Appendix D: QRA Assessment Parameters

1 HUMAN HEALTH INPUT DATA SUMMARY – PRIORY SERVICE STATION

1.1 CONCEPTUAL EXPOSURE MODEL DEVELOPMENT

Exposure Assumptions

For high density residential (with basement) land-use, a number of exposure assumptions are defined in CLR10. For this assessment it is assumed that the site will be fully encapsulated by structural slabs, sealed roadway or managed landscaped gardens such that direct contact with existing in-situ soil is not viable. The following assumptions have been made with due regard to parameters presented in CLR10:

Parameter	*Value*
Critical receptor	female child
Duration of exposure	6 years
Mean body weight for 0-6 year old females in the UK	14.5 kg
Mean body height for 0-6 year old females in the UK	93 cm
Exposure frequency for vapour inhalation	a maximum 365 days per year, of which on average, 92% of the day is spent indoors, and 8% outdoors on site
Time weighted average breathing rate indoors, accounting for passive and active breathing rates and durations, is for 0-6 year old females in the UK	0.2 m^3/hour
Time weighted average breathing rate outdoors, accounting for passive and active breathing rates and durations for 0-6 year old females in the UK	0.4 m^3/hour

(All data sourced from CLR10 and CLEA Briefing Note 1)

Note URS' Human7 model calculates exposure for each age class separately. Time-weighted average values for the critical receptor have been provided above for simplicity.

General Assumptions

The parameter values used to define the soil and indoor air fate and transport models used to calculate the exposure point PCOC concentrations are detailed below. Guidelines for parameter values provided in CLR10 have been adhered to where appropriate.

The building parameters used in the model are as presented in the CLEA model and accompanying briefing notes. In the modelled scenario the residential building is a two-storey property with basement that is not in itself an enclosed space i.e. the air in the basement is assumed to mix freely with the air in the above ground floors. If the building design to be constructed on this site is significantly different to this then URS recommend that the risk assessment be revised to reflect this change from the default residential property.

Modelling algorithms assume vapour ingress into buildings via foundation cracks only. Given that such cracks would be in the saturated zone at the site, this pathway is not considered viable. However, to acknowledge that vapours may be present in unsaturated shallow soils abutting the sidewalls of the basement

and pass through these walls, modelling adopts unsaturated shallow soils beneath foundations.

It is also noted that this conservative model does not take into account any vapour barrier, which may be fitted during construction. Further, as the depth to groundwater is shallow on site (approximately 1.3m) consideration of a damp proof membrane will have to be given during the design of the basement to prevent the ingress of groundwater. The use of a damp proof membrane may give further protection to the health of future receptors by blocking or restricting the pathway for vapour migration into the building, reducing potential exposure to inhalation of contaminant vapours.

Parameter	*Units*	*Residential value*	*Justification*
		Outdoor Box Model	
Height of box	m	0.46	Equal to half the mean body height for the critical receptor, as advised in CLR 10.
Length of box	m	15	Default for ASTM outdoor air algorithm and basis of its calibration.
Wind speed	ms^{-1}	3	Value recommended in CLR 10
		Building Parameters	
Building air exchange rate	hr-1	0.5	Value recommended in CLEA Briefing Note 3
Height of living space (above ground)	cm	480	Value recommended in CLEA Briefing Note 3
Height of living space (below ground)	cm	220	Value recommended in CLEA Briefing Note 3
Building length	cm	640	Value recommended in CLEA Briefing Note 3
Building Width	cm	640	Value recommended in CLEA Briefing Note 3
Foundation or slab thickness	cm	15	Value recommended in CLEA Briefing Note 3
Floor-wall seam crack width	cm	0.2	Value recommended in CLEA Briefing Note 3
Indoor/outdoor pressure differential	$g/cm/s^2$	40	Value recommended in CLEA Briefing Note 3
Averaging time for surface emission vapour flux	yrs	6	Value recommended in CLR 10
		Unsaturated Zone – Shallow soil	
Soil type	-	CLR10 Sandy	Review of the borehole and trial pit logs indicate that shallow soil generally comprises sandy gravel and gravel with some clay. The properties of Sandy (UK) are considered the closest representation of this stratum.
Total porosity	%	46	Published value for soil type, CLR10
Air content	%	31	Published value for soil type, CLR10
Water content	%	15	Published value for soil type, CLR10
Soil bulk density	gcm^{-3}	1.6	Published value for soil type, CLR10
Fraction of organic carbon	-	0.0143	Adopted Foc is the geometric mean of laboratory derived Foc values for 16 samples collected from site shallow soils and made ground. Foc varied between 0.004 and 0.086.
Effective air permeability	cm^2	7.2 E-08	Calculated value for soil type
		Soil & Groundwater parameters	
Depth to groundwater	m	1.3 (outdoors) 2.40 (indoors)	Average standing water level for monitoring rounds carried out in March 2006, November 2007, January and March 2008 was 1.3m bgl. Water levels varied between 0.745m and 2.045m bgl over this period. Depth selected is depth of below ground living space for residential scenario plus 15cm foundation slab thickness + 5cm nominal diffusion path length.
Nominal depth to shallow soil sources	m	0.2	Allowance made for a nominal diffusive path length of 5 cm below nominal foundation thickness of 15 cm.
Shallow soil thickness	m	1.3	Unsaturated soils extend from ground level to the water table at 1.3 m bgl. Maximum depth of Made Ground is 3.6mbgl.
Depth to base of unsaturated zone	m	1.3	Laboratory information indicates contamination to be present at or below the

contamination			surface of the groundwater unit.

2 STAGE 3 SSTLS

Compound	High Density Residential (with basement) SSTL	
	Unsaturated Soil (0-1.3m bgl) (vapours only) (mg/l g)	Groundwater (mg/l)
Metals		
Arsenic	No path	No path
Beryllium	No path	No path
Cadmium	No path	No path
Chromium	No path	No path
Copper	No path	No path
Lead	No path	No path
Mercury	No path	No path
Nickel	No path	No path
Selenium	No path	No path
Vanadium	No path	No path
Zinc	No path	No path
TPH		
Aliphatics >C5-C6	Sat	1.71
Aliphatics >C6-C8	Sat	1.21
Aliphatics >C8-C10	45.3	0.0460
Aliphatics >C10-C12	84.4	0.0337
Aliphatics >C12-C16	Sat	Sat
Aliphatics >C16-C21	Sat	Sat
Aromatics >C5-C7	52.6	5.65
Aromatics >C7-C8	59.3	4.91
Aromatics >C8-C10	23.5	1.52
Aromatics >C10-C12	130	5.72
Aromatics >C12-C16	724	Sat
Aromatics >C16-C21	Sat	Sat
Aromatics >C21-C35	Sat	Sat
PAH/SVOC		
Naphthalene	11.1	1.06
Acenaphthylene	617	10.8
Acenaphthene	7,380	Sat
Fluorene	Sat	Sat
Phenanthrene	Sat	Sat
Anthracene	Sat	Sat
Fluoranthene	Sat	Sat
Pyrene	Sat	Sat
Benzo(a)anthracene	Sat	Sat
Chrysene	Sat	Sat
Benzo(b)fluoranthene	Sat	Sat
Benzo(k)fluoranthene	Sat	Sat
Benzo(a)pyrene	3,350	0.251
Indeno(1,2,3-cd)pyrene	Sat	Sat
Dibenz(a,h)anthracene	Sat	Sat
Benzo(ghi)perylene	Sat	Sat
VOCs		
Benzene	0.144	0.06
Toluene	11.2	3.91
MTBE	136	405
Ethylbenzene	35.9	8.47
o-Xylene	19.9	4.84
m-Xylene	19.0	4.24
p-Xylene	16.5	3.85

No path = pathway not considered viable
Sat = unacceptable risk to receptor cannot be achieved due to calculated saturation of vapour pathway

Project ABB - Controlled Waters Risk Assessment			Version 3a 8 June 2007
MODEL NAME	Soil and groundwater concentrations to theoretical 50m well		
SITE Nr			
SITE NAME	Priory SS		
MODELLER	Mairead Glennon	DATE	01-Apr-08
APPROVED BY	*Lauren Ballarini*	DATE	*01-Apr-08*

