
APPENDIX C

SOIL PATHWAY

This appendix describes the methods used to derive the activity specific body-weighted soil adherence factors and is divided into four sections: (1) Background; (2) Body Part-Specific Surface Areas and Activity-Specific Soil Adherence Factors; (3) Overall Weighted Soil Adherence Factors; and (4) soil loading at the hypothetical mono-layer for the Soil Conservation Service standard soil classifications.

Background

Recent data from Kissel et al. [Kissel et al. (1996a), Kissel et al. (1996b), Kissel et al.(1998), and Holmes et al. (1999)] provide evidence to demonstrate that:

- Soil properties influence adherence;
- Soil adherence varies considerably across different parts of the body; and
- Soil adherence varies with activity.

Given these results, the EPA now recommends that an activity which best represents all soils, body parts, and activities be selected (U.S. EPA, 1997a). Body-part-weighted AFs can then be calculated and used in estimating exposure via dermal contact with soil based on assumed exposed body parts. Data on body-part-specific AFs for specific activities are summarized in Exhibit C-2 and were taken from *Exposure Factors Handbook* (U.S. EPA, 1997a), Table 6-12 and from Holmes et al. (1999). The raw data are available electronically at <http://depts.washington.edu/jkspage> as presented in Exhibit C-2. These body-part-specific adherence data are then combined as a surface weighted average and 95th percentile for each activity using the exposed body parts that are listed for each scenario. The surface area calculations are presented in Exhibit C-1 and the overall values in Exhibit C-3 and Exhibit 3-3.

Body-Part-Specific Surface Areas

The surface area parameter (SA) describes the amount of skin exposed to the contaminated media. The amount of skin exposed depends upon the exposure scenario. Clothing is expected to limit the extent of the exposed surface area in cases of soil contact. All SA estimates used 50th percentile values to correlate with the

EXHIBIT C-1
BODY PART-SPECIFIC SURFACE AREA CALCULATIONS
(CHILDREN)

CHILDREN	Fraction of Total SA (unitless) ¹								Total Body SA (m ² 50th %tile) ²			
	Age (y)	Head	Face ³	Arms	Forearms ⁴	Hands	Legs	Lower legs ⁴	Feet	Age (y)	Male Child	Female Child
<1 ⁵	0.182	0.0607	0.137	0.0617	0.053	0.206	0.082	0.0654	<1 ⁵	0.603	0.579	
1<2	0.165	0.0550	0.13	0.0585	0.0568	0.231	0.092	0.0627	1<2 ⁵	0.603	0.579	
2<3	0.142	0.0473	0.118	0.0531	0.053	0.232	0.093	0.0707	2<3	0.603	0.579	
3<4	0.136	0.0453	0.144	0.0648	0.0607	0.268	0.107	0.0721	3<4	0.664	0.649	
4<5	0.138	0.0460	0.14	0.0630	0.057	0.278	0.111	0.0729	4<5	0.731	0.706	
5<6 ⁶	0.131	0.0437	0.131	0.0590	0.0471	0.271	0.108	0.069	5<6 ⁶	0.793	0.779	
6<7	0.131	0.0437	0.131	0.0590	0.0471	0.271	0.108	0.069	6<7	0.866	0.843	
7<8 ⁶	0.12	0.0400	0.123	0.0554	0.053	0.287	0.115	0.0758	7<8 ⁶	0.936	0.917	
8<9 ⁶	0.12	0.0400	0.123	0.0554	0.053	0.287	0.115	0.0758	8<9 ⁶	1	1	
9<10	0.12	0.0400	0.123	0.0554	0.053	0.287	0.115	0.0758	9<10	1.07	1.06	
10<11 ⁶	0.0874	0.0291	0.137	0.0617	0.0539	0.305	0.122	0.0703	10<11 ⁶	1.18	1.17	
11<12 ⁶	0.0874	0.0291	0.137	0.0617	0.0539	0.305	0.122	0.0703	11<12 ⁶	1.23	1.3	
12<13	0.0874	0.0291	0.137	0.0617	0.0539	0.305	0.122	0.0703	12<13	1.34	1.4	
13<14	0.0997	0.0332	0.121	0.0545	0.0511	0.32	0.128	0.0802	13<14	1.47	1.48	
14<15 ⁶	0.0796	0.0265	0.131	0.0590	0.0568	0.336	0.134	0.0693	14<15 ⁶	1.61	1.55	
15<16 ⁶	0.0796	0.0265	0.131	0.0590	0.0568	0.336	0.134	0.0693	15<16 ⁶	1.7	1.57	
16<17	0.0796	0.0265	0.131	0.0590	0.0568	0.336	0.134	0.0693	16<17	1.76	1.6	
17<18	0.0758	0.0253	0.175	0.0788	0.0513	0.308	0.123	0.0728	17<18	1.8	1.63	
<u>Fraction of Total SA: Age-Weighted Body Part-Specific Average</u>												
<1 to <6	0.149	0.050	0.133	0.060	0.055	0.248	0.099	0.069	Total SA (<1to<6yr):	0.666	0.645	0.656
<7 to <18	0.097	0.032	0.133	0.060	0.053	0.307	0.123	0.072	Total SA (<7to<18yr):	1.330	1.293	1.312
<u>Surface Area by Body Part (cm²)⁷</u>												
<1 to <6	977	326	874	393	358	1624	650	451				
<7 to <18	1276	425	1749	787	700	4026	1610	949				

1. Taken from *Exposure Factors Handbook* 1997, Table 6-8.

3. Face SA was assumed to be 1/3 of head SA.

5. Due to lack of data for indicated ages, it was assumed that children <1 and 1<2 yr old had the same total SA as children 2<3 yr old.

