TABLES

TABLE 1
SOIL DATA BEFORE AND AFTER AERATION TREATMENT
(mg/kg)

Parameter	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Average Values[a]		Tier 1 Vapour Inhalation
	before	after	before	after	before	after	before	after	before	after	before	after	Guideline[a]
Benzene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	ND		1.6
Toluene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	ND		1900
Ethylbenzene	0.017	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.025	<0.015	0.0129	0.0075	930
Xylenes	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	ND		250
PHC F1	14	15	17	<10	11	14	15	19	<10	16	12.4	13.8	610
PHC F2	528	420	577	523	480	497	462	375	476	399	504.6	442.8	3100
PHC F3	554	411	559	481	451	450	429	389	465	366	491.6	419.4	-
PHC F4	147	88	107	99	95	91	85	95	118	<50	110.4	79.6	-
Moisture (%)	15.6	16.2	17.5	16.5	16.9	16.1	16.4	15.1	16.9	17.5	16.5		-
PSA % >75µm	14.1	-	5	-	19.1	-	15	-	13.9	-	13.4	-	-
Bulk Density (kg/m^3)	1110	-	1090	-	1090	-	1110	-	1090	-	1100	-	-

a - ESRD (2010) Tier 1 Soil and Groundwater Remediation Guidelines for fine-grained soil and agricultural land use
ND - values below laboratory detection limit

TABLE 2
1-HOUR AVERAGED AIR CONCENTRATIONS OF PHCS
(μg/m^3)

Parameter	Source 10-Aug-12	Downwind 10-Aug-12	Background 10-Aug-12	Tolerable Concentration[a]	Occupational Exposure Limit[d]	
					8 hour	15 minute
Benzene	0.93	<0.64	<0.64	3.03[b]	1600	8000
Toluene	<0.75	<0.75	<0.75	3800	188000	-
Ethylbenzene	1.04	<0.87	<0.87	1000	434000	543000
Xylenes	<2.6	<2.6	<2.6	180	434000	651000
PHC F1	34	<30	<30	16000[c]	-	-
PHC F2	600	207	<30	980[c]	-	-

a - ESRD (2010) Tier 1 Soil and Groundwater Remediation Guidelines, Table C.7 Human Toxicity Reference Values
b - Risk Specific Concentration
c - based on default soil vapour mass fractions from CCME (2008)
d - Alberta Occupational Health and Safety Code (2009)

TABLE 3
MEASURED AND PREDICTED AIR CONCENTRATIONS AT EMISSION SOURCE
(μg/m^3)

Parameter	Measured 1-hour	Predicted		Relative Percent Difference	
		Short term	Long term	Short term	Long term
Benzene	0.93	-	-	-	-
Toluene	<0.75	-	-	-	-
Ethylbenzene	1.04	-	3.3	-	217
Xylenes	<2.6	-	-	-	-
PHC F1	34	-	3200	-	9312
PHC F2	600	81000	130000	13400	21567

APPENDIX A
CASE STUDY

TABLE A.1

CASE STUDY INPUT VALUES[a]

Parameter	Value
Contaminant thickness (m)	2
Source length (m)	20
Contaminated area (m^2)	400
Benzene - Maximum Concentration (mg/kg)	3.22
Benzene - Average Concentration (mg/kg)	0.49
Toluene - Maximum Concentration (mg/kg)	0.09
Toluene - Average Concentration (mg/kg)	0.04
Ethylbenzene - Maximum Concentration (mg/kg)	227
Ethylbenzene - Average Concentration (mg/kg)	17
Xylenes - Maximum Concentration (mg/kg)	246
Xylenes - Average Concentration (mg/kg)	16
PHC F1 - Maximum Concentration (mg/kg)	3340
PHC F1 - Average Concentration (mg/kg)	277
PHC F2 - Maximum Concentration (mg/kg)	47200
PHC F2 - Average Concentration (mg/kg)	1272

a - for remaining inputs the spreadsheet default value was applied

TABLE A.2
CASE STUDY OUTPUT VALUES

Category	Ex-Situ Treatment		Landfil Disposal
	No biofilter	With biofilter	
Contaminant Source Emissions of Greenhouse Gases (t CO_2)	5.70E+00		1.30E+00
Particulate Emissions (kg)	2.40E+02		3.90E+02
Engine Combustion Emissions of Criteria Air Contaminants (kg)			
CH_4	2.73E-02	2.76E-02	2.50E-02
CO	2.31E+00	2.33E+00	1.80E+00
N_2O	3.48E-01	3.53E-01	2.90E-01
NO_x	4.56E+00	4.61E+00	3.70E+00
SO_x	7.96E-02	8.08E-02	6.70E-02
CO_2	8.26E+02	8.38E+02	7.00E+02
VOC	5.53E-01	5.58E-01	4.30E-01
Short-term Exposure Concentrations (mg/m^3)			
Benzene	7.70E-01		1.60E+02
Toluene	-		3.30E+01
Ethylbenzene	5.50E+01		2.10E+04
Xylenes	5.60E+01		8.10E+03
PHC F1	7.30E+02		1.50E+05
PHC F2	1.10E+04		1.40E-01
Long-term Exposure Concentrations (mg/m^3)[a]			
Benzene	1.20E-01	4.80E-02	7.40E-01
Toluene	9.70E-03	3.90E-03	5.20E-02
Ethylbenzene	4.10E+00	1.70E+00	2.30E+02
Xylenes	3.90E+00	1.60E+00	1.30E+01
PHC F1	6.70E+01	2.70E+01	2.40E+02
PHC F2	3.10E+02	1.20E+02	2.20E-04

a - Day 5 average 8-hour concentraion

APPENDIX B
USER GUIDANCE

Appendix B

Spreadsheet Tool User Guidance

BACKGROUND

The Spreadsheet Tool is used to compare the relative emissions and exposure concentrations between ex-site soil treatment using an allu bucket and disposal of contaminated soils in a landfill.

