

Soil Cleanup Levels for Industrial Land Use

Table 745-1

Notes on Developing Method A Table Values
Washington State Department of Ecology
Clarc Notes

Method A Notes.doc

Notes on the Development of Method A Cleanup Levels WAC 173-340-720, 740, and 745

The following tables were prepared as part of the rule-making process for the amended MTCA rule adopted February 12, 2001. The information in the tables was used when Ecology developed the Method A Cleanup Levels for the revised regulation.

The tables compile cleanup level calculations for various exposure pathways for both carcinogenic and noncarcinogenic health effects, applicable state and federal laws, laboratory practical quantitation limits and other relevant information that was used to develop the Method A cleanup levels. While this is useful background information, **the values in these tables are not the adopted rule and should not be used as Method A cleanup levels.** Use the tables, footnotes and accompanying text in the adopted regulation to develop Method A cleanup levels.

NOTE: Some columns in these tables refer to "current" and "proposed" Method A values. "Current" as used in these tables refers to the cleanup levels as they existed prior to the adoption of the February 12, 2001 rule amendments. "Proposed" as used in these tables are the cleanup levels that were adopted on February 12, 2001.

February 9, 2001
November 23, 2004 revision (1)

TO: Interested Persons

FROM: Pete Kmet, Senior Environmental Engineer
Toxics Cleanup Program

SUBJECT: Calculations for Table 745-1
Method A Soil Cleanup Levels for Industrial Properties

Attached are several tables in excel format providing information on the development of the Method A soil cleanup levels for industrial properties in Table 745-1, WAC 173-340-900.

Table 1: A quick summary providing Method A cleanup levels for industrial properties (Table 745-1) and a brief explanation of the reasoning in the development of Method A values.

Table 2: A detailed compilation of the information considered in the development of Method A soil cleanup levels for unrestricted land uses. This information includes:

- The Method B direct contact exposure pathway soil values for each substance. This includes values for both soil ingestion and soil ingestion plus dermal adsorption (adsorption through the skin) for both carcinogens and non-carcinogens, where sufficient information was available for the calculations as of February, 2001;
- The results for the soil leaching pathway from the 3 and 4 phase models as of February, 2001;
- Terrestrial ecological evaluation values from Tables 749-2 and 749-3;
- Regulatory values from other laws as of February, 2001; and
- Natural background, practical quantitation limits and other relevant information available as of February, 2001.

Table 3: Describes the assumptions used to calculate the standard Method C soil direct contact cleanup values for industrial land uses for carcinogens using equation 745-2 in WAC 173-340-745(5)(b)(iii)(B)(II).

Table 4: Describes the assumptions used to calculate the standard Method C soil direct contact cleanup values for industrial land uses for non-carcinogens using equation 745-1 in WAC 173-340-745(5)(b)(iii)(B)(I).

Table 5: Describes the assumptions and equation used to calculate the modified Method C values for industrial land uses assuming concurrent soil ingestion plus dermal (skin) absorption for carcinogens using equation 745-5 in WAC 173-340-745(3)(b)(iii)(B).

Table 6: Describes the assumptions and equation used to calculate the modified Method C values for industrial land uses assuming concurrent soil ingestion plus dermal (skin) absorption for noncarcinogens using equation 745-4 in WAC 173-340-745(3)(b)(iii)(A).

Table 7: Describes the assumptions and equations used to calculate soil concentrations protective of ground water for drinking water use, using the 3 phase leaching model.

Tables 8-10: 4-phase model results summary sheets for 2 brands of fresh gasoline and these same gasolines using various weathered compositions.

(1) This memo and attached excel tables explain the basis for the Method A cleanup levels in the MTCA rule adopted February 12, 2001. The memos and tables have been slightly revised from the originals issued on February 9, 2001 to clarify certain information in response to questions received since issuance of the original memos and tables. The original memos and tables can be found in appendix D of the concise explanatory statement for the February 12, 2001 rule amendments (http://www.ecy.wa.gov/programs/tcp/regs/reg_main.html)

