

Vapour Phase Partitioning and Diffusion

Introduction

The modelling of emissions from an open pond or lagoon (or pool) has been undertaken utilising the models presented in USEPA Air Emissions Model for Waste and Wastewater (WATER9 2001¹). This model supersedes WATER8 (USEPA, 1994²). WATER8 is the emissions model recommended for estimating emissions to air from wastewater treatment collection and storage systems by Environment Australia (EA, 1999³). It is noted that the equations relevant to the assessment of emissions from a pond (or lagoon) have not changed in the updated model.

The modelling of emissions from such a water body assumes that the environment is non-aerated, non-biological and the surface is quiescent (i.e. non-turbulent) for most of the time.

Emission Rate from Surface

The rate of volatilisation of chemicals in water (or wastewater) can be estimated using mass transfer theory that incorporates two resistances to mass transfer in series, the liquid-phase resistance and the gas-phase resistance. The individual mass transfer coefficients depend on the individual COPC properties and the system parameters. The following equations have been used to calculate the emission rate from the water surface (USEPA 1994 and EA 1999).

$$E = -\frac{\partial c}{\partial t} = K \cdot A \cdot c$$

.....Equation P1

where:

E = emission rate of chemical from the surface (g/s)

C = concentration of chemical in liquid (g/m³)

K = overall mass transfer coefficient (m/s), refer to Equation P2

A = liquid surface area (m²)

t = time (s)

¹ USEPA WATER9, 2001. Users Guide for WATER9 Software, Office of Air Quality Planning and Standards, USEPA, February 2001.

² USEPA WATER8, 1994. Air Emissions Models for Waste and Wastewater, WATER8, EPA-453/R-94-080A, November 1994.

³ EA, 1999. National Pollutant Inventory, Emission Estimation Technique Manual for Sewage and Wastewater Treatment. Environment Australia 1999.

Vapour Phase Partitioning and Diffusion

$$K = \left[\frac{1}{k_L} + \frac{1}{k_g \cdot k_{eq}} \right]^{-1}$$

.....Equation P2

where:

k_L = liquid-phase mass transfer coefficient (m/s), refer to following sections for calculation

k_g = gas-phase mass transfer coefficient (m/s), refer to following sections for calculation

k_{eq} = equilibrium constant or partition coefficient

= $H/(RT)$

H = Henry's Law Constant (atm.m³/g.mol)

R = universal gas constant = 8.21×10^{-5} (atm.m³/g.mol.K)

T = temperature of water (K)

Mass Transfer Rates

The gas-phase mass transfer coefficient is calculated using the following equation developed from experiments on evaporation of isopropyl benzene, gasoline and water to air:

$$k_g = 4.82 \times 10^{-3} \cdot U_{10}^{0.78} \cdot Sc_G^{-0.67} \cdot d_e^{-0.11} \quad (\text{m/s})$$

.....Equation P3

where:

k_g = gas-phase mass transfer coefficient (m/s)

U_{10} = windspeed at 10m height above the surface (m/s)

Sc_G = Schmidt number on gas side

= $\mu_G / (\rho_G \cdot Da)$

μ_G = viscosity of air = 1.81×10^{-4} g/cm/s

ρ_G = density of air = 1.2×10^{-3} g/cm³

Da = diffusivity of chemical in air (cm²/s)

d_e = effective diameter of water body (m)

= $2(A/\pi)^{0.5}$

A = area of water body (m²)

4.82×10^{-3} = empirical constant (m/s (m/s)^{-0.78}(m)^{0.11})

The liquid-phase mass transfer coefficient is calculated using an equation which depends on the ratio between the fetch (linear distance across water body, F) to depth (D) ratio and the wind speed at 10m height. Based on these values one of the following equations is applicable:

$$k_L = (2.78 \times 10^{-6}) \cdot \left(\frac{Dw}{De} \right)^{2/3} \quad [0 < U_{10} < 3.25 \text{ m/s, all F/D ratios}] \quad \text{.....Equation P4}$$

$$k_L = (2.605 \times 10^{-9} \cdot (F/D) + 1.277 \times 10^{-7}) \cdot U_{10}^2 \cdot \left(\frac{Dw}{De} \right)^{2/3}$$

[$U_{10} > 3.35$ m/s, $14 < F/D < 51.2$]

.....Equation P5

Vapour Phase Partitioning and Diffusion

$$k_L = (2.611 \times 10^{-7}) \cdot U_{10}^2 \cdot \left(\frac{D_w}{D_e} \right)^{2/3}$$

$$[U_{10} > 3.25 \text{ m/s, } F/D > 51.2]$$

.....Equation P6

where:

k_L = liquid-phase mass transfer coefficient (m/s)

U_{10} = windspeed at 10m height above the surface (m/s)

D_w = diffusivity of chemical in water (cm^2/s)

D_e = diffusivity of ether in water = 8.5×10^{-6} (cm^2/s)

2.611×10^{-7} = empirical constant (per (m/s))

Concentration in Air

A simple box model has been used in estimating concentrations in air within the breathing zone above the water surface which may be available for inhalation during wading and swimming activities. The model assumes that emissions of COPC from the surface of the water are mixed with ambient air in a zone above the surface, known as a mixing zone. The concentration in air can be calculated using the following equation:

$$C_b = \frac{ER}{H \cdot R}$$

.....Equation P5

where:

C_b = concentration in breathing zone (g/m^3)

ER = emission rate of chemical from the surface ($\text{g}/\text{m}^2/\text{s}$), this is the emission rate (E) calculated as above per unit area (E/A)

H = height of mixing zone (m),

R = rate of air exchange (1/s), this is the time taken for air to travel through the box assumed for the purpose of mixing. This is the wind-speed near the surface of the water divided by the distance across the mixing zone. In the case of a swimmer, the head will be close to the water surface and the mixing zone can be assumed to be small, say 1m x 1m in area.

Key Modelling Parameters and Calculations

Calculations undertaken for the estimation of air emissions and concentrations associated with the presence of volatile COPC in surface water within a pond, pool or lagoon are included in the following:

Concentrations in Air from Pond or Lagoon

(Reference: Air Emissions Models for Waste and Wastewater, USEPA 1994)

General Parameters		All Calculations	Calculations for high tide					
U =	Windspeed (m/s)	5						
depth =	Depth of pond (m)	1.5						
d =	Diameter of pond (m)	80						
A =	Area of pond (m ²)	5026.5						
F/D =	Fetch to depth ratio (unitless)	53						
T =	Absolute Temperature (K)	293						
R =	Universal gas constant (atm.m ³ /g.mol.K)	8.21E-05						
De =	Diffusivity of ether in water (cm ² /s)	8.50E-06						
ug =	Viscosity of air (g/cm.s)	1.81E-04						
pg =	Density of air (g/cm ³)	1.20E-03						
Chemical Parameters		EDC	VC	CTC	TCE	PCE	cis-1,2-DCE	1,1-DCE
Cw =	Concentration in water (mg/L)	1	1	1	1	1	1	1
C =	Concentration in water (g/m ³)	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
H =	Henry's Law (atm.m ³ /g.mol)	0.0011	0.027	0.03	0.103	0.0184	0.00408	0.0261
MW =	Molecular Weight	98.96	62.5	153.8	131.4	165.83	96.95	96.95
Da =	Diffusivity in air (cm ² /s)	0.1040	0.106	0.078	0.079	0.072	0.0736	0.09
Dw =	Diffusivity in water (cm ² /s)	9.90E-05	1.20E-06	8.80E-06	9.10E-06	8.20E-06	1.10E-05	1.04E-05
log Kow =	log octanol/water partition coeff. (L/kg)	1.5	1.62	2.83	2.4	3.4	2.1	2.1
Calculations		EDC	VC	CTC	TCE	PCE	cis-1,2-DCE	1,1-DCE
SCg =	Schmidt number on gas side	1.45	1.42	1.93	1.91	2.09	2.05	1.68
Kl =	Liquid Phase Mass Transfer Coefficient (m/s)	3.36E-05	1.77E-06	6.68E-06	6.83E-06	6.37E-06	7.75E-06	7.47E-06
Kg =	Gas Phase Mass Transfer Coefficient (m/s)	4.74E-03	4.80E-03	3.91E-03	3.94E-03	3.71E-03	3.76E-03	4.30E-03
Keq =	Equilibrium constant (unitless)	4.57E-02	1.12E+00	1.25E+00	4.28E+00	7.65E-01	1.70E-01	1.08E+00
K =	Overall Mass Transfer Coefficient (m/s)	2.91E-05	1.77E-06	6.67E-06	6.83E-06	6.36E-06	7.66E-06	7.46E-06
E =	Emission rate from water surface (g/s)	1.46E-01	8.89E-03	3.35E-02	3.43E-02	3.20E-02	3.85E-02	3.75E-02

Concentrations in Air from Pond or Lagoon

(Reference: Air Emissions Models for Waste and Wastewater, USEPA 1994)