Contaminant Concentrations

	Max Soil (mg/kg)	Max GW conc (µg/l)	Max Product Thickness (mm)	Comments	List 1 or 2 substance	Soil Source Zone (1, 2 or 3)
TPH Groups						
GRO + TPH<C10	0.973	-	-	Soil Source 1: whole site	1	1
Aromatic >C10-C12	0.023	-	-	Soil Source 1: whole site	1	1
Aromatic >C12-C16	1.645	-	-	Soil Source 1: whole site	1	1
Aromatic >C16-C21	10.1	-	-	Soil Source 1: whole site	1	1
Aromatic >C21-C35	21.962	-	-	Soil Source 1: whole site	1	1
Aliphatic >C10-C12	0.019	-	-	Soil Source 1: whole site	1	1
Aliphatic >C12-C16	3.869	-	-	Soil Source 1: whole site	1	1
Aliphatic >C16-C21	10.364	-	-	Soil Source 1: whole site	1	1
Aliphatic >C21-C35	14.383	-	-	Soil Source 1: whole site	1	1
Total TPH	68	0	-		1	1
BTEX						
Benzene	-	-	-	-	1	1
Toluene	0.58	-	-	Soil source 2: TK01, TK02, TK03.	1	2
Ethylbenzene	-	-	-	-	1	1
Xylene	1.53	-	-	Soil source 2: TK01, TK02, TK03.	1	2
MTBE	-	-	-		1	1
PAH's						
Acenaphthene	-	-	-	-	1	1
Acenaphthylene	-	-	-	-	1	1
Anthracene	-	-	-	-	1	1
Benzo (a) anthracene	4.1	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Benzo (a) pyrene	3.6	0.035	-	Soil Source 3: 1996m2 in 2 areas	1	3
Benzo (b) fluoranthene 5	5.1	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Benzo (ghi) perylene 5	-	-	-	-	1	1
Benzo (k) fluoranthene 5	1.2	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Chrysene	-	-	-	-	1	1
Dibenzo (a,h) anthracene	0.83	0.017	-	Soil Source 3: 1996m2 in 2 areas	1	3
Fluoranthene	9.4	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Fluorene	-	-	-	-	1	1
Indeno (1,2,3-cd) pyrene 5	1.8	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Naphthalene	0.212	-	-	Soil Source 1: whole site	1	1
Phenanthrene	6.4	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Pyrene	0.473	-	-	Soil Source 1: whole site	1	1
PAH (total of 4)	8.3	0	-		1	1
METALS						
Arsenic	11.102	-	-	Soil Source 1: whole site	2	1
Cadmium	1.735	-	-	Soil Source 1: whole site	1	1
Chromium	17.238	-	-	Soil Source 1: whole site	2	1
Copper	22.171	-	-	Soil Source 1: whole site	2	1
Lead	67.036	-	-	Soil Source 1: whole site	2	1
Mercury	-	-	-		1	1
Nickel	28.714	-	-	Soil Source 1: whole site	2	1
Selenium	-	-	-		2	1
Zinc	165.58	-	-	Soil Source 1: whole site	2	1
Barium	-	-	-		2	1
Beryllium	-	-	-		2	1
Molybdenum	-	-	-		2	1
Vanadium	-	-	-		2	1

[redacted] Soil [redacted]

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SITE Nr			
SITE NAME	Priory SS		
MODELLER	Mairead Glennon	DATE	01-Apr-08
APPROVED BY	*Lauren Ballarini*	DATE	*01-Apr-08*

Source Dimensions	Source 1	Source 2	Source 3	GW Source	
LENGTH (PARALLEL TO FLOW)	78.6	2.8	70	35.4	METRES
WIDTH (PERPENDICULAR TO FLOW)	36	5.7	28.5	40	METRES
MAXIMUM AGE OF SOIL SOURCE	18	18	18	18	Years
MTBE LIMITATION	22	22	22	22	Years

Receptors

Nr of Receptors	2	Receptor Nr	2
Description	Theoretical 50m well		
Water Target Values (EQS =2 or DWS = 1)	1		
Shortest Horizontal Distance to Receptor	50	metres	
Vertical distance through saturated aquifer	0		NA - modelling horizontally

Note. if unsaturated pathway simulated between source & groundwater set E76 to zero - spreadsheet will use unsaturated zone thickness (E91 to E97)

Pathways

	enter YES or NO	
ATTENUATION SOIL TO GROUNDWATER (UNSATURATED VERTICAL)	YES	
DILUTION WITHIN GROUNDWATER for List I & II Substances	YES	NO DILUTION - is only applied to List I Substances if no groundwater contamination is present, or sli
ATTENUATION ALONG HORIZONTAL (SATURATED)	YES	If Saturated Vertical pathway (not unsat zone) set to YES, hor pathway must be set to NO
ATTENUATION ALONG VERTICAL (SATURATED)	NO	If Hor pathway set to YES, vert sat pathway must be set to NO
DRAINAGE PATHWAY	NO	Not Programmed into model

Pathway Parameters

		Minimum	Unit	Comments	Stochastic Parameterisation
Soil Type at source.		SAND			
Fraction of organic carbon at Source.	*Minimum*		percent		
	Most Likely	1.43	percent	Geomean of 16 representative samples, checked for TPH interference	[redacted]
	Maximum		percent		
Unsaturated zone thickness	*Minimum*		metres		
	Most Likely	0	metres	Justification	[redacted]
	Maximum		metres		
Depth to free phase product (if present)		0	metres		
Infiltration Rate	*Minimum*		metres/year		
	Most Likely	0.071	metres/year	10% of longterm annual average rainfall Casement Aerodrome	[redacted]
	Maximum		metres/year		
PSD Conductivity		0	metres/day		
Literature value of Hyd Conductivity (saturated)		5.00	metres/day		
Modelled Hydraulic Conductivity	*Minimum*		metres/day		
	Most Likely	0.0002	metres/day	Midpoint of Consim range for clays.	[redacted]
	Maximum		metres/day		
Hydraulic Gradient	*Minimum*				
	Most Likely	0.031		Calculated from 4 March 2008 contour map	[redacted]
	Maximum				
Effective Porosity	*Minimum*		Percent		
	Most Likely	16.00	Percent	Effective porosity value from Kruseman & de Ridder for till	[redacted]
	Maximum		Percent		
Thickness of Aquifer		5	metres	5m of clay observed on site.	
Thickness of GW mixing zone		1.000	metres	Default Calculation	
Thickness of groundwater source		5	metres	Default Calculation	
Decay Rate Type - UNSATURATED ZONE		1			
Decay Rate Type - SATURATED ZONE PATHWAY		1			
Vertical Conductivity	*Minimum*		metres/day		
	Most Likely		metres/day	n/a	[redacted]
	Maximum		metres/day		

Project ABB - Controlled Waters Risk Assessment			Version 3a 8 June 2007
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SITE Nr			
SITE NAME	Priory SS		
MODELLER	Muiread Glennon	DATE	01-Apr-08
APPROVED BY	*Lauren Ballarini*	DATE	*01-Apr-08*

Contaminant Concentrations

	Max Soil (mg/kg)	Max GW conc (µg/l)	Max Product Thickness (mm)	Comments	List 1 or 2 substance	Soil Source Zone (1, 2 or 3)
TPH Groups						
GRO + TPH<C10	0.973	-	-		1	1
Aromatic >C10-C12	0.023	-	-	Soil Source 1: whole site	1	1
Aromatic >C12-C16	1.645	-	-	Soil Source 1: whole site	1	1
Aromatic >C16-C21	10.1	-	-	Soil Source 1: whole site	1	1
Aromatic >C21-C35	21.962	-	-	Soil Source 1: whole site	1	1
Aliphatic >C10 C12	0.019	-	-	Soil Source 1: whole site	1	1
Aliphatic >C12-C16	3.869	-	-	Soil Source 1: whole site	1	1
Aliphatic >C16-C21	10.364	-	-	Soil Source 1: whole site	1	1
Aliphatic >C21-C35	14.383	-	-	Soil Source 1: whole site	1	1
Total TPH	0.3	0	-		1	1
BTEX						
Benzene	-	-	-		1	1
Toluene	0.58	-	-	Source 2: TK01, TK02, TK03	1	2
Ethylbenzene	-	-	-		1	1
Xylene	1.53	-	-	Source 2: TK01, TK02, TK03	1	2
MTBE	-	-	-		1	1
PAH's						
Acenaphtene	-	-	-	-	1	1
Acenaphthylene	-	-	-	-	1	1
Anthracene	-	-	-	-	1	1
Benzo (a) anthracene	4.1	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
benzo (a) pyrene	3.6	0.035	-	Soil Source 3: 1996m2 in 2 areas	1	3
Benzo (b) fluoranthene *	5.1	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Benzo (ghi) perylene *	-	-	-	-	1	1
Benzo (k) fluoranthene *	1.2	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Chrysene	-	-	-	-	1	1
Dibenzo (a,h) anthracene	0.83	0.017	-	Soil Source 3: 1996m2 in 2 areas	1	3
Fluoranthene	9.4	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Fluorene	-	-	-	-	1	1
Indeno (1,2,3-cd) pyrene *	1.8	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Napthalene	0.212	-	-	Soil Source 1: whole site	1	1
Phenanthrene	6.4	-	-	Soil Source 3: 1996m2 in 2 areas	1	3
Pyrene	0.473	-	-	Soil Source 1: whole site	1	1
PAH (total of 4)	8.1	0	-		1	1
METALS						
Arsenic	11.102	-	-	Soil Source 1: whole site	2	1
Cadmium	1.735	-	-	Soil Source 1: whole site	1	1
Chromium	17.238	-	-	Soil Source 1: whole site	2	1
Copper	22.171	-	-	Soil Source 1: whole site	2	1
Lead	67.036	-	-	Soil Source 1: whole site	2	1
Mercury	-	-	-		1	1
Nickel	28.714	-	-	Soil Source 1: whole site	2	1
Selenium	-	-	-		2	1
Zinc	165.58	-	-	Soil Source 1: whole site	2	1
Barium	-	-	-		2	1
Beryllium	-	-	-		2	1
Molybdenum	-	-	-		2	1
Vanadium	-	-	-		2	1

