APPENDIX G

Human Receptor Characteristics, Human Health Exposure Equations and Worked Example

1.0 INTRODUCTION

This appendix provides technical information (*i.e.,* quantitative input parameters, model assumptions and a worked example) used in the assessment of exposure and related human health risks.

Refer to the main report for a detailed discussion regarding the rationale used to derive specific input parameters and exposure assumptions.

The estimation of exposure to chemicals of potential concern (COPC) was based on the following parameters:

- The physical/chemical characteristics of COPC, which determine the interaction and behaviour of a chemical with its surrounding environment (*e.g*., water solubility, volatility, tendency to bind to particles);
- The characteristics of the environmental media within the Local Risk Assessment Study Area (LRASA) (*e.g*., air, soil, and water), as well as the quantities of chemicals entering the media from various sources, and their persistence in these media;
- The behavioural and lifestyle characteristics of the human receptors that determine the actual exposures through interactions of the receptors with the various pathways (*e.g*., respiration rate, body weight); and
- The equations and algorithms used to predict exposures to the receptors.

This Appendix provides the human receptor selection and characterization, assumptions and a worked example.

1.1 Human Receptor Selection and Characterization

1.1.1 Receptor Selection

For the current risk assessment, human receptors in five life stages (infant, toddler or preschool child, child, adolescent, and adult) were evaluated to predict risks associated with exposure to COPC. To appropriately assess the potential lifetime cancer risk (LCR) and incremental lifetime cancer risk (ILCR) of individuals to carcinogenic compounds, a lifetime or composite receptor was also considered. The composite receptor incorporates all life stages of a receptor. Composite receptor parameters were derived by calculating a weighted average for each parameter from each of the five life stages. Age-specific data were first weighted according to the age class duration (*e.g*., the weighting factor for a toddler is 4.5 years/75 years) and summed to derive a composite value. An example of this calculation is included below. The characteristics of each receptor type and life stage are presented in Tables 1 to 12.

Composite Receptor Body Weight = $\frac{0.5}{75}8.2kg + \frac{4.5}{75}16.5kg + \frac{7}{75}32.9kg + \frac{8}{75}59.7kg + \frac{56}{75}70.7kg$

Composite Receptor Body Weight = 63.3 kg

1.1.2 Receptor Characterization

Physical and behavioural characteristics of receptors at each life stage are presented in Tables 1 through 14. The ages associated with each receptor life stage are as follows: Infant (0 to < 6 months); Toddler (6 months to <5 years); Child (5 to 11 years); Teen (12 to 19 years) and Adult (20 to 75 years), as per guidance from Health Canada (2004). General physical and behavioural characteristics specific to each receptor life stage (*e.g*., body weight, breathing rate, food consumption rate, *etc*.) were used to approximate the amount of chemical exposure received by each receptor.

The HHRA must be sufficiently comprehensive to ensure that those receptors with the greatest potential for exposure to COPC, and those that have the greatest sensitivity, or potential for developing adverse effects from these exposures, are included. With this in mind, the selection of hypothetical, reasonable "worst-case" receptors, with somewhat exaggerated life style habits (to ensure a conservative assessment), were considered in the current assessment.

The following provides additional context with respect to how each receptor of concern may be exposed to COPC.

- Local Residents – Individuals living within the LRASA may be exposed to COPC *via* direct contact with air, soil, and dust. These individuals may also be exposed to COPC through the consumption of backyard garden produce Infant residents may be exposed to COPC through the consumption of breast milk. Eight residential clusters were considered in the Multi-Pathway human health risk assessment (HHRA).

- Local Farmers and their children – This receptor group living within the LRASA may be exposed to COPC *via* direct contact with air, soil, and dust while residing and working on the farm. These individuals may also be exposed to COPC through the consumption of backyard garden produce. This receptor group may spend significant amounts of time outdoors and rely more heavily on locally derived (home grown) foods (*e.g*., produce, beef, dairy, poultry, *etc*.) compared to those local residents who do not farm and eat locally grown foods.

- Day Care attendees – Numerous day care facilities are located within the LRASA. Toddlers attending day cares and adult day care workers could be exposed to COPC *via* direct contact with air, soil, and dust.

- Recreation User – Sport – Since there are various recreational sports fields within the LRASA, the potential health risks to users of these fields were evaluated. These individuals may be exposed to COPC *via* direct contact with potentially impacted air and soil.

- Recreation User – Camping – These individuals may use specific areas in the immediate vicinity of the Energy-from-Waste (EFW) facility for general recreational purposes (*e.g*.,

hiking, running, *etc*.) and, therefore, may come into direct contact with air and/or soil potentially impacted by the COPC.

- Additional Exposure due to Swimming – On occasion, individuals may use the local water bodies to swim wade or play during the summer months. Exposures may occur through incidental ingestion and dermal contact from the surface water. The risks incurred from this exposure pathway can be added to any receptor.

- Additional Exposure due to Hunting and Angling – Hunters and anglers use the land in the local risk assessment study area and may be exposed to COPC through the consumption of local wild game and fish caught within the local risk assessment study area. The risks incurred from this exposure pathway can be added to any receptor.

The current assessment has used the most up-to-date Canadian regulatory guidance and literature (*e.g*., Richardson 1997; Health Canada 2004). However, it is recognized that the US Environmental Protection Agency (US EPA) publishes a wide array of regulatory guidance containing receptor characterization data not currently available from Canadian regulatory sources and, therefore, a number of US EPA documents were used as a source of human receptor characterization data. The US EPA (2005) document serves as a primary source for many of the fate and transport methods and general exposure scenarios. The receptor data published in Human Health Risk Assessment Protocol for Use at Hazardous Waste Combustion Facilities (HHRAP) (US EPA, 2005) has been designed to work with these fate and transport methods and the general exposure approaches. As such, HHRAP (US EPA, 2005) was also used to help characterize human receptors.

Assumptions have been made for receptor parameters for which no regulatory values were available, including the exposure frequency for recreational activities and the duration of each event.

Tables 1 to 12 provide the receptor characteristics used for the Multi-Pathway HHRA. The residential receptor characteristics in the following tables were applied to all residents from the eight residential clusters considered in the Multi-Pathway HHRA (i.e., Tooley, Bowmanville, Port Darlington, Oshawa, Courtice, Courtice Road, Maple Grove, and Solina Road). For further information regarding receptor types, residential clusters, and the selection of receptor characteristics, please refer to the main report.

Table 1-1 Receptor Characteristics – Residential – Infant Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
ATnc-s	Non Carcinogenic Effects - Summer	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
ATnc-w	Non Carcinogenic Effects - Winter	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	0.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	8.2	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	30	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	8.83	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A

IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
IRbreastmilk	Breast Milk Ingestion Rate	0.742	L/day	US EPA Exposure Factors Handbook, 1997: Table 14-16
SAsummer	Exposed Surface Area - Summer	2110	cm^2/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	652	cm^2/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	320	cm^2/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	3620	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-2 Receptor Characteristics – Residential – Toddler Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004

ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	200	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	24.7	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0.0127	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-63
IRapp	Ingestion Rate of Aboveground Protected Produce	0.0248	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-64
IRbp	Ingestion Rate of Belowground Produce	0.0038	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-65
IRfr	Ingestion Rate of Garden Fruit	0.0146	kg/day	US EPA Exposure Factors Handbook, 1997: Table 13-8
IRwat	Water Ingestion Rate	0.6	L/day	Health Canada, 2004
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	3470	cm^2/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	890	cm^2/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	430	cm^2/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	6130	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-	Health Canada, 2004

			soil/cm²	
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm²	Health Canada, 2004

Table 1-3 Receptor Characteristics – Residential – Composite and Mother Receptors

Averaging Times				
ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
General Parameters				
BW	Body Weight	63.3	kg	Calculated
IRsoil	Soil Ingestion Rate	60	mg/d	Calculated
IRdust	Dust Ingestion Rate	4.46	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0.0221	kg/day	Calculated

IRapp	Ingestion Rate of Aboveground Protected Produce	0.0422	kg/day	Calculated
IRbp	Ingestion Rate of Belowground Produce	0.00922	kg/day	Calculated
IRfr	Ingestion Rate of Garden Fruit	0.0763	kg/day	Calculated
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	8876	cm^2/day	Calculated
SAwinter	Exposed Surface Area - Winter	1373	cm^2/day	Calculated
SAhand	Exposed Surface Area - hand	833	cm^2/day	Calculated
SAwater	Exposed Surface Area - Water	16182	cm^2/day	Calculated
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-4 Receptor Characteristics – Recreation User – Sport Toddler Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	0.166667	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004

ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0.166667	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	32	days/year	Calculated
EFSummer	Exposure Frequency - Summer	32	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	200	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	3470	cm^2/day	Richardson, 1997

SAwinter	Exposed Surface Area - Winter	890	cm²/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	430	cm²/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	6130	cm²/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm²	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm²	Health Canada, 2004

Table 1-5 Receptor Characteristics – Recreation User – Sport Composite Receptors

Averaging Times				
ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	0.166667	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0.166667	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	32	days/year	Calculated
EFSummer	Exposure Frequency - Summer	32	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
General Parameters				
BW	Body Weight	63.3	kg	Calculated
IRsoil	Soil Ingestion Rate	60	mg/d	Calculated
IRdust	Dust Ingestion Rate	0	mg/d	N/A

IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	8876	cm^2/day	Calculated
SAwinter	Exposed Surface Area - Winter	1373	cm^2/day	Calculated
SAhand	Exposed Surface Area - hand	833	cm^2/day	Calculated
SAwater	Exposed Surface Area - Water	16182	cm^2/day	Calculated
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-6 Receptor Characteristics – Recreation User –Camping – Toddler Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	1	unitless	Assumed

ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	14	days/year	Calculated
EFSummer	Exposure Frequency - Summer	14	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	200	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A

IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	3470	cm²/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	890	cm²/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	430	cm²/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	6130	cm²/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm²	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm²	Health Canada, 2004

Table 1-7 Receptor Characteristics – Recreation User – Camping – Composite Receptors

Averaging Times				
ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	14	days/year	Calculated
EFSummer	Exposure Frequency - Summer	14	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
General Parameters				
BW	Body Weight	63.3	kg	Calculated

IRsoil	Soil Ingestion Rate	60	mg/d	Calculated
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	8876	cm^2/day	Calculated
SAwinter	Exposed Surface Area - Winter	1373	cm^2/day	Calculated
SAhand	Exposed Surface Area - hand	833	cm^2/day	Calculated
SAwater	Exposed Surface Area - Water	16182	cm^2/day	Calculated
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-8 Receptor Characteristics – Farmer – Infant Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
ATnc-s	Non Carcinogenic Effects - Summer	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
ATnc-w	Non Carcinogenic Effects - Winter	183	days	Health Canada, 2004 - Based on 0 - 6 months of age
Exposure Times				

ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	0.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	8.2	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	30	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	8.83	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A

IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
IRbreastmilk	Breast Milk Ingestion Rate	0.742	L/day	US EPA Exposure Factors Handbook, 1997: Table 14-16
SAsummer	Exposed Surface Area - Summer	2110	cm²/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	652	cm²/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	320	cm²/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	3620	cm²/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm²	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm²	Health Canada, 2004

Table 1-9 Receptor Characteristics – Farmer – Toddler Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004