General Parameters		All Calculations		Calculations for low tide				
U =	Windspeed (m/s)		5					
depth =	Depth of pond (m)		1					
d =	Diameter of pond (m)		50					
A =	Area of pond (m ²)		1963.5					
F/D =	Fetch to depth ratio (unitless)		50					
T =	Absolute Temperature (K)		293					
R =	Universal gas constant (atm.m ³ /g.mol.K)		8.21E-05					
De =	Diffusivity of ether in water (cm ² /s)		8.50E-06					
ug =	Viscosity of air (g/cm.s)		1.81E-04					
pg =	Density of air (g/cm ³)		1.20E-03					
Chemical Parameters		EDC	VC	CTC	TCE	PCE	cis-1,2-DCE	1,1-DCE
Cw =	Concentration in water (mg/L)	1	1	1	1	1	1	1
C =	Concentration in water (g/m ³)	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
H =	Henry's Law (atm.m ³ /g.mol)	0.0011	0.027	0.03	0.103	0.0184	0.00408	0.0261
MW =	Molecular Weight	98.96	62.5	153.8	131.4	165.83	96.95	96.95
Da =	Diffusivity in air (cm ² /s)	0.1040	0.106	0.078	0.079	0.072	0.0736	0.09
Dw =	Diffusivity in water (cm ² /s)	9.90E-05	1.20E-06	8.80E-06	9.10E-06	8.20E-06	1.10E-05	1.04E-05
log Kow=	log octanol/water partition coeff. (L/kg)	1.5	1.62	2.83	2.4	3.4	2.1	2.1
Calculations		EDC	VC	CTC	TCE	PCE	cis-1,2-DCE	1,1-DCE
SCg =	Schmidt number on gas side	1.45	1.42	1.93	1.91	2.09	2.05	1.68
KI =	Liquid Phase Mass Transfer Coefficient (m/s)	3.32E-05	1.75E-06	6.60E-06	6.75E-06	6.30E-06	7.66E-06	7.38E-06
Kg =	Gas Phase Mass Transfer Coefficient (m/s)	4.99E-03	5.06E-03	4.12E-03	4.15E-03	3.90E-03	3.96E-03	4.53E-03
Keq =	Equilibrium constant (unitless)	4.57E-02	1.12E+00	1.25E+00	4.28E+00	7.65E-01	1.70E-01	1.08E+00
K =	Overall Mass Transfer Coefficient (m/s)	2.90E-05	1.75E-06	6.59E-06	6.75E-06	6.28E-06	7.57E-06	7.37E-06
E =	Emission rate from water surface (g/s)	5.69E-02	3.43E-03	1.29E-02	1.32E-02	1.23E-02	1.49E-02	1.45E-02

Calculated Air Concentrations from Estuary

(Reference: WATER9 2001 and USEPA 1994)

Based on average calculated for low and high tide using data to the end of September 2008

General Parameters

A = Area of surface (m²)
average low and high tide

Parameters used in Model

3495

Hs Height of breathing zone for swimmer (m)
Hb Height of breathing zone for beach play (m)
Hw Height of breathing zone for child & wading (m)
Ha Height of breathing zone for adult (m)
Hc Height of breathing zone for bird watching (m)
Ww Width of mixing zone near water (m)
Ws Width of mixing zone standing/wading (m)
U Windspeed near water (m/s)

Parameters used in Calculation of Air Concentration

0.1
0.3
0.5
1.5
1
2
2
2

Calculations

Chemical	Emission Rate based on 1 mg/L (g/s)	Concentration in Water - Wading (mg/L)	Concentration in Water - Swimming (mg/L)	Concentration in Water - New Boat Ramp (mg/L)	Concentration in Water - Pore Water (mg/L)	Concentration in Water - Bird Watching (mg/L)	Concentration in Water - Adult Visiting (mg/L)	Concentration in Water - Child Visiting (mg/L)
1,2-Dichloroethane (EDC)	1.01E-01	9.10E-01	2.70E-02	4.79E-01	5.70E-01	4.39E+00	9.10E-01	9.10E-01
Vinyl chloride	6.16E-03	1.30E-01	5.30E-02	6.50E-02	1.98E-01	5.52E+00	1.30E-01	1.30E-01
Carbon tetrachloride	2.32E-02	1.90E-02	8.60E-03	1.20E-02	1.00E-03	8.00E-02	1.90E-02	1.90E-02
Trichloroethene (TCE)	2.38E-02	4.20E-02	1.79E-02	3.80E-02	1.80E-02	7.14E-01	4.20E-02	4.20E-02
Tetrachloroethene (PCE)	2.21E-02	3.10E-02	1.76E-02	2.20E-03	2.00E-03	1.57E-01	3.10E-02	3.10E-02
cis-1,2-Dichloroethene	2.67E-02	7.40E-02	2.40E-02		4.00E-02	2.66E+00	7.40E-02	7.40E-02
1,1-Dichloroethene	2.60E-02	1.90E-03	1.00E-03		1.10E-02	5.68E-01	1.90E-03	1.90E-03

Chemical	Emission Rate for 1 mg/L (g/m ² /s)	Concentration in Air - Wading (mg/m ³)	Concentration in Air - Swimming (mg/m ³)	Concentration in Air - New Boat Ramp Play (mg/m ³)	Concentration in Air - Pore Water Play (mg/m ³)	Concentration in Air - Bird Watching (mg/m ³)	Concentration in Air - Adult Visiting (mg/m ³)	Concentration in Air - Child Visiting (mg/m ³)
1,2-Dichloroethane (EDC)	2.90E-05	5.3E-02	7.8E-03	4.6E-02	5.5E-02	1.3E-01	1.8E-02	2.6E-02
Vinyl chloride	1.76E-06	4.6E-04	9.3E-04	3.8E-04	1.2E-03	9.7E-03	1.5E-04	2.3E-04
Carbon tetrachloride	6.65E-06	2.5E-04	5.7E-04	2.7E-04	2.2E-05	5.3E-04	8.4E-05	1.3E-04
Trichloroethene (TCE)	6.81E-06	5.7E-04	1.2E-03	8.6E-04	4.1E-04	4.9E-03	1.9E-04	2.9E-04
Tetrachloroethene (PCE)	6.34E-06	3.9E-04	1.1E-03	4.6E-05	4.2E-05	9.9E-04	1.3E-04	2.0E-04
cis-1,2-Dichloroethene	1.14E-05	1.7E-03	2.7E-03		1.5E-03	3.0E-02	5.6E-04	8.5E-04
1,1-Dichloroethene	3.15E-06	1.2E-05	3.1E-05		1.2E-04	1.8E-03	4.0E-06	6.0E-06

Exposure to Chemicals via Ingestion of Surface Water (Inner Estuary)

Adults - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)		Exposure Calculations (RME)	
		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Ingestion Rate (IRw)	L/day or L/hr	0.005	Incidental ingestion of 5 ml (1 teaspoon) of water per day while wading	0.05	Ingestion of 50 ml/hour during swimming activities
Time Spent Swimming (ET)	hours/day	-	Not required	1	Assume swimming for 1 hour per day in estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in water.	100%	Assume 100% bioavailability via ingestion of chemicals in water.
Intake Factor = $\frac{IRw \cdot ET \cdot B \cdot EF \cdot ED}{BW \cdot AT}$	L/kg/day	1.2E-05	NonThreshold	8.0E-05	NonThreshold
		1.2E-05	Threshold	8.0E-05	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Water (mg/L)	Daily Intake		Calculated Risk		Concentration in Water (mg/L)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)		
				TOTAL	3.8E-6	6.5E-4		TOTAL	1.0E-5	1.8E-3		
1,2-Dichloroethane (EDC)	1.2E-02	NT	0.91	1.1E-05	1.1E-05	1.3E-7	--	0.27	2.2E-05	2.2E-05	2.6E-7	--
Vinyl chloride	2.3E+00	NT	0.13	1.6E-06	1.6E-06	3.7E-6	--	0.053	4.3E-06	4.3E-06	9.8E-6	--
Carbon tetrachloride	T	5.0E-04	0.02	2.5E-07	2.5E-07	--	5.0E-4	0.0086	6.9E-07	6.9E-07	--	1.4E-3
Trichloroethene (TCE)	T	2.4E-02	0.042	5.2E-07	5.2E-07	--	2.2E-5	0.0179	1.4E-06	1.4E-06	--	6.0E-5
Tetrachloroethene (PCE)	T	9.2E-03	0.031	3.8E-07	3.8E-07	--	4.1E-5	0.0176	1.4E-06	1.4E-06	--	1.5E-4
cis-1,2-Dichloroethene	T	1.0E-02	0.074	9.1E-07	9.1E-07	--	9.1E-5	0.024	1.9E-06	1.9E-06	--	1.9E-4
1,1-Dichloroethene	T	4.6E-02	0.0019	2.3E-08	2.3E-08	--	5.1E-7	0.001	8.0E-08	8.0E-08	--	1.7E-6

↑
Average of maximum concentrations from SW028, SW048, SW029, SW054-59
Data considered to end Sept 2008

↑
Average of max concentrations from low/high tide SW048, high tide SW028, SW054-SW059
Data considered to end Sept 2008

Dermal Exposure to Chemicals via Contact with Surface Water (Inner Estuary)

Adults - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)		Exposure Calculations (RME)	
		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Surface Area (SAw)	cm ²	9910	Hands, legs and feet - USEPA 1997 data for adult male (90 percentile)	21850	Whole adult body surface area during swimming
Exposure Time (ET)	hr/day	1	Assume adult wades in water for 1 hour per time	1	Assume adult gets completely wet for 1 hour each time
Conversion Factor (CF)	L/cm ³	1.E-03	Conversion of units	1.E-03	Conversion of units
Intake Factor = $\frac{SAw \cdot ET \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	L-hr/(cm ² -kg-day)	2.4E-02	NonThreshold	3.5E-02	NonThreshold
		2.4E-02	Threshold	3.5E-02	Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data			Concentration in Water	Daily Intake		Calculated Risk		Concentration in Water	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	Dermal Permeability		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(cm/hr)		(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)		(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
						TOTAL	2.8E-4	2.9E-2		TOTAL	4.9E-5	1.8E-2	
1,2-Dichloroethane (EDC)	1.2E-02	NT	5.3E-3	0.92	1.2E-04	1.2E-04	1.4E-6	--	0.27	5.0E-05	5.0E-05	6.0E-7	--
Vinyl chloride	2.3E+00	NT	1.1E-2	0.44	1.2E-04	1.2E-04	2.8E-4	--	0.053	2.1E-05	2.1E-05	4.8E-5	--
Carbon tetrachloride	T	5.0E-04	2.2E-2	0.016	8.6E-06	8.6E-06	--	1.7E-2	0.0086	6.6E-06	6.6E-06	--	1.3E-2
Trichloroethene (TCE)	T	2.4E-02	1.6E-2	0.069	2.7E-05	2.7E-05	--	1.1E-3	0.0179	1.0E-05	1.0E-05	--	4.2E-4
Tetrachloroethene (PCE)	T	9.2E-03	4.8E-2	0.032	3.8E-05	3.8E-05	--	4.1E-3	0.0176	3.0E-05	3.0E-05	--	3.2E-3
cis-1,2-Dichloroethene	T	1.0E-02	1.5E-2	0.18	6.6E-05	6.6E-05	--	6.6E-3	0.024	1.3E-05	1.3E-05	--	1.3E-3
1,1-Dichloroethene	T	4.6E-02	1.6E-2	0.023	8.9E-06	8.9E-06	--	1.9E-4	0.001	5.6E-07	5.6E-07	--	1.2E-5

