ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
GROUNDWATER BRANCH

1400 COLISEUM BOULEVARD,
MONTGOMERY, ALABAMA 36110-2059
Ph.: (334) 270-5655 *Fax: (334) 270-5631*

MAILING ADDRESS: P.O. BOX 301463
MONTGOMERY, ALABAMA 36130

ARBCA FOR USTs
TIER 3 REPORT FORMS
(Revision 1.0, November 2001)

(Optional - to be used if using the same models as in Tier 1. Otherwise, the format is determined in workplan)

SITE NAME:	
UST INCIDENT NO.:	
FACILITY ID:	
DATE FORM COMPLETED:	
FORM COMPLETED BY:	

ARBCA REPORT FORMS

TABLE OF CONTENTS

Indicate the report forms used in this ARBCA analysis.
Check ☑ to select.

TIER 3 FORMS

31.	Tier 3 Evaluation	☐
32.	Tier 3 Fate and Transport Parameters	☐
33.	Justification for Tier 3 Fate and Transport Parameters	☐
34.	Tier 3 Exposure Factors	☐
35.	Justification for Tier 3 Exposure Factors	☐
36.	Tier 3 Conclusions and Recommendations	☐

ATTACHMENTS

Additional attachments used in this ARBCA analysis. Additional attachments, besides those listed in Tier 1 and Tier 2 Table of Contents are to be listed here.

ARBCA SUMMARY REPORT	FORM NO. 31
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 EVALUATION

The ADEM requires that the owner/operator submit a workplan for a Tier 3 evaluation. This workplan must be approved by the ADEM prior to conducting a Tier 3 evaluation. Discuss previously conducted Tier 1 and Tier 2 analyses that led to a Tier 3 evaluation. In addition, discuss models used in Tier 3 evaluation.

ARBCA SUMMARY REPORT	FORM NO. 32
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 FATE AND TRANSPORT PARAMETERS

Parameter	Symbol	Unit	Tier 1 Default Value	Tier 3 Value	Source
SOIL PARAMETERS:					
Length of Soil Source Area Parallel to Wind Direction	W_a	cm	1500		
Depth to Subsurface Soil Sources	L_s	cm	30.48		
Lower Depth of Surficial Soil Zone	d	cm	30.48		
Thickness of Capillary Fringe	h_{cap}	cm	5		
Thickness of Vadose Zone	h_v	cm	295		
Dry Soil Bulk Density in the Vadose Zone	ρ_s	g/cm^3	1.8		
Fractional Organic Carbon Content in the Vadose Zone	foc	g-C/g-soil	0.01		
Total Soil Porosity in the Vadose Zone	θ_T	cm^3/cm^3-soil	0.3		
Volumetric Water Content in Vadose Zone	θ_{ws}	cm^3/cm^3	0.1		
Volumetric Air Content in Vadose Zone	θ_{as}	cm^3/cm^3	0.2		
Volumetric Water Content in Capillary Fringe	θ_{wcap}	cm^3/cm^3	0.27		
Volumetric Air Content in Capillary Fringe	θ_{acap}	cm^3/cm^3	0.03		
Volumetric Water Content in Foundation or Wall Cracks	θ_{wcrack}	cm^3/cm^3	0.1		
Volumetric Air Content in Foundation/Wall Cracks	θ_{acrack}	cm^3/cm^3	0.2		
GROUNDWATER PARAMETERS:					
Depth to Groundwater	L_{gw}	cm	300		
Width of GW Source Area Perpendicular to GW Flow Direction	Y	cm	1500		
Length of GW Source Area Parallel to GW Flow Direction	W	cm	1500		
Total Soil Porosity in the Saturated Zone	θ_{TS}	cm^3/cm^3-soil	0.3		
Dry Soil Bulk Density in the Saturated Zone	ρ_{ss}	g/cm^3	1.8		
Fractional Organic Carbon Content in the Saturated Zone	foc_s	g-C/g-soil	0.01		
Groundwater Mixing Zone Thickness	δ_{gw}	cm	200		
Hydraulic Conductivity in the Saturated Zone	K	cm/year	31536		
Hydraulic Gradient in the Saturated Zone	i	--	0.005		
Groundwater Darcy Velocity	U_{gw}	cm/year	157.68		
Infiltration Rate	I	cm/year	14.8		
STREAM PARAMETERS:					
Stream Flow Rate (Calculated per Appendix C)	Q_{sw}	ft^3/day	variable		Site-specific
AMBIENT AIR PARAMETERS:					
Breathing Zone Height	δ_a	cm	200		
Wind Speed within the Breathing Zone	U_a	cm/s	225		
ENCLOSED SPACE PARAMETERS:					
Enclosed Space Air Exchange Rate:					
Residential	ER	1/sec	0.00014		
Commercial/Construction Worker	ER	1/sec	0.00023		
Enclosed Space Volume/Infiltration Area Ratio:					
Residential	L_B	cm	200		
Commercial/Construction Worker	L_B	cm	300		