7. Body-part-weighted SA for children was calculated by multiplying body-part-specific fraction of total SA by total SA (avg. of male and female). Adult body-part SA was taken from 50%tile body-part SA (avg. of Male/Female). All areas reported to two significant digits.

2. Taken from *Exposure Factors Handbook* 1997, Table 6-6 (male) and Table 6-7 (female).

4. Assumed forearm-to-arm ratio (0.45) and lowerleg-to-leg ratio (0.4) equivalent to an adult.

6. Due to lack of data for indicated ages, it was assumed that body-part-specific fraction of total SA was equal to that of the next oldest age with data.

8. Taken from *Exposure Factors Handbook* 1997, Tables 6-2 (male) and 6-3 (female).

EXHIBIT C-1
BODY PART-SPECIFIC SURFACE AREA CALCULATIONS
(ADULTS)

ADULT			
	<u>Surface Area of Adults (50th percentile⁸) (cm²)</u>		
Body Part	Male	Female	Average
Total	19400	16900	18150
Face ³	433	370	402
Forearms ⁴	1310	1035	1173
Hands	990	817	904
Lower legs ⁴	2560	2180	2370
Feet	1310	1140	1225

1. Taken from *Exposure Factors Handbook* 1997, Table 6-8.
2. Taken from *Exposure Factors Handbook* 1997, Table 6-6 (male) and Table 6-7 (female).
3. Face SA was assumed to be 1/3 of head SA.
4. Assumed forearm-to-arm ratio (0.45) and lower leg-to-leg ratio (0.4) equivalent to an adult.
5. Due to lack of data for indicated ages, it was assumed that children <1 and 1<2 yr old had the same total SA as children 2<3 yr old.
6. Due to lack of data for indicated ages, it was assumed that body-part-specific fraction of total SA was equal to that of the next oldest age with data.
7. Body-part-weighted SA for children was calculated by multiplying body-part-specific fraction of total SA by total SA (avg. of male and female). Adult body-part SA was taken from 50thtile body-part SA (avg. of Male/Female). All areas are reported to two significant digits.
8. Taken from *Exposure Factors Handbook* 1997, Tables 6-2 (male) and 6-3 (female).

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)	
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile
Children Playing (dry soil)	CPGp014		M	0.193	0.015	0.056	0.002	x		
	CPGp015		M	0.139	0.010	0.022	0.004	x		
	CPGp016		F	0.021	0.002	0.020	0.002	x		
	CPGp017		M	0.147	0.018	0.017	0.002	x		
	CPGp018		F	0.102	0.095	0.336	0.022	x		
			Avg(ln x)	-2.337	-4.305	-3.163	-5.565	x		
			Stdev(ln x)	0.881	1.424	1.250	1.042	x		
			GeoMean	0.097	0.014	0.042	0.004	x		
			1-tailed t-dist. value	2.132	2.132	2.132	2.132	x		
			95th Percentile	0.632	0.281	0.608	0.035	x		
(face, forearms, hands, lowerlegs)								0.040	0.431	
Daycare Children No. 1a	D1a1	6.5	M	0.252	0.027	0.067	x	0.205		
	D1a2	4	M	0.088	0.044	0.015	x	0.087		
	D1a3	2	M	0.208	0.043	0.030	x	0.024		
	D1a4	1.75	M	0.081	0.027	0.023	x	0.110		
	D1a5	1	M	0.114	0.029	0.041	x	0.031		
	D1a6	1	F	0.043	0.008	0.027	x	0.171		
Daycare Children No. 1b	D1b1	6.5	M	0.094	0.018	0.026	x	0.210		
	D1b2	4	M	0.089	0.024	0.019	x	0.117		
	D1b3	2	M	0.505	0.037	0.023	x	0.126		
	D1b4	1.75	M	0.104	0.035	0.027	x	0.111		
	D1b5	1	M	0.263	0.084	0.018	x	0.082		
	D1b6	1	F	0.091	0.017	0.026	x	0.204		
Daycare Children No. 3	D3a	4.5	M	0.031	0.015	0.017	x	0.015		
	D3b	1.5	F	0.026	0.010	0.020	x	0.008		
	D3c	1.3	M	0.040	0.011	0.040	x	0.013		
	D3d	2	M	0.050	0.010	0.003	x	0.000		
			Avg(ln x)	-2.375	-3.791	-3.787	x	-3.015		
			Stdev(ln x)	0.823	0.652	0.652	x	1.630		
			GeoMean	0.093	0.023	0.023	x	0.049		
			1-tailed t-dist. value	1.753	1.753	1.753	x	1.753		
		95th Percentile	0.394	0.071	0.071	x	0.853			
(forearms, hands, lowerlegs, feet)								0.043	0.324	