↑
Weighted average of max concentrations from SW028, SW048, SW029
SW054-59 (80%) and BP64-66 and BP42-44 from 0.1m depth (20%)
Data considered to end Sept 2008

↑
Average of maximum concentrations from low/high tide SW048, high tide SW028,
SW054-SW059
Data considered to end Sept 2008

Exposure to Chemicals via Ingestion of Sediments (unchanged from HHRA (URS, 2005))

Adults - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)		Exposure Calculations (RME)	
		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Ingestion Rate (IRs)	mg/day	50	Ingestion of 50% to 200% of daily soil intake (25 mg/day) as sediments	50	Ingestion of 50% to 200% of daily soil intake (25 mg/day) as sediments
Fraction Ingested (FI)	-	100%	Assume all sediment ingested from estuary	100%	Assume all sediment ingested from estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in sediment.	100%	Assume 100% bioavailability via ingestion of chemicals in sediment.
Conversion factor (CF)	mg to kg	1.E-06	Conversion	1.E-06	Conversion
Intake Factor = $\frac{IRs \cdot FI \cdot B \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg/kg/day	1.2E-07	NonThreshold	8.0E-08	NonThreshold
		1.2E-07	Threshold	8.0E-08	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
					TOTAL		5.7E-3			TOTAL		5.0E-4
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	6.8E-08	6.8E-08	--	4.2E-4	3.30E-01	2.6E-08	2.6E-08	--	1.7E-4
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	1.9E-06	1.9E-06	--	5.2E-3	1.50E+00	1.2E-07	1.2E-07	--	3.4E-4

↑
Maximum concentration from 1996 to 2004 data

↑
Maximum concentration from sandflats, 2004 data

Dermal Exposure to Chemicals via Contact with Sediments (unchanged from HHRA (URS, 2005))

Adults - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME)			
Units	Wading in Estuary		Swimming in Estuary		
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Surface Area (SAs)	cm ²	5450	Hands, lower legs and feet - USEPA 1997 data for adult male (90 percentile)	5450	Hands, lower legs and feet - USEPA 1997 data for adult male (90 percentile)
Adherence Factor (AF)	mg/cm ²	0.39	Weighted factor based on measured data from reed gatherers, USEPA 1997	0.39	Weighted factor based on measured data from reed gatherers, USEPA 1997
Dermal Absorption Rate (Abs)	per hour	0.005	Rate per hour for adults as per Hawley 1985 and SEDISOIL 1996	0.005	Rate per hour for adults as per Hawley 1985 and SEDISOIL 1996
Exposure Time (ET)	hr/day	4	Assume that sediment remains on skin for 4 hours before washing	4	Assume that sediment remains on skin for 4 hours before washing
Matrix Effect (ME)	-	15%	Absorption of chemicals from soil matrix is 15% from pure compound	15%	Absorption of chemicals from soil matrix is 15% from pure compound
Conversion Factor (CF)	mg to kg	1.E-06	Conversion	1.E-06	Conversion
Intake Factor = $\frac{SAs \cdot AF \cdot Abs \cdot ET \cdot ME \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg-hr/kg/day	1.6E-08	NonThreshold	1.0E-08	NonThreshold
		1.6E-08	Threshold	1.0E-08	Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
				TOTAL			7.2E-4		TOTAL			6.4E-5
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	8.6E-09	8.6E-09	--	5.4E-5	3.30E-01	3.4E-09	3.4E-09	--	2.1E-5
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	2.4E-07	2.4E-07	--	6.7E-4	1.50E+00	1.5E-08	1.5E-08	--	4.3E-5

↑
Maximum concentration from 1996 to 2004 data

↑
Maximum concentration from sandflats, 2004 data

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Adults - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)			
		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Inhalation Rate (InhR)	m ³ /hr	2.2	Inhalation rate equivalent to walking at 6.4 km/hr, CSMS 1996	2.2	Inhalation rate equivalent to walking at 6.4 km/hr, CSMS 1996
Exposure Time (ET)	hours/day	1	Assume wading for 1 hour per day	1	Assume swimming for 1 hour per day in estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalation	100%	Assume 100% bioavailability via inhalation
Fraction Inhaled (FI)	-	100%	Assume all time spent near water at estuary	100%	Assume all time spent swimming in estuary
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	5.4E-03	NonThreshold	3.5E-03	NonThreshold
		5.4E-03	Threshold	3.5E-03	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration		Daily Intake		Calculated Risk		Concentration		Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Air		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)		(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/m ³)		(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
							2.9E-6	4.0E-3					3.8E-7	4.9E-3
							TOTAL						TOTAL	
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02		2.9E-04	2.9E-04	2.8E-6	--	7.84E-03		2.8E-05	2.8E-05	2.7E-7	--
Vinyl chloride	3.1E-02		5.10E-04		2.8E-06	2.8E-06	8.5E-8	--	9.34E-04		3.3E-06	3.3E-06	1.0E-7	--
Dichloromethane		2.3E-01	1.40E-03		7.6E-06	7.6E-06	--	3.3E-5	2.20E-03		7.8E-06	7.8E-06	--	3.4E-5
Chloroform	1.5E-03	2.0E-02	9.80E-04		5.3E-06	5.3E-06	7.8E-9	2.7E-4	9.60E-04		3.4E-06	3.4E-06	5.0E-9	1.7E-4
Carbon tetrachloride		6.1E-04	2.53E-04		1.4E-06	1.4E-06	--	2.2E-3	5.72E-04		2.0E-06	2.0E-06	--	3.3E-3
Trichloroethene (TCE)	1.5E-03		1.10E-03		6.0E-06	6.0E-06	9.0E-9	--	1.30E-03		4.6E-06	4.6E-06	6.9E-9	--
Tetrachloroethene (PCE)		4.7E-02	4.10E-03		2.2E-05	2.2E-05	--	4.7E-4	4.40E-03		1.6E-05	1.6E-05	--	3.3E-4
cis-1,2-Dichloroethene		1.0E-02	1.69E-03		9.2E-06	9.2E-06	--	9.2E-4	2.75E-03		9.7E-06	9.7E-06	--	9.7E-4
1,1-Dichloroethene		5.7E-02	9.00E-04		4.9E-06	4.9E-06	--	8.5E-5	9.00E-04		3.2E-06	3.2E-06	--	5.6E-5

↑
Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m) and modelled air concentration from surface water, to Sept 2008

↑
Maximum of air concentration measured from PEAM1 (0.1m) and PEAM2 (0.2m) and modelled air concentration from surface water, to Sept 2008

Exposure to Chemicals via Inhalation of Volatiles

Adults - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)		Exposure Calculations (RME)	
		Bird Watching		Visiting	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Bird watching for 60% of total time visiting estuary (104 day per year)	41	Visiting for 41 days per year
Exposure Duration (ED)	years	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996	70	Lifetime exposure assumed as per NEPM 1999 and CSMS 1996
Body Weight (BW)	kg	70	USEPA 1989 and CSMS 1996	70	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Inhalation Rate (InhR)	m ³ /hr	0.64	Inhalation rate equivalent to sitting by adult male, CSMS 1996	2.2	Inhalation rate equivalent to walking at 6.4 km/hr, CSMS 1996
Exposure Time (ET)	hours/day	4	Assume bird watching in area for 4 hours at low tide	4	Assume visiting in area for 4 hours during low tide
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalation	100%	Assume 100% bioavailability via inhalation
Fraction Inhaled (FI)	-	100%	Assume all time spent near water at estuary	100%	Assume all time spent near estuary
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	6.3E-03	NonThreshold	1.4E-02	NonThreshold
		6.3E-03	Threshold	1.4E-02	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration			Daily Intake		Calculated Risk		Concentration			Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient				
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)				
					TOTAL	4.1E-6	2.3E-2			TOTAL	7.6E-6	1.0E-2				
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02	3.3E-04	3.3E-04	3.3E-6	--	5.28E-02	7.5E-04	7.5E-04	7.3E-6	--				
Vinyl chloride	3.1E-02		3.70E-03	2.3E-05	2.3E-05	7.2E-7	--	5.10E-04	7.2E-06	7.2E-06	2.2E-7	--				
Dichloromethane		2.3E-01	1.40E-03	8.8E-06	8.8E-06	--	3.9E-5	1.40E-03	2.0E-05	2.0E-05	--	8.6E-5				
Chloroform	1.5E-03	2.0E-02	1.40E-03	8.8E-06	8.8E-06	1.3E-8	4.4E-4	9.80E-04	1.4E-05	1.4E-05	2.0E-8	6.9E-4				
Carbon tetrachloride		6.1E-04	2.53E-04	1.6E-06	1.6E-06	--	2.6E-3	2.53E-04	3.6E-06	3.6E-06	--	5.8E-3				
Trichloroethene (TCE)	1.5E-03		6.40E-03	4.0E-05	4.0E-05	6.1E-8	--	1.10E-03	1.6E-05	1.6E-05	2.3E-8	--				
Tetrachloroethene (PCE)		4.7E-02	4.10E-03	2.6E-05	2.6E-05	--	5.5E-4	4.10E-03	5.8E-05	5.8E-05	--	1.2E-3				
cis-1,2-Dichloroethene		1.0E-02	3.04E-02	1.9E-04	1.9E-04	--	1.9E-2	1.69E-03	2.4E-05	2.4E-05	--	2.4E-3				
1,1-Dichloroethene		5.7E-02	1.15E-04	7.3E-07	7.3E-07	--	1.3E-5	9.00E-04	1.3E-05	1.3E-05	--	2.2E-4				

