.0E-03	1.00E-03	1.20E-03	1.20E-03
Sc	21		1.50E-02		1.50E-02
Se	34	1.5E-02	1.50E-02		1.50E-02
Si	14	4.0E-05	4.00E-05		4.00E-05
Sm	62	5.0E-03	3.16E-04		3.16E-04
Sn	50	8.0E-02	8.00E-02		8.00E-02
Sr	38	6.0E-04	8.00E-03	1.30E-03	1.30E-03
Ta	73	6.0E-04	1.34E-05		1.34E-05
Tb	65		2.00E-05		2.00E-05
Tc	43	4.0E-01	6.32E-03		6.32E-03
Te	52	7.7E-02	7.00E-03	7.00E-03	7.00E-03
Th	90	2.0E-04	4.00E-05	2.30E-04	2.30E-04
Ti	22	1.0E-06	1.73E-04		1.73E-04
Tl	81		4.00E-02		4.00E-02
Tm	69		4.50E-03		4.50E-03
U	92	3.4E-04	3.00E-04	3.90E-04	3.90E-04
V	23	2.5E-03	2.50E-03		2.50E-03
W	74		4.00E-02		4.00E-02
Y	39	4.6E-03	1.00E-03		1.00E-03
Yb	70		4.00E-03		4.00E-03
Zn	30	3.0E-02	1.00E-01	1.60E-01	1.60E-01
Zr	40	3.4E-02	1.84E-04	1.20E-06	1.20E-06

Table 5. Water-to-Fish Bioaccumulation Factors (L/kg)

Element	Z	Prior to 2010 Value SRS	2008 Value Lee and Coffield	2010 Value IAEA #472	2010/2016 Values Jannik et al.
Ac	89	2.5E+01	2.50E+01		2.50E+01
Ag	47	2.3E+00	5.00E+00	1.10E+02	1.10E+02
Al	13	1.0E+01	5.00E+02	5.10E+01	5.10E+01
Am	95	2.5E+01	3.00E+01	2.40E+02	2.40E+02
As	33		1.70E+03	3.30E+02	3.30E+02
At	85	1.5E+01	1.50E+01		1.50E+01
Au	79	3.5E+01	3.30E+01	2.40E+02	2.40E+02
Ba	56		4.00E+00	1.20E+00	1.20E+00
Be	4	2.0E+00	1.00E+02		1.00E+02
Bi	83	1.5E+01	1.50E+01		1.50E+01
Bk	97	2.5E+01	2.50E+01		2.50E+01
Br	35		4.00E+02	9.10E+01	9.10E+01
C	6	4.6E+03	5.00E+04	4.00E+05	3.00E+00
Ca	20	4.0E+01	4.00E+01	1.20E+01	1.20E+01
Cd	48	2.0E+02	2.00E+02		2.00E+02
Ce	58		3.00E+01	2.50E+01	2.50E+01
Cf	98	2.5E+01	2.50E+01		2.50E+01
Cl	17	5.0E+01	5.00E+01	4.70E+01	4.70E+01
Cm	96	2.5E+01	3.00E+01		3.00E+01
Co	27	5.0E+01	3.00E+02	7.60E+01	7.60E+01
Cr	24		4.00E+00	4.00E+01	4.00E+01
Cs	55	3.0E+03	3.00E+03	2.50E+03	3.00E+03
Cu	29		2.00E+02	2.30E+02	2.30E+02
Dy	66		3.00E+01	6.50E+02	6.50E+02
Er	68		3.00E+01		3.00E+01
Es	99	1.0E+01	2.50E+01		2.50E+01
Eu	63		3.00E+01	1.30E+02	1.30E+02
F	9		1.00E+01		1.00E+01
Fe	26	1.0E+02	2.00E+02	1.70E+02	1.70E+02
Fr	87	3.0E+01	3.00E+01		3.00E+01
Ga	31	3.3E+02	4.00E+02		4.00E+02
Gd	64	2.5E+01	3.00E+01		3.00E+01
Ge	32	3.3E+03	4.00E+03		4.00E+03
He	2		1.00E+00		1.00E+00
H	1	9.0E-01	1.00E+00		1.00E+00
Hf	72	3.3E+00	3.00E+02	1.10E+03	1.10E+03
Hg	80	1.0E+03	1.00E+03	6.10E+03	6.10E+03
Ho	67	2.5E+01	3.00E+01		3.00E+01
I	53	1.5E+01	4.00E+01	3.00E+01	3.00E+01
In	49	1.0E+04	1.00E+04		1.00E+04
Ir	77	1.0E+01	1.00E+01		1.00E+01
K	19	1.0E+03	1.00E+03	3.20E+03	3.20E+03
La	57	2.5E+01	3.00E+01	3.70E+01	3.70E+01
Lu	71	2.5E+01	2.50E+01		2.50E+01
Mg	12		5.00E+01	3.70E+01	3.70E+01
Mn	25	1.0E+02	4.00E+02	2.40E+02	2.40E+02
Mo	42	1.0E+01	1.00E+01	1.90E+00	1.90E+00
N	7		2.00E+05		2.00E+05
Na	11		2.00E+01	7.60E+01	7.60E+01

