EPA 747-R-96-008
May 1997

LEAD EXPOSURE ASSOCIATED WITH RENOVATION AND REMODELING ACTIVITIES:

ENVIRONMENTAL FIELD SAMPLING STUDY
VOLUME II: APPENDICES

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APPENDIX A

SUPPORTING TABLES AND FIGURES OF EFSS DATA

A.0 SUPPORT TABLES AND FIGURES OF EFSS DATA

A.1 DESCRIPTIVE STATISTICS ON SAMPLE WEIGHTS, LEAD LOADINGS, AND LEAD CONCENTRATIONS BY SAMPLE TYPE, IN THE CARPET REMOVAL PHASE

This section presents descriptive summaries on lead exposure data for the various sample types considered in the EFSS carpet removal substudy. These summaries, cited in Chapters 6 and 7A, are presented within six sets of tables, grouped according to the sample type considered:

Total number of samples collected and analyzed: Table CR-1.

Personal and ambient air results: Tables CR-2a, CR-2b.

Pre- and post-activity floor vacuum dust results: Tables CR-3a through CR-3d.

Stainless steel dustfall collector (SSDC) dust sample results using vacuum techniques, collected at 1-hour and 2-hours following the activity: Tables CR-4a through CR-4d.

Pre- and post-activity window sill dust results: Tables CR-5a through CR-5d.

SSDC dust sample results collected at 1-hour following the activity, using vacuum and wipe techniques: Tables CR-6a, CR-6b.

Table CR-1 reports the number of samples planned, the number of samples collected, and the number of analytical results received. The remaining tables present summary statistics, such as the number of samples with nonmissing data values, the arithmetic and geometric means, the standard deviation of the log-transformed data, and the minimum and maximum data values. Within each set of tables, the first table represents statistics over all study data, while subsequent tables include statistics calculated for each study unit. Lead exposure data summarized in these tables include the physical sample weights (g) and lead concentrations (µg/g) for vacuum samples, lead loadings (µg/ft^2) for vacuum and wipe samples, and lead concentrations (µg/m^3) for personal air and ambient air samples. The personal air lead concentrations are expressed in terms of task-length average (TLA) exposures for a given worker, defined as the average exposure over the duration of activity.

Sample types are placed within a given set of tables above so that their results can be compared. Therefore, these tables also include differences in sample results between pairs of adjoining samples at a given location. Tables CR-3a and CR-3b consider differences in results between adjoining pre- and post-activity floor dust samples. Tables CR-4a through CR-4d consider differences between 1-hour and 2-hour results from SSDC vacuum dust samples. Tables CR-5a through CR-5d include differences in results between adjoining pre- and post-activity window sill samples, and Tables CR-6a through CR-6b include differences between 1-hour vacuum and wipe SSDC sample results. The same statistics are presented for the paired differences as for the individual sample results. However, the statistic identified as the "geometric mean" represents the geometric mean of the ratio between the two adjoining sample results at a given location (e.g., post- vs. pre-activity, 2-hour vs. 1-hour, wipe vs. vacuum).

In addition to the above tables, this section also includes boxplots of lead loading and concentration data for the different types of settled dust samples. Figures CR-1a and CR-1b present lead loading and concentration data, respectively, for the three types of settled dust samples collected prior to the start of carpet removal activity (pre-activity carpet data, window sill data, and floor data). Figures CR-2a and CR-2b contain boxplots for lead loading and concentration data, respectively, for the five types of settled dust samples collected following completion of carpet removal activities (1-hour vacuum from floors and SSDCs, 1-hour wipe from SSDCs, and 2-hour vacuum from SSDCs). Chapter 5 includes a discussion of how to interpret boxplots, as well as the boxplots for personal air and ambient air sample lead loadings.

Table CR-1. Numbers of Field Samples Collected and Results Reported in the EFSS Carpet Removal Substudy, by Study Unit

Unit ID	Number of Proposed Samples[1]		Number of Proposed Samples Collected[2]		Number of Extra Samples Collected[3]	Total Number of Samples Collected	Number of Analytical Results Received
	Reg.	QC	Reg.	QC			
1-01	26	9	26	9	2	37	37
1-02	26	9	26	9	0	35	35
1-03	26	9	26	9	0	35	35
1-04	26	9	26	9	0	35	35
2-01	26	9	25	9	0	34	34
2-02	26	9	26	9	0	35	35
2-03	26	9	25	9	1	35	35
2-05	26	9	26	9	0	35	35
Total	208	72	206	72	3	281	281

(1) A breakdown of the number of proposed samples by sample type is presented in Table 7A-1.
(2) Two proposed samples were not collected: both were personal air samples at units where a single R&R worker performed carpet removal.
(3) Extra samples consisted of additional cassette samples necessary for personal air monitoring over the duration of carpet removal activity.

Table CR-2a. Descriptive Statistics (Across All Units) of Lead Concentrations (μg/m^3) Associated with Personal Air and Ambient Air Samples During Carpet Removal

Sample Type	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
During-Activity Personal Exposure Samples[2]	14	35.87	8.44	1.77	0.86	221.3
Pre-Activity Ambient Air Samples	8	0.10	0.09	0.43	0.05	0.17
During-Activity Ambient Air Samples	16	1.48	0.33	1.58	0.06	13.38

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Results summarize worker exposure over the entire job. Three of the 14 workers in this study had multiple cassette samples taken within non-overlapping time intervals during the activity. For these workers, cumulative results over the entire job were calculated from the multiple samples.

Table CR-2b. Descriptive Statistics (for Each Unit) of Lead Concentrations (µg/m^3) Associated with Personal Air and Ambient Air Samples During Carpet Removal

Unit ID	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value	Baseline (Pre-Activity) Value
Personal Air Sample Results[2]							
1-01	2	55.58	55.41	0.11	51.25	59.91	
1-02	2	3.81	3.67	0.40	2.77	4.86	
1-03	2	7.00	6.85	0.30	5.56	8.44	
1-04	2	174.7	168.4	0.39	128.1	221.3	
2-01	1	1.48	1.48	.	1.48		
2-02	2	4.56	4.08	0.68	2.52	6.60	
2-03	1	7.39	7.39	.	7.39		
2-05	2	0.97	0.97	0.16	0.86	1.08	
Ambient Air Sample Results							
1-01	2	2.87	1.42	1.88	0.38	5.36	0.10
1-02	2	0.13	0.11	0.89	0.06	0.20	0.09
1-03	2	0.10	0.10	0.20	0.09	0.12	0.17
1-04	2	6.83	1.92	2.75	0.28	13.38	0.07
2-01	2	0.12	0.12	0.16	0.11	0.14	0.09
2-02	2	0.22	0.19	0.88	0.10	0.35	0.05
2-03	2	1.45	1.44	0.16	1.29	1.61	0.14
2-05	2	0.14	0.14	0.29	0.11	0.17	0.06

(1) Standard deviation of the log-transformed data (expressed in log measurement units).

(2) For units 1-01 and 2-03, results summarize worker exposure over the entire job. Three of the 14 workers in this study had multiple cassette samples taken within non-overlapping time intervals during the activity. For these workers, cumulative results over the entire job were calculated from the multiple samples.

Table CR-3a. Descriptive Statistics (Across All Units) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from Floors Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")[1]

Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
Sample Weight (g)						
Pre-activity	24	0.0607	0.0304	1.1323	0.0057	0.4536
Post-activity	24	0.1677	0.1205	0.8087	0.0357	0.6285
Paired Differences (post minus pre)	24	0.1070	3.9666[3]		-.2910	0.5179
Loadings (µg/ft²)						
Pre-activity	24	84.14	14.44	1.98	1.38	564.5
Post-activity	24	591.3	130.4	1.67	6.38	6135
Paired Differences (post minus pre)	24	507.1	9.03[3]		-195	6132
Concentrations (µg/g)						
Pre-activity	24	1336.8	475.1	1.4	36.7	9179.2
Post-activity	24	2875.8	1081.4	1.4	71.9	20662
Paired Differences (post minus pre)	24	1539.0	2.3[3]		-3554	20571

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) Geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-3b. Descriptive Statistics (for Each Unit) of Sample Weights (g) Associated with Vacuum Samples from Floors Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")[(1)]

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(2)]	Minimum Value	Maximum Value
1-01	Pre	3	0.0112	0.0110	0.2343	0.0090	0.0142
	Post	3	0.1800	0.1545	0.7018	0.0741	0.2999
1-02	Pre	3	0.0395	0.0344	0.6261	0.0207	0.0693
	Post	3	0.1526	0.0993	1.1448	0.0357	0.3419
1-03	Pre	3	0.0337	0.0216	1.1183	0.0113	0.0784
	Post	3	0.0851	0.0848	0.1111	0.0747	0.0919
1-04	Pre	3	0.0299	0.0263	0.6463	0.0132	0.0476
	Post	3	0.3225	0.2801	0.6707	0.1394	0.5311
2-01	Pre	3	0.0543	0.0499	0.5330	0.0272	0.0741
	Post	3	0.0751	0.0746	0.1409	0.0646	0.0856
2-02	Pre	3	0.0096	0.0089	0.4566	0.0057	0.0142
	Post	3	0.0802	0.0654	0.7558	0.0390	0.1556
2-03	Pre	3	0.1691	0.0583	1.9238	0.0100	0.4536
	Post	3	0.1435	0.1149	0.9053	0.0411	0.2267
2-05	Pre	3	0.1386	0.1313	0.4234	0.0806	0.1723
	Post	3	0.3026	0.2186	1.0012	0.0858	0.6285
Paired Differences (Post minus pre)[(3)]							
1-01		3	0.1688	14.099		0.0599	0.2909
1-02		3	0.1131	2.8810		-.0336	0.3212
1-03		3	0.0515	3.9342		0.0135	0.0775
1-04		3	0.2926	10.670		0.0918	0.5179
2-01		3	0.0208	1.4963		0.0010	0.0374
2-02		3	0.0706	7.3181		0.0302	0.1499
2-03		3	-.0256	1.9713		-.2910	0.2167
2-05		3	0.1640	1.6649		0.0052	0.4656

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-3c. Descriptive Statistics (for Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Floors Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")[(1)]

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(2)]	Minimum Value	Maximum Value
1-01	Pre	3	1.70	1.67	0.23	1.38	2.16
	Post	3	146.2	107.5	0.99	41.28	295.5
1-02	Pre	3	12.45	11.43	0.52	6.70	18.78
	Post	3	35.02	28.27	0.77	16.69	68.68
1-03	Pre	3	13.97	6.30	1.52	2.61	36.68
	Post	3	108.5	36.87	1.93	6.38	292.3
1-04	Pre	3	3.19	3.09	0.29	2.61	4.34
	Post	3	2183	637.2	1.96	183.2	6135
2-01	Pre	3	280.9	188.1	1.20	52.21	564.5
	Post	3	494.7	192.1	1.70	54.87	1332
2-02	Pre	3	2.86	2.86	0.01	2.85	2.89
	Post	3	185.8	103.9	1.64	15.77	316.6
2-03	Pre	3	32.49	29.89	0.52	16.66	45.77
	Post	3	167.7	119.9	1.17	30.92	240.2
2-05	Pre	3	325.5	315.2	0.30	261.4	447.5
	Post	3	1410	488.2	1.83	119.6	3857
Paired Differences (Post minus pre)[(3)]							
1-01		3	144.5	64.50		39.90	293.9
1-02		3	22.58	2.47		-2.09	61.98
1-03		3	94.54	5.85		3.77	255.6
1-04		3	2179	205.9		178.8	6132
2-01		3	213.8	1.02		-171	767.8
2-02		3	182.9	36.28		12.92	313.7
2-03		3	135.2	4.01		-4.12	223.5
2-05		3	1084	1.55		-195	3595

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-3d. **Descriptive Statistics (for Each Unit) of Lead Concentrations (µg/g) Associated with Vacuum Samples from Floors Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")[1]**

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	Pre	3	152.9	152.0	0.1	133.9	172.9
	Post	3	868.9	695.5	0.9	248.7	1372.8
1-02	Pre	3	337.0	331.7	0.2	271.1	416.4
	Post	3	304.8	284.8	0.4	200.9	467.6
1-03	Pre	3	310.2	292.6	0.4	231.4	467.9
	Post	3	1204.0	434.9	1.9	71.9	3180.4
1-04	Pre	3	126.7	117.9	0.4	90.8	198.1
	Post	3	7469.8	2274.7	2.0	433.5	20662
2-01	Pre	3	4716.0	3773.3	0.8	1919.3	9179.2
	Post	3	5932.2	2575.2	1.6	730.6	15564
2-02	Pre	3	342.6	320.8	0.4	203.8	500.1
	Post	3	2910.9	1590.3	1.4	404.2	6883.0
2-03	Pre	3	1805.6	513.1	2.4	36.7	4576.5
	Post	3	1084.0	1043.5	0.3	752.2	1477.2
2-05	Pre	3	2903.7	2401.1	0.7	1553.5	5552.6
	Post	3	3231.8	2233.8	1.2	617.5	6136.6
Paired Differences (Post minus pre)[3]							
1-01		3	716.1	4.6		114.8	1221.1
1-02		3	-32.2	0.9		-170.5	196.6
1-03		3	893.8	1.5		-159.5	2712.5
1-04		3	7343.1	19.3		235.5	20571
2-01		3	1216.3	0.7		-2319	6385.1
2-02		3	2568.4	5.0		80.3	6679.2
2-03		3	-721.6	2.0		-3554	1440.5
2-05		3	328.2	0.9		-2611	4531.7

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-4a. **Descriptive Statistics (Across All Units) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at 1-hour and 2-hours Following Completion of Carpet Removal[1]**

Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
Sample Weight (g)						
One hour post-activity	24	0.0288	0.0223	0.6999	0.0077	0.1127
Two hours post-activity	24	0.0423	0.0305	0.8151	0.0043	0.2245
Paired Differences (2-hr minus 1-hr)	24	0.0135	1.3682[3]		-.0452	0.2087
Loadings (µg/ft²)						
One hour post-activity	24	72.68	24.33	1.50	2.61	621.0
Two hours post-activity	24	109.8	38.63	1.50	2.61	937.8
Paired Differences (2-hr minus 1-hr)	24	37.14	1.59[3]		-193	316.8
Concentrations (µg/g)						
One hour post-activity	24	2427.8	1089.9	1.2	214.3	19839
Two hours post-activity	24	2935.1	1264.8	1.2	280.8	29867
Paired Differences (2-hr minus 1-hr)	24	507.4	1.2[3]		-6244	10028

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) Geometric mean of the ratio of the two-hour result to the result of the adjoining one-hour sample. No measurement units are associated with this value.

Table CR-4b. Descriptive Statistics (for Each Unit) of Sample Weights (g) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at 1-hour and 2-hours Following Completion of Carpet Removal[1]

Unit ID	Time Post-Activity	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	1-hr.	3	0.0499	0.0327	1.1205	0.0127	0.1127
	2-hrs.	3	0.0548	0.0495	0.5957	0.0249	0.0721
1-02	1-hr.	3	0.0435	0.0341	0.8809	0.0141	0.0821
	2-hrs.	3	0.0361	0.0327	0.5296	0.0234	0.0602
1-03	1-hr.	3	0.0206	0.0195	0.4229	0.0122	0.0277
	2-hrs.	3	0.0276	0.0229	0.8154	0.0091	0.0425
1-04	1-hr.	3	0.0269	0.0260	0.3296	0.0178	0.0317
	2-hrs.	3	0.0465	0.0422	0.5207	0.0311	0.0770
2-01	1-hr.	3	0.0190	0.0165	0.6880	0.0079	0.0309
	2-hrs.	3	0.0232	0.0226	0.2671	0.0192	0.0308
2-02	1-hr.	3	0.0172	0.0139	0.7768	0.0077	0.0335
	2-hrs.	3	0.0235	0.0148	1.2455	0.0043	0.0519
2-03	1-hr.	3	0.0264	0.0203	0.8773	0.0098	0.0537
	2-hrs.	3	0.0981	0.0516	1.5458	0.0103	0.2245
2-05	1-hr.	3	0.0266	0.0235	0.6520	0.0114	0.0405
	2-hrs.	3	0.0286	0.0280	0.2593	0.0212	0.0354
Paired Differences (2-hr. minus 1-hr)[3]							
1-01		3	0.0049	1.5139		-.0452	0.0477
1-02		3	-.0073	0.9592		-.0219	0.0093
1-03		3	0.0070	1.1752		-.0031	0.0205
1-04		3	0.0196	1.6208		0.0001	0.0453
2-01		3	0.0042	1.3741		-.0001	0.0117
2-02		3	0.0063	1.0620		-.0061	0.0184
2-03		3	0.0717	2.5482		0.0005	0.2087
2-05		3	0.0020	1.1937		-.0068	0.0179

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the two-hour result to the result of the adjoining one-hour sample. No measurement units are associated with this value.

Table CR-4c. Descriptive Statistics (for Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at 1-hour and 2-hours Following Completion of Carpet Removal[1]

Unit ID	Time Post-Activity	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	1-hr.	3	103.3	60.55	1.48	11.65	205.7
	2-hrs.	3	80.47	56.31	1.10	18.25	163.2
1-02	1-hr.	3	18.66	13.88	0.98	5.10	36.51
	2-hrs.	3	14.34	13.07	0.53	7.74	22.39
1-03	1-hr.	3	9.44	7.55	0.92	2.61	13.35
	2-hrs.	3	13.04	8.95	1.16	2.61	25.89
1-04	1-hr.	3	282.1	197.7	1.00	96.91	621.0
	2-hrs.	3	437.1	316.5	0.96	154.3	937.8
2-01	1-hr.	3	82.21	36.87	1.53	13.67	216.0
	2-hrs.	3	38.96	34.67	0.57	23.00	66.69
2-02	1-hr.	3	39.98	10.04	2.10	2.85	114.0
	2-hrs.	3	143.7	40.83	2.37	3.33	372.9
2-03	1-hr.	3	34.93	27.72	0.82	13.96	68.60
	2-hrs.	3	117.9	77.76	1.21	22.10	244.7
2-05	1-hr.	3	10.79	9.53	0.59	6.78	18.82
	2-hrs.	3	33.04	21.57	1.23	5.95	68.58
Paired Differences (2-hr. minus 1-hr)[3]							
1-01		3	-22.8	0.93		-42.5	6.60
1-02		3	-4.32	0.94		-14.1	2.65
1-03		3	3.60	1.19		-2.74	13.53
1-04		3	155.0	1.60		57.40	316.8
2-01		3	-43.3	0.94		-193	53.01
2-02		3	103.7	4.07		0.22	259.0
2-03		3	82.98	2.81		8.14	222.5
2-05		3	22.24	2.26		-0.83	49.76

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the two-hour result to the result of the adjoining one-hour sample. No measurement units are associated with this value.

Table CR-4d. Descriptive Statistics (for Each Unit) of Lead Concentrations (µg/g) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at 1-hour and 2-hours Following Completion of Carpet Removal[1]

Unit ID	Time Post-Activity	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	1-hr.	3	2179.4	1852.5	0.7	917.7	3795.5
	2-hrs.	3	1327.5	1137.9	0.7	732.9	2418.2
1-02	1-hr.	3	408.8	407.2	0.1	361.6	444.6
	2-hrs.	3	407.5	399.9	0.2	330.9	519.7
1-03	1-hr.	3	419.3	387.1	0.5	214.3	561.6
	2-hrs.	3	412.2	390.4	0.4	287.3	609.1
1-04	1-hr.	3	10038	7592.7	0.9	3057.2	19839
	2-hrs.	3	12972	7499.2	1.4	2004.0	29867
2-01	1-hr.	3	3216.1	2238.5	1.0	927.2	6990.3
	2-hrs.	3	1854.9	1532.1	0.8	746.7	3402.4
2-02	1-hr.	3	1357.3	722.3	1.3	299.2	3402.4
	2-hrs.	3	3922.3	2766.9	1.1	774.4	7185.7
2-03	1-hr.	3	1369.9	1368.3	0.1	1277.5	1424.7
	2-hrs.	3	1565.5	1506.2	0.3	1090.0	2145.3
2-05	1-hr.	3	433.7	405.9	0.5	242.2	594.3
	2-hrs.	3	1018.9	769.8	1.0	280.8	1937.3
Paired Differences (2-hr. minus 1-hr)[3]							
1-01		3	-851.9	0.6		-2964	593.1
1-02		3	-1.2	1.0		-72.7	99.6
1-03		3	-7.1	1.0		-141.8	73.0
1-04		3	2934.6	1.0		-1053	10028
2-01		3	-1361	0.7		-6244	1671.6
2-02		3	2565.0	3.8		475.2	3783.4
2-03		3	195.6	1.1		-317.5	720.6
2-05		3	585.2	1.9		38.5	1472.7

(1) Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) The geometric mean column contains the geometric mean of the ratio of the two-hour result to the result of the adjoining one-hour sample. No measurement units are associated with this value.

Table CR-5a. **Descriptive Statistics (Across All Units) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from Window Sills Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")**

Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
Sample Weight (g)						
Pre-activity	16	0.2535	0.0970	1.6046	0.0059	1.1394
Post-activity	16	0.3087	0.1380	1.3282	0.0195	1.6537
Paired Differences (post minus pre)	16	0.0552	1.4235[2]		-.7865	1.4214
Loadings (µg/ft^2)						
Pre-activity	16	4208	417.5	2.32	21.58	41459
Post-activity	16	4404	661.3	2.22	11.81	26581
Paired Differences (post minus pre)	16	196.2	1.58[2]		-14879	16392
Concentrations (µg/g)						
Pre-activity	16	7396.5	2161.8	1.7	102.0	52985
Post-activity	16	7878.4	2303.8	1.5	250.0	66776
Paired Differences (post minus pre)	16	481.9	1.1[2]		-6248	13791

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-5b. Descriptive Statistics (for Each Unit) of Sample Weights (g) Associated with Vacuum Samples from Window Sills Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value
1-01	Pre	2	0.1686	0.1685	0.0138	0.1669	0.1702
	Post	2	0.1162	0.1162	0.0037	0.1159	0.1165
1-02	Pre	2	0.0618	0.0617	0.0103	0.0613	0.0622
	Post	2	0.2488	0.1199	1.9222	0.0308	0.4668
1-03	Pre	2	0.1776	0.0677	2.2901	0.0134	0.3417
	Post	2	0.0831	0.0661	0.9920	0.0328	0.1334
1-04	Pre	2	0.6859	0.5145	1.1245	0.2323	1.1394
	Post	2	1.0033	0.7639	1.0922	0.3529	1.6537
2-01	Pre	2	0.2120	0.1205	1.6473	0.0376	0.3863
	Post	2	0.5123	0.2869	1.6731	0.0879	0.9366
2-02	Pre	2	0.0124	0.0106	0.8232	0.0059	0.0189
	Post	2	0.0238	0.0234	0.2583	0.0195	0.0281
2-03	Pre	2	0.6808	0.6797	0.0815	0.6416	0.7200
	Post	2	0.4092	0.3910	0.4299	0.2885	0.5299
2-05	Pre	2	0.0292	0.0249	0.8161	0.0140	0.0444
	Post	2	0.0729	0.0713	0.3033	0.0575	0.0883
Paired Differences (Post minus pre)[(2)]							
1-01		2	-.0523	0.6894		-.0543	-.0504
1-02		2	0.1871	1.9418		-.0305	0.4046
1-03		2	-.0945	0.9776		-.2083	0.0194
1-04		2	0.3175	1.4849		-.7865	1.4214
2-01		2	0.3003	2.3808		0.0503	0.5503
2-02		2	0.0114	2.2167		0.0006	0.0222
2-03		2	-.2716	0.5753		-.3531	-.1901
2-05		2	0.0437	2.8580		0.0131	0.0743

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-5c. Descriptive Statistics (for Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Window Sills Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value
1-01	Pre	2	535.2	339.2	1.46	121.19	949.2
	Post	2	157.9	156.8	0.17	139.05	176.7
1-02	Pre	2	1850	1612	0.76	942.19	2757
	Post	2	990.0	812.3	0.92	424.12	1556
1-03	Pre	2	82.46	71.67	0.77	41.69	123.2
	Post	2	393.4	392.1	0.12	361.44	425.4
1-04	Pre	2	111.5	111.2	0.09	104.06	118.9
	Post	2	1236	1012	0.92	526.05	1946
2-01	Pre	2	5576	4795	0.80	2730.3	8422
	Post	2	16052	13449	0.87	7289.5	24814
2-02	Pre	2	64.31	48.06	1.13	21.58	107.0
	Post	2	155.6	59.47	2.29	11.81	299.5
2-03	Pre	2	25395	19668	1.05	9330.3	41459
	Post	2	16098	12217	1.10	5615.3	26581
2-05	Pre	2	51.62	46.70	0.64	29.63	73.60
	Post	2	152.9	74.08	1.91	19.14	286.7
Paired Differences (Post minus pre)[(2)]							
1-01		2	-377	0.46		-772.5	17.86
1-02		2	-860	0.50		-1201	-518
1-03		2	311.0	5.47		238.22	383.7
1-04		2	1125	9.10		407.19	1842
2-01		2	10475	2.80		4559.2	16392
2-02		2	91.33	1.24		-9.77	192.4
2-03		2	-9297	0.62		-14879	-3715
2-05		2	101.3	1.59		-54.46	257.1

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-5d. Descriptive Statistics (for Each Unit) of Lead Concentrations (µg/g) Associated with Vacuum Samples from Window Sills Collected Before Carpet Removal ("pre") and at 1-hour Following Completion of Carpet Removal ("post")

Unit ID	Time	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	Pre	2	3182.3	1639.6	1.8	454.9	5909.6
	Post	2	1042.3	1030.4	0.2	885.0	1199.7
1-02	Pre	2	4538.6	3960.2	0.8	2321.6	6755.5
	Post	2	1294.0	1027.9	1.0	508.0	2080.0
1-03	Pre	2	735.5	506.2	1.3	201.9	1269.0
	Post	2	3404.2	2833.2	0.9	1517.0	5291.5
1-04	Pre	2	412.4	271.6	1.4	102.0	722.9
	Post	2	3304.9	1663.9	1.9	449.4	6160.4
2-01	Pre	2	27328	9411.9	2.4	1671.9	52985
	Post	2	34308	11088	2.5	1841.0	66776
2-02	Pre	2	3462.6	1791.3	1.8	499.4	6425.9
	Post	2	2234.3	1026.9	2.0	250.0	4218.5
2-03	Pre	2	17029	13665	1.0	6867.1	27192
	Post	2	16439	14755	0.7	9191.2	23687
2-05	Pre	2	2482.6	2319.7	0.5	1598.2	3366.9
	Post	2	999.8	946.0	0.5	676.2	1323.3
Paired Differences (Post minus pre)[2]							
1-01		2	-2140	0.6		-5025	744.8
1-02		2	-3245	0.3		-6248	-241.6
1-03		2	2668.8	5.6		1315.1	4022.4
1-04		2	2892.4	6.1		-273.5	6058.3
2-01		2	6980.0	1.2		169.2	13791
2-02		2	-1228	0.6		-2207	-249.4
2-03		2	-590.1	1.1		-3504	2324.0
2-05		2	-1483	0.4		-2691	-274.9

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) The geometric mean column contains the geometric mean of the ratio of the post-activity result to the result of the adjoining pre-activity sample. No measurement units are associated with this value.

Table CR-6a. Descriptive Statistics (Across All Units) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum and Wipe Samples from Stainless Steel Dustfall Collectors Collected at 1-hour Following Completion of Carpet Removal[1]

Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
Vacuum	16	85.59	23.04	1.65	2.61	621.0
Wipe	16	58.84	27.06	1.31	3.19	333.6
Paired Difference (Wipe minus vacuum)	16	-26.8	1.17[3]		-287	77.96

[1] Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table. Only regular vacuum samples located side-by-side with a wipe sample are included in the calculation of vacuum sample results.
[2] Standard deviation of the log-transformed data (expressed in log measurement units).
[3] Geometric mean of the ratio of the wipe result to the result of the adjoining sample collected by vacuum. No measurement units are associated with this value.

Table CR-6b. Descriptive Statistics (for Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum and Wipe Samples from Stainless Steel Dustfall Collectors Collected at 1-hour Following Completion of Carpet Removal[1]

Unit ID	Sample Type	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	Vacuum Wipe	2 2	108.7 48.82	48.95 35.66	2.03 1.18	11.65 15.48	205.7 82.16
1-02	Vacuum Wipe	2 2	9.74 21.56	8.56 19.29	0.73 0.68	5.10 11.94	14.37 31.18
1-03	Vacuum Wipe	2 2	7.48 35.46	5.68 22.06	1.10 1.49	2.61 7.70	12.35 63.22
1-04	Vacuum Wipe	2 2	358.9 254.2	245.3 241.5	1.31 0.46	96.91 174.9	621.0 333.6
2-01	Vacuum Wipe	2 2	116.5 22.14	60.54 22.09	1.80 0.09	16.97 20.66	216.0 23.62
2-02	Vacuum Wipe	2 2	58.55 48.29	18.83 17.82	2.55 2.34	3.11 3.41	114.0 93.17
2-03	Vacuum Wipe	2 2	18.10 32.69	17.62 32.46	0.33 0.17	13.96 28.81	22.24 36.57
2-05	Vacuum Wipe	2 2	6.78 7.51	6.78 6.14	0.00 0.93	6.78 3.19	6.78 11.82
Paired Differences (wipe minus vacuum)[3]							
1-01		2	-59.9	0.73		-124	3.83
1-02		2	11.83	2.25		6.84	16.81
1-03		2	27.98	3.89		5.09	50.87
1-04		2	-105	0.98		-287	77.96
2-01		2	-94.3	0.36		-192	3.69
2-02		2	-10.3	0.95		-20.8	0.30
2-03		2	14.59	1.84		6.57	22.61
2-05		2	0.72	0.91		-3.59	5.04

[1] Only results for regular samples (i.e., no side-by-side QC samples) are represented in this table. Only regular vacuum samples located side-by-side with a wipe sample are included in the calculation of vacuum sample results.

(2) Standard deviation of the log-transformed data (expressed in log measurement units).

(3) The geometric mean column contains the geometric mean of the ratio of the wipe result to the result of the adjoining sample collected by vacuum. No measurement units are associated with this value.

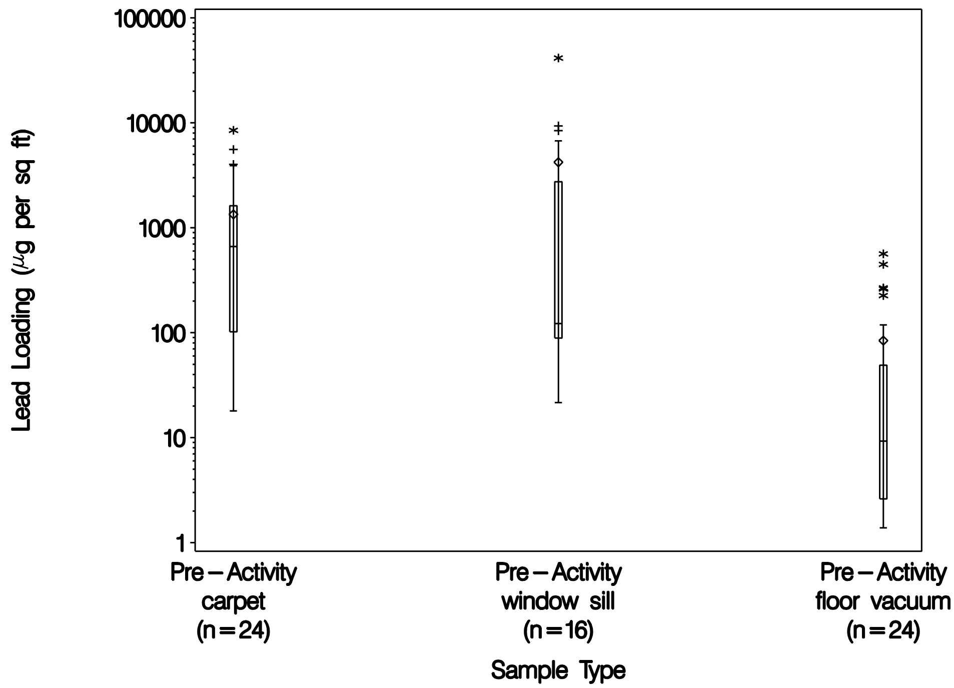


Figure CR-1a. **Boxplots of Lead Loadings ($\mu g/ft^2$) for Three Types of Dust Samples Taken Prior to Carpet Removal Activities**

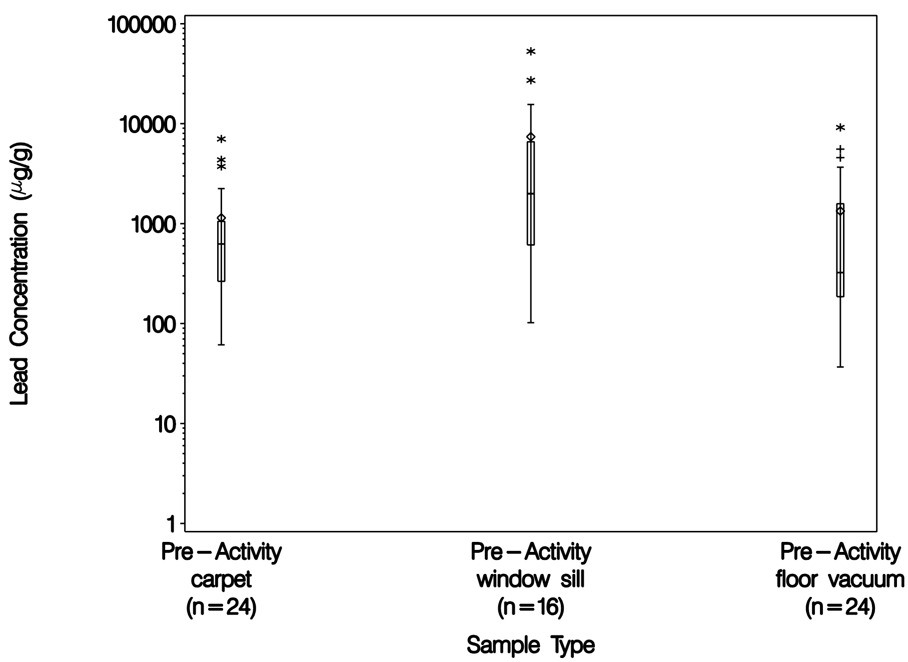


Figure CR-1b. **Boxplots of Lead Concentrations ($\mu g/g$) for Three Types of Dust Samples Taken Prior to Carpet Removal Activities**

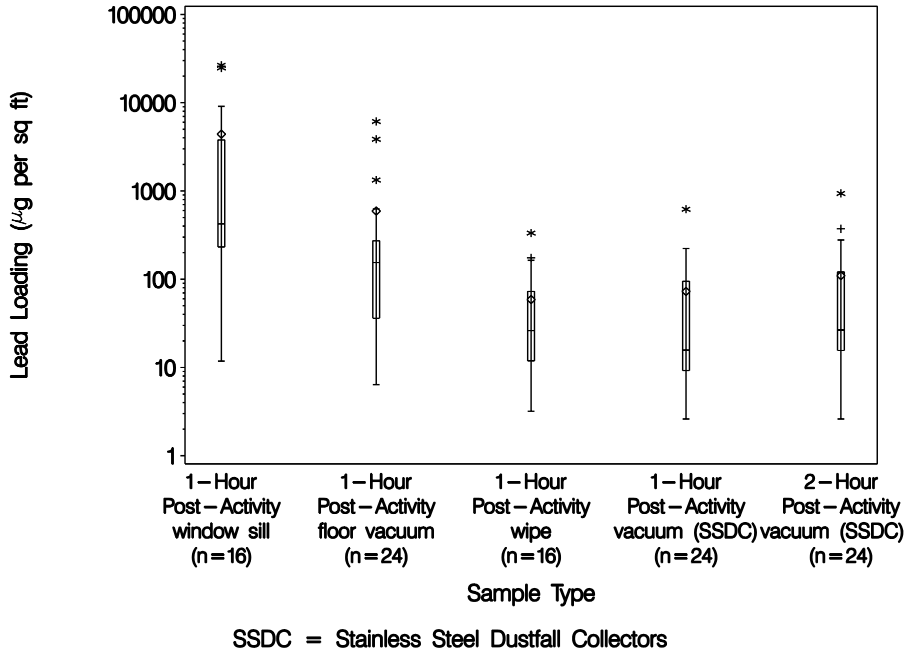


Figure CR-2a. **Boxplots of Lead Loadings (µg/ft^2) for Five Types of Post-Activity Settled Dust Samples**

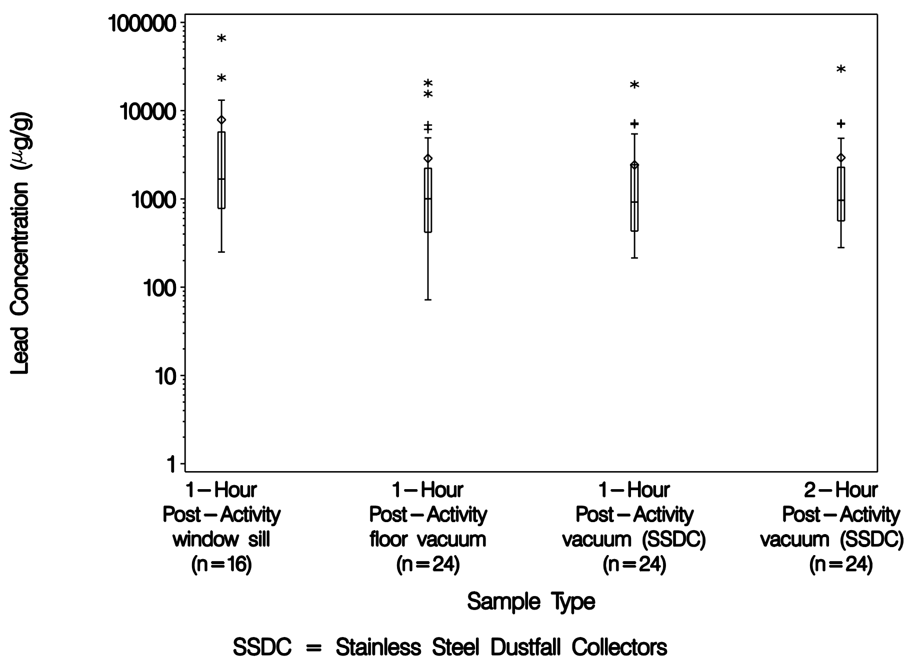


Figure CR-2b. **Boxplots of Lead Concentrations (µg/g) for Four Types of Post-Activity Settled Dust Samples**

A.2 DESCRIPTIVE STATISTICS ON SAMPLE WEIGHTS, LEAD LOADINGS, AND LEAD CONCENTRATIONS BY SAMPLE TYPE, IN THE WINDOW REPLACEMENT PHASE

This section presents descriptive summaries on lead exposure data for the various sample types considered in the EFSS window replacement phase. These summaries, cited in Section 7B and Chapter 6, are presented within six sets of tables, grouped according to the sample type considered:

Total number of samples collected and analyzed: Table WR-1.
Personal and ambient air results: Tables WR-2a, WR-2b.