Table 1: Quick Summary -- Basis for Method A Industrial Land Use Soil Values

		1991 Method A	2001 adopted	Basis for Standard
Hazardous Substance	CAS Number	Cleanup Level mg/kg	Cleanup Level mg/kg	
Arsenic	7440-38-2	200	20	Protection of drinking water, adjusted for background (1)
Benzene	71-43-2	0.5	0.03	Protection of drinking water--based on both 3 and 4 phase models.
Benzo(a)Pyrene	50-32-8	none	2	Protection of drinking water--3 phase model.
Cadmium	7440-43-9	10	2	Protection of drinking water, adjusted for PQL.
Chromium (total)	7440-47-3	500.0	none	Replaced by values for Cr III and Cr VI.
Chromium VI	18540-29-9		19	Protection of drinking water--3 phase model.
Chromium III	16065-83-1		2000	Protection of drinking water--3 phase model.
DDT	50-29-3	5	4	Protection of drinking water--3 phase model.
Ethylbenzene	100-41-4	20	6	Protection of drinking water--3 phase model.
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	Protection of drinking water, adjusted for PQL
Lead	7439-92-1	1000.0	1000	Ingestion (3)
Lindane	58-89-9	20	0.01	Protection of drinking water, adjusted for PQL
Methylene chloride	75-09-2	0.5	0.02	Protection of drinking water--3 phase model.
Mercury (inorganic)	7439-97-6	1	2	Protection of drinking water--3 phase model.
MTBE	1634-04-4	none	0.1	Protection of drinking water--3 phase model.
Naphthalenes	91-20-3	none	5	Protection of drinking water--3 phase model. Total of naphthalene, 1-methyl naphthalene & 2-methyl naphthalene
PAHs (carcinogenic)		20	none	Replaced by benzo(a)pyrene.
PCB Mixtures	1336-36-3	10.0	10	ARAR. This is a total value for all PCBs in the soil sample.
Tetrachloroethylene	127-18-4	0.5	0.05	Protection of drinking water--3 phase model.
Toluene	108-88-3	40	7	Protection of drinking water--3 phase model.
1,1,1 Trichloroethane	71-55-6	20	2	Protection of drinking water--3 phase model.
Trichloroethylene	79-01-5	0.5	0.03	Protection of drinking water--3 phase model.
Xylenes	1330-20-7	20	9	Protection of drinking water--3 phase model. Total of all m, o & p xylene.
TPH (total)	14280-30-9			
Gasoline range organics	6842-59-6			
GRO with benzene		100	30	Protection of drinking water--4 phase model, assuming weathered gasoline composition.
GRO w/o benzene		100	100 (5)	Protection of drinking water--4 phase model, assuming highly weathered gasoline composition.
Diesel Range Organics		200	2000	Protection of drinking water--residual saturation
Heavy Oils		200	2000	Protection of drinking water--residual saturation for diesel.
Electrical Insulating Mineral Oil		200 (4)	4000	Protection of drinking water--residual saturation
(1) Based on background value in table 740-1. Ecology intends to review and, if appropriate, update this value in a future rulemaking.				
(2) This can also be used as the total toxic equivalents for all cPAHs. See WAC 173-340-708(8).				
(3) Ecology decision not to change at this time. Ecology intends to review and, if appropriate, update this value in a future rulemaking.				
(4) Ecology also issued a fact sheet in 1995 (#95-157-TCP) allowing the use of 2000 mg/kg at electrical substations and switchyards.				
With the adoption of the rule in 2001, this fact sheet has been withdrawn.				
(5) To use this value no benzene must be present in the soil and the total of ethyl benzene, toluene & xylene must be less than 1% of the gasoline mixture.				

Table 2: Summary Table for Method A Industrial Soil Cleanup Values in Table 745-1

Method A Soil Cleanup Levels -for Industrial Land Uses									
		2001 adopted Method A	Ingestion	Dermal + Ingestion	Leaching Using		100 X		
Hazardous Substance	CAS Number	Cleanup Level mg/kg (1)	Noncarc. mg/kg (2)	Noncarc. mg/kg (3)	4-phase Model mg/kg (4)	Residual Saturation mg/kg (5)	Ground water C/U level mg/kg (6)	Vapor mg/kg (7)	
TPH (total)	14280-30-9								
Gasoline range organics	6842-59-6	100							
GRO with benzene			210,000	150,000	1 / 23 to 28	1,000	80	unknown	
GRO without benzene					105	1,000	100	unknown	
Diesel Range Organics		200	170,000	39,000	No upper limit	2,000	50	>10,000	
Heavy Oils (8)		200	170,000	39,000	No upper limit	2,000	50	>10,000	
Electrical Insulating Mineral Oil		2000 (9)	340,000	70,000	No upper limit	4,000	100	Not volatile	
(1) From WAC 173-340-740 Table 2 [1/26/96 revision].									
(2) Calculated using surrogates. See 1/29/99 Steve Robb memo.									
(3) Calculated using surrogates and equation 740-4. See 1/29/99 Steve Robb memo.									
(4) Calculated using 4 phase model. For GRO with benzene, 1st value assumes fresh gas (3% benzene); 2nd values assume weathered gas (~0.1% benzene). For GRO without benzene, assumes no benzene present in gasoline mixture and that ethyl benzene, toluene and xylene are less than 1% of the gas.									
For diesel, heavy oils and mineral oil, "no upper limit" means HI of 1 never exceeded. This is true only if the soil is above the water table.									
(5) Residual saturation for coarse soils from Coen and Mercer for gas and diesel and BPA study for mineral oil.									
(6) Calculated using 1991 method of 100 X table 720-1 proposed ground water cleanup level.									
(7) Gasoline vapors not calculated. The current Method A value of 100 ppm thought to be protective for vapor pathway. Diesel vapors based on qualitative observations at sites by PLIA.									
(8) Based on diesel composition.									
(9) Ecology also issued a fact sheet in 1995 (#95-157-TCP) allowing the use of 2000 mg/kg at electrical substations and switchyards.									
With the adoption of the rule in 2001, this fact sheet has been withdrawn.									