Table 5. Water-to-Fish Bioaccumulation Factors (L/kg) *(continued)*

Element	Z	Prior to 2010 Value	2008 Value	2010 Value	2010/2016 Values
		SRS	Lee and Coffield	IAEA #472	Jannik et al.
Nb	41	3.0E+04	3.00E+02		3.00E+02
Nd	60		3.00E+01		3.00E+01
Ni	28	1.0E+02	1.00E+02	2.10E+01	2.10E+01
Np	93	1.0E+02	2.10E+01		2.10E+01
O	8		1.00E+00		1.00E+00
Os	76	1.0E+05	1.00E+03		1.00E+03
P	15		5.00E+04	1.40E+05	1.40E+05
Pa	91	1.1E+01	1.00E+01		1.00E+01
Pb	82	3.0E+02	3.00E+02	2.50E+01	2.50E+01
Pd	46	1.0E+01	1.00E+01		1.00E+01
Pm	61		3.00E+01		3.00E+01
Po	84	5.0E+02	5.00E+01	3.60E+01	3.60E+01
Pr	59		3.00E+01		3.00E+01
Pt	78	1.0E+02	3.50E+01		3.50E+01
Pu	94	3.5E+00	3.00E+01	2.1E+04*	3.00E+01
Ra	88	5.0E+01	5.00E+01	4.00E+00	4.00E+00
Rb	37	2.0E+03	2.00E+03	4.90E+03	4.90E+03
Re	75	1.2E+02	1.20E+02		1.20E+02
Rh	45		1.00E+01		1.00E+01
Rn	86	5.7E+01	7.55E-10		7.55E-10
Ru	44	1.0E+01	1.00E+02	5.50E+01	5.50E+01
S	16		8.00E+02		8.00E+02
Sb	51	1.0E+00	1.00E+02	3.70E+01	3.70E+01
Sc	21	1.0E+02	1.00E+02	1.90E+02	1.90E+02
Se	34	1.7E+02	1.70E+02	6.00E+03	6.00E+03
Si	14	2.5E+00	2.00E+01		2.00E+01
Sm	62	2.5E+01	3.00E+01		3.00E+01
Sn	50	3.0E+03	3.00E+03		3.00E+03
Sr	38	3.0E+01	6.00E+01	2.90E+00	2.90E+00
Ta	73	3.0E+04	3.00E+02		3.00E+02
Tb	65		3.00E+01	4.10E+02	4.10E+02
Tc	43	1.5E+01	2.00E+01		2.00E+01
Te	52	4.0E+02	4.00E+02	1.50E+02	1.50E+02
Th	90	3.0E+01	1.00E+02	6.00E+00	6.00E+00
Ti	22	1.0E+03	1.00E+03	1.90E+02	1.90E+02
Tl	81	1.0E+04	1.00E+04	9.00E+02	9.00E+02
U	92	2.0E+00	1.00E+01	9.60E-01	9.60E-01
V	23	1.0E+01	2.00E+02	9.70E+01	9.70E+01
W	74		1.00E+01		1.00E+01
Y	39	2.5E+01	3.00E+01	4.00E+01	4.00E+01
Zn	30		3.50E+02	3.40E+03	3.40E+03
Zr	40	3.3E+00	3.00E+02	2.20E+01	2.20E+01

*At this time, the plutonium value of 21,000 L/kg is considered suspect.