Pre- and post-activity floor vacuum dust results: Tables WR-3a through WR-3l.

Stainless steel dustfall collector (SSDC) dust sample results using vacuum techniques, collected at 1-hour and 2-hours following the activity: Tables WR-4a through WR-4d.

Pre-activity window well dust results: Tables WR-5a, WR-5b.

Interior and Exterior Paint Chip results: Tables WR-6a, WR-6b.

Table WR-1 reports the number of samples planned, the number of samples collected, the number of analytical results received, and the number of analytical results used in the statistical analysis. The remaining tables present summary statistics, including the number of samples with non-missing data values, the arithmetic and geometric means, the standard deviation of the log-transformed data, and the minimum and maximum data values. Within each set of tables, the first table represents statistics over all study data, while subsequent tables include statistics calculated for each study unit. Lead exposure data included in these tables include the physical sample weights (g) and lead concentrations (µg/g) for vacuum samples, lead loadings (µg/ft^2) for vacuum samples, lead loadings for paint chip samples (mg/cm^2) and lead concentrations (µg/m^3) for personal air and ambient air samples. The personal air lead concentrations are expressed in terms of task-length average (TLA) exposures for a given worker, defined as the average exposure over the duration of activity.

Similar sample types are placed within a given set of tables above so that their results can be compared. These comparisons are made using the differences in sample results between pairs of adjoining samples at a given location. Tables WR-2a through WR-2l present differences in results between adjoining pre- and post-activity floor dust samples. Tables WR-3a through WR-3d present differences between 1-hour and 2-hour results from SSDC vacuum dust samples. The same statistics are presented for the paired differences as for the individual sample results. However, the statistics identified as the "geometric mean" represents the geometric mean of the ratio between the two adjoining sample results at a given location (e.g., post- vs. pre-activity, 2-hour vs. 1-hour).

In addition to the above tables, this section also includes boxplots of lead loading and concentration data for the different types of settled dust samples. Figures WR-1a and WR-1b present lead loadings and lead concentrations, respectively, for four pre-activity settled dust samples (1 window well, 3 floor). Figures WR-2a and WR-2b present lead loadings and lead concentrations, respectively, for five post-activity settled dust samples (3 floor, 2 SSDC). Figure WR-3 presents boxplots of interior and exterior paint chip lead loadings from removed windows. Chapter 5 includes a discussion of how to interpret boxplots.

Table WR-1. Numbers of Field Samples Collected and Results Reported by Unit in the R&R/EFSS Window Replacement Phase

Unit ID	Number of Proposed Samples		Number of Proposed Samples Collected[1]		Number of Extra Samples Collected[2]		Total Number of Samples Collected	Number of Analytical Results Received[3]	Number of Analytical Results Used in Analysis[4]
	Reg.	QC	Reg.	QC	Reg.	QC			
1-01	42	6	42	6	1	1	50	47	46
2-01	42	6	40	6	8	0	54	50	50
3-01	42	6	39	6	3	0	48	47	46
4-01	42	6	41	6	3	1	51	49	49

(1) The number of proposed samples collected differs from number of proposed samples for units 2-01, 3-01 and 4-01. For unit 2-01, one pre- and one post-activity settled dust (floor) sample at 3 feet were not collected. For unit 3-01, two post-activity tarpaulin samples and one post-activity settled dust (floor) sample at 3 feet were not collected. For unit 4-01, one post-activity tarpaulin sample was not collected.

(2) Two additional regular samples were collected at unit 2-01: one post-activity tarpaulin and one exterior paint chip. One additional 2-hour post-activity settled dust (stainless steel dust collector) sample was collected at unit 3-01. Two additional QC samples, both paint chip field blanks, were collected at units 1-01 and 4-01. Additional personal air monitor samples collected when filled cassettes were replaced account for the other regular samples in this column.

(3) Tarpaulin samples were collected but not analyzed. They will be archived.

(4) One window well sample from unit 1-01 was deleted from the analysis because it was identified as an outlier. One 2-hour post-activity settled dust (stainless steel dust collector) sample was deleted from analysis because of a protocol deviation. This collector was placed after activity had been completed.

Table WR-2a. Descriptive Statistics (Across All Units) of Lead Concentrations ($\mu g/m^3$) Associated With Personal Air, Pre-Activity Area Air, and During-Activity Area Air Samples Collected During Window Replacement

Sample Type	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value
During-Activity Personal Exposure Samples	8	13.95	7.48	1.19	2.41	44.29
Pre-Activity Ambient Air Samples	4	0.83	0.30	1.58	0.10	2.86
Post-Activity Ambient Air Samples	8	1.54	1.16	0.82	0.29	4.16

(1) Standard deviation of the log transformed data (expressed in log measurement units).

Table WR-2b. Descriptive Statistics (Within Each Unit) of Lead Concentrations ($\mu g/m^3$) Associated With Personal Air, Pre-Activity Area Air, and During-Activity Area Air Samples Collected During Window Replacement

Unit ID	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value	Baseline (Pre-Activity Value)
Personal Air Sample Results							
1-01	2	2.88	2.87	0.17	2.55	3.22	
2-01	2	3.45	3.29	0.44	2.41	4.49	
3-01	2	37.98	37.46	0.24	31.67	44.29	
4-01	2	11.50	8.85	1.07	4.15	18.84	
Ambient Air Sample Results							
1-01	2	0.56	0.50	0.74	0.29	0.84	0.10
2-01	2	1.00	0.55	0.48	0.68	1.33	0.10
3-01	2	3.41	3.33	0.32	2.66	4.16	0.27
4-01	2	1.18	1.17	0.16	1.05	1.31	2.86

(1) Standard deviation of the log transformed data (expressed in log measurement units).

Table WR-3a. Descriptive Statistics (Across All Units) of Sample Weight (g) Associated With Vacuum Samples from Floors Collected Before ("pre") and at One Hour Following Completion of Window Replacement ("post")

Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.(1)	Minimum Value	Maximum Value
Pre-activity	0	12	4.1668	0.7219	2.5855	0.0076	20.4911
Pre-activity(2)	3	11	0.7965	0.3436	1.8286	0.0055	2.8148
Pre-activity(3)	6	16	0.6935	0.1588	2.4357	0.0008	2.9056
Post-activity	0	12	3.1297	0.7992	2.5822	0.0058	7.1463
Post-activity(4)	3	10	0.9499	0.2878	2.3679	0.0037	3.3809
Post-activity(3)	6	16	0.9403	0.2498	2.0747	0.0088	3.2372
Paired Difference (Post minus Pre)	0	12	-1.0371	1.1070(5)	.	-14.7512	4.4551
Paired Difference (Post minus Pre)(3,4)	3	10	0.3552	1.0335(5)	.	-0.3251	2.8118
Paired Difference (Post minus Pre)(3,6)	6	15	0.2584	1.4730(5)	.	-0.8229	2.2498

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) One pre-activity floor sample at 3 feet was not collected at unit 2-01.
(3) Results include both regular and QC samples.
(4) Two post-activity floor samples at 3 feet were not collected: one at unit 2-01 and one at unit 3-01.
(5) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(6) One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-3b. Descriptive Statistics (Across All Units) of Lead Loading ($\mu g/ft^2$) Associated With Vacuum Samples from Floors Collected Before ("pre") and at One Hour Following Completion of Window Replacement ("post")

Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.(1)	Minimum Value	Maximum Value
Pre-activity	0	12	58016.8	1913.3	3.63	9.0	439845.0
Pre-activity(2)	3	11	5424.6	490.6	3.22	2.3	29402.0
Pre-activity(3)	6	16	3562.0	334.3	2.99	1.7	18443.2
Post-activity	0	12	35499.4	3912.1	3.02	19.0	109740.0
Post-activity(4)	3	10	5504.4	1293.5	2.43	56.0	12702.0
Post-activity(3)	6	16	9357.9	878.4	3.01	10.4	54515.0
Paired Difference (Post minus Pre)	0	12	-22517.3	2.0(5)	.	-354160.0	92013.0
Paired Difference (Post minus Pre)(3,4)	3	10	448.8	3.5(5)	.	-19060.0	10856.4
Paired Difference (Post minus Pre)(3,6)	6	15	6179.1	2.6(5)	.	-540.3	36071.8

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) One pre-activity floor sample at 3 feet was not collected at unit 2-01.
(3) Results include both regular and QC samples.
(4) Two post-activity floor samples at 3 feet were not collected: one at unit 2-01 and one at unit 3-01.
(5) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(6) One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-3c. Descriptive Statistics (Across All Units) of Lead Concentration (µg/g) Associated With Vacuum Samples from Floors Collected Before ("pre") and at One Hour Following Completion of Window Replacement ("post")

Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
Pre-activity	0	12	7047.0	2650.2	1.58	228.5	33003.6
Pre-activity[2]	3	11	5735.5	1503.0	1.74	155.6	37114.5
Pre-activity[3]	6	16	4243.5	2105.1	1.37	136.0	16470.1
Post-activity	0	12	11299.6	4886.5	1.80	234.8	26874.7
Post-activity[4]	3	10	11112.0	4494.7	2.19	31.8	32346.0
Post-activity[3]	6	16	6898.3	3516.2	1.25	632.4	31728.1
Paired Difference (Post minus Pre)	0	12	4251.7	1.8[5]	.	-15767.1	23378.0
Paired Difference (Post minus Pre)[3,4]	3	10	5126.8	3.2[5]	.	-27343.0	31925.8
Paired Difference (Post minus Pre)[3,6]	6	15	2838.0	1.7[5]	.	-5856.75	28448.5

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) One pre-activity floor sample at 3 feet was not collected at unit 2-01.
(3) Results include both regular and QC samples.
(4) Two post-activity floor samples at 3 feet were not collected: one at unit 2-01 and one at unit 3-01.
(5) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(6) One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-3d. Descriptive Statistics (Within Each Unit) of Sample Weight (g) Associated With Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 0 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	Pre-Activity	3	0.0514	0.0468	0.5121	0.0347	0.0846
	Post-Activity	3	0.0414	0.0212	1.4559	0.0058	0.1024
	Paired Difference (Post minus pre)	3	-0.0100	0.4522[2]	.	-0.0292	0.0178
2-01	Pre-Activity	3	1.1503	0.2333	3.0698	0.0076	2.8584
	Post-Activity	3	3.6090	1.3251	2.4222	0.0809	5.7063
	Paired Difference (Post minus pre)	3	2.4588	5.6788[2]	.	0.0733	4.4551
3-01	Pre-Activity	3	3.7352	3.4471	0.4749	2.5883	5.9636
	Post-Activity	3	4.9993	4.7908	0.3486	3.7681	7.1463
	Paired Difference (Post minus pre)	3	1.2641	1.3898[2]	.	1.1145	1.4951
4-01	Pre-Activity	3	11.7303	7.2101	1.4526	1.3725	20.4911
	Post-Activity	3	3.8689	3.0337	0.9652	0.9993	5.7399
	Paired Difference (Post minus pre)	3	-7.8613	0.4208[2]	.	-14.7512	-0.3732

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.

Table WR-3e. Descriptive Statistics (Within Each Unit) of Sample Weight (g) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 3 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value
1-01	Pre-Activity	3	0.0727	0.0337	1.7291	0.0055	0.1721
	Post-Activity	3	0.0550	0.0146	2.0594	0.0037	0.1559
	Paired Difference (Post minus pre)	3	-0.0177	0.4328[(2)]	.	-0.0352	-0.0018
2-01[(3)]	Pre-Activity	2	0.3519	0.2769	1.0189	0.1347	0.5691
	Post-Activity	2	1.8266	0.9595	1.7812	0.2723	3.3809
	Paired Difference (Post minus pre)	2	1.4747	3.4655[(2)]	.	0.1376	2.8118
3-01[(4)]	Pre-Activity	3	1.6617	1.4741	0.5900	0.8863	2.8148
	Post-Activity	2	1.1396	0.9819	0.7911	0.5612	1.7179
	Paired Difference (Post minus pre)	2	0.0544	0.9204[(2)]	.	-0.3251	0.4339
4-01	Pre-Activity	3	0.9516	0.9422	0.1726	0.7922	1.1187
	Post-Activity	3	1.1339	1.1213	0.1808	0.9700	1.3732
	Paired Difference (Post minus pre)	3	0.1823	1.1901[(2)]	.	-0.1487	0.4294

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(3) One set of the pre- and post-activity samples at this unit were not collected due to space and time constraints.
(4) The post-activity sample was not collected. Sampler ran out of sampling bottles.

Table WR-3f. Descriptive Statistics (Within Each Unit) of Sample Weight (g) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 6 Feet from the Windows[(1)]

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(2)]	Minimum Value	Maximum Value
1-01	Pre-Activity	4	0.0466	0.0184	2.1805	0.0008	0.0967
	Post-Activity	4	0.0500	0.0413	0.7165	0.0224	0.0952
	Paired Difference (Post minus pre)[(4)]	3	-0.0196	1.8163[(3)]	.	-0.0438	0.0223
2-01	Pre-Activity	4	0.0744	0.0252	1.6986	0.0062	0.2505
	Post-Activity	4	0.1002	0.0409	1.6376	0.0088	0.2981
	Paired Difference (Post minus pre)	4	0.0258	1.6228[(3)]	.	0.0009	0.0478
3-01	Pre-Activity	4	1.1280	1.0180	0.5600	0.4699	1.5553
	Post-Activity	4	1.5855	1.3877	0.6043	0.7324	2.7197
	Paired Difference (Post minus pre)	4	0.4575	1.3632[(3)]	.	-0.8229	2.2498
4-01	Pre-Activity	4	1.5252	1.3453	0.5583	0.7727	2.9056
	Post-Activity	4	2.0256	1.6609	0.7565	0.7517	3.2372
	Paired Difference (Post minus pre)	4	0.5004	1.2346[(3)]	.	-0.5511	1.9870

(1) Includes QC samples and regular samples.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(4) One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-3g. Descriptive Statistics (Within Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 0 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	Pre-Activity	3	79.4	36.4	1.58	9.0	202.9
	Post-Activity	3	246.4	226.9	0.50	140.0	379.1
	Paired Difference (Post minus pre)	3	167.0	6.2[2]	.	113.7	211.1
2-01	Pre-Activity	3	419.3	220.3	1.78	28.4	653.0
	Post-Activity	3	1191.2	389.8	2.62	19.0	1980.5
	Paired Difference (Post minus pre)	3	771.9	1.8[2]	.	-9.4	1403.8
3-01	Pre-Activity	3	35699.2	31474.6	0.61	17727.0	60108.0
	Post-Activity	3	96981.7	96448.9	0.13	84851.0	109740.0
	Paired Difference (Post minus pre)	3	61282.5	3.1[2]	.	24743.0	92013.0
4-01	Pre-Activity	3	195869.0	53110.0	2.76	2342.1	439845.0
	Post-Activity	3	43578.4	27459.9	1.35	6224.0	85685.1
	Paired Difference (Post minus pre)	3	-152291.0	0.5[2]	.	-354160.0	3881.9

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.

Table WR-3h. Descriptive Statistics (Within Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 3 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	Pre-Activity	3	15.1	10.0	1.29	2.3	26.8
	Post-Activity	3	884.0	255.1	2.00	56.0	2476.4
	Paired Difference (Post minus pre)	3	868.9	25.5[2]	.	39.8	2449.6
2-01[3]	Pre-Activity	2	93.5	67.7	1.20	29.0	158.0
	Post-Activity	2	84.7	81.5	0.39	61.7	107.6
	Paired Difference (Post minus pre)	2	-8.8	1.2[2]	.	-50.3	32.7
3-01[4]	Pre-Activity	3	8255.4	7746.0	0.46	4623.8	11027.0
	Post-Activity	2	10427.0	10427.0	0.00	10425.0	10429.0
	Paired Difference (Post minus pre)	2	2601.6	1.5[2]	.	-598.0	5801.2
4-01	Pre-Activity	3	11557.4	5706.5	1.45	1845.6	29402.0
	Post-Activity	3	10456.0	10302.4	0.21	8324.1	12702.0
	Paired Difference (Post minus pre)	3	-1101.3	1.8[2]	.	-19060.0	10856.4

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(3) Both the pre- and post-activity samples at this unit were not collected due to space and time constraints.
(4) The post-activity sample was not collected. Sampler ran out of sampling bottles.

Table WR-3i. Descriptive Statistics (Within Each Unit) of Lead Loadings ($\mu g/ft^2$) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 6 Feet from the Windows[1]

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[2]	Minimum Value	Maximum Value
1-01	Pre-Activity	4	20.3	11.8	1.40	1.7	48.8
	Post-Activity	4	104.7	72.0	1.03	20.2	252.8
	Paired Difference (Post minus pre)[4]	3	96.5	7.2[3]	.	18.5	239.7
2-01	Pre-Activity	4	41.6	40.1	0.32	25.9	51.5
	Post-Activity	4	70.5	41.9	1.21	10.4	190.4
	Paired Difference (Post minus pre)	4	28.9	1.0[3]	.	-20.2	151.8
3-01	Pre-Activity	4	6117.5	4048.8	1.05	1227.2	15796.0
	Post-Activity	4	10641.9	9004.5	0.74	3162.9	17136.4
	Paired Difference (Post minus pre)	4	4524.4	2.2[3]	.	-540.3	11542.8
4-01	Pre-Activity	4	8068.4	6496.9	0.70	4272.7	18443.2
	Post-Activity	4	26614.4	21937.5	0.72	9668.8	54515.0
	Paired Difference (Post minus pre)	4	18545.9	3.4[3]	.	5369.0	36071.8

(1) Includes QC samples and regular samples.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(4) One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-3j. Descriptive Statistics (Within Each Unit) of Lead Concentrations ($\mu g/g$) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 0 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	Pre-Activity	3	1136.8	776.9	1.11	260.2	2398.8
	Post-Activity	3	13862.3	10711.0	0.96	3702.4	24129.3
	Paired Difference (Post minus pre)	3	12725.5	13.8[2]	.	1303.6	23378.0
2-01	Pre-Activity	3	1650.1	944.1	1.40	228.5	3735.9
	Post-Activity	3	301.2	294.2	0.26	234.8	393.0
	Paired Difference (Post minus pre)	3	-1348.9	0.3[2]	.	-3501.1	47.4
3-01	Pre-Activity	3	11469.1	9130.8	0.80	4906.9	22651.5
	Post-Activity	3	20958.7	20132.1	0.36	13483.1	26874.7
	Paired Difference (Post minus pre)	3	9489.6	2.2[2]	.	-133.2	20025.8
4-01	Pre-Activity	3	13935.6	7366.1	1.48	1706.4	33003.6
	Post-Activity	3	10076.3	8988.3	0.57	6228.4	17236.4
	Paired Difference (Post minus pre)	3	-3859.3	1.2[2]	.	-15767.1	4521.9

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.

Table WR-3k. Descriptive Statistics (Within Each Unit) of Lead Concentrations (µg/g) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 3 Feet from the Windows

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.(1)	Minimum Value	Maximum Value
1-01	Pre-Activity	3	324.8	296.5	0.56	155.6	420.2
	Post-Activity	3	19535.7	17469.5	0.57	10376.5	32346.0
	Paired Difference (Post minus pre)	3	19210.8	58.9(2)	.	9977.8	31925.8
2-01(3)	Pre-Activity	2	352.0	324.4	0.58	215.4	488.6
	Post-Activity	2	129.3	84.9	1.39	31.8	226.7
	Paired Difference (Post minus pre)	2	-222.7	0.26(2)	.	-456.7	11.3
3-01(4)	Pre-Activity	3	6427.0	5254.7	0.75	3238.4	12441.6
	Post-Activity	2	12325.9	10619.4	0.79	6068.5	18583.4
	Paired Difference (Post minus pre)	2	4304.6	1.59(2)	.	2467.4	6141.8
4-01	Pre-Activity	3	14043.7	6056.6	1.59	1955.5	37114.4
	Post-Activity	3	9200.9	9188.0	0.065	8581.5	9771.4
	Paired Difference (Post minus pre)	3	-4842.7	1.52(2)	.	-27343.0	7294.4

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.
(3) Both the pre- and post-activity samples at this unit were not collected due to space and time constraints.
(4) The post-activity sample was not collected. Sampler ran out of sampling bottles.

Table WR-3l. Descriptive Statistics (Within Each Unit) of Lead Concentrations (µg/g) Associated with Vacuum Samples from Floors Collected Before ("pre") and One Hour Following Completion of Window Replacement ("post") -- at a Distance of 6 Feet from the Windows[1]

Unit ID	Data Representation	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.(2)	Minimum Value	Maximum Value
1-01	Pre-Activity	4	953.8	641.5	1.15	136.0	2160.4
	Post-Activity	4	2351.9	1741.8	0.94	688.8	4263.7
	Paired Difference (Post minus pre)(4)	3	1895.0	4.0(3)	.	-1284.8	4127.8
2-01	Pre-Activity	4	3289.0	1593.7	1.70	154.0	8161.3
	Post-Activity	4	1189.2	1024.0	0.61	632.4	2304.5
	Paired Difference (Post minus pre)	4	-2099.8	0.6(3)	.	-5856.8	484.6
3-01	Pre-Activity	4	5950.0	3977.4	0.94	2381.0	16345.2
	Post-Activity	4	7909.2	6488.8	0.67	4318.5	17677.3
	Paired Difference (Post minus pre)	4	1959.2	1.6(3)	.	1332.1	2483.5
4-01	Pre-Activity	4	6781.0	4829.3	0.94	1809.6	16470.1
	Post-Activity	4	16142.9	13208.1	0.74	5691.2	31728.1
	Paired Difference (Post minus pre)	4	9361.9	2.7(3)	.	1076.9	28448.5

(1) Includes QC samples and regular samples.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).
(3) Geometric mean represents ratio of the post-activity result to the result of the corresponding pre-activity sample. No measurement units are associated with this value.

[4] One pre-activity/post-activity pair is excluded because the pre-activity sample location differed from the post-activity sample location.

Table WR-4a. **Descriptive Statistics (Across All Units) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at One and Two Hours Following Completion of Window Replacement**

Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
Sample Weight (g)							
One-hour	0	12	4.6002	1.2420	1.8070	0.1095	21.7653
One-hour[2]	6	16	0.2710	0.0428	2.1259	0.0023	1.6381
Two-hour	6	4	0.1048	0.0522	1.5476	0.0097	0.2056
Paired Differences (2-hr minus 1-hr)	6	4	0.0409	1.3878[3]	0.5332	-0.0040	0.1123
Lead Loading (µg/ft^2)							
One-hour	0	12	84604.1	24736.3	1.67	3104.0	331410.0
One-hour[2]	6	16	770.6	240.6	1.75	15.4	4155.0
Two-hour	6	4	5252.5	519.6	2.69	40.4	20192.0
Paired Differences (2-hr minus 1-hr)	6	4	5247.3	2.9[3]	0.58	37.7	20183.7
Lead Concentration (µg/g)							
One-hour	0	12	27274.5	13826.9	1.54	489.6	87222.4
One-hour[2]	6	16	29669.2	5620.2	1.88	114.4	335193.5
Two-hour	6	4	33634.9	9951.8	2.15	763.1	98210.1
Paired Differences (2-hr minus 1-hr)	6	4	23553.2	2.1[3]	0.94	-697.9	71879.3

(1) Standard deviations of the log-transformed data (expressed in log measurement units).
(2) Results for both regular and QC samples.
(3) Geometric mean of the ratio of the 2-hour result to the result of the adjoining 1-hour sample. No measurement units are associated with this value.

Table WR-4b. Descriptive Statistics (for Each Unit) of Sample Weight (g) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at One and Two Hours Following Completion of Carpet Removal

Unit ID	Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(1)]	Minimum Value	Maximum Value
1-01	One-hour	0	3	0.1968	0.1812	0.5038	0.1095	0.2999
	One-hour[(2)]	6	4	0.0066	0.0056	0.6380	0.0031	0.0137
	Two-hour	6	1	0.0097	0.0097	.	0.0097	0.0097
	Paired Differences (2-hr minus 1-hr)	6	1	-0.0040	0.7080[(3)]	.	-0.0040	-0.0040
2-01	One-hour	0	3	8.5455	4.3343	1.3981	1.8604	21.7653
	One-hour[(2)]	6	4	0.9407	0.5462	1.4693	0.0713	1.6381
	Two-hour	6	1	0.1836	0.1836	.	0.1836	0.1836
	Paired Differences (2-hr minus 1-hr)	6	1	0.1123	2.5750[(3)]	.	0.1123	0.1123
3-01	One-hour	0	3	2.8128	2.3217	0.7399	1.2872	5.3255
	One-hour[(2)]	6	4	0.0233	0.0111	1.4289	0.0023	0.0706
	Two-hour	6	1	0.0203	0.0203	.	0.0203	0.0203
	Paired Differences (2-hr minus 1-hr)	6	1	0.0073	1.5615[(3)]	.	0.0073	0.0073
4-01	One-hour	0	3	6.8456	1.3053	2.5906	0.1107	19.3900
	One-hour[(2)]	6	4	0.1135	0.0992	0.6714	0.0369	0.1578
	Two-hour	6	1	0.2056	0.2056	.	0.2056	0.2056
	Paired Differences (2-hr minus 1-hr)	6	1	0.0478	1.3029[(3)]	.	0.0478	0.0478

(1) Standard deviations of the log-transformed data (expressed in log measurement units).
(2) Results for both regular and QC samples.
(3) Geometric mean of the ratio of the 2-hour result to the result of the adjoining 1-hour sample. No measurement units are associated with this value.

Table WR-4c. Descriptive Statistics (for Each Unit) of Lead Loading (µg/ft^2) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at One and Two Hours Following Completion of Carpet Removal

Unit ID	Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	One-hour	0	3	11908.7	8417.5	0.98	4489.1	26158.0
	One-hour[2]	6	4	285.8	70.3	1.89	15.4	1039.1
	Two-hour	6	1	40.4	40.4	.	40.4	40.4
	Paired Differences (2-hr minus 1-hr)	6	1	37.7	2.6339[3]	.	37.7	37.7
2-01	One-hour	0	3	83903.3	26367.0	1.90	7361.3	233692.9
	One-hour[2]	6	4	840.4	327.8	1.48	104.2	2863.4
	Two-hour	6	1	140.1	140.1	.	140.1	140.1
	Paired Differences (2-hr minus 1-hr)	6	1	135.5	1.3450[3]	.	135.5	135.6
3-01	One-hour	0	3	129459.7	60404.1	1.54	16387.0	331410.0
	One-hour[2]	6	4	166.5	105.2	1.31	16.7	365.5
	Two-hour	6	1	637.4	637.4	.	637.4	637.4
	Paired Differences (2-hr minus 1-hr)	6	1	632.4	4.2953[3]	.	632.4	632.5
4-01	One-hour	0	3	113144.7	27927.6	2.32	3104.0	313980.0
	One-hour[2]	6	4	1789.6	1382.7	0.80	619.0	4155.0
	Two-hour	6	1	20192.0	20192.0	.	20192.0	20192.0
	Paired Differences (2-hr minus 1-hr)	6	1	20183.7	4.8597[3]	.	20183.7	20183.7

(1) Standard deviations of the log-transformed data (expressed in log measurement units).
(2) Results for both regular and QC samples.
(3) Geometric mean of the ratio of the 2-hour result to the result of the adjoining 1-hour sample. No measurement units are associated with this value.

Table WR-4d. Descriptive Statistics (for Each Unit) of Lead Concentration (µg/g) Associated with Vacuum Samples from Stainless Steel Dustfall Collectors at One and Two Hours Following Completion of Carpet Removal

Unit ID	Data Representation	Distance (feet)	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
1-01	One-hour	0	3	52798.0	46459.8	0.63	24788.0	87222.4
	One-hour[2]	6	4	88953.5	12547.8	2.43	1120.3	335193.5
	Two-hour	6	1	4168.2	4168.2	.	4168.2	4168.2
	Paired Differences (2-hr minus 1-hr)	6	1	3048.0	3.7207[3]	.	3048.0	3048.0
2-01	One-hour	0	3	1967.8	1413.2	1.05	489.6	3956.8
	One-hour[2]	6	4	956.8	600.1	1.28	114.4	1827.1
	Two-hour	6	1	763.1	763.1	.	763.1	763.1
	Paired Differences (2-hr minus 1-hr)	6	1	-697.9	0.5223[3]	.	-697.9	-697.9
3-01	One-hour	0	3	32397.0	26017.3	0.81	12730.7	62230.8
	One-hour[2]	6	4	10727.3	9505.6	0.57	5177.3	19074.7
	Two-hour	6	1	31398.0	31398.0	.	31398.0	31398.0
	Paired Differences (2-hr minus 1-hr)	6	2	19983.4	2.7507[3]	.	19983.4	19983.4
4-01	One-hour	0	3	21935.3	21396.3	0.27	16192.9	28039.8
	One-hour[2]	6	4	18039.1	13938.6	0.87	5322.2	32116.5
	Two-hour	6	1	98210.1	98210.1	.	98210.1	98210.1
	Paired Differences (2-hr minus 1-hr)	6	1	71879.3	3.7300[3]	.	71879.3	71879.3

(1) Standard deviations of the log-transformed data (expressed in log measurement units).
(2) Results for both regular and QC samples.
(3) Geometric mean of the ratio of the 2-hour result to the result of the adjoining 1-hour sample. No measurement units are associated with this value.

Table WR-5a. Descriptive Statistics (Across All Units) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from Window Wells Taken Prior to Window Replacement[(1)]

Data Parameter	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(2)]	Minimum Value	Maximum Value
Sample Weights (g)	11 (12)	4.906 (4.529)	3.029 (2.552)	1.258 (1.338)	0.295 (0.295)	13.576 (13.576)
Loadings (µg/ft²)	11 (12)	185742.2 (170456.3)	134531.0 (95884.2)	0.94 (1.48)	26786.0 (2311.7)	415342.3 (415342.3)
Concentrations (µg/g)	11 (12)	28476.47 (26293.65)	23482.54 (19336.86)	0.653 (0.917)	8458.91 (2282.63)	70067.02 (70067.02)

(1) Results in parentheses summarize values with outlier included.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).

Table WR-5b. Descriptive Statistics (Within Each Unit) of Sample Weights, Lead Loadings, and Lead Concentrations Associated with Vacuum Samples from the Window Wells Taken Prior to Window Replacement[(1)]

Unit ID	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[(2)]	Minimum Value	Maximum Value
Sample Weights (g)						
1-01	2 (3)	0.297 (0.327)	0.297 (0.324)	0.0081 (0.1532)	0.295 (0.295)	0.298 (0.387)
2-01	3	2.924	2.913	0.1071	2.613	3.237
3-01	3	5.525	5.304	0.3411	4.295	7.861
4-01	3	9.341	8.464	0.5718	4.483	13.577
Lead Loadings (µg/ft²)						
1-01	2 (3)	44014.3 (30113.4)	42687.2 (16150.0)	0.35 (1.70)	33287.6 (2311.7)	54741.0 (54741.0)
2-01	3	224769.5	215579.7	0.36	145304.8	296279.6
3-01	3	203828.0	178221.1	0.65	91663.5	336049.0
4-01	3	223114.3	136222.9	1.44	26786.0	415342.3
Lead Concentration (µg/g)						
1-01	2 (3)	56582.26 (38482.65)	54952.43 (19031.35)	0.34 (1.85)	43098.31 (2282.63)	70067.02 (70067.02)
2-01	3	20689.59	18248.23	0.67	8458.91	27171.01
3-01	3	27467.15	22990.21	0.70	15303.16	51756.13
4-01	3	18535.23	17510.97	0.43	10623.19	23130.62

(1) Results in parentheses summarize values calculated with outlier included.
(2) Standard deviation of the log-transformed data (expressed in log measurement units).

Table WR-6a. Descriptive Statistics (Across All Units) of Sample Weight, Lead Loadings, and Lead Concentrations Associated with Interior and Exterior Paint Chip Samples Collected Following Completion of Window Replacement

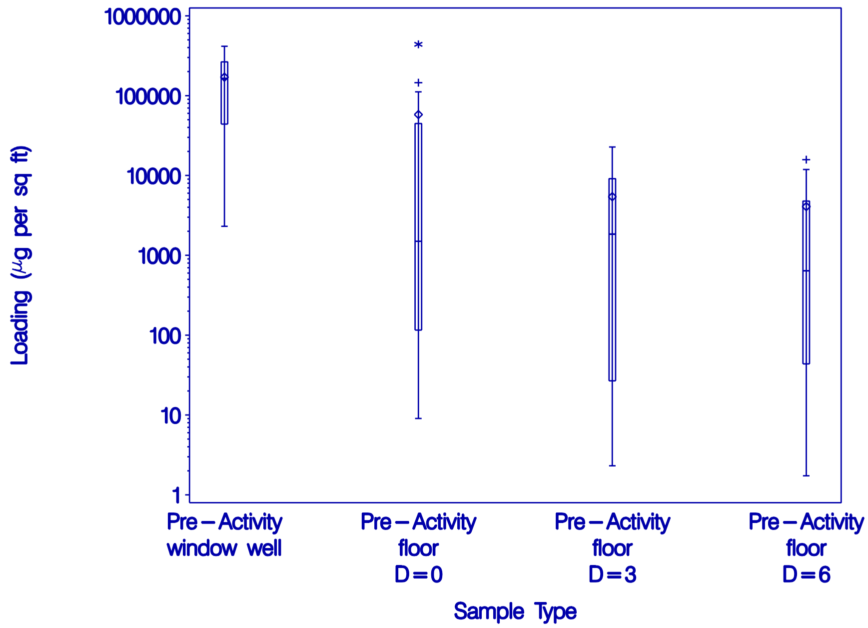
Location	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
Sample Weights (g)[2]						
Exterior	13[3]	0.5828	0.5621	0.2592	0.4951	1.0110
Interior	12	0.6335	0.6021	0.3168	0.4901	1.0327
Loadings (mg/cm^2)						
Exterior	13[3]	20.566	11.991	1.410	0.339	49.651
Interior	12	6.825	2.190	2.307	0.037	23.270
Concentrations (mg/g)						
Exterior	13[3]	135.32	105.09	0.958	7.71	227.52
Interior	12	82.66	33.83	1.969	1.21	190.33

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Sample weights represent the weight of subsamples used in the chemical analysis. In several instances, two subsamples from the same chip were analyzed. In such cases, the results from the two subsamples were combined to form a single observation.
(3) An extra paint chip sample was collected at unit 2-01 from a window where no other samples were collected.

