1. DERIVATION OF GROUNDWATER REMEDIATION TARGETS

As shown in Table 2-2 of the Remediation Action Plan, the derived groundwater remediation target for each of the individual chemicals of concern (COC) is: -

Table 1 Remediation Targets

Parameter	Remediation Targets(mg/L)
Mineral Oil and Gasoline (TPH)	No Free Product*
Benzene	**17**
Toluene	520*
Ethybenzene	170*
Xylenes	200*
Chromium (VI)	21
Copper	280
Nickel	140
Mercury	0.081*

"*" Indicates solubility value of that contaminant in water is below the risk-based target concentration

The source concentration used for each of the parameter is shown below. They are derived from the maximum concentration of that parameter found on site irrespective of their locations. However, if they were not detected, the detection limits were used. Also, chromium is all assumed to be Cr (VI) for conservative assessment.

Table 2 Source Concentrations

Parameter	Source concentration (mg/L)	Oral slope factor 1/(mg/kg-day)	Oral reference dose (mg/kg/d)
Mineral Oil and Gasoline (TPH)	1.3	N.A.	4.00E-02 to 5.00E+00 [1]
Benzene	2.0E-3	2.90E-02 [3]	3.00E-03 [2]
Toluene	2.0E-3	N.A.	2.00E-01 [2]
Ethybenzene	2.0E-3	N.A.	1.00E-01 [3]
Xylenes	6.0E-3	N.A.	2.00E+00 [2]
Chromium (VI)	3.8E+0	7.30E-03 [2]	3.00E-03 [2]
Copper	7.2E-1	N.A.	4.00E-02 [2]
Nickel	4.6E-1	N.A.	2.00E-02 [2]
Mercury	6.0E-3	N.A.	3.00E-04 [3]

Using benzene as an example, the risk based groundwater remediation target (RBSL) is derived as follows. Remediation targets for other parameters can be derived similarly. The only pre-requisite is that they should have recognised oral slope factors or oral reference dose. This is the reason why the remediation target for lead cannot be derived this way.

1.1 Exposure Pathway

The applicable and dominant complete pathways is direct groundwater ingestion

[1] TPH Criteria Working Group, 1996 (range of oral reference dose depends on the aliphatic and aromatic portion and the chain length/ molecular weight)

[2] EPA Region III Risk Based Concentration Table, EPA Region 3, March 7, 1995

[3] Standard Provisional Guide for Risk-based Corrective Action, ASTM PS 104-98

1.2 Receptor

The most sensitive receptors in this case are the construction workers.

1.3 Calculations : Direct Groundwater Ingestion

Using benzene as an example

1. Groundwater conc.	= 2.0E-03 mg/L	
2. Natural attenuation factor	= 1 (dimensionless)	
3. Exposure medium	= 2.0E-03 mg/L	(1)/(2)
4. Exposure multiplier = (IRxEFxED)/(BWxAT)	= 2.0E-06 L/kg/day	
5. Average Daily Intake Rate	= 4.0E-09 mg/kg/day	(3) x (4)
6. Maximum Pathway Intake (groundwater ingestion as dominating pathway)	= 4.0E-09 mg/kg/day	
7. Maximum Carcinogenic Intake Rate	= 4.0E-09 mg/kg/day	
8. Oral Slope Factor [reference [3]]	= 2.9E-02 (mg/kg-day)^-1	
9. Individual COC Risk	= 1.2E-10	(7) x (8)
10. Maximum Toxicant Intake Rate	= 2.8E-07 mg/kg/d	
11. Oral Reference Dose [reference [2]]	= 3.0E-3 mg/kg/d	
12. Individual COC hazard quotient	= 9.4E-05	(10)/(11)

Total pathway carcinogenic risk =5.6E-8 < 1E-06 [ref. [4]]

(contributed by benzene and Cr(VI) only but dominated by Cr(VI))

Total pathway hazard index =1.9E-01 < 1

(After adding contributions from all other COC)

where

IR = water ingestion rate = 0.02 L/d

EF = exposure frequency = 180 d/yr (construction workers' exposure for 6 months of site foundation works, superstructure works not applicable)

ED = exposure duration = 1 yr (construction workers)

BW = body weight = 70 kg

AT = Averaging time (d) = 70 yrs x 365 days (for carcinogens), or ED x 365 days (for non-carcinogens)

Therefore Risk Based Screening Level (RBSL) for groundwater

= Minimum of [Groundwater conc./ Hazard Quotient or groundwater conc. x individual risk guideline/ individual risk]

= Minimum of [21.3 mg/L or 17 mg/L]

= 17 mg/L >> groundwater conc. at 2.0E-03 mg/L **(Therefore acceptable)**

[4] USEPA individual risk guideline