Evaluating Food Consumption Associated with Fishing and Hunting by Native Americans for Risk Assessments:

A Research Report Supporting the 2016 EPA Document on Biota Modeling for Superfund Risk Assessment

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INTRODUCTION

In 2016, the Environmental Protection Agency (EPA) and Oak Ridge National Laboratory (ORNL) created a hierarchal selection process of biota modeling in the Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) Calculators. This report, "Biota Modeling in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators for Use in EPA Superfund Risk Assessment: Explanation of Intake Rate Derivation, Transfer Factor Compilation, and Mass Loading Factor Sources," significantly improves the accuracy of risk assessment modeling for the consumption of produce and animal products sourced from contaminated land and/or land irrigated with contaminated water. The key updated elements of the process are intake rates, transfer factors, and mass loading factors.

The Manning et al. (2016) document specifies 10 animal products. This report aims to supplement that 2016 report by incorporating animal products that have been found in Native American diets, specifically from hunting and fishing activities. These new food items are based on various food consumption surveys and reports (later listed). While these sources do not represent all Native Americans, these additions aim to create more comprehensive and inclusive risk assessment models.

TRANSFER FACTOR SOURCE COMILATION AND METHODS

Soil to tissue transfer factors (TF) are used in the PRG and DCC calculators to model radionuclide transfer to animal products before human consumption. Key components for TFs are animal intake rates of food, water, and soil. Manning et al. (2016) provides these values for farm animals in her report. However, as the new animal products in this report are wild animals, there is less consistency and measurability than for farm animals. The EPA Wildlife Exposure Factors Handbook provides some of these intake rates and are presented in Appendix C. For fish species in particular, there are few studies that measure intake rates due the wide variability in nature.

Table B-1 in Appendix B outlines the TF sources and hierarchy for each of the animal products. The TV source hierarchy is as follows:

1. IAEA
2. EA
3. NCRP-123
4. RADSSL
5. RESRAD
6. Baes paper

Some of the TFs listed in the hierarchy are already represented within the existing DCC and PRG calculator framework. Table B-1 classifies the new produce types within the existing groups. These groups were categorized using IAEA TRS-472 food groups.

INGESTION RATES

Ingestion rates are based on data from reports by the following:

1. Environment International Ltd. for the Confederated Tribes of the Colville Reservation (2012)
2. Harper and Ranco (2009) in conjunction with five federally recognized Tribal Nations in Maine for the EPA
3. New York State Energy and Development Administration (NYSERDA) (2015)
4. CB&I Federal Services LLC (2017) for the EPA.
5. Harper (2002) in conjunction with the Spokane Tribal Cultural Resources Program
6. Harper (2005) for the Washoe Tribe of Nevada and California
7. Polissar et al. (2016) for the EPA and Nez Perce Tribe
8. Polissar et al. (2016) for the EPA and Shoshone-Bannock Tribes
9. Harper (2008) for the Quapaw Tribe in Oklahoma
10. Integral Consulting Inc. (2007) for International Paper at a St. Regis Paper company site

Ingestion rates from each report are provided by Appendix C. The formatting and data differ for each table due to the varying information provide by each source. Again, the ingestion rates are not representative of all Native Americans but will provide greater insight into potential risks associated with produce consumption absent more tribal or site-specific data.

Harper and Ranco (2009) break down ingestion rates into 'Inland-Anadromous", "Inland Non-Anadromous", and "Coastal". However, the ingestion rates of produce are the same for all three. As a result, only one table is used here that represents each of the three areas in the original source.

In the NYSERDA (2015) report, Table C-3 presents the average of 6 different areas within the nation. For deer consumption, the original data was in pounds year for two people. For turkey consumption, the original data was in pounds per year for one person. To make it more consistent with other data, it is converted to grams per day.

As for the Polissar et al. (2016) reports, two methods were presented for selecting intake rates of various fish species: food frequency questionnaires and 45-hour recall responses. For this report, the food frequency questionnaire data is presented because it presents values based on broader times periods of fish consumption. They also presented higher values, which allows for more conservative risk assessments.

The new transfer factor values that are not included in the DCC and PRG calculators can be found here. The TFs of animal products that already fit into existing food categories in the calculators are not relisted in this spreadsheet.