Table WR-6b. Descriptive Statistics (Within Each Unit) of Sample Weight, Lead Loadings, and Lead Concentrations Associated with Interior and Exterior Paint Chip Samples Collected Following Completion of Window Replacement

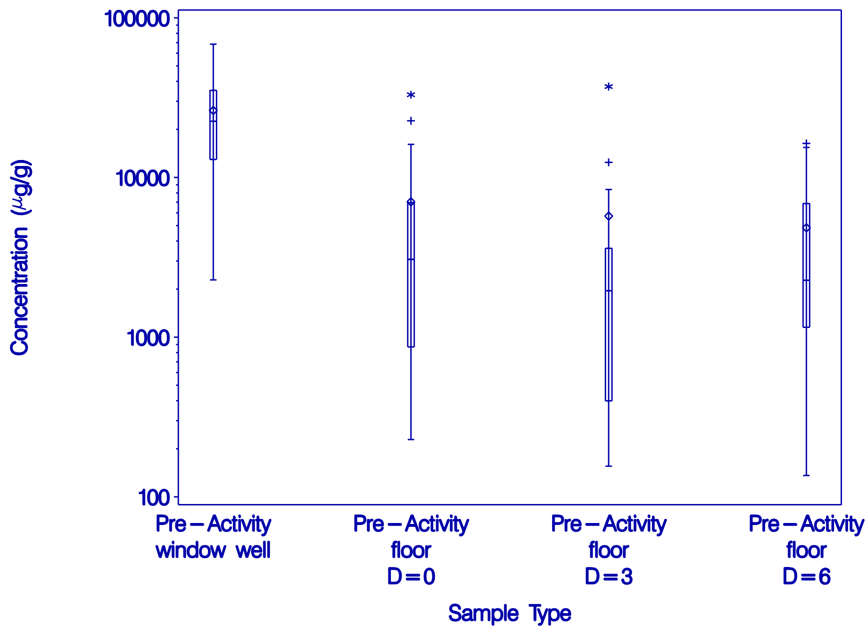
Unit ID	Location	N	Arithmetic Mean	Geometric Mean	Log Std. Dev.[1]	Minimum Value	Maximum Value
Sample Weights (g)[2]							
1-01	Exterior	3	0.6687	0.6319	0.4002	0.4951	1.0028
	Interior	3	0.6765	0.6396	0.3979	0.5073	1.0127
2-01	Exterior	4[3]	0.6291	0.5978	0.3504	0.4964	1.0110
	Interior	3	0.5089	0.5089	0.0153	0.5021	0.5174
3-01	Exterior	3	0.5025	0.5025	0.0062	0.4998	0.5059
	Interior	3	0.5052	0.5052	0.0062	0.5016	0.5072
4-01	Exterior	3	0.5154	0.5154	0.0193	0.5040	0.5212
	Interior	3	0.8434	0.7989	0.4233	0.4901	1.0327
Lead Loadings (mg/cm^2)							
1-01	Exterior	3	9.63	7.26	1.029	2.284	16.422
	Interior	3	5.897	4.75	0.901	1.6867	8.619
2-01	Exterior	4[3]	36.948	34.33	0.472	17.620	49.651
	Interior	3	0.057	0.055	0.336	0.037	0.068
3-01	Exterior	3	24.911	23.991	0.345	16.344	31.917
	Interior	3	8.368	8.339	0.103	7.440	9.089
4-01	Exterior	3	5.314	2.436	1.815	0.339	12.067
	Interior	3	12.976	10.566	0.815	4.573	23.270
Lead Concentrations (mg/g)							
1-01	Exterior	3	127.11	94.86	1.078	27.41	189.91
	Interior	3	80.43	65.48	0.876	23.90	116.99
2-01	Exterior	4[3]	139.04	136.20	0.243	95.841	162.11
	Interior	3	1.46	1.45	0.158	1.21	1.59
3-01	Exterior	3	196.66	194.83	0.169	162.85	227.52
	Interior	3	122.04	117.26	0.361	77.35	146.71
4-01	Exterior	3	77.23	44.44	1.549	7.71	146.01
	Interior	3	126.71	117.48	0.480	72.88	190.33

(1) Standard deviation of the log-transformed data (expressed in log measurement units).
(2) Sample weights represent the total weight of the subsamples taken from each paint chip collected. In several instances, two subsamples from the same chip were analyzed. In such cases, the results from the two subsamples were combined to form a single observation.
(3) An extra paint chip sample was collected at unit 2-01 from a window where no other samples were collected.



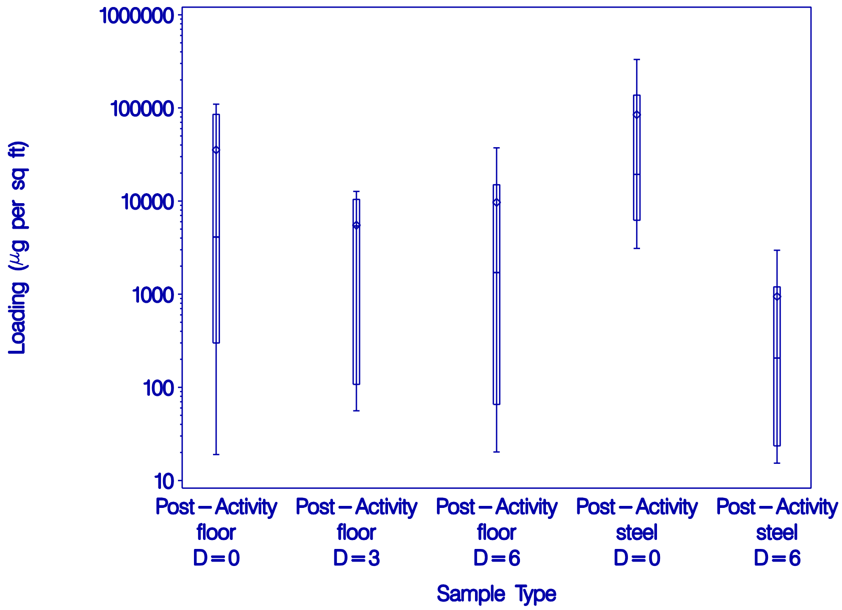
D = distance from window (ft.)

Figure WR-1a. Boxplots of Lead Loadings ($\mu g/ft^2$) for Vacuum Dust Samples From the Floors and Window Wells Taken Prior to Window Replacement Activities



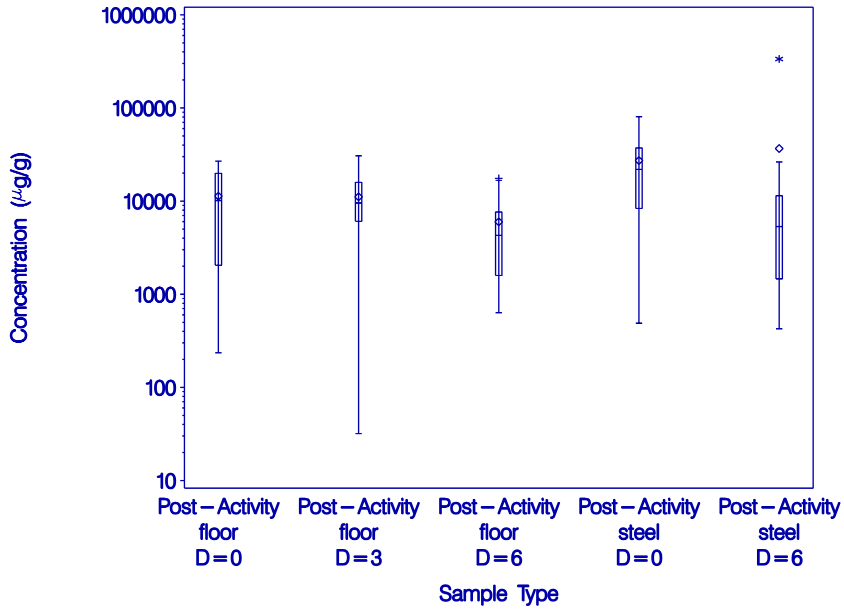
D = distance from window (ft.)

Figure WR-1b. Boxplots of Lead Concentrations (µg/g) for Vacuum Dust Samples From Floors and Window Wells Taken Prior to Window Replacement Activities



D = distance from window (ft.)

Figure WR-2a. **Boxplots of Lead Loadings ($\mu g/ft^2$) for Vacuum Dust Samples From Floors and Stainless Steel Dustfall Collectors Taken One-Hour After Completion of the Window Replacement Activities**



D = distance from window (ft.)

Figure WR-2b. Boxplots of Lead Concentrations (µg/g) for Vacuum Dust Samples From Floors and Stainless Steel Dustfall Collectors Taken One-Hour After Completion of the Window Replacement Activities

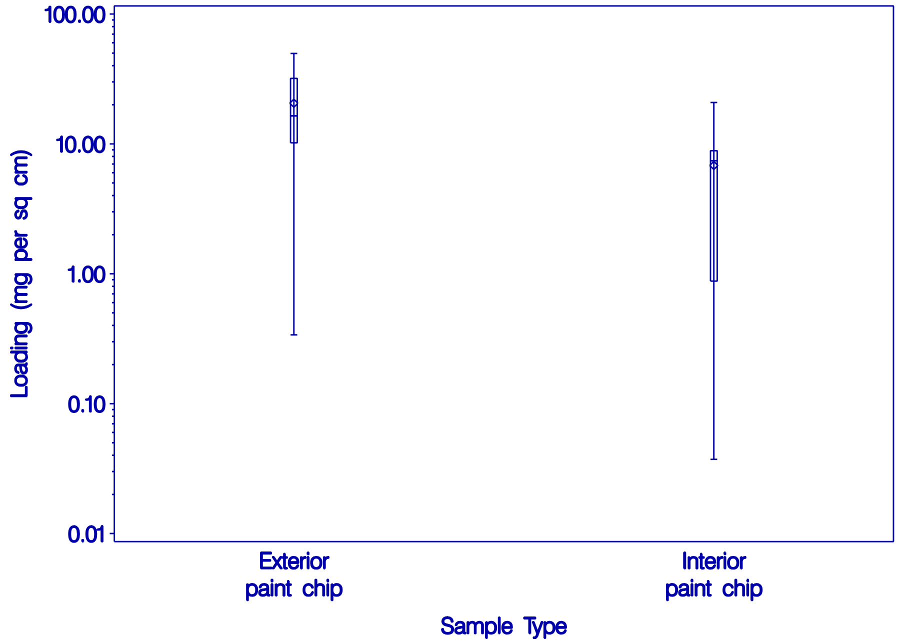


Figure WR-3. **Boxplots of Lead Loadings (mg/cm^2) for Paint Chip Samples Taken from the Interior and Exterior of the Window Frames After Completion of the Window Replacement Activities**

A.3 DESCRIPTIVE STATISTICS OF DATA FROM THE CED PHASE

Table CED-1 presents descriptive statistics on lead levels from personal air monitoring of R&R workers in the CED phase of the EFSS. Lead levels were expressed in terms of task-length averages (TLAs, or average exposure over the duration of activity, in $\mu g/m^3$ of air) for a given target activity and substrate on which the activity was performed. For each activity/substrate combination, Table CED-1 presents the number of monitoring results, the arithmetic and geometric means, the standard deviation of log-transformed data, and the minimum and maximum observed values. Because these data tended to be lognormally distributed, the geometric means are better indicators of central tendency within the data distributions than are the arithmetic means.

One objective of the CED phase was to study the relationship between lead disturbance generated by performing a target R&R activity and the distance from the activity at which lead loadings are being measured from settled dust samples. This relationship helps explain potential lead exposures associated with a given activity and was quantified through statistical modeling procedures. Exploratory analysis demonstrated that the relationship between settled dust lead loading and distance from activity was well approximated by the following linear model:

$$\log(\text{loading}) = \bullet_0 + \bullet_1(\text{Distance}) + \text{Error} \qquad \text{(A-1)}$$

where $\bullet_0$ and $\bullet_1$ are parameters which quantify the linear relationship. This model was fitted separately to data for each experimental unit, or for each combination of individual target activity applications within a study unit.

From the fitted regression lines determined through Model (A-1), estimates are obtained for three indicators of lead disturbance (these indicators are discussed further in Section C.5 of Appendix C):

- lead disturbance within a 6'x1' gradient from the target activity;
- estimated lead loading in dust that settles from zero to one foot from the target activity; and
- estimated lead loading in dust that settles from five to six feet from the target activity.

For each model fitting, Table CED-2 presents these estimates, in addition to the estimates of $\bullet_0$ and $\bullet_1$ from the model. One row of Table CED-2 exists for each experimental unit.

A series of figures follow Table CED-2 which present predicted lead disturbance (in log units) as a function of distance from activity, as determined through statistical modeling results. Each figure contains a number of plots representing a particular target activity and substrate:

Figure CED-1: Drilling into wood;
Figure CED-2: Drilling into plaster;
Figure CED-3: Sawing into wood;
Figure CED-4: Sawing into plaster;
Figure CED-5: Wood door modification;
Figure CED-6: Sanding of painted wood;
Figure CED-7: HVAC ductwork removal;
Figure CED-8: Demolition.

The first plot in each figure contains prediction curves for each fit of Model (A-1) within this activity/substrate combination (as given by the dashed lines). Separate fits of the model were made for each occurrence of the activity/substrate in the study (i.e., each experimental unit), as indicated in Table CED-2. Also in this plot are prediction curves of single fits of the "population model" (solid line) and the "two-stage" model (thick-dashed line). Both models, explained in Section C.4 of Appendix C, predict lead disturbance for the activity/substrate group across the entire CED phase. As both models give nearly equivalent predictions, the solid and thick-dashed lines are nearly plotted on top of each other.

Subsequent plots in Figures CED-1 to CED-8 illustrate the result of fitting model (A-1) to each experimental unit in the study by plotting the observed settled dust lead loadings (in the log domain) versus distance from activity, as well as the fitted prediction curve. These plots are identified by the building and room in which the activity was monitored.

Table CED-1. Summary Statistics for Task-Length Average Personal Worker Lead Levels ($\mu g/m^3$) During Each Combination of CED Activity and Substrate

Task	# Data Points	Arithmetic Mean	Geometric Mean	Log Std Dev	Minimum Value	Maximum Value
Clean/Plaster	4	27.701	24.461	0.5503	14.592	53.283
Clean/Wood	2	103.44	102.36	0.2050	88.549	118.33
Demolition	20	152.63	106.81	0.7406	33.553	947.06
Door Modification/ Wood	6	819.93	486.45	1.1722	112.03	2280.4
Drill/Plaster	6	6.9075	6.2510	0.5181	2.6168	11.598
Drill/Wood	7	26.324	15.147	1.2947	3.3666	50.235
HVAC Removal	4	50.075	49.623	0.1571	40.381	58.310
Component Removal/Wood	2	344.01	343.84	0.0451	333.05	354.97
Abrasive Sanding	9	544.82	332.75	1.0110	73.645	2311.7
Saw/Plaster	2	145.51	109.99	1.1080	50.245	240.77
Saw/Wood	6	581.85	545.84	0.3801	397.48	967.99

Table CED-2. Parameter Estimates β_0 and β_1 from Model (A-1) Predicting Dust Lead Loadings as a Function of Distance for Each Target Activity Execution

Target Activity	Substrate	Experimental Units		Estimated Intercept	Estimated Slope	Standard Error σ_{Error}	Estimated 6'×1' Pb Loading Gradient ($\mu g/ft^2$)	Estimated [0-1] Foot SSDC Pb Loading ($\mu g/ft^2$)	Estimated [5-6] Foot SSDC Pb Loading ($\mu g/ft^2$)
		Housing Unit	Room Within Housing Unit						
Drill	Wood	1	1	10.380	-1.1925	1.47741	26993.61	18816.75	48.43
		1	2	11.955	-1.4844	2.71843	104755.44	81025.60	48.44
		1	3	13.469	-1.7255	1.18628	410006.67	337003.16	60.36
		2	1	13.813	-1.7086	0.91359	583773.22	478061.49	93.16
		2	2	14.154	-1.6607	1.43482	844857.25	684354.03	169.52
		3	1	13.275	-1.3747	2.01080	423647.21	316579.67	327.67
		3	2	13.400	-1.2554	1.13787	525651.40	376064.36	706.58
	Plaster	1	1	7.5953	-1.3107	0.77360	1516.75	1108.23	1.58
		1	2	10.507	-1.3807	1.48990	26488.24	19833.98	19.92
		2	1	11.242	-1.3615	0.64877	55979.71	41645.92	46.03
		2	2	13.041	-2.8209	0.78250	163361.07	153632.09	0.12
Saw	Wood	1	1	13.297	-.75521	0.86596	780165.95	418058.28	9578.93
		1	2	12.949	-.70625	1.27843	586669.04	301508.19	8824.58
		2	1	12.750	-.78775	0.38276	433427.74	238386.68	4642.06
		2	2	12.420	-.96080	1.54356	256929.19	159130.84	1304.36
		3	1	13.870	-.68145	0.46151	1523083.13	765410.31	25359.74
		3	2	10.500	-.11757	1.70431	156279.63	34251.88	19027.54
	Plaster	1	1	10.035	-.80017	1.01382	28280.92	15704.81	287.39
		2	1	12.536	-1.0822	2.10227	256606.54	169909.58	759.16

Table CED-2. (Continued)

Target Activity	Substrate	Experimental Units: Housing Unit	Experimental Units: Room Within Housing Unit	Estimated Intercept	Estimated Slope	Standard Error σ_{Error}	Estimated 6'×1' Pb Loading Gradient (µg/ft²)	Estimated [0-1] Foot SSDC Pb Loading (µg/ft²)	Estimated [5-6] Foot SSDC Pb Loading (µg/ft²)
Door	Wood	1	1	9.2792	-.21432	0.67524	36170.83	9642.98	3302.36
		1	2	10.518	-.28567	1.17483	106102.69	32158.29	7708.57
		2	1	10.273	-.21935	1.47167	96601.78	25998.98	8682.52
		2	2	9.5765	-.38191	0.97219	33944.39	11987.57	1775.94
		3	1	13.183	-.63441	0.41639	818758.77	393356.02	16488.61
		3	2	13.924	-.79357	0.68776	1392338.34	769266.98	14549.66
Sand	Wood	1	1	10.842	-.40035	1.59203	116164.82	42139.05	5693.01
		2	1	13.090	-.32664	0.72129	1273125.24	412936.95	80650.04
		3	1	10.797	-.32348	0.70356	129339.09	41738.87	8281.43
HVAC	Duct	1	1	10.255	-.56498	1.55988	48612.03	21714.48	1287.96
		2	1	5.6465	-.13735	0.27278	1157.86	264.70	133.20
Demolition	Plaster	1	1	7.1450	-.10665	0.23008	5618.30	1202.44	705.48
		1	2	7.3677	-.24732	0.63808	4952.48	1403.33	407.49
		2	1	8.5595	-.24404	0.37631	16430.70	4628.28	1366.13
		2	2	7.4882	-.11647	0.33018	7713.99	1686.67	942.13
		3	1	13.494	-.59585	1.56133	1182861.30	546294.38	27769.24
		3	2	10.291	-.17133	1.59569	110443.37	27075.59	11496.07
		3	3	6.7415	-.43914	1.24668	1790.13	685.39	76.27
	Wood/Plaster	1	1	6.5466	0.10274	1.01864	5781.13	733.92	1226.72
		2	1	15.326	-1.0641	1.06563	4249824.23	2788243.68	13632.21

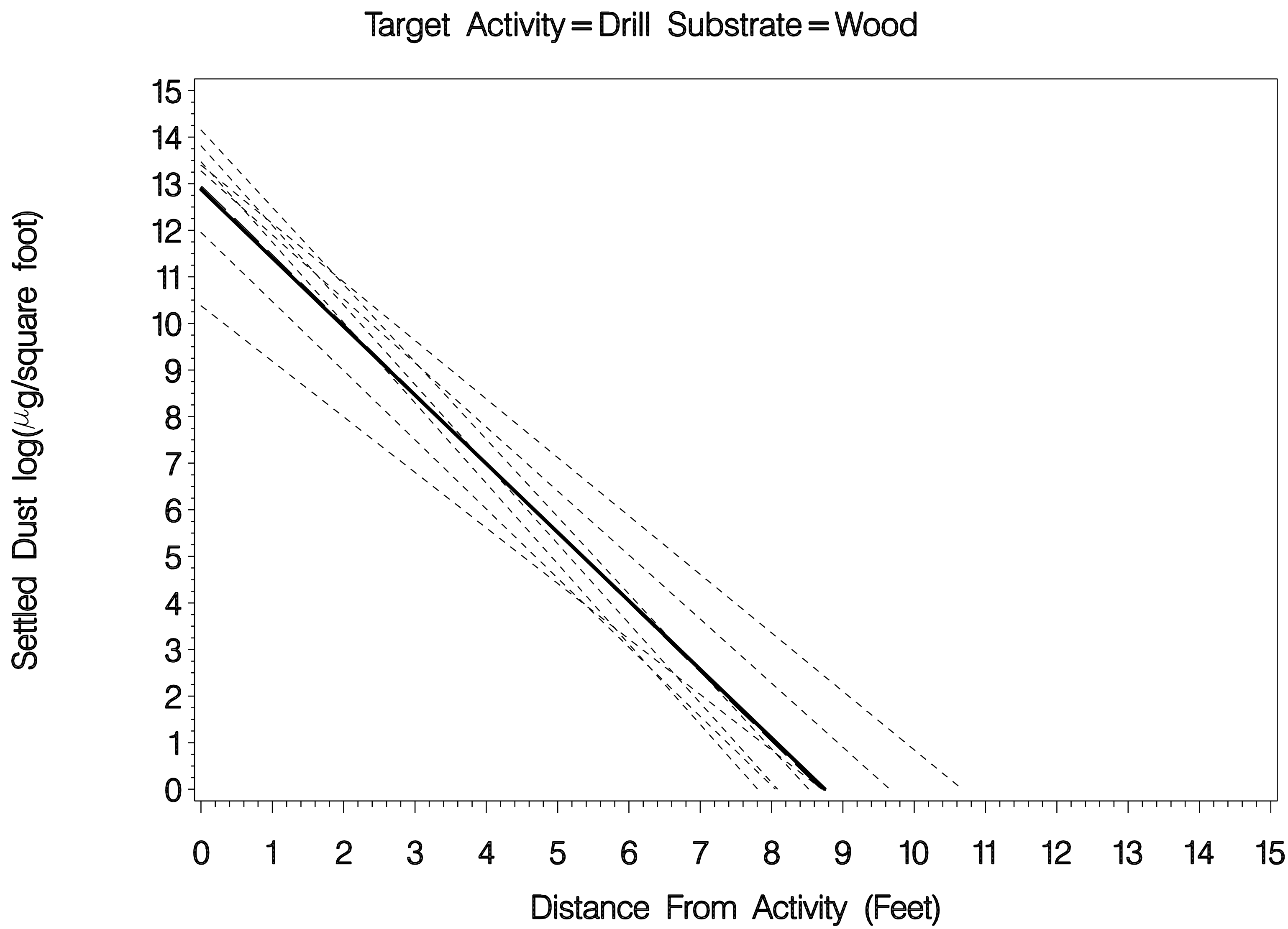

Target Activity=Drill Substrate=Wood
Settled Dust log(μg/square foot)
Distance From Activity (Feet)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Figure CED-1.

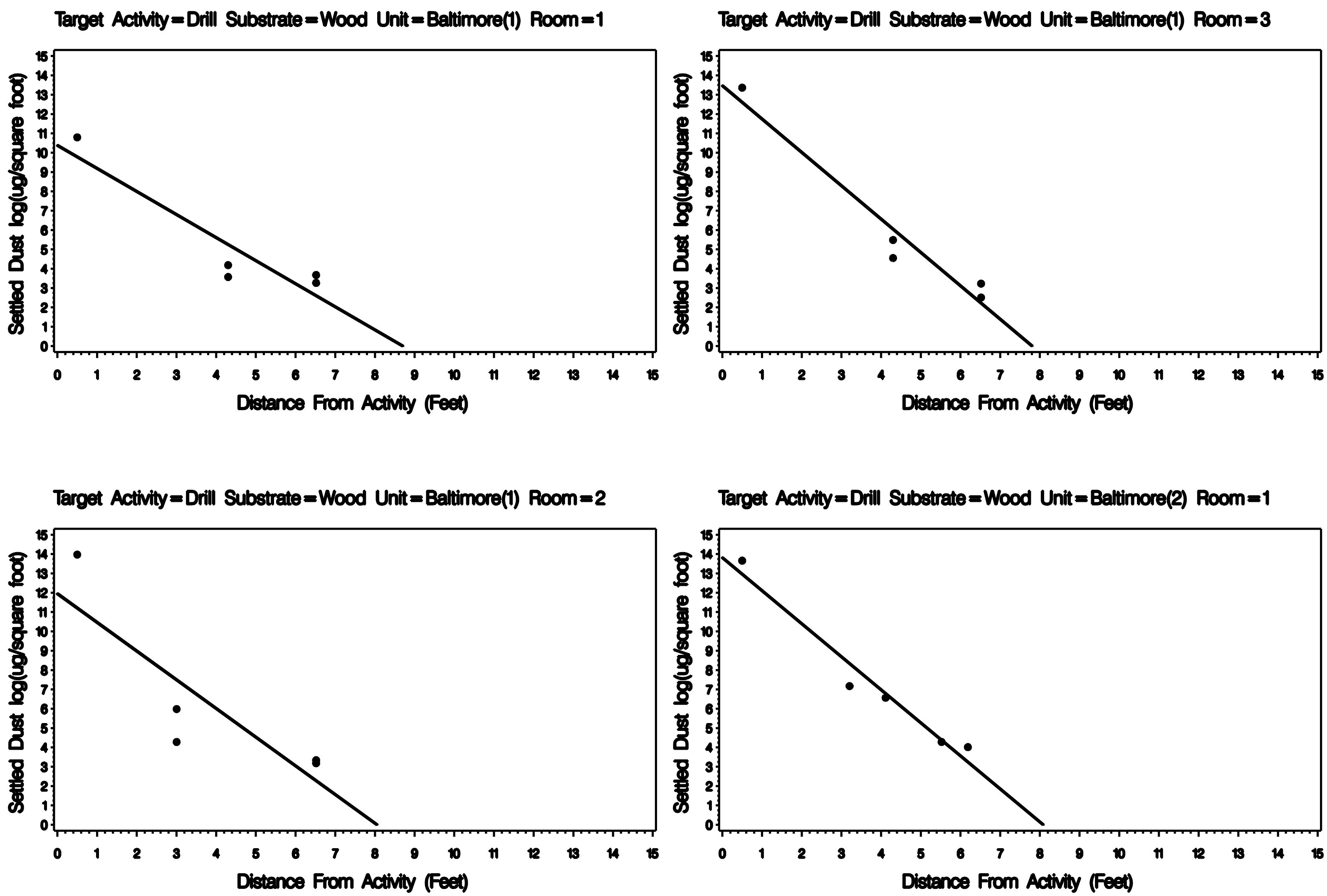


Figure CED-1. (Continued)

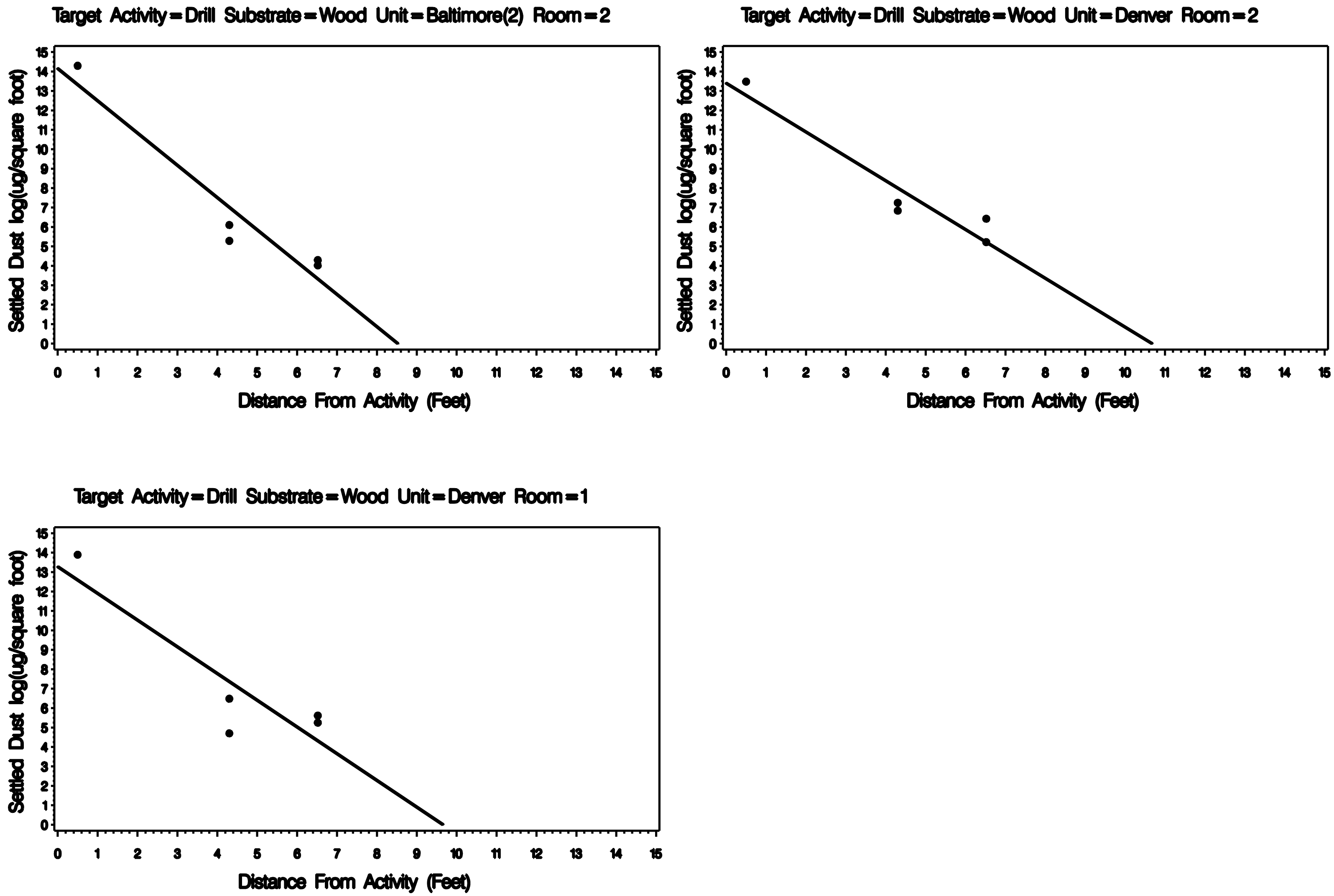


Figure CED-1. (Continued)

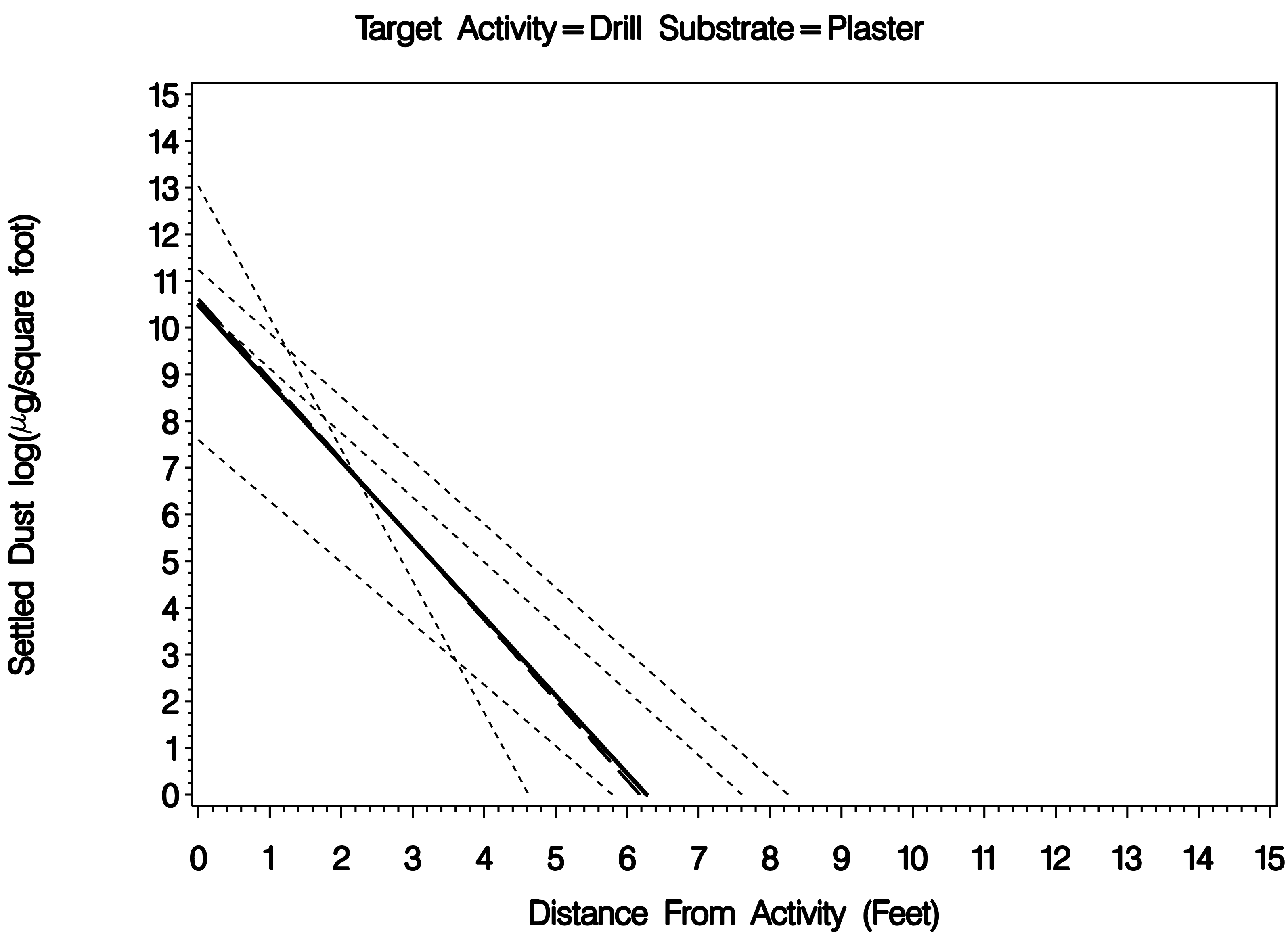

Target Activity=Drill Substrate=Plaster
Settled Dust log(μg/square foot)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Distance From Activity (Feet)

Figure CED-2.