Table 6. Water to Saltwater Invertebrates Bioaccumulation Factors (L/kg)

Element	Z	Prior to 2010 Value	2008 Value	2003 Value	2010/2016 Values
		SRS	Lee and Coffield	PNNL 13421	Jannik et al.
Ac	89	1.00E+03	N/A	1.00E+03	1.00E+03
Ag	47	3.33E+03	N/A	3.50E+02	3.50E+02
Al	13	6.00E+01	N/A		6.00E+01
Am	95	1.00E+03	N/A	3.60E+02	3.60E+02
As	33		N/A	3.00E+02	3.00E+02
Ba	56	1.00E+02	N/A	1.00E+00	1.00E+00
Be	4	2.00E+02	N/A	1.00E+04	1.00E+04
Bi	83	1.00E+01	N/A	1.00E+03	1.00E+03
Bk	97	1.00E+03	N/A		1.00E+03
Br	35		N/A	1.00E+01	1.00E+01
C	6	1.40E+03	N/A	2.00E+04	2.00E+04
Ca	20	1.25E+01	N/A	5.00E+00	5.00E+00
Cd	48	2.50E+05	N/A	5.00E+03	5.00E+03
Ce	58	6.00E+02	N/A	5.00E+02	5.00E+02
Cf	98	1.00E+03	N/A	5.00E+02	5.00E+02
Cl	17	1.90E-02	N/A	1.00E+00	1.00E+00
Cm	96	1.00E+03	N/A	4.60E+02	4.60E+02
Co	27	1.00E+03	N/A	2.00E+03	2.00E+03
Cr	24	2.00E+03	N/A	5.00E+02	5.00E+02
Cs	55	2.50E+01	N/A	3.00E+01	3.00E+01
Cu	29	1.70E+03	N/A	5.00E+03	5.00E+03
Dy	66		N/A	1.00E+03	1.00E+03
Er	68		N/A	5.00E+02	5.00E+02
Es	99	1.00E+01	N/A	7.00E+03	7.00E+03
Eu	63	1.00E+03	N/A	1.00E+03	1.00E+03
F	9		N/A	4.00E+00	4.00E+00
Fe	26	2.00E+04	N/A	5.00E+03	5.00E+03
Fr	87		N/A		3.00E+01
Ga	31		N/A	1.00E+04	1.00E+04
Gd	64	1.00E+03	N/A	2.00E+03	2.00E+03
Ge	32	1.57E+04	N/A		4.00E+03
He	2		N/A	1.00E+00	1.00E+00
H	1	9.30E-01	N/A		9.30E-01
Hf	72	2.00E+01	N/A	1.00E+03	1.00E+03
Hg	80	3.33E+04	N/A	2.00E+04	2.00E+04
Ho	67	1.00E+03	N/A	1.00E+03	1.00E+03
I	53	5.00E+01	N/A	5.00E+01	5.00E+01
In	49		N/A	1.00E+04	1.00E+04
Ir	77	2.00E+03	N/A	1.00E+02	1.00E+02
K	19	6.58E+00	N/A		6.58E+00
La	57	1.00E+03	N/A	1.00E+02	1.00E+02
Lu	71	1.00E+03	N/A		1.00E+03
Mn	25	1.00E+04	N/A	8.00E+02	8.00E+02
Mo	42	1.00E+01	N/A	2.00E+01	2.00E+01
N	7		N/A	1.00E+00	1.00E+00
Na	11	1.90E-01	N/A	1.00E+00	1.00E+00
Nb	41	1.00E+02	N/A	5.00E+01	5.00E+01
Ni	28	2.50E+02	N/A	5.00E+02	5.00E+02
Np	93	1.00E+01	N/A	1.00E+01	1.00E+01

Table 6. Water to Saltwater Invertebrates Bioaccumulation Factors (L/kg) ***(continued)***