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Children Playing (wet soil)	CPGp01		M	1.398	0.026	1.320	0.013	x			
	CPGp02		F	0.290	0.005	0.184	0.010	x			
	CPGp03		M	0.127	0.009	0.037	0.012	x			
	CPGp04		M	0.928	0.069	0.669	0.009	x			
	CPGp05		M	0.036	0.008	0.004	0.005	x			
	CPGp06		F	0.565	0.011	0.010	0.002	x			
	CPGp07		F	0.681	0.015	0.131	0.006	x			
	CPGp08		M	0.163	0.006	0.072	0.004	x			
	CPGp09		F	4.743	0.101	0.778	0.006	x			
	CPGp10		M	4.969	0.064	0.001	0.002	x			
	CPGp11		M	0.274	0.003	0.000	0.001	x			
	CPGp12		F	1.384	0.005	0.001	0.001	x			
	CPGp13		M	4.326	0.034	0.002	0.006	x			
				Avg(ln x)	-0.421	-4.185	-3.634	-5.409			x
			Stdev(ln x)	1.509	1.134	2.732	0.870	x			
			GeoMean	0.656	0.015	0.026	0.004	x			
			1-tailed t-dist. value	1.782	1.782	1.782	1.782	x			
			95th Percentile	9.660	0.115	3.439	0.021	x			
(face, forearms, hands, lowerlegs)										3.327	
Indoor Children No. 1	IK1a	13	F	0.003	0.004	0.004	x	0.011			
	IK1b	11.5	M	0.008	0.003	0.003	x	0.010			
	IK1c	10	M	0.014	0.011	0.011	x	0.020			
	IK1d	6.5	M	0.009	0.002	0.002	x	0.011			
Indoor Children No. 2	IK2a	13	F	0.022	0.005	0.002	x	0.004			
	IK2b	11.5	M	0.011	0.003	0.002	x	0.007			
	IK2c	10	M	0.015	0.010	0.005	x	0.015			
	IK2d	6.5	M	0.010	0.001	0.002	x	0.007			
	IK2e	7	M	0.025	0.004	0.004	x	0.014			
	IK2f	3	F	0.009	0.005	0.004	x	0.015			
Daycare Children No. 2	D2a	4	M	0.042	0.015	0.018	x	0.063			
	D2b	1	F	0.064	0.020	0.012	x	0.056			
	D2c	1	M	0.070	0.020	0.007	x	0.035			
	D2d	2	M	0.070	0.032	0.009	x	0.034			
	D2e	2	M	0.159	0.033	0.011	x	0.041			
				Avg(ln x)	-3.889	-4.912	-5.282	x			-4.089
				Stdev(ln x)	1.076	0.994	0.743	x			0.823
				GeoMean	0.020	0.007	0.005	x			0.017
			1-tailed t-dist. value	1.761	1.761	1.761	x	1.761			
			95th Percentile	0.136	0.042	0.019	x	0.071			
(forearms, hands, lowerlegs, feet)										0.011	0.059

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Children-in-Mud No. 1	K1a	11	M	74.283	5.863	36.130	x	51.528			
	K1b	11	M	42.074	2.672	15.022	x	19.960			
	K1c	10	F	18.669	0.931	18.440	x	36.569			
	K1d	14	M	108.669	58.217	86.589	x	104.444			
	K1e	9	M	13.222	23.164	38.571	x	2.377			
	K1f	9	M	22.203	91.537	68.453	x	20.507			
Children-in-Mud No. 2	K2a	11	M	145.065	54.855	15.457	x	22.738			
	K2b	11	M	99.781	2.353	11.983	x	9.923			
	K2c	10	F	31.991	13.949	2.042	x	0.051			
	K2d	14	M	103.279	46.281	20.643	x	43.810			
	K2e	9	M	16.018	3.568	12.798	x	4.975			
	K2f	9	M	49.127	5.104	7.145	x	35.152			
				Avg(ln x)	3.808	2.386	2.919	x			2.539
				Stdev(ln x)	0.836	1.515	1.012	x			2.022
				GeoMean	45.059	10.873	18.525	x			12.663
				1-tailed t-dist. value	1.796	1.796	1.796	x			1.796
			95th Percentile	202.293	165.249	113.959	x	478.270			
(forearms, hands, lowerlegs, feet)									20.601	230.663	