↑
Maximum of air concentration measured from PEAM5, PEAM6 and PEAM7 (0.5m) and modelled air concentration from surface water (max), to Sept 2008

↑
Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m) and modelled air concentration from surface water (max), to Sept 2008

Exposure to Chemicals via Ingestion of Surface Water (Inner Estuary)

Older Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Swimming in Estuary	
Exposure Parameters						
Exposure Frequency (EF)	days/year	84	Wading in estuary for 60% of total time (140 day per year)		56	Swimming in estuary for 40% of total time (140 days per year)
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age		10	Exposure during time between 5 and 15 years of age
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996		34.5	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996		25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996		3650	USEPA 1989 and CSMS 1996
Ingestion Rate (IRw)	L/day or L/hr	0.01	Incidental ingestion of 10 ml (2 teaspoons) of water per day while wading		0.05	Ingestion of 50 ml/hour during swimming activities
Time Spent Swimming (ET)	hours/day	-	Not required		2	Assume swimming for 2 hours per day in estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in water.		100%	Assume 100% bioavailability via ingestion of chemicals in water.
Intake Factor = $\frac{IRw \cdot ET \cdot B \cdot EF \cdot ED}{BW \cdot AT}$		L/kg/day	9.5E-06	NonThreshold	6.4E-05	NonThreshold
			6.7E-05	Threshold	4.4E-04	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Water (mg/L)	Daily Intake		Calculated Risk		Concentration in Water (mg/L)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RFD		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)		
				TOTAL	3.0E-6	3.5E-3		TOTAL	8.0E-6	1.0E-2		
1,2-Dichloroethane (EDC)	1.2E-02	NT	0.91	8.7E-06	6.1E-05	1.0E-7	--	0.27	1.7E-05	1.2E-04	2.1E-7	--
Vinyl chloride	2.3E+00	NT	0.13	1.2E-06	8.7E-06	2.8E-6	--	0.053	3.4E-06	2.4E-05	7.7E-6	--
Carbon tetrachloride	T	5.0E-04	0.02	1.9E-07	1.3E-06	--	2.7E-3	0.0086	5.5E-07	3.8E-06	--	7.7E-3
Trichloroethene (TCE)	T	2.4E-02	0.042	4.0E-07	2.8E-06	--	1.2E-4	0.0179	1.1E-06	8.0E-06	--	3.3E-4
Tetrachloroethene (PCE)	T	9.2E-03	0.031	3.0E-07	2.1E-06	--	2.2E-4	0.0176	1.1E-06	7.8E-06	--	8.5E-4
cis-1,2-Dichloroethene	T	1.0E-02	0.074	7.1E-07	4.9E-06	--	4.9E-4	0.024	1.5E-06	1.1E-05	--	1.1E-3
1,1-Dichloroethene	T	4.6E-02	0.0019	1.8E-08	1.3E-07	--	2.8E-6	0.001	6.4E-08	4.4E-07	--	9.7E-6

↑
Average of maximum concentrations from SW028, SW048, SW029, SW054-59
Data considered to end Sept 2008

↑
Average of maximum concentrations from HT/LT tide SW048, HT SW028, SW054-SW059
Data considered to end Sept 2008

Dermal Exposure to Chemicals via Contact with Surface Water (Inner Estuary)

Older Children - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Swimming in Estuary	
Units					
Exposure Parameters					
Exposure Frequency (EF)	days/year	84	Wading in estuary for 60% of total time (140 day per year)	56	Swimming in estuary for 40% of total time (140 days per year)
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age	10	Exposure during time between 5 and 15 years of age
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996	34.5	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996	3650	USEPA 1989 and CSMS 1996
Surface Area (SAw)	cm ²	6567	Hands, legs and feet - USEPA 1997 data for children (12-13 yrs)	15300	Wholebody surface area (male child 11-12 yrs, 90 percentile, USEPA 1997)
Exposure Time (ET)	hr/day	2	Assume wading for 2 hours each day	2	Assume swimming for 2 hours each day
Conversion Factor (CF)	L/cm ³	1.E-03	Conversion of units	1.E-03	Conversion of units
Intake Factor = $\frac{SAw \cdot ET \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$		1.3E-02	NonThreshold	1.9E-02	NonThreshold
		8.8E-02	Threshold	1.4E-01	Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data			Concentration in Water (mg/L)	Daily Intake		Calculated Risk		Concentration in Water (mg/L)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)	Dermal Permeability (cm/hr)		NonThreshold	Threshold	NonThreshold Risk (unitless)	Hazard Quotient (unitless)		NonThreshold	Threshold	NonThreshold Risk (unitless)	Hazard Quotient (unitless)
						TOTAL	1.4E-4	1.0E-1			TOTAL	2.7E-5	7.1E-2
1,2-Dichloroethane (EDC)	1.2E-02	NT	5.3E-3	0.92	6.1E-05	4.3E-04	7.3E-7	--	0.27	2.8E-05	1.9E-04	3.3E-7	--
Vinyl chloride	2.3E+00	NT	1.1E-2	0.44	6.2E-05	4.4E-04	1.4E-4	--	0.053	1.2E-05	8.1E-05	2.7E-5	--
Carbon tetrachloride	T	5.0E-04	2.2E-2	0.016	4.4E-06	3.1E-05	--	6.2E-2	0.0086	3.7E-06	2.6E-05	--	5.2E-2
Trichloroethene (TCE)	T	2.4E-02	1.6E-2	0.069	1.4E-05	9.7E-05	--	4.1E-3	0.0179	5.6E-06	3.9E-05	--	1.6E-3
Tetrachloroethene (PCE)	T	9.2E-03	4.8E-2	0.032	1.9E-05	1.3E-04	--	1.5E-2	0.0176	1.6E-05	1.1E-04	--	1.2E-2
cis-1,2-Dichloroethene	T	1.0E-02	1.5E-2	0.18	3.4E-05	2.3E-04	--	2.3E-2	0.024	7.0E-06	4.9E-05	--	4.9E-3
1,1-Dichloroethene	T	4.6E-02	1.6E-2	0.023	4.6E-06	3.2E-05	--	7.0E-4	0.001	3.1E-07	2.2E-06	--	4.7E-5

↑
Weighted average of max concentrations from SW028, SW048, SW029
SW054-59 (80%) and BP64-66 and BP42-44 from 0.1m depth (20%)
Data considered to end Sept 2008

↑
Average of maximum concentrations from low/high tide SW048, high tide SW028
and SW054-SW059
Data considered to end Sept 2008

Exposure to Chemicals via Ingestion of Sediments (unchanged from HHRA (URS, 2005))

Older Children - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Swimming in Estuary	
Units					
Exposure Parameters					
Exposure Frequency (EF)	days/year	84	Wading in estuary for 60% of total time (140 day per year)	56	Swimming in estuary for 40% of total time (140 days per year)
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age	10	Exposure during time between 5 and 15 years of age
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996	34.5	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996	3650	USEPA 1989 and CSMS 1996
Ingestion Rate (IRs)	mg/day	100	Ingestion of 50% to 200% of daily soil intake (50 mg/day) as sediments	100	Ingestion of 50% to 200% of daily soil intake (50 mg/day) as sediments
Fraction Ingested (FI)	-	100%	Assume all sediment ingested from estuary	100%	Assume all sediment ingested from estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in sediment.	100%	Assume 100% bioavailability via ingestion of chemicals in sediment.
Conversion factor (CF)	mg to kg	1.E-06	Conversion	1.E-06	Conversion
Intake Factor = $\frac{IRs \cdot FI \cdot B \cdot CFEF \cdot ED}{BW \cdot AT}$	kg/kg/day	9.5E-08	NonThreshold	6.4E-08	NonThreshold
		6.7E-07	Threshold	4.4E-07	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration			Daily Intake		Calculated Risk		Concentration			Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient				
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)				
					TOTAL		3.1E-2			TOTAL		2.8E-3				
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	5.2E-08	3.7E-07	--	2.3E-3	3.30E-01	2.1E-08	1.5E-07	--	9.2E-4				
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	1.4E-06	1.0E-05	--	2.8E-2	1.50E+00	9.5E-08	6.7E-07	--	1.9E-3				

↑
Maximum concentration from 1996 to 2004 data

↑
Maximum concentration from sandflats, 2004 data

Dermal Exposure to Chemicals via Contact with Sediments (unchanged from HHRA (URS, 2005))