Element	Z	Prior to 2010 Value	2008 Value	2003 Value	2010/2016 Values
		SRS	Lee and Coffield	PNNL 13421	Jannik et al.
P	15	3.00E+04	N/A	3.80E+04	3.80E+04
Pa	91	1.00E+01	N/A	1.00E+01	1.00E+01
Pb	82	1.00E+03	N/A	1.00E+03	1.00E+03
Pd	46	2.00E+03	N/A	3.00E+02	3.00E+02
Pm	61	1.00E+03	N/A	1.00E+03	1.00E+03
Po	84	2.00E+04	N/A	5.00E+04	5.00E+04
Pr	59		N/A	1.00E+03	1.00E+03
Pt	78	2.00E+03	N/A		2.00E+03
Pu	94	1.00E+02	N/A	3.00E+02	3.00E+02
Ra	88	1.00E+02	N/A	1.00E+02	1.00E+02
Rb	37	1.70E+01	N/A	2.00E+02	2.00E+02
Re	75	5.95E+01	N/A		5.95E+01
Rh	45		N/A	1.00E+02	1.00E+02
Rn	86		N/A		
Ru	44	1.00E+03	N/A	1.00E+02	1.00E+02
S	16	4.40E-01	N/A	1.00E+00	1.00E+00
Sb	51	5.00E+00	N/A	1.00E+02	1.00E+02
Sc	21		N/A	3.00E+02	3.00E+02
Se	34	1.00E+03	N/A	5.00E+03	5.00E+03
Si	14	3.33E+01	N/A	5.00E+04	5.00E+04
Sm	62	1.00E+03	N/A	1.00E+03	1.00E+03
Sn	50	1.00E+03	N/A	5.00E+04	5.00E+04
Sr	38	2.00E+01	N/A	1.00E+00	1.00E+00
Ta	73	1.67E+04	N/A	3.00E+03	3.00E+03
Tb	65		N/A	1.00E+03	1.00E+03
Tc	43	5.00E+01	N/A	1.00E+01	1.00E+01
Te	52	1.00E+05	N/A	1.00E+03	1.00E+03
Th	90	2.00E+03	N/A	1.00E+03	1.00E+03
Ti	22	1.00E+03	N/A		1.00E+03
Tl	81		N/A	1.00E+03	1.00E+03
U	92	1.00E+01	N/A	1.00E+01	1.00E+01
V	23	5.00E+01	N/A		5.00E+01
W	74		N/A	1.00E+01	1.00E+01
Y	39	1.00E+03	N/A	1.00E+03	1.00E+03
Zn	30	5.00E+04	N/A	5.00E+04	5.00E+04
Zr	40	8.00E+01	N/A	5.00E+01	5.00E+01

Table 7. 2010/2016 Vegetable Production as a Function of Distance and Sector

Based on 2012 Weighted Vegetable Production Grid surrounding SRS increased 10 times for unreported (home use) production (Kg/yr)

Sector	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi	Total
N	3.2E+05	7.0E+05	1.0E+06	5.5E+05	2.6E+06
NNE	2.9E+05	4.9E+05	1.4E+05	9.6E+04	1.0E+06
NE	2.9E+05	4.1E+05	6.9E+05	2.2E+05	1.6E+06
ENE	2.7E+04	4.4E+04	8.0E+04	3.5E+05	5.0E+05
E	1.9E+05	1.3E+05	2.3E+05	8.0E+05	1.3E+06
ESE	2.6E+04	4.4E+04	4.2E+05	1.3E+06	1.8E+06
SE	2.8E+04	4.5E+04	1.2E+05	1.5E+05	3.3E+05
SSE	2.8E+04	3.8E+04	7.7E+04	6.2E+04	2.1E+05
S	1.4E+04	8.0E+03	1.1E+04	1.5E+04	4.8E+04
SSW	9.4E+04	9.8E+04	1.8E+05	2.5E+05	6.1E+05
SW	4.6E+04	6.2E+04	9.8E+04	1.8E+05	3.9E+05
WSW	7.8E+03	1.2E+04	1.8E+04	2.2E+04	5.9E+04
W	8.3E+03	1.2E+04	1.9E+04	1.5E+04	5.5E+04
WNW	9.1E+03	8.9E+03	2.1E+04	3.5E+04	7.4E+04
NW	2.2E+04	6.7E+03	6.2E+03	4.2E+03	3.9E+04
NNW	8.2E+03	1.2E+04	1.8E+04	5.0E+04	8.8E+04
Total	**1.4E+06**	**2.1E+06**	**3.2E+06**	**4.1E+06**	**1.1E+07**