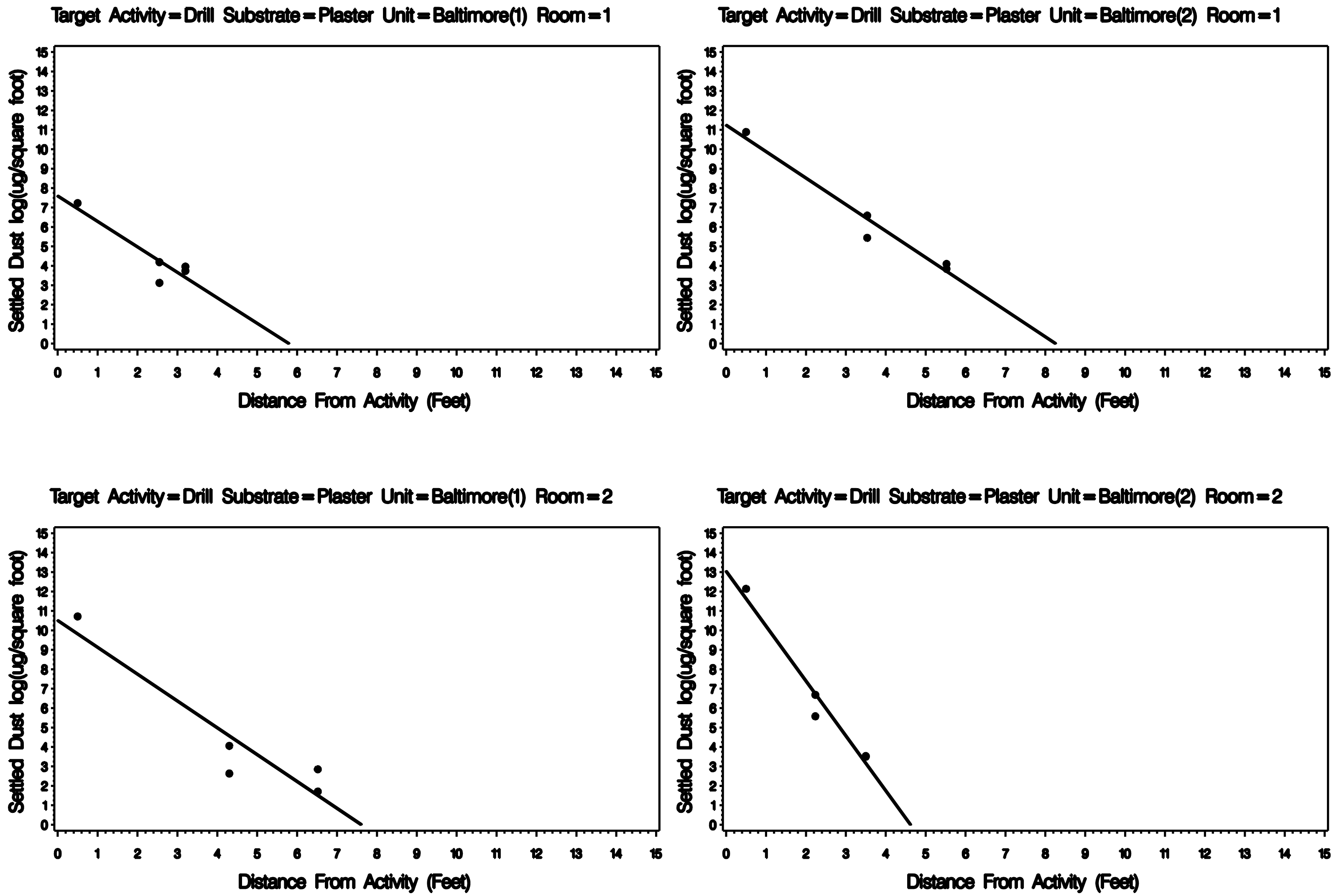
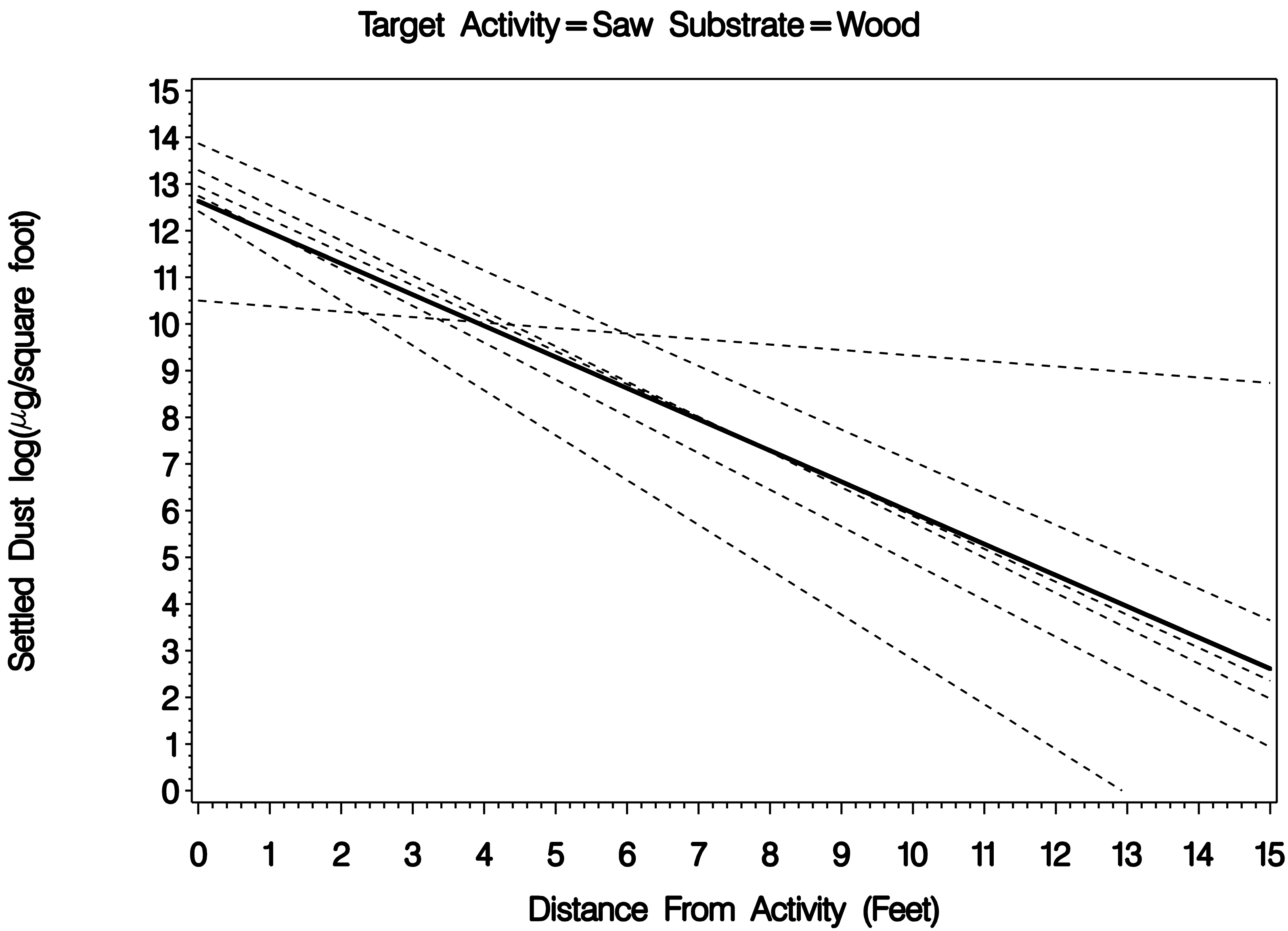


Figure CED-2. (Continued)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Settled Dust log(μg/square foot)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Distance From Activity (Feet)

Figure CED-3.

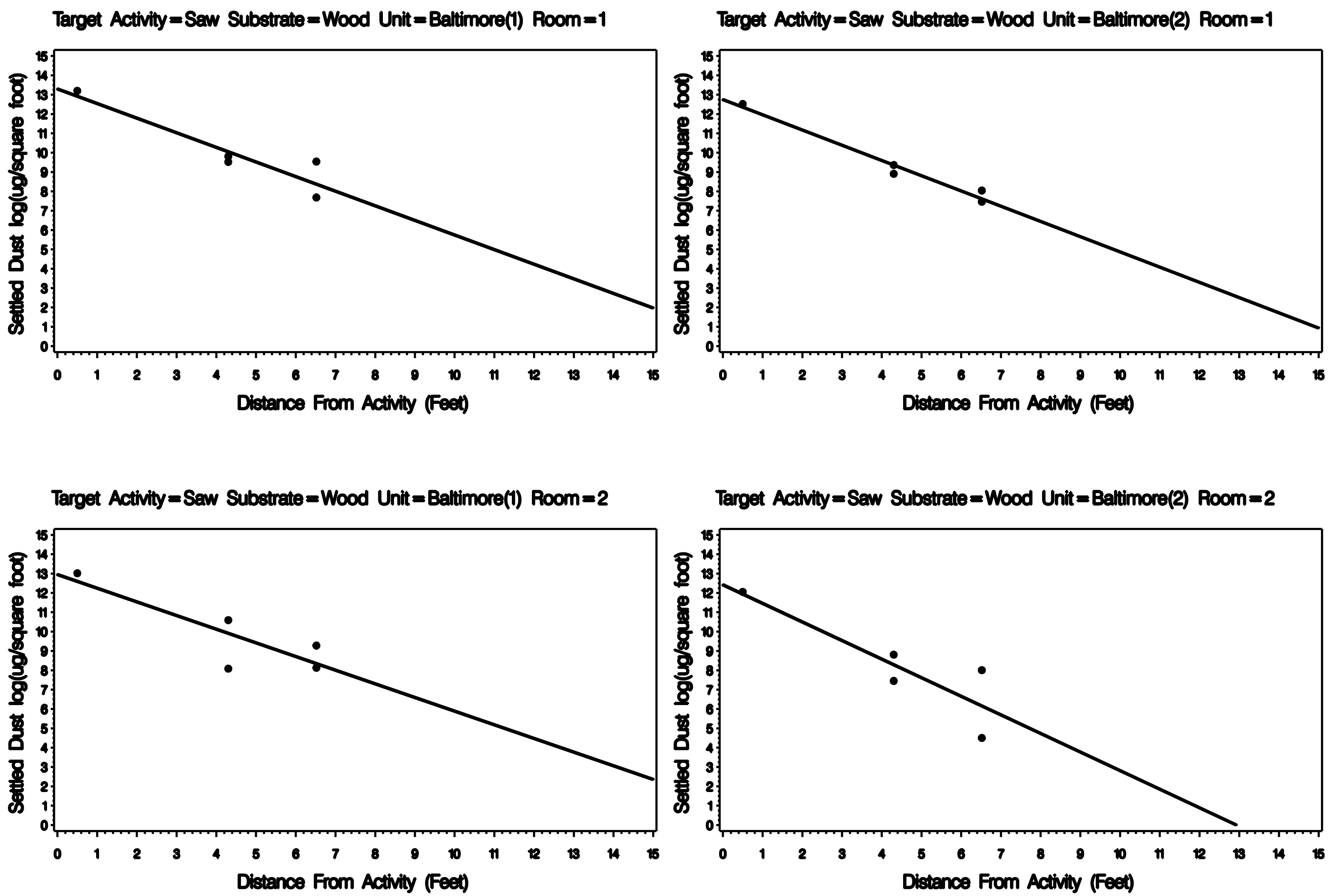


Figure CED-3. (Continued)

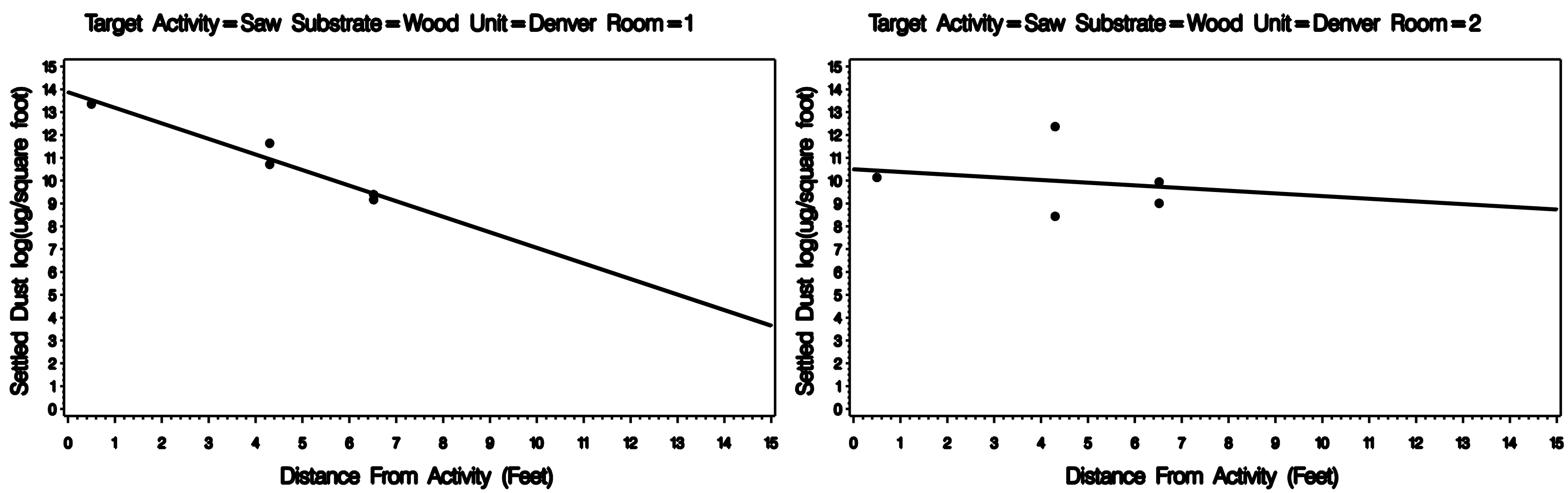


Figure CED-3. (Continued)

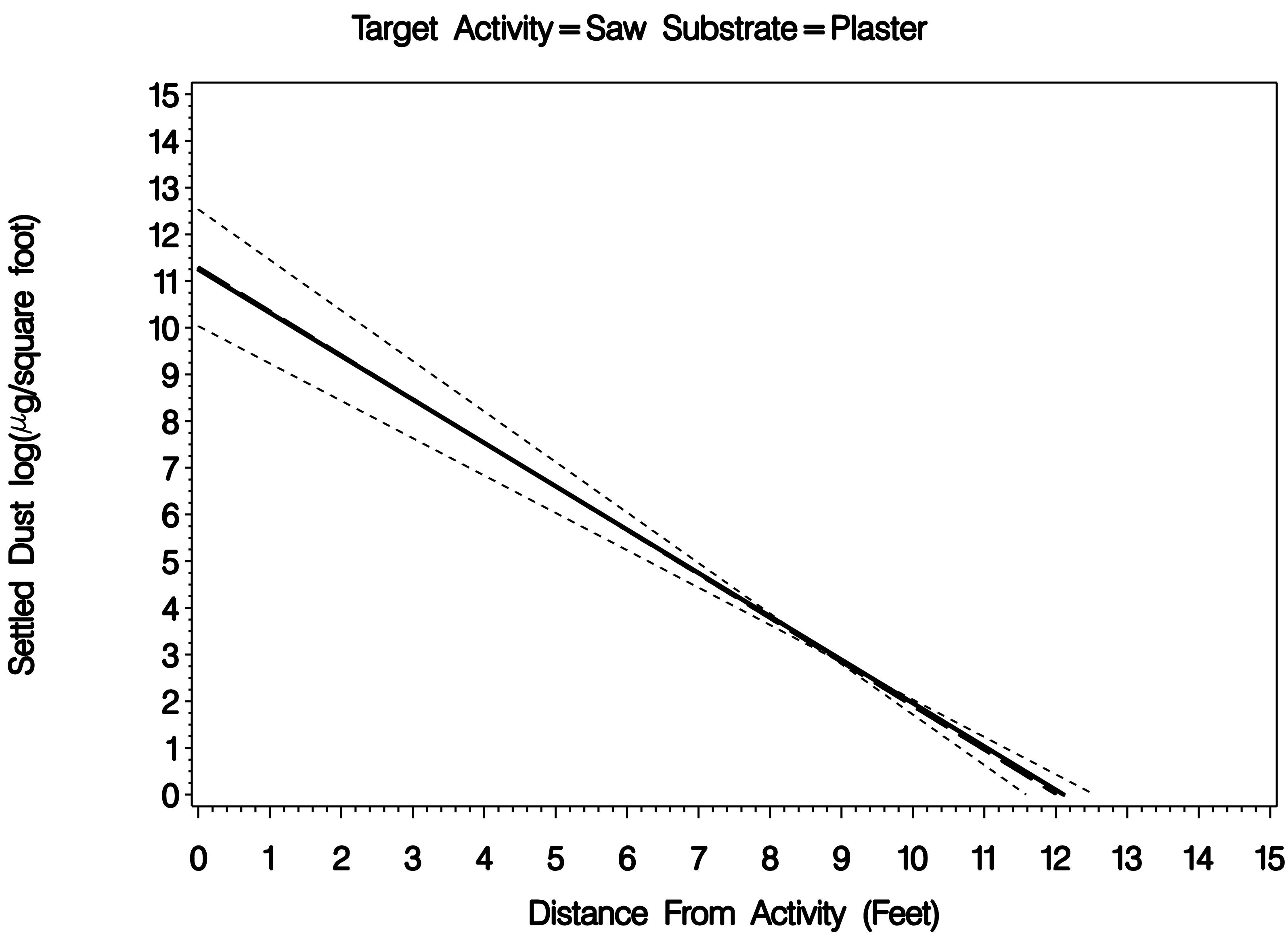

Target Activity=Saw Substrate=Plaster
Settled Dust log(μg/square foot)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Distance From Activity (Feet)

Figure CED-4.

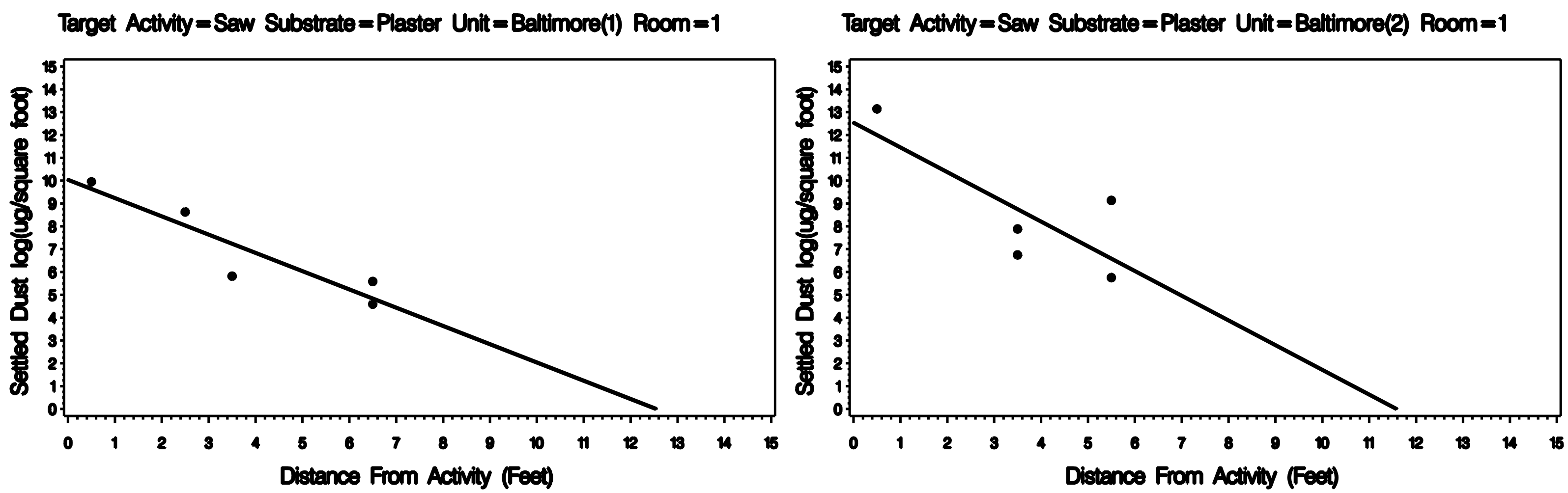


Figure CED-4. (Continued)

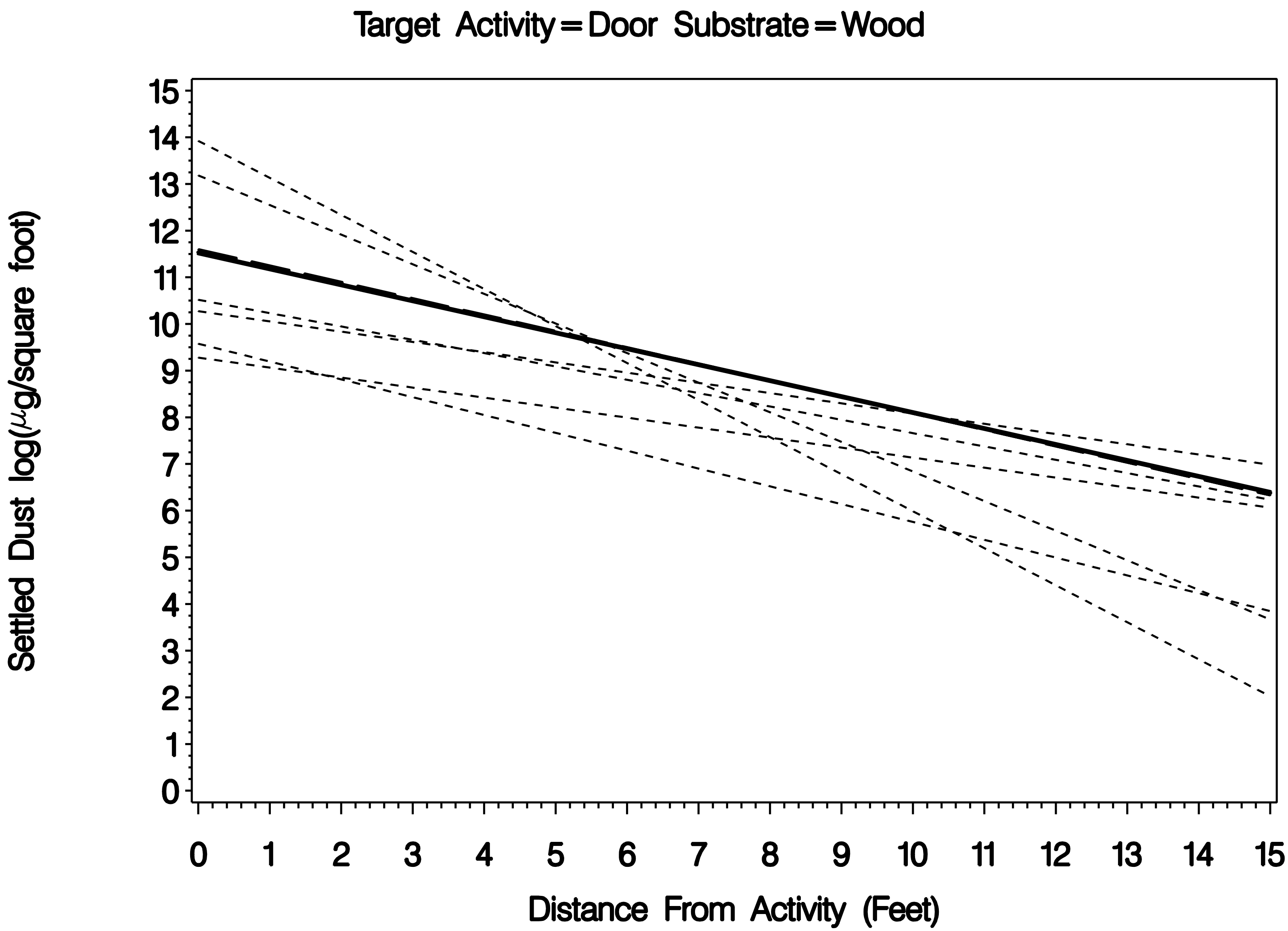

Target Activity=Door Substrate=Wood
Settled Dust log(μg/square foot)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Distance From Activity (Feet)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Figure CED-5.

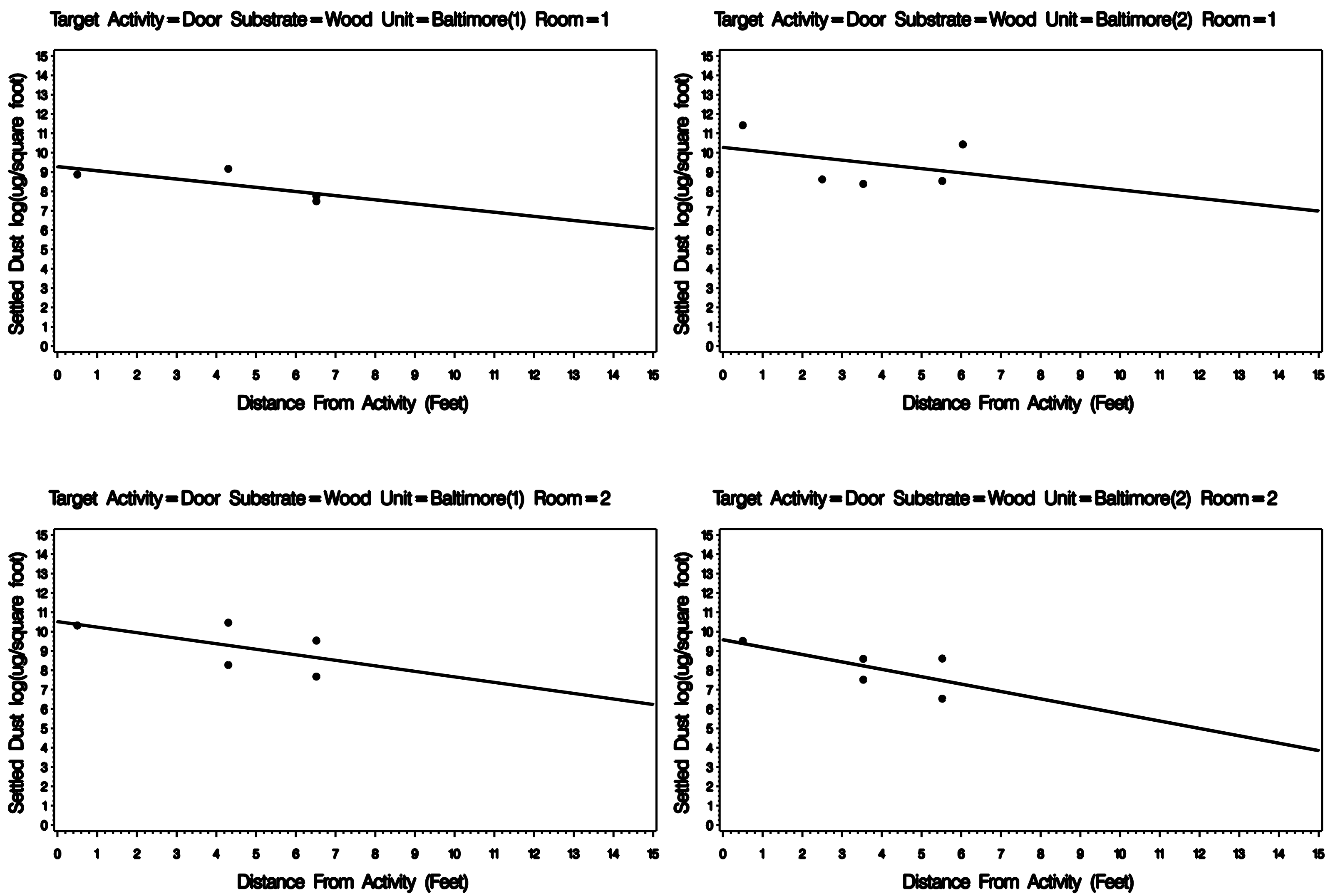


Figure CED-5. (Continued)

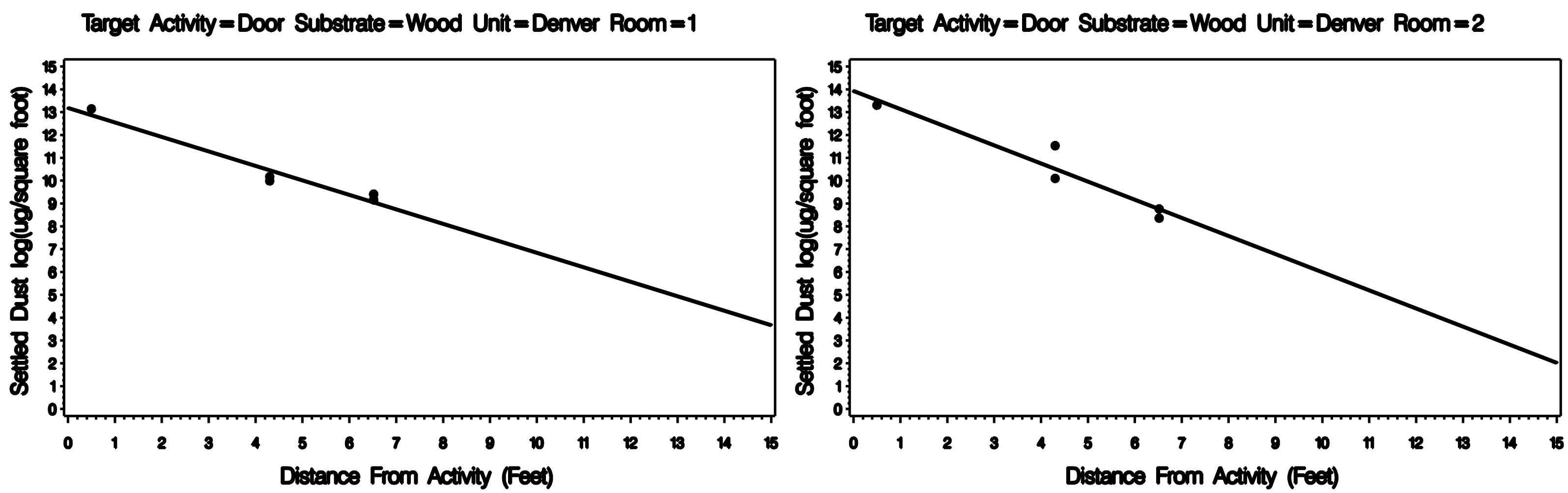
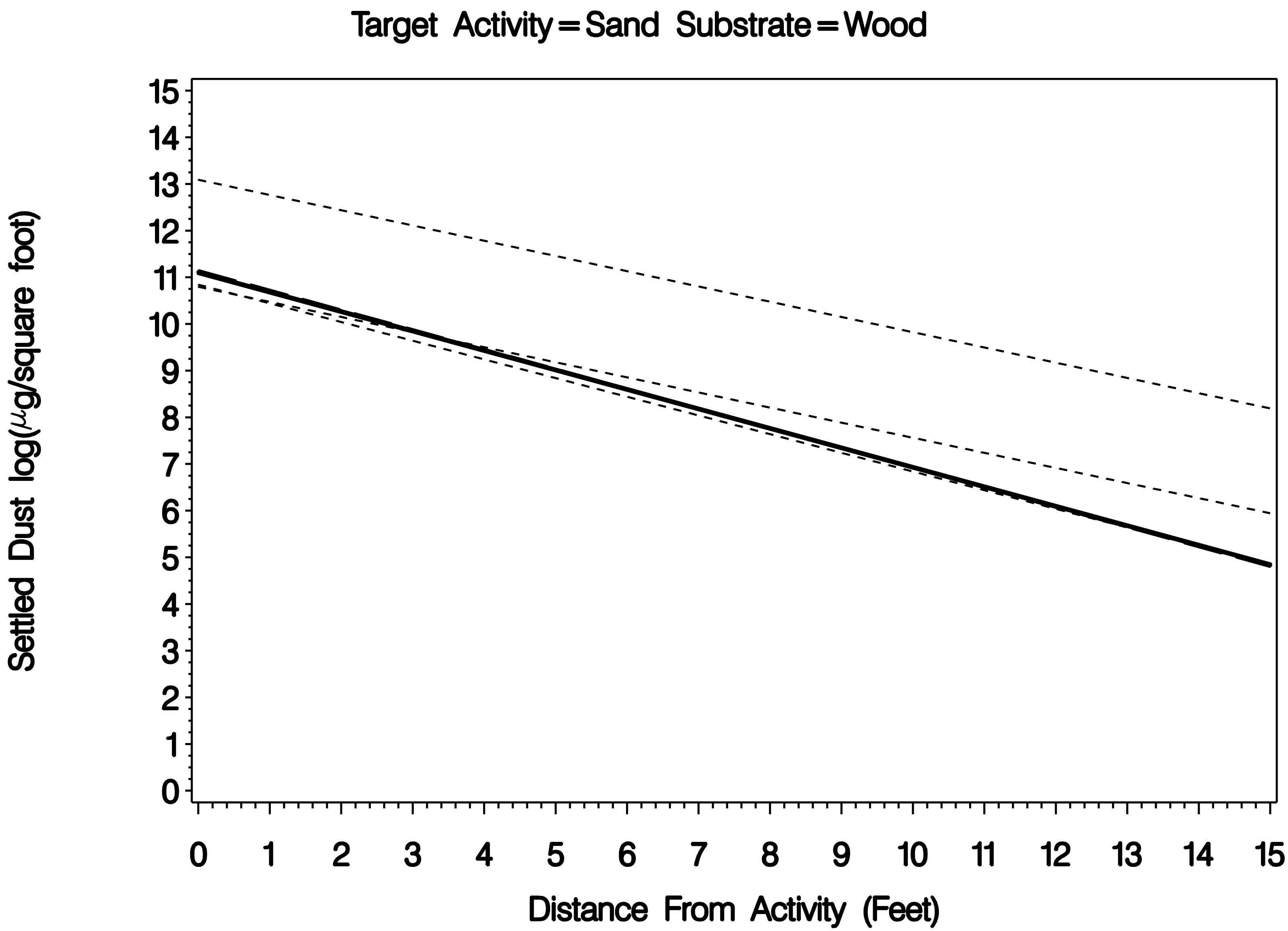


Figure CED-5. (Continued)



Target Activity=Sand Substrate=Wood
Settled Dust log(μg/square foot)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Distance From Activity (Feet)

Figure CED-6.

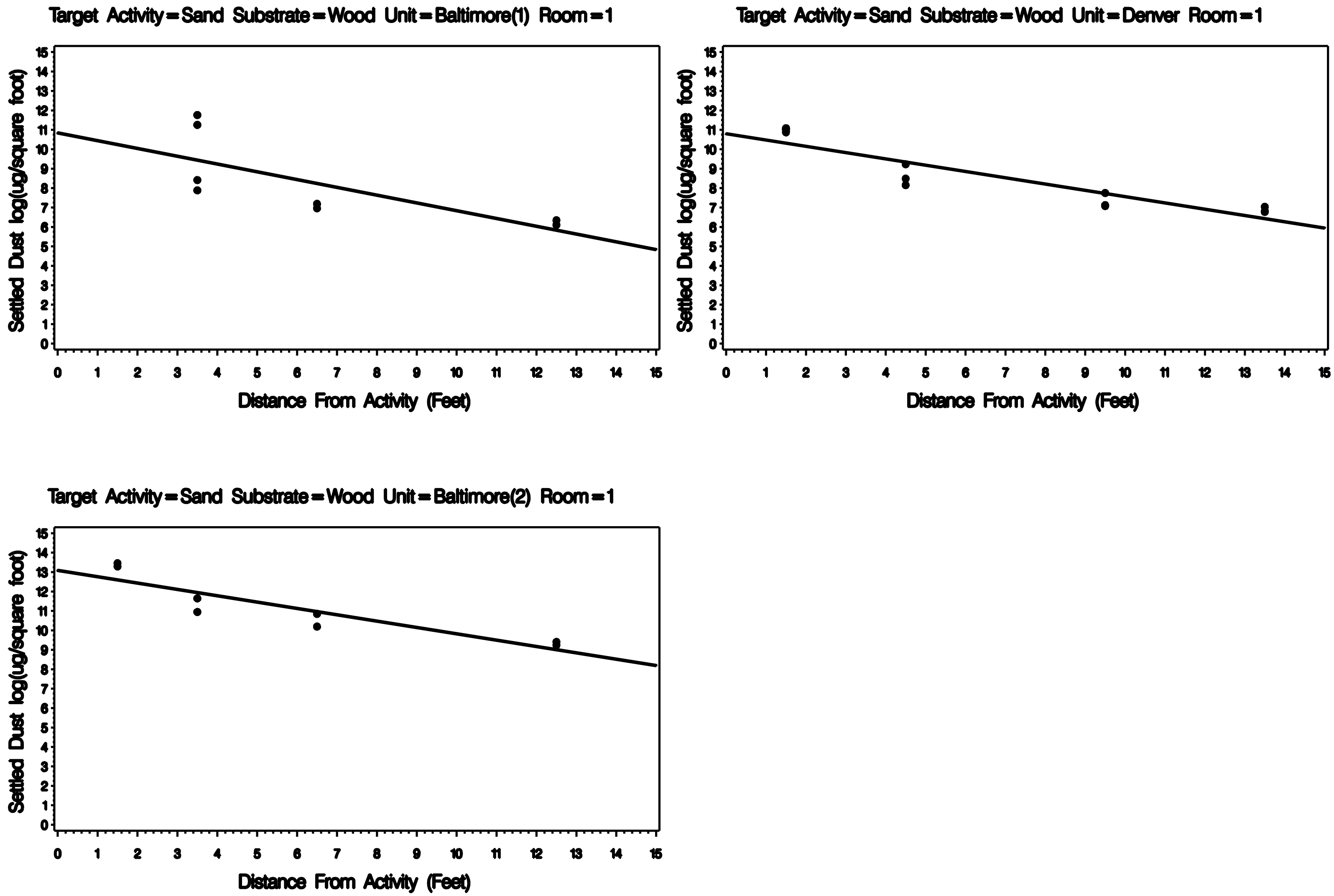


Figure CED-6. (Continued)

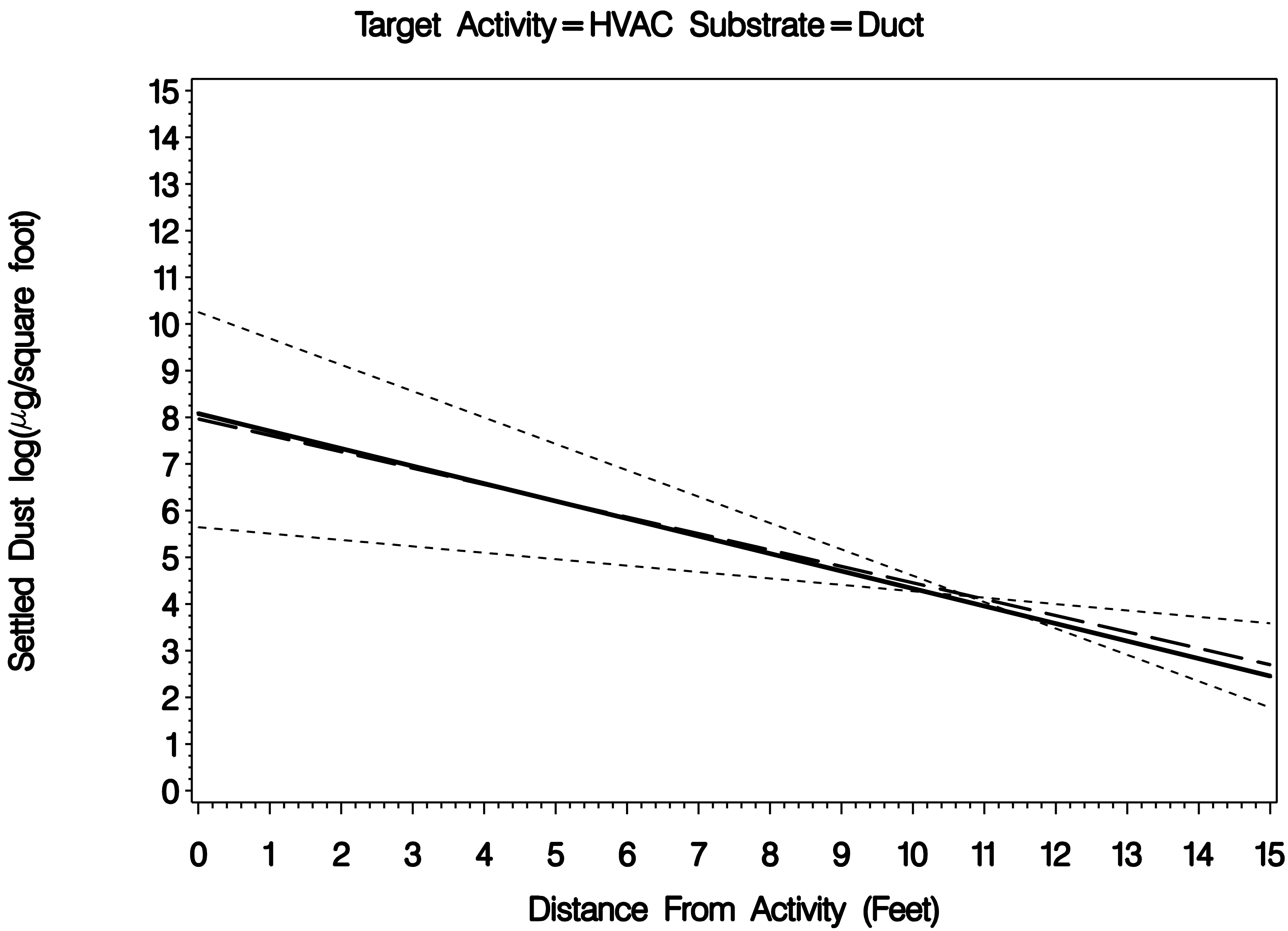

Target Activity=HVAC Substrate=Duct
Settled Dust log(μg/square foot)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Distance From Activity (Feet)

Figure CED-7.