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APPENDIX A – TRANSFER FACTOR SOURCE COMPILATION

Table A-1. Transfer Factor Hierarchy

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source
Fish (fresh water)	Freshwater fish	IAEA TRS 472	49-Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Fish (marine)	Marine fish	IAEA TRS 479	19-Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Invertebrates (fresh water)	Freshwater invertebrates	IAEA TRS 472	44-Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Eu, Fe, Hf, Hg, I, K, La, Lu, Mg, Mn, Mo, Na, Np, Pb, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sm, Sr, Tc, Th, U, V, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			

Mollusk	Mollusks	IAEA TRS 479	6-Am, Cs, I, Po, Pu, Sr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Frog	Frog carcass	IAEA TRS 472	15-Al, As, Ca, Cd, Co, Cr, Cs, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Reptiles (snakes)	Reptile carcass	IAEA TRS 472	6-Ca, Co, Cs, K, Mg, Na	freshwater reptile	IAEA TRS 479	17- Am, As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Po, Ra, Se, Sn, Sr, Th, U, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Deer	Mammals: herbivorous	IAEA TRS 479	8-Am, Cd, Cs, Pb, Po, Pu, Ra, Sr	Whitetailed Deer	NRPA SPACE 2016:2	9-Am, C, Cl, I, Np, Se, Tc, Th, U	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Moose	Moose	NORMALYSA	9- Ac, Cs, Pa, Pb, Po, Ra, Sr, Th, U	Mammals: Herbivorous	IAEA TRS 479	3-Am, Cd, Pu	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Elk	Mammals: Rangifer	IAEA TRS 479	6-Am, Cs, Pb, Po, Pu, Sr	Mammals: Herbivorous	IAEA TRS 480	3-Am, Cd, Pu	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Caribou	Mammals: Rangifer	IAEA TRS 479	6-Am, Cs, Pb, Po, Pu, Sr	Mammals: Herbivorous	IAEA TRS 481	3-Am, Cd, Pu	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Horse	Horse	IAEA TRS 472	2-Fe, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Big horn Sheep	Mutton	IAEA TRS 472	14-Ag, Am, Cd, Ce, Co, Cs, I, Mn, Na, Pu, Ru, S, Sr, Zn	Sheep	UK-EA	21-Au, Ba, Br, Ca, Cr, Er, Eu, Ga, In, Lu, Mo, Nb, Ni, P, Rb, Se, Sm, Tl, V, Y, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Groundhogs	Rat (Apodemus agrarius)	Beresford et al.	2-Cs, Sr	Brown Rat	NRPA SPACE 2016:2	11- C, Cl, I, Np, Pb, Po, Ra, Se, Tc, Th, U	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Rabbit	Rabbit	NRPA SPACE 2016:2	12-C, Cl, Cs, I, Np, Pb, Po, Ra, Se, Tc, Th, U	Mammals: herbivorous	IAEA TRS 479		None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Squirrel	Rat (Apodemus agrarius)	Beresford et al.	2-Cs, Sr	Brown Rat	NRPA SPACE 2016:2	11- C, Cl, I, Np, Pb, Po, Ra, Se, Tc, Th, U	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Beaver	Rat (Apodemus agrarius)	Beresford et al.	2-Cs, Sr	Brown Rat	NRPA SPACE 2016:2	11- C, Cl, I, Np, Pb, Po, Ra, Se, Tc, Th, U	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Muskrat	Rat (Apodemus agrarius)	Beresford et al.	2-Cs, Sr	Brown Rat	NRPA SPACE 2016:2	11- C, Cl, I, Np, Pb, Po, Ra, Se, Tc, Th, U	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Bear	Bear meat	TECDOC 1616	1- Cs	Mammals: omnivorous	IAEA TRS 479	8-Am, Ba, Co, Cs, Pb, Po, Pu, Sr,	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Wild cats	Mammals: carnivorous	IAEA TRS 479	9-Cd, Cs, Mn, Ni, Pb, Po, Pu, Ra, Sr,	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Duck eggs	Egg	IAEA TRS 472	31-Am, Ba, Ca, Cd, Ce, Co, Cs, Cu, Fe, I, K, La, Mn, Mo, Na, Nb, Nd, P, Pm, Po, Pr, Pu, Ru, Se, Sr, Tc, Te, U, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Turkey	Poultry	IAEA TRS 472	30-Ag, Am, Ba, Ca, Cd, Co, Cs, Cu, Fe, Hg I, La, Mn, Mo, Na, Nb, Nd, Pm, Po, Pr, Pu, Ru, Se, Sr, Tc, Te, U, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Duck	Mallard duck	NRPA SPACE 2016:2	12-C, Cl, Cs, I, Np, Pb, Po, Ra, Se, Tc, Th, U	Poultry	IAEA TRS 472	30-Ag, Am, Ba, Ca, Cd, Co, Cu, Fe, Hg, La, Mn, Mo, Na, Nb, Nd, Pm, Pr, Pu, Ru, Sr, Te, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Quail	Poultry	IAEA TRS 472	30-Ag, Am, Ba, Ca, Cd, Co, Cs, Cu, Fe, Hg I, La, Mn, Mo, Na, Nb, Nd, Pm, Po, Pr, Pu, Ru, Se, Sr, Tc, Te, U, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Pheasant	Pheasant	NRPA SPACE 2016:2	12-C, Cl, Cs, I, Np, Pb, Po, Ra, Se, Tc, Th, U	Poultry	IAEA TRS 472	30-Ag, Am, Ba, Ca, Cd, Co, Cs, Cu, Fe, Hg I, La, Mn, Mo, Na, Nb, Nd, Pm, Po, Pr, Pu, Ru, Se, Sr, Tc, Te, U, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