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Grounds keepers No. 1	G1a	52	M	0.444	0.007	x	0.004	0.024			
	G1b	29	F	0.053	0.004	x	0.001	0.013			
Grounds keepers No. 2	G2a	33	F	0.037	0.001	0.001	0.007	x			
	G2b	34	M	0.195	0.006	0.001	0.018	x			
	G2c	28	M	0.171	0.004	0.002	0.024	x			
	G2d	37	F	0.056	0.001	0.001	0.007	x			
	G2e	22	M	0.133	0.003	0.001	0.005	x			
Grounds keepers No. 3	G3a	43	M	0.026	0.005	0.003	0.009	x			
	G3b	40	F	0.006	0.001	0.000	0.001	x			
	G3c	45	F	0.058	0.002	x	0.003	0.004			
	G3d	30	M	0.029	0.002	0.002	0.013	x			
	G3e	43	M	0.034	0.002	0.001	0.005	x			
	G3f	49	M	0.029	0.003	0.001	0.002	x			
	G3g	62	M	0.086	0.004	0.001	0.010	x			
	G3g	62	M	0.086	0.004	0.001	0.010	x			
Grounds keepers No. 4	G4a	38	F	0.067	0.011	0.000	0.002	x			
	G4b	30	M	0.030	0.021	0.001	0.006	x			
	G4c	22	M	0.128	0.027	0.001	0.005	x			
	G4d	34	F	0.050	0.005	0.002	0.002	x			
	G4e	27	F	0.017	0.010	x	0.002	0.018			
	G4f	29	M	0.034	0.012	0.000	0.001	x			
	G4g	35	M	0.053	0.022	0.001	0.003	x			
Grounds keepers No. 5	G5a	44	M	0.052	0.032	0.001	0.006	x			
	G5b	43	M	0.014	0.033	0.001	0.005	x			
	G5c	40	F	0.016	0.018	0.001	0.001	x			
	G5d	64	M	0.033	0.049	0.001	0.006	x			
	G5e	45	F	0.042	0.030	0.001	0.002	x			
	G5f	31	M	0.056	0.045	0.002	0.006	x			
	G5g	49	M	0.033	0.024	0.001	0.004	x			
	G5h	19	M	0.037	0.002	0.001	0.008	x			
				Avg(ln x)	-3.069	-4.983	-6.942	-5.468			-4.388
				Stdev(ln x)	0.863	1.278	0.565	0.819			0.776
			GeoMean	0.046	0.007	0.001	0.004	0.012			
			1-tailed t-dist. value	1.701	1.701	1.711	1.701	2.353			
			95th Percentile	0.202	0.060	0.003	0.017	0.077			
Residential Scenario (face, forearms, hands, lowerlegs)								0.011	0.055		
Commercial/Industrial (face, forearms, hands)								0.021	0.105		

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Landscape/ Rockery	LR1	43	F	0.067	0.034	x	0.010	x			
	LR2	36	M	0.159	0.060	x	0.007	x			
	LR3	27	M	0.091	0.039	x	0.007	x			
	LR4	43	M	0.028	0.010	x	0.002	x			
				Avg(ln x)	-2.630	-3.507	x	-5.168			x
				Stdev(ln x)	0.730	0.755	x	0.635			x
				GeoMean	0.072	0.030	x	0.006			x
				1-tailed t-dist. value	2.353	2.353	x	2.353			x
				95th Percentile	0.402	0.177	x	0.025			x
Residential Scenario (face, forearms, hands, lowerlegs)								0.041	0.234		
Commercial/Industrial (face, forearms, hands)								0.041	0.234		
Gardeners No. 1	GA1a	16	F	0.515	0.055	0.065	0.065	x			
	GA1b	21	F	0.262	0.026	x	0.025	x			
	GA1c	22	F	0.094	0.030	x	0.043	x			
	GA1d	35	F	0.071	0.267	x	0.059	0.066			
	GA1e	22	F	0.177	0.035	x	0.097	x			
	GA1f	27	M	0.310	0.044	0.080	x	0.440			
	GA1g	23	F	0.257	0.033	x	0.060	x			
	GA1h	31	F	0.194	0.070	x	0.088	x			
	Gardeners No. 2	GA2a	43	F	0.155	0.048	0.053	0.093			x
GA2b		32	M	0.173	0.059	x	x	0.263			
GA2c		34	M	0.262	0.071	x	0.058	x			
GA2d		32	F	0.083	0.018	0.013	0.024	x			
GA2e		33	F	2.057	0.407	x	0.056	x			
GA2f		52	F	0.116	0.049	0.028	0.031	x			
GA2g		26	F	0.043	0.017	0.013	0.047	x			
				Avg(ln x)	-1.662	-2.961	-3.411	-2.949	-1.626		
				Stdev(ln x)	0.919	0.872	0.802	0.463	0.983		
				GeoMean	0.190	0.052	0.033	0.052	0.197		
			1-tailed t-dist. value	1.761	1.761	2.015	1.782	2.920			
			95th Percentile	0.958	0.240	0.166	0.119	3.473			
Residential Scenario (face, forearms, hands, lowerlegs)								0.068	0.328		
Commercial/Industrial (face, forearms, hands)								0.102	0.482		
Irrigation Installers	IR1	41	M	0.281	0.039	0.007	0.006	x			
	IR2	35	M	0.279	0.014	0.004	0.006	x			
	IR3	20	M	0.110	0.003	0.004	0.004	x			
	IR4	23	M	0.132	0.008	0.003	0.008	x			
	IR5	28	M	0.129	0.045	0.015	0.008	x			
	IR6	23	M	0.300	0.062	0.007	0.007	x			
				Avg(ln x)	-1.671	-4.007	-5.214	-5.064			x
				Stdev(ln x)	0.467	1.170	0.610	0.289			x
				GeoMean	0.188	0.018	0.005	0.006			x
			1-tailed t-dist. value	2.015	2.015	2.015	2.015	x			
			95th Percentile	0.482	0.192	0.019	0.011	x			
(face, forearms, hands)								0.078	0.268		