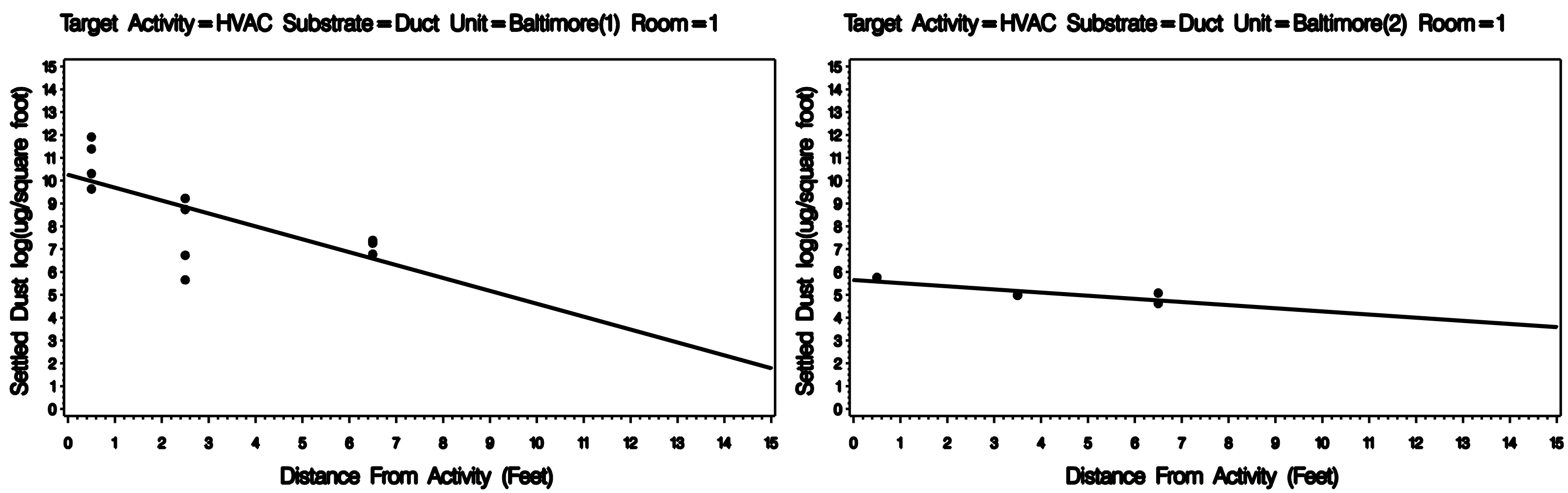


Figure CED-7. (Continued)

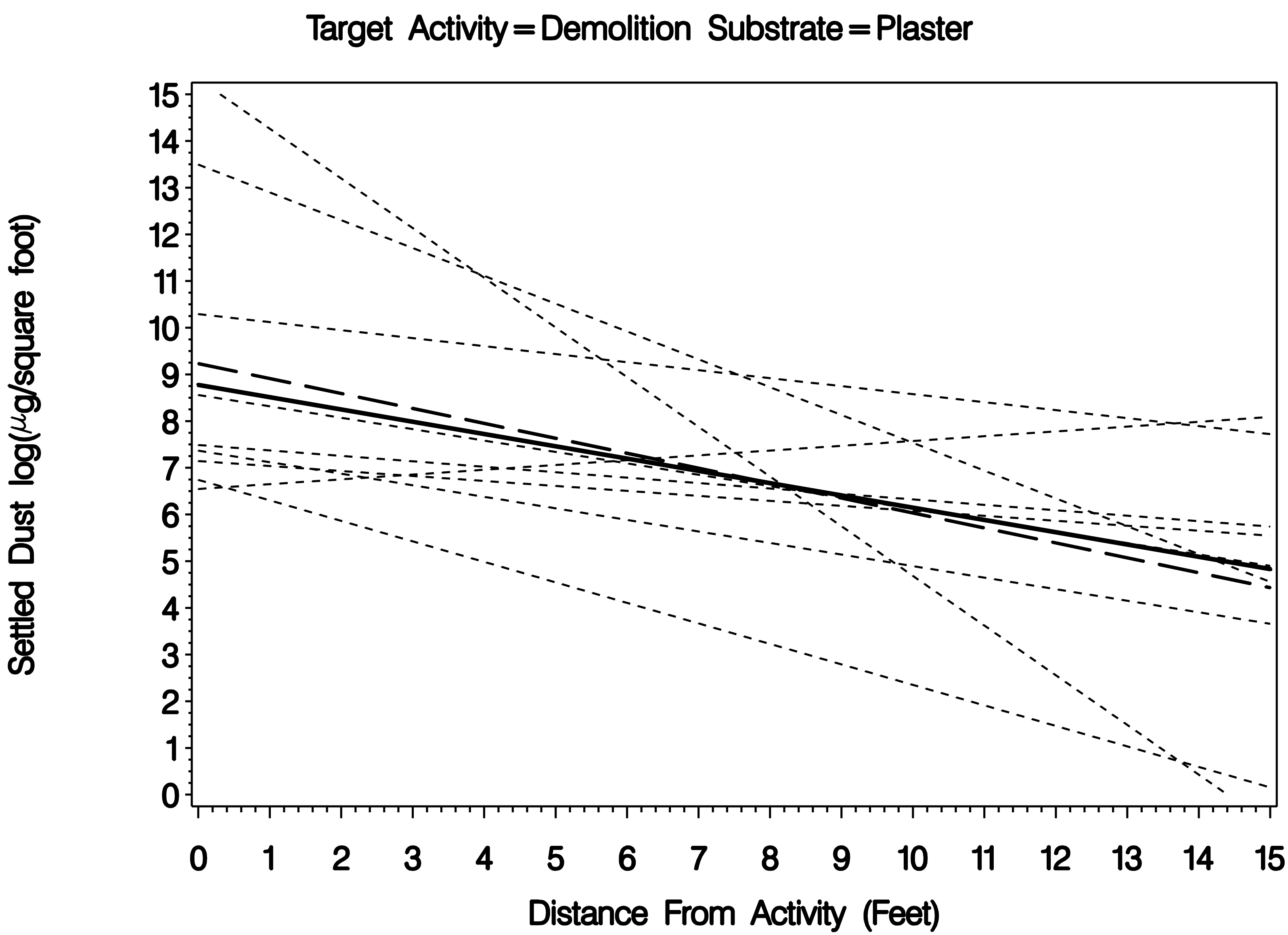

Target Activity=Demolition Substrate=Plaster
Settled Dust log(μg/square foot)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Distance From Activity (Feet)

Figure CED-8.

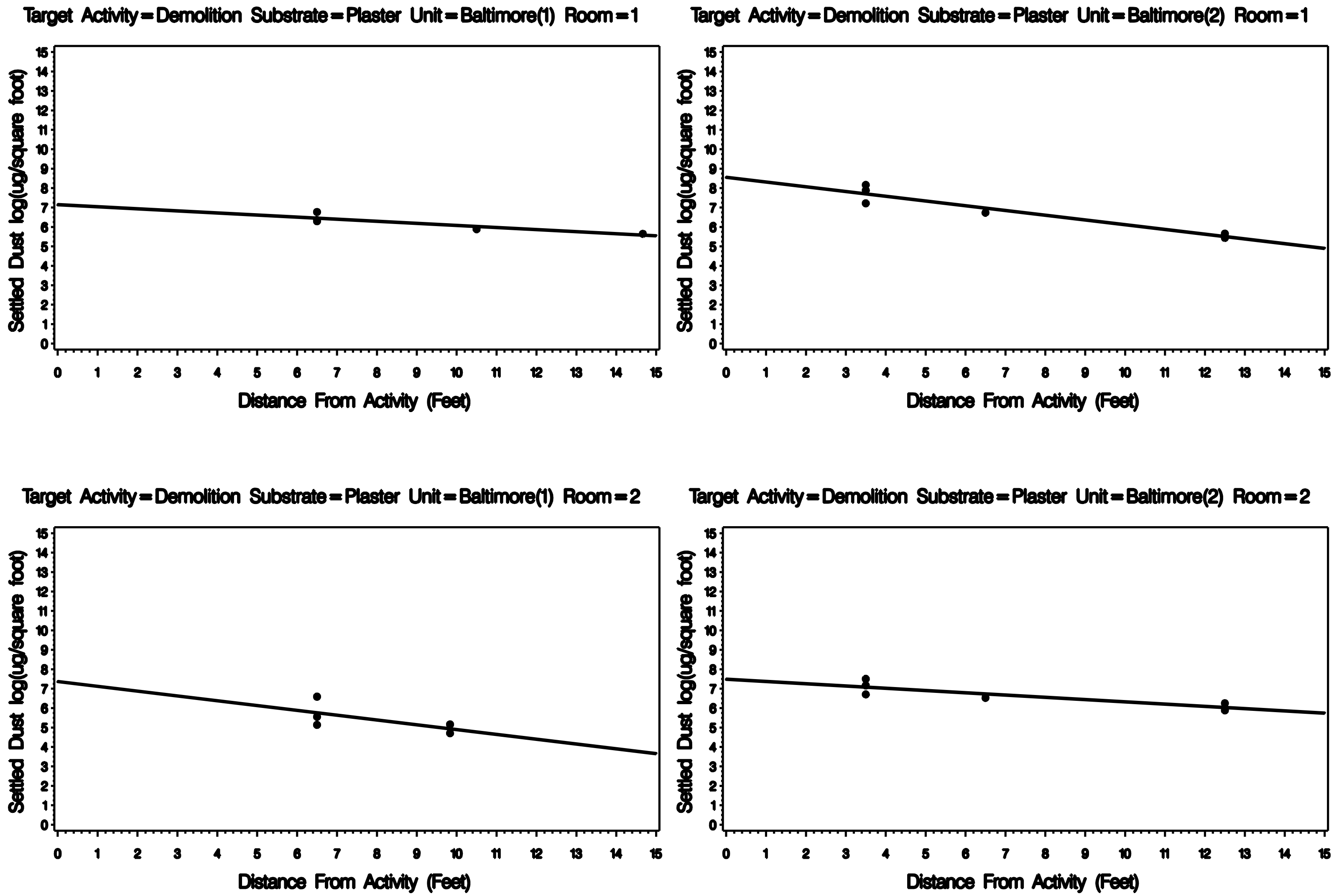


Figure CED-8. (Continued)

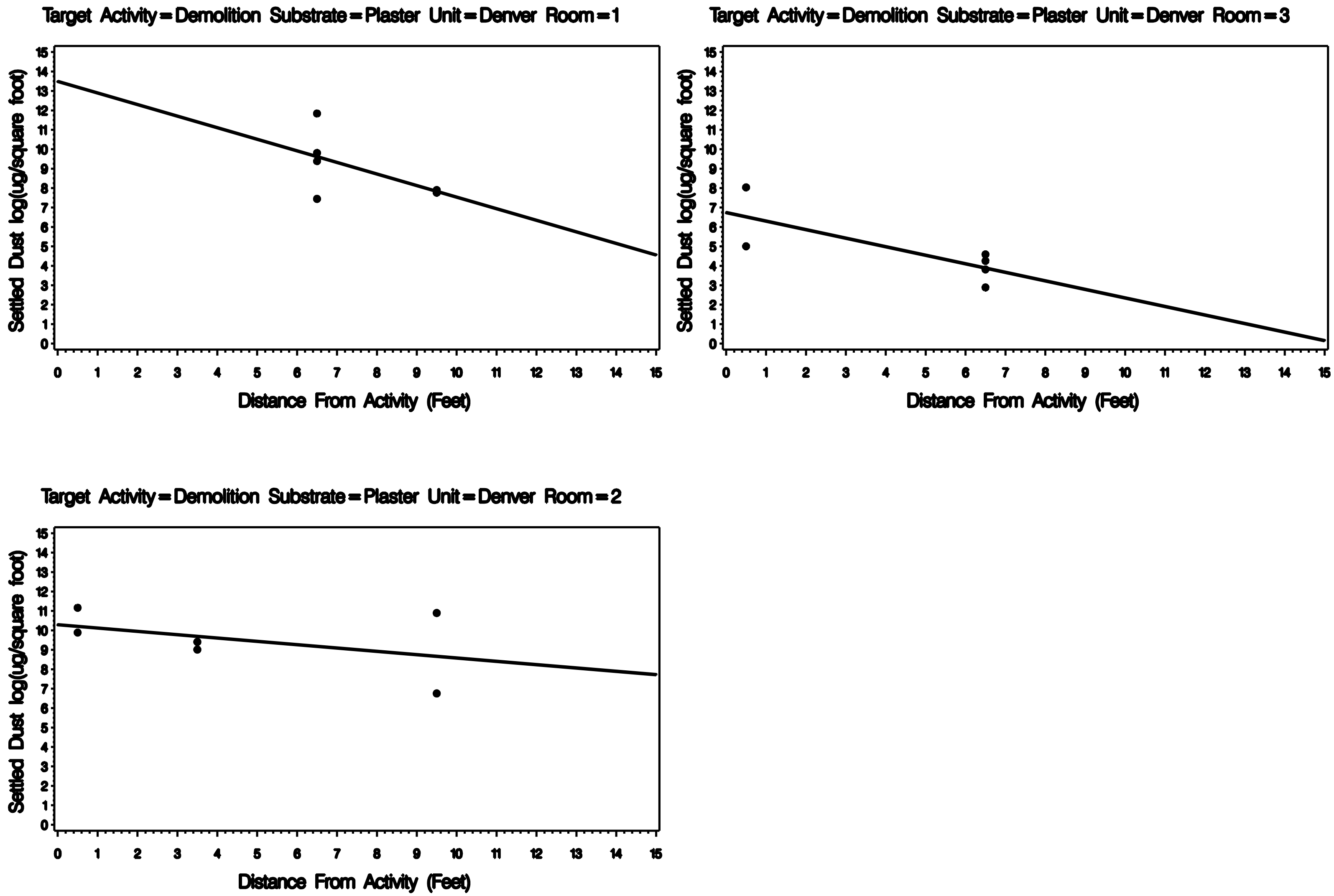


Figure CED-8. (Continued)

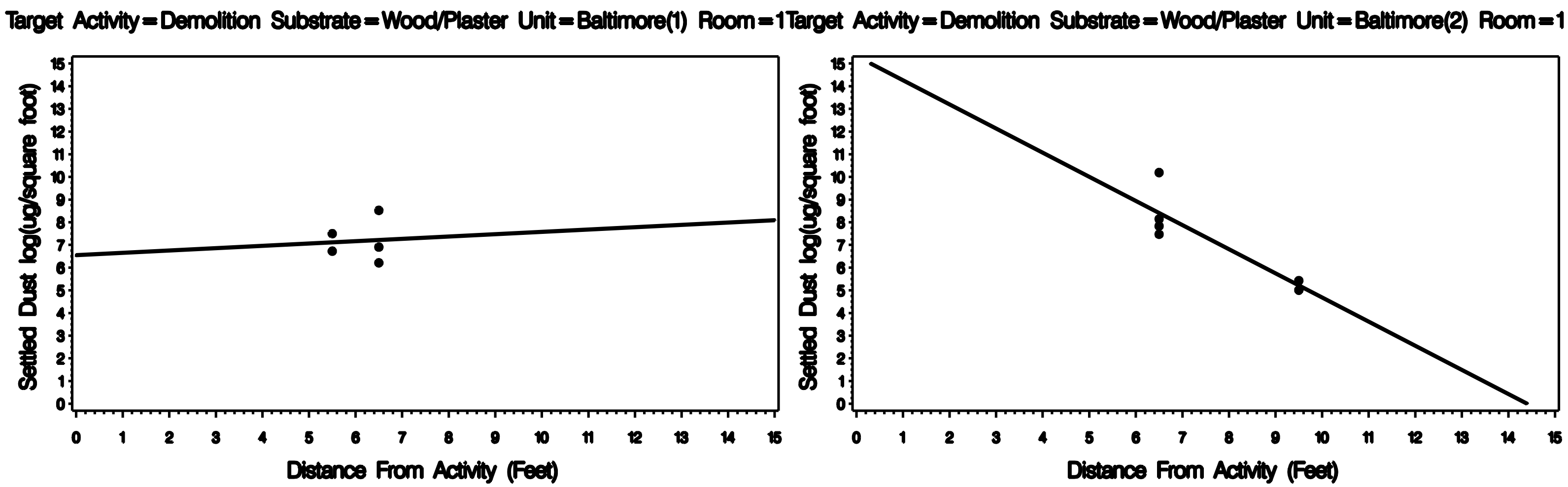


Figure CED-8. (Continued)

A.4 DESCRIPTIVE STATISTICS OF DATA FROM THE CLEANUP INVESTIGATION

Section 7D presents design and results of an investigation of the effects of cleanup procedures on lead levels in settled dust that remain for occupants to encounter. For each combination of R&R activity and cleanup method, the following tables describe the collected data:

Table CI-1: Lead loadings in paint chip samples taken from surfaces disturbed by R&R activity

Table CI-2: Lead loadings in post-activity settled dust samples taken prior to cleanup

Table CI-3: Lead loadings in post-cleanup settled dust samples

Table CI-4: Lead loadings in next-day SSDC vacuum-dust samples.

Table CI-1. Descriptive Statistics for Measured Lead Loadings (mg/cm^2) in Paint Chip Samples Taken from Surfaces Disturbed by R&R Activity in the Cleanup Investigation

R&R Activity	Cleanup Method	N[1]	Arithmetic Mean	Geometric Mean	Log Std. Dev.	Minimum	Maximum
Drilling	Broom	3	1.77	0.32	2.42	0.08	5.15
Drilling	Vacuum	3	4.72	1.31	2.86	0.05	9.17
Abrasive Sanding	Broom	3	7.19	1.91	2.97	0.06	12.60
Abrasive Sanding	Vacuum	3	14.27	14.17	0.14	12.17	15.84

(1) One result exists for each experimental unit (i.e., each time the activity/cleanup method combination was performed).

Table CI-2. Descriptive Statistics for Measured Lead Loadings ($\mu g/ft^2$) in Post-Activity Settled Dust Samples Taken Prior to Cleanup in the Cleanup Investigation

R&R Activity	Cleanup Method	Distance from Activity (ft.)	N[(1)]	Arithmetic Mean	Geometric Mean	Log Std. Dev.	Min.	Max.
Drilling	Broom	0	3	141773	26739	2.38	5332	411270
		3	3	425	176	1.93	22.3	1013
		6	3	203	65	2.60	3.3	392
Drilling	Vacuum	0	3	253005	73508	2.81	2869	444986
		3	3	471	312	1.08	144	1074
		6	3	287	146	1.83	17.7	463
Abrasive Sanding	Broom	0	3	3021341	653201	3.34	13831	5096250
		3	3	3177	715	2.26	121	9075
		6	3	17405	1376	3.71	30.6	50500
Abrasive Sanding	Vacuum	0	3	371105	202540	1.60	34421	762190
		3	3	8443	5277	1.37	1150	16374
		6	3	796	491	1.43	96.9	1452

(1) One result exists for each experimental unit (i.e., each time the activity/cleanup method combination was performed).

Table CI-3. Descriptive Statistics for Measured Lead Loadings ($\mu g/ft^2$) in Post-Cleanup Settled Dust Samples Taken in the Cleanup Investigation

R&R Activity	Cleanup Method	Distance from Activity (ft.)	N[1]	Arithmetic Mean	Geometric Mean	Log Std. Dev.	Min.	Max.
LEAD LOADINGS IN DUST-VACUUM SAMPLES								
Drilling	Broom	0	3	93	42	1.79	6.2	219
		3	6	66	24	1.72	3.3	256
		6	3	22	12	1.40	3.3	53
Drilling	Vacuum	0	3	217	52	2.52	3.8	582
		3	6	89	40	1.52	4.5	318
		6	3	40	27	1.13	9.0	85
Abrasive Sanding	Broom	0	3	3941	235	3.53	12	11720
		3	6	2936	232	2.29	33	16918
		6	3	1794	336	2.38	82	5212
Abrasive Sanding	Vacuum	0	3	3731	388	2.92	53	11041
		3	6	114	62	1.32	7.6	373
		6	3	306	161	1.36	65	769
LEAD LOADINGS IN DUST-WIPE SAMPLES								
Drilling	Broom	0	3	266	166	1.27	46	579
		6	3	202	124	1.33	30	427
Drilling	Vacuum	0	3	805	360	1.84	50	1857
		6	3	166	123	1.03	41	312
Abrasive Sanding	Broom	0	3	2995	1074	1.80	255	8131
		6	3	2830	829	2.04	149	7854
Abrasive Sanding	Vacuum	0	3	905	808	0.60	425	1402
		6	3	432	303	1.07	108	904

[1] At zero and six feet from activity, one result exists for each experimental unit (i.e., each time the activity/cleanup method combination was performed). At three feet from activity, two dust-vacuum results and one dust-wipe result exist for each experimental unit.

Table CI-4. Descriptive Statistics for Measured Lead Loadings (µg/ft^2) in Next-Day SSDC Vacuum-Dust Samples Taken in the Cleanup Investigation

R&R Activity	Cleanup Method	Distance from Activity (ft.)	N[(1)]	Arithmetic Mean	Geometric Mean	Log Std. Dev.	Min.	Max.
Drilling	Broom	0	3	92	57	1.16	25	216
		6	2	48	46	0.47	33	64
Drilling	Vacuum	0	3	119	95	0.79	53	234
		6	3	42	40	0.37	31	61
Abrasive Sanding	Broom	0	3	79	60	0.99	20	138
		6	3	261	155	1.33	41	588
Abrasive Sanding	Vacuum	0	3	28	27	0.34	19	36
		6	3	13	12	0.60	5.9	17

(1) One result exists for each experimental unit (i.e., each time the activity/cleanup method combination was performed). For drilling/broom cleanup, results for only two experimental units were available.

APPENDIX B

DATA PROCESSING AND OUTLIER DETECTION

B.0 DATA PROCESSING AND OUTLIER DETECTION

B.1 DATA PROCESSING

The following subsections discuss how the requirements for data processing were met in the EFSS. Specifically, these discussions address data storage, data transfer, data tracking, database verification, and necessary data manipulations prior to the statistical analysis.

B.1.1 Data Storage, Transfer, and Tracking

All requirements concerning the storage, tracking, and transfer of the study data were followed in the EFSS as specified in the Quality Assurance Project Plan (QAPjP). Within several overnight shipments, MRI provided Battelle with the analytical study data in hard-copy listings and on diskette in Lotus spreadsheet format. These listings represented results for specific analytical batches. Battelle has stored the original data listings and diskettes in a locked file cabinet, along with the original completed field data logs for which Battelle is responsible. Battelle has made backup diskettes of the data spreadsheet files; these backups are currently stored in the office of the database manager. The study database created by Battelle from the MRI data files is stored on the hard disk of the database manager, and relevant data for statistical summary and analysis are located on a network hard disk accessible by Battelle statisticians.

Battelle was responsible for entering data from the field sample logs into the study database. After verifying the accuracy of the data entry (Section B.1.2), Battelle merged these data with the analytical data sent by MRI in creating the study database.

Data tracking has been done in accordance with the QAPjP. All dates corresponding to significant events in the collection, laboratory analysis, and transfer of the data are recorded in the Battelle study database. Tracking programs confirmed that all data corresponding to collected field samples and laboratory samples were included in the study database.

B.1.2 Data Verification

Prior to entering data into the study database, Battelle verified the correctness and accuracy of study data in the following ways:

- Battelle staff hand-entered data from the field sampling logs, using double data entry techniques and hand-checking to ensure that accurate data were entered.

- When a batch of analytical data was received from MRI, Battelle compared the submitted hard-copy data listings with listings made of the contents of the Lotus spreadsheets. This verification procedure included spot-checking of calculations.

- Information used to identify the records in the electronic database were compared with similar information from the sample field logs, to verify overall data consistency.

Battelle staff members reviewed any discrepancies found in the data verification procedure, making any necessary corrections to the database as a result. In this review, Battelle notified MRI of any data issues that needed to be brought to their attention.

B.1.3 Data Manipulation

The QAPjP for the EFSS notes that data values for variables to be included in the statistical analysis may need to be transformed based on their underlying distributional forms. Statistical analyses and/or data summary were performed on three data variables: physical sample weight, lead concentration, and lead loadings. Battelle statisticians examined the distribution of these variables and concluded that within each study phase, statistical analyses were more appropriately applied to the log-transformed data values. The data transformation issue is further discussed in Section 5.2.

B.2 OUTLIER DETECTION

Outliers are loosely defined as data values which do not coincide with preconceived assumptions on the data distribution for the given parameter. The assumptions are usually functions of the observed distribution of the parameter data, given the underlying distribution has some known form (e.g., lognormality). When data values are identified as outliers, they are generally reviewed for accuracy, and any erroneous data are corrected or are omitted from statistical analyses. Numerous outliers can imply that the assumptions on the data distribution are not appropriate, and special care should be taken in applying appropriate methodologies in the statistical analyses.

In each phase of the R&R study, outlier analyses were conducted using three methods:

- logic checks,
- formal statistical tests, and
- graphical review.

The outlier analyses were applied to sample weight, lead concentration, and lead loading data. The above methods flagged data values for individual samples, as well as pairs of samples (i.e., samples taken from adjoining areas and having results with some expected intrinsic relationship) whose results were inconsistent in some way. The findings of the outlier analyses are presented below for each study phase.

B.2.1 Logic Checks

As a first step in the outlier detection process, logic checks were performed to flag results which ran contrary to intuition or some underlying criterion. One check flagged those individual sample results having non-positive lead loadings. Within each phase, no results were flagged for this reason. Another set of checks within the window replacement and carpet removal phases flagged sample pairs in the following way:

- One hour/two hour settled dust sample pairs: Flag those pairs where a stainless steel dustfall collector (SSDC) sample collected two hours following the activity had a lower lead loading than the adjoining SSDC sample collected one hour following the activity.

- Pre-activity/post-activity floor dust sample pairs: Flag those pairs where a floor dust sample collected post-activity had a lower lead loading than the adjoining floor dust sample collected prior to start of the activity.

Note that only lead loadings were included in the above two types of logic checks. Lead concentrations were not considered, as it is possible that R&R activity could result in either higher or lower lead concentrations in settled dust over time, according to how dust is distributed as a result of the activity.

Results

Table B-1 contains a list of sample pairs which failed one of the two logic checks in the carpet removal phase. In this phase, five of the 24 pre-/post-activity sample pairs resulted in a higher sample lead loading for the pre-activity sample than for the post-activity sample. Two of these five samples had the post-activity sample loading decrease by more than 50%. It is suspected that these five results are due to normal spatial variability, as the field sample logs revealed no unusual circumstances with sample collection for these pairs.

Seven of the 24 one-/two-hour post-activity sample pairs in the carpet removal phase resulted in a higher sample lead loading for the one-hour sample than for the two-hour sample. Of these seven samples, five had the one-hour sample location closer to the activity than the adjoining two-hour sample location. This finding supports the notion that these violations to the logic checks may be the result of spatial variability. The largest deviation between one- and two-hour results was found with a sample pair from unit 2-01, where the one-hour result (216.0 $\mu g/ft^2$) was nearly ten times larger than the two-hour result (23.0 $\mu g/ft^2$). This deviation was nearly five times greater than the next largest deviation and therefore was considered a candidate for review.

Table B-1 also contains a list of sample pairs which failed one of the two logic checks in the window replacement phase. None of the four one-/two-hour post-activity SSDC sample pairs resulted in a higher sample lead loading for the one-hour sample than for the two-hour sample. However, 9 of the 34 pre-/post-activity sample pairs resulted in a higher sample lead loading for the pre-activity sample than for the post-activity sample. Of these, the two samples with the largest negative difference were reported to MRI for further investigation but no problem was uncovered in the laboratory analysis. These sample pairs were both taken from unit 4-01. It is suspected that all other results are due to normal spatial variability, as the field sample logs revealed no unusually circumstances with sample collection for these pairs.

Table B-1. Sample Pairs in the Carpet Removal and Window Replacement Phases Whose Lead Loadings Were Flagged by Logic Checks

1. Pre-Activity/Post-Activity Floor Dust Sample Pairs: Pre-activity lead loading larger than post-activity lead loading

Unit ID	Location	Distance from Activity	Pre-Activity Sample		Post-Activity Sample		(Post-activity result) - (pre-activity result)	Ratio of Pre-activity to post-activity results
			Sample ID	Lead Loading (µg/ft^2)	Sample ID	Lead Loading (µg/ft^2)		
Carpet Removal Phase								
1-02	Hall (L2)		60058	18.78	60056	16.69	-2.09	0.89
2-01	Hall (L2)		62091	226.0	62031	54.87	-171.1	0.24
2-03	Kitchen (L1)		60411	35.04	62221	30.92	-4.12	0.88
2-05	Foyer (L1)		60701	267.7	60691	125.8	-141.9	0.47
2-05	Kitchen (L3)		60746	447.5	60796	252.4	-195.2	0.56
Window Replacement Phase								
2-01	1 (BED2)	6	60482	51.46	60332	50.97	-0.49	0.99
2-01	2 (BED2)	3	60477	157.95	60432	107.62	-50.33	0.68
2-01	1 (HAL)	0	60487	28.39	60362	19.0	-9.39	0.67
2-01	1 (HAL)	6	60522	50.60	60402	30.42	-20.18	0.60
3-01	1	3	60302	11027.00	60577	10429.00	-598.00	0.95
3-01	10	6	60612	3703.20	60322	3162.90	-540.30	0.85
4-01	13 (BED1)	0	60494	439845.0	60504	85685.11	-354159.89	0.19
4-01	13 (BED1)	3	60569	29402.00	60424	10342.00	-19060.00	0.35
4-01	17(LVG1)	0	60559	145420.0	60439	38826.0	-106594.00	0.27

2. One-hour/Two-hour Post-Activity SSDC Sample Pairs: One-hour lead loading larger than two-hour lead loading

Unit ID	Location	1-hr. Post-Activity Sample		2-hr. Post-Activity Sample		(1-hr. result) - (2-hr. result)	Ratio of 1-hr. to 2-hr. results
		Sample ID	Lead Loading (µg/ft^2)	Sample ID	Lead Loading (µg/ft^2)		
Carpet Removal Phase							
1-01	Bathroom (L2)	60017	205.7	60006	163.2	-42.5	0.79
1-01	Kitchen (L3)	60010	92.61	60002	59.94	-32.7	0.65
1-02	Hall (L3)	60064	36.50	60070	22.39	-14.1	0.61
1-02	Hall (L1)	60061	14.37	60054	12.89	-1.48	0.90
1-03	Kitchen (L3)	60101	13.35	60099	10.61	-2.74	0.79

2-01	Hall (L2)	62006	216.0	62116	23.00	-193.0	0.11
2-05	Foyer (L1)	60771	6.78	60751	5.95	-0.83	0.88

B.2.2 Formal Statistical Tests

The primary statistical approach to outlier detection was the fitting of simple linear models to estimate how individual data points deviate from the central tendency of the observed data distribution. While the specific methods differed across the three study phases, this basic approach was taken in each phase.

Methodology

In the carpet removal phase, the following analysis of variance model was fitted to the log-transformed data Y_i (i=1,...,n):

$$Y_i \qquad \mu \qquad {}_i \ , \qquad\qquad \text{(B-1)}$$

where μ represents an overall mean value and • $_i$ represents deviation from the mean. For each model fit, the absolute value of each studentized residual was compared to the upper (1-• /2n)*100 percentile of the Student-t distribution, where n is the number of residuals and • is the overall significance level. Those observations whose studentized residuals exceeded this percentile (in absolute value) were declared outliers at the • level. This test takes a Bonferroni approach, implying that the overall error rate in falsely identifying an observation as an outlier is no higher than • .

In the window replacement phase, the Grubbs outlier test was used. In the Grubbs test, the most extreme of the log-transformed data (maximum or minimum) was subtracted from the mean value, and the corresponding absolute difference was divided by the standard deviation of the log-transformed data. If the absolute value of this statistic exceeded the critical value tabulated in Grubbs (1950), the data point was declared an outlier. This procedure yields similar results to the method used in the carpet removal phase.

In the CED phase, the Grubbs test was applied to the residuals in some modelled relationship. The primary step in the outlier detection process consisted of flagging data points that differ statistically from some underlying statistical relationship with a series of covariates. Two models from Section C.4 of Appendix C were considered in this outlier test according to the type of data considered: Model (CED-1) for personal air lead concentrations, and Model (CED-3) for SSDC sample lead loadings. The minimum and maximum residuals (divided by their standard error) from the model fit were compared against critical values tabulated by Grubbs (1950). A data point was flagged as an outlier if its residual exceeded the critical values at either the • =0.05 or 0.10 level.

Each formal outlier test was run at the 0.05 and 0.10 significance levels. Significance at a lower • level denotes a more severe outlier.

Carpet Removal Phase Results

In the carpet removal phase, the study data were partitioned into several data classifications, and Model (B-1) was fitted separately to data within each classification. These classifications and their associated samples sizes are as follows:

Vacuum samples (for sample weight, loading, and concentration):

- Regular pre-activity floor dust samples (n=40);
- QC (side-by-side) pre-activity floor dust samples (n=8);
- Pre-activity carpet dust samples (n=24);
- Regular 1-hr. post-activity samples (n=64);
- Regular 2-hr. post-activity samples (n=24);
- QC (side-by-side) 1-hr. post-activity samples (n=16);
- QC (side-by-side) 2-hr. post-activity samples (n=8).

Vacuum samples (for sample weight and concentration only):

- Field blanks (n=8 for sample weight, n=7 for concentration).