Older Children - Penrhyn Estuary

General Data/ Equations	Units	Exposure Calculations (RME)		Exposure Calculations (RME)	
		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	84	Wading in estuary for 60% of total time (140 day per year)	56	Swimming in estuary for 40% of total time (140 days per year)
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age	10	Exposure during time between 5 and 15 years of age
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996	34.5	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996	3650	USEPA 1989 and CSMS 1996
Surface Area (SAs)	cm ²	3732	Hands, lower legs and feet - USEPA 1997 data for male 11-12 yrs (90%)	3732	Hands, lower legs and feet - USEPA 1997 data for male 11-12 yrs (90%)
Adherence Factor (AF)	mg/cm ²	0.41	Weighted factor based on measured data from reed gatherers, USEPA 1997	0.41	Weighted factor based on measured data from reed gatherers, USEPA 1997
Dermal Absorption Rate (Abs)	per hour	0.01	Rate per hour for children as per Hawley 1985 and SEDISOIL 1996	0.01	Rate per hour for children as per Hawley 1985 and SEDISOIL 1996
Exposure Time (ET)	hr/day	8	Assume that sediment remains on skin for 8 hours before washing	8	Assume that sediment remains on skin for 8 hours before washing
Matrix Effect (ME)	-	15%	Absorption of chemicals from soil matrix is 15% from pure compound	15%	Absorption of chemicals from soil matrix is 15% from pure compound
Conversion Factor (CF)	mg to kg	1.E-06	Conversion	1.E-06	Conversion
Intake Factor = $\frac{SAs \cdot AF \cdot Abs \cdot ET \cdot ME \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg-hr/kg/day	1.7E-08 1.2E-07	NonThreshold Threshold	1.2E-08 8.2E-08	NonThreshold Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Sediment (mg/kg)	Daily Intake		Calculated Risk		Concentration in Sediment (mg/kg)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)
				TOTAL					TOTAL			
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	9.6E-09	6.7E-08	--	5.6E-3	3.30E-01	3.8E-09	2.7E-08	--	1.7E-4
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	2.6E-07	1.8E-06	--	5.2E-3	1.50E+00	1.7E-08	1.2E-07	--	3.4E-4

↑
Maximum concentration from 1996 to 2004 data

↑
Maximum concentration from sandflats, 2004 data

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Older Children - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME) Wading in Estuary				Exposure Calculations (RME) Swimming in Estuary			
Units									
Exposure Parameters									
Exposure Frequency (EF)	days/year	84	Wading in estuary for 60% of total time (140 day per year)			56	Swimming in estuary for 40% of total time (140 days per year)		
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age			10	Exposure during time between 5 and 15 years of age		
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996			34.5	USEPA 1989 and CSMS 1996		
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996			25550	USEPA 1989 and CSMS 1996		
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996			3650	USEPA 1989 and CSMS 1996		
Inhalation Rate (InhR)	m ³ /hr	1.6	Inhalation rate equivalent to exercising, CSMS 1996			1.6	Inhalation rate equivalent to exercising, CSMS 1996		
Exposure Time (ET)	hours/day	4	Assume wading for 2 hours per day			1	Assume swimming for 1 hour per day in estuary		
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalation			100%	Assume 100% bioavailability via inhalation		
Fraction Inhaled (FI)	-	100%	Assume all time spent near water at estuary			100%	Assume all time spent swimming in estuary		
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	6.1E-03	NonThreshold			1.0E-03	NonThreshold		
		4.3E-02	Threshold			7.1E-03	Threshold		

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration		Daily Intake		Calculated Risk		Concentration		Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)		(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	
					TOTAL		3.3E-6	3.2E-2			TOTAL		1.1E-7	9.8E-3
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02		3.2E-04	2.3E-03	3.2E-6	--	7.84E-03	8.0E-06	5.6E-05	7.8E-8	--	
Vinyl chloride	3.1E-02		5.10E-04		3.1E-06	2.2E-05	9.6E-8	--	9.34E-04	9.5E-07	6.6E-06	2.9E-8	--	
Dichloromethane		2.3E-01	1.40E-03		8.5E-06	6.0E-05	--	2.6E-4	2.20E-03	2.2E-06	1.6E-05	--	6.8E-5	
Chloroform	1.5E-03	2.0E-02	9.80E-04		6.0E-06	4.2E-05	8.8E-9	2.1E-3	9.60E-04	9.8E-07	6.8E-06	1.4E-9	3.4E-4	
Carbon tetrachloride		6.1E-04	2.53E-04		1.5E-06	1.1E-05	--	1.8E-2	5.72E-04	5.8E-07	4.1E-06	--	6.7E-3	
Trichloroethene (TCE)	1.5E-03		1.10E-03		6.7E-06	4.7E-05	1.0E-8	--	1.30E-03	1.3E-06	9.2E-06	2.0E-9	--	
Tetrachloroethene (PCE)		4.7E-02	4.10E-03		2.5E-05	1.8E-04	--	3.7E-3	4.40E-03	4.5E-06	3.1E-05	--	6.6E-4	
cis-1,2-Dichloroethene		1.0E-02	1.69E-03		1.0E-05	7.2E-05	--	7.2E-3	2.75E-03	2.8E-06	2.0E-05	--	2.0E-3	
1,1-Dichloroethene		5.7E-02	9.00E-04		5.5E-06	3.8E-05	--	6.7E-4	9.00E-04	9.1E-07	6.4E-06	--	1.1E-4	

↑
Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m) and modelled air concentration from surface water, to Sept 2008

↑
Maximum of air concentration measured from PEAM1 (0.1m) and PEAM2 (0.2m) and modelled air concentration from surface water, to Sept 2008

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Older Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Visiting Inner Estuary	
Exposure Parameters				
Exposure Frequency (EF)	days/year	41	Visiting for 41 days per year	
Exposure Duration (ED)	years	10	Exposure during time between 5 and 15 years of age	
Body Weight (BW)	kg	34.5	USEPA 1989 and CSMS 1996	
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	
Averaging Time - Threshold (ATn)	days	3650	USEPA 1989 and CSMS 1996	
Inhalation Rate (InhR)	m ³ /hr	1.6	Inhalation rate equivalent to exercising, CSMS 1996	
Exposure Time (ET)	hours/day	4	Assume visiting in area for 4 hours during low tide	
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalation	
Fraction Inhaled (FI)	-	100%	Assume all time spent near estuary	
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	3.0E-03	NonThreshold	Threshold
		2.1E-02		

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
					TOTAL	1.6E-6	1.5E-2
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02	1.6E-04	1.1E-03	1.5E-6	--
Vinyl chloride	3.1E-02		5.10E-04	1.5E-06	1.1E-05	4.7E-8	--
Dichloromethane		2.3E-01	1.40E-03	4.2E-06	2.9E-05	--	1.3E-4
Chloroform	1.5E-03	2.0E-02	9.80E-04	2.9E-06	2.0E-05	4.3E-9	1.0E-3
Carbon tetrachloride		6.1E-04	2.53E-04	7.5E-07	5.3E-06	--	8.6E-3
Trichloroethene (TCE)	1.5E-03		1.10E-03	3.3E-06	2.3E-05	4.9E-9	--
Tetrachloroethene (PCE)		4.7E-02	4.10E-03	1.2E-05	8.5E-05	--	1.8E-3
cis-1,2-Dichloroethene		1.0E-02	1.69E-03	5.0E-06	3.5E-05	--	3.5E-3
1,1-Dichloroethene		5.7E-02	9.00E-04	2.7E-06	1.9E-05	--	3.3E-4

↑
Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m) and modelled air concentration from surface water, to Sept 2008

Exposure to Chemicals via Ingestion of Surface Water (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Swimming in Estuary	
Exposure Parameters						
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)		41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age		4	Exposure during time between 1 and 5 years of age
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996		13.2	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996		25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996		1460	USEPA 1989 and CSMS 1996
Ingestion Rate (IRw)	L/day or L/hr	0.01	Incidental ingestion of 10 ml (2 teaspoons) of water per day while wading		0.05	Ingestion of 50 ml/hour during swimming activities
Time Spent Swimming (ET)	hours/day	-	Not required		0.5	Assume swimming for 1/2 hour per day in estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in water		100%	Assume 100% bioavailability via ingestion of chemicals in water
Intake Factor = $\frac{IRw \cdot ET \cdot B \cdot EF \cdot ED}{BW \cdot AT}$		L/kg/day	7.5E-06	NonThreshold	1.2E-05	NonThreshold
			1.3E-04	Threshold	2.1E-04	Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Water	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Water	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/L)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/L)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
					TOTAL	2.3E-6	6.9E-3			TOTAL	1.5E-6	4.8E-3
1,2-Dichloroethane (EDC)	1.2E-02	NT	0.91	6.8E-06	1.2E-04	8.2E-8	--	0.27	3.3E-06	5.7E-05	3.9E-8	--
Vinyl chloride	2.3E+00	NT	0.13	9.7E-07	1.7E-05	2.2E-6	--	0.053	6.4E-07	1.1E-05	1.5E-6	--
Carbon tetrachloride	T	5.0E-04	0.02	1.5E-07	2.6E-06	--	5.3E-3	0.0086	1.0E-07	1.8E-06	--	3.7E-3
Trichloroethene (TCE)	T	2.4E-02	0.042	3.1E-07	5.5E-06	--	2.3E-4	0.0179	2.2E-07	3.8E-06	--	1.6E-4
Tetrachloroethene (PCE)	T	9.2E-03	0.031	2.3E-07	4.1E-06	--	4.4E-4	0.0176	2.1E-07	3.7E-06	--	4.1E-4
cis-1,2-Dichloroethene	T	1.0E-02	0.074	5.5E-07	9.7E-06	--	9.7E-4	0.024	2.9E-07	5.1E-06	--	5.1E-4
1,1-Dichloroethene	T	4.6E-02	0.0019	1.4E-08	2.5E-07	--	5.4E-6	0.001	1.2E-08	2.1E-07	--	4.6E-6

↑
Average of maximum concentrations from SW028, SW048, SW029, SW054-59
Data considered to end Sept 2008

↑
Average of maximum concentrations from HT/LT tide SW048, HT SW028, SW054-SW059
Data considered to end Sept 2008