[redacted] Soil [redacted]

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SITE Nr			
SITE NAME	Priory SS		
MODELLER	Mairead Gleanon	DATE	01-Apr-08
APPROVED BY	*Lauren Ballarini*	DATE	*01-Apr-08*

Source Dimensions	Source 1	Source 2	Source 3	GW Source	
LENGTH (PARALLEL TO FLOW)	78.6	2.8	70	35.4	METRES
WIDTH (PERPENDICULAR TO FLOW)	36	5.7	28.5	40	METRES
MAXIMUM AGE OF SOIL SOURCE	18	18	18	18	Years
MTBE LIMITATION	22	22	22	22	Years

Receptors

Nr of Receptors	2	Receptor Nr	1	
Description	Little Dargle River			
Water Target Values (EQS =2 or DWS = 1)	2			
Shortest Horizontal Distance to Receptor		50	metres	
Vertical distance through saturated aquifer		0		NA - modelling horizontally

Note: if unsaturated pathway simulated between source & groundwater set E76 to zero - spreadsheet will use unsaturated zone thickness (E91 to E97)

Pathways

	enter YES or NO	
ATTENUATION SOIL TO GROUNDWATER (UNSATURATED VERTICAL)	YES	
DILUTION WITHIN GROUNDWATER for List I & II Substances	YES	NO DILUTION - is only applied to List I Substances if no groundwater contamination is present, or su
ATTENUATION ALONG HORIZONTAL (SATURATED)	YES	If Saturated Vertical pathway (not unsat zone) set to YES, hor pathway must be set to NO
ATTENUATION ALONG VERTICAL (SATURATED)	NO	If Hor pathway set to YES, vert sat pathway must be set to NO
DRAINAGE PATHWAY	NO	Not Programmed into model

Pathway Parameters

		Minimum	Unit	Comments
Soil Type at source.		SAND		
Fraction of organic carbon at Source.	*Minimum*		percent	
	Most Likely	1.43	percent	Geomean of 16 representative samples, checkal for TPH interference
	Maximum		percent	
Unsaturated zone thickness	*Minimum*		metres	
	Most Likely	0	metres	Justification
	Maximum		metres	
Depth to free phase product (if present)		0	metres	
Infiltration Rate	*Minimum*		metres/year	
	Most Likely	0.071	metres/year	10% of longterm annual average rainfall Casement Aerodrome
	Maximum		metres/year	
PSD Conductivity		0	metres/day	
Literature value of Hyd Conductivity (saturated)		5.00	metres/day	
Modelled Hydraulic Conductivity	*Minimum*		metres/day	
	Most Likely	0.0002	metres/day	Midpoint of Consim range for clays.
	Maximum		metres/day	
Hydraulic Gradient	*Minimum*			
	Most Likely	0.031		Calculated from 4 March 2008 contour map
	Maximum			
Effective Porosity	*Minimum*		Percent	
	Most Likely	16.00	Percent	Effective porosity value from Kruseman & de Ridder for till
	Maximum		Percent	
Thickness of Aquifer		5	metres	5m of clay observed on site.
Thickness of GW mixing zone		5.000	metres	Default Calculation
Thickness of groundwater source		5	metres	Default Calculation
Decay Rate Type - UNSATURATED ZONE		1		
Decay Rate Type - SATURATED ZONE PATHWAY		1		
Vertical Conductivity	*Minimum*		metres/day	
	Most Likely		metres/day	n/a
	Maximum		metres/day	

Stochastic Paramterisation