Wipe samples (for sample loading):

- Regular 1-hr. post-activity samples (n=16);
- QC (side-by-side) 1-hr. post-activity samples (n=8).

Air samples (for sample loading):

- Pre-activity ambient air samples (n=8);
- During-activity ambient air samples (n=16);
- During-activity personal air samples (n=14).

Table B-2 indicates that only one data point was flagged as an outlier at the • =0.10 level: the lead concentration in a 2-hour post-activity vacuum sample taken from a stainless steel dustfall collector at unit 1-04. Its value of 29,867 µg/g was over four times higher than the next largest lead concentration among the 2-hour samples. In addition, four data points were declared outliers at the • =0.20 level:

- The vacuum field blank taken at unit 1-02 had a lead concentration of 173.2 µg/g, compared to a range of 509-1376 µg/g among the other seven vacuum field blanks in the study.

- The ambient air sample taken during the activity in unit 1-04 was 13.38 µg/m^3, while the highest reading among the other units was 5.36 µg/m^3. The pre-activity (baseline) ambient air sample result for this unit was not larger than that for the other units.

However, the two personal air sample results for this unit were the highest in the study, both falling above the OSHA worker action level of 30 µg/m^3.

Table B-2. Data Values in the Carpet Removal Phase Identified as Outliers by Formal Statistical Tests

Unit ID	Instr. Batch	Sample Prep Batch	Sample ID	Sample Medium	Sample Type	Location	Parameter	Sample value	• Level	Hi/Lo
1-02	E10193A	602	60089	Vacuum	Field blank	---	Lead conc.	173.2 µg/g	0.20	Low
1-04	V11013A	605	60106	Ambient air	During activity	Bedroom #3	Sample loading	13.38 µg/m^3	0.20	High
1-04	E10213A	604	60143	Vacuum	2-hr post-activity (SSDC)	Bathroom #1 (L1)	Lead conc.	29867 µg/g	0.10	High
2-01	E10213A	604	62011	Vacuum	1-hr post-activity (SSDC) QC side-by-side samples only)	Hall (L3)	Sample weight	0.0009 g	0.20	Low
2-01	E11303A	607	60991	Vacuum	1-hr post-activity (window sill)	Bedroom #1	Lead conc.	66776 µg/g	0.20	High

- The sample weight for a one-hour post-activity QC side-by-side sample, taken from a stainless steel dustfall collector in unit 2-01, where the weight of 0.0009 g fell below the next lowest weight of 0.0058 g among these QC side-by-side samples.

- A lead concentration of 66,776 µg/g for a one-hour post-activity vacuum sample from a window sill, compared to a range of 71.86-23,687 µg/g for the other post-activity window sill dust samples.

The field sample logs indicated no special citations which would indicate why these samples had unusually low or high results, and MRI reported no problems in the laboratory analysis after further investigation. Thus, they were included in the statistical analysis.

Window Replacement Phase Results

Outliers detected in the formal statistical tests on window replacement data are presented in Table B-3. As in the carpet removal phase, the study data were initially partitioned into several data classifications. Grubbs test was run separately on data within each classification. These classifications and their associated sample sizes were as follows:

Table B-3. Data Values in the Window Replacement Phase Identified as Outliers by Formal Statistical Tests

Unit ID	Instr. Batch	Samp. Prep. Batch	Sample ID	Sample Medium	Sample Type	Parameter	Sample Value	• Level	Hi/Lo
1-01	E11153A	614	60230	Vacuum	Window Well	Loading Lead Conc.	2311.65 2282.63	0.10 0.05	Low
4-01	E02104A	620	60359	Paint chip	Exterior	Loading Lead Conc.	7.711 7.711	0.05 0.05	Low
1-01	E11173A	616	60257	Paint chip	Exterior	Lead Conc.	27.409	0.05	Low
1-01	E11153A	614	60237	Vacuum	Pre-activity floor at 3 feet	Sample Weight	0.0055	0.10	Low

<u>Vacuum floor dust samples (for sample weight, loading, and concentration)</u>:

- Regular pre-activity samples at 0 feet (n=12);
- Regular pre-activity samples at 3 feet (n=12);
- Regular pre-activity samples at 6 feet including QC (side-by-side) samples (n=16);
- Regular 1-hr. post-activity samples at 0 feet (n=12);
- Regular 1-hr. post-activity samples at 3 feet (n=12);
- Regular 1-hr. post-activity samples at 6 feet including QC (side-by-side) samples (n=16);

<u>Vacuum Stainless Steel Dust Collector (SSDC) samples (for sample weight, loading, and concentration)</u>:

- Regular 1-hr. post-activity samples at 0 feet (n=12);
- Regular 1-hr. post-activity samples at 6 feet including QC (side-by-side) samples (n=16);
- Regular 2-hr. post-activity samples at 6 feet (n=4);

<u>Vacuum Window Well dust samples (for sample weight, loading, and concentration)</u>:

- Pre-activity window well samples (n=12);

<u>Vacuum samples (for sample weight and concentration only)</u>:

- Field blanks (n=8 for sample weight, n=7 for concentration).

Paint chip samples (for sample weight, loading, and concentration):

- Interior (n=12);
- Exterior (n=12);

Air samples (for sample loading):

- Pre-activity ambient air samples (n=4);
- During-activity ambient air samples (n=8);
- During-activity personal air samples (n=8).

Table B-3 presents those window replacement data that were identified as outliers by the formal statistical test. Only three samples were flagged as outliers at the • =0.05 level: the lead concentration for a window well sample taken at unit 1-01, the lead loading and concentration for an exterior paint chip sample taken at unit 4-01, and the lead concentration for an exterior paint chip sample at unit 1-01. In addition, one data point was declared an outlier at the • =0.10 level: the sample weight for a pre-activity 3-foot floor dust sample taken at unit 1-01.

The field sample logs indicated no special citations which would indicate why these samples had unusually extreme results. These results were reported to MRI for further investigation. For the window well sample, MRI reported the presence of insects in the sample; for the two paint chip samples, MRI reported substrate in the sample.

CED Phase Results

Outliers detected in the formal statistical tests are presented in Table B-4. Three data points were identified as outliers relative to the fitted model, two of which were associated with demolition activities. No indication was given from the field sample logs as to why these three results may have been unusual. Also, these data points were not identified in other outlier procedures, and MRI reported no problems with the laboratory analyses of these samples. As a result, they were included in statistical analyses.

Table B-4. Data Values in the CED Phase Identified as Outliers by Formal Statistical Tests

Unit ID	Instr. Batch	Sample Prep Batch	MRI ID	Sample Medium	Activity	Parameter	Data Value	• Level	Hi/Lo
Balt. (1)	E04044A	625	60709	SSDC Wipe	HVAC	Loading	285.66	0.10	Low
Balt. (2)	V04134A	630	60884	Personal Exp.	Demolition	Loading	947.05	0.05	High
Denver (3)	E05264B	634	60853	SSDC Vacuum	Demolition	Loading	53845	0.10	High

B.2.3 Graphical Review

The aim of graphical review of data for outlier detection was to visually observe those data points which deviated from the general distribution of all data points. Two plotting procedures were used to check for outliers in each of the three phases:

- the exploratory plotting and regression fitting procedure, and

- the single sample and simultaneous plotting procedure.

Exploratory plotting and regression fitting was applied to the carpet removal and window replacement phases, while single sample and simultaneous plotting were used in the window replacement and CED phases. A description of each of these procedures follows.

Exploratory Plotting and Regression Fitting: The exploratory plotting procedure characterizes the overall relationship between the results of settled dust samples that are paired in some way (e.g., wipe/vacuum sample pairs), flagging those samples whose results deviate substantially from this observed relationship.

The relationship between paired sample results is observed by creating a scatterplot of the log-transformed results of one sampling approach versus the other (e.g., wipe versus vacuum), fitting a linear regression equation to the points in the plot, and flagging those points which deviate substantially from the fitted line. Data points are flagged if the studentized residual exceeds a value of two in absolute value. The results of one or both samples represented by a given flagged point in the plot are then labeled as potential outliers.

Single Sample and Simultaneous Plotting: For single (i.e., unpaired) sample results, descriptive plots, including lognormal probability plots of lead concentration, lead loading and sample weight, and scatterplots were used to identify unusual observations.

Scatterplots were created of log-transformed loadings versus log-transformed weights or concentrations grouped into appropriate categories (e.g., by distance from activity). Possible confounding factors which could explain extreme results, such as dwelling unit, were then examined. In cases where such a factor was deemed to explain deviations, the observation was not included as an outlier. An example of a simultaneous scatterplot used to identify outliers in the single sample case is presented in Figure B-1 for paint chip sample results in the CED study. Note the high variability among Baltimore(1) samples, which excludes the observation associated with a low loading and low concentration from consideration. Dwelling unit in this case is a confounding variable. In addition, dilution factors could explain some extreme values. For example, an observation appearing as an outlier in a plot of lead concentration versus weight may not appear as an outlier in a plot of lead loading versus weight.

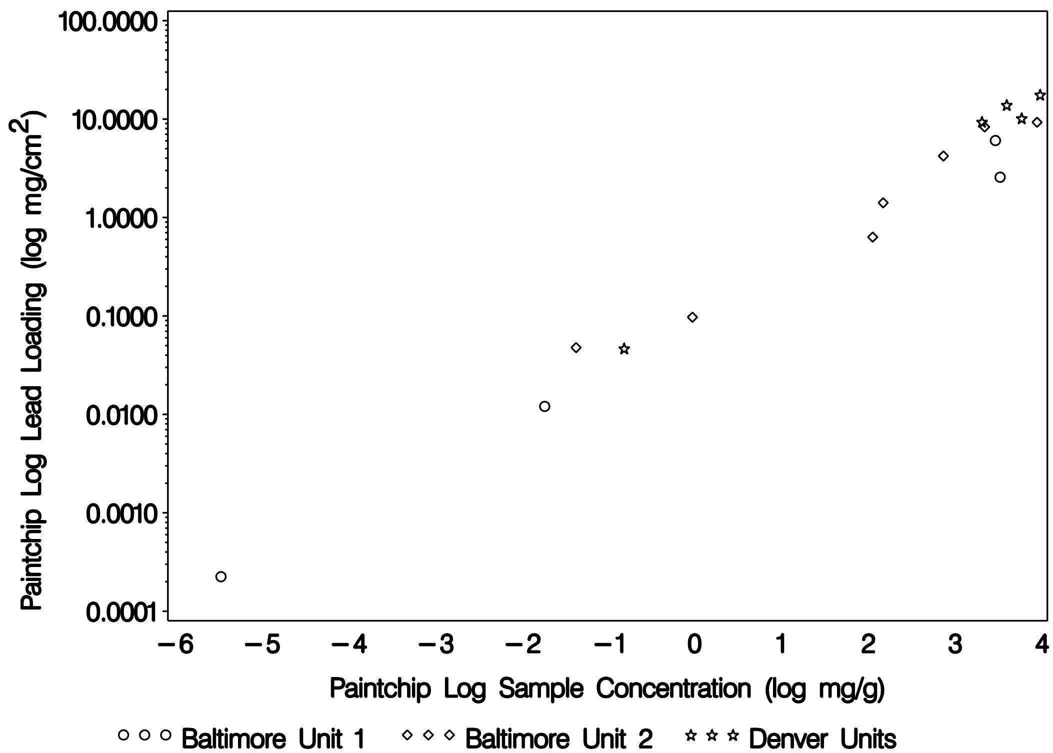


Figure B-1. **Scatterplot of Paint Chip Log Lead Loadings versus Paint Chip Log Lead Concentrations for the Demolition CED Activities**

Only data associated with "regular" samples were included in the exploratory plotting procedure for the 1-hour vs. 2-hour and vacuum vs. wipe comparisons (i.e., results for samples with a field QC purpose, such as side-by-side samples, were not included). Some of the scatterplots reviewed in this outlier analysis are found throughout this report. The regression fittings were conducted separately within the same data categories that were considered in the formal statistical tests procedure.

Carpet Removal Phase Results

Table B-5 presents those paired samples which have been flagged in the exploratory plotting and regression fitting procedure for the carpet removal phase. The pre-activity/post-activity pairs that were flagged had much larger post-activity results relative to their pre-activity results. One pair occurred in unit 1-04, which had high lead levels in all samples. In the wipe/vacuum pair that was flagged (unit 2-01, location L2) the vacuum sample loading was higher than the wipe sample loading. Note that the loading and concentration associated with the 1-hr post-activity vacuum sample were also much higher than that for the 2-hr post-activity sample at the same location. This unexpected result of observing higher loadings for a 1-hr sample compared to a 2-hr sample was flagged in the logic check procedure above. The other two 1-hr/2-hr sample pairs that were flagged had much higher results for the 2-hour sample.

Table B-5. Sample Pairs in the Carpet Removal Phase Identified as Outliers by Graphical Review and Regression Analysis

1. Pre-Activity/Post-Activity Floor Dust Sample Pairs

Unit ID	Location	Parameter	Pre-Activity Sample		Post-Activity Sample	
			Sample ID	Result	Sample ID	Result
2-05	Bathroom (L2)	Sample wgt.	60666	0.1629 g	60676	0.6285 g
1-04	Bathroom #1 (L1)	Lead loading	60128	2.61 µg/ft^2	60148	6,135 µg/ft^2
		Lead conc.	60128	90.78 µg/g	60148	20,662 µg/g

2. One-hour/Two-hour Post-Activity SSDC Sample Pairs

Unit ID	Location	Parameter	Pre-Activity Sample		Post-Activity Sample	
			Sample ID	Result	Sample ID	Result
2-03	Bathroom (L2)	Sample wgt.	62216	0.0158 g	60436	0.2245 g
2-01	Hall (L2)	Lead loading	62006	216.0 µg/ft^2	62116	23.0 µg/ft^2
		Lead conc.	62006	6990 µg/g	62116	746.7 µg/g
2-02	Sun room (L3)	Lead loading	60486	2.85 µg/ft^2	60466	54.82 µg/ft^2
		Lead conc.	60486	370.2 µg/g	60466	3807 µg/g

3. Wipe/Vacuum SSDC Sample Pairs

Unit ID	Location	Parameter	Wipe Sample		Vacuum Sample	
			Sample ID	Result	Sample ID	Result
2-01	Hallway (L2)	Lead loading	62186	23.62 µg/ft^2	62006	216.0 µg/ft^2

Window Replacement Phase Results

Table B-6 presents those results in the window replacement phase which have been flagged in the single sample and simultaneous plotting procedure.

None of the paired samples for the 2-hour versus 1-hour comparisons were identified as outliers. In addition, those paired samples for the pre-activity versus post-activity floor dust comparisons identified as outliers did not differ from outliers detected in the logic check. Therefore, paired samples are not included in Table B-6.

Table B-6. Sample Results in the Window Replacement Phase Identified as Outliers by Graphical Review and Regression Analysis

Unit ID	Instr. Batch	Sample Prep. Batch	Sample ID	Sample Medium	Sample Type	Component ID	Parameter	Sample Value	Comment
1-01	E11153A	614	60230	Window Well	Vacuum	2 (DEN)	Loading Conc.	2311.65 2282.63	Low value for loading, concentration.
1-01	E11153A E11153A	614 614	60233 60184	Window Well	Vacuum	2 (KIT) 2 (BAT)	Loading Conc. Weight Loading Conc. Weight	33287.56 43098.31 .2950 54740.95 70067.02 .2984	Unusually high concentrations and loadings for a low sample weight.
1-01 4-01 4-01	E11173A E02104A E02104A	616 620 620	60257 60344 60359	Paint chip	Exterior	2 (DEN) 17 (LVG1) 13 (BED1)	Loading Loading Loading	2.28 3.54 0.34	Low values for concentrations and loadings.
4-01 4-01	E02104A E02104A	620 620	60339 60359	Paint chip	Exterior	20 (LVG1) 13 (BED1)	Weight Conc. Weight	0.5211 146.01 0.5212	High weights: 60339 has an unusually low concentration compared to a high weight.

CED Phase Results

Although several observations appeared at the extremes of these plots for SSDC samples, distance from activity provided reasonable evidence for such deviations. For paint chip samples several observations also appeared at the extremes of these plots. However, dwelling unit provided reasonable evidence for such deviations. No observations for either the SSDC or paint chip samples deviated substantially from the linear relation expected between log transformed concentrations and loadings.

Paired samples included the nine vacuum/vacuum side-by-side pairs and the twelve vacuum/wipe side-by-side pairs. No outliers were detected when considering the relationship between paired samples.

B.2.4 <u>Outlier Summary</u>

Outliers were considered serious contenders for rejection from statistical analyses when they either failed two or more of the outlier checking procedures (logic checks, graphical review or formal statistical tests) or Battelle's field log sheets revealed some sampling protocol deviation. Only one outlier in the three phases of the R&R study was deleted from the statistical analyses. A breakdown of outlier analysis results within each phase is as follows:

<u>Carpet Removal</u> 10 sample pairs and 5 additional single samples were flagged by at least one of the above three analysis methods. Examination of the sample log sheets revealed no immediate explanation for any of the results, and no problems were uncovered with these results as a result of laboratory analysis. Therefore, none of these flagged results were removed from the statistical analysis.
<u>Window Replacement</u> 9 sample pairs and 8 additional single samples were flagged by at least one of the above three analysis methods. Examination of the sample log sheets and review of laboratory analysis documentation revealed no immediate explanation for any of the extreme results. However, one of these flagged results has been removed from the statistical analysis. The window well sample (MRI ID 60230) was flagged in both the graphical review and formal statistical test. In addition, this result appeared inconsistent with other measurements within the same unit and the same window. Thus, this sample was removed from the analyses.
<u>CED</u> Three samples were identified as possible outliers by formal statistical tests. No outliers were flagged by either graphical review or logic checks. Examination of the sample log sheets revealed no immediate explanation for these three results, and no results were excluded from statistical analysis.

APPENDIX C

STATISTICAL METHODS AND MODELS IN THE EFSS

C.0 STATISTICAL METHODS AND MODELS IN THE EFSS

In this appendix, the approaches to statistical analysis of the EFSS data are presented in detail. Section C.1 presents statistical models used in the carpet removal and window replacement phases to characterize the statistical relationship between lead exposure and predictor variables. The approach to estimating components of variation on the lead exposure data within these two phases is presented in Section C.2. Section C.3 contains the method used in the window replacement phase to estimate the effect of distance from activity on settled dust sample lead loadings. Section C.4 presents statistical methods used to characterize lead disturbance associated with various R&R activities in the CED phase. Section C.5 presents the approach to estimating lead disturbance within a 6' x 1' dustfall gradient in an effort to compare potential lead hazards in settled dust across CED activities. Section C.6 presents the methodology used to calculate 95% confidence intervals for the 50th, 75th, and 95th percentile of worker personal exposure results and for the percentage of results above the OSHA permissible exposure limit of 50 µg/m^3. Finally, Section C.7 presents the meta-analysis methodology for combining the surface preparation results with results obtained from sources independent from the R&R study.

C.1 MODELS IN THE CARPET REMOVAL AND WINDOW REPLACEMENT PHASES TO EVALUATE FACTORS OR MEASUREMENTS IN RELATION TO LEAD EXPOSURE

Methods

In the carpet removal and window replacement phases, a common statistical modeling approach was used to express the distribution of lead in dust and air as a function of pre-activity lead levels and/or other activity characteristics. Lead measurements were initially classified as to the type of exposure represented and the approach to collecting the sample (personal worker exposures, ambient air exposures, loadings from SSDC dust samples, etc.). A set of covariates were identified as potential predictors of the lead measurements within each classification. A statistical model evaluated the significance of the association between lead measurements and the covariates. A reduced form of the model was used to characterize variability (Section C.2).

For the carpet removal data, the common model form across data categories was generally loglinear, characterizing a linear relationship between the natural logarithm lead exposure measurement and a series of p (• 1) log-transformed covariates and duration of activity. The model form was

$$\log(Y_{ij}) \quad \log(\mu) \quad \sum_{k\,1}^{p} {}_k\log(X_{kij}) \quad T_i \quad H_i \quad L_{j(i)} \quad , \qquad \text{(C-1)}$$

where Y_{ij} is the lead exposure measurement for the sample taken at the jth location within the ith study unit, µ represents the (unknown) geometric mean lead measurement across the study phase, X_{kij} represents the value associated with the jth location within the ith study unit of covariate X_k, $\bullet_k$ is the (unknown) multiplicative effect of covariate X_k on the lead loading, T_i is the duration of carpet removal (minutes) in the ith unit, • is the (unknown) additive effect of activity duration on the log lead measurement, H_i represents the random effect of the i^{th} study unit (normally distributed with mean zero and variance $\bullet_u^2$), and $L_{j(i)}$ represents the random effect of the j^{th} sample location within the i^{th} study unit (normally distributed with mean zero and variance $\bullet_L^2$). Only data corresponding to "regular" (i.e., not side-by-side) samples were included in these model fits. The MIXED procedure in the SAS® System was used to fit model (C-1) to each category of lead loading data, resulting in estimates for the model parameters μ, $\bullet_1, ..., \bullet_p$, • , $\bullet_u^2$, and $\bullet_L^2$ for a given category.

For the carpet removal phase, Table C-1 lists the data categories and the covariate group considered within each category. Each data category considered a specific group of covariates X_k in model (C-1). According to the model, each covariate X_k has a multiplicative effect on the (untransformed) lead loading, with the parameter $\bullet_k$ representing the extent of the effect associated with covariate X_k. Thus, a test of whether $\bullet_k$ is significantly different from zero indicates whether the covariate X_k is significantly associated with the lead exposure measurement in the given data category. Similarly, a test of whether • is significantly different from zero indicates whether the duration of carpet removal activity is significantly associated with lead exposure.

In the window replacement phase, a model similar to Model (C-1) was fitted to lead measurements. Due to the small numbers of data points within each category of lead measurement considered, each fit of the model included only one covariate. Therefore, the model took the form

$$\log(Y_{ij}) \quad \log(\mu) \quad {}_k\log(X_{kij}) \quad H_i \quad L_{j(i)} \quad , \qquad \text{(C-1a)}$$

where the notation is interpreted in the same manner as for Model (C-1). The only exception was for ambient air lead concentrations, where the pre-activity ambient air lead concentration for the study unit was included as a covariate within each fit of model (WR-2). Multiple covariates were considered within each data category; the model was fitted a number of times equal to the number of covariates considered for the data category. Table C-2 lists the data categories and the covariates considered in the various model fits within the category. The MIXED procedure in the SAS® System was used to fit each model.

Results

Results of fitting the various models in Table C-1 on carpet removal data (models (CPT-1) to (CPT-4)) are presented in Table C-3. This table presents estimates and associated standard errors for model parameters μ, $ß_1, ..., ß_p$, and • . The estimated parameters $\bullet_k$ and • were generally not significantly different from zero at the 0.05 level, implying that their associated covariates were not statistically associated with the lead loading of the sample type of interest. However, the models were fit to a small number of data points that generally had high variability, resulting in statistical tests with low power to detect differences from zero.

Results of fitting the models in Table C-2 on window removal data (models (WR-1) to (WR-5)) are presented in Tables C-4a through C-4d. These table presents model parameter estimates and their standard errors. Table C-4a presents results from fitting model (WR-1) with different covariates to personal exposure data. Table C-4b contains results from fitting model (WR-2) with different covariates to area air data. Results from fitting models (WR-3) and (WR-4) with different covariates to SSDC settled dust lead loading data are found in Table C-4c. Finally, Table C-4d presents results from fitting model (WR-5) with different covariates to lead amounts disturbed in a 6'x1' dustfall gradient. The estimated parameters • $_k$ were generally not significantly different from zero at the 0.05 level.

Table C-1. Data Categories and Covariates Considered in Fitting Model Form (C-1) to Lead Loading Data in the Carpet Removal Phase

Model ID Number	Data Category	Covariates Included in the Model
(CPT-1)	Personal Worker Exposures (µg/m^3)	X_{1i}: Geometric mean lead loading in carpet in the ith unit. X_{2i}: Geometric mean lead loading in pre-activity floor dust samples in the ith unit. X_{3i}: Geometric mean lead loading in pre-activity window sill dust samples in the ith unit.
(CPT-2)	Area Airborne Exposures (µg/m^3)	X_{1i}: Geometric mean lead loading in carpet in the ith unit. X_{2i}: Geometric mean lead loading in pre-activity floor dust samples in the ith unit. X_{3i}: Geometric mean lead loading in pre-activity window sill dust samples in the ith unit. X_{4i}: Lead loading in the pre-activity area air sample in the ith unit.
(CPT-3)	1-hour post-activity lead loadings from floors or SSDCs (µg/ft^2)	X_{1i}: Geometric mean lead loading in carpet in the ith unit. X_{2ij}: Lead loading in the adjacent pre-activity floor dust sample (jth location within ith unit). X_{3i}: Geometric mean lead loading in pre-activity window sill dust samples in the ith unit.
(CPT-4)	1-hour post-activity lead loadings from window sills (µg/ft^2)	X_{1i}: Geometric mean lead loading in carpet in the ith unit. X_{2i}: Geometric mean lead loading in pre-activity floor dust samples in the ith unit. X_{3ij}: Lead loading in the adjacent pre-activity window sill dust sample (jth location in the ith unit).

Table C-2. Data Categories and Covariates Considered in Fitting Model Form (C-1a) to Lead Loading Data in the Window Replacement Phase

Model ID Number	Data Category	Number of Model Fits	Covariates Considered Among the Model Fits (For a given data category, each covariate was included in <u>only one</u> model fit, with the exception of area airborne exposures, where covariate X_{7ij} was included in every fit of Model (WR-2))
(WR-1)	Personal Worker Exposures ($\mu g/m^3$)	7	X_{1ij}: Pre-act. floor dust lead loading at 0 ft. from window. X_{2ij}: Pre-act. floor dust lead loading at 3 ft. from window. X_{3ij}: Pre-act. floor dust lead loading at 6 ft. from window. X_{4ij}: Pre-act. window well dust lead loading. X_{5ij}: Lead content of paint chips collected from the interior sash/frame of the window. X_{6ij}: Lead content of paint chips collected from the exterior sash/frame of the window. X_{7i}: Pre-activity ambient air lead loading in the i^{th} unit.
(WR-2)	Area Airborne Exposures ($\mu g/m^3$)	6	X_{1ij}: Pre-act. floor dust lead loading at 0 ft. from window. X_{2ij}: Pre-act. floor dust lead loading at 3 ft. from window. X_{3ij}: Pre-act. floor dust lead loading at 6 ft. from window. X_{4ij}: Pre-act. window well dust lead loading. X_{5ij}: Lead content of paint chips collected from the interior sash/frame of the window. X_{6ij}: Lead content of paint chips collected from the exterior sash/frame of the window. X_{7i}: Pre-activity ambient air lead loading in the i^{th} unit (included in <u>every</u> model fit to area airborne exposure data).
(WR-3)	1-hour post-activity lead loadings from SSDCs at zero feet from window ($\mu g/ft^2$)	6	X_{1ij}: Pre-act. floor dust lead loading at 0 ft. from window. X_{2ij}: Pre-act. floor dust lead loading at 3 ft. from window. X_{3ij}: Pre-act. window well dust lead loading. X_{4ij}: Lead content of paint chips collected from the interior sash/frame of the window. X_{5ij}: Lead content of paint chips collected from the exterior sash/frame of the window. X_{6i}: Pre-activity ambient air lead loading in the i^{th} unit.
(WR-4)	1-hour post-activity lead loadings from SSDCs at six feet from window ($\mu g/ft^2$)	6	X_{1ij}: Pre-act. floor dust lead loading at 3 ft. from window. X_{2ij}: Pre-act. floor dust lead loading at 6 ft. from window. X_{3ij}: Pre-act. window well dust lead loading. X_{4ij}: Lead content of paint chips collected from the interior sash/frame of the window. X_{5ij}: Lead content of paint chips collected from the exterior sash/frame of the window. X_{6i}: Pre-activity ambient air lead loading in the i^{th} unit.

Table C-2. Data Categories and Covariates Considered in Fitting Model Form (C-1a) to Lead Loading Data in the Window Replacement Phase

(WR-5)	Estimated lead amount in 6'x1' gradient from window	7	X_{1ij}: Pre-act. floor dust lead loading at 0 ft. from window. X_{2ij}: Pre-act. floor dust lead loading at 3 ft. from window. X_{3ij}: Pre-act. floor dust lead loading at 6 ft. from window. X_{4ij}: Pre-act. window well dust lead loading. X_{5ij}: Lead content of paint chips collected from the interior sash/frame of the window. X_{6ij}: Lead content of paint chips collected from the exterior sash/frame of the window. X_{7i}: Pre-activity ambient air lead loading in the i^{th} unit.

Table C-3. Parameter Estimates (and Standard Errors) from Fitting Statistical Models to Evaluate Factors Relating to Lead Disturbance in Carpet Removal Data

Standard errors of model parameter estimates are in parentheses.

Model Parameter(1)	Estimates from Modeling Personal-Air Lead Conc. (Model CPT-1)	Estimates from Modeling Ambient Air Lead Conc. (Model CPT-2)	Estimates from Modeling Post-Activity Floor Dust Lead Loading (Model CPT-3)	Estimates from Modeling 1-hr. Post-Activity SSDC Dust Lead Loading (Model CPT-3)	Estimates from Modeling Post-Activity Window Sill Dust Lead Loading (Model CPT-4)
µ	1.521 (5.104)	-3.666 (6.591)	5.623 * (2.383)	1.761 (2.586)	3.552 (2.890)
• 1	0.219 (0.679)	0.089 (0.497)	-0.139 (0.314)	0.078 (0.339)	-0.328 (0.392)
• 2	-0.831 (0.487)	-0.472 (0.373)	0.289 (0.209)	-0.198 (0.216)	0.173 (0.281)
• 3	-0.120 (0.492)	0.010 (0.421)	-0.463 (0.231)	-0.099 (0.251)	0.591 * (0.241)
• 4		0.021 (0.018)			
•	0.020 (0.024)	-0.421 (1.666)	0.021 (0.011)	0.020 (0.012)	0.009 (0.013)

* Estimate is significantly different from zero at the • =0.05 level.
(1) Model parameters • k correspond to covariates in the order given in Table C-1.

Table C-4a. Parameter Estimates (and Standard Errors) from Fitting Model (WR-1) to Evaluate Factors Relating to Lead Disturbance for Personal Exposure Samples in the Window Replacement Phase[1]

Covariate	Model Parameter	
	µ	• 1
Pre-activity Floor Lead Loading (0 feet)	-0.0372 (1.07)	0.271 (0.130)
Pre-activity Floor Lead Loading (3 feet)	0.122 (0.833)	0.313 (0.125)
Pre-activity Floor Lead Loading (6 feet)	0.264 (0.953)	0.298 (0.147)
Window Well Lead Loading	-6.64 (12.1)	0.739 (1.03)
Interior Paint Chip Lead Loading	1.81 (0.656)	0.253 (0.286)
Exterior Paint Chip Lead Loading	1.75 (1.81)	0.109 (0.695)
Pre-activity Ambient Air Lead Concentration	2.36 (0.899)	0.284 (0.492)

(1) Standard errors of model parameter estimates are in parentheses. See Model (C-1a) for parameter interpretation.
Note: None of the estimates are significantly different from zero at the 0.05 level.

Table C-4b. Parameter Estimates (and Standard Errors) from Fitting Model (WR-2) to Evaluate Factors Relating to Lead Disturbance for During-Activity Area Air Samples in the Window Replacement Phase[1]

Covariate	Model Parameter		
	μ	$\bullet_1$[2]	$\bullet_2$[3]
Window Well Lead Loading	-8.12 (9.45)	0.0708 (0.367)	0.713 (0.797)
Exterior Paint Chip Lead Loading	-1.07 (0.984)	0.610 (0.388)	0.821 (0.510)
Interior Paint Chip Lead Loading	0.234 (1.11)	0.0978 (0.580)	0.0458 (0.368)
Pre-activity Floor Lead Loading (0 feet)	-3.16[4] (0.819)	-0.518[4] (0.186)	0.355[4] (0.0810)
Pre-activity Floor Lead Loading (3 feet)	-2.40[4] (0.652)	-0.394 (0.164)	0.344[4] (0.0784)
Pre-activity Floor Lead Loading (6 feet)	-2.88[4] (0.756)	-5.44[4] (0.190)	0.404[4] (0.0921)

(1) Standard errors of model parameter estimates are in parentheses. See Model (C-1a) for parameter interpretation.
(2) Parameter estimate for pre-activity area air.
(3) Parameter estimate for listed covariate.
(4) Estimate is significantly different from zero at the • =0.05 level.

Table C-4c. Parameter Estimates (and Standard Errors) from Fitting Models (WR-3) and (WR-4) to Evaluate Factors Relating to Lead Disturbance for SSDCs at Zero and Six Feet from Windows Being Removed[1]

Covariate	Model Parameter	
	μ	$\bullet_1$
Zero feet		
Window Well Lead Loading	-1.82 (5.61)	1.02 (0.474)
Interior Paint Chip Lead Loading	10.1 (0.533)	0.0785 (0.226)
Exterior Paint Chip Lead Loading	10.8 (1.05)	-0.289 (0.374)
Pre-activity Floor Lead Loading (0 feet)	8.69 (1.10)	0.188 (0.132)
Pre-activity Floor Lead Loading (3 feet)	7.90 (0.851)	0.325[2] (0.123)
Pre-activity Ambient Air Lead Concentration	10.3 (0.668)	0.169 (0.365)
Six feet		
Window Well Lead Loading	4.35 (2.45)	0.120 (0.630)
Interior Paint Chip Lead Loading	5.45 (0.891)	0.0923 (0.361)
Exterior Paint Chip Lead Loading	6.44 (1.22)	-0.382 (0.427)
Pre-activity Floor Lead Loading (3 feet)	3.64 (1.52)	0.270 (0.219)
Pre-activity Floor Lead Loading (6 feet)	4.39 (1.52)	0.195 (0.229)
Pre-activity Ambient Air Lead Concentration	6.33 (0.750)	0.659 (0.410)

(1) Standard errors of model parameter estimates are in parentheses. See Model (C-1a) for parameter interpretation.
(2) Estimate is significantly different from zero at the • =0.05 level.

Table C-4d. Parameter Estimates (and Standard Errors) from Fitting Model (WR-5) Evaluate Factors Relating to Estimated Total Lead Disturbance in a Six-foot by One-foot Gradient Perpendicular to Windows Being Removed[1]

Covariate	Model Parameter	
	μ	$\bullet_1$
Total Lead		
Window Well Lead Loading	0.276 (5.22)	0.906 (0.441)
Interior Paint Chip Lead Loading	11.4[2] (0.984)	-0.269 (0.351)
Exterior Paint Chip Lead Loading	10.7[2] (0.528)	0.0871 (0.225)
Pre-activity Floor Lead Loading (0 feet)	9.38[2] (1.02)	0.189 (0.122)
Pre-activity Floor Lead Loading (3 feet)	8.59[2] (0.750)	0.326[2] (0.109)
Pre-activity Floor Lead Loading (6 feet)	9.47[2] (0.933)	0.228 (0.142)
Pre-activity Ambient Air Lead Concentration	11.1[2] (0.617)	0.249 (0.337)

(1) Standard errors of model parameter estimates are in parentheses. See Model (C-1a) for parameter interpretation.
(2) Estimate is significantly different from zero at the • =0.05 level.

C.2 ESTIMATING COMPONENTS TO TOTAL VARIABILITY IN LOG-TRANSFORMED LEAD LOADING DATA IN THE CARPET REMOVAL AND WINDOW REPLACEMENT PHASES

The models in Section C.1, used to evaluate the relationship of pre-activity lead measurements and activity characteristics to lead exposures in a given data category, contained random effects to characterize unit-to-unit variability (denoted by $\bullet_u^2$) and within-unit (i.e., location-to-location) variability (denoted by $\bullet_L^2$) in the response variable (log-transformed lead loadings). In addition, a third variance component can be characterized when results from side-by-side QC samples within a sampling location are available for analysis. This third component, denoted by $\bullet_R^2$, represents variability present in results within a sampling location at a given study unit, and could be estimated for floor dust and SSDC samples. Estimating these three variance components provides information on how one variance component dominates another relative to the total variability in the response.