APPENDIX B – INGESTION RATE COMPILATION

Table B-1. Environment International Ltd. (2012). Colville Reservation.

Species type	Percent of population consuming	Average consumption frequency (times per year)	Consumers sourcing from local area
Fish			
Salmon	73%	15	74%
Trout	46%	13	92%
Walleye	12%	9	91%
Smallmouth Bass	11%	21	93%
Crawfish	9%	13	85%
Mussels	8%	9	12%
Largemouth Bass	7%	22	85%
Panfish	6%	25	79%
Burbot	4%	9	30%
Sturgeon	3%	40	68%
Lake Whitefish	2%	9	91%
Mountain Whitefish	1%	8	69%
Lamprey	1%	12	13%
Aquatic animals (turtles, snakes, frogs)	1%	18	100%
Northern Pikeminnow	1%	7	87%
Sucker	<1%	6	100%
Other	<1%	6 (meat) 52 (head/skins/ organs/eggs)	0%
Wild animals			
Deer	76%	38	90%
Elk	46%	22	84%
Moose	28%	14	90%
Bear	4%	19	81%
Small animals	2%	7	84%
Bighorn Sheep	2%	8	100%
Wild cats	1%	6	89%
Other Wild animals (horse)	<1%	6	100%
Beaver	0%	N/A	N/A

Table B-2. Harper & Ranco (2009). 5 Maine Tribes.

Food category	% of 2000 kcal	Equivalent kcal day	Rep kcal/100g	Grams per day
Inland - anadromous				
Resident fish and other aquatic resources	10	200	175	114
Anadromous & marine fish, shellfish	35	700	175	400
Game (large and small)	30	600	175	343
Fowl & eggs	7	140	200	70
Inland - non-anadromous				
Resident fish and other aquatic resources	25	500	175	286
Anadromous & marine fish, shellfish	0	0	175	0
Game (large and small)	50	1000	175	571
Fowl & eggs	7	140	200	70
Coastal				
Resident fish and other aquatic resources	5	100	175	57
Anadromous & marine fish, shellfish	40	800	175	457
Game (large and small)	25	500	175	286
Fowl & eggs	12	240	200	120

Table B-3. NYSERDA (2015). Seneca Nation.

	Quantity consumed (g/day)	
Food Category	**Adults**	**Children (1-5y/o)**
Fish	64.80	194.40
Crustacean	0.00	0.00
Deer	121.50	N/A
Turkey	74.78	N/A

Table B-4. CB&I Federal Services LLC (2017). Fallon Paiute-Shoshone Tribe.

Food Category	Quantity consumed (grams per day)
Small Game	180
Waterfowl	40
Freshwater game fish	200

Table B-5. Harper (2002). Spokane Tribe.