General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	200	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	24.7	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0.0127	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-63
IRapp	Ingestion Rate of Aboveground Protected Produce	0.0248	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-64
IRbp	Ingestion Rate of Belowground Produce	0.0038	kg/day	US EPA, 2005; US EPA Exposure Factors Handbook, 1997: Table 13-65
IRfr	Ingestion Rate of Garden Fruit	0.0146	kg/day	US EPA Exposure Factors Handbook, 1997: Table 13-8
IRwat	Water Ingestion Rate	0.6	L/day	Health Canada, 2004
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0.0124	kg/day	US EPA, 2005: Table C-1-3 (Child ingestion rate used as a proxy, multiplied by toddler BW)
IRmilk	Milk Ingestion Rate	0.374	L/day	US EPA, 2005: Table C-1-3 (Child ingestion rate used as a proxy, multiplied by toddler BW)
IRpork	Pork Ingestion Rate	0.00693	kg/day	US EPA, 2005: Table C-1-3 (Child ingestion rate used as a proxy, multiplied by toddler BW)
IRpoultry	Poultry Ingestion Rate	0.00743	kg/day	US EPA, 2005: Table C-1-3 (Child ingestion rate used as a proxy, multiplied by toddler BW)
IRegg	Egg Ingestion Rate	0.00891	kg/day	US EPA, 2005: Table C-1-3 (Child ingestion rate used as a proxy, multiplied by toddler BW)
SAsummer	Exposed Surface Area - Summer	3470	cm^2/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	890	cm^2/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	430	cm^2/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	6130	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-10 Receptor Characteristics – Farmer – Composite and Mother Receptors

Averaging Times				

ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
General Parameters				
BW	Body Weight	63.3	kg	Calculated
IRsoil	Soil Ingestion Rate	60	mg/d	Calculated
IRdust	Dust Ingestion Rate	4.46	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0.0221	kg/day	Calculated
IRapp	Ingestion Rate of Aboveground Protected Produce	0.0422	kg/day	Calculated
IRbp	Ingestion Rate of Belowground Produce	0.00922	kg/day	Calculated
IRfr	Ingestion Rate of Garden Fruit	0.0763	kg/day	Calculated
IRwat	Water Ingestion Rate	1.34	L/day	Calculated

IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0.0752	kg/day	Calculated (Adult and child ingestion rates were used as a proxy for teen and infant ingestion rates respectively)
IRmilk	Milk Ingestion Rate	0.901	L/day	Calculated (Adult and child ingestion rates were used as a proxy for teen and infant ingestion rates respectively)
IRpork	Pork Ingestion Rate	0.0342	kg/day	Calculated (Adult and child ingestion rates were used as a proxy for teen and infant ingestion rates respectively)
IRpoultry	Poultry Ingestion Rate	0.0409	kg/day	Calculated (Adult and child ingestion rates were used as a proxy for teen and infant ingestion rates respectively)
IRegg	Egg Ingestion Rate	0.0466	kg/day	Calculated (Adult and child ingestion rates were used as a proxy for teen and infant ingestion rates respectively)
SAsummer	Exposed Surface Area - Summer	8876	cm^2/day	Calculated
SAwinter	Exposed Surface Area - Winter	1373	cm^2/day	Calculated
SAhand	Exposed Surface Area - hand	833	cm^2/day	Calculated
SAwater	Exposed Surface Area - Water	16182	cm^2/day	Calculated
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

Table 1-11 Receptor Characteristics – Day Care – Toddler Receptors

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	0.333333	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004

ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	200	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	24.7	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	3470	cm^2/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	890	cm^2/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	430	cm^2/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	6130	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004

SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm²	Health Canada, 2004

Table 1-12 Receptor Characteristics – Day Care – Adult Receptors

Averaging Times				
ATc	Carcinogenic Effects	27740	days	Based on a 76 year lifetime
ATnc	Non Carcinogenic Effects	20440	days	Based on 20 to 75 years of age
ATnc-s	Non Carcinogenic Effects - Summer	20440	days	Based on 20 to 75 years of age
ATnc-w	Non Carcinogenic Effects - Winter	20440	days	Based on 20 to 75 years of age
Exposure Times				
ET	Exposure Time	0.333333	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0.333333	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	56	years	Health Canada, 2004
General Parameters				
BW	Body Weight	70.7	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	50	mg/d	Ontario Ministry of the Environment, 2008
IRdust	Dust Ingestion Rate	0	mg/d	Calculated
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A

IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	9660	cm^2/day	Richardson, 1997
SAwinter	Exposed Surface Area - Winter	1430	cm^2/day	Richardson, 1997
SAhand	Exposed Surface Area - hand	890	cm^2/day	Richardson, 1997
SAwater	Exposed Surface Area - Water	17700	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0.01	mg-soil/cm^2	Health Canada, 2004
SAFhand	Soil Adherence Rate - hand	0.1	mg-soil/cm^2	Health Canada, 2004

1.1.3 Additional Exposure from Swimming Scenario

A separate evaluation of the potential additional exposures related to swimming in local bodies of water was also evaluated. To address the potential for additional exposure arising from swimming, risks related to local receptors swimming/wading/playing for short periods of time during summer months in local lake or river water bodies were assessed. To characterize the potential exposures, a number of different watersheds throughout the LRASA were evaluated. To ensure risks were not underestimated, for this scenario each of the receptor groups was conservatively assumed to swim in the watershed that had the highest predicted concentration of each COPC. The following additional exposure pathways were evaluated for each of the five receptor groups:

- Incidental ingestion of surface water; and
- Dermal contact with surface water.

Given the depositional source of the COPC, it was assumed that any concentration present in the sediment would be equivalent to concentrations predicted for surrounding soils. As such, all potential exposures to sediment were already accounted for in the daily exposures to soils evaluated in the five primary exposure scenarios.

Assumptions with respect to average number of swimming events per year (14 events) and duration of each swimming event (2 hours) were based on knowledge of local recreational swimming habits. The characteristics associated with the Additional Exposures from Swimming scenario are provided in Table 1-13 and Table 1-14.

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Table 1-13 Receptor Characteristics – Additional Exposures from Swimming – Toddler Scenario

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	1	event/day	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	14	days/year	Calculated
EFSummer	Exposure Frequency - Summer	14	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
t_{event}	Event Duration	2	hours/event	Assumed
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	0	mg/d	N/A
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A

IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0.6	L/day	Health Canada, 2004
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	0	cm^2/day	N/A
SAwinter	Exposed Surface Area - Winter	0	cm^2/day	N/A
SAhand	Exposed Surface Area - hand	0	cm^2/day	N/A
SAwater	Exposed Surface Area - Water	6130	cm^2/day	Richardson, 1997
SAFbody	Soil Adherence Rate - body	0	mg-soil/cm^2	N/A
SAFhand	Soil Adherence Rate - hand	0	mg-soil/cm^2	N/A

Table 1-14 Receptor Characteristics – Additional Exposures from Swimming – Composite Scenario

Averaging Times				
ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	1	event/day	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004

ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	1	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	14	days/year	Calculated
EFSummer	Exposure Frequency - Summer	14	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	0	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
t_{event}	Event Duration	2	hours/event	Assumed
General Parameters				
BW	Body Weight	63.3	kg	Calculated
IRsoil	Soil Ingestion Rate	0	mg/d	N/A
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	1.34	L/day	Calculated
IRfish	Fish Ingestion Rate	0	kg/day	N/A
IRwgame	Wild Game Ingestion Rate	0	kg/day	N/A
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A

SAsummer	Exposed Surface Area - Summer	0	cm^2/day	N/A
SAwinter	Exposed Surface Area - Winter	0	cm^2/day	N/A
SAhand	Exposed Surface Area - hand	0	cm^2/day	N/A
SAwater	Exposed Surface Area - Water	16182	cm^2/day	Calculated
SAFbody	Soil Adherence Rate - body	0	mg-soil/cm^2	N/A
SAFhand	Soil Adherence Rate - hand	0	mg-soil/cm^2	N/A

1.1.4 Hunting and Angling Scenario

A separate evaluation of the potential incremental exposure related to hunting and angling in the Assessment Area is also conducted. This assessment scenario involves the potential for a local resident receptor to hunt and fish in the Assessment Area throughout the year. It is assumed that they may be exposed to COPC through the consumption of local wild game and fish caught within the Assessment Area. The following additional exposure pathways were evaluated for the local resident groups:

- Ingestion of local wild game; and
- Ingestion of local fish

To ensure potential risks would not be under-estimated, hunters and anglers were assumed to be exposed to the maximum concentrations on COPC in food items. The characteristics associated with the Hunting and Angling scenario are provided in Table 1-15 and Table 1-16.

Table 1-15 Receptor Characteristics – Hunting and Angling – Toddler Scenario

Averaging Times				
ATnc	Non Carcinogenic Effects	1643	days	Based on 7 months to 4.99 years of age
ATnc-s	Non Carcinogenic Effects - Summer	1643	days	Based on 7 months to 4.99 years of age
ATnc-w	Non Carcinogenic Effects - Winter	1643	days	Based on 7 months to 4.99 years of age
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	4.5	years	Health Canada, 2004
General Parameters				
BW	Body Weight	16.5	kg	Health Canada, 2004
IRsoil	Soil Ingestion Rate	0	mg/d	N/A
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A

IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0.00563	kg/day	US EPA Exposure Factors Handbook, 1999: Table 10-61
IRwgame	Wild Game Ingestion Rate	0.0165	kg/day	US EPA Exposure Factors Handbook, 1997: Table 13-45
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	0	cm^2/day	N/A
SAwinter	Exposed Surface Area - Winter	0	cm^2/day	N/A
SAhand	Exposed Surface Area - hand	0	cm^2/day	N/A
SAwater	Exposed Surface Area - Water	0	cm^2/day	N/A
SAFbody	Soil Adherence Rate - body	0	mg-soil/cm^2	N/A
SAFhand	Soil Adherence Rate - hand	0	mg-soil/cm^2	N/A

Table 1-16 Receptor Characteristics – Hunting and Angling – Composite Scenario

Averaging Times				
ATc	Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc	Non Carcinogenic Effects	27375	days	Based on a 75 year lifetime
ATnc-s	Non Carcinogenic Effects - Summer	27375	days	Based on a 75 year lifetime
ATnc-w	Non Carcinogenic Effects - Winter	27375	days	Based on a 75 year lifetime
Exposure Times				
ET	Exposure Time	1	unitless	Assumed
ETSum-Ind-Ing	Exposure Time - Summer - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETSum-Out-Ing	Exposure Time - Summer - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004

ETWinter-Ind-Ing	Exposure Time - Winter - Indoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
ETWinter-Out-Ing	Exposure Time - Winter - Outdoor - Ingestion & Dermal Contact	0	unitless	Health Canada, 2004
EF	Exposure Frequency	365	days/year	Calculated
EFSummer	Exposure Frequency - Summer	214	days/year	Environment Canada, 2008 or Assumed
EFWinter	Exposure Frequency - Winter	151	days/year	Environment Canada, 2008 or Assumed
ED	Exposure Duration	75	years	Health Canada, 2004
General Parameters				
BW	Body Weight	63.3	kg	Calculated
IRsoil	Soil Ingestion Rate	0	mg/d	N/A
IRdust	Dust Ingestion Rate	0	mg/d	N/A
IRap	Ingestion Rate of Aboveground Exposed Produce	0	kg/day	N/A
IRapp	Ingestion Rate of Aboveground Protected Produce	0	kg/day	N/A
IRbp	Ingestion Rate of Belowground Produce	0	kg/day	N/A
IRfr	Ingestion Rate of Garden Fruit	0	kg/day	N/A
IRwat	Water Ingestion Rate	0	L/day	N/A
IRfish	Fish Ingestion Rate	0.0115	kg/day	Calculated
IRwgame	Wild Game Ingestion Rate	0.0632	kg/day	Calculated
IRbeef	Beef Ingestion Rate	0	kg/day	N/A
IRmilk	Milk Ingestion Rate	0	L/day	N/A
IRpork	Pork Ingestion Rate	0	kg/day	N/A
IRpoultry	Poultry Ingestion Rate	0	kg/day	N/A
IRegg	Egg Ingestion Rate	0	kg/day	N/A
SAsummer	Exposed Surface Area - Summer	0	cm^2/day	N/A
SAwinter	Exposed Surface Area - Winter	0	cm^2/day	N/A
SAhand	Exposed Surface Area - hand	0	cm^2/day	N/A

SAwater	Exposed Surface Area - Water	0	cm^2/day	N/A
SAFbody	Soil Adherence Rate - body	0	mg-soil/cm^2	N/A
SAFhand	Soil Adherence Rate - hand	0	mg-soil/cm^2	N/A

1.1.5 Fraction of Media Consumed from Site

With regards to the ingestion of various agricultural or other media, it is not always assumed that all of the food consumed is derived from the Site. Table 1-17 displays the fractions of various media consumed by resident, farmer and hunter/angler receptors from the Site.