Table 8. 2010/2016 Beef Production as a Function of Distance and Sector

Based on 2012 Weighted Beef Production Grid surrounding SRS increased 25% for unreported (home use) production (Kg/yr)

Sector	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi	Total
N	4.5E+04	9.5E+04	1.6E+05	2.0E+05	4.9E+05
NNE	4.1E+04	9.1E+04	1.7E+05	2.1E+05	5.0E+05
NE	4.2E+04	7.6E+04	1.1E+05	5.7E+04	2.8E+05
ENE	3.0E+04	5.0E+04	8.4E+04	4.0E+05	5.7E+05
E	3.5E+04	7.9E+04	1.2E+05	1.1E+05	3.5E+05
ESE	2.9E+04	5.0E+04	6.9E+04	8.5E+04	2.3E+05
SE	3.1E+04	5.0E+04	8.0E+04	1.7E+05	3.4E+05
SSE	3.2E+04	5.2E+04	6.5E+04	8.1E+04	2.3E+05
S	8.8E+04	8.8E+04	1.2E+05	1.5E+05	4.5E+05
SSW	3.6E+04	6.1E+04	3.5E+04	1.9E+04	1.5E+05
SW	4.4E+04	7.1E+04	8.6E+04	5.3E+04	2.5E+05
WSW	1.1E+05	1.1E+05	9.9E+04	1.2E+05	4.4E+05
W	1.1E+05	1.7E+05	1.6E+05	2.0E+05	6.5E+05
WNW	6.1E+04	1.1E+05	2.5E+05	4.6E+05	8.8E+05
NW	3.2E+04	5.3E+04	4.7E+04	1.2E+05	2.6E+05
NNW	1.2E+05	1.8E+05	2.6E+05	5.7E+05	1.1E+06
Total	**8.8E+05**	**1.4E+06**	**1.9E+06**	**3.0E+06**	**7.2E+06**

Table 9. 2010/2016 Milk Production as a Function of Distance and Sector

Based on 2012 Weighted Milk Production Grid surrounding SRS Increased 25% for unreported (home use) production (L/yr)

Sector	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi	Total
N	6.6E+03	2.8E+06	6.0E+06	5.6E+06	1.4E+07
NNE	6.0E+03	1.8E+06	4.0E+06	4.7E+06	1.1E+07
NE	6.0E+03	1.1E+06	3.4E+06	8.4E+05	5.4E+06
ENE	7.0E+03	1.2E+04	1.9E+05	2.7E+06	2.9E+06
E	5.9E+03	1.0E+06	2.2E+06	1.4E+06	4.6E+06
ESE	6.7E+03	1.2E+04	6.8E+04	2.0E+05	2.8E+05
SE	7.2E+03	1.8E+04	4.0E+05	1.1E+06	1.5E+06
SSE	7.3E+03	3.7E+04	3.4E+05	2.8E+05	6.7E+05
S	3.1E+06	8.8E+05	1.1E+06	1.2E+06	6.3E+06
SSW	9.5E+02	0.0E+00	1.3E+04	2.4E+04	3.8E+04
SW	3.5E+05	3.1E+05	4.4E+05	3.4E+05	1.4E+06
WSW	4.2E+06	3.2E+06	1.2E+06	1.1E+06	9.7E+06
W	4.4E+06	6.7E+06	5.1E+06	4.7E+06	2.1E+07
WNW	1.6E+06	2.9E+06	5.7E+06	7.1E+06	1.7E+07
NW	5.4E+03	3.6E+01	1.7E+05	2.1E+06	2.3E+06
NNW	4.6E+06	7.2E+06	1.0E+07	9.4E+06	3.1E+07
Total	**1.8E+07**	**2.8E+07**	**4.0E+07**	**4.3E+07**	**1.3E+08**

Table 10. SRS Typical Person (*previously Average Individual*) Behavioral Parameters for Dose Calculations