Table 2: Summary Table for Method A Industrial Soil Cleanup Values in Table 745-1

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Table 2: Summary Table for Method A Industrial Soil Cleanup Values in Table 745-1

Method A Soil Cleanup Levels -for Industrial Land Uses										
	Ecological Simplified Evaluation	Ecological Indicator Concentration mg/kg (2)	Most Stringent Non-Eco Path mg/kg	Controlling Non-Eco Pathway	ARARs mg/kg	PQL mg/kg (3)	Background mg/kg	1991 Method A Cleanup Level mg/kg	2001 adopted Method A Cleanup Level mg/kg	Basis for Standard
Hazardous Substance										
TPH (total)										
Gasoline range organics										
GRO with benzene	1,000 to 12,000	1,000 to 5,000	23 to 28	Leaching		5 (NWTPH-Gx)		100	30	Protection of drinking water(4)
GRO without benzene	1,000 to 12,000	1,000 to 5,000	105	Leaching		5 (NWTPH-Gx)		100	100	Protection of drinking water(5)
Diesel Range Organics	2,000 to 15,000	2,000 to 6,000	2000	Leaching		25 (NWTPH-Dx)		200	2000	Residual Saturation
Heavy Oils (6)	2,000 to 15,000	2,000 to 6,000	2000	Leaching		100 (NWTPH-Dx)		200	2000	Residual Saturation
Electrical Insulating Mineral Oil			4000	Leaching		100 (NWTPH-Dx)		200 (7)	4000	Residual Saturation
(1) Value from Table 749-2 for unrestricted land use. For reference only, not used in developing Method A values.										
(2) Most stringent indicator value from Table 749-3. For reference only, not used in developing Method A values.										
(3) From Manchester Lab.										
(4) Based on 4-phase model results for weathered gasoline with 0.1% benzene, a typical value for gasoline contaminated sites.										
(5) Based on 4-phase model results for weathered gasoline assuming no benzene present in soil and that ethyl benzene, toluene & xylene are less than 1% of the gasoline mixture.										
(6) Based on diesel composition.										
(7) Ecology also issued a fact sheet in 1995 (#95-157-TCP) allowing the use of 2000 mg/kg at electrical substations and switchyards.										
With the adoption of the rule in 2001, this fact sheet has been withdrawn.										

Table 3: Method C Industrial Soil Calculations for Carcinogens

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Table 4: Soil Ingestion -- Method C Industrial Soil Calculations for Noncarcinogens

Risk Calculations--Noncarcinogenic Effects of Soil Ingestion											
Parameter	CAS No.	Reference Dose (1) (mg/kg-day)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Soil Ing. Rate (mg/day)	G.I. Abs. Fraction (unitless)	Frequency of Contact (unitless)	Method C Noncarc(2) (mg/kg)	ARAR (3) (mg/kg)	HQ @ ARAR (4) (unitless)
Arsenic (5)	7440-38-2	0.0003	70	1,000,000	1	50	1.0	0.4	1,050		
Benzene	71-43-2	0.003	70	1,000,000	1	50	1.0	0.4	10,500		
Cadmium	7440-43-9	0.001	70	1,000,000	1	50	1.0	0.4	3,500		
T Chromium	7440-47-3	not available									
Chromium III	16065-83-1	1.5	70	1,000,000	1	50	1.0	0.4	5,250,000		
Chromium VI	18540-29-9	0.003	70	1,000,000	1	50	1.0	0.4	10,500		
DDT	50-29-3	0.0005	70	1,000,000	1	50	1.0	0.4	1,750		
Ethylbenzene	100-41-4	0.1	70	1,000,000	1	50	1.0	0.4	350,000		
Ethylene dibromide (EDB)	106-93-4	not available									
Lead	7439-92-1	not available									
Lindane	58-89-9	0.0003	70	1,000,000	1	50	1.0	0.4	1,050		
Methylene chloride	75-09-2	0.06	70	1,000,000	1	50	1.0	0.4	210,000		
Mercury (inorganic)	7439-97-6	0.0003	70	1,000,000	1	50	1.0	0.4	1,050		
MTBE	1634-04-4	not available									
Naphthalene	91-20-3	0.02	70	1,000,000	1	50	1.0	0.4	70,000		
cPAH Mixtures	na	not available									
Benzo[a]anthracene	56-55-3	not available									
Benzo[b]fluoranthene	205-99-2	not available									
Benzo[k]fluoranthene	207-08-9	not available									
Benzo[a]pyrene	50-32-8	not available									
Chrysene	218-01-9	not available									
Dibenzo[a,h]anthracene	53-70-3	not available									
Ideno[1,2,3-cd]pyrene	207-08-9	not available									
(1) Source of RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.											
(2) Value calculated using equation 740-1 and default assumptions in that equation.											
(3) Applicable, relevant and appropriate requirement.											
(4) ARAR divided by Method B value in column K. Bolded values indicate ARAR exceeds MTCA requirement that HQ not exceed 1.0.											
(5) The MTCA 2.0 CLARC tables (Feb, 1996 edition) use a GI absorption fraction of 0.4. That number is no longer thought to be valid and 1.0 is used here.											

Table 4: Soil Ingestion -- Method C Industrial Soil Calculations for Noncarcinogens

Risk Calculations--Noncarcinogenic Effects of Soil Ingestion											
Parameter	CAS No.	Reference Dose (1) (mg/kg-day)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Soil Ing. Rate (mg/day)	G.I. Abs. Fraction (unitless)	Frequency of Contact (unitless)	Method C Noncarc(2) (mg/kg)	ARAR (3) (mg/kg)	HQ @ ARAR (4) (unitless)
PCB mixtures	1336-36-3	not available								1.0	
High Risk & Persistence		not available									
Low Risk & Persistence		not available									
Lowest Risk & Persistence		not available									
Aroclor 1016	12674-11-2	0.00007	70	1,000,000	1	50	1.0	0.4	245.0	1.0	0.004
Aroclor 1248	12672-29-6	not available									
Aroclor 1254	11097-69-1	0.00002	70	1,000,000	1	50	1.0	0.4	70.0	1.0	0.01
Aroclor 1260		not available									
Tetrachloroethylene (PCE)	127-18-4	0.01	70	1,000,000	1	50	1.0	0.4	35,000		
Toluene	108-88-3	0.2	70	1,000,000	1	50	1.0	0.4	700,000		
1,1,1 Trichloroethane	71-55-6	0.9	70	1,000,000	1	50	1.0	0.4	3,150,000		
Trichloroethylene	79-01-6	not available									
Xylenes	1330-20-7	2.0	70	1,000,000	1	50	1.0	0.4	7,000,000		
m-Xylene	108-38-3	not available									
o-xylene	95-47-6	not available									
p-xylene		not available									
(1) Source of RfDs is EPA's IRIS database except for 1,1,1, TCE which is from HEAST.											
(2) Value calculated using equation 740-1 and default assumptions in that equation.											
(3) Applicable, relevant and appropriate requirement. Source for PCBs is 40 CFR Part 761.61(a)(4)(i)(A).											
(4) ARAR divided by Method B value in column K. Bolded values indicate ARAR exceeds MTCA requirement that HQ not exceed 1.0.											

Table 5: Method C Industrial Calculations for Carcinogens for Soil Ingestion plus Dermal Contact

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Table 5: Method C Industrial Calculations for Carcinogens for Soil Ingestion plus Dermal Contact

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Table 6: Method C Industrial Calculations for Noncarcinogens for Soil Ingestion plus Dermal Contact

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Table 6: Method C Industrial Calculations for Noncarcinogens for Soil Ingestion plus Dermal Contact