Table 1-17 - Fraction of various media consumed by resident, farmer and hunter/angler receptors from Site

Media	Resident[a]	Farmer[a]	Hunter/Angler[b]
Aboveground Exposed Produce	0.233	0.42	0
Aboveground Protected Produce	0.178	0.394	0
Belowground Produce	0.106	0.173	0
Fruit	0.116	0.328	0
Wild Game	0	0	1
Fish	0	0	1
Beef	0	0.478	0
Pork	0	0.239	0
Dairy	0	0.254	0
Poultry	0	0.151	0
Eggs	0	0.214	0

[a] US EPA Exposure Factors Handbook, Table 13-71

[b] Assumed

2.0 CALCULATING HUMAN EXPOSURE RATES FOR NON-CARCINOGENS

The exposure point concentrations generated through fate and transport modeling were carried forward into the human health model to calculate human exposure rates. The following equations were used to evaluate all receptors, scenarios, and non-carcinogenic COPC. Tables of Site Input Parameters and Chemical Parameters are found Appendices A and C, respectively.

The following is a worked example of the calculations used to evaluate the risk to a local toddler resident from the Tooley residential grouping exposed to the non-carcinogenic form of arsenic. In some cases, arsenic was not applicable to the pathway under consideration; here, an alternative chemical has been specified and used in the calculation.

2.1 Exposure from Soil/Dust

2.1.1 Soil/Dust Ingestion – Summer - Outdoor

The following equation determines the intake of soil while outdoors in the summer due to ingestion, for a local toddler from the Tooley residential grouping.

$$Intake_{SDINGSO} = \frac{IR_{soil} \times AF_{oral} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (1)$$

Where:			Units
$Intake_{SDINGSO}$	=	daily intake from ingestion of soil/dust – summer outdoor	kg/kg-day
IR_{soil}	=	ingestion rate of soil (100)	mg/day
AF_{oral}	=	oral absorption factor (1)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of soil/dust – summer outdoor for a local toddler resident from the Tooley residential grouping is 3.6×10^{-6} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDINGSO} = Intake_{SDINGSO} \times C_s \quad (2)$$

Where:			Units
$CDI_{SDINGSO}$	=	chronic daily intake from ingestion of soil/dust - summer outdoor	mg/kg-day
$Intake_{SDINGSO}$	=	daily intake from ingestion of soil/dust - summer outdoor (non-carcinogenic)	

kg/kg-day

C_s	=	concentration of chemical in soil (4 x 10^{-5})	mg/kg

The CDI from ingestion of soil/dust – summer outdoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 1.4 x 10^{-10} mg/kg-day.

2.1.2 Soil/Dust Ingestion – Summer – Indoor

The following equation determines the intake of indoor dust generated form soil in the summer due to ingestion, for a local toddler from the Tooley residential grouping.

$$Intake_{SDINGSI} = \frac{IR_{dust} \times AF_{oral} \times FR_{soili} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (3)$$

Where:			Units
$Intake_{SDINGSI}$	=	daily intake from ingestion of soil/dust - summer indoor	kg/kg-day
IR_{dust}	=	ingestion rate of dust (24.7)	mg/day
AF_{oral}	=	oral absorption factor (1)	unitless
FR_{soili}	=	fraction of dust derived from soil (0.8)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1 x 10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of soil/dust – summer indoor for a local toddler resident from the Tooley residential grouping is 7.2 x 10^{-7} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDINGSI} = Intake_{SDINGSI} \times C_s \quad (4)$$

Where:			Units
$CDI_{SDINGSI}$	=	chronic daily intake from ingestion of soil/dust - summer indoor	mg/kg-day
$Intake_{SDINGSI}$	=	daily intake from ingestion of soil/dust - summer indoor (non-carcinogenic)	kg/kg-day
C_s	=	concentration of chemical in soil (4 x 10^{-5})	mg/kg

The CDI from ingestion of soil/dust – summer indoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 2.8 x 10^{-11} mg/kg-day.

2.1.2.1 Dust Ingestion Rate

The dust ingestion rate calculation applies only to infant, toddler, and child receptors, as it is based on the frequency of finger mouthing events.

$$IR_{dust} = SA_{finger} \times SAF_{finger} \times FR_{soili} \times FME \times ET \times CF \quad (5)$$

Where:			Units
IR_{dust}	=	ingestion rate of dust	mg/day
SA_{finger}	=	surface area of ½ finger (8.75)	cm^2/event
SAF_{finger}	=	soil adherence factor – finger (0.056)	mg/cm^2
FR_{soili}	=	fraction of dust from soil – indoor (0.8)	unitless
FME	=	frequency of finger mouthing events (9)	events/hour
ET	=	exposure time (1)	hours/day
CF	=	Conversion Factor (7)	

The dust ingestion rate for a local toddler resident from the Tooley residential grouping is 24 mg/hr.

2.1.3 Soil/Dust Ingestion – Winter - Outdoor

The following equation determines the intake of soil while outdoors in the winter due to ingestion, for a local toddler from the Tooley residential grouping.

$$Intake_{SDINGWO} = \frac{IR_{soil} \times AF_{oral} \times FR_{snow} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (6)$$

Where:			Units
$Intake_{SDINGWO}$	=	daily intake from ingestion of soil/dust - winter outdoor	kg/kg-day
IR_{soil}	=	ingestion rate of soil (100)	mg/day
AF_{oral}	=	oral absorption factor (1)	unitless
FR_{snow}	=	fraction of winter that site is not snow covered (0.61)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (151)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of soil/dust – winter outdoor for a local toddler resident from the Tooley residential grouping is 1.5×10^{-6} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDINGWO} = Intake_{SDINGWO} \times C_s \quad (7)$$

Where:			Units
$CDI_{SDINGWO}$	=	chronic daily intake from ingestion of soil/dust - winter outdoor	mg/kg-day
$Intake_{SDINGWO}$	=	daily intake from ingestion of soil/dust - winter outdoor (non-carcinogenic)	kg/kg-day
C_s	=	concentration of chemical in soil (4×10^{-5})	mg/kg

The CDI from ingestion of soil/dust – winter outdoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 6.1×10^{-11} mg/kg-day.

2.1.4 Soil/Dust Dermal – Summer - Outdoor

The following equation determines the intake of soil while outdoors in the summer due to dermal contact, for a local toddler from the Tooley residential grouping. For summer exposure, the exposed surface area – body parameter assumes the head, arms and legs are exposed.

$$Intake_{SDERMSO} = \frac{\left((SA_{body} \times SAF_{body}) + (SA_{hand} \times SAF_{hand})\right) \times AF_{dermal} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (8)$$

Where:			Units
$Intake_{SDERMSO}$	=	daily intake from dermal contact with soil/dust - summer outdoor	kg/kg-day
SA_{body}	=	exposed surface area - body (summer) (3470)	cm^2
SAF_{body}	=	soil adherence factor – body (0.01)	mg-soil/cm^2
SA_{hand}	=	exposed surface area – hand (430)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from dermal contact with soil/dust – summer outdoor for a local toddler resident from the Tooley residential grouping is 8.3×10^{-8} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDERMSO} = Intake_{SDERMSO} \times C_s \quad (9)$$

Where:			Units
$CDI_{SDERMSO}$	=	chronic daily intake from dermal contact of soil/dust - summer outdoor	mg/kg-day
			mg/kg-day
$Intake_{SDERMSO}$	=	daily intake from dermal contact with soil/dust - summer outdoor (non-carcinogenic)	
			mg/kg-day
C_s	=	concentration of chemical in soil (4×10^{-5})	mg/kg

The CDI from dermal contact with soil/dust – summer outdoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 3.3×10^{-12} mg/kg-day.

2.1.5 Soil/Dust Dermal – Summer – Indoor

The following equation determines the intake of indoor dust generated from soil in the summer due to dermal contact, for a local toddler from the Tooley residential grouping.

$$Intake_{SDERMSI} = \frac{\left((SA_{hand} \times SAF_{hand})\right) \times AF_{dermal} \times FR_{soil} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (10)$$

Where:			Units
$Intake_{SDERMSI\ c\ or\ nc}$	=	daily intake from dermal contact with soil/dust - summer outdoor	kg/kg-day
SA_{hand}	=	exposed surface area – hand (430)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless
FR_{soili}	=	fraction of dust derived from soil (0.8)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from dermal contact with soil/dust – summer indoor for a local toddler resident from the Tooley residential grouping is 3.7×10^{-8} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDERMSI} = Intake_{SDERMSI} \times C_s \quad (11)$$

Where:			Units
$CDI_{SDERMSI}$	=	chronic daily intake from dermal contact of soil/dust - summer outdoor	mg/kg-day
			mg/kg-day

$Intake_{SDERMSI}$ = daily intake from dermal contact with soil/dust - summer outdoor (non-carcinogenic) mg/kg-day

C_s = concentration of chemical in soil (4×10^{-5}) mg/kg

The CDI from dermal contact with soil/dust – summer indoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 1.5×10^{-12} mg/kg-day.

2.1.6 Soil/Dust Dermal – Winter - Outdoor

The following equation determines the intake of soil while outdoors in the winter due to dermal contact, for a local toddler from the Tooley residential grouping. For winter exposure, the exposed surface area – body parameter assumes only the head is exposed.

$$Intake_{SDERMWO} = \frac{\left(\left(SA_{body} \times SAF_{body}\right) + \left(SA_{hand} \times SAF_{hand}\right)\right) \times AF_{dermal} \times FR_{snow} \times ET \times EF \times ED \times CF}{BW \times AT_{nc}} \quad (12)$$

Where:			Units
$Intake_{SDERMWO\ c\ or\ nc}$	=	daily intake from dermal contact with soil/dust - winter outdoor	kg/kg-day
SA_{body}	=	exposed surface area - body (winter) (890)	cm^2
SAF_{body}	=	soil adherence factor – body (0.01)	mg-soil/cm^2
SA_{hand}	=	exposed surface area – hand (430)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless
FR_{snow}	=	fraction of winter that ground is not snow-covered (0.61)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (151)	days/year
ED	=	exposure duration (4.5)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from dermal contact with soil/dust – winter outdoor for a local toddler resident from the Tooley residential grouping is 2.4×10^{-8} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{SDERMWO} = Intake_{SDERMWO} \times C_s \quad (13)$$

Where:			Units
$CDI_{SDERMWO}$	=	chronic daily intake from dermal contact of soil/dust - winter outdoor	mg/kg-day

$Intake_{SDERMWO\ nc}$ = daily intake from dermal contact with soil/dust - winter outdoor (non-carcinogenic) mg/kg-day

C_s = concentration of chemical in soil (4×10^{-5}) mg/kg

The CDI from dermal contact with soil/dust – winter outdoor for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 9.5×10^{-13} mg/kg-day.

2.2 Exposure from Food Consumption

The following equations are used to assess the potential risk resulting from ingestion of produce grown in backyard gardens, agricultural products, wild game, and fish. The ingestion rates of produce, agricultural products, wild game, and fish differ depending on the receptor chosen. In general, food consumption rates were taken from the Exposure Factors Handbook (US EPA, 1997), US EPA HHRAP (2005), or Health Canada, 2004a. Receptor specific inputs are discussed in the appropriate sections below.

2.2.1 Ingestion of Homegrown Aboveground Exposed Garden Produce

The following equation determines the intake of homegrown exposed garden produce, for a local toddler from the Tooley residential grouping.

$$Intake_{AGPROD} = \frac{IR_{ap} \times F_p \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (14)$$

Where:			Units
$Intake_{AGPROD}$	=	daily intake from the ingestion of aboveground produce	kg/kg-day
IR_{ap}	=	ingestion rate of aboveground produce (0.0127)	kg/day
F_{ap}	=	fraction of aboveground produce consumed from site (0.233)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of home-grown aboveground exposed garden produce for a local toddler resident from the Tooley residential grouping is 1.8×10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{AGPROD} = Intake_{AGPROD} \times \left(P_d + Pr_{ag} + P_v\right) \quad (15)$$

Where: Units

CDI_{AGPROD}	=	chronic daily intake from ingestion of aboveground produce	mg/kg-day
$Intake_{AGPROD}$	=	daily intake from ingestion of aboveground produce (non-carcinogenic)	kg/kg-day
P_d	=	concentration in produce due to direct (wet and dry) deposition	mg/kg
P_v	=	concentration in produce from air-to-plant transfer	mg/kg
Pr_{ag}	=	concentration in aboveground produce due to root uptake	mg/kg

Note: $P_d + P_v + Pr_{ag}$ is the total concentration in aboveground produce. (2.4×10^{-6})

The CDI from ingestion of home-grown aboveground exposed garden produce for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 4.3×10^{-10} mg/kg-day.

2.2.2 Ingestion of Homegrown Aboveground Protected Garden Produce

The following equation determines the intake of homegrown aboveground protected garden produce, for a local toddler from the Tooley residential grouping.

$$Intake_{AGPPROD} = \frac{IR_{app} \times F_{app} \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (16)$$

Where:			Units
$Intake_{AGPPROD}$	=	daily intake from the ingestion of aboveground protected produce	kg/kg-day
IR_{app}	=	ingestion rate of aboveground protected produce (0.025)	kg/day
F_{app}	=	fraction of aboveground protected produce consumed from site (0.178)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of aboveground protected garden produce for a local toddler resident from the Tooley residential grouping is 2.7×10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{AGPPROD} = Intake_{AGPPROD} \times Pr_{ag} \quad (17)$$

Where:			Units
$CDI_{AGPPROD}$	=	chronic daily intake from ingestion of aboveground protected produce	mg/kg-day
$Intake_{AGPPROD\ nc}$	=	daily intake from ingestion of aboveground protected produce (non-carcinogenic)	kg/kg-day
Pr_{ag}	=	concentration in aboveground produce due to root uptake (2.5×10^{-7})	mg/kg

The CDI from ingestion of aboveground protected garden produce for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 6.8 x 10^{-11} mg/kg-day.

2.2.3 Ingestion of Homegrown Belowground Garden Produce

The following equation determines the intake of homegrown belowground garden produce, for a local toddler from the Tooley residential grouping.

$$Intake_{BGPROD} = \frac{IR_{bp} \times F_{bp} \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (18)$$

Where:			Units
$Intake_{BGPROD}$	=	daily intake from the ingestion of belowground produce	kg/kg-day
IR_{bp}	=	ingestion rate of belowground produce (0.004)	kg/day
F_{bp}	=	fraction of belowground produce consumed from site (0.106)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of belowground garden produce for a local toddler resident from the Tooley residential grouping is 2.4 x 10^{-5} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{BGPROD} = Intake_{BGPROD} \times Pr_{bg} \quad (19)$$

Where:			Units
CDI_{BGPROD}	=	chronic daily intake from ingestion of belowground produce	mg/kg-day
$Intake_{BGPROD\ nc}$	=	daily intake from ingestion of belowground produce (non-carcinogenic)	kg/kg-day
Pr_{bg}	=	concentration in belowground produce due to root uptake (3.2 x 10^{-7})	mg/kg

The CDI from ingestion of belowground garden produce for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic arsenic is 7.8 x 10^{-12} mg/kg-day.

2.2.4 Ingestion of Homegrown Garden Fruit

The following equation determines the intake of homegrown garden fruit, for a local toddler from the Tooley residential grouping. Arsenic concentrations were not available for homegrown garden fruit, therefore dioxins/furans were used for this example calculation.

$$Intake_{\ Fruit} = \frac{IR_{fr}\ x\ F_{fr} x\ AF_{oral}\ x\ EF\ x\ ED}{BW\ x\ AT_{nc}} \quad (20)$$

Where:			Units
$Intake_{fruitc\ or\ nc}$	=	daily intake from the ingestion of homegrown fruit	kg/kg-day
IR_{fr}	=	ingestion rate of homegrown fruit (0.0146)	kg/day
F_{fr}	=	fraction of homegrown fruit consumed from site (0.116)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of homegrown garden fruit for a local toddler resident from the Tooley residential grouping is 1.0 x 10^{-4} kg/kg-day.

The chronic daily intake of dioxins/furans is calculated as follows:

$$CDI_{Fruit} = Intake_{Fruit}\ x\ C_{fr} \quad (21)$$

Where:			Units
CDI_{fruit}	=	chronic daily intake from ingestion of homegrown fruit	mg/kg-day
$Intake_{Fruit}$	=	daily intake from ingestion of homegrown fruit (non-carcinogenic)	kg/kg-day
C_{fr}	=	concentration in belowground homegrown fruit (2.8 x 10^{-11})	mg/kg

The CDI from ingestion of homegrown garden fruit for a local toddler resident in the Tooley residential grouping exposed to non-carcinogenic dioxins/furans is 2.9 x 10^{-15} mg/kg-day.

2.2.5 Ingestion of Beef

The following is an example of calculations used to evaluate the risk from ingestion of beef to a farmer toddler exposed to non-carcinogenic arsenic. In the case of beef, specific ingestion rates were only made available for child and adult receptors. These consumption rates were used as a proxy for toddler and teen consumption rates.

$$Intake_{\ Beef} = \frac{IR_{beef} \times F_{beef} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (22)$$

Where:			Units
$Intake_{beef}$	=	daily intake from the ingestion of beef	kg/kg-day
IR_{beef}	=	ingestion rate of beef (0.0124)	kg/day
F_{beef}	=	fraction of beef consumed from site (0.478)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of beef for a local toddler in the farmer grouping is 3.6 x 10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{Beef} = Intake_{Beef}\ x\ C_{Beef} \quad (23)$$

Where:			Units
CDI_{beef}	=	chronic daily intake from ingestion of beef	mg/kg-day
$Intake_{beef}$	=	daily intake from ingestion of beef (non-carcinogenic)	kg/kg-day
C_{beef}	=	concentration in beef (5.9 x 10^{-7})	mg/kg

The CDI from ingestion of beef for a local toddler in the farmer grouping exposed to non-carcinogenic arsenic is 2.1 x 10^{-10} mg/kg-day.

2.2.6 Ingestion of Milk

The following is an example of calculations used to evaluate the risk from ingestion of milk to a farmer toddler exposed to non-carcinogenic arsenic. In the case of milk, specific ingestion rates were only made available for child and adult receptors. These consumption rates were used as a proxy for toddler and teen consumption rates.

$$Intake_{\ Milk} = \frac{IR_{milk} \times F_{milk} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (24)$$

Where:			Units
$Intake_{milk}$	=	daily intake from the ingestion of milk	L/kg-day
IR_{milk}	=	ingestion rate of milk (0.374)	L/day
F_{milk}	=	fraction of milk consumed from site (0.254)	unitless

AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of milk for a local toddler inthe farmer grouping is 5.8 x 10^{-3} L/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{Milk} = Intake_{Milk}\ x\ C_{Milk} \quad (25)$$

Where:			Units
CDI_{Milk}	=	chronic daily intake from ingestion of milk	mg/kg-day
$Intake_{Milk}$	=	daily intake from ingestion of milk (non-carcinogenic)	L/kg-day
C_{Milk}	=	concentration in milk (2.5 x 10^{-8})	mg/L

The CDI from ingestion of milk for a local toddler in the farmer grouping exposed to non-carcinogenic arsenic is 1.5 x 10^{-10} mg/kg-day.

2.2.7 Ingestion of Pork

The following is an example of calculations used to evaluate the risk from ingestion of pork to a farmer toddler exposed to non-carcinogenic arsenic. In the case of pork, specific ingestion rates were only made available for child and adult receptors. These consumption rates were used as a proxy for toddler and teen consumption rates.

$$Intake_{\ Pork} = \frac{IR_{pork}\ \times F_{pork} \times AF_{oral} \times\ EF\ \times\ ED}{BW\ \times\ AT_{nc}} \quad (26)$$

Where:			Units
$Intake_{pork}$	=	daily intake from the ingestion of pork	kg/kg-day
IR_{pork}	=	ingestion rate of pork (0.0069)	kg/day
F_{pork}	=	fraction of pork consumed from site (0.239)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of pork for a local toddler in the farmer grouping is 1.0 x 10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{pork} = Intake_{pork}\ x\ C_{pork} \quad (27)$$

Where:			Units
CDI_{pork}	=	chronic daily intake from ingestion of pork	mg/kg-day
$Intake_{pork}$	=	daily intake from ingestion of pork (non-carcinogenic)	kg/kg-day
C_{pork}	=	concentration in pork (9.3 x 10^{-8})	mg/kg

The CDI from ingestion of pork for a local toddler in the farmer grouping exposed to non-carcinogenic arsenic is 9.3 x 10^{-12} mg/kg-day.

2.2.8 Ingestion of Poultry

The following is an example of calculations used to evaluate the risk from ingestion of poultry to a farmer toddler exposed to non-carcinogenic arsenic. In the case of poultry, specific ingestion rates were only made available for child and adult receptors. These consumption rates were used as a proxy for toddler and teen consumption rates.

$$Intake_{\ Poultry} = \frac{IR_{poultry}\ \times F_{poultry} \times AF_{oral} \times\ EF\ \times\ ED}{BW\ \times\ AT_{nc}} \quad (28)$$

Where:			Units
$Intake_{poultry}$	=	daily intake from the ingestion of poultry	kg/kg-day
$IR_{poultry}$	=	ingestion rate of poultry (0.0074)	kg/day
$F_{poultry}$	=	fraction of poultry consumed from site (0.151)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of poultry for a local toddler in the farmer grouping is 6.8 x 10^{-5} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{poultry} = Intake_{poultry}\ x\ C_{poultry} \quad (29)$$

Where:			Units
$CDI_{poultry}$	=	chronic daily intake from ingestion of poultry	mg/kg-day
$Intake_{poultry}$	=	daily intake from ingestion of poultry (non-carcinogenic)	kg/kg-day

$C_{poultry}$	=	concentration in poultry (1.9 x 10^{-9})	mg/kg

The CDI from ingestion of poultry for a local toddler in the farmer grouping exposed to non-carcinogenic arsenic is 1.3 x 10^{-13} mg/kg-day.

2.2.1 Ingestion of Eggs

The following is an example of calculations used to evaluate the risk from ingestion of eggs to a farmer toddler exposed to non-carcinogenic arsenic. In the case of eggs, specific ingestion rates were only made available for child and adult receptors. These consumption rates were used as a proxy for toddler and teen consumption rates.

$$Intake_{Eggs} = \frac{IR_{eggs} \times F_{eggs} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (30)$$

Where:			Units
$Intake_{eggs}$	=	daily intake from the ingestion of eggs	kg/kg-day
IR_{eggs}	=	ingestion rate of eggs (0.0089)	kg/day
F_{eggs}	=	fraction of eggs consumed from site (0.214)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of eggs for a local toddler resident from the farmer grouping is 1.2 x 10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{eggs} = Intake_{eggs} \, x \, C_{eggs} \quad (31)$$

Where:			Units
CDI_{eggs}	=	chronic daily intake from ingestion of eggs	mg/kg-day
$Intake_{eggs}$	=	daily intake from ingestion of eggs (non-carcinogenic)	kg/kg-day
C_{eggs}	=	concentration in eggs (1.1 x 10^{-9})	mg/kg

The CDI from ingestion of eggs for a local toddler in the farmer grouping exposed to non-carcinogenic arsenic is 1.3 x 10^{-13} mg/kg-day.

2.2.2 Ingestion of Wild Game

The following is an example of calculations used to evaluate the risk from ingestion of wild game to a toddler from a hunting/angling household, exposed to non-carcinogenic arsenic.

$$Intake_{WG} = \frac{IR_{wg} \times F_{wg} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (32)$$

Where:			Units
$Intake_{WG\ c\ or\ nc}$	=	daily intake from the ingestion of wild game	kg/kg-day
IR_{wg}	=	ingestion rate of wild game (0.0165)	kg/day
F_{wg}	=	fraction of wild game consumed from site (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen = (1643)	days

The daily intake from ingestion of wild game for a hunter/angler – toddler is 1.0 x 10^{-3} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{wg} = Intake_{wg}\ x\ C_{wg} \quad (33)$$

Where:			Units
CDI_{wg}	=	chronic daily intake from ingestion of wild game	mg/kg-day
$Intake_{wg}$	=	daily intake from ingestion of wild game (non-carcinogenic)	kg/kg-day
A_{wg}	=	concentration of COPC in wild game (9.49 x 10^{-8})	mg/kg

The CDI from ingestion of wild game for a hunter/angler – toddler exposed to non-carcinogenic arsenic is 9.49 x 10^{-11} mg/kg-day.

2.2.3 Ingestion of Fish

The model is able to calculate different concentrations for a lake and a river within the same watershed. For the assessment of risk, all fish are assumed to come from McLaughlin Bay which yields the highest intake for each COPC; therefore, for the purposes of this assessment, all fish were assumed to come from a lake. A hunting/angling household toddler receptor was assumed for this worked example.

$$Intake_{FISH-LAKE} = \frac{IR_{fish} \times F_{fish} \times F_{fish\_cont} \times F_{fish\_lake} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (34)$$

Where:			Units
$Intake_{FISH\text{-}LAKE\ c\ or\ nc}$	=	daily intake from the ingestion of fish	kg/kg-day

IR_{fish}	=	ingestion rate of fish (0.00563)	kg/day
F_{fish}	=	fraction of total fish consumed that is caught by receptor (1)	unitless
F_{fish_cont}	=	fraction of caught fish from site (i.e., that is potentially contaminated) (1)	unitless
F_{fish_lake}	=	fraction of total fish ingestion from lake (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of fish for a hunter/angler – toddler is 3.4 x 10^{-4} kg/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{FISH-LAKE} = Intake_{FISH-LAKE}\ x\ C_{FISH-LAKE} \quad (35)$$

Where:			Units
$CDI_{FISH-LAKE}$	=	chronic daily intake from ingestion of fish from the lake	mg/kg-day
$Intake_{FISH-LAKE}$	=	daily intake from ingestion of fish from the lake (non-carcinogenic)	kg/kg-day
$C_{FISH-LAKE}$	=	fish tissue concentration (lake) (2.8 x 10^{-5})	mg/kg

The CDI from ingestion of fish for a hunter/angler – toddler exposed to non-carcinogenic arsenic is 9.6 x 10^{-9} mg/kg-day.

2.2.4 Exposure from Surface Water

The following equations are used to assess the potential risk to a toddler resulting from dermal exposure and incidental ingestion of surface water from swimming.

Dermal absorbed dose per event for organic compounds is calculated as follows:
If $t_{event} \leq t^*$ then:

$$DA_{event} = 2\ AF_{Dermal}\ x\ K_p\ x\ C_w \sqrt{\frac{6\tau_{event}\ x\ t_{event}}{\pi}} \quad (36)$$

If $t_{event} > t^*$ then:

$$DA_{event} = AF_{Dermal}\ x\ K_p\ x\ C_w \left[\frac{t_{event}}{1+B} + 2\ \tau_{event}\left(\frac{1+3\ B+3B^2}{(1+B)^2}\right)\right] \quad (37)$$

For Inorganic Compounds

$$DA_{event} = K_p \; x \; C_w \; x \; t_{event} \quad (38)$$

Where		Units
DA_{event} =	Dermal dose absorbed per event	mg/cm^2 – event
AF_{Dermal} =	Dermal Absorption Factor (NA to arsenic)	unitless
K_p=	Dermal permeability coefficient of compound in water (0.001)	cm/hr
C_w =	Chemical concentration in water (5.7 x 10^{-10})	(mg/cm^3)
τ_{event} =	Lag time per event (NA to arsenic)	(hr/event)
t_{event} =	Event duration (2)	(hr/event)
t^* =	Time to reach steady state (NA to arsenic)	(hr) (2.4 τ_{event})
B =	Dimesionless ratio of the permeability coefficient through the stratum of corneum relative to its permeability coefficient across the viable epidermis (NA to arsenic)	(unitless)

A number of the above parameters are equation-driven:

$$\tau_{event} = 0.105 \times 10^{0.0056\,MW} \quad (39)$$

where MW is the molecular weight of the compound, g/mol

$$B = \frac{K_p\sqrt{MW}}{2.6} \quad (40)$$

$$if\ B > 0.6, t^* = 6K_p\left(b - \sqrt{b^2 - c^2}\right) \quad (41)$$

$$else\ if\ B \leq 0.6, t^* = 2.4K_p \quad (42)$$

where,

$$b = \frac{2((1+B)^2)}{\pi} - c \quad (43)$$

$$c = \frac{1 + 3B + 3(B^2)}{3(1+B)} \quad (44)$$

The dermal dose per event for arsenic from contact with surface water for a swimmer – toddler is 1.1 x 10^{-12} mg/cm^2 – event.

$$Intake_{DERMAL} = \frac{SA_{water} \times ET \times EF \times ED}{BW \times AT_{nc}} \quad (45)$$

Where:			Units
$Intake_{DERMAL}$	=	daily dermal intake from contact with surface water	cm^2-event/kg-day
SA_{water}	=	exposed surface area (6130)	cm^2
ET	=	exposure time (1)	event/day
EF	=	exposure frequency (14)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake for arsenic from dermal contact with surface water for a swimmer – toddler is 14.2 cm^2-event/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{DERMAL} = DA_{event} \times Intake_{DERMAL} \quad (46)$$

Where:			Units
CDI_{DERMAL}	=	chronic daily intake from ingestion of surface water	mg/kg-day
DA_{event}	=	dermal dose absorbed per event (1.1×10^{-12})	mg/cm^2-event
$Intake_{DERMAL}$	=	daily intake from dermal contact with surface water (14.2)	cm^2-event/kg-day

The CDI from dermal contact with surface water for a swimmer – toddler exposed to non-carcinogenic arsenic is 1.6×10^{-11} mg/kg-day.

Incidental ingestion of surface water from swimming is calculated as follows:

$$Intake_{WATER} = \frac{IR_{water} \times F_{water} \times AF_{oral} \times EF \times ED}{BW \times AT_{nc}} \quad (47)$$

Where:			Units
$Intake_{WATER}$	=	daily intake from the ingestion of surface water	L/kg-day
IR_{water}	=	ingestion rate of surface water (0.6)	L/day
F_{water}	=	fraction of surface water consumed from site (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (14)	days/year
ED	=	exposure duration (4.5)	years
BW	=	body weight of receptor (16.5)	kg
AT_{nc}	=	averaging time non-carcinogen (1643)	days

The daily intake from ingestion of surface water for a swimmer – toddler is 1.4×10^{-3} L/kg-day.

The chronic daily intake of arsenic is calculated as follows:

$$CDI_{WATER} = Intake_{DERMAL} \times C_{sw} \quad (48)$$

Where:			Units
CDI_{water}	=	chronic daily intake from ingestion of surface water	mg/kg-day
$Intake_{water\ nc}$	=	daily intake from ingestion of surface water (non-carcinogenic)	L/kg-day
C_{sw}	=	surface water concentration (5.7×10^{-7})	mg/L

The CDI from ingestion of surface water for a swimmer – toddler exposed to non-carcinogenic arsenic is 7.9×10^{-10} mg/kg-day.

2.2.5 Exposure from Breast Milk

The following equations are used to assess the potential risk from ingestion of breast milk for an infant receptor. For the purposes of this assessment, all organics are assumed to transfer through breast milk. The equations are detailed in McKone (1993) and US EPA (2005). The same equation is used for all organics, with the exception of dioxins and furans and PCBs. The equations for dioxins and furans are presented separately, below, where appropriate. As arsenic is not assumed to transfer through breast milk, dioxins/furans were used as the example for this calculation.

The intake of breast milk for all organics (including dioxins and furans and PCBs) is calculated using the following equation:

$$Intake_{BMILK} = \frac{IR_{BMILK} \times EF \times ED \times \rho_{bmilk}}{BW \times AT_{nc}} \quad (49)$$

Where:			Units
$Intake_{BMILK}$	=	daily intake from the ingestion of breast milk	kg/kg-day
IR_{BMILK}	=	ingestion rate of breast milk (0.742)	L/day
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (0.5)	years
ρ_{bmilk}	=	density of breast milk (1.03)	g/mL or kg/L
BW	=	body weight of receptor (8.2)	kg
AT_{nc}	=	averaging time non-carcinogen (183)	days

For a residential infant, the daily intake from ingestion of breast milk is 0.093 kg/kg-day.

The concentration of a COPC in breast milk (C_{BMILK}) is calculated using the following equations:

$$C_{BMILK} = [EXP_{mother} \times BW_{mother} \times BTF_{bmilk}] \quad (50)$$

$$C_{BMILK-dioxins} = \frac{EXP_{mother} \times h \times f_1}{0.693 \times f_2} \quad (51)$$

Where:			Units
C_{BMILK}	=	concentration in breast milk	mg/kg
EXP_{mother}	=	total intake of the mother (via all pathways) (6.5×10^{-14})	mg/kg-day
BW_{mother}	=	body weight of the mother (NA to dioxins)	kg
BTF_{bmilk}	=	breast milk biotransfer factor; discussed below (NA to dioxins)	day/kg
h	=	half-life of dioxin in mother (2,555)	days
f_1	=	fraction of ingested dioxin that is stored in fat (0.9)	unitless
f_2	=	fraction of mother's body weight that is fat (0.3)	unitless

The concentration of dioxins in breast milk is 7.2×10^{-10} mg/kg.

For the intake of breast milk, an inter-media transfer factor must be used for organics (excluding dioxins and furans and PCBs). This is the ratio of the concentration of the chemical in the contact or exposure medium of breast milk to the concentration of the chemical in the "environmental compartment" of the mother due to the exposure of the mother to the chemical in each of the environmental compartments of ambient air, water, and soil (McKone, 1993). The inter-media transfer factor in this circumstance is the partition factor, BTF_{bmilk}, the ratio of chemical concentration in mother's milk (days/kg milk) and is calculated using the following equation:

$$BTF_{BMILK} = 2.0 \times 10^{-7} \times K_{ow} \quad (52)$$

Where:			Units
BTF_{bmilk}	=	breast milk biotransfer factor	d/kg milk
K_{ow}	=	octanol-water partition coefficient (NA for dioxins)	unitless

Finally, the chronic daily intake of breast milk by the infant is calculated as follows:

$$CDI_{infant} = Intake_{bmilk} \times C_{bmilk} \times AF_{oral} \quad (53)$$

$$CDI_{infant-dioxins} = Intake_{bmilk} \times C_{bmilk} \times AF_{oral} \times F_{bmfat} \quad (54)$$

Where:			Units
CDI_{infant}	=	chronic daily intake from ingestion of breast milk	mg/kg-day
$Intake_{BMILK}$	=	daily intake from the ingestion of breast milk (0.093)	kg/kg-day

C_{BMILK}	=	concentration in breast milk (7.2×10^{-10})	mg/kg
F_{bmfat}	=	fraction of breast milk that is fat (0.04)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless

The chronic daily intake of dioxins in breast milk is 2.7×10^{-12} mg/kg-day for the residential infant.

2.2.6 Risk Characterization

After the various intakes are derived, the final step is the calculation of the non-carcinogenic hazard quotient (HQ) values and incremental lifetime cancer risks (ILCR) for each of the pathways and receptors identified. ILCRs and HQs are then summed for individual receptors, across all applicable exposure pathways to obtain an estimate of the total individual ILCRs and HQs for specific receptors.

2.2.7 Non-carcinogenic Chemicals

The potential for non-carcinogenic health effects resulting from exposure to a chemical is generally assessed by comparing an exposure estimate to a reference dose (RfD). An RfD is a daily oral intake rate that is estimated to pose no appreciable risk of adverse health effects, even to sensitive populations (US EPA, 1998a). For example, the HQ for arsenic exposure due to the soil/dust ingestion – summer – outdoor pathway was calculated as follows.

$$HQ_x = \frac{CDI_x}{RfD_x \times AF_{RfD}} \quad (55)$$

Where:			Units
HQ_x	=	hazard quotient for pathway x	unitless
CDI_x	=	COPC-specific chronic daily intake for pathway x (1.4×10^{-10})	mg/kg-day
RfD_x	=	COPC-specific reference dose for pathway x (0.0003)	mg/kg-day
AF_{RfD}	=	COPC-specific reference dose absorption factor (1)	unitless

Using the included values above, the HQ for non-carcinogenic arsenic for the soil/dust ingestion – summer – outdoor pathway for the Tooley residential grouping toddler receptor is 4.7×10^{-7}.

The total non-carcinogenic hazard attributable to exposure to a COPC via all exposure pathways is calculated as follows:

$$HQ_{total} = \sum_i HQ_x \quad (56)$$

Where:			Units
HQ_{total}	=	hazard quotient for a specific COPC	unitless
HQ_x	=	hazard quotient for a specific exposure pathway x	unitless

Summing all relevant pathways for the Tooley residential grouping toddler receptor, the total HQ for non-carcinogenic arsenic is 2.48×10^{-6} (Table 2-1).

Table 2-1 Summary of pathways considered for the total HQ for the Tooley residential grouping toddler receptor

Pathway	Calculated HQ
Soil/Dust Ingestion – Summer – Outdoor	4.74×10^{-7}
Soil/Dust Ingestion – Summer – Indoor	9.37×10^{-8}
Soil/Dust Ingestion – Winter – Outdoor	2.04×10^{-7}
Soil/Dust Dermal – Summer – Outdoor	1.11×10^{-8}
Soil/Dust Dermal – Summer – Indoor	4.89×10^{-9}

Soil/Dust Dermal – Winter – Outdoor	3.17×10^{-9}
Ingestion of Aboveground Exposed Garden Produce	1.44×10^{-6}
Ingestion of Aboveground Protected Garden Produce	2.25×10^{-7}
Ingestion of Belowground Garden Produce	2.60×10^{-8}
Total of All Pathways	**2.48×10^{-6}**

Carcinogenic Chemicals

3.0 CALCULATING HUMAN EXPOSURE RATES FOR CARCINOGENS

The following is a worked example of calculations used to evaluate the risk to a Local Resident - composite receptor from exposure to carcinogenic arsenic.

3.1 Exposure from Soil/Dust

3.1.1 Soil/Dust Ingestion – Summer - Outdoor

The following equation determines the intake of soil while outdoors in the summer due to ingestion, for a local composite receptor from the Tooley residential grouping.

$$Intake_{SDINGSO_c} = \frac{IR_{soil} \times AF_{oral} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (57)$$

Where:			Units
$Intake_{SDINGSOc}$	=	daily intake from ingestion of soil/dust – summer outdoor	kg/kg-day
IR_{soil}	=	ingestion rate of soil (25)	mg/day
AF_{oral}	=	oral absorption factor (1)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (75)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake of soil/dust – summer outdoor for a composite receptor from the Tooley residential grouping is 2.3×10^{-7} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDINGSO} = Intake_{SDINGSO_c} \times C_s \quad (58)$$

Where:			Units
$LADD_{SDINGSO}$	=	lifetime average daily dose from ingestion of soil/dust - summer outdoor	mg/kg-day
$Intake_{SDINGSO\ c}$	=	daily intake from ingestion of soil/dust - summer outdoor (carcinogenic)	kg/kg-day
C_s	=	concentration of chemical in soil (4.0×10^{-5})	mg/kg

The LADD from ingestion of soil/dust – summer outdoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 9.2×10^{-12} mg/kg-day.

3.1.2 Soil/Dust Ingestion – Summer – Indoor

The following equation determines the intake of indoor dust generated form soil in the summer due to ingestion, for a local composite receptor from the Tooley residential grouping.

$$Intake_{SDINGSI_c} = \frac{IR_{dust} \times AF_{oral} \times FR_{soili} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (59)$$

Where:			Units
$Intake_{SDINGSIc}$	=	daily intake from ingestion of soil/dust - summer indoor	kg/kg-day
IR_{dust}	=	ingestion rate of dust (4.46)	mg/day
AF_{oral}	=	oral absorption factor (1)	unitless
FR_{soili}	=	fraction of dust derived from soil (0.8)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (75)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake of soil/dust– summer indoor for a composite receptor from the Tooley residential grouping is 3.3×10^{-8} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDINGSI} = Intake_{SDINGSI_c} \times C_s \quad (60)$$

Where:			Units
$LADD_{SDINGSI}$	=	lifetime average daily dose from ingestion of soil/dust - summer indoor	mg/kg-day
$Intake_{SDINGSI\,c}$	=	daily intake from ingestion of soil/dust - summer indoor (carcinogenic)	kg/kg-day
C_s	=	concentration of chemical in soil (4.0×10^{-5})	mg/kg

The LADD from ingestion of soil/dust – summer indoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 1.3×10^{-12} mg/kg-day.

3.1.3 Soil/Dust Ingestion – Winter - Outdoor

The following equation determines the intake of soil while outdoors in the winter due to ingestion, for a local composite receptor from the Tooley residential grouping.

$$Intake_{SDINGWO_c} = \frac{IR_{soil} \times AF_{oral} \times FR_{snow} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (61)$$

Where:			Units
$Intake_{SDINGWOc}$	=	daily intake from ingestion of soil/dust - winter outdoor	kg/kg-day
IR_{soil}	=	ingestion rate of soil (25)	mg/day

AF_{oral}	=	oral absorption factor (1)	unitless
FR_{snow}	=	Fraction of winter that site is not snow covered (0.61)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (151)	days/year
ED	=	exposure duration (75)	years
CF	=	conversion factor (1 x 10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake of soil/dust– winter outdoor for a composite receptor from the Tooley residential grouping is 9.8 x 10^{-8} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDINGWO} = Intake_{SDINGWO_c} \times C_s \quad (62)$$

Where:			Units
$LADD_{SDINGWO}$	=	lifetime average daily dose from ingestion of soil/dust - winter outdoor	mg/kg-day
$Intake_{SDINGWO\ c}$	=	daily intake from ingestion of soil/dust - winter outdoor (carcinogenic)	kg/kg-day
C_s	=	concentration of chemical in soil (4.0 x 10^{-5})	mg/kg

The LADD from ingestion of soil/dust – winter outdoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 3.9 x 10^{-12} mg/kg-day.

3.1.4 Soil/Dust Dermal – Summer - Outdoor

The following equation determines the intake of soil while outdoors in the summer due to dermal contact, for a local composite receptor from the Tooley residential grouping. For summer exposure, the exposed surface area – body parameter assumes the head, arms and legs are exposed.

$$Intake_{SDERMSO_c} = \frac{\left(\left(SA_{body} \times SAF_{body}\right) + \left(SA_{hand} \times SAF_{hand}\right)\right) \times AF_{dermal} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (63)$$

Where:			Units
$Intake_{SDERMSOc}$	=	daily intake from dermal contact with soil/dust - summer outdoor	kg/kg-day
SA_{body}	=	exposed surface area - body (summer) (8880)	cm^2
SAF_{body}	=	soil adherence factor – body (0.01)	mg-soil/cm^2
SA_{hand}	=	exposed surface area – hand (833)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless

ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (75)	years
CF	=	conversion factor (1 x 10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from dermal contact with soil/dust – summer outdoor for a composite receptor from the Tooley residential grouping is 4.7 x 10^{-8} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDERMSO} = Intake_{SDERMSO_c} \times C_s \quad (64)$$

Where:			Units
$LADD_{SDINGSO}$	=	lifetime average daily dose from dermal contact of soil/dust - summer outdoor	mg/kg-day
$Intake_{SDERMSO\ c}$	=	daily intake from dermal contact with soil/dust - summer outdoor (carcinogenic)	mg/kg-day
C_s	=	concentration of chemical in soil (4.0 x 10^{-5})	mg/kg

The LADD from dermal contact with soil/dust – summer outdoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 1.89 x 10^{-12} mg/kg-day.

3.1.5 Soil/Dust Dermal – Summer – Indoor

The following equation determines the intake of indoor dust generated from soil in the summer due to dermal contact, for a local composite receptor from the Tooley residential grouping.

$$Intake_{SDERMSI_c} = \frac{\left((SA_{hand} \times SAF_{hand})\right) \times AF_{dermal} \times FR_{soil} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (65)$$

Where:			Units
$Intake_{SDERMSIc}$	=	daily intake from dermal contact with soil/dust - summer indoor	kg/kg-day
SA_{hand}	=	exposed surface area – hand (833)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless
FR_{soili}	=	fraction of dust derived from soil (0.8)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (214)	days/year
ED	=	exposure duration (75)	years

CF	=	conversion factor (1 x 10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from dermal contact with soil/dust – summer indoor for a composite receptor from the Tooley residential grouping is 1.8 x 10^{-8} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDERMSI} = Intake_{SDERMSI_c} \times C_s \quad (66)$$

Where:

			Units
$LADD_{SDINGSI}$ outdoor	=	lifetime average daily dose from dermal contact of soil/dust - summer	mg/kg-day
$Intake_{SDERMSI\ c}$ (carcinogenic)	=	daily intake from dermal contact with soil/dust - summer outdoor	mg/kg-day
C_s	=	concentration of chemical in soil (4.0 x 10^{-5})	mg/kg

The LADD from dermal contact with soil/dust – summer indoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 7.3 x 10^{-13} mg/kg-day.

3.1.6 Soil/Dust Dermal – Winter - Outdoor

The following equation determines the intake of soil while outdoors in the winter due to dermal contact, for a local composite receptor from the Tooley residential grouping. For winter exposure, the exposed surface area – body parameter assumes only the head is exposed.

$$Intake_{SDERMWO_c} = \frac{\left(\left(SA_{body} \times SAF_{body}\right) + \left(SA_{hand} \times SAF_{hand}\right)\right) \times AF_{dermal} \times FR_{snow} \times ET \times EF \times ED \times CF}{BW \times AT_c} \quad (67)$$

Where:

			Units
$Intake_{SDERMWOc}$	=	daily intake from dermal contact with soil/dust - winter outdoor	kg/kg-day
SA_{body}	=	exposed surface area - body (winter) (1370)	cm^2
SAF_{body}	=	soil adherence factor – body (0.01)	mg-soil/cm^2
SA_{hand}	=	exposed surface area – hand (833)	cm^2
SAF_{hand}	=	soil adherence factor – hand (0.1)	mg-soil/cm^2
AF_{dermal}	=	dermal absorption factor (0.03)	unitless

FR_{snow}	=	fraction of winter that ground is not snow-covered (0.61)	unitless
ET	=	exposure time (1)	unitless
EF	=	exposure frequency (151)	days/year
ED	=	exposure duration (75)	years
CF	=	conversion factor (1×10^{-6})	kg/mg
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from dermal contact with soil/dust – winter outdoor for a composite receptor from the Tooley residential grouping is 1.14×10^{-8} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{SDERMWO} = Intake_{SDERMWO_c} \times C_s \quad (68)$$

Where:			Units
$LADD_{SDINGWO}$	=	lifetime average daily dose from dermal contact of soil/dust - winter outdoor	mg/kg-day
$Intake_{SDERMWO\ c}$ (carcinogenic)	=	daily intake from dermal contact with soil/dust - winter outdoor	mg/kg-day
C_s	=	concentration of chemical in soil (4.0×10^{-5})	mg/kg

The LADD from dermal contact with soil/dust – winter outdoor for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 4.6×10^{-13} mg/kg-day.

3.2 Exposure from Food Consumption

The following equations are used to assess the potential risk resulting from ingestion of produce grown in backyard gardens, wild game, and fish. The ingestion rates of produce, wild game, and fish differ depending on the receptor chosen. In general, food consumption rates were taken from the Exposure Factors Handbook (US EPA, 1997) or Health Canada, 2004a. Receptor specific inputs are discussed in the appropriate sections below.

3.2.1 Ingestion of Homegrown Aboveground Exposed Garden Produce

The following equation determines the intake of homegrown exposed garden produce, for a local composite receptor from the Tooley residential grouping.

$$Intake_{AGPROD_c} = \frac{IR_{ap} \times F_p \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (69)$$

Where:			Units
$Intake_{AGPRODc}$	=	daily intake from the ingestion of aboveground produce	kg/kg-day
IR_{ap}	=	ingestion rate of aboveground produce (0.0221)	kg/day
F_{ap}	=	fraction of aboveground produce consumed from site (0.233)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of homegrown aboveground exposed garden produce for a composite receptor from the Tooley residential grouping is 8.0 x 10^{-5} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{AGPROD} = Intake_{AGPROD_c} \times \left(P_d + Pr_{ag} + P_v\right) \qquad (70)$$

Where:			Units
$LADD_{AGPROD}$	=	lifetime average daily dose from ingestion of aboveground produce	mg/kg-day
$Intake_{AGPROD\ c}$	=	daily intake from ingestion of aboveground produce (carcinogenic)	kg/kg-day
P_d	=	concentration in produce due to direct (wet and dry) deposition	mg/kg
P_v	=	concentration in produce from air-to-plant transfer	mg/kg
Pr_{ag}	=	concentration in aboveground produce due to root uptake	mg/kg

Note: $P_d + P_v + Pr_{ag}$ is the total concentration in aboveground produce. (2.4 x 10^{-6})

The LADD from ingestion of homegrown aboveground exposed garden produce for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 1.9 x 10^{-10} mg/kg-day.

3.2.2 Ingestion of Homegrown Aboveground Protected Garden Produce

The following equation determines the intake of homegrown aboveground protected garden produce, for a local composite receptor from the Tooley residential grouping.

$$Intake_{AGPPROD_c} = \frac{IR_{app} \times F_{app} \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_c} \qquad (71)$$

Where:			Units
$Intake_{AGPPRODc}$	=	daily intake from the ingestion of aboveground protected produce	kg/kg-day
IR_{app}	=	ingestion rate of aboveground protected produce (0.0422)	kg/day
F_{app}	=	fraction of aboveground protected produce consumed from site (0.178)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless

EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of aboveground protected garden produce for a composite receptor from the Tooley residential grouping is 1.2 x 10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{AGPROD} = Intake_{AGPROD_c} \times Pr_{ag} \quad (72)$$

Where:			Units
$LADD_{AGPPROD}$	=	lifetime average daily dose from ingestion of aboveground protected produce	mg/kg-day
$Intake_{AGPPROD\ c}$	=	daily intake from ingestion of aboveground protected produce (carcinogenic)	kg/kg-day
Pr_{ag}	=	concentration in aboveground produce due to root uptake (2.5 X 10^{-7})	mg/kg

The LADD from ingestion of aboveground protected garden produce for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 3.0 x 10^{-11} mg/kg-day.

3.2.3 Ingestion of Homegrown Belowground Garden Produce

The following equation determines the intake of homegrown belowground garden produce, for a local composite receptor from the Tooley residential grouping.

$$Intake_{BGPROD_c} = \frac{IR_{bp} \times F_{bp} \times WP \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (73)$$

Where:			Units
$Intake_{BGPRODc}$	=	daily intake from the ingestion of belowground produce	kg/kg-day
IR_{bp}	=	ingestion rate of belowground produce (0.00922)	kg/day
F_{bp}	=	fraction of belowground produce consumed from site (0.106)	unitless
WP	=	washing/peeling factor (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of belowground garden produce for a composite receptor from the Tooley residential grouping is 1.5 x 10^{-5} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{BGPROD} = Intake_{BGPROD_c} \times Pr_{bg} \quad (74)$$

Where:			Units
$LADD_{BGPROD}$	=	lifetime average daily dose from ingestion of belowground produce	mg/kg-day
$Intake_{BGPROD\ c}$	=	daily intake from ingestion of belowground produce (carcinogenic)	kg/kg-day
Pr_{bg}	=	concentration in belowground produce due to root uptake (3.2×10^{-7})	mg/kg

The LADD from ingestion of belowground garden produce for a composite receptor from the Tooley residential grouping exposed to carcinogenic arsenic is 4.8×10^{-12} mg/kg-day.

3.2.4 Ingestion of Homegrown Garden Fruit

The following equation determines the intake of homegrown garden fruit, for a local composite receptor from the Tooley residential grouping. Arsenic concentrations were not available for homegrown garden fruit, therefore pentachlorophenol was used for this example calculation.

$$Intake_{\ Fruit_{\ c}} = \frac{IR_{fr} \ x \ F_{fr} x \ AF_{oral} \ x \ EF \ x \ ED}{BW \ x \ AT_c} \quad (75)$$

Where:			Units
$Intake_{fruitc}$	=	daily intake from the ingestion of homegrown fruit	kg/kg-day
IR_{fr}	=	ingestion rate of homegrown fruit (0.076)	kg/day
F_{fr}	=	fraction of homegrown fruit consumed from site (0.116)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of homegrown garden fruit for a local composite resident from the Tooley residential grouping is 1.4×10^{-4} kg/kg-day.

The lifetime average daily dose of pentachlorophenol is calculated as follows:

$$\mathrm{LADD}_{Fruit} = Intake_{Fruit_c} \ x \ C_{fr} \quad (76)$$

Where:			Units
$LADD_{fruit}$	=	lifetime average daily dose from ingestion of homegrown fruit	mg/kg-day

$Intake_{fruitc}$	=	daily intake from ingestion of homegrown fruit (carcinogenic)	kg/kg-day
C_{fr}	=	concentration in belowground homegrown fruit (1.4×10^{-6})	mg/kg

The LADD from ingestion of homegrown garden fruit for a local composite resident in the Tooley residential grouping exposed to pentachlorophenol is 1.9×10^{-10} mg/kg-day.

3.2.5 Ingestion of Beef

The following is an example of calculations used to evaluate the risk from ingestion of beef to a farmer composite receptor exposed to carcinogenic arsenic.

$$Intake_{Beef_c} = \frac{IR_{beef} \times F_{beef} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (77)$$

Where:			Units
$Intake_{beefc}$	=	daily intake from the ingestion of beef	kg/kg-day
IR_{beef}	=	ingestion rate of beef (0.075)	kg/day
F_{beef}	=	fraction of beef consumed from site (0.478)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of beef for a local toddler resident from the farmer grouping is 5.6×10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$\mathrm{LADD}_{Beef} = Intake_{Beef_c} \, x \, C_{Beef} \quad (78)$$

Where:			Units
$LADD_{beef}$	=	lifetime average daily dose from ingestion of beef	mg/kg-day
$Intake_{beefc}$	=	daily intake from ingestion of beef (carcinogenic)	kg/kg-day
C_{beef}	=	concentration in beef (5.9×10^{-7})	mg/kg

The LADD from ingestion of beef for a local toddler in the farmer grouping exposed to carcinogenic arsenic is 3.3×10^{-10} mg/kg-day.

3.2.6 Ingestion of Milk

The following is an example of calculations used to evaluate the risk from ingestion of milk to a farmer composite receptor exposed to carcinogenic arsenic.

$$Intake_{Milk_c} = \frac{IR_{milk} \times F_{milk} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (79)$$

Where:			Units
$Intake_{milkc}$	=	daily intake from the ingestion of milk	L/kg-day
IR_{milk}	=	ingestion rate of milk (0.9)	L/day
F_{milk}	=	fraction of milk consumed from site (0.254)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of milk for a local toddler resident from the farmer grouping is 3.6 x 10^{-3} L/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$\mathrm{LADD}_{Milk} = Intake_{Milk_c} \, x \, C_{Milk} \quad (80)$$

Where:			Units
$LADD_{Milk}$	=	lifetime average daily dose from ingestion of milk	mg/kg-day
$Intake_{Milkc}$	=	daily intake from ingestion of milk (carcinogenic)	L/kg-day
C_{Milk}	=	concentration in milk (2.5 x 10^{-8})	mg/L

The LADD from ingestion of milk for a local toddler in the farmer grouping exposed to carcinogenic arsenic is 9.0 x 10^{-11} mg/kg-day.

3.2.7 Ingestion of Pork

The following is an example of calculations used to evaluate the risk from ingestion of pork to a farmer composite receptor exposed to carcinogenic arsenic.

$$Intake_{Pork_c} = \frac{IR_{pork} \times F_{pork} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (81)$$

Where:			Units
$Intake_{porkc}$	=	daily intake from the ingestion of pork	kg/kg-day
IR_{pork}	=	ingestion rate of pork (0.034)	kg/day
F_{pork}	=	fraction of pork consumed from site (0.239)	unitless

AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of pork for a local toddler resident from the farmer grouping is 1.3 x 10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{pork} = Intake_{pork_c} \, x \, C_{pork} \qquad (82)$$

Where:			Units
$LADD_{pork}$	=	lifetime average daily dose from ingestion of pork	mg/kg-day
$Intake_{porkc}$	=	daily intake from ingestion of pork (carcinogenic)	kg/kg-day
C_{pork}	=	concentration in pork (9,3 x 10^{-8})	mg/kg

The LADD from ingestion of pork for a local toddler in the farmer grouping exposed to carcinogenic arsenic is 1.2 x 10^{-11} mg/kg-day.

3.2.8 Ingestion of Poultry

The following is an example of calculations used to evaluate the risk from ingestion of poultry to a farmer composite receptor exposed to carcinogenic arsenic.

$$Intake_{\ Poultry_c} = \frac{IR_{poultry} \times F_{poultry} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \qquad (83)$$

Where:			Units
$Intake_{poultryc}$	=	daily intake from the ingestion of poultry	kg/kg-day
$IR_{poultry}$	=	ingestion rate of poultry (0.041)	kg/day
$F_{poultry}$	=	fraction of poultry consumed from site (0.151)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of poultry for a local toddler resident from the farmer grouping is 9.7 x 10^{-5} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{poultry} = Intake_{poultry_c} \, x \, C_{poultry} \quad (84)$$

Where:			Units
$LADD_{poultry}$	=	lifetime average daily dose from ingestion of poultry	mg/kg-day
$Intake_{poultryc}$	=	daily intake from ingestion of poultry (carcinogenic)	kg/kg-day
$C_{poultry}$	=	concentration in poultry (1.9 x 10^{-9})	mg/kg

The LADD from ingestion of poultry for a local toddler in the farmer grouping exposed to carcinogenic arsenic is 1.8 x 10^{-13} mg/kg-day.

3.2.9 Ingestion of Eggs

The following is an example of calculations used to evaluate the risk from ingestion of eggs to a farmer composite receptor exposed to carcinogenic arsenic.

$$Intake_{Eggs_c} = \frac{IR_{eggs} \times F_{eggs} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (85)$$

Where:			Units
$Intake_{eggsc}$	=	daily intake from the ingestion of eggs	kg/kg-day
IR_{eggs}	=	ingestion rate of eggs (0.047)	kg/day
F_{eggs}	=	fraction of eggs consumed from site (0.214)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of eggs for a local toddler resident from the farmer grouping is 1.6 x 10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{eggs} = Intake_{eggs_c} \, x \, C_{eggs} \quad (86)$$

Where:			Units
$LADD_{eggs}$	=	lifetime average daily dose from ingestion of eggs	mg/kg-day
$Intake_{eggsc}$	=	daily intake from ingestion of eggs (carcinogenic)	kg/kg-day
C_{eggs}	=	concentration in eggs (1.06 x 10^{-9})	mg/kg

The LADD from ingestion of eggs for a local toddler in the farmer grouping exposed to carcinogenic arsenic is 1.7 x 10^{-13} mg/kg-day.

Appendix G – Human Receptor Characteristics, Human Health Exposure Equations and Worked Example

3.2.10 Ingestion of Wild Game

The following is an example of calculations used to evaluate the risk from ingestion of wild game to a composite receptor from a hunting/angling household, exposed to non-carcinogenic arsenic.

$$Intake_{WG_c} = \frac{IR_{wg} \times F_{wg} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (87)$$

Where:			Units
$Intake_{WGc}$	=	daily intake from the ingestion of wild game	kg/kg-day
IR_{wg}	=	ingestion rate of wild game (0.0632)	kg/day
F_{wg}	=	fraction of wild game consumed from site (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen = (27375)	days

The daily intake from ingestion of wild game for a hunter angler composite receptor is 9.9 x 10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{wg} = Intake_{wg_c} \, x \, C_{wg} \quad (88)$$

Where:			Units
$LADD_{WG}$	=	lifetime average daily dose from ingestion of wild game	mg/kg-day
$Intake_{WGc}$	=	daily intake from ingestion of wild game (carcinogenic)	kg/kg-day
C_{wg}	=	concentration of COPC in wild game (9.5 x 10^{-8})	mg/kg

The LADD from ingestion of wild game for a hunter angler composite receptor exposed to carcinogenic arsenic is 9.4 x 10^{-11} mg/kg-day.

3.2.11 Ingestion of Fish

The model is able to calculate different concentrations for a lake and a river within the same watershed. For the assessment of risk, all fish are assumed to come from McLaughlin Bay which yields the highest intake for each COPC. For the purposes of this assessment, all fish were assumed to come from a lake. A hunter/angler composite receptor was assumed for this worked example.

$$Intake_{FISH-LAKE_c} = \frac{IR_{fish} \times F_{fish} \times F_{fish\_cont} \times F_{fish\_lake} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (89)$$

Where:			Units
$Intake_{FISH-LAKEc}$	=	daily intake from the ingestion of fish	kg/kg-day
IR_{fish}	=	ingestion rate of fish (0.0115)	kg/day
F_{fish}	=	fraction of total fish consumed that is caught by receptor (1)	unitless
F_{fish_cont}	=	fraction of caught fish from site (i.e., that is potentially contaminated) (1)	unitless
F_{fish_lake}	=	fraction of total fish ingestion from lake (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (365)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_c	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of fish for a hunter angler composite receptor is 1.8 x 10^{-4} kg/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{FISH-LAKE} = Intake_{FISH-LAKE_c} \; x \; C_{FISH-LAKE} \qquad (90)$$

Where:			Units
$LADD_{fish\_lake}$	=	lifetime average daily dose from ingestion of fish from the lake	mg/kg-day
$Intake_{fish\_lakec}$	=	daily intake from ingestion of fish from the lake (carcinogenic)	kg/kg-day
C_{fish_lake}	=	fish tissue concentration (lake) (2.9 x 10^{-5})	mg/kg

The LADD from ingestion of fish for a hunter angler composite receptor exposed to carcinogenic arsenic is 5.2 x 10^{-9} mg/kg-day.

3.2.12 Exposure from Surface Water

The following equations are used to assess the potential risk to a composite receptor resulting from dermal exposure and incidental ingestion of surface water from swimming.

Dermal absorbed dose per event for organic compounds is calculated as follows:
If $t_{event} \leq t^*$ then:

$$DA_{event} = 2 \; AF_{Dermal} \; x \; K_p \; x \; C_w \sqrt{\frac{6\tau_{event} \; x \; t_{event}}{\pi}} \qquad (91)$$

If $t_{event} > t^*$ then:

$$DA_{event} = AF_{Dermal}\ x\ K_p\ x\ C_w \left[\frac{t_{event}}{1+B} + 2\ \tau_{event}\left(\frac{1+3\ B+3B^2}{(1+B)^2}\right)\right] \quad (92)$$

For Inorganic Compounds

$$DA_{event} = K_p\ x\ C_w\ x\ t_{event} \quad (93)$$

Where		Units
DA_{event} =	Dermal dose absorbed per event	mg/cm^2 – event
AF_{Dermal} =	Dermal Absorption Factor (NA to arsenic)	unitless
K_p=	Dermal permeability coefficient of compound in water (0.001)	cm/hr
C_w =	Chemical concentration in water (5.3×10^{-10})	(mg/cm^3)
τ_{event} =	Lag time per event (NA to arsenic)	
t_{event} =	Event duration (2)	(hr/event)
t^* =	Time to reach steady state (NA to arsenic)	(hr) (2.4 τ_{event})
B =	Dimesionless ratio of the permeability coefficient through the stratum of corneum relative to its permeability coefficient across the viable epidermis (NA to arsenic)	(unitless)

A number of the above parameters are equation-driven:

$$\tau_{event} = 0.105 \times 10^{0.0056\ MW} \quad (94)$$

where MW is the molecular weight of the compound, g/mol

$$B = \frac{K_p\sqrt{MW}}{2.6} \quad (95)$$

$$if\ B > 0.6, t^* = 6K_p\left(b - \sqrt{b^2 - c^2}\right) \quad (96)$$

$$else\ if\ B \leq 0.6, t^* = 2.4K_p \quad (97)$$

where,

$$b = \frac{2((1+B)^2)}{\pi} - c \quad (98)$$

$$c = \frac{1+3B+3(B^2)}{3(1+B)} \quad (99)$$

The dermal dose per event for arsenic from contact with surface water for a swimmer – composite is 1.1 x 10^{-12} mg/cm^2 – event.

$$Intake_{DERMAL_c} = \frac{SA_{water} \times ET \times EF \times ED}{BW \times AT_c} \quad (100)$$

Where:			Units
$Intake_{DERMALc}$	=	daily dermal intake from contact with surface water	cm^2-event/kg-day
SA_{water}	=	exposed surface area (16182)	cm^2
ET	=	exposure time (1)	event/day
EF	=	exposure frequency (14)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg
AT_{nc}	=	averaging time carcinogen (27375)	days

The daily intake for arsenic from dermal contact with surface water for a swimmer – composite is 9.68 cm^2-event/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{DERMAL} = DA_{event} \times Intake_{DERMAL_c} \quad (101)$$

Where:			Units
$LADD_{DERMAL}$	=	lifetime average daily dose from ingestion of surface water	mg/kg-day
DA_{event}	=	dermal dose absorbed per event (1.1 x 10^{-12})	mg/cm^2-event
$Intake_{DERMALc}$	=	daily intake from dermal contact with surface water (9.68)	cm^2-event/kg-day

The LADD from dermal contact with surface water for a swimmer – composite exposed to carcinogenic arsenic is 1.1 x 10^{-11} mg/kg-day.

Incidental ingestion of surface water from swimming is calculated as follows:

$$Intake_{WATER_c} = \frac{IR_{water} \times F_{water} \times AF_{oral} \times EF \times ED}{BW \times AT_c} \quad (102)$$

Where:			Units
$Intake_{WATERc}$	=	daily intake from the ingestion of surface water	L/kg-day
IR_{water}	=	ingestion rate of surface water (1.34)	L/day
F_{water}	=	fraction of surface water consumed from site (1)	unitless
AF_{oral}	=	oral absorption factor (1)	unitless
EF	=	exposure frequency (14)	days/year
ED	=	exposure duration (75)	years
BW	=	body weight of receptor (63.3)	kg

AT_{nc}	=	averaging time carcinogen (27375)	days

The daily intake from ingestion of surface water for a swimmer composite receptor is 8.0 x 10^{-4} L/kg-day.

The lifetime average daily dose of arsenic is calculated as follows:

$$LADD_{water} = Intake_{water_c} \times C_{sw} \quad (103)$$

Where:			Units
$LADD_{water}$	=	lifetime average daily dose from ingestion of surface water	mg/kg-day
$Intake_{waterc}$	=	daily intake from ingestion of surface water	L/kg-day
C_{sw}	=	surface water concentration (5.7 x 10^{-7})	mg/L

The LADD from ingestion of surface water for a swimmer composite receptor exposed to carcinogenic arsenic is 4.6 x 10^{-10} mg/kg-day.

3.2.13 Risk Characterization

After the various intakes are derived, the final step is the calculation of the incremental lifetime cancer risks (ILCR) and non-carcinogenic hazard quotient (HQ) values for each of the pathways and receptors identified. ILCRs and HQs are then summed for individual receptors, across all applicable exposure pathways to obtain an estimate of the total individual ILCRs and HQs for specific receptors.

3.2.14 Carcinogenic chemicals

For carcinogenic chemicals, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of a specific exposure to that chemical (US EPA, 2005). Since carcinogenic risk estimates are over a lifetime of exposure, a composite receptor comprising five separate life stages (infant, toddler, child, teen, adult) was used to evaluate carcinogenic intakes, with the exception of the daycare receptor, where an adult worker was used, as it is reasonable to assume that no person will be present in their working environment during other lifestages for any significant amount of time. A lifetime average daily dose was derived for each receptor and each exposure pathway to get a pathway specific cancer risk. For example, the ILCR for arsenic exposure due to the soil/dust ingestion – summer – outdoor pathway was calculated as follows.

$$ILCR_x = LADD_x \times \frac{CSF_x}{AF_{CSF}} \quad (104)$$

Where:			Units
$ILCR_x$	=	incremental lifetime cancer risk for pathway x	unitless
$LADD_x$	=	COPC-specific lifetime average daily dose for pathway x (9.17 x 10^{-12})	mg/kg-day

CSF_x	=	COPC-specific cancer slope factor for pathway x (1.5)	$(mg/kg\text{-}day)^{-1}$
AF_{CSF}	=	COPC-specific cancer slope factor absorption factor (1)	unitless

Using the included values above, the ICLR for arsenic for the soil/dust ingestion – summer – outdoor pathway for the Tooley residential grouping composite receptor is 1.4 x 10^{-11}.

The total carcinogenic hazard attributable to exposure to a COPC via all exposure pathways is calculated as follows:

$$ILCR_{total} = \sum_{i} ILCR_x \quad (105)$$

Where:			Units
$ILCR_{total}$	=	total risk for a specific COPC	unitless
$ILCR_x$	=	incremental lifetime cancer risk for pathway x	unitless

Summing all relevant pathways for the Tooley residential grouping composite receptor, the total ILCR for arsenic is is 3.67 x 10^{-10} (Table 3-1).

Table 3-1 Summary of pathways considered for the total ILCR for the Tooley residential grouping composite receptor

Pathway	Calculated ILCR
Soil/Dust Ingestion – Summer – Outdoor	1.38 x 10^{-11}
Soil/Dust Ingestion – Summer – Indoor	1.96 x 10^{-12}
Soil/Dust Ingestion – Winter – Outdoor	5.92 x 10^{-12}
Soil/Dust Dermal – Summer – Outdoor	2.83 x 10^{-12}
Soil/Dust Dermal – Summer – Indoor	1.10 x 10^{-12}
Soil/Dust Dermal – Winter – Outdoor	6.87 x 10^{-13}
Ingestion of Aboveground Exposed Garden Produce	2.89 x 10^{-10}
Ingestion of Aboveground Protected Garden Produce	4.45 x 10^{-11}
Ingestion of Belowground Garden Produce	7.32 x 10^{-12}
Total of All Pathways	**3.67 x 10^{-10}**

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