Parameter	Units	1977	1991	2008	2010	2016	% Difference 2010 Jannik/ 2016 Jannik
		NRC Default	Hamby	Lee and Coffield	Jannik et al.	Jannik et al.	
Average Individual and Population Usage							
Inhalation Rate	m^3/yr	8,000	8,000	5,548	5,548	5,000	-9.88%
Drinking Water consumption rate	L/yr	370	370	337	337	300	-10.88%
Leafy Vegetable consumption rate	kg/yr	64	21	21	21	11	-47.62%
Other Produce consumption rate	kg/yr	190	163	163	163	89	-45.40%
Meat consumption rate	kg/yr	95	43	43	43	32	-25.58%
Milk consumption rate	L/yr	110	120	120	120	69	-42.50%
Fish consumption rate	kg/yr	6.9	9	9	9	3.7	-58.89%
Invertebrate consumption rate	kg/yr	1	2	N/A	2	1.5	-25.00%
Soil consumption rate	kg/yr	-	-	0.0365	0.0365	0.0365	0%
Shoreline Exposure Time	hr/yr	8.3	23.0	23.0	10.0	10.0	0%
Swimming Exposure Time	hr/yr	-	8.9	8.9	7.0	7.0	0%
Boating Exposure Time	hr/yr	-	21.0	21.0	22.0	22.0	0%
Population Shoreline Exposure Time	per.-hr	-	9.60E+05	N/A	8.22E+05	8.22E+05	0%
Population Swimming Exposure Time	per.-hr	-	1.60E+05	N/A	2.95E+05	2.95E+05	0%
Population Boating Exposure Time	per.-hr	-	1.10E+06	N/A	3.11E+06	3.11E+06	0%
Fraction of year working in garden	-	-	-	0.01	0.01	0.01	0%
Fraction of year residing in home	-	-	-	0.7	0.7	0.7	0%
Time taking a shower	min/d	-	-	10	10	10	0%
Population served - BJWSA (Chelsea)	persons	-	5.00E+04	N/A	7.70E+04	8.29E+04	7.01%
Population served - BJWSA (Purrysburg)	persons	-	N/A	N/A	5.80E+04	6.42E+04	10.69%
Population served - Savannah I&D	persons	-	1.50E+04	N/A	2.63E+04	3.50E+04	33.08%

Table 11. SRS Reference Person (*previously Maximally Exposed Individual*) Behavioral Parameters for Dose Calculations

Parameter	Units	1977 NRC Default	1991 Hamby	2008 Lee and Coffield	2010 Jannik et al.	2016 Jannik et al.	% Difference 2010 Jannik/ 2016 Jannik
Maximally Exposed Individual Usage							
Inhalation Rate	m^3/yr	8,000	8,000	N/A	8,000	6,400	-20.00%
Drinking Water consumption rate	L/yr	730	730	N/A	730	800	9.59%
Leafy Vegetable consumption rate	kg/yr	64	43	N/A	43	31	-27.91
Other Produce consumption rate	kg/yr	520	276	N/A	276	289	4.71%
Meat consumption rate	kg/yr	110	81	N/A	81	81	0.00%
Milk consumption rate	L/yr	310	230	N/A	230	260	13.04%
Fish consumption rate	kg/yr	21	19	N/A	19	24	26.32%
Invertebrate consumption rate	kg/yr	5	8	N/A	8	9	12.50%
Soil consumption rate	kg/yr	-	-	N/A	0.0365	0.0365	0.00%
Shoreline Exposure Time	hr/yr	12	23.0	N/A	20.0	20	0.00%
Swimming Exposure Time	hr/yr	-	8.9	N/A	14.0	14	0.00%
Boating Exposure Time	hr/yr	-	21.0	N/A	44.0	44	0.00%

Table 12. Average Recreational Usage Rates

Survey Activity	2005 Percentage Participating	2005 Average Annual Frequency	1991 Survey Hours per Occasion	2010/2016 per Capita Usage (hr/yr)
Shoreline Usage				
Fresh water fishing	38%	5.0	5	9.50
				10
Swimming Usage				
Lake/River Swimming	28%	4.0	3	3.36
Jet and Water Skiing	28%	4.0	3	3.36
				7
Boating Usage				
Canoeing, kayaking, rafting	11%	1.0	3	0.33
Boating/Sailing	55%	8.0	5	22.00
				22

SC 2005 Recreational Participation & Preference Study
http://www.scprt.com/our-partners/tourismstatistics/researchreports.aspx

Table 13. Weighted Usage Fractions

Activity	State Usage Available Fraction	2000 Population Fraction*	Weighted Usage Fraction	Population Usage (person-hr/yr)
Shoreline				
SC, surf/bank fishing	0.041	0.6	0.0246	
GA, warmwater fishing	0.085	0.4	0.034	
			0.059	**8.22E+05**
Swimming				
SC, beach areas	0.032	0.6	0.0192	
GA, lake swimming	0.027	0.4	0.0108	
			0.030	**2.95E+05**
Boating				
SC, boat use average**	0.13	0.6	0.078	
GA, boating/sailing	0.057	0.4	0.0228	
			0.101	**3.11E+06**

* Assumes 60% of population lives in SC and 40% of population lives in Georgia.
Based on Projected Census Data for Counties
** Average of "other fishing" and "boat ramps" fractions

	Base Census 2000	Projected Census 2010
50 mile Counties SC Population	739,715	832,000
50 mile Counties GA Population	507,226	571,000
Total	**1,246,941**	**1,403,000**

Figure 1. Vegetable Production by County

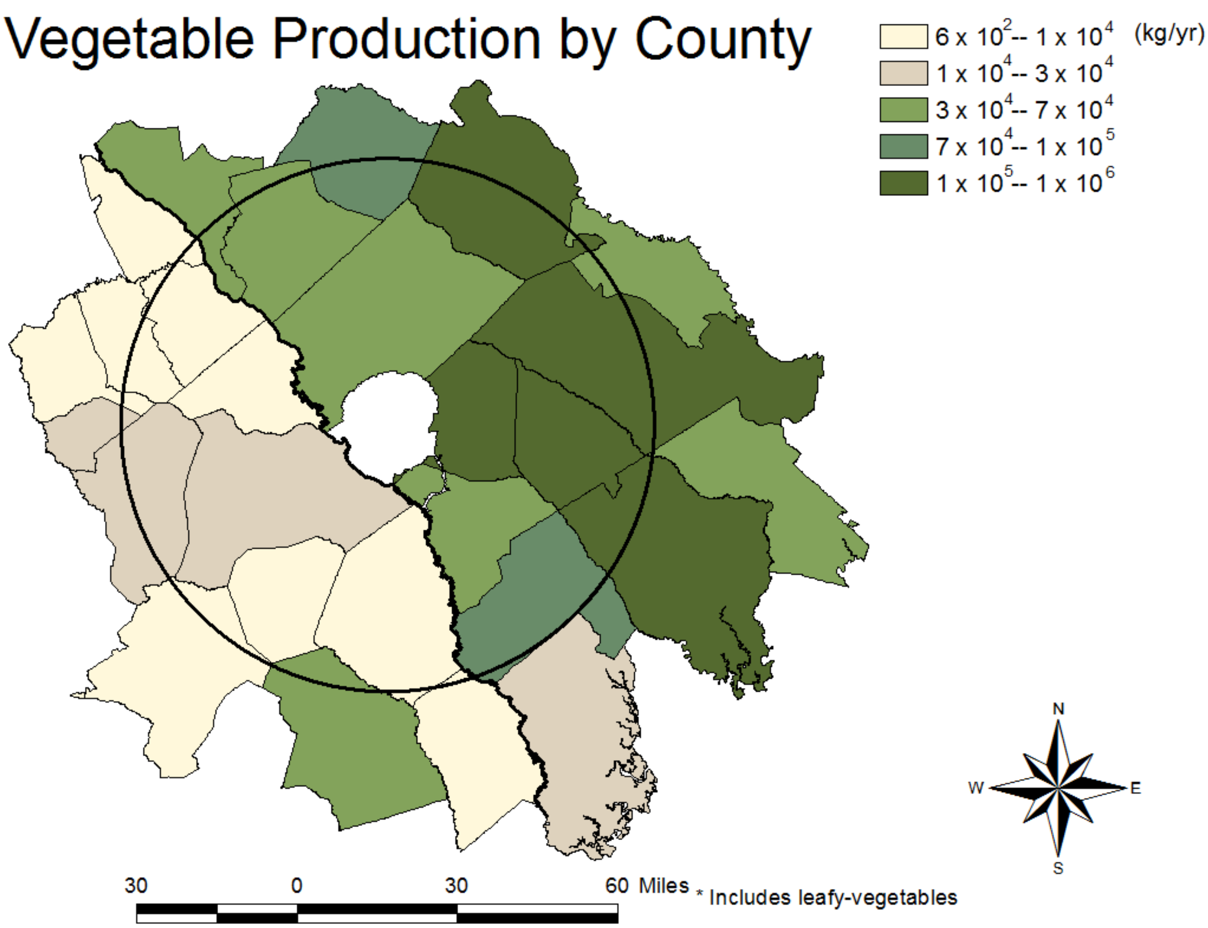

Figure 2. Beef Production by County

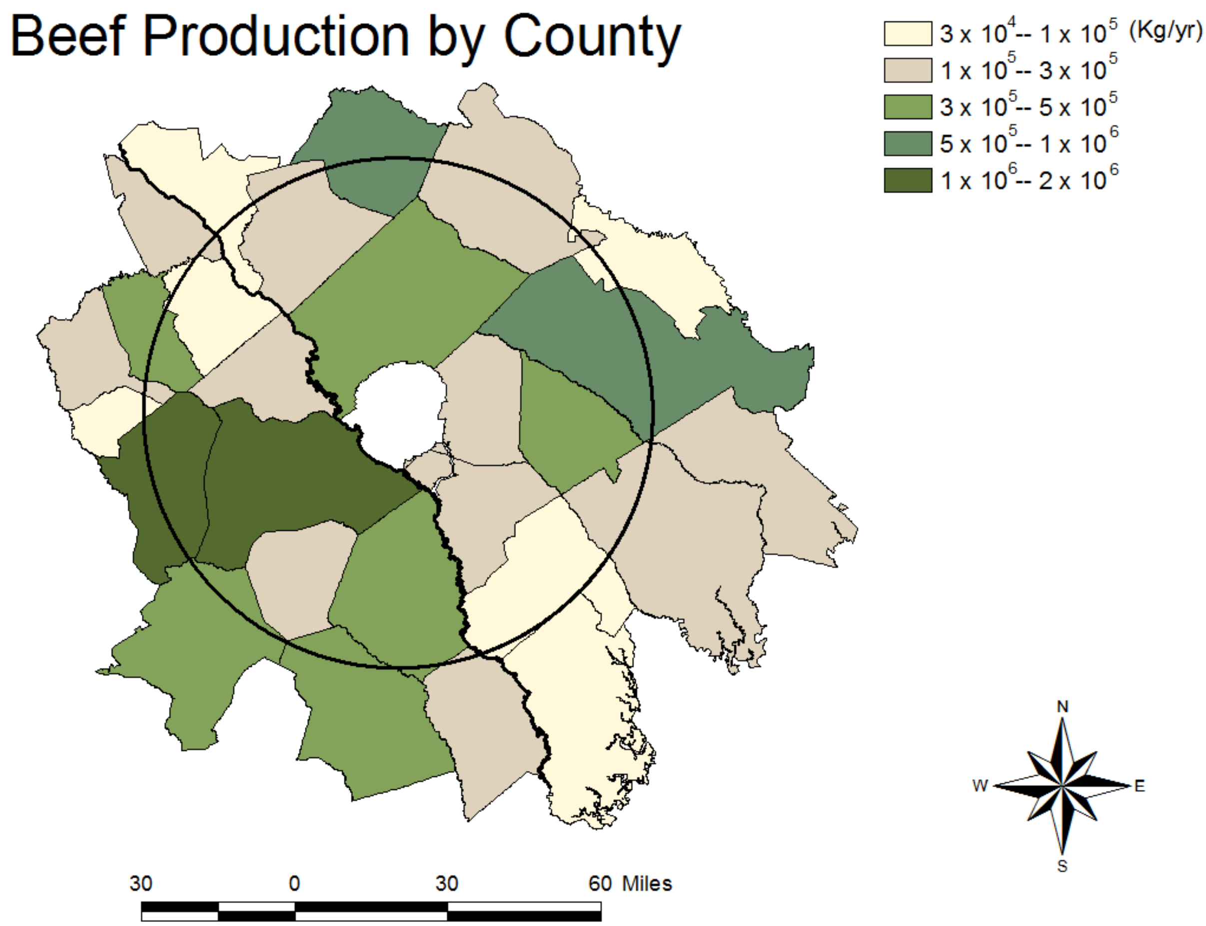

Figure 3. Milk Production by County