Risk Calculations--Noncarcinogenic Effects of Soil Ingestion + Dermal Contact																
Parameter	CAS No.	Hazard Index (unitless)	Avg. Body Weight (kg)	Averaging Time (days)	Exposure Frequency (unitless)	Exposure Duration (years)	Oral Ref. Dose (1) (mg/kg-day)	Soil Ing. Rate (mg/day)	G.I. Abs. Fraction (unitless)	Unit Conv. Factor (mg/kg)	G.I. Conv. Factor (unitless)	Dermal Rfd (2) (mg/kg-day)	Surface Area (mg/cm ²)	Adherence Factor (mg/cm ²)	Dermal Abs. Fraction (unitless)	Method C Noncarc(2) (mg/kg)
PCB mixtures	1336-36-3						not available									
High Risk & Persistence							not available									
Low Risk & Persistence							not available									
Lowest Risk & Persistence							not available									
Aroclor 1016	12674-11-2	1	70	7,300	250	20	0.00007	50	1	1,000,000	0.81	0.000057	2,500	0.2	0.14	52.4
Aroclor 1248	12672-29-6						not available									
Aroclor 1254	11097-69-1	1	70	7,300	250	20	0.00002	50	1	1,000,000	0.81	0.000016	2,500	0.2	0.14	15.0
Aroclor 1260							not available									
Tetrachloroethylene (PCE)	127-18-4	1	70	7,300	250	20	0.01	50	1	1,000,000	0.80	0.0080	2,500	0.2	0.03	14,865
Toluene	108-88-3	1	70	7,300	250	20	0.2	50	1	1,000,000	0.80	0.16	2,500	0.2	0.03	297,309
1,1,1 Trichloroethane	71-55-6	1	70	7,300	250	20	0.9	50	1	1,000,000	0.80	0.72	2,500	0.2	0.0005	1,828,174
Trichloroethylene	79-01-6						not available									
Xylenes	1330-20-7	1	70	7,300	250	20	2.0	50	1	1,000,000	0.80	1.6	2,500	0.2	0.03	2,973,091
m-Xylene	108-38-3						not available									
o-xylene	95-47-6						not available									
p-xylene							not available									
(1) Source of oral RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.																
(2) Dermal Rfd = Oral Rfd X GI abs. conversion factor. This factor is chemical specific. See equation 745-4.																
(3) Calculated using equation 745-4 and default assumptions.																

Table 7: 3-Phase Model Assumptions and Results

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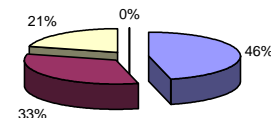
Table 7: 3-Phase Model Assumptions and Results

3-Phase Model Results													
		Pore Water		NAPL			Pore Water		Vapor		Soil		Sum
	CAS No.	Concentration	Solubility	in	Csat		Concentration	Water Mass	Concentration	Vapor Mass	Concentration	Soil Mass	Mass
		(mg/l) (7)	(mg/l) (3)	Soil? (8)	(mg/kg) (9)		(mg/l) (7)	(mg/kg) (10)	(mg/m ³) (11)	(mg/kg) (12)	(mg/kg) (13)	(mg/kg) (14)	(mg/kg) (15)
PCB Mixtures													
Arochlor 1016	12674-11-2	0.0020	0.42	No	45		0.0020	0.00040	0.24	2.06E-05	0.21	0.21	0.21
Arochlor 1260		0.0020	0.08	No	66		0.0020	0.00040	0.38	3.28E-05	1.64	1.64	1.65
Tetrachloroethylene (PCE)	127-18-4	0.10	200	No	106		0.10	0.020	75	0.0065	0.0265	0.0265	0.053
Toluene	108-88-3	20	526	No	191		20	4.0	5440	0.47	2.80	2.80	7.3
1,1,1 Trichloroethane	71-55-6	4.0	1,330	No	527		4.0	0.80	2820	0.24	0.54	0.54	1.58
Trichloroethylene	79-01-6	0.10	1,100	No	364		0.10	0.020	42	0.0037	0.0094	0.0094	0.033
Xylenes	1330-20-7	20	171	No	78		20	4.0	5580	0.48	4.66	4.66	9.1
m-xylene	108-38-3	20	161	No	68		20	4.0	6020	0.52	3.92	3.92	8.4
o-xylene	95-47-6	20	178	No	82		20	4.0	4260	0.37	4.82	4.82	9.2
p-xylene		20	185	No	100		20	4.0	6280	0.54	6.22	6.22	10.8
(7) Pore water concentration = ground water cleanup level X dilution factor													
(8) There is NAPL in the soil if the pore water concentration exceeds the solubility limit.													
(9) C sat is the soil concentration above which there is NAPL in the soil. It is calculated by substituting the solubility limit for the [ground water cleanup level X DF] in equation 747-1.													
(10) Water mass = [Pore water concentration X soil water fraction] / soil bulk density. This is the mass of contaminant in the water phase.													
(11) Vapor concentration = Pore water concentration X Henry's Constant X 1000.													
(12) Vapor mass = [Vapor concentration X soil air fraction] / soil bulk density. This is the mass of contaminant in the vapor phase.													
(13) Soil concentration = Pore water concentration X Kd													
(14) Soil mass = [Pore water concentration X Kd X soil bulk density] / soil bulk density. This is the mass of contaminant in the soil phase.													
(15) Sum mass = water mass + vapor mass + soil mass. This value equals the soil cleanup level.													

Table 8: 4-Phase Model Results using Fresh ARCO Gasoline

Solid:	46.1%
Air:	33.0%
Water:	20.9%
NAPL:	NONE
	100.0%

Soil - Mass Distribution



■ Solid:
■ Air:
■ Water:
■ NAPL:

	Equilibrium Composition %	Protective Soil ppm	Predicted G.W. ug/l
Aliphatics	ARCO 1		
EC >5-6	29.93%	0.27	3.49
EC >6-8	15.31%	0.14	1
EC >8-10	3.77%	0.03	0.0
EC >10-12	2.56%	0.02	0.00
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics		0.00	
Benzene	3.67%	0.033	5.86
Toluene	14.62%	0.13	18
Ethylbenzene	2.73%	0.02	3
Xylenes	13.45%	0.12	13
EC >8-10	4.15%	0.04	1
EC >10-12	7.47%	0.07	1
EC >12-16	0.0191	0.02	0
EC >16-21		0.00	0
EC >21-35		0.00	0
Naphthalene	0.43%	0.00	0
MTBE		0.00	0
Total	100.00%	0.90	47

Total soil porosity: default is 0.43 n 0.430 Unitless
Volumetric water content: default is 0.3 Qw 0.300 Unitless
Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
Soil bulk density measured: default is 1.5 rb 1.500 kg/l
*or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **0.90**

Predicted Ground Water TPH (ug/l): **47**

HI @ Predicted G.W. Concentration: 0.27

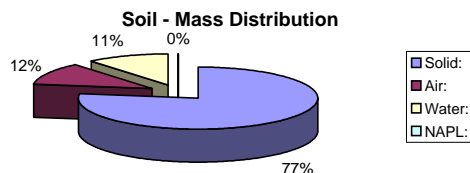
Volumetric NAPL Content, QNAPL : NAPL phase is not existing!
NAPL Saturation (%), QNAPL/n: N/A
Type of model used for computation: 3-Phase Model
Computation completed? **Yes!**
TPH Distribution @ 4-phase in soil pore system:
Total Mass distributed in Water Phase: 20.89% in Solid: 46.11%
Total Mass distributed in Air Phase: 33.00% in NAPL: NONE

Soil Concentration = 0.90

Gasoline composition from 9/3/98 neat product analysis conducted by Northcreek Analytical, Inc under contract to Ecology.
This is a summary sheet from an Excel program created by Hun Seak Park while at the Pollution Liability Insurance Agency (PLIA) and modified by Ecology staff.
For this particular composition, the allowable soil concentration is controlled by the predicted concentration of benzene (5.86 ug/l) in the ground water.

Table 9: 4-Phase Model Results using ARCO #5 (ARCO composition closest to 0.1% benzene)

Solid:	77.2%
Air:	11.8%
Water:	11.1%
NAPL:	NONE
	100.0%



	Equilibrium Composition %	Protective Soil ppm	Predicted G.W. ug/l
Aliphatics	ARCO 5		
EC >5-6	1.36%	0.38	4.93
EC >6-8	13.4%	3.74	22
EC >8-10	12.8%	3.59	4.6
EC >10-12	10.8%	3.02	0.58
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics		0.00	
Benzene	0.066%	0.019	3.29
Toluene	2.8%	0.80	109
Ethylbenzene	1.8%	0.51	59
Xylenes	10.0%	2.81	308
EC >8-10	11.6%	3.26	89
EC >10-12	26.3%	7.35	135
EC >12-16	7.7%	2.16	21
EC >16-21		0.00	0
EC >21-35		0.00	0
Naphthalene	1.27%	0.35	17
MTBE		0.00	0
Total	100.00%	28.00	774

Total soil porosity: default is 0.43

Volumetric water content: default is 0.3

Initial volumetric air content: default is 0.13

Soil bulk density measured: default is 1.5

*or, use soil bulk density computed @solid density=2.65kg/l:

Fraction Organic Carbon: default is 0.001

Dilution Factor: default is 20

n	0.430	Unitless
Qw	0.300	Unitless
Qa	0.130	Unitless
rb	1.500	kg/l
	1.811	kg/l
foc	0.0010	Unitless
DF	20.0	Unitless

Soil Concentration:

28.00

Predicted Ground Water TPH (ug/l):

774

HI @ Predicted G.W. Concentration:

1.01

Volumetric NAPL Content, QNAPL :

NAPL phase is not existing!

NAPL Saturation (%), QNAPL/n:

N/A

Type of model used for computation:

3-Phase Model

Computation completed?

Yes!

TPH Distribution @ 4-phase in soil pore system:

Total Mass distributed in Water Phase: 11.05% in Solid: 77.18%

Total Mass distributed in Air Phase: 11.76% in NAPL: NONE

Soil Concentration = 28.00

Gasoline composition is fresh product weathered to approximately 0.1% benzene, simulated by removal of mass in dissolved and vapor phases by successive model runs.

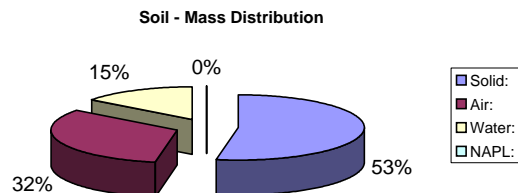
This benzene composition is typical of soil benzene concentrations found in soils at gasoline contaminated sites in WA State.

This is a summary sheet from an Excel program created by Hun Seak Park while at the Pollution Liability Insurance Agency (PLIA) and modified by Ecology staff.

For this particular composition, the allowable soil concentration is controlled by the predicted hazard index of the gasoline mixture in the ground water.

Table 10: 4-Phase Model Results using Fresh BP Gasoline

Solid:	52.9%
Air:	32.4%
Water:	14.8%
NAPL:	NONE
	100.0%



	Equilibrium Composition %	Protecti ve Soil ppm	Predicted G.W. ug/l
Aliphatics	Fresh BP		
EC >5-6	28.48%	0.28	3.69
EC >6-8	17.2%	0.17	1
EC >8-10	4.6%	0.05	0.1
EC >10-12	5.5%	0.06	0.01
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics		0.00	
Benzene	2.9%	0.029	5.16
Toluene	7.7%	0.08	11
Ethylbenzene	1.7%	0.02	2
Xylenes	8.9%	0.09	10
EC >8-10	5.5%	0.06	2
EC >10-12	9.2%	0.09	2
EC >12-16	6.6%	0.07	1
EC >16-21	0.0%	0.00	0
EC >21-35	0.0%	0.00	0
Naphthalene	1.6%	0.02	1
MTBE	0.0%	0.00	0
Total	100.0%	1.00	37

Total soil porosity: default is 0.43 n 0.430 Unitless
Volumetric water content: default is 0.3 Qw 0.300 Unitless
Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
Soil bulk density measured: default is 1.5 rb 1.500 kg/l
*or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **1.00**

Predicted Ground Water TPH (ug/l): **37**
HI @ Predicted G.W. Concentration: 0.24

Volumetric NAPL Content, QNAPL : NAPL phase is not existing!
NAPL Saturation (%), QNAPL/n: N/A
Type of model used for computation: 3-Phase Model
Computation completed? **Yes!**
TPH Distribution @ 4-phase in soil pore system:

Total Mass distributed in Water Phase: 14.75% in Solid: 52.87%

Total Mass distributed in Air Phase: 32.38% in NAPL: NONE

Soil Concentration = 1.00

Gasoline composition from 9/3/98 neat product analysis conducted by Northcreek Analytical, Inc under contract to Ecology.

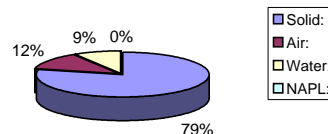
This is a summary sheet from an Excel program created by Hun Seak Park while at the Pollution Liability Insurance Agency (PLIA) and modified by Ecology staff.

For this particular composition, the allowable soil concentration is controlled by the predicted concentration of benzene (5.16 ug/l) in the ground water.

Table 11: 4-Phase Model Results for BP #4 (BP composition closest to 0.1% benzene)

Solid:	78.7%
Air:	12.4%
Water:	8.9%
NAPL:	NONE
	100.0%

Soil - Mass Distribution



	Equilibrium Composition %	Protective Soil ppm	Predicted G.W. ug/l
Aliphatics	BP #4		
EC >5-6	2.640%	0.58	7.53
EC >6-8	14.131%	3.11	18
EC >8-10	9.935%	2.19	2.8
EC >10-12	13.808%	3.04	0.58
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics			
Benzene	0.127%	0.028	4.95
Toluene	2.003%	0.44	61
Ethylbenzene	1.135%	0.25	29
Xylenes	6.427%	1.41	155
EC >8-10	10.248%	2.25	62
EC >10-12	20.242%	4.45	82
EC >12-16	16.106%	3.54	34
EC >16-21	0.000%	0.00	0
EC >21-35	0.000%	0.00	0
Naphthalene	3.198%	0.70	34
MTBE	0.000%	0.00	0
			0
Total	100.000%	22.00	490

Total soil porosity: default is 0.43
Volumetric water content: default is 0.3
Initial volumetric air content: default is 0.13
Soil bulk density measured: default is 1.5
*or, use soil bulk density computed @solid density=2.65kg/l:
Fraction Organic Carbon: default is 0.001
Dilution Factor: default is 20

n	0.430	Unitless
Qw	0.300	Unitless
Qa	0.130	Unitless
rb	1.500	kg/l
	1.811	kg/l
foc	0.0010	Unitless
DF	20.0	Unitless

Soil Concentration: **22.00**

Predicted Ground Water TPH (ug/l): **490**

HI @ Predicted G.W. Concentration: 0.92

Volumetric NAPL Content, QNAPL : NAPL phase is not existing!
NAPL Saturation (%), QNAPL/n: N/A
Type of model used for computation: 3-Phase Model 78.72%
Computation completed? **Yes!**

TPH Distribution @ 4-phase in soil pore system:
Total Mass distributed in Water Phase: 8.90% in Solid: NONE

Total Mass distributed in Air Phase: 12.37% in NAPL:

Soil Concentration = 22.00

Gasoline composition is fresh product weathered to approximately 0.1% benzene, simulated by removal of mass in dissolved and vapor phases by successive model runs.

This benzene composition is typical of soil benzene concentrations found in soils at gasoline contaminated sites in WA State.

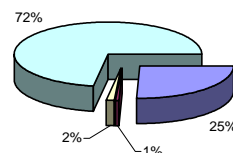
This is a summary sheet from an Excel program created by Hun Seak Park while at the Pollution Liability Insurance Agency (PLIA) and modified by Ecology staff.

For this particular composition, the allowable soil concentration is controlled by the predicted concentration of benzene (4.95 ug/l) in the ground water.

Table 12: 4-Phase Model Results for BP #24 (least weathered composition with HI<1 at 100 PPM in the Soil)

Solid:	25.5%
Air:	0.6%
Water:	1.5%
NAPL:	72.4%
	100.0%

Soil - Mass Distribution



■ Solid:
■ Air:
■ Water:
■ NAPL:

	Equilibrium Composition %	Protective Soil ppm	Predicted G.W. ug/l
Aliphatics	BP #24		
EC >5-6	0.0%	0.00	0.00
EC >6-8	0.1%	0.06	0
EC >8-10	10.5%	10.98	2.8
EC >10-12	31.4%	32.94	0.61
EC >12-16	0.0%	0.00	0.00
EC >16-21	0.0%	0.00	0.00
Aromatics		0.00	
Benzene	0.0%	0.000	0.00
Toluene	0.0%	0.00	0
Ethylbenzene	0.0%	0.00	0
Xylenes	0.0%	0.01	1
EC >8-10	3.7%	3.93	71
EC >10-12	21.2%	22.31	206
EC >12-16	31.3%	32.84	88
EC >16-21	0.0%	0.00	0
EC >21-35	0.0%	0.00	0
Naphthalene	1.8%	1.92	30
MTBE	0.0%	0.00	0
Total	100.0%	105.00	399

Total soil porosity: default is 0.43

Volumetric water content: default is 0.3

Initial volumetric air content: default is 0.13

Soil bulk density measured: default is 1.5

*or, use soil bulk density computed @solid density=2.65kg/l:

Fraction Organic Carbon: default is 0.001

Dilution Factor: default is 20

n	0.430	Unitless
Qw	0.300	Unitless
Qa	0.130	Unitless
rb	1.500	kg/l
	1.811	kg/l
foc	0.0010	Unitless
DF	20.0	Unitless

Soil Concentration:

105.00

Predicted Ground Water TPH (ug/l):

399

HI @ Predicted G.W. Concentration:

1.00

Volumetric NAPL Content, QNAPL :

0.000

NAPL Saturation (%), QNAPL/n:

0.03%

Type of model used for computation:

4-Phase Model

Computation completed?

Yes!

TPH Distribution @ 4-phase in soil pore system:

Total Mass distributed in Water Phase: 1.52% in Solid: 25.49%

Total Mass distributed in Air Phase: 0.62% in NAPL: 72.37%

Soil Concentration = 105.00

Gasoline composition is fresh product weathered until 100 PPM in the soil will pass, simulated by removal of mass in dissolved and vapor phases by successive model runs.

This composition represents highly weathered gasoline with no detectable benzene in the soil.

This is a summary sheet from an Excel program created by Hun Seak Park while at the Pollution Liability Insurance Agency (PLIA) and modified by Ecology staff.

For this particular composition, the allowable soil concentration is controlled by the predicted hazard index of the gasoline mixture in the ground water.