PRIMARY INPUTS

The 'Primary User Inputs' tab of the spreadsheet contains all of the inputs required to complete the emission and exposure calculations. Only cells with a border require inputs. All other cell values are calculated from other entries and are shown for reference. Default values are included in column D if site specific values are not available.

Site inputs are related to the amount of contaminated soil and the size of the contaminated area (cells **C7**, **C8**, and **C9**) and must contain values site-specific values. The size of the contaminated area should be based on exceedances of the ESRD (2010) Tier 1 Soil and Groundwater Remediation Guidelines.

The soil analytical results (cells **C16** through **C27**) are intended to represent only the contaminated area, and uncontaminated delineation boreholes and background samples should not be included when calculating the average concentrations. If a parameter has not been detected a concentration of 0 mg/kg should be entered.

Equipment inputs are separated between ex-situ (cells **C33** through **C40**) and landfill disposal (cells **C43** through **C49**) options and should be altered based on the expected work schedule. While default values have been provided based on the estimated volume of impacted soil, it is recommended that at minimum the transport distance (cells **C39** and **C49**) be adjusted to reflect the site location and nearest treatment or landfill facilities.

SECONDARY INPUTS

The 'Secondary User Inputs' tab of the spreadsheet contains additional inputs based on site-specific information that may not be available in all cases. Only cells with a border require inputs. All other cell values are calculated from other entries and are shown for reference. Default values are included in the columns adjacent to the input cells if site specific values are not available. Changing these inputs from the default values is only recommended if there is sufficient site specific data available to support the user values.

The majority of site inputs (cells **C8** through **C12**) are based on detailed soil parameters from within the contaminated area. The box defined height parameter (**C13**) is based on the height of the allu bucket used for ex-situ remediation. Changes to these parameters will alter the estimated soil mass and the partitioning and transport behavior of the vapour emissions.

Vehicular traffic and equipment process particulate emissions (rows **20** through **28**) are based on expected average values in Alberta or Canada, and only alteration of the mean vehicle weight (cell **D28**) and mean wind speed (cell **D25**) is recommended. Changes to these parameters should be made utilizing the US EPA (2006) document referenced in the spreadsheet tool.

Combustion engine particulate emissions are based on literature values for diesel energy content (cell **D37**), engine emission production (cells **D38** through **D41**) and fuel usage (cells **D42** through **D45**). Combustion engine emissions for criteria air contaminants have been obtained from the GHGenius emission model for four separate fuel uses. Any changes to equipment specific inputs should be supported by data from the original manufacturer and reflect the conditions under which the equipment will be operating.

Biofilter contaminant removal efficiency includes options for overall efficiency (cell **D60**) as well as efficiencies for individual PHC contaminants (cells **D61** through **D66**). The overall removal efficiency value will be applied for any chemicals which do not have a chemical specific removal efficiency. The spreadsheet tool does not make any verification that overall and chemical specific removal efficiencies are consistent. While an overall efficiency of 60% is recommended based on difficult to treat compounds, data for the applied biofilter can be used to support a higher overall efficiency or a higher efficiency for specific compounds at the site. Caution is advised when adjusting these inputs, ensuring that differences in soil type, contaminant concentration, and environmental conditions that may alter the achieved biofilter efficiency from the expected efficiency are accounted for.

CALCULATIONS

All calculations related to determining contaminant emissions are included on the 'Calculations' tab. Calculations are divided between contaminant source emissions of greenhouse gases, particulate emissions, engine combustion emissions, and ex-situ exposure estimates. Default values for chemical parameters recommended by the ESRD (2010) are also included. This tab does not include any options for input, and has been included solely as a reference tool so that the end-user can view each step of the calculation process. Calculations related to estimating volatile exposure during excavations are included separately on the 'Calculation – VOC Exposure' tab. Similarly, there are no options for input on this tab, and it is intended only for user reference. Important calculation outputs on both tabs are highlighted red.

OUTPUT

The spreadsheet tool output includes multiple comparisons of ex-situ treatment and landfill disposal remedial options. The greenhouse gas emissions (cells **E6** and **E7**), particulate emissions (cells **E12** and **E13**), and engine combustion emissions (rows **19** and **20**) are compared directly between the two remediation options with the method having the lower value highlighted green and the method resulting in the higher value highlighted red.

Exposure concentrations of PHC contaminants in air for ex-situ treatment and landfill disposal are separately compared to Alberta's 8-hour and 15-minute occupational exposure guidelines.

Excavation exposure is estimated for a 5 day period starting when the contaminated soil is exposed, and if the excavation is ongoing the Day 1 average concentrations should be applied. If the concentrations are highly variable across the site then the user can adjust the average concentrations on the INPUT tab in order to determine the expected exposure concentrations from each area being allu treated or excavated; however, it should be noted that doing so invalidates the overall emissions comparisons, which are based on overall site values.

Predicted concentrations which meet occupational exposure guidelines are highlighted in green and predicted concentrations exceeding the exposure guidelines are highlighted in red. The applied Alberta occupational exposure guidelines for 8-hour (rows **29** and **42**) and 15 minute (rows **30** and **43**) exposure are included for reference.