Food category	Adult consumption (gpd)	Adult consumption (kcal/day)
Fish (high fish diet)	885	1300
Fish (low fish diet)	75	180
Big game (high game diet)	885	1000
Big game (low game diet)	100	110
Local small game	50	75
Aquatic foods (mussels and crayfish)	175	120

Table B-6. Harper (2005). Washoe Tribe.

Food Category	Percent of total calories	Daily Quantity (gpd)
Fish and shellfish	15%	200
Game (large and small, and fowl)	15%	300

Table B-7. Polissar et al. (2016). Nez Perce Tribe.

Species group	Mean consumption (gpd)
All finfish and shellfish	123.4
Near coastal/ estuarine/freshwater/ anadromous finfish and shellfish)	104
Salmon and steelhead	79
Resident trout	13.5
other freshwater finfish and shellfish	14.3
marine finfish and shellfish	51
unspecified	8.1

Table B-8. Polissar et al. (2016). Shoshone-Bannock Tribes.

Species group	Mean consumption (gpd)
All finfish and shellfish	158.5
Near coastal/ estuarine/freshwater/ anadromous finfish and shellfish)	109.7
Salmon and steelhead	44.3
Resident trout	11.7
other freshwater finfish and shellfish	4.7
marine finfish and shellfish	97.7
unspecified	0

Table B-9. Harper et al. (2008). Quapaw Tribe.

Food Category	**Ingestion Rate (g/d)**
Large game	267
Small game	69
Fowl & eggs	53
Aquatic & fish	120

Table B-10. Integral Consulting Inc. (2007).

Food Category	**Adult Consumption Rate (g/day) Uncooked**	**Child Consumption Rate (g/day) Uncooked**
Fish	74	31
Recreational Fish	15	7.8

APPENDIX C – FOOD, WATER, AND SOIL INTAKE RATES

Table C-1. Food and Water Intake Rates.

	Food Intake Rate (g/day)	Water Intake Rate (L/day)
Reptiles and Amphibians		
Herbivores	$0.019Wt^{0.841}$(g)	Not identified
Insectivores	$0.013Wt^{0.773}$(g)	Not identified
Mammals		
All Mammals	$0.235Wt^{0.822}$(g)	$0.099Wt^{0.90}$(kg)
Rodents	$0.621Wt^{0.564}$(g)	Not identified
Herbivores	$0.577Wt^{0.727}$(g)	Not identified
Birds		
All Birds	$0.648Wt^{0.651}$(g)	$0.059Wt^{0.67}$(kg)
Passerines	$0.398Wt^{0.850}$(g)	Not identified
Non-Passerines	$0.301Wt^{0.751}$(g)	Not identified
Sea Birds	$0.485Wt^{0.704}$(g)	Not identified

Source: EPA (1993)

Wt is the body weight (wet) of the animal in grams (g) or (kg). Food intake rates are in grams of dry matter per day.

According to EPA (1993), soil intake rates are highly variable and difficult to measure for species in the wild. As a result, the following figure presents an equation that can be used to calculate the soil ingestion rates for an organism given the specific environment and circumstances.

Figure C-1. Wildlife Oral Dose Equation for Soil or Sediment Ingestion Exposure.

$$ADD_{pot} = \left(\sum_{k=1}^{m} (C_k \times FS \times IR_{total}(\text{dry weight}) \times FR_k)\right)/BW \qquad [4\text{-}23]$$

ADD_{pot} = Potential average daily dose (e.g., in mg/kg-day).

C_k = Average contaminant concentration in soils in the k^{th} foraging area (e.g., in mg/kg dry weight).

FS = Fraction of soil in diet (as percentage of diet on a dry-weight basis divided by 100; unitless).

IR_{total} = Food ingestion rate on a dry-weight basis (e.g., in kg/day). Nagy's (1987) equations for estimating FI rates on a dry-weight basis (presented in Section 3.1) can be used to estimate a value for this factor. If the equations for estimating FI rates on a wet-weight basis presented in Section 4.2 are used, conversion to ingestion rates on a dry-weight basis would be necessary.

FR_k = Fraction of total food intake from the k^{th} foraging area (unitless).

BW = Body weight (e.g., in kg).

m = Total number of foraging areas.

Source: EPA (1993)