The covariates within the models in Section C.1 generally were not significantly associated with lead measurements. As a result, reported estimates of the three variance components were obtained after fitting the following model to data within each of the data categories in Tables C-1 and C-2:

$$\log(Y_{ijk}) \quad \log(\mu) \quad H_i \quad L_{j(i)} \quad\quad _{k(ij)} \;, \tag{C-2}$$

where Y_{ijk} is the k^{th} replicate lead loading at the j^{th} location in the i^{th} unit, μ is an estimate of the study-wide geometric mean, H_i is a random effect of the i^{th} unit (normally distributed with mean zero and variance • $_u^2$), $L_{j(i)}$ is a random effect of the j^{th} location in the i^{th} unit (normally distributed with mean zero and variance • $_L^2$), and • $_{k(ij)}$ is a random effect of the k^{th} replicate within the j^{th} location in the i^{th} unit (normally distributed with mean zero and variance • $_R^2$). Note that for data categories without side-by-side QC sample data (e.g., personal and ambient air exposures, window-sill dust lead loadings), the variance component • $_R^2$ cannot be estimated.

Restricted maximum likelihood estimation techniques were applied to estimate the variance components • $_u^2$, • $_L^2$, and • $_R^2$ (where appropriate) using the MIXED procedure in the SAS® System. For the sample types where no side-by-side QC samples were collected, • $_R^2$ was set to zero. The total variability in log-transformed lead loadings within the data category was then assumed to be • $_u^2$+• $_L^2$+• $_R^2$. To determine the extent to which a single variance component dominated total variability, ratios of each variance component to total variability were expressed in percentage terms.

The results of fitting the variance component Model (C-2) to lead measurements are presented in Section 7A-2.2.4 for the carpet removal phase and Section 7B-2.2.4 for the window replacement phase.

C.3 MODELING THE RELATIONSHIP BETWEEN LEAD EXPOSURE AND DISTANCE FROM ACTIVITY AREA IN THE WINDOW REPLACEMENT PHASE

The sampling design of the window replacement phase specified that for each window being removed, a settled dust sample from a SSDC be collected at one hour after completion of the activity at two distances from the window (zero feet and six feet). It was desired to determine whether distance from the activity could explain the lead loadings found in the SSDC dustfall samples. The statistical model used to evaluate this relationship was

$$\log(Y_{ij}) \quad \log(\mu) \quad d_{ij} \quad H_i \quad L_{j(i)} \;, \tag{C-3}$$

where d_{ij} represents the distance from the window of the j^{th} location within the i^{th} study unit, ß is the (unknown) additive effect of d_{ij} on the log lead measurement $\log(Y_{ij})$, and the remaining model parameters are interpreted in the same manner as model (C-1a) in Section C.1. Thus, a test of whether the parameter • is significantly different from zero indicates whether the distance is significantly associated with the SSDC lead loadings.

Results of fitting model (C-3) to the SSDC lead loadings in the window replacement phase are presented and discussed in Section 7B-2.2.3.

C.4 MODELS IN THE CED PHASE TO EVALUATE FACTORS OR MEASUREMENTS IN RELATION TO LEAD EXPOSURE

Section 7C presents the results of several statistical models for lead exposure data from the CED phase of the EFSS. These models were used to:

- characterize the statistical relationship between personal exposure to airborne lead and predictor variables such as target activity, substrate, and pre-activity lead levels; and

- explain the lead loading in settled dust as a function of distance, target activity, substrate, and pre-activity lead levels.

This section presents the statistical methodology upon which the results of Section 7C were based.

Like the models in Section C.1, the characterization of the distributions of lead in air, settled dust, and paint in the CED phase are based on linear models that describe the natural logarithm of the observed lead loadings as a function of one or more covariates, or predictor variables. The models also characterize total variability in the response as a function of several sources of variability, such as worker-to-worker variability and unit-to-unit variability.

The MIXED procedure in the SAS® System was used to fit the models to relate the measured lead loadings to appropriate explanatory variables. This procedure accommodates both fixed and random effects factors, as well as a variety of statistical dependence structures.

In describing the model fitting procedure, the following terms are used:

Subunit -- a portion of a dwelling unit where a specific CED activity was performed. This can be an entire room or a portion of a room.

Experimental unit -- the occurrence of a specific CED activity (i) within a subunit (k) of a dwelling unit (j). This is generally represented by EU_{ijk}.

Table C-5 provides a summary of the statistical models applied to CED data. These models were generally fit separately to each combination of target activity and substrate. The models appear in the order that they are referenced in Section 7C.

Table C-5. Statistical Models Considered in the CED Phase to Characterize Lead Loadings

Model	Response Variable[(1)]	Model Fit Separately By	Predictor Variables	Variance Components
CED-1	$\log(PEM_{ijkl})$	Activity/Substrate	None	• Unit • Worker • Task(Unit) • Error
CED-2	$\log(PEM_{ijkl})$	Activity	Substrate	• Worker • Error
CED-3 CED-4	$\log(Dust_{ijkl})$	Exper. Unit	Distance	• Intercept • Slope • Error
CED-5	$\log(Dust_{ijkl})$	Activity/Substrate	Distance	• Intercept • Slope • Error
CED-6	$\log(Dust_{ijkl})$	Activity	Distance, Substrate	• Intercept • Slope • Error
CED-7	$\log(PEM_{ijkl})$	Activity	Substrate, Paint	• Worker • Error
CED-8	$\log(Dust_{ijkl})$	Activity	Distance, Substrate, Paint	• Intercept • Slope • Error

(1) PEM = personal exposure monitor result ($\mu g/m^3$).
Dust = dust lead loading ($\mu g/ft^2$).

Each model in Table C-5 is presented in further detail in the following subsections, along with estimates of model parameters obtained from fitting the models.

C.4.1 Variance Components Associated with Worker Personal Exposure Levels

Model

To characterize the components of variability in personal exposure measurements, the following model was fit separately for each combination of target activity and substrate (denoted by subscript i):

$$\log(PEM_{ijkl}) = \mu_i + Unit_j + Task_k(Unit_j) + Worker_l + e_{ijkl} \qquad \text{(CED-1)}$$

where

PEM_{ijkl} is the personal exposure measurement ($\mu g/m^3$) for the l^{th} worker within subunit k of the j^{th} dwelling unit;

μ_i is the mean of the log(PEM) responses over the activity;

$Unit_j$ is a random effect attributable to the j^{th} dwelling unit, having standard deviation $\bullet_{Unit}$;

$Task_k(Unit_j)$ is a random effect attributable to the occurrence of subunit k within dwelling unit j, having standard deviation $\bullet_{Task(Unit)}$;

$Worker_l$ is a random effect attributable to the l^{th} worker performing the activity, having standard deviation $\bullet_{Worker}$; and

e_{ijkl} is a random term representing replicate variability and measurement error, having standard deviation $\bullet_{Error}$.

The four random effects are each assumed to be independent from each other and have a normal distribution with mean zero. In addition, the random effect $Worker_l$ is assumed to be crossed with $Unit_j$ and $Task_k(Unit_j)$.

In the above model, $\bullet_{Unit}$ is interpreted as a measure of heterogeneity that exists between different dwelling units and is estimable only if multiple dwelling units were considered. The component $\bullet_{Task(Unit)}$ is interpreted as a measure of the variability that exists between occurrences of activity (i) in multiple subunits (k) within dwelling unit (j), and is estimable only if data for multiple subunits exist. The component $\bullet_{Worker}$ is interpreted as a measure of heterogeneity between different workers performing the same activity, and is estimable only when data for multiple workers at a given activity are present.

Results

For each activity, Table C-6 presents estimates of the geometric mean and those variance components which were estimable as a result of fitting model (CED-1) to log-transformed personal exposure data.

Table C-6. Estimated Variance Components and Geometric Mean Resulting from Fitting Model (CED-1) to Personal Exposure Results for a Given CED Activity/Substrate Combination

Model (CED-1): $\log(PEM_{ijkl}) = \mu_i + Unit_j + Task_k(Unit_j) + Worker_l + e_{ijkl}$

CED Activity	Substrate	Model parameter estimates				
		Geometric Mean	$\bullet_{Worker}$	$\bullet_{Unit}$	$\bullet_{Task(Unit)}$	$\bullet_{Error}$
Drilling	Plaster	6.76	0.434			0.313
	Wood	15.15	0.000			1.295
Sawing	Plaster	109.99				1.108
	Wood	545.84	0.000			0.380
Sanding (hand)	Wood	254.06	0.000	0.860		0.589
Sanding (power)	Wood	570.82				
Door Modification	Wood	590.29	0.896			0.847
Component Removal	Wood	343.84				0.045
HVAC	Duct	49.62		0.147		0.101

Demolition	Plaster	107.83		0.463	0.451	0.475
Cleanup	Plaster	24.46				0.550
	Wood	102.36				0.205

C.4.2 <u>Differences in Worker Personal Exposure Lead Levels that are Attributable to Substrate (Plaster Versus Wood)</u>

Model (CED-1) in the previous subsection was fitted to personal exposure lead levels for a given combination of CED activity and substrate to estimate variance components in these levels. For three of the activities (drilling, sawing, and cleanup), separate modeling results were obtained for wood and plaster substrates (Table C-6). For these activities, it is desired to estimate differences in modeled worker exposure lead levels that are attributable to wood versus plaster substrates.

Model

The following model was fit separately <u>for drilling, sawing, and cleanup activities</u> to characterize differences due to substrate:

$$\log(PEM_{ijkl}) = \mu_i + \bullet_i \bullet \text{Plaster}_{ijk} + \text{Worker}_l + e_{ijkl}\ , \qquad \text{(CED-2)}$$

where

PEM_{ijkl} is the personal exposure lead concentration ($\mu g/m^3$) for the l^{th} worker within subunit k of the j^{th} dwelling unit;

μ_i is the mean of the log(PEM) responses over the activity;

$\bullet_i$ measures the additive effect on the log(PEM) response that results from performing the i^{th} CED activity on plaster;

Plaster_{ijk} =1 if EU_{ijk} corresponds to performing an activity that disturbed a painted plaster surface, and equals zero otherwise;

Worker_l is a random effect attributable to the l^{th} worker performing the activity, having standard deviation $\bullet_{\text{Worker(i)}}$; and

e_{ijkl} is a random term representing replicate variability and measurement error, having standard deviation $\bullet_{\text{Error(i)}}$.

The two random effects are each assumed to be independent from each other and have a normal distribution with mean zero. Note that those random effects included in model (CED-1) but not in model (CED-2) were associated with variance components which were not estimable for any of these three CED activities.

In model (CED-2), • $_{\text{Worker (i)}}$ is interpreted as a measure of heterogeneity between different workers performing the ith activity, and the error term • $_{\text{Error (i)}}$ represents replication and measurement error.

Results

For drilling, sawing, and cleanup activities, Table C-7a presents estimates of model parameters resulting from fitting model (CED-2) to log-transformed personal exposure data.

Table C-7a. Parameter Estimates from Fitting Model (CED-2) to Personal Exposure Results for Drilling, Sawing, and Cleanup Activities

Model (CED-2): $\log(PEM_{ijkl}) = \mu_i +$ • $_i$• $Plaster_{ijk} + Worker_l + e_{ijkl}$

CED Activity (i)	Parameter estimates (standard errors in parentheses)			
	μ_i	• $_i$	• $_{\text{Worker (i)}}$	• $_{\text{Error (i)}}$
Drilling	2.696 (0.416)	-0.798 (0.529)	0.428	0.938
Sawing	6.302 (0.232)	-1.602 (0.465)	0.000	0.570
Cleanup	4.991 (0.391)	-1.703 (0.248)	0.538	0.252

Note that model (CED-1) provides separate estimates of • $_{\text{Worker}}$ and • $_{\text{Error}}$ for plaster and wood substrates, while model (CED-2) provides a common estimate for these two variance components over both substrates. As a result, model (CED-2) can be considered a reduced version of model (CED-1), as it has two fewer parameters. A likelihood ratio testing procedure has been applied to assess the adequacy of the model (CED-2) over model (CED-1). The results of this testing procedure are presented in Table C-7b.

Table C-7b. Results of the Likelihood Ratio Testing Procedure for Comparing Model (CED-2) Relative to Model (CED-1)

CED Activity	-2*log(L)			Likelihood Ratio Test Statistic	Degrees of Freedom	P-Value
	Model (CED-1): Plaster	Model (CED-1): Wood	Model (CED-2)			
Drilling	8.2874	22.0721	35.0591	4.6996	2	0.095
Sawing	3.7361	6.3087	12.7690	2.7242	2	0.256
Cleanup	5.6944	0.3614	6.1779	0.1221	2	0.941

The results of the likelihood ratio testing procedure demonstrate no statistical differences between the two models at the 0.05 level of significance for any of the three CED activities. Therefore, model (CED-2) provides an adequate description of the data while estimating the substrate effect on worker personal exposures to airborne lead.

C.4.3 Association Between Potential Lead Hazard to Occupants and CED Activity/Substrate Combinations

The goal of the statistical analysis of lead loadings in settled dust samples from stainless steel dustfall collectors (SSDCs) is to characterize the potential lead hazard to occupants that may result from the dust and debris generated by a given CED activity. SSDCs were placed at varying distances from a surface being disrupted by an activity, in order to measure the amount of lead generated by each CED activity. As a result, the effect that distance has on potential lead exposure to occupants that results from a specific CED activity can be estimated.

Model

For a given experimental unit EU_{ijk} (i.e., the occurrence of activity i within subunit k of dwelling unit j), the relationship between lead loadings from SSDC samples and distance from activity was expressed by the following linear regression model:

$$\log(Dust_{ijkl}) = \bullet^{*}_{0(ijk)} + \bullet^{*}_{1(ijk)} \bullet\ Distance_{ijkl} + Error_{ijkl}\ , \qquad \text{(CED-3)}$$

where

$\log(Dust_{ijkl})$ is the log-transformed dust lead loading (µg/ft^2) associated with the l^{th} SSDC sample occurring at EU_{ijk};

$\bullet^{*}_{0(ijk)}$ is the unknown intercept term;

$\bullet^{*}_{1(ijk)}$ is the unknown slope term, relating the change in $\log(Dust_{ijkl})$ associated with a unit change in distance;

$Distance_{ijkl}$ is the distance that the l^{th} SSDC has been placed from the surface being disrupted by the activity in EU_{ijk}; and

$Error_{ijkl}$ is a random term representing replicate variability and measurement error, having standard deviation $\bullet_{Error(ijk)}$.

Note that model (CED-3) expresses the untransformed lead loading data as an exponential function:

$$Dust_{ijkl} = \exp\{\bullet^{*}_{0(ijk)}\} \bullet \exp\{\bullet^{*}_{1(ijk)} \bullet\ Distance_{ijkl}\} \bullet\ e_{ijkl} \qquad \text{(CED-4)}$$

where e_{ijkl} represents multiplicative error in the model.

Although model (CED-3) implies separate fits to data for each experimental unit EU_{ijk}, our goal is to determine an overall relationship between lead loadings and distance from activity for an entire CED activity/substrate combination. Two approaches were used to achieve this goal:

1. **Two Stage Model Approach**. Fit model (CED-3) independently to data for each experimental unit EU_{ijk}. We then assume that the vectors of parameter estimates ($\hat{\ }^{*}_{0(ijk)}$, $\hat{\ }^{*}_{1(ijk)}$) obtained from each fit are a set of independent and identically distributed observations from a multivariate normal distribution with mean ($\bullet^{*}_{0i}$, $\bullet^{*}_{1i}$) and covariance matrix $\bullet_{\bullet *i}$. The mean and covariance matrix are estimated based on the observed parameter estimates.

2. **Population Model Approach**. The following random effects model is fit separately for each combination of CED activity and substrate (denoted by i):

$$\log(Dust_{ijkl}) = \bullet_{0i} + \bullet_{1i} \bullet\ Distance_{ijkl} + R_{0ijk} + R_{1ijk} \bullet\ Distance_{ijkl} + e_{ijkl}, \qquad \text{(CED-5)}$$

where, in addition to the terms in model (CED-3),

$\bullet_{0i}$ is the population average intercept for activity i;

$\bullet_{1i}$ is the population average slope relating $\log(Dust_{ijkl})$ to $Distance_{ijkl}$ for activity i,

$R_{0ijk} = (\bullet^{*}_{0(ijk)} - \bullet_{0i})$ is a random effect representing the difference between $\bullet_{0i}$ and $\bullet^{*}_{0(ijk)}$ (the intercept for EU_{ijk} under model (CED-3));

$R_{1ijk} = (\bullet^{*}_{1(ijk)} - \bullet_{1i})$ is a random effect representing the difference between $\bullet_{1i}$ and $\bullet^{*}_{1(ijk)}$ (the slope for EU_{ijk} under model (CED-3)); and

e_{ijkl} is the error term associated with this model.

Across experimental units, the vectors (R_{0ijk}, R_{1ijk}) are assumed to be independent and bivariate-normally distributed with mean (0,0) and covariance $\bullet_{Ri}$. In addition, the error term e_{ijkl} is assumed to be normally distributed with mean zero and standard deviation $\bullet_{Error\ (i)}$.

Results

Both approaches were applied to the settled dust data for each CED activity/substrate combination to obtain an overall estimate of the linear relationship between log-transformed lead loading and distance from activity. The results are given in Table C-8.

Table C-8 shows that the slope and intercept estimates and their associated standard errors are very consistent between the two statistical approaches for each CED activity/substrate combination. As a result, the population model approach (i.e., fitting model (CED-5)) was taken in the final characterization.

The estimated relationship between lead loading and distance for a given CED activity was later used to quantify the amount of lead disturbed in a 6'x1' dustfall gradient from the surface being disrupted. The dustfall gradient approach is presented in Section C.5.

Table C-8. Estimates of the Intercept and Slope (and Associated Standard Errors) from the Two Stage and the Population Models of Settled Dust Lead Loading as a Function of Distance

			Two Stage Approach		Population Model Approach	
Target Activity	**Substrate**	**Number of EU_{ijk}'s**	$\bullet^{*}_{0i}$ (se($\bullet_{0i}$))	$\bullet^{*}_{1i}$ (se($\bullet_{1i}$))	$\bullet_{0i}$ (se($\bullet_{0i}$))	$\bullet_{1i}$ (se($\bullet_{1i}$))
Drilling	Plaster	4	10.596 (1.133)	-1.718 (0.368)	10.484 (1.096)	-1.671 (0.344)
Drilling	Wood	7	12.921 (0.497)	-1.486 (0.083)	12.877 (0.602)	-1.472 (0.121)
Sawing	Plaster	2	11.286 (1.250)	-0.941 (0.141)	11.249 (1.203)	-0.929 (0.247)
Sawing	Wood	6	12.631 (0.472)	-0.668 (0.117)	12.631 (0.474)	-0.668 (0.117)
Abrasive Sanding	Wood	3	11.576 (0.757)	-0.350 (0.025)	11.522 (0.737)	-0.342 (0.047)
Door Modification	Wood	6	11.126 (0.795)	-0.422 (0.098)	11.099 (0.707)	-0.417 (0.094)
HVAC Removal	Duct	2	7.951 (2.304)	-0.351 (0.214)	8.080 (2.207)	-0.375 (0.226)
Demolition	Plaster	9	9.218 (1.062)	-0.320 (0.114)	8.775 (0.839)	-0.263 (0.071)

C.4.4 Differences in the Relationship Between Lead in Settled Dust and Distance that can be Attributed to Substrate (Plaster Versus Wood)

Model (CED-5) in the previous subsection was fitted to SSDC lead loadings for a given combination of CED activity and substrate to characterize the relationship between lead loading and distance from the activity. For two of the activities (drilling and sawing), separate modeling results were obtained for wood and plaster substrates. For these activities, it is desired to estimate differences in the relationship with distance that is attributable to wood versus plaster substrates.

Model

The following model was fit separately <u>for drilling and sawing activities</u> to characterize differences due to substrate:

$$\log(\mathrm{Dust}_{ijkl}) = \bullet^{(W)}_{0i} + \bullet^{(W)}_{1i}\bullet \mathrm{Distance}_{ijkl} + \mathrm{Plaster}_{ijk}\,[\bullet^{(P\text{-}W)}_{0i} + \bullet^{(P\text{-}W)}_{1i}\bullet \mathrm{Distance}_{ijkl}] + [1-\mathrm{Plaster}_{ijk}]\,[R^{(W)}_{0ijk} + R^{(W)}_{1ijk}\bullet \mathrm{Distance}_{ijkl}] + \mathrm{Plaster}_{ijk}\,[R^{(P)}_{0ijk} + R^{(P)}_{1ijk}\bullet \mathrm{Distance}_{ijkl}] + e_{ijkl}, \qquad \text{CED-6}$$

where

$\log(\mathrm{Dust}_{ijkl})$ is the log-transformed dust lead loading (µg/ft^2) associated with the l^{th} SSDC sample occurring at EU_{ijk};

$\bullet^{(W)}_{0i}$ is the population average intercept for activity i when performed on wood surfaces;

$\bullet^{(W)}_{1i}$ is the population average slope relating $\log(\mathrm{Dust}_{ijkl})$ to $\mathrm{Distance}_{ijkl}$ for activity i when performed on wood surfaces;

$\mathrm{Distance}_{ijkl}$ is the distance that the l^{th} SSDC has been placed from the surface being disrupted by the activity in EU_{ijk};

$\mathrm{Plaster}_{ijk} = 1$ if EU_{ijk} corresponds to performing an activity that disturbed a painted plaster surface, and equals zero otherwise;

$\bullet^{(P\text{-}W)}_{0i}$ is the population average difference in intercept attributable to substrate (Plaster-Wood) for activity i;

$\bullet^{(P\text{-}W)}_{1i}$ is the population average difference in slope relating $\log(\mathrm{Dust}_{ijkl})$ to $\mathrm{Distance}_{ijkl}$ attributable to substrate (Plaster-Wood) for activity i;

$R^{(W)}_{0ijk} = (\bullet^{*}_{0(ijk)} - \bullet^{(W)}_{0i})$ is a random effect which explains the difference between $\bullet^{(W)}_{0i}$ and $\bullet^{*}_{0(ijk)}$ (the intercept in model (CED-3) for EU_{ijk});

$R^{(W)}_{0ijk} = (\bullet^{*}_{1(ijk)} - \bullet^{(W)}_{1i})$ is a random effect which explains the difference between $\bullet^{(W)}_{1i}$ and $\bullet^{*}_{1(ijk)}$ (the slope in model (CED-3) for EU_{ijk});

$R^{(P)}_{0ijk} = (\bullet^{*}_{0(ijk)} - \bullet^{(P)}_{0i})$ is a random effect which explains the difference between $\bullet^{(P)}_{0i}$ and $\bullet^{*}_{0(ijk)}$;

$R^{(P)}_{0ijk} = (\bullet^{*}_{1(ijk)} - \bullet^{(P)}_{1i})$ is a random effect which explains the difference between $\bullet^{(P)}_{1i}$ and $\bullet^{*}_{1(ijk)}$; and

e_{ijkl} is the error term.

The vectors of random effects ($R^{(W)}_{0ijk}$, $R^{(W)}_{1ijk}$) are assumed to be independent and bivariate-normally distributed with mean (0,0) and covariance matrix $\bullet_{R(W)i}$. The vector random effects ($R^{(P)}_{0ijk}$, $R^{(P)}_{1ijk}$) are assumed to be independent and bivariate-normally distributed with mean (0,0) and covariance matrix $\bullet_{R(P)i}$. The error term e_{ijkl} is assumed to be normally distributed with mean zero and standard deviation $\bullet_{Error\ (i)}$.

Results

Table C-9a presents the parameter estimates that result from fitting model (CED-6) to lead loading data separately for drilling and sawing activities.

Table C-9a. Parameter Estimates from Fitting Model (CED-6) to Settled Dust Lead Loadings for Drilling and Sawing Activities

Model CED-6:

$$\log(Dust_{ijkl}) = \bullet^{(W)}_{0i} + \bullet^{(W)}_{1i} \bullet \ Distance_{ijkl} + Plaster_{ijk}\,[\bullet^{(P-W)}_{0i} + \bullet^{(P-W)}_{1i} \bullet \ Distance_{ijkl}] + (1-Plaster_{ijk})\,[R^{(W)}_{0ijk} + R^{(W)}_{1ijk} \bullet \ Distance_{ijkl}] + Plaster_{ijk}\,[R^{(P)}_{0ijk} + R^{(P)}_{1ijk} \bullet \ Distance_{ijkl}] + e_{ijkl}$$

CED Activity	$\bullet^{(W)}_{0i}$	$\bullet^{(W)}_{1i}$	$\bullet^{(P-W)}_{0i}$	$\bullet^{(P-W)}_{1i}$	$R^{(W)}_{0ijk}$ Std Dev.	$R^{(W)}_{1ijk}$ Std Dev.	$R^{(P)}_{0ijk}$ Std Dev.	$R^{(P)}_{1ijk}$ Std Dev	$\bullet_{Error\ (i)}$
Drilling	12.884 (0.558)	-1.474 (0.110)	-2.536 (1.175)	-0.133 (0.321)	0.543	0.000	1.490	0.422	1.402
Sawing	12.631 (0.553)	-0.668 (0.127)	-1.350 (1.342)	-0.271 (0.254)	0.501	0.179	1.282	0.000	1.253

Note that model (CED-5) provides separate estimates of $\bullet_{Error}$ for plaster and wood substrates, while model (CED-6) provides a common estimate over both substrates. As a result, model (CED-6) can be considered a reduced version of model (CED-5), as it has one fewer parameter. A likelihood ratio testing procedure has been applied to assess the adequacy of the model (CED-6) over model (CED-5). The results of this testing procedure are presented in Table C-9b.

Table C-9b. Results of the Likelihood Ratio Testing Procedure for Comparing Model (CED-6) to Model (CED-5)

CED Activity	-2*log(L)			Likelihood Ratio Test Statistic	Degrees of Freedom	P-Value
	Model (CED-6): Plaster	Model (CED-6): Wood	Model (CED-5)			
Drilling	69.8120	135.3740	208.0132	2.8272	1	0.093
Sawing	36.6159	102.2258	139.8868	1.0451	1	0.307

The results of the likelihood ratio testing procedure demonstrate no statistical differences between the two models at the 0.05 level of significance for either CED activity. As a result, model (CED-6) provides an adequate description of the data while estimating the substrate effect on potential occupant exposures to lead in settled dust.

C.4.5 Investigating the Substrate Effect on Worker Personal Exposure Monitoring Results after Adjusting for the Effects of Pre-activity Paint Lead Loading

For three CED activities (drilling, sawing, and cleanup), model (CED-2) presented in Section C.4.2 investigated the difference in worker exposure to airborne lead that is attributable to substrate effects (wood versus plaster). The results of that analysis demonstrated a potential substrate effect, although it was not statistically significant at the 0.05 level. One cause for the substrate effect was higher paint lead loadings on wood surfaces in comparison to plaster surfaces. By adjusting model (CED-2) to include an effect of paint lead loading, we can investigate whether this cause is appropriate.

Model

The following random effects model, fit separately to each of the three activities (denoted by i), was used to measure differences in the response of worker exposure to airborne lead that are attributable to substrate after adjusting for the effect of paint lead loading:

$$\log(PEM_{ijkl}) = \mu_i + \bullet_{0i} \bullet Paint_{ijk} + \bullet_{i} \bullet Plaster_{ijk} + Worker_l + e_{ijkl}, \qquad \text{(CED-7)}$$

where the model terms have the same interpretation as in model (CED-2), with the following addition:

- $\bullet_{0i}$ measures the effect of paint lead loading on the log(PEM) response for activity i.

Results

Table C-10 presents the parameter estimates and associated standard errors from model (CED-7).

Table C-10. Parameter Estimates from Fitting Model (CED-7) to Personal Exposure Results for Drilling, Sawing, and Cleanup Activities

Model CED-7: $\log(PEM_{ijkl}) = \mu_i + \bullet_{0i} \bullet Paint_{ijk} + \bullet_{1i} \bullet Plaster_{ijk} + Worker_l + e_{ijkl}$

CED Activity	Parameter estimates (standard errors in parentheses)				
	μ_i	$\bullet_{0i}$	$\bullet_{1i}$	$\bullet_{Worker (i)}$	$\bullet_{Error (i)}$
Drilling	1.916 (0.593)	0.109 (0.064)	-0.374 (0.602)	0.079	0.938
Sawing	6.238 (0.508)	0.009 (0.061)	-1.556(0.597)	0.000	0.623

C.4.6 Investigating the Substrate Effect on the Relationship Between Lead Loading in Settled Dust and Distance After Adjusting for the Effects of Pre-Activity Paint Lead Loading

For two CED activities (drilling and sawing), model (CED-6) presented in section C.4.4 investigated the difference in lead loadings from SSDC samples that is attributable to substrate (wood versus plaster). The results of that analysis demonstrated a potential substrate effect, although it was not statistically significant at the 0.05 level, indicating higher lead loadings in settled dust for activities which disturbed a lead-painted wood surface. One cause for the substrate effect was higher paint lead loadings on wood surfaces in comparison to plaster surfaces. By adjusting model (CED-2) to include an effect of paint lead loading, we can investigate whether this cause is appropriate.

Model

The following model was used to measure differences in lead loadings from SSDCs that are attributable to substrate within drilling and sawing activities (denoted by i), after adjusting for the effect of paint lead loading:

$$\log(Dust_{ijkl}) = \bullet^{(W)}_{0i} + \bullet^{(W)}_{1i} \bullet Distance_{ijkl} + Plaster_{ijk}[\bullet^{(P-W)}_{0i} + \bullet^{(P-W)}_{1i} \bullet Distance_{ijkl}] + \bullet_{i} \bullet Paint_{ijk} + [1-Plaster_{ijk}][R^{(W)}_{0ijk} + R^{(W)}_{1ijk} \bullet Distance_{ijkl}] + Plaster_{ijk}[R^{(P)}_{0ijk} + R^{(P)}_{1ijk} \bullet Distance_{ijkl}] + e_{ijkl}, \tag{CED-8}$$

where the model terms have the same interpretation as in model (CED-6), with the following addition:

$\bullet_i$ measures the effect of paint lead loading on the log-transformed lead loading for activity i.

Results

Table C-11 presents the parameter estimates that result from fitting model (CED-8) to drilling and sawing activity data.

Table C-11. Parameter Estimates from Fitting Model (CED-8) to SSDC Lead Loading Data for Drilling and Sawing Activities

Model CED-8:

$$\log(\text{Dust}_{ijkl}) = \bullet^{(W)}_{0i} + \bullet^{(W)}_{1i}\bullet\ \text{Distance}_{ijkl} + \text{Plaster}_{ijk}\,[\bullet^{(P\text{-}W)}_{0i} + \bullet^{(P\text{-}W)}_{1i}\bullet\ \text{Distance}_{ijkl}] + \bullet_{i}\bullet\ \text{Paint}_{ijk} + (1-\text{Plaster}_{ijk})\,[R^{(W)}_{0ijk} + R^{(W)}_{1ijk}\bullet\ \text{Distance}_{ijkl}] + \text{Plaster}_{ijk}\,[R^{(P)}_{0ijk} + R^{(P)}_{1ijk}\bullet\ \text{Distance}_{ijkl}] + e_{ijkl}$$

CED Activity	$\bullet^{(W)}_{0i}$	$\bullet^{(W)}_{1i}$	$\bullet^{(P\text{-}W)}_{0i}$	$\bullet^{(P\text{-}W)}_{1i}$	$\bullet_{i}$	$R^{(W)}_{0ijk}$ Std Dev.	$R^{(W)}_{1ijk}$ Std Dev.	$R^{(P)}_{0ijk}$ Std Dev.	$R^{(P)}_{1ijk}$ Std Dev	$\bullet_{\text{Error (i)}}$
Drilling	10.991 (0.980)	-1.480 (0.314)	-0.730 (1.329)	-0.160 (0.412)	0.258 (0.114)	0.520	0.047	1.415	0.363	1.301
Sawing	11.554 (0.724)	-0.668 (0.128)	-0.595 (1.359)	-0.268 (0.278)	0.148 (0.066)	0.488	0.186	1.260	0.000	1.236

C.5 QUANTIFYING LEAD DISTURBANCE IN A 6' X 1' DUSTFALL GRADIENT

As stated earlier, the goal of the statistical analysis of settled dust lead-loadings is to determine the potential occupant exposure to lead which results from each R&R activity. Fitting the models in Sections C.3 and C.4 resulted in a prediction curve for each R&R activity. This curve predicts the average amount of lead in settled dust that is expected to fall within different distance intervals. For the i^{th} activity, this curve has the following form:

$$\text{Lead in Dust } (\mu g/ft^2) = \exp(\bullet_{0i})\bullet\ \exp(\bullet_{1i}\bullet\ \text{Distance})$$

and is estimated by estimating the model parameters $\bullet_{0i}$ and $\bullet_{1i}$. By integrating two areas underneath this estimated curve, we obtain two estimates of lead disturbance:

- area underneath the curve from zero to one foot distance from the activity (i.e., an estimate of the expected lead-loading of an SSDC located adjacent to the activity).

- area underneath the curve from five to six feet distance from the activity.

The measure that was chosen to represent the potential occupant exposure to lead in settled dust for each CED Activity is a 6'×1' gradient lead-loading, which is obtained by integrating the area underneath the estimated curve from zero to six feet distance from the activity.

The parameter estimates $\hat{\ }_{0i}$ and $\hat{\ }_{1i}$ are obtained from a random effects regression model. We assume that they jointly follow a multivariate normal distribution with mean ($\bullet_{0i}$ and $\bullet_{1i}$) and covariance $\bullet_{\cdot\, i}$. To obtain an estimate of the 6'×1' gradient lead-loading (and associated standard error) for each CED activity we used the Multivariate Delta Method (Bishop, Fienberg and Holland 1975, page 492):

> If (X_1,X_2) follow a multivariate normal distribution with mean (μ_1,μ_2) and variance Σ, then a continuous and differentiable function of $X_1$and X_2, $f(X_1,X_2)$ has the following asymptotic distribution:
>
> $f(X_1,X_2)$ is asymptotically distributed with mean $f(\mu_1,\mu_2)$ and variance $[df/d(\mu_1,\mu_2)]\Sigma[df/d(\mu_1,\mu_2)]'$.

In our estimates of the 6'×1' gradient lead-loading (and associated standard error) for each CED activity, $f(\hat\beta_{0i},\hat\beta_{1i})$ has the following form:

$$f(\hat\beta_{0i},\hat\beta_{1i}) = \int_0^6 \exp(\hat\beta_{0i}+\hat\beta_{1i}x)dx = \frac{\exp(\hat\beta_{0i}+6\hat\beta_{1i})-\exp(\hat\beta_{0i})}{\hat\beta_{1i}}$$

and $[df/d(\beta_{0i},\beta_{1i})]$ has the following form:

$$df/d(\hat\beta_{0i},\hat\beta_{1i}) = \left[\left(\frac{\exp(\hat\beta_{0i}+6\hat\beta_{1i})-\exp(\hat\beta_{0i})}{\hat\beta_{1i}}\right),\left(-\frac{\exp(\hat\beta_{0i}+6\hat\beta_{1i})-\exp(\hat\beta_{0i})}{\hat\beta_{1i}^2}+\frac{6\exp(\hat\beta_{0i}+6\hat\beta_{1i})}{\hat\beta_{1i}}\right)\right]$$

The estimated 6'×1' gradient lead-loadings for each CED activity/subtask combination was estimated as $f(\hat\beta_{0i},\hat\beta_{1i})$ and their associated standard deviations were estimated as the square root of $[df/d(\hat\beta_{0i},\hat\beta_{1i})]\Sigma[df/d(\hat\beta_{0i},\hat\beta_{1i})]$. The estimated [0-1] and [5-6] foot SSDC and their associated standard deviations were estimated by adjusting the limits of integration on the function $f(\beta_{0i},\beta_{1i})$ and adjusting $df/d(\beta_{0i},\beta_{1i})$ accordingly.

C.6 METHODOLOGY UNDERLYING NORMAL DISTRIBUTION THEORY CONFIDENCE INTERVALS, CONFIDENCE INTERVAL FOR A PERCENTILE, AND CONFIDENCE INTERVAL FOR THE PROPORTION LESS (GREATER) THAN A SPECIFIED VALUE

This section discusses the methodology underlying the calculation of confidence intervals on distribution percentiles and on the probability of being less (greater) than a specified level. This methodology is applied to the (natural) logarithms of personal exposure lead concentrations ($\mu g/m^3$ of air). Since air volume is proportional to sampling time, these loadings are effectively adjusted for sampling time. Confidence intervals are constructed for each R&R activity.

The confidence interval procedures are based on components of variance models having either one, two, or three variance components. The appropriate model was determined by those variance components that could be estimated from the available data. The variance components within these models are as follows:

Model #1
(one variance component): Worker-to-worker

Model #2
(two variance components): Unit-to-unit
Worker-to-worker within units

Model #3
(three variance components): Unit-to-unit
Worker-to-worker within units
Replicate variability within workers

The only activity where three variance components can be estimated is demolition.

For each activity where the two- and three-variance component models are appropriate, it is assumed that the data sets are (approximately) balanced or nearly balanced (i.e., the number of workers within units is (approximately) the same across units and the number of replicate determinations within workers is (approximately) the same across workers within units). If the data sets are only nearly balanced, we use the harmonic mean of levels (e.g. workers within units) in the confidence interval calculations.