Exposure to Chemicals via Ingestion of Surface Water (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations			Exposure Calculations (RME) Beach Play in Sandy Discharge Zone				
Exposure Parameters							
Exposure Frequency (EF)	days/year	41	Beach play for 40% of total time (104 days per year)				
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age				
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996				
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996				
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996				
Ingestion Rate (IRw)	L/day or L/hr	0.1	Incidental ingestion of 100 ml of water per day during beach play				
Time Spent Swimming (ET)	hours/day						
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in water				
Intake Factor = $\frac{IRw \cdot ET \cdot B \cdot EF \cdot ED}{BW \cdot AT}$			4.9E-05	NonThreshold			
			8.5E-04	Threshold			
<i>Daily Intake from Water = Concentration in Water x Intake Factor</i> <i>NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor</i> <i>Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)</i>							
Chemical	Toxicity Data		Concentration in Water	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/L)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
					TOTAL	2.2E-5	6.1E-3
1,2-Dichloroethane (EDC)	1.2E-02	NT	0.57	2.8E-05	4.9E-04	3.3E-7	--
Vinyl chloride	2.3E+00	NT	0.198	9.6E-06	1.7E-04	2.2E-5	--
Carbon tetrachloride	T	5.0E-04	0.001	4.9E-08	8.5E-07	--	1.7E-3
Trichloroethene (TCE)	T	2.4E-02	0.018	8.8E-07	1.5E-05	--	6.4E-4
Tetrachloroethene (PCE)	T	9.2E-03	0.002	9.7E-08	1.7E-06	--	1.8E-4
cis-1,2-Dichloroethene	T	1.0E-02	0.04	1.9E-06	3.4E-05	--	3.4E-3
1,1-Dichloroethene	T	4.6E-02	0.011	5.3E-07	9.4E-06	--	2.0E-4

↑
Maximum pore water concentration from BP64, BP65 and BP66
Data considered to end Sept 2008

Dermal Exposure to Chemicals via Contact with Surface Water (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME)			
Units		Wading in Estuary		Swimming in Estuary	
Exposure Parameters					
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age	4	Exposure during time between 1 and 5 years of age
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996	13.2	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996	1460	USEPA 1989 and CSMS 1996
Surface Area (SAw)	cm ²	2922	Hands, legs and feet - USEPA 1997 data for children (3-4 yrs)	7290	Wholebody surface area (male child 3-4 yrs, 90 percentile, USEPA 1997)
Exposure Time (ET)	hr/day	2	Assume wading for 2 hours each day	0.5	Assume swimming for 1/2 hour each day
Conversion Factor (CF)	L/cm ³	1.E-03	Conversion of units	1.E-03	Conversion of units
Intake Factor = $\frac{SAw \cdot ET \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	L-hr/(cm ² -kg-day)	4.4E-03	NonThreshold	1.8E-03	NonThreshold
		7.6E-02	Threshold	3.1E-02	Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data			Concentration in Water (mg/L)	Daily Intake		Calculated Risk		Concentration in Water (mg/L)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)	Dermal Permeability (cm/hr)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)		NonThreshold Risk (unitless)	Hazard Quotient (unitless)		
						TOTAL	1.5E-5	9.1E-2			TOTAL	2.5E-6	1.6E-2
1,2-Dichloroethane (EDC)	1.2E-02	NT	5.3E-3	0.91	2.1E-05	3.7E-04	2.5E-7	--	0.27	2.5E-06	4.4E-05	3.0E-8	--
Vinyl chloride	2.3E+00	NT	1.1E-2	0.13	6.4E-06	1.1E-04	1.5E-5	--	0.053	1.1E-06	1.9E-05	2.4E-6	--
Carbon tetrachloride	T	5.0E-04	2.2E-2	0.02	1.9E-06	3.4E-05	--	6.8E-2	0.0086	3.4E-07	5.9E-06	--	1.2E-2
Trichloroethene (TCE)	T	2.4E-02	1.6E-2	0.042	2.9E-06	5.1E-05	--	2.2E-3	0.0179	5.1E-07	8.9E-06	--	3.7E-4
Tetrachloroethene (PCE)	T	9.2E-03	4.8E-2	0.031	6.5E-06	1.1E-04	--	1.2E-2	0.0176	1.5E-06	2.6E-05	--	2.8E-3
cis-1,2-Dichloroethene	T	1.0E-02	1.5E-2	0.074	4.8E-06	8.4E-05	--	8.4E-3	0.024	6.3E-07	1.1E-05	--	1.1E-3
1,1-Dichloroethene	T	4.6E-02	1.6E-2	0.0019	1.3E-07	2.3E-06	--	5.0E-5	0.001	2.8E-08	4.9E-07	--	1.1E-5

↑
Weighted average of max concentrations from SW028, SW048, SW029 SW054-59 (80%) and BP64-66 and BP42-44 from 0.1m depth (20%)
Data considered to end Sept 2008

↑
Average of maximum concentrations from low/high tide SW048, high tide SW028 and SW054-SW059
Data considered to end Sept 2008

Dermal Exposure to Chemicals via Contact with Surface Water (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Beach Play in Sandy Discharge Zone	
Exposure Parameters				
Exposure Frequency (EF)		days/year	41	Beach play for 40% of total time (104 days per year)
Exposure Duration (ED)		years	4	Exposure during time between 1 and 5 years of age
Body Weight (BW)		kg	13.2	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)		days	25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)		days	1460	USEPA 1989 and CSMS 1996
Surface Area (SAw)		cm ²	6610	Wholebody surface area (male child 2-3 yrs, 90 percentile, USEPA 1997)
Exposure Time (ET)		hr/day	2	Assume beach play for 2 hours each day
Conversion Factor (CF)		L/cm ³	1.E-03	Conversion of units
Intake Factor = $\frac{SAw \cdot ET \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$		L-hr/(cm ² -kg-day)	6.4E-03 1.1E-01	NonThreshold Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data			Concentration in Water (mg/L)	Daily Intake (mg/kg/day)		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)	Dermal Permeability (cm/hr)		NonThreshold	Threshold	NonThreshold Risk (unitless)	Hazard Quotient (unitless)
						TOTAL	3.3E-5	1.5E-2
1,2-Dichloroethane (EDC)	1.2E-02	NT	5.3E-3	0.57	1.9E-05	3.4E-04	2.3E-7	--
Vinyl chloride	2.3E+00	NT	1.1E-2	0.198	1.4E-05	2.5E-04	3.3E-5	--
Carbon tetrachloride	T	5.0E-04	2.2E-2	0.001	1.4E-07	2.5E-06	--	5.0E-3
Trichloroethene (TCE)	T	2.4E-02	1.6E-2	0.018	1.9E-06	3.2E-05	--	1.4E-3
Tetrachloroethene (PCE)	T	9.2E-03	4.8E-2	0.002	6.2E-07	1.1E-05	--	1.2E-3
cis-1,2-Dichloroethene	T	1.0E-02	1.5E-2	0.04	3.8E-06	6.7E-05	--	6.7E-3
1,1-Dichloroethene	T	4.6E-02	1.6E-2	0.011	1.1E-06	2.0E-05	--	4.3E-4

↑
Maximum pore water concentration from BP64, BP65 and BP66
Data considered to end Sept 2008

Exposure to Chemicals via Ingestion of Sediments (unchanged from HHRA (URS, 2005))

Young Children - Penrhyn Estuary

General Data/ Equations		Units		Exposure Calculations (RME) Wading in Estuary				Exposure Calculations (RME) Beach Play in Estuary						
Exposure Parameters														
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)	41	Beach play for 40% of total time (104 days per year)									
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age	4	Exposure during time between 1 and 5 years of age									
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996	13.2	USEPA 1989 and CSMS 1996									
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	25550	USEPA 1989 and CSMS 1996									
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996	1460	USEPA 1989 and CSMS 1996									
Ingestion Rate (IRs)	mg/day	200	Ingestion of 50% to 200% of daily soil intake (100 mg/day) as sediments	200	Ingestion of 50% to 200% of daily soil intake (100 mg/day) as sediments									
Fraction Ingested (FI)	-	100%	Assume all sediment ingested from estuary	100%	Assume all sediment ingested from estuary									
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in sediment	100%	Assume 100% bioavailability via ingestion of chemicals in sediment									
Conversion factor (CF)	mg to kg	1.E-06	Conversion	1.E-06	Conversion									
Intake Factor = $\frac{IRs \cdot FI \cdot B \cdot CFEF \cdot ED}{BW \cdot AT}$	kg/kg/day	1.5E-07	NonThreshold	9.7E-08	NonThreshold									
		2.6E-06	Threshold	1.7E-06	Threshold									
<i>Daily Intake from Water = Concentration in Water x Intake Factor</i> <i>NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor</i> <i>Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)</i>														
Chemical	Toxicity Data		Concentration		Daily Intake		Calculated Risk		Concentration		Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient		
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)		
					TOTAL		1.2E-1			TOTAL		1.2E-1		
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	8.2E-08	1.4E-06	--	9.0E-3	5.50E-01	5.3E-08	9.4E-07	--	5.9E-3		
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	2.3E-06	3.9E-05	--	1.1E-1	1.51E+01	2.3E-06	3.9E-05	--	1.1E-1		
			↑	Maximum concentration from 1996 to 2004 data				↑	Maximum concentration from 1996 to 2004 data					

Exposure to Chemicals via Ingestion of Sediments (unchanged from HHRA (URS, 2005))