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)	
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile
Staged Activity:	APDGPo1a		M	0.131	0.003	0.001	0.003	x		
Pipe Layers	APDGPo2a		M	0.243	0.036	0.258	0.006	x		
(dry soil)	APDGPo3a		M	0.216	0.010	0.113	0.020	x		
	APDGPo4a		F	0.158	0.009	0.046	0.003	x		
	APDGPo5a		F	0.106	0.008	0.093	0.003	x		
	APDGPo6a		F	0.174	0.008	0.296	0.003	x		
	APDGPo1b		M	0.182	0.005	0.000	0.001	x		
	APDGPo2b		M	0.125	0.007	0.166	0.007	x		
	APDGPo3b		M	0.133	0.108	0.115	0.004	x		
	APDGPo4b		F	0.397	0.011	0.095	0.004	x		
	APDGPo5b		F	0.124	0.015	0.112	0.008	x		
	APDGPo6b		F	0.075	0.004	0.393	0.007	x		
	APDGPo1c		M	0.551	0.005	0.001	0.002	x		
	APDGPo2c		M	0.311	0.022	0.355	0.006	x		
	APDGPo3c		M	0.184	0.088	0.246	0.004	x		
	APDGPo4c		F	0.226	0.019	0.131	0.006	x		
	APDGPo5c		F	0.168	0.010	0.104	0.012	x		
	APDGPo6c		F	0.133	0.012	0.579	0.008	x		
			Avg(ln x)	-1.721	-4.419	-2.713	-5.354	x		
			Stdev(ln x)	0.484	0.984	2.214	0.663	x		
			GeoMean	0.179	0.012	0.066	0.005	x		
			1-tailed t-dist. value	1.740	1.740	1.740	1.740	x		
			95th Percentile	0.416	0.067	3.122	0.015	x		
								(face, forearms, hands)	0.072	0.186
Construction Workers	CO1	26	M	0.376	0.132	0.066	0.033	x		
	CO2	27	M	0.283	0.044	0.046	0.013	x		
	CO3	24	M	0.230	0.129	0.056	0.045	x		
	CO4	22	M	0.179	0.061	0.052	0.023	x		
	CO5	22	M	0.440	0.128	0.125	0.035	x		
	CO6	30	M	0.141	0.102	0.080	0.026	x		
	CO7	24	M	0.164	0.132	x	0.058	x		
	CO8	21	M	0.266	0.105	0.063	0.021	x		
			Avg(ln x)	-1.418	-2.328	-2.716	-3.550	x		
			Stdev(ln x)	0.401	0.416	0.334	0.478	x		
			GeoMean	0.242	0.098	0.066	0.029	x		
			1-tailed t-dist. value	1.895	1.895	1.943	1.895	x		
			95th Percentile	0.518	0.215	0.127	0.071	x		
								(face, forearms, hands)	0.139	0.302

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)			
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile		
Heavy Equipment Operators No. 1	E1a	54	M	0.115	0.053	x	0.064	x	0.203	0.732		
	E1b	34	M	0.281	0.080	x	0.104	x				
	E1c	51	M	0.155	0.091	x	0.152	x				
	E1d	21	M	0.940	0.161	x	0.109	x				
Heavy Equipment Operators No. 2	E2a	54	M	0.206	0.192	x	0.146	x				
	E2b	34	M	0.430	0.339	x	0.194	x				
	E2c	51	M	0.227	0.223	x	0.499	x				
	E2d	21	M	0.500	0.358	x	0.200	x				
			Avg(ln x)	-1.245	-1.867	x	-1.874	x				
			Stdev(ln x)	0.682	0.692	x	0.605	x				
			GeoMean	0.288	0.155	x	0.154	x				
			1-tailed t-dist. value	1.895	1.895	x	1.895	x				
			95th Percentile	1.049	0.573	x	0.483	x				
(face, forearms, hands)											0.203	0.732
Utility Workers No. 1	U1a	45	M	0.149	0.052	x	0.095	x			0.242	0.856
	U1b	27	M	0.243	0.131	x	0.079	x				
	U1c	24	M	0.561	0.184	x	0.084	x				
	U1d	35	M	0.364	0.783	x	0.215	x				
	U1e	24	M	0.437	0.311	x	0.082	x				
Utility Workers No. 2	U2a	23	M	0.269	0.189	x	0.062	x				
	U2b	28	M	0.906	0.835	x	0.197	x				
	U2c	24	M	0.187	0.179	x	0.074	x				
	U2d	34	M	0.109	0.298	x	0.113	x				
	U2e	24	M	0.221	0.219	x	0.092	x				
	U2f	36	M	0.390	0.426	x	0.119	x				
			Avg(ln x)	-1.226	-1.385	x	-2.283	x				
			Stdev(ln x)	0.611	0.793	x	0.393	x				
			GeoMean	0.293	0.250	x	0.102	x				
			1-tailed t-dist. value	1.812	1.812	x	1.812	x				
			95th Percentile	0.889	1.053	x	0.208	x				
(face,forearms,hands)									0.242	0.856		

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)	
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile
Staged Activity:	APWGPo1a		M	2.122	0.018	1.410	0.019	x		
Pipe Layers (wet soil)	APWGPo2a		M	19.708	0.999	3.730	0.018	x		
	APWGPo3a		M	10.531	0.030	0.000	0.001	x		
	APWGPo4a		M	0.334	0.005	0.001	0.002	x		
	APWGPo5a		F	0.019	0.001	0.169	0.000	x		
	APWGPo6a		F	0.445	0.013	0.001	0.004	x		
	APWGPo7a		F	0.978	0.003	0.012	0.003	x		
	APWGPo1b		M	4.573	0.113	3.411	0.019	x		
	APWGPo2b		M	14.032	0.446	1.856	0.018	x		
	APWGPo3b		M	3.319	0.001	0.001	0.004	x		
	APWGPo4b		M	1.257	0.018	0.005	0.004	x		
	APWGPo5b		F	4.052	0.013	0.905	0.011	x		
	APWGPo6b		F	1.050	0.018	0.002	0.001	x		
	APWGPo7b		F	1.872	0.004	0.001	0.006	x		
	APWGPo1c		M	1.263	0.370	2.005	0.012	x		
	APWGPo2c		M	7.890	0.439	2.485	0.018	x		
	APWGPo3c		M	6.866	0.147	2.124	0.007	x		
	APWGPo4c		M	0.087	0.002	0.001	0.002	x		
	APWGPo5c		F	6.280	0.085	1.662	0.037	x		
	APWGPo6c		F	0.181	0.010	0.003	0.003	x		
	APWGPo7c		F	3.658	0.029	0.087	0.004	x		
			Avg(ln x)	0.527	-3.741	-3.008	-5.325	x		
			Stdev(ln x)	1.758	2.058	3.607	1.320	x		
			GeoMean	1.694	0.024	0.049	0.005	x		
			1-tailed t-dist. value	1.725	1.725	1.725	1.725	x		
			95th Percentile	35.138	0.826	24.864	0.047	x		
								(face, forearms, hands)	0.630	13.212
Soccer Players No. 1	S1a	13	M	0.068	0.019	0.022	0.012	x		
	S1b	14	M	0.052	0.021	0.251	0.020	x		
	S1c	14	M	0.116	0.005	0.015	0.012	x		
	S1d	15	M	0.120	0.006	0.047	0.011	x		
	S1e	13	M	0.280	0.026	0.092	0.009	x		
	S1f	14	M	0.170	0.004	0.060	0.009	x		
	S1g	13	M	0.146	0.015	0.008	0.020	x		
	S1h	13	M	0.055	0.007	0.005	0.006	x		
			Avg(ln x)	-2.224	-4.555	-3.481	-4.457	x		
			Stdev(ln x)	0.589	0.714	1.322	0.398	x		
			GeoMean	0.108	0.011	0.031	0.012	x		
			1-tailed t-dist. value	1.895	1.895	1.895	1.895	x		
			95th Percentile	0.330	0.041	0.377	0.025	x		
								(face, forearms, hands, lowerlegs)	0.039	0.250

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)	
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile
Soccer Players No. 2	S2a	31	F	0.042	0.003	0.004	0.012	x		
	S2b	24	F	0.075	0.003	0.003	0.016	x		
	S2c	34	F	0.063	0.003	0.007	0.011	x		
	S2d	30	F	0.043	0.008	0.033	0.038	x		
	S2e	24	F	0.049	0.021	0.042	0.015	x		
	S2f	25	F	0.055	0.005	0.379	0.020	x		
	S2g	29	F	0.075	0.002	0.007	0.014	x		
	S2h	24	F	0.001	0.002	0.004	0.012	x		
Soccer Players No. 3	S3a	28	F	0.012	0.005	0.010	0.009	x		
	S3b	24	F	0.014	0.002	0.008	0.012	x		
	S3c	30	F	0.039	0.002	0.004	0.014	x		
	S3d	34	F	0.020	0.002	0.010	0.007	x		
	S3e	31	F	0.013	0.013	0.012	0.015	x		
	S3f	28	F	0.026	0.003	0.005	0.008	x		
	S3g	25	F	0.021	0.002	0.013	0.027	x		
				Avg(ln x)	-3.638	-5.632	-4.540	-4.274	x	
				Stdev(ln x)	1.047	0.780	1.253	0.439	x	
				GeoMean	0.026	0.004	0.011	0.014	x	
			1-tailed t-dist. value	1.761	1.761	1.761	1.761	x		
			95th Percentile	0.166	0.014	0.097	0.030	x		
								(face, forearms, hands, lowerlegs)	0.012	0.084