Models

The forms of the variance component models are as follows:

One Variance Component Model:

$Y_k = \mu + e_k \quad k=1,...,n \quad Y_k \bullet \text{ ind } N(\mu, \bullet_e^2)$

Two Variance Components Model:

$Y_{ij} = \mu + h_i + w_{j(i)} \quad i=1,...,I; \; j=1,...,J$

$h_i \bullet \text{ ind } N(0, \bullet_h^2); \quad w_{j(i)} \bullet \text{ ind } N(0, \bullet_w^2)$

Three Variance Components Model:

$Y_{ijk} = \mu + h_i + w_{j(i)} + e_{ijk} \qquad i=1,...,I; \; j=1,...,J; \; k=1,...,n$

$h_i \bullet \text{ ind } N(0, \bullet_h^2);$
$w_{j(i)} \bullet \text{ ind } N(0, \bullet_w^2);$
$e_{ijk} \bullet \text{ ind } N(0, \bullet_e^2)$

C.6.1 Normal Theory Two-Sided 100(1-•) Percent Confidence Interval on the p-th Distribution Percentile

One objective of the analysis of personal exposure data is to compare (across activities) potential lead exposures associated with each R&R activity. This is done by summarizing the distribution of personal exposure data for each activity by a single summary statistic, and estimating the error associated with the statistic. This statistic has been taken to be the 75th percentile of the distribution. The same methods were used to estimate the 50th and 95th percentiles as well. This section presents the statistical approach taken to calculate confidence intervals on these estimated distribution percentiles.

The (1-•)*100% two-sided confidence intervals calculated in this section are based on the noncentral Student-t distribution. The methods for calculating these confidence intervals are as follows, according to the variance component model applied to the personal exposure data for a given R&R activity:

A. One Variance Component

$$Y_k \ (k \ 1,...,n) \quad \text{ind} \ N(u, \ {}^{2}_{e})$$

$$\bar{Y}. \ \frac{1}{n} \sum_{k\ 1}^{n} Y_k \qquad\qquad \bar{Y}. \ N(\mu, \ {}^{2}_{e}/n)$$

$$s^2 \ \frac{1}{(n\ 1)} \sum_{i\ 1}^{n} (Y_i \ \bar{Y}.)^2 \qquad s^2 \ {}^{2}_{e}X^2/$$

where • =n-1 d.f.

Let μ + • $_p$• $_e$ denote the p-th percentile of the normal distribution, 0• p• 1; • $_p$ = • $^{-1}$(p). We wish to place a 100(1-•) percent two-sided confidence interval on μ + • $_p$• $_e$. Determine k_1, k_2 such that

$$P(\bar{Y}. \ k_1 s \ \mu \quad {}_{p \ e} \ \bar{Y}. \ k_2 s) \ 1$$

Determine k_1, k_2 such that

$$P(\bar{Y}. \ k_1 s > \mu \quad {}_{p \ e}) \quad /2$$

$$P(\bar{Y}. \ k_2 s < \mu \quad {}_{p \ e}) \quad /2$$

Rearranging these inequalities implies that

$$k_1 \quad \frac{1}{\sqrt{n}} t'_{\;;\;/2} \quad {}_p\sqrt{n}$$

is the lower 100• /2 percentile of the noncentral t distribution with • d.f. and noncentrality • $_p$• n. Similarly

$$k_2 \quad \frac{1}{\sqrt{n}} t'_{\;;1\;\;/2} \quad {}_p\sqrt{n}$$

is the upper 100• /2 percentile of the noncentral t distribution with • d.f. and noncentrality • $_p$• n. A 100(1-•) percent two-sided confidence interval on µ + • $_p$• $_e$ is thus

$$(\overline{Y}. \quad \frac{1}{\sqrt{n}} \; t'_{\;;\;/2} \quad {}_p\sqrt{n} \quad s, \; \overline{Y}. \quad \frac{1}{\sqrt{n}} \; t'_{\;;1\;\;/2} \quad {}_p\sqrt{n} \quad s)$$

where $t'_{\bullet}$ (• $_p$• n) represents the noncentral t-distribution with • =n-1 d.f and noncentrality parameter • $_p$• n, and where • $_p$=• $^{-1}$(p).

B. Two Variance Components

Y_{ij}, i=1,...,I; j=1,...,J
Y_{ij} = µ + h_i + $w_{j(i)}$
h_i • ind N(0, • $_h{}^2$); $w_{j(i)}$ • N(0, • $_w{}^2$); h_i, $w_{j(i)}$ are independent
Y_{ij} • N(µ, • $_h{}^2$ + • $_w{}^2$)• N(µ,• ^{2})

$$\hat{\mu} \quad \overline{\overline{Y}}.. \quad \frac{1}{IJ} \sum_{i\,1}^{I} \sum_{j\,1}^{J} Y_{ij} \qquad\qquad \hat{\mu} \quad N\left(\mu, \; \frac{^2_h}{I} \quad \frac{^2_w}{IJ}\right) \quad N(\mu, \; ^2)$$

The mean square among units is MSH, with I-1 df.

$$MSH \quad \frac{J}{I\;1} \sum_{i\,1}^{I} (\overline{Y}_i. \; \overline{\overline{Y}}..)^2 \qquad\qquad MSH \quad (J \; ^2_h \quad ^2_w) \; ^2_{I\;1}/(I\;\;1)$$

The mean square among workers within units is MSW, with I(J-1)d.f.

$$MSW \quad \frac{1}{I(J\;\;1)} \sum_{i\,1}^{I} \sum_{j\,1}^{J} (Y_{ij} \quad \overline{\overline{Y}}_i.)^2 \qquad\qquad MSW \quad ^2_w \; ^2_{I(J\;\;1)}/I(J\;\;1)$$

Let

$$
\begin{array}{lll}
{}^{2} & {}^{2}_{h} & {}^{2}_{w} \\
{}^{2} & {}^{2}_{h}/I & {}^{2}_{w}/IJ \\
r & {}^{2}_{h}/{}^{2}_{w} &
\end{array}
$$

Then • ^{2}, • ^{2}, and r are estimated as

$$
\begin{array}{ll}
\hat{}^{2} & \frac{1}{J}\ \text{MSH} \quad \left(\frac{J\ 1}{J}\right)\ \text{MSW} \\
\hat{}^{2} & \frac{1}{IJ}\ \text{MSH} \quad , \quad \text{with } I\ 1\ \text{d.f.} \\
\hat{r} & \frac{1}{J}\left(\frac{\text{MSH}}{\text{MSW}}\right) \quad \frac{1}{J}
\end{array}
$$

In analogy with the one variance component case (Section A), we wish to place a 100(1-•) percent two-sided confidence interval on the p-th percentile of the distribution of Y, namely µ+• $_p$• , where • $_p$ = • $^{-1}$(p). Determine k_1, k_2 such that

$$
P(\bar{\bar{Y}}.. \quad k_1\hat{} \quad \mu \quad {}_p \quad \bar{\bar{Y}}.. \quad k_2\ \hat{}) \quad 1
$$

Determine k_1, k_2 such that

$$
\begin{array}{l}
P(\bar{\bar{Y}}.. \quad k_1\hat{} > \mu \quad {}_p) \quad /2 \\
P(\bar{\bar{Y}}.. \quad k_2\hat{} < \mu \quad {}_p) \quad /2
\end{array}
$$

Rearranging these inequalities implies that

$$
/2 \quad P\left(\frac{\frac{\mu\ \bar{\bar{Y}}..}{} \quad {}_p\overline{\ }}{\hat{}/} < k_1\frac{\hat{}}{\hat{}}\right)
$$

Assume that $\hat{}/\hat{}$ on the right hand side of this inequality is approximately equal to • /• . This is asymptotically correct. Then

$$
k_1 \quad \frac{1}{/}\ t'_{I\ 1;\ /2}\left(\ {}_p\overline{\ }\right)
$$

the lower 100 • /2 percentile of the noncentral t distribution with I-1 d.f. and noncentrality parameter $_p -$. Estimate • /• by

$$\hat{}/\hat{} \quad \left[\frac{\frac{1}{J}\ \mathrm{MSH} \quad \left(\frac{J\ 1}{J}\right)\mathrm{MSW}}{\frac{1}{IJ}\ \mathrm{MSH}}\right]^{1/2} \quad \left[IJ\left(\frac{\hat{r} \quad 1}{J\hat{r} \quad 1}\right)\right]^{1/2}$$

Similarly

$$/2 \quad P\left(\frac{\mu\ \overline{\overline{Y}}..\qquad _p -}{\hat{}/} > k_2 \frac{\hat{}}{\hat{}}\right)$$

As above, assume that $\hat{}/\hat{}$ on the right hand side of this inequality is approximately equal to • /• . Then

$$k_2 \quad \frac{1}{/}\ t'_{I\ 1;1\ \ /2}\left(\ _p -\right)$$

is the upper 100 • /2 percentile of the noncentral t distribution with I-1 d.f. and noncentrality parameter $_p -$. As above,

$$\hat{}/\hat{} \quad \left[IJ\left(\frac{\hat{r} \quad 1}{J\hat{r} \quad 1}\right)\right]^{1/2}$$

C. Three Variance Components

This case is an extension of the two variance component case.

Y_{ijk}, i=1,...,I; j=1,...,J; k=1,..., n

$Y_{ijk} = \mu + h_i + w_{j(i)} + e_{ijk}$

h_i • ind N(o,• $_h^2$); $w_{j(i)}$ • N(o,• $_w^2$); e_{ijk} • N(o,• $_e^2$); h_i, $w_{j(i)}$, e_{ijk} are independent

Y_{ijk} • N(μ,• $_h^2$ + • $_w^2$ + • $_e^2$) • N (μ,• ^{2})

$$\hat{\mu} = \bar{\bar{Y}}_{...} = \frac{1}{IJn}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{n} Y_{ijk} \qquad \hat{\mu} \sim N\left(\mu, \frac{\sigma_h^2}{I} + \frac{\sigma_w^2}{IJ} + \frac{\sigma_e^2}{IJn}\right) = N(\mu, \tau^2)$$

The mean square among units is MSH, with I-1 d.f.

$$MSH = \frac{Jn}{I-1}\sum_{i=1}^{I}(\bar{Y}_{i..} - \bar{\bar{Y}}_{...})^2 \qquad MSH \sim (Jn\sigma_h^2 + n\sigma_w^2 + \sigma_e^2)\chi^2_{I-1}/(I-1)$$

The mean square among workers within units is MSW, with I(J-1)d.f.

$$MSW = \frac{n}{I(J-1)}\sum_{i=1}^{I}\sum_{j=1}^{J}(\bar{Y}_{ij.} - \bar{Y}_{i..})^2 \qquad MSW \sim (n\sigma_w^2 + \sigma_e^2)\chi^2_{I(J-1)}/I(J-1)$$

The mean square among replicate determinations within workers is MSE, with IJ(n-1) d.f.

$$MSE = \frac{1}{IJ(n-1)}\sum_{i=1}^{I}\sum_{J=1}^{J}\sum_{k=1}^{n}(Y_{ijk} - \bar{Y}_{ij.})^2 \qquad MSE \sim \sigma_e^2\chi^2_{IJ(n-1)}/IJ(n-1)$$

Let

$$\sigma^2 = \sigma_h^2 + \sigma_w^2 + \sigma_e^2$$

$$\tau^2 = \sigma_h^2/I + \sigma_w^2/IJ + \sigma_e^2/IJn$$

σ^2, τ^2 are estimated as

$$\hat{\sigma}^2 = \frac{MSH}{Jn} + \left(\frac{J-1}{J}\right)\frac{MSW}{n} + \left(\frac{n-1}{n}\right)MSE$$

$$\hat{\tau}^2 = \frac{1}{IJn}MSH \text{, with } I-1 \text{ d.f.}$$

In analogy with the previous case of two variance components (Section B), we wish to place a $100(1-\alpha)$ percent two sided confidence interval on the p-th percentile of the distribution of Y, namely $\mu + \gamma_p\sigma$, where $\gamma_p = \Phi^{-1}(p)$. Determine k_1, k_2 such that

$$P(\bar{\bar{Y}}_{...} + k_1\hat{\tau} \le \mu + \gamma_p\sigma \le \bar{\bar{Y}}_{...} + k_2\hat{\tau}) = 1 - \alpha/2$$

In direct analogy with the two variance component case,

$$k_1 \quad \frac{1}{(\ /\ )}\ t'_{I\ 1;\quad /2}\left(\ _p\ -\right)$$

$$k_2 \quad \frac{1}{(\ /\ )}\ t'_{I\ 1\ ;\ 1\quad /2}\left(\ _p\ -\right)$$

Estimate • /• by

$$\hat{}/\hat{} \quad \left[IJ \left(\frac{\frac{MSH}{J} \quad \left(\frac{J\ 1}{J}\right) MSW \quad (n\ 1)\ MSE}{MSH} \right) \right]^{1/2}$$

If n=1 this reduces to the expression for $\hat{}/\hat{}$ in the two variance component case.

C.6.2 Normal Theory Two-Sided 100(1-•) Percent Confidence Interval on P(Y>a)

The theory presented in this section is used to calculate a (1-•)*100% two-sided confidence interval on the probability that a given random variable Y exceeds a pre-specified threshold value (a), based on assumptions on its underlying distribution. In the EFSS, this method is applied to obtaining confidence intervals on the proportion of workers whose personal exposure sample results exceed the OSHA permissible exposure limit of 50 µg/m^3.

Assume that

$$Y\ N(\mu,\ ^2)$$

and let

$$q \quad P(Y>a) \quad 1 \quad \left(\frac{a\ \mu}{}\right)$$

Then

$$p \quad 1\ q \quad \left(\frac{a\ \mu}{}\right)$$

This implies that

$$a \quad \mu \quad _p$$

where $_p \quad ^1(p)$.

We wish to place a two-sided 100(1-•) percent confidence interval on p, and therefore equivalently on q• 1-p. This is the inverse problem to that considered in the previous section.

For each value of p, 0<p<1, a two-sided 100(1-•) percent confidence interval on µ+• $_{p}$• is (• $_{l}$(p), • $_{u}$(p)) where

$$_{l}(p) \quad \bar{Y} \quad \left(\frac{1}{/}\right) \; t'_{;\,/2} \; (\;_{p}\;/\;)\;\hat{}$$

$$_{u}(p) \quad \bar{Y} \quad \frac{1}{(\;/\;)} \; t'_{;1\;\;/2} \; (\;_{p}\;/\;)\;\hat{}$$

As in the previous section, • /• and • can be expressed as follows, given the variance components model being considered:

One Variance Component: $/ \quad \sqrt{n}\;, \quad n\;\;1$

Two Variance Components: $/ \quad \left[\frac{{}^{2}_{h} \qquad {}^{2}_{w}}{{}^{2}_{h}/I \qquad {}^{2}_{w}/IJ}\right]^{1/2} \;, \qquad I\;\;1$

Three Variance Components: $/ \quad \left[\frac{{}^{2}_{h} \qquad {}^{2}_{w} \qquad {}^{2}_{e}}{{}^{2}_{h}/I \qquad {}^{2}_{w}/IJ \qquad {}^{2}_{e}/IJn}\right]^{1/2} \;, \quad I\;\;1$

and • /• are estimated as discussed previously.

If • is the true (unknown) value of p such that a • µ+• . • , then with probability at least 1-• , the value a will fall within the confidence interval for µ+• . • . The 1-• confidence interval on p• P(Y<a) is thus {p: • $_{l}$(p)• a• • $_{u}$(p)}. The boundaries • $_{l}$(p), • $_{u}$(p) are each increasing functions of p. Therefore, the lower and upper confidence bounds for p are

$$p_{l} \quad \underset{p}{\min} \quad _{u}(p) \quad a \quad \underset{p}{\min}\left\{ t'_{;1\;\;/2}\left(\;_{p}\;-\right) \quad \frac{a\;\bar{Y}}{\hat{}}\left(-\right)\right\}$$

$$p_{u} \quad \underset{p}{\max} \quad _{l}(p) \quad a \quad \underset{p}{\max}\left\{ t'_{;\,/2}\left(\;_{p}\;-\right) \quad \frac{a\;\bar{Y}}{\hat{}}\left(-\right)\right\}$$

The degrees of freedom, • , are • =n-1 in the one variance component case; • =I-1 in the two and three variance component cases (balanced design).

The upper and lower confidence bounds on q• 1-p are obtained directly from p_l and p_u. Namely

$$q_l \quad 1 \;\; p_u$$

$$q_u \quad 1 \;\; p_l$$

C.7 MODELS USED TO ESTIMATE MEAN EXPOSURE LEVELS ACROSS STUDIES IN COMBINING OTHER SOURCES OF SURFACE PREPARATION DATA

The individual data points were available for all surface preparation studies located in the search for other sources of data. Therefore within-study and between-study variability could be estimated directly from the data rather than approximated by statistical meta-analytic techniques. To characterize the components of variability in personal worker exposures the following model was fit separately for interior and exterior dry surface preparation:

$$\log(PEM_{ij}) = \mu + Study_i + Worker_j \qquad \text{(OS-1)}$$

where

PEM_{ij} is the personal exposure lead concentration (µg/m^3) for the jth worker in the ith study

µ is the mean of the log (PEM) responses

$Study_i$ is the random effect of the ith study (normally distributed with mean zero and variance ^2_S)

$Worker_j$ is a random effect of the jth Worker (normally distributed with mean zero and variance ^2_W).

Parameter estimates for each model fit are presented in Table 7E-4 of Volume 1. Estimates of the 75th and 95th percentiles of the distribution and confidence intervals for the geometric mean, 75th and 95th percentile were calculated according to the methodology presented in Section C.6 of Appendix C. Likewise, estimates of the percent of workers exceeding the OSHA PEL and their associated 95th confidence interval were calculated according to the methodology presented in Section C.6 of Appendix C.

APPENDIX D

QUALITY CONTROL

D.0 QUALITY CONTROL

To ensure that the sampling and analysis protocols employed in the EFSS produced data of sufficient quality, a number of different quality control (QC) samples were included in the study design for each study phase. Field QC samples were intended to help assess variability introduced by the sampling method and to detect potential biases from field sources such as sample transfer and handling. The types of field QC samples collected in this study were:

- Field blanks: Lead-free samples prepared in the laboratory and transported to the field, to assess potential bias or contamination. Field blanks consisted of a sample collection medium (dust bottle, wipe, filter cassette, paint chip collection vial) removed from packaging, connected to any necessary sampling device (vacuum, air pump) and immediately removed, then packaged without actually taking a dust sample. At a given study unit, one field blank of each sampling media to be used on that day was taken prior to R&R activities and field sampling.

- Field side-by-side samples: Vacuum and wipe samples collected in areas adjoining "regular" sample areas, to determine variability due to the sample collection process.

In addition, laboratory QA/QC measures were implemented during the analysis of the field samples.

Section D.1 of this appendix presents a statistical summary of the field blank data. Tables of the side-by-side sample results, along with results for adjoining regular samples, are presented in Section D.2 (a discussion of side-by-side sample results is found in Section 6.4). Results of laboratory QA/QC sample analysis that deviated from data quality objectives are summarized in Section D.3.

D.1 FIELD BLANKS

The following field blanks were collected within each phase of the EFSS:

- Carpet removal: Four field blank samples were collected at each of the eight study units prior to carpet removal activities, one for each sample type considered in this phase (vacuum, wipe, personal air, and ambient air);

- Window replacement: Three field blank samples were collected at each of the four study units prior to window replacement activities, one for each sample type considered in this phase (vacuum, personal air, and ambient air);

- CED phase: at a given study unit, one field blank sample was collected for each sample medium to be employed on that day (vacuum, wipe, personal air, paint chip).

Field blank results for all sample types were reported in terms of lead content (i.e., µg lead per sample). In addition, vacuum field blank samples were reported in µg lead per gram of dust in the sample.

Tables D-1a through D-1c present the results of analysis on the field blank samples for the carpet removal, window replacement, and CED phases, respectively. The results (µg/sample) for all three phases were generally close to the analytical detection limit associated with the given sample medium, despite the frequency to which detected results were observed within the field blanks. Detected results are primarily the result of instrument sensitivity. These tables indicate that no apparent bias in sample collection and handling was observed as a result of reviewing the field blank data.

Table D-1a. Descriptive Summaries of Field Blank Sample Results Within the Carpet Removal Phase

	Sample Types				
	Vacuum		Wipe	Personal Air	Ambient Air
	µg/sample	µg/g	µg/sample	µg/sample	µg/sample
Arithmetic Mean (S.E.)	2.19 (1.09)	679.5 (374)	2.72 (0.58)	0.215 (0.250)	0.209 (0.073)
Minimum/ Maximum Result	0.450/ 3.12	173.2/ 1,376	2.34/ 3.94	0.093/ 0.831	0.110/ 0.312
% Not Detected Results	62.5%	57.1% (n=7)	50%	0%	0%

Note: This summary is based on analysis of n=8 field blank samples.

Table D-1b. Descriptive Summaries of Field Blank Sample Results Within the Window Replacement Phase

	Sample Types				
	Vacuum		Paint Chip	Personal Air	Ambient Air
	µg/sample	µg/g	µg/sample	µg/sample	µg/sample
Arithmetic Mean (S.E.)	2.09 (0.58)	1259.81 (1422.82)	6.08 (0.01)	0.080 (0.006)	0.102 (0.050)
Minimum/ Maximum Result	1.72/ 2.94	45.008/ 3263.33	6.07/ 6.09	0.075/ 0.089	0.047/ 0.151
% Not Detected Results	50%	50%	100%	0%	0%

Note: Summaries for vacuum, personal air, and ambient air are based on analysis of n=4 field blanks. Summaries for paint chip are based on analysis of n=2 field blanks (at units 1-01 and 4-01).

Table D-1c. Descriptive Summaries of Field Blank Sample Results Within the CED Phase

	Sample Types (Number of Samples)				
	Dust Vacuum (N=4)		Paint Chip (N=2)(1)	Personal Air (N=5)	Dust Wipe (N=4)
	µg/sample	µg/g	µg/sample	µg/sample	µg/sample
Arithmetic Mean (S.E.)	11.31 (10.335)	0.0013 (0.000483)	10.19 (6.537)	0.1568 (0.0921)	4.461 (0.7213)
Minimum/ Maximum Result	2.33/ 20.85	0.0006/ 0.0017	5.57/ 14.81	0.075/ 0.276	3.519/ 5.277
% Not Detected Results	25%		0%	0%	75%

D.2 FIELD SIDE-BY-SIDE SAMPLES

Side-by-side QC samples were collected for various dust vacuum and wipe samples throughout the three EFSS phases. Section 6.4 contains a detailed discussion of the results of the statistical analysis of the side-by-side sample data relative to their adjoining regular sample results.

Tables D-2a through D-2c contain sample weights, lead concentrations, and lead loadings within pairs of dust samples, where pairs constituted a side-by-side sample and its adjoining regular sample. The first set of columns in the table contain results for the sample from each pair that was collected first, the second set of columns are for the sample collected second, and the third set of columns indicate summaries of differences between the two samples in a pair.

Within a pair, the regular sample was usually (but not always) taken prior to the side-by-side sample in all three phases. At the same time, when vacuum collection methods were used, lower lead loadings were usually observed within the sample collected second. These facts suggest that some bias may be introduced to the second sample area when the first sample is collected. This issue is discussed further in Section 6.3.

Table D-2a. Sample Loadings, Concentrations, and Weights for Each Sample Pair Defined by a Regular Dust Sample and an Adjoining Side-by-Side QC Sample, in the R&R Carpet Removal Phase

	Sample Taken First in the Pair					Sample Taken Second in the Pair					Difference in Results (First Sample Minus Second Sample)			
Unit ID	MRI ID	Time Col.	Loading (µg/ft^2)	Conc. (µg/g)	Sample Weight (g)	MRI ID	Time Col.	Loading (µg/ft^2)	Conc. (µg/g)	Sample Weight (g)	Loading (µg/ft^2)	Conc. (µg/g)	Sample Weight (g)	Tim e (min.)
Vacuum Dust Sampling from Floor Surfaces (Pre-Activity)														
1-01	60022	09:49	32.42	493.38	0.0657	60020	09:59	1.56	172.92	0.0090	30.86	320.46	0.0567	10
1-02	60065	08:26	6.69	323.43	0.0207	60067	08:34	5.28	225.83	0.0234	1.41	97.60	-0.0027	8
1-03	60105	09:01	2.61	231.37	0.0113	60048	09:08	2.61	272.34	0.0096	0.00	-40.97	0.0017	7
1-04	60145	08:25	2.61	52.08	0.0502	60129	08:35	2.61	198.06	0.0132	0.00	-146.0	0.0370	10
2-01	62036	09:26	564.52	9179.19	0.0615	62051	09:37	121.21	1864.77	0.0650	443.31	7314.4	-0.0035	11
2-02	62336	15:20	2.85	500.07	0.0057	60556	15:29	11.51	1211.79	0.0095	-8.66	-711.7	-0.0038	9
2-03	60986	14:09	45.77	4576.50	0.0100	62246	14:16	5.96	960.48	0.0062	39.81	3616.0	0.0038	7
2-05	60746	08:46	447.54	5552.61	0.0806	60741	08:57	347.85	3229.81	0.1077	99.69	2322.8	-0.0271	11
Vacuum Dust Sampling from Floor Surfaces (1-hour Post-Activity)														
1-01	60021	14:31	655.33	1227.89	0.5337	60008	14:39	295.49	985.29	0.2999	359.84	242.60	0.2338	8
1-02	60062	10:59	68.68	200.87	0.3419	60066	11:07	36.45	358.38	0.1017	32.23	-157.5	0.2402	8
1-03	60100	12:05	26.88	359.80	0.0747	60098	12:12	20.93	426.23	0.0491	5.95	-66.43	0.0256	7
1-04	60131	11:41	2290.80	10532.4	0.2175	60142	11:49	230.24	433.52	0.5311	2060.6	10099	-0.3136	8
2-01	62016	14:33	1332.30	15564.3	0.0856	62056	14:42	351.28	5593.63	0.0628	981.02	9970.6	0.0228	9
2-02	60461	18:05	224.93	1445.57	0.1556	60491	18:12	232.09	4227.51	0.0549	-7.16	-2782	0.1007	7
2-03	60451	19:28	452.15	2132.78	0.2120	62096	19:35	231.86	1022.76	0.2267	220.29	1110.0	-0.0147	7
2-05	60726	12:20	167.83	1822.26	0.0921	60796	12:30	252.37	2941.38	0.0858	-84.54	-1119	0.0063	10
Vacuum Dust Sampling from Stainless Steel Dustfall Collectors (1-Hour Post-Activity)														
1-01	60010	14:48	92.61	3795.49	0.0244	60009	14:56	8.87	1528.49	0.0058	83.74	2267.0	0.0186	8
1-02	60064	11:15	36.50	444.64	0.0821	60071	11:26	40.27	291.63	0.1381	-3.77	153.01	-0.0560	11
1-03	60101	12:19	13.35	481.88	0.0277	60097	12:26	8.60	411.48	0.0209	4.75	70.39	0.0068	7
1-04	60137	11:57	128.46	7216.85	0.0178	60135	12:05	94.58	8520.45	0.0111	33.88	-1304	0.0067	8
2-01	62041	14:50	13.67	1730.76	0.0079	62011	14:57	3.06	3397.78	0.0009	10.61	-1667	0.0070	7
2-02	60486	18:19	2.85	370.18	0.0077	60446	18:26	4.11	596.09	0.0069	-1.26	-225.9	0.0008	7
2-03	62111	19:42	24.30	1786.54	0.0136	62231	19:46	68.60	1277.54	0.0537	-44.30	509.00	-0.0401	4
2-05	60781	12:05	19.78	464.23	0.0426	60736	12:12	18.82	464.62	0.0405	0.96	-0.39	0.0021	7

Table D-2a. (Continued)

Unit ID	Sample Taken First in the Pair: MRI ID	Time Col.	Loading ($\mu g/ft^2$)	Conc. (µg/g)	Sample Weight (g)	Sample Taken Second in the Pair: MRI ID	Time Col.	Loading ($\mu g/ft^2$)	Conc. (µg/g)	Sample Weight (g)	Difference in Results (First Sample Minus Second Sample): Loading ($\mu g/ft^2$)	Conc. (µg/g)	Sample Weight (g)	Tim e (min.)
Vacuum Dust Sampling from Stainless Steel Dustfall Collectors (2-Hours Post-Activity)														
1-01	60002	15:11	59.94	831.38	0.0721	60003	15:16	17.81	415.10	0.0429	42.13	416.28	0.0292	5
1-02	60070	11:56	22.39	371.96	0.0602	60068	12:04	30.30	157.40	0.1925	-7.91	214.56	-0.1323	8
1-03	60102	12:59	2.61	168.67	0.0155	60099	13:05	10.61	340.10	0.0312	-8.00	-171.4	-0.0157	6
1-04	60144	12:43	219.14	7046.30	0.0311	60136	12:49	196.50	7528.74	0.0261	22.64	-482.4	0.0050	6
2-01	62021	15:31	66.69	3402.40	0.0196	62001	15:39	12.23	1547.47	0.0079	54.46	1854.9	0.0117	8
2-02	60466	19:17	54.82	3806.60	0.0144	60506	19:24	3.01	567.55	0.0053	51.81	3239.1	0.0091	7
2-03	60421	20:35	86.94	1461.19	0.0595	62106	20:37	32.49	1511.07	0.0215	54.45	-49.88	0.0380	2
2-05	60696	12:54	68.58	1937.32	0.0354	60671	13:00	13.22	297.06	0.0445	55.36	1640.3	-0.0091	6
Wipe Dust Sampling from Stainless Steel Dustfall Collectors (1-Hour Post-Activity)														
1-02	60076	11:00	23.23			60074	11:03	11.94			11.29			3
1-03	60111	11:58	7.70			60113	12:00	4.64			3.06			2
1-04	60126	11:45	174.87			60124	11:47	188.56			-13.69			2
2-01	62186	14:20	23.62			62191	14:25	16.18			7.44			5
2-02	62196	18:21	93.17			60606	18:26	392.87			-299.7			5
2-03	62276	19:19	74.11			62261	19:21	28.81			45.30			2
2-05	60806	11:43	11.82			62151	11:45	2.42			9.40			2

Table D-2b. Sample Loadings, Concentrations, and Weights for Each Sample Pair Defined by a Regular Dust Sample and an Adjoining Side-by-Side QC Sample, in the R&R Window Replacement Phase

	Sample Taken First in the Pair					Sample Taken Second in the Pair					Difference in Results (First Sample Minus Second Sample)			
Unit ID	MRI ID	Time Col.	Loading (µg/ft²)	Conc. (µg/g)	Sample Weight (g)	MRI ID	Time Col.	Loading (µg/ft²)	Conc. (µg/g)	Sample Weight (g)	Loading (µg/ft²)	Conc. (µg/g)	Sample Weight (g)	Time (min.)
Vacuum Dust Sampling from Floor Surfaces (Pre-Activity)[1]														
2-01	60522	08:37	50.60	8161.29	0.0062	60472	08:45	25.85	3271.77	0.0079	24.75	4889.5	-0.0017	8
3-01	60367	08:19	1227.20	2611.62	0.4699	60252	08:27	3743.45	2462.15	1.5204	-2516.25	149.47	-1.0505	8
4-01	60454	09:50	18443.2	16470.1	1.1198	60469	09:59	4272.70	3279.63	1.3028	14171	13190	-0.1830	9
Vacuum Dust Sampling from Floor Surfaces (Post-Activity)[1]														
2-01	60402	17:22	30.42	2304.55	0.0132	60392	17:30	10.40	1181.25	0.0088	20.02	1123.3	0.0044	8
3-01	60592	13:49	12770.0	4695.37	2.7197	60587	13:52	9498.10	4945.64	1.9205	3271.9	-250.27	0.7992	3
4-01	60484	14:20	54515.0	17547.0	3.1068	60509	14:25	23850.0	31728.1	0.7517	30665	-14181.1	2.3551	5
Vacuum Dust Sampling from Stainless Steel Dustfall Collectors (Post-Activity)[1]														
2-01	60457	17:43	206.50	424.72	0.4862	60352	17:49	187.39	114.40	1.6381	19.11	310.33	-1.1519	6
3-01	60537	13:30	148.39	11414.6	0.0130	60597	13:34	135.43	19074.6	0.0071	12.96	-7660.03	0.0059	4
4-01	60399	13:40	4155.00	26330.8	0.1578	60549	13:50	1185.10	32116.5	0.0369	2969.9	-5785.73	0.1209	10

[1] Collected approximately six feet from a window that was removed.

Table D-2c. Loadings for Each Sample Pair Defined by a Regular Dust Sample and an Adjoining Side-by-Side QC Sample, Both Collected by Vacuum Techniques, in the R&R CED Phase

Activity	Sample Taken First in the Pair			Sample Taken Second in the Pair			Difference in Loadings (µg/ft^2)
	MRI ID	Time Collected	Loading (µg/ft^2)	MRI ID	Time Collected	Loading (µg/ft^2)	
1372 N. Carey Street, Baltimore, MD							
Wall Demolition, 2nd Floor Bathroom	61159	10:15	2671.70	60969	10:22	1365.40	1306.3
Wall Demolition, 3rd Floor Bathroom	61799	15:08	817.26	61669	15:15	1297.50	-480.24
Wall Demolition, Kitchen	61849	13:27	3438.80	61834	13:30	2521.80	917.00
960 Lipan Street, Denver, CO							
Door, Baseboard, Frame Removal, Bedrooms	60448	15:06	48944.5	60403	15:18	23794	25150.5
	60483	15:50	75693	60413	15:55	25652	50041
Wall Demolition, Kitchen	60418	17:01	138631	60443	17:07	11968	126663
Window Sanding, Dining Room	60633	15:47	918.29	60848	15:51	1140.2	-221.91
	60878	15:56	1187.70	60843	16:00	1241.8	-54.10
Wall Demolition, Dining Room	61213	11:06	45.25	61198	11:14	98.64	-53.39

D.3 SUMMARY OF LABORATORY QA/QC FINDINGS

In their data reports, MRI summarized the results of analyzing laboratory QA/QC samples within each instrumental and sample preparation batch. In the carpet removal phase, environmental samples were analyzed across eight instrumental analysis batches and nine sample preparation batches Samples in the window replacement samples were analyzed across nine instrumental analysis batches and thirteen sample preparation batches. Samples in the CED phase were analyzed across 16 instrumental analysis batches and 13 sample preparation batches.

In all three phases, the results of analyzing initial calibration verification and continuing calibration verification samples in each instrumental analysis batch were within the protocol criteria of ±10%. This indicates that the analytical instrument was properly calibrated for all of the sample analyses.

Table D-3a through D-3c report the status of meeting data quality objectives within batches in the carpet removal, window replacement, and CED phases, respectively. These tables also show the number of field samples, duplicate samples, and field blanks analyzed in each of the instruments analysis batches. Most of the incidents where data quality objectives were not met occurred in analysis of NIST standard reference material (SRM) 1646.

Table D-3a. Summary of Conclusions Made in Analysis of Laboratory QA/QC Samples in the Carpet Removal Phase

Instrument Analysis Batch	Total Number of Field Samples Analyzed	Sample Preparation Batch	Notes
Personal Air (MCE Filter) Cassettes			
V10293A V11013A[1]	20 Field Samples 7 Field Blanks 3 Field Samples 0 Field Blank	605	Percent recovery for NIST SRM 1646 was 71%, which was below the lower control limits. Historical data continued to be monitored throughout the study. Percent recovery for NIST SRM 2704 was 90%, meeting the data quality objectives.
V10283B	19 Field Samples 8 Field Blanks	606	Percent recovery for NIST SRM 1646 was 77.5%, which falls below the lower control limit as published in the QAPjP. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary. Percent recovery for NIST SRM 2704 was 105%, which meets the data quality objectives.
Dust Wipe Samples			
E07223A	24 Field Samples 8 Field Blanks	601	Percent recovery for NIST SRM 2704 and NIST SRM 1646 were 93.5% and 102.2%, respectively, meeting the data quality objectives.
E10193A	32 Field Samples 2 Field Blanks	602	Percent recovery for NIST SRM 1646 was 75.3% for batch 602, which falls between the lower warning limit and the lower control limit as published in the QAPjP. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary. Percent recovery for NIST SRM 2704 was 94.6%, meeting data quality objectives.
Dust Vacuum Samples			
E10213A	36 Field Samples 1 Field Blank 36 Field Samples 2 Field Blanks	603 604	Percent recoveries for the NIST SRM 1646 were 71.7% for batch 603 and 75.0% for batch 604, both of which fall below the lower control limits as published in the QAPjP. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary. Percