4.0 EXPOSURE ASSESSMENT

The goal of the exposure assessment for a HHRA is to determine the total daily exposure (or dose) of a contaminant (mg of contaminant per kg of body weight per day). Conceptual diagrams were used to determine which exposure pathways needed to be assessed for each of the human health receptor scenarios: Storage Facility Employee (adult) and Local Resident (adult and child).

Mathematical exposure equations provided in the POPs ToolKit (http://www.popstoolkit.com/riskassessment/eco.aspx) were used to complete the Exposure Assessment calculations (Figure 4.1).

Figure 4.1 Equations used in the Exposure Assessment.

Accidental Soil Ingestion Dose Calculation (hide)

$$Dose_{SoilIngestion} = \frac{(C_S \times IR_S \times AF_{GIT} \times D_{Hours} \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times 16 \times 365 \times LE} =$$

C_S =		mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
IR_S =		kg/day	Accidental soil ingestion rate for adult (see Table: Receptor Characteristics)
AF_{GIT} =		(unitless)	Absorption Factor for the gastrointestinal tract. **Use a value of 1** for a preliminary risk assessment (as recommended by Health Canada, 2004)
D_{Hours} =		# of hours	Hours per-day with exposure (0 - 16) *(16 is the maximum assumed awake hours per day)*
D_{Days} =		# of days in a week	Days in a week with exposure (0 - 7)
D_{Weeks} =		# of weeks in a year	Weeks in a year with exposure (0 - 52)
D_{Years} =	N/A	years	Number of years of exposure (not used for non-carcinogens)
BW =		kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE =	N/A	years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Food Ingestion Dose Calculation (hide)

$$Dose_{FoodIngestion} = \frac{(C_{food} \times IR_{food} \times AF_{GIT} \times D_{Days} \times D_{Years})}{BW \times 365 \times LE} =$$

C_{food} =		mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
IR_{food} =		kg/day	Food ingestion rate (see Table: Receptor Characteristics)
AF_{GIT} =		(unitless)	Absorption Factor for the gastrointestinal tract. **Use a value of 1 for a preliminary risk assessment** (as recommended by Health Canada, 2004)
D_{Days} =		# of days in a year food item is ingested	Number of days in a year food from the site is ingested (0 - 365)
D_{Years} =	N/A	years	Number of years of exposure (not used for non-carcinogens)
BW =		kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE =	N/A	years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Figure 4.1 (Cont'd.)

Inhalation of contaminated particles Dose Calculation (hide)

$$Dose_{ParticleInhalation} = \frac{(C_S \times P_{Air} \times IR_A \times AF_{Inh} \times D_{Hours} \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times 365 \times LE \times 10e^{-9}} =$$

C_S =		mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
P_{Air} =		µg/m^3	Concentration of particles in the air. **Use 0.76µg/m^3** for typical conditions as per USEPA (1992)
IR_A =		m^3/hour	Inhalation rate (see Table: Receptor Characteristics)
AF_{Inh} =		(unitless)	Absorption Factor for the lungs. **Use a value of 1** for a preliminary risk assessment (as recommended by Health Canada, 2004)
D_{Hours} =		# of hours in a day	Hours of a day with exposure (0 - 24)
D_{Days} =		# of days in a week	Days in a week with exposure (0 - 7)
D_{Weeks} =		# of weeks in a year	Weeks in a year with exposure (0 - 52)
D_{Years} =	N/A	years	Number of years of exposure (not used for non-carcinogens)
BW =		kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE =	N/A	years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Dermal contact with contaminated soil Dose Calculation (hide)

$$Dose_{DermalContact} = \frac{(C_S \times SA_H \times SL_H \times AF_{Skin} \times EF \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times 365 \times LE} =$$

C_S =		mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
SA_H =		cm^2	Surface area of hands (assumes only hands are exposed, see Table: Receptor Characteristics)
SL_H =		kg/cm^2 - event	Soil loading to exposed skin (see Table: Receptor Characteristics). For a given area of skin, hands will be exposed to a greater mass of contaminated soil than skin on other parts of the body. Health Canada (2004) give hands a 10x greater loading (SLH) than other skin covered portions of the body.
AF_{Skin} =		(unitless)	Absorption Factor for the skin (see Table: Relative Dermal Absorption Factors)
EF =		events/day	number of dermal exposures per day
D_{Days} =		# of days in a week	Days in a week with exposure (0 - 7)
D_{Weeks} =		# of weeks in a year	Weeks in a year with exposure (0 - 52)
D_{Years} =	N/A	years	Number of years of exposure (not used for non-carcinogens)
BW =		kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE =	N/A	years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

4.1 IDENTIFICATION OF DATA NEEDS

The Exposure Assessment model required concentration data for soil and food items. For PCBs (and other POPs), the absorption of contaminants from water was not assessed, because the concentration in water will generally be extremely low (due to low solubility and greater affinity to sequester into sediment); potential for dermal exposure via water as a major pathway is therefore reduced.

The maximum concentrations measured in each exposure scenario data grouping (i.e., on-site soils, near-field off-site soils, sediments and tissues) was used in the exposure model (Table 4.1) to provide a reasonable worst-case exposure estimate given the limited number of samples available. The reason for using the maximum is that it provides a reasonable worst-case exposure estimate for a small amount of data. If the data set was larger, for instance more than 20 quantified measurements in each data grouping, then it would be acceptable to use the 90th percentile concentration or a 95% upper confidence limit of the mean. An exception was made for the fish data, because fish where collected from very different environments. Fish collected from the Chao Phraya River were purposely left out of analysis, because contaminant concentrations observed in tissue may be a reflection of other upstream sources of these chemicals.

As discussed in methods section (section 2.6.2), a sub-set of the samples assessed using CALUX analysis were re-assessed using HR-GCMS. The results of the CALUX (section 3.1, Appendix A2) and the HR-GCMS analysis (Table 4.2) were both considered for selecting model input concentrations. Consistent with the conservative approach adopted for screening level risk assessments, the higher of the CALUX or HR-GCMS results was adopted for the risk assessment calculations (Table 4.3).

PCDDs/PCDFs and DL-PCBs concentrations, expressed as pg TEQ/g, were added together before running the exposure model. The reason for doing this is as follows:

- PCDDs/PCDFs and DL-PCBs are likely form the same source (Johnson et al., 2008), and therefore their exposure is coincident;
- Because dioxins/furans and DL-PCBs are expressed in terms of 2,3,7,8 TCDD toxic equivalence, the concentrations can be added together; and
- By adding PCDDs/PCDFs and DL-PCBs together, the risk assessment provides a more conservative estimate of risk from similar acting contaminants.

Table 4.1 Contaminant concentration data needs for each exposure scenario.

	MEA Facility Employee	Local Residents	Aquatic Animal	Terrestrial Animal
Soils				
On-site Surface Soils	Yes			Yes
Off-site Soils		Yes	Yes	Yes
Sediments			Yes	
Tissue	Yes	Yes		

Table 4.2 HR-GCMS analysis results for PCBs and PCDD/F.

		PCDDs/Fs - TEQs (TEQs, WHO 2005)		DL-PCBs (TEQs, WHO 2005)		Total PCDDs/ Fs	Total PCBs
		pg TEQ/g		pg TEQ/g		pg/g	pg/g
Soils or Dust[1]		ND=0	ND=1/ 2DL	ND=0	ND=1/ 2DL		
08THA005	Storage area (concrete floor).	NM	NM	197.00	199.00	NM	NM
08THA010	Ditch near the storage area.	NM	NM	152	154	NM	NM
08THA019	River bed center of site.	1.59	1.61	0.74	0.76	386.44	29600
Tissue Data[2]							
08THA-036	Apple snail (Pila ampullaceal) collected from river in front of the site.	NM	NM	0.0532	0.094	NM	NM

"NM" indicates that the parameter was not assessed.
"(##)" indicates that the concentration was measured, but does not meet minimum quantification criteria, therefore there is greater uncertainty associated with this concentration.
"TEQ" is toxic equivalence quotient.
[1] Concentration was based on dry weight of soil.
[2] Concentration was based on wet weight of tissue.

Table 4.3 Contaminant concentrations to be used in the exposure model.

Contaminant Of Potential Concern	pg TEQ/g (WHO 2005)
On-site Soils[1]	
PCB	216.9
PCDD/PCDFs	14.0
PCB + PCDD/PCDFs	230.7
Off-site Soils[1]	
PCB	114.3
PCDD/PCDFs	20.6
PCB + PCDD/PCDFs	134.9
Fish Tissue Data[2]	
PCB	577.5
PCDD/PCDFs	72.4
PCB + PCDD/PCDFs	649.9

Once the exposure concentrations have been selected, the next step is to assemble a model input table (Table 4.4). This table provides all the variables required to run the exposure component of the risk assessment model. If possible, country-specific variables should be put into the table. However, where country specific values do not exist, values can be extracted from a default table provided in the model. It should be understood; however, that the default values were intended for a Canadian population. Consequently many of the values should be refined. For instance, the default body weight for an adult is given as 70.7 kg. In most Asian countries, the average body weights of an adult are closer to 60kg.

Table 4.4 Risk Characterization Tool Input Table.

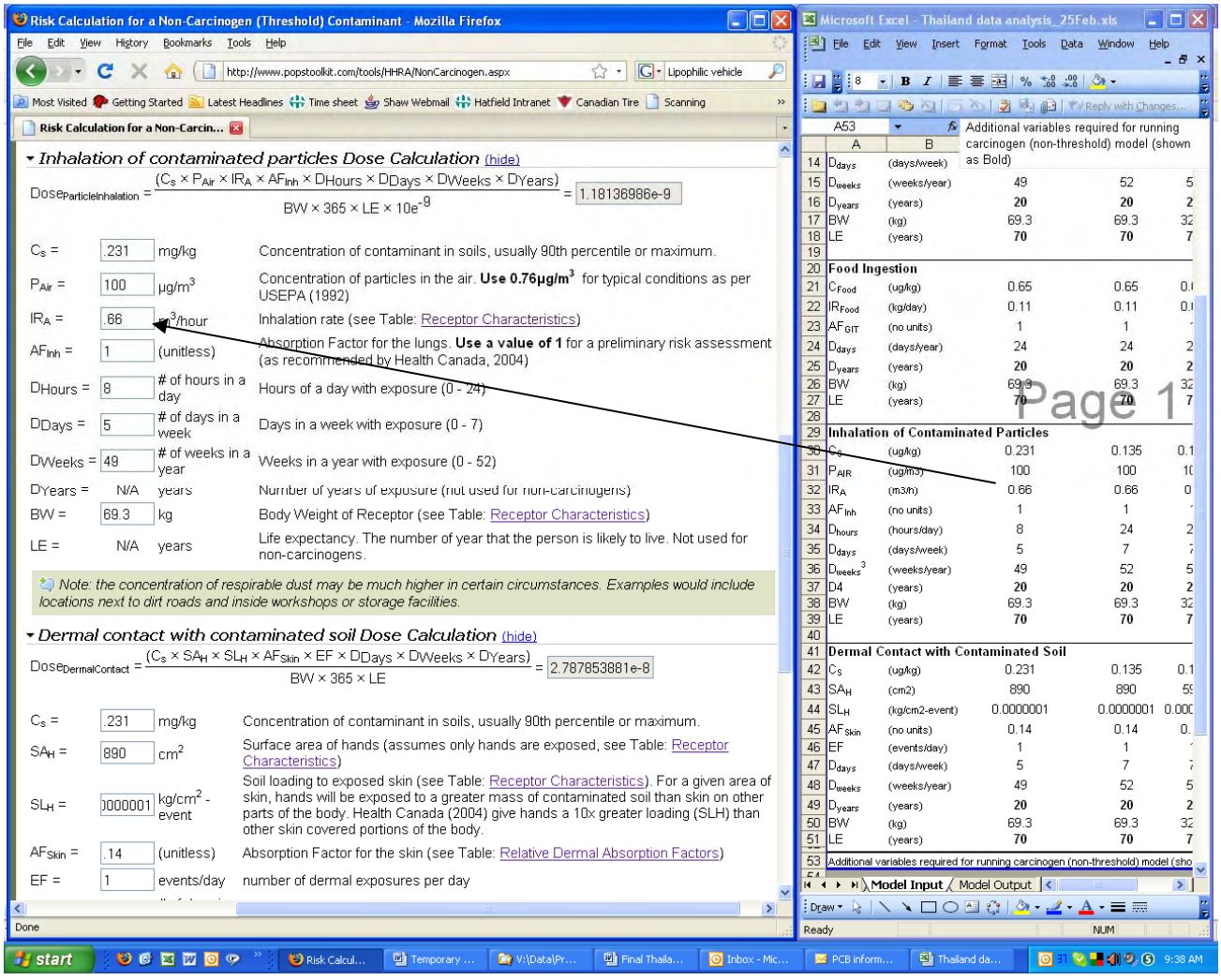
Location		MEA Employee	Local Resident	
		Adult	Adult	Child
		Storage site	Home	Home
Accidental Soil Ingestion				
C_S	(ug/kg)	0.231	0.135	0.135
IR_S	kg/day	0.00002	0.00002	0.00002
AF_{GIT}	(no units)	1	1	1
D_{hours}	(hours/day)	8	16	16
D_{days}	(days/week)	5	7	7
D_{weeks}	(weeks/year)	49	52	52
D_{years}	(years)	**20**	**20**	**20**
BW	(kg)	69.3	69.3	32.9
LE	(years)	**70**	**70**	**70**
Food Ingestion				
C_{Food}	(ug/kg)	0.65	0.65	0.65
IR_{Food}	(kg/day)	0.11	0.11	0.09
AF_{GIT}	(no units)	1	1	1
D_{days}	(days/year)	24	24	24
D_{years}	(years)	**20**	**20**	**20**
BW	(kg)	69.3	69.3	32.9
LE	(years)	**70**	**70**	**70**
Inhalation of Contaminated Particles				
C_S	(ug/kg)	0.231	0.135	0.135
P_{AIR}	(ug/m3)	100	100	100
IR_A	(m3/h)	0.66	0.66	0.6
AF_{Inh}	(no units)	1	1	1
D_{hours}	(hours/day)	8	24	24
D_{days}	(days/week)	5	7	7
D_{weeks}^3	(weeks/year)	49	52	52
D4	(years)	**20**	**20**	**20**
BW	(kg)	69.3	69.3	32.9
LE	(years)	**70**	**70**	**70**
Dermal Contact with Contaminated Soil				
C_S	(ug/kg)	0.231	0.135	0.135
SA_H	(cm2)	890	890	590
SL_H	(kg/cm2-event)	0.0000001	0.0000001	0.0000001
AF_{Skin}	(no units)	0.14	0.14	0.14
EF	(events/day)	1	1	1
D_{days}	(days/week)	5	7	7
D_{weeks}	(weeks/year)	49	52	52
D_{years}	(years)	**20**	**20**	**20**
BW	(kg)	69.3	69.3	32.9
LE	(years)	**70**	**70**	**70**

Additional variables are required for running carcinogen (non-threshold) model, these are shown in **Bold.**

4.2 VARIABLE ENTRY INTO MODELING

The variables provided in the data table were used to populate the risk assessment model (Table 4.2). On the right hand side of the figure is an Excel window showing the data input table.

Figure 4.2 Data entry into the Exposure Assessment component of the Risk Assessment tool.



As the input table is filled in, exposure doses are calculated automatically. Once all the required variables are put into the model the calculated doses for all potential exposure routes are presented at the bottom of the window. According to this model simulation, exposure via the diet from eating contaminated fish contributes the greatest concentration of PCBs + PCDDs/PCDFs TEQs.