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Farmers No. 1	F1a	39	F	0.380	0.025	0.002	0.014	x	0.117	0.448	
	F1b	39	F	0.326	0.020	0.003	0.013	x			
	F1c	44	M	0.794	0.190	0.015	0.025	x			
	F1d	42	M	0.301	0.132	0.012	0.022	x			
Farmers No. 2	F2a	41	F	0.245	0.033	0.033	0.027	x			
	F2b	40	F	0.622	0.175	0.224	0.321	x			
	F2c	43	M	0.571	0.337	0.170	0.045	x			
	F2d	39	M	0.538	0.154	0.008	0.014	x			
	F2e	19	M	0.584	0.142	0.014	0.038	x			
	F2f	18	M	0.407	0.094	0.018	0.022	x			
				Avg(ln x)	-0.802	-2.376	-4.033	-3.524			x
				Stdev(ln x)	0.374	0.966	1.506	0.932			x
				GeoMean	0.448	0.093	0.018	0.029			x
				1-tailed t-dist. value	1.833	1.833	1.833	1.833			x
			95th Percentile	0.890	0.546	0.280	0.163	x			
(face, forearms, hands, lowerlegs)								0.117			0.448
Rugby Players No. 1	R1a	22	M	0.207	0.163	0.266	0.072	x	0.129	0.609	
	R1b	20	M	0.427	0.279	0.695	0.119	x			
	R1c	20	M	1.123	0.451	0.733	0.094	x			
	R1d	20	M	0.338	0.152	0.267	0.008	x			
	R1e	21	M	0.237	0.156	0.237	0.066	x			
	R1f	22	M	0.456	0.418	0.341	0.197	x			
	R1g	22	M	0.413	0.345	0.503	0.032	x			
	R1h	21	M	0.454	0.399	0.189	0.059	x			
Rugby Players No. 2	R2a	33	M	0.147	0.093	0.203	0.066	x			
	R2b	28	M	0.074	0.095	0.064	0.038	x			
	R2c	27	M	0.168	0.141	0.190	0.044	x			
	R2d	26	M	0.139	0.102	0.160	0.055	x			
	R2e	23	M	0.195	0.178	0.140	0.043	x			
	R2f	27	M	0.097	0.058	0.086	0.029	x			
	R2g	27	M	0.164	0.229	0.253	0.070	x			
	R2h	30	M	0.179	0.071	0.173	0.039	x			
Rugby Players No. 3	R3a	27	M	0.052	0.028	0.050	0.021	x			
	R3b	26	M	0.052	0.040	0.083	0.015	x			
	R3c	27	M	0.073	0.023	0.051	0.015	x			
	R3d	27	M	0.043	0.025	0.042	0.022	x			
	R3e	30	M	0.033	0.034	0.060	0.015	x			
	R3f	27	M	0.109	0.042	0.062	0.045	x			
	R3g	24	M	0.023	0.028	0.061	0.020	x			
				Avg(ln x)	-1.919	-2.282	-1.896	-3.244			x
				Stdev(ln x)	0.968	0.978	0.858	0.773	x		
				GeoMean	0.147	0.102	0.150	0.039	x		
			1-tailed t-dist. value	1.717	1.717	1.717	1.717	x			
			95th Percentile	0.774	0.547	0.655	0.147	x			
(face, forearms, hands, lowerlegs)								0.129	0.609		

EXHIBIT C-2

ACTIVITY BODY PART-SPECIFIC SOIL ADHERENCE FACTORS (continued)

Activity	ID	Age	Gender	Post-activity Loading (mg/cm ²)					Weighted AFs (mg/cm ²)		
				Hands	Arms	Legs	Faces	Feet	Geometric Mean	95th Percentile	
Archeologists	AR1	16	F	0.139	0.060	0.031	0.103	0.299			
	AR2	21	F	0.175	0.066	0.021	0.062	x			
	AR3	22	F	0.098	0.019	0.002	0.037	x			
	AR4	35	F	0.158	0.083	0.138	0.102	0.357			
	AR5	22	M	0.201	0.064	0.070	0.047	0.161			
	AR6	27	M	0.114	0.018	0.047	0.030	0.233			
	AR7	23	M	0.138	0.025	0.030	0.023	0.194			
				Avg(ln x)	-1.950	-3.203	-3.567	-2.996			0.249
				Stdev(ln x)	0.248	0.651	1.400	0.584			0.079
				GeoMean	0.142	0.041	0.028	0.050			1.283
			1-tailed t-dist. value	1.943	1.943	1.943	1.943	2.132			
			95th Percentile	0.230	0.144	0.429	0.156	1.518			
(face, forearms, hands, lowerlegs, feet)								0.302	0.546		
Reed Gatherers	RD1	67	F	0.733	0.086	0.333	x	0.844			
	RD2	50	F	0.583	0.017	0.006	x	0.041			
	RD3	42	F	1.392	0.049	0.391	x	1.024			
	RD4	45	F	0.315	0.022	0.820	x	4.492			
				Avg(ln x)	-0.418	-3.336	-1.837	x			-0.457
				Stdev(ln x)	0.613	0.742	2.215	x			1.965
				GeoMean	0.658	0.036	0.159	x			0.633
				1-tailed t-dist. value	2.353	2.353	2.353	x			2.353
				95th Percentile	2.787	0.204	29.245	x			64.598
	(forearms, hands, lowerlegs, feet)										0.316
Tae Kwon Do	TK1	42	M	0.006	0.002	0.002	x3	0.005			
	TK2	8	M	0.013	0.001	0.001	x	0.004			
	TK3	8	M	0.008	0.000	0.003	x	0.004			
	TK4	10	M	0.006	0.011	0.006	x	0.001			
	TK5	11	M	0.011	0.005	0.001	x	0.005			
	TK6	12	M	0.003	0.001	0.001	x	0.002			
	TK7	14	F	0.003	0.005	0.003	x	0.001			
				Avg(ln x)	-5.081	-6.289	-6.230	x			-6.014
				Stdev(ln x)	0.581	1.301	0.599	x			0.743
				GeoMean	0.006	0.002	0.002	x			0.002
			1-tailed t-dist. value	1.943	1.943	1.943	x	1.943			
			95th Percentile	0.019	0.023	0.006	x	0.010			
(forearms, hands, lowerlegs, feet)								0.003	0.012		

Daycare Children No. 2 from 1997 *Exposure Factors Handbook* (U.S. EPA, 1997), Table 6-11, and Indoor Children Nos 1 & 2 were combined.

average body weights used for all scenarios and pathways. This was done to prevent inconsistent parameter combinations as body weight and SA are dependent variables. Body part-specific SAs were calculated as described under Chapter 3 for adult (>18 years old), teenager (>6 to <18 years old), and child (<1 to <6 years old) receptors and documented in Exhibit C-1.

Weighted Soil Adherence Factors

Given that soil adherence is dependent upon the body part, it is necessary to calculate an overall body part-weighted AF for each activity. The assumed clothing scenario determines which body part-specific AFs are used in calculating the 50th and 95th percentile weighted AFs. The weighted AFs are used in combination with the relative absorption, exposure frequency and duration, exposed surface area, body weight, and averaging time to estimate the dermally absorbed dose. Details on the methods used to calculate the overall weighted AFs are contained under Chapter 3 of the document. The results from the supporting calculations are shown in Exhibit 3-3.

Mono-Layer Soil Loading for USDA Soil Particle Classification

The range of possible soil adherence factors (AF) was calculated using the U.S. Department of Agriculture's (USDA) soil particle size classes expressed in centimeters, the particle density ($P_{particle} = 2.65 \text{ g/cm}^3$) from the Soil Screening Guidance (U.S. EPA, 1996b), and the Duff and Kissel (1996) equation for a mono-layer, assuming spherical particles and face-centered packing,

$$AF_{monolayer} = [P_{particle} \frac{\pi d^3}{6d^2}] = P_{particle} \frac{\pi d}{6}$$

These values can be used as bounding estimates as maximums for AF using site-specific soil properties. The AF should not exceed these estimated values based on the mono-layer theory. To restate the recommendation of this guidance, construct the RME exposure scenario with a site-specific upper-end activity pattern, mean AF from Exhibit C-3, and upper-end exposure time. The uncertainty can be bounded by using these maximum estimated mono-layer AF values.

EXHIBIT C-3

**OVERALL BODY PART-SPECIFIC WEIGHTED
SOIL ADHERENCE FACTORS**

	Age (years)	Weighted Soil Adherence Factor (mg/cm ²)	
		Geometric Mean	95 th Percentile
CHILDREN¹			
Indoor Children	1-13	0.01	0.06
Daycare Children (playing indoors and outdoors)	1-6.5	0.04	0.3
Children Playing (dry soil)	8-12	0.04	0.4
Children Playing (wet soil)	8-12	0.2	3.3
Children-in-Mud ²	9-14	21	231
RESIDENTIAL ADULTS³			
Grounds keepers	>18	0.01	0.06
Landscaper/Rockery	>18	0.04	0.2
Gardeners	>16	0.07	0.3
COMMERCIAL/INDUSTRIAL ADULTS⁴			
Grounds keepers	>18	0.02	0.1
Landscaper/Rockery	>18	0.04	0.2
Staged Activity: Pipe Layers (dry soil)	>15	0.07	0.2
Irrigation Installers	>18	0.08	0.3
Gardeners	>16	0.1	0.5
Construction Workers	>18	0.1	0.3

¹ Weighted AF based on exposure to face, forearms, hands, lower legs, & feet.

² Information on soil adherence values for the Children-in-Mud scenario is provided to illustrate the range of values for this type of activity. However, the application of these data to the dermal dose equations in this guidance may result in a significant overestimation of dermal risk. Therefore, it is recommended that the 95 percentile AF values not be used in a quantitative dermal risk assessment. See Exhibit C-4 for bounding estimates.

³ Weighted AF based on exposure to face, forearms, hands, & lower legs.

⁴ Weighted AF based on exposure to face, forearms, & hands.

Note: this results in different weighted AFs for similar activities between residential and commercial/industrial exposure scenarios.

EXHIBIT C-3

**OVERALL BODY PART-SPECIFIC WEIGHTED
SOIL ADHERENCE FACTORS (continued)**

	Age (years)	Weighted Soil Adherence Factor (mg/cm ²)	
		Geometric Mean	95 th Percentile
COMMERCIAL/INDUSTRIAL ADULTS⁴ (continued)	>18	0.2	0.7
Utility Workers	>18	0.2	0.9
Staged Activity: Pipe Layers (wet soil)	>15	0.6	13
MISCELLANEOUS ACTIVITIES⁵			
Soccer Players #2 (adults)	>18	0.01	0.08
Soccer Players #1 (teens, moist conditions)	13-15	0.04	0.3
Farmers	>20	0.1	0.4
Rugby Players	>21	0.1	0.6
Archeologists	>19	0.3	0.5
Reed Gatherers	>22	0.3	27

⁵ Weighted AF based on all body parts for which data were available

EXHIBIT C-4

**ESTIMATION OF SOIL ADHERENCE FACTOR AT MONO-LAYER
FOR USDA PARTICLE SIZE SOIL CLASSIFICATIONS**

Soil Particle Classification*	Diameter (mm)	AF at mono-layer (mg/cm ²)
Clay, total	<0.002	<0.28
Silt, total	0.002-0.05	0.28-6.9
Silt, fine	0.002-0.02	0.28-2.8
Silt, coarse	0.02-0.05	2.8-6.9
Sand, total	0.05-2.0	6.9-277.5
Very fine sand	0.05-0.1	6.9-13.9
Fine sand	0.1-0.25	13.9-34.7
Medium sand	0.25-0.5	34.7-69.4
Coarse sand	0.5-1.0	69.4-138.8
Very coarse sand	1.0-2.0	138.8-277.5
* USDA 2007. U.S. Department of Agriculture Natural Resources Conservation Service, National Soil Survey Handbook, Particle Size (618.43) http://soils.usda.gov/technical/handbook/contents/part618.html		