ARBCA SUMMARY REPORT	FORM NO. 32
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 FATE AND TRANSPORT PARAMETERS

Parameter	Symbol	Unit	Tier 1 Default Value	Tier 3 Value	Source
ENCLOSED SPACE PARAMETERS continued:					
Enclosed Space Foundation or Wall Thickness:					
Residential	L_{crack}	cm	15		
Commercial/Construction Worker	L_{crack}	cm	15		
Areal Fraction of Cracks in Foundation/Walls:					
Residential	η	cm^2/cm^2	0.01		
Commercial/Construction Worker	η	cm^2/cm^2	0.01		
PARTICULATE EMISSION RATE:					
Residential and Commercial	Pe	g/cm^2-sec	6.90E-14		
Construction Worker	Pe	g/cm^2-sec	6.90E-09		
AVERAGING TIME FOR VAPOR FLUX:					
Resident Child	τ	sec	1.89E+08		
Resident Adult	τ	sec	9.46E+08		
Commercial Worker	τ	sec	7.88E+08		
Construction Worker	τ	sec	3.15E+07		
GROUNDWATER RESOURCE PROTECTION PARAMETERS:					
Distance from the Downgradient Edge of the Groundwater Source to the Point of Exposure	Xpoe	ft	variable		Site-specific
Longitudinal Dispersivity	α_x	ft	Xpoe/10		Site-specific
Transverse Dispersivity	α_y	ft	Xpoe/30		Site-specific
Vertical Dispersivity	α_z	ft	Xpoe/200		Site-specific
Distance from the Downgradient Edge of the Groundwater Source to the Point of Compliance	Xpoc	ft	variable		Site-specific
Longitudinal Dispersivity	α_x	ft	Xpoc/10		Site-specific
Transverse Dispersivity	α_y	ft	Xpoc/30		Site-specific
Vertical Dispersivity	α_z	ft	Xpoc/200		Site-specific
STREAM PROTECTION PARAMETERS:					
Distance from the Downgradient Edge of the Groundwater Source to the Stream	Xs	ft	variable		Site-specific
Longitudinal Dispersivity	α_x	ft	Xs/10		Site-specific
Transverse Dispersivity	α_y	ft	Xs/30		Site-specific
Vertical Dispersivity	α_z	ft	Xs/200		Site-specific
Distance from the Downgradient Edge of the Groundwater Source to the Point of Compliance	Xspoc	ft	variable		Site-specific
Longitudinal Dispersivity	α_x	ft	Xspoc/10		Site-specific
Transverse Dispersivity	α_y	ft	Xspoc/30		Site-specific
Vertical Dispersivity	α_z	ft	Xspoc/200		Site-specific

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

1.	**Length of soil source area parallel to wind direction (W_a) [cm]**
2.	**Depth to subsurface soil sources (L_s) [cm]**
3.	**Lower depth of surficial soil zone (d) [cm]**
4.	**Thickness of capillary fringe (h_{cap}) [cm]**
5.	**Thickness of vadose zone (h_v) [cm]**
6.	**Dry soil bulk density in the vadose zone (ρ_s) [g/cm^3]**
7.	**Fractional organic carbon content in the vadose zone (foc) [g-C/g-soil]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