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Swimming in Estuary				
Exposure Parameters							
Exposure Frequency (EF)	days/year	41	Swimming in estuary for 40% of total time (104 days per year)				
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age				
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996				
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996				
Averaging Time - Threshold (ATn)	days	1500	USEPA 1989 and CSMS 1996				
Ingestion Rate (IRs)	mg/day	200	Ingestion of 50% to 200% of daily soil intake (100 mg/day) as sediments				
Fraction Ingested (FI)	-	100%	Assume all sediment ingested from estuary				
Bioavailability (B)	-	100%	Assume 100% bioavailability via ingestion of chemicals in sediment				
Conversion factor (CF)	mg to kg	1.E-06	Conversion				
Intake Factor = $\frac{IRs \cdot FI \cdot B \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg/kg/day	9.7E-08	NonThreshold				
		1.7E-06	Threshold				
<i>Daily Intake from Water = Concentration in Water x Intake Factor</i>							
<i>NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Fa</i>							
<i>Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)</i>							
Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Sediment	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
					TOTAL		1.0E-2
Hexachlorobenzene (HCB)	T	1.6E-04	3.30E-01	3.2E-08	5.5E-07	--	3.4E-3
Mercury (as total, inorganic)	T	3.6E-04	1.50E+00	1.5E-07	2.5E-06	--	7.0E-3

↑
Maximum concentration from sandflats, 2004 data

Dermal Exposure to Chemicals via Contact with Sediments (unchanged from HHRA (URS, 2005))

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Beach Play in Estuary	
Exposure Parameters						
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)		41	Beach Play for 40% of total time (104 days per year)
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age		4	Exposure during time between 1 and 5 years of age
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996		13.2	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996		25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996		1460	USEPA 1989 and CSMS 1996
Surface Area (SAs)	cm ²	2922	Hands, legs and feet - USEPA 1997 data for children (3-4 yrs)		6610	Wholebody surface area (male child 2-3 yrs, 90 percentile, USEPA 1997)
Adherence Factor (AF)	mg/cm ²	1	Refer to discussion in report		1	Refer to discussion in report
Dermal Absorption Rate (Abs)	per hour	0.01	Rate per hour for children as per Hawley 1985 and SEDISOIL 1996		0.01	Rate per hour for children as per Hawley 1985 and SEDISOIL 1996
Exposure Time (ET)	hr/day	8	Assume that sediment remains on skin for 8 hours before washing		8	Assume that sediment remains on skin for 8 hours before washing
Matrix Effect (ME)	-	15%	Absorption of chemicals from soil matrix is 15% from pure compound		15%	Absorption of chemicals from soil matrix is 15% from pure compound
Conversion Factor (CF)	mg to kg	1.E-06	Conversion		1.E-06	Conversion
Intake Factor = $\frac{SAs \cdot AF \cdot Abs \cdot ET \cdot ME \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg-hr/kg/day	2.6E-08	NonThreshold		3.9E-08	NonThreshold
		4.6E-07	Threshold		6.7E-07	Threshold

Daily Intake from Water = Concentration in Water x Dermal Permeability x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Sediment (mg/kg)	Daily Intake		Calculated Risk		Concentration in Sediment (mg/kg)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)
				TOTAL			2.1E-2		TOTAL			3.1E-2
Hexachlorobenzene (HCB)	T	1.6E-04	5.50E-01	1.4E-08	2.5E-07	--	1.6E-3	5.50E-01	2.1E-08	3.7E-07	--	2.3E-3
Mercury (as total, inorganic)	T	3.6E-04	1.51E+01	4.0E-07	6.9E-06	--	2.0E-2	1.51E+01	5.8E-07	1.0E-05	--	2.9E-2

↑
Maximum concentration from 1996 to 2004 data

↑
Maximum concentration from 1996 to 2004 data

**Dermal Exposure to Chemicals via
Contact with Sediments (unchanged
from HHRA (URS, 2005))**

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Swimming in Estuary	
Exposure Parameters				
Exposure Frequency (EF)	days/year	41	Swimming in estuary for 40% of total time (104 days per year)	
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age	
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996	
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996	
Averaging Time - Threshold (ATn)	days	1500	USEPA 1989 and CSMS 1996	
Surface Area (SAs)	cm ²	2922	Hands, legs and feet - USEPA 1997 data for children (3-4 yrs)	
Adherence Factor (AF)	mg/cm ²	1	Refer to discussion in report	
Dermal Absorption Rate (Abs)	per hour	0.01	Rate per hour for children as per Hawley 1985 and SEDISOIL 1996	
Exposure Time (ET)	hr/day	8	Assume that sediment remains on skin for 8 hours before washing	
Matrix Effect (ME)	-	15%	Absorption of chemicals from soil matrix is 15% from pure compound	
Conversion Factor (CF)	mg to kg	1.E-06	Conversion	
Intake Factor = $\frac{SAs \cdot AF \cdot Abs \cdot ET \cdot ME \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$	kg-hr/kg/day	1.7E-08	NonThreshold	
		2.9E-07	Threshold	

Daily Intake from Water = Concentration in Water x Dermal Permeability
NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x S
Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Sediment	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD		NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
				TOTAL			1.8E-3
Hexachlorobenzene (HCB)	T	1.6E-04	3.30E-01	5.6E-09	9.6E-08	--	6.0E-4
Mercury (as total, inorganic)	T	3.6E-04	1.50E+00	2.6E-08	4.4E-07	--	1.2E-3

↑
Maximum concentration from sandflats, 2004 data

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations		Units	Exposure Calculations (RME) Wading in Estuary		Exposure Calculations (RME) Swimming in Estuary	
Exposure Parameters						
Exposure Frequency (EF)	days/year	63	Wading in estuary for 60% of total time (104 day per year)		41	Swimming in estuary for 40% of total time (104 days per year)
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age		4	Exposure during time between 1 and 5 years of age
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996		13.2	USEPA 1989 and CSMS 1996
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996		25550	USEPA 1989 and CSMS 1996
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996		1500	USEPA 1989 and CSMS 1996
Inhalation Rate (InhR)	m ³ /hr	1.25	Inhalation rate equivalent active play, CSMS 1996		1.25	Inhalation rate equivalent active play, CSMS 1996
Exposure Time (ET)	hours/day	2	Assume wading for 2 hours and visiting up to 4 hours per day		0.5	Assume swimming for 1/2 hours per day in estuary
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalator		100%	Assume 100% bioavailability via inhalator
Fraction Inhaled (FI)	-	100%	Assume all time spent near water at estuary		100%	Assume all time spent swimming in estuary
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	1.9E-03 3.3E-02	NonThreshold Threshold		3.0E-04 5.2E-03	NonThreshold Threshold

Daily Intake from Water = Concentration in Water x Intake Factor

NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor

Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)

Chemical	Toxicity Data		Concentration in Air (mg/m ³)	Daily Intake		Calculated Risk		Concentration in Air (mg/m ³)	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor (mg/kg-day) ⁻¹	Threshold ADI, TDI or RfD (mg/kg/day)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)		NonThreshold (mg/kg/day)	Threshold (mg/kg/day)	NonThreshold Risk (unitless)	Hazard Quotient (unitless)
					TOTAL	1.0E-6	2.4E-2			TOTAL	3.3E-8	7.1E-3
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02	9.9E-05	1.7E-03	9.7E-7	--	7.84E-03	2.4E-06	4.1E-05	2.3E-8	--
Vinyl chloride	3.1E-02		5.10E-04	9.5E-07	1.7E-05	2.9E-8	--	9.34E-04	2.8E-07	4.8E-06	8.7E-9	--
Dichloromethane		2.3E-01	1.40E-03	2.6E-06	4.6E-05	--	2.0E-4	2.20E-03	6.7E-07	1.1E-05	--	5.0E-5
Chloroform	1.5E-03	2.0E-02	9.80E-04	1.8E-06	3.2E-05	2.7E-9	1.6E-3	9.60E-04	2.9E-07	5.0E-06	4.3E-10	2.5E-4
Carbon tetrachloride		6.1E-04	2.53E-04	4.7E-07	8.3E-06	--	1.4E-2	5.72E-04	1.7E-07	3.0E-06	--	4.9E-3
Trichloroethene (TCE)	1.5E-03		1.10E-03	2.1E-06	3.6E-05	3.1E-9	--	1.30E-03	4.0E-07	6.7E-06	5.9E-10	--
Tetrachloroethene (PCE)		4.7E-02	4.10E-03	7.7E-06	1.3E-04	--	2.8E-3	4.40E-03	1.3E-06	2.3E-05	--	4.8E-4
cis-1,2-Dichloroethene		1.0E-02	1.69E-03	3.2E-06	5.5E-05	--	5.5E-3	2.75E-03	8.3E-07	1.4E-05	--	1.4E-3
1,1-Dichloroethene		5.7E-02	9.00E-04	1.7E-06	2.9E-05	--	5.1E-4	9.00E-04	2.7E-07	4.7E-06	--	8.2E-5

↑
Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m)
and modelled air concentration from surface water, to Sept 2008

↑
Maximum of air concentration measured from PEAM1 (0.1m) and PEAM2 (0.2m)
and modelled air concentration from surface water, to Sept 2008