8.	**Total soil porosity in the vadose zone (θ_T) [cm^3/cm^3-soil]**
9.	**Volumetric water content in the vadose zone (θ_{ws}) [cm^3/cm^3]**
10.	**Volumetric air content in the vadose zone (θ_{as}) [cm^3/cm^3]**
11.	**Volumetric water content in the capillary fringe (θ_{wcap}) [cm^3/cm^3]**
12.	**Volumetric air content in the capillary fringe (θ_{acap}) [cm^3/cm^3]**
13.	**Volumetric water content in foundation or wall cracks (θ_{wcrack}) [cm^3/cm^3]**
14.	**Volumetric air content in foundation or wall cracks (θ_{acrack}) [cm^3/cm^3]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

15.	**Depth to groundwater (L_{gw}) [cm]**
16.	**Width of GW source area perpendicular to GW flow direction (Y) [cm]**
17.	**Length of GW source area parallel to GW flow direction (W) [cm]**
18.	**Total soil porosity in the saturated zone (θ_{TS}) [cm^3/cm^3-soil]**
19.	**Dry soil bulk density in the saturated zone (ρ_{ss}) [g/cm^3]**
20.	**Fractional organic carbon content in the saturated zone (foc_s) [g-C/g-soil]**
21.	**Groundwater mixing zone thickness (δ_{gw}) [cm]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

22.	**Hydraulic conductivity in the saturated zone (K) [cm/year]**
23.	**Hydraulic gradient in the saturated zone (i) [--]**
24.	**Groundwater Darcy Velocity (U_{gw}) [cm/year]**
25.	**Infiltration rate (I) [cm/year]**
26.	**Stream flow rate (Q_{sw}) [ft^3/day].** ***If calculated using Bingham (1982, Appendix C), show calculations and justify input values used.***
27.	**Breathing zone height (δ_a) [cm]**
28.	**Wind speed within the breathing zone (U_a) [cm/s]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

29.	**Enclosed space air exchange rate: residential (ER) [1/sec]**
30.	**Enclosed space air exchange rate: commercial/construction worker (ER) [1/sec]**
31.	**Enclosed space volume-infiltration area ratio: residential (L_B) [cm]**
32.	**Enclosed space volume-infiltration area ratio: commercial/construction worker (L_B) [cm]**
33.	**Enclosed space foundation or wall thickness: residential (L_{crack}) [cm]**
34.	**Enclosed space foundation or wall thickness: commercial/construction worker (L_{crack}) [cm]**
35.	**Areal fraction of cracks in foundation/walls: residential (η) [cm^2/cm^2]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

36.	**Areal fraction of cracks in foundation/walls: commercial/construction worker (η) [cm^2/cm^2]**
37.	**Particulate emission rate: residential and commercial (Pe) [g/cm^2-sec]**
38.	**Particulate emission rate: construction worker (Pe) [g/cm^2-sec]**
39.	**Averaging time for vapor flux: resident child (τ) [sec]**
40.	**Averaging time for vapor flux: resident adult (τ) [sec]**
41.	**Averaging time for vapor flux: commercial worker (τ) [sec]**
42.	**Averaging time for vapor flux: construction worker (τ) [sec]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

43.	Distance from the downgradient edge of the groundwater source to the point of exposure (Xpoe) [ft]
43a.	Longitudinal dispersivity (α_x) [ft]
43b.	Transverse dispersivity (α_y) [ft]
43c.	Vertical dispersivity (α_z) [ft]
44.	Distance from the downgradient edge of the groundwater source to the point of compliance for protection of POC (Xpoc) [ft]
44a.	Longitudinal dispersivity (α_x) [ft]
44b.	Transverse dispersivity (α_y) [ft]

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

44c.	**Vertical dispersivity (α_z) [ft]**
45.	**Distance from the downgradient edge of the groundwater source to the stream (Xs) [ft]**
45a.	**Longitudinal dispersivity (α_x) [ft]**
45b.	**Transverse dispersivity (α_y) [ft]**
45c.	**Vertical dispersivity (α_z) [ft]**
46.	**Distance from the downgradient edge of the groundwater source to the point of compliance for stream protection (Xspoc) [ft]**
46a.	**Longitudinal dispersivity (α_x) [ft]**

ARBCA SUMMARY REPORT	FORM NO. 33
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 FATE AND TRANSPORT PARAMETERS

46b.	Transverse dispersivity (α_y) [ft]
46c.	Vertical dispersivity (α_z) [ft]
47.	
48.	
49.	
50.	
51.	

ARBCA SUMMARY REPORT	FORM NO. 34
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 EXPOSURE FACTORS

Parameter	Symbol	Unit	Tier 1 Default Value	Tier 3 Value	Source
Averaging Time					
Carcinogen	AT_c	years	70		
Non-Carcinogen	AT_n	years	=Exposure Duration		
Body Weight					
Child Receptors	BW	kg	15		
Adult Receptors	BW	kg	70		
Exposure Duration					
Resident Child	ED	years	6		
Resident Adult	ED	years	30		
Commercial Worker	ED	years	25		
Construction Worker	ED	years	1		
Exposure Frequency					
Resident Child	EF	days/year	350		
Resident Adult	EF	days/year	350		
Commercial Worker	EF	days/year	250		
Construction Worker	EF	days/year	250		
Soil Ingestion Rate					
Resident Child	IR_{soil}	mg/day	200		
Resident Adult	IR_{soil}	mg/day	100		
Commercial Worker	IR_{soil}	mg/day	50		
Construction Worker	IR_{soil}	mg/day	100		
Groundwater Ingestion Rate (IRW)					
Resident Adult	IR_w	L/day	2		
Hourly Indoor Inhalation Rate					
Resident Child	$IR_{air\text{-}indoor}$	m^3/hr	0.417		
Resident Adult	$IR_{air\text{-}indoor}$	m^3/hr	0.633		
Commercial Worker	$IR_{air\text{-}indoor}$	m^3/hr	1.5		
Construction Worker	$IR_{air\text{-}indoor}$	m^3/hr	1.5		

ARBCA SUMMARY REPORT	FORM NO. 34
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 EXPOSURE FACTORS

Parameter	Symbol	Unit	Tier 1 Default Value	Tier 3 Value	Source
Exposure Time for Indoor Inhalation					
Resident Child	ET_{in}	hr/day	24		
Resident Adult	ET_{in}	hr/day	24		
Commercial and Construction Workers	ET_{in}	hr/day	10		
Hourly Outdoor Inhalation Rate					
Resident Child	$IR_{air\text{-}outdoor}$	m^3/hr	1.0		
Resident Adult	$IR_{air\text{-}outdoor}$	m^3/hr	1.5		
Commercial and Construction Workers	$IR_{air\text{-}outdoor}$	m^3/hr	1.5		
Exposure Time for Outdoor Inhalation					
Resident Child	ET_{out}	hr/day	10		
Resident Adult	ET_{out}	hr/day	10		
Commercial and Construction Workers	ET_{out}	hr/day	10		
Skin Surface Area					
Resident Child	SA	cm^2/day	2500		
Resident Adult	SA	cm^2/day	5000		
Commercial Worker	SA	cm^2/day	5000		
Construction Worker	SA	cm^2/day	5000		
Relative Absorption Factors					
Oral Relative Absorption Factor	RAF_o	--	1		
Dermal Relative Absorption Factor					
Volatiles	RAF_d	--	0.5		
PAHs	RAF_d	--	0.05		
Metals	RAF_d	--	0.001		
Soil to Skin Adherence Factor					
Resident Child	M	mg/cm^2	0.5		
Resident Adult	M	mg/cm^2	0.5		
Commercial Worker	M	mg/cm^2	0.5		
Construction Worker	M	mg/cm^2	0.5		
Target Risk Level	TR	--	$1x10^{-5}$		
Target Hazard Quotient	THQ	--	1		

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

1.	**Averaging time for carcinogens (AT_c) [years]**
2.	**Averaging time for non-carcinogens (AT_n) [years]**
3.	**Body weight: child receptors (BW) [kg]**
4.	**Body weight: adult receptors (BW) [kg]**
5.	**Exposure duration: resident child (ED) [years]**
6.	**Exposure duration: resident adult (ED) [years]**
7.	**Exposure duration: commercial worker (ED) [years]**

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

8.	Exposure duration: construction worker (ED) [years]
9.	Exposure frequency: resident child (EF) [days/year]
10.	Exposure frequency: resident adult (EF) [days/year]
11.	Exposure frequency: commercial worker (EF) [days/year]
12.	Exposure frequency: construction worker (EF) [days/year]
13.	Soil ingestion rate: resident child (IR_{soil}) [mg/day]
14.	Soil ingestion rate: resident adult (IR_{soil}) [mg/day]