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations			Units	Exposure Calculations (RME) Beach Play in Estuary					
Exposure Parameters									
Exposure Frequency (EF)		days/year	41	Swimming in estuary for 40% of total time (104 days per year)					
Exposure Duration (ED)		years	4	Exposure during time between 1 and 5 years of age					
Body Weight (BW)		kg	13.2	USEPA 1989 and CSMS 1996					
Averaging Time - NonThreshold (ATc)		days	25550	USEPA 1989 and CSMS 1996					
Averaging Time - Threshold (ATn)		days	1500	USEPA 1989 and CSMS 1996					
Inhalation Rate (InhR)		m ³ /hr	1.25	Inhalation rate equivalent active play, CSMS 1996					
Exposure Time (ET)		hours/day	2	Assume beach play for 2 hour each day					
Bioavailability (B)		-	100%	Assume 100% bioavailability via inhalation					
Fraction Inhaled (FI)		-	100%	Assume all time spent swimming in estuary					
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$			m ³ /kg/day	1.2E-03	NonThreshold				
				2.1E-02	Threshold				
<i>Daily Intake from Water = Concentration in Water x Intake Factor</i> <i>NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor</i> <i>Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)</i>									
Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk			
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient		
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)		
					TOTAL	7.2E-7	8.1E-3		
1,2-Dichloroethane (EDC)	9.8E-03		5.60E-02	6.8E-05	1.2E-03	6.7E-7	--		
Vinyl chloride	3.1E-02		1.20E-03	1.5E-06	2.5E-05	4.5E-8	--		
Dichloromethane		2.3E-01	2.00E-03	2.4E-06	4.1E-05	--	1.8E-4		
Chloroform	1.5E-03	2.0E-02	1.20E-03	1.5E-06	2.5E-05	2.1E-9	1.2E-3		
Carbon tetrachloride		6.1E-04	2.22E-05	2.7E-08	4.6E-07	--	7.5E-4		
Trichloroethene (TCE)	1.5E-03		1.30E-03	1.6E-06	2.7E-05	2.4E-9	--		
Tetrachloroethene (PCE)		4.7E-02	4.40E-03	5.3E-06	9.1E-05	--	1.9E-3		
cis-1,2-Dichloroethene		1.0E-02	1.70E-03	2.1E-06	3.5E-05	--	3.5E-3		
1,1-Dichloroethene		5.7E-02	1.20E-03	1.5E-06	2.5E-05	--	4.3E-4		

↑
Maximum concentration measured from PEAM2, PEAM3, PEAM4 and PEAM8 (0.2m) and modelled air concentration from surface water, to Sept 2008

Exposure to Chemicals via Inhalation of Volatiles (Inner Estuary)

Young Children - Penrhyn Estuary

General Data/ Equations		Exposure Calculations (RME)					
Units		Visiting Inner Estuary					
Exposure Parameters							
Exposure Frequency (EF)	days/year	41	Visiting for 41 days per year				
Exposure Duration (ED)	years	4	Exposure during time between 1 and 5 years of age				
Body Weight (BW)	kg	13.2	USEPA 1989 and CSMS 1996				
Averaging Time - NonThreshold (ATc)	days	25550	USEPA 1989 and CSMS 1996				
Averaging Time - Threshold (ATn)	days	1460	USEPA 1989 and CSMS 1996				
Inhalation Rate (InhR)	m ³ /hr	1.25	Inhalation rate equivalent active play, CSMS 1996				
Exposure Time (ET)	hours/day	4	Assume visiting in area for 4 hours during low tide				
Bioavailability (B)	-	100%	Assume 100% bioavailability via inhalation				
Fraction Inhaled (FI)	-	100%	Assume all time spent near estuary				
Intake Factor = $\frac{InhR \cdot ET \cdot B \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$	m ³ /kg/day	2.4E-03	NonThreshold				
		4.3E-02	Threshold				
<i>Daily Intake from Water = Concentration in Water x Intake Factor</i> <i>NonThreshold Risk = Daily Intake from Air for NonThreshold Effects x Slope Factor</i> <i>Hazard Quotients = (Daily Intake from Air for Threshold Effects/ADI)</i>							
Chemical	Toxicity Data		Concentration	Daily Intake		Calculated Risk	
	Non-Threshold Slope Factor	Threshold ADI, TDI or RfD	in Air	NonThreshold	Threshold	NonThreshold Risk	Hazard Quotient
	(mg/kg-day) ⁻¹	(mg/kg/day)	(mg/m ³)	(mg/kg/day)	(mg/kg/day)	(unitless)	(unitless)
				TOTAL		1.3E-6	3.2E-2
1,2-Dichloroethane (EDC)	9.8E-03		5.28E-02	1.3E-04	2.2E-03	1.3E-6	--
Vinyl chloride	3.1E-02		5.10E-04	1.2E-06	2.2E-05	3.8E-8	--
Dichloromethane		2.3E-01	1.40E-03	3.4E-06	6.0E-05	--	2.6E-4
Chloroform	1.5E-03	2.0E-02	9.80E-04	2.4E-06	4.2E-05	3.5E-9	2.1E-3
Carbon tetrachloride		6.1E-04	2.53E-04	6.1E-07	1.1E-05	--	1.8E-2
Trichloroethene (TCE)	1.5E-03		1.10E-03	2.7E-06	4.7E-05	4.0E-9	--
Tetrachloroethene (PCE)		4.7E-02	4.10E-03	1.0E-05	1.7E-04	--	3.7E-3
cis-1,2-Dichloroethene		1.0E-02	1.69E-03	4.1E-06	7.2E-05	--	7.2E-3
1,1-Dichloroethene		5.7E-02	9.00E-04	2.2E-06	3.8E-05	--	6.7E-4

↑
 Maximum concentration measured from PEAM5 and PEAM7 (0.5m)
 Maximum of air concentration measured from PEAM5 and PEAM7 (0.5m)
 and modelled air concentration from surface water, to Sept 2008

Summary of Risk (Inner Estuary Exposures)

Exposure to Target Chemicals at Penrhyn Estuary

Adults

Exposure Pathway	Calculated Non-Threshold Risk	Calculated HI
<u>Exposure to COPC via Ingestion of Surface Water</u>		
Wading in Estuary	3.8E-06	0.00065
Swimming in Estuary	1.0E-05	0.0018
<u>Dermal Exposure to COPC via Contact with Surface Water</u>		
Wading in Estuary	2.8E-04	0.029
Swimming in Estuary	4.9E-05	0.018
<u>Exposure to COPC via Ingestion of Sediments</u>		
Wading in Estuary	0.0E+00	0.0057
Swimming in Estuary	0.0E+00	0.00050
<u>Dermal Exposure to COPC via Contact with Sediments</u>		
Wading in Estuary	0.0E+00	0.00072
Swimming in Estuary	0.0E+00	0.000064
<u>Exposure to COPC via Inhalation of Volatiles</u>		
Wading in Estuary	2.9E-06	0.0040
Swimming in Estuary	3.8E-07	0.0049
Bird Watching	4.1E-06	0.023
Visiting (no wading or swimming)	7.6E-06	0.010
Total Exposure from Wading	3.E-04	0.04
Total Exposure from Swimming	6.E-05	0.03
Exposure During Bird Watching	4.E-06	0.02
Exposure for Visitor (no wading or swimming)	8.E-06	0.01

Data considered to end September 2008

Older Children

Exposure Pathway	Calculated Non-Threshold Risk	Calculated HI
<u>Exposure to COPC via Ingestion of Surface Water</u>		
Wading in Estuary	3.0E-06	0.0035
Swimming in Estuary	8.0E-06	0.010
<u>Dermal Exposure to COPC via Contact with Surface Water</u>		
Wading in Estuary	1.4E-04	0.10
Swimming in Estuary	2.7E-05	0.071
<u>Exposure to COPC via Ingestion of Sediments</u>		
Wading in Estuary	0.0E+00	0.031
Swimming in Estuary	0.0E+00	0.0028
<u>Dermal Exposure to COPC via Contact with Sediments</u>		
Wading in Estuary	0.0E+00	0.0056
Swimming in Estuary	0.0E+00	0.00051
<u>Exposure to COPC via Inhalation of Volatiles</u>		
Wading in Estuary	3.3E-06	0.032
Swimming in Estuary	1.1E-07	0.0098
Visiting (no wading or swimming)	1.6E-06	0.015
Total Exposure from Wading	2.E-04	0.2
Total Exposure from Swimming	4.E-05	0.09
Exposure for Visitor (no wading or swimming)	2.E-06	0.02

Data considered to end September 2008

Summary of Risk (Inner Estuary Exposures)

Exposure to Target Chemicals at Penrhyn Estuary

Young Children

Exposure Pathway	Calculated Non-Threshold Risk	Calculated HI
<u>Exposure to COPC via Ingestion of Surface Water</u>		
Wading in Estuary	2.3E-06	0.0069
Beach Play in Sandy Discharge Zone	2.2E-05	0.0061
Swimming in Estuary	1.5E-06	0.0048
<u>Dermal Exposure to COPC via Contact with Surface Water</u>		
Wading in Estuary	1.5E-05	0.091
Beach Play in Sandy Discharge Zone	3.3E-05	0.015
Swimming in Estuary	2.5E-06	0.016
<u>Exposure to COPC via Ingestion of Sediments</u>		
Wading in Estuary	0.0E+00	0.12
Beach Play in Sandy Discharge Zone	0.0E+00	0.12
Swimming in Estuary	0.0E+00	0.010
<u>Dermal Exposure to COPC via Contact with Sediments</u>		
Wading in Estuary	0.0E+00	0.021
Beach Play in Sandy Discharge Zone	0.0E+00	0.031
Swimming in Estuary	0.0E+00	0.0018
<u>Exposure to COPC via Inhalation of Volatiles</u>		
Wading in Estuary	1.0E-06	0.024
Beach Play in Sandy Discharge Zone	7.2E-07	0.0081
Swimming in Estuary	3.3E-08	0.0071
Visiting (no wading or swimming)	1.3E-06	0.032
Total Exposure from Wading	2.E-05	0.3
Total Exposure from Beach Play in Sandy Discharge Zone	6.E-05	0.2
Total Exposure from Swimming	4.E-06	0.04
Exposure for Visitor (no wading or swimming)	1.E-06	0.03

Data considered to end September 2008

Lifetime Calculations

Total Exposure from Wading	5.E-04	0.3
Total Exposure from Beach Play	6.E-05	0.2
Total Exposure from Swimming	1.E-04	0.09
Exposure for Visitor (no wading or swimming)	1.E-05	0.03
Total Wading, swimming, beach play	6.E-04	0.5