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

15.	Soil ingestion rate: commercial worker (IR_{soil}) [mg/day]
16.	Soil ingestion rate: construction worker (IR_{soil}) [mg/day]
17.	Groundwater ingestion rate: resident adult (IR_w) [L/day]
18.	Hourly indoor inhalation rate: resident child ($IR_{air\text{-}indoor}$) [m^3/hr]
19.	Hourly indoor inhalation rate: resident adult ($IR_{air\text{-}indoor}$) [m^3/hr]
20.	Hourly indoor inhalation rate: commercial worker ($IR_{air\text{-}indoor}$) [m^3/hr]
21.	Hourly indoor inhalation rate: construction worker ($IR_{air\text{-}indoor}$) [m^3/hr]

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

22.	Exposure time for indoor inhalation: resident child (ET_{in}) [hrs/day]
23.	Exposure time for indoor inhalation: resident adult (ET_{in}) [hrs/day]
24.	Exposure time for indoor inhalation: commercial and construction workers (ET_{in}) [hrs/day]
25.	Hourly outdoor inhalation rate: resident child ($IR_{air\text{-}outdoor}$) [m^3/hr]
26.	Hourly outdoor inhalation rate: resident adult ($IR_{air\text{-}outdoor}$) [m^3/hr]
27.	Hourly outdoor inhalation rate: commercial and construction workers ($IR_{air\text{-}outdoor}$) [m^3/hr]
28.	Exposure time for outdoor inhalation: resident child (ET_{out}) [hrs/day]

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

29.	Exposure time for outdoor inhalation: resident adult (ET_{out}) [hrs/day]
30.	Exposure time for outdoor inhalation: commercial and construction workers (ET_{out}) [hrs/day]
31.	Skin surface area: resident child (SA) [cm^2/day]
32.	Skin surface area: resident adult (SA) [cm^2/day]
33.	Skin surface area: commercial worker (SA) [cm^2/day]
34.	Skin surface area: construction worker (SA) [cm^2/day]
35.	Oral relative absorption factor (RAF_o) [--]

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

36.	Dermal relative absorption factor: volatiles (RAF_d) [--]
37.	Dermal relative absorption factor: PAHs (RAF_d) [--]
38.	Dermal relative absorption factor: metals (RAF_d) [--]
39.	Soil-skin adherence factor: resident child (M) [mg/cm^2]
40.	Soil-skin adherence factor: resident adult (M) [mg/cm^2]
41.	Soil-skin adherence factor: commercial worker (M) [mg/cm^2]
42.	Soil-skin adherence factor: construction worker (M) [mg/cm^2]

ARBCA SUMMARY REPORT	FORM NO. 35
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

JUSTIFICATION FOR TIER 3 EXPOSURE FACTORS

43.	Taget risk level (TR) [--]
44.	Taget hazard quotient (THQ) [--]
45.	
46.	
47.	
48.	
49.	

ARBCA SUMMARY REPORT	FORM NO. 36
UST Incident No(s):	**Facility ID:**
Date Form Completed:	**Form Completed By:**

TIER 3 CONCLUSIONS AND RECOMMENDATIONS

1.	**Are on-site soil and groundwater concentrations protective of current and reasonable future on-site receptors?**
2.	**Are off-site soil and groundwater concentrations protective of current and reasonable future off-site receptors?**
3.	**Are source soil concentrations protective of groundwater at a POE?**
4.	**Are source groundwater concentrations protective of groundwater at a POE?**
5.	**Are the source soil and groundwater concentrations protective of a stream?**
6.	**Is site recommended for NFA status?**

ARBCA SUMMARY REPORT	FORM NO. 36
UST Incident No(s):	Facility ID:
Date Form Completed:	Form Completed By:

TIER 3 CONCLUSIONS AND RECOMMENDATIONS

7.	Is compliance monitoring of groundwater recommended?
8.	Are interim remediation and reevaluation recommended?
9.	Is remediation to applicable Tier 3 standards recommended?
10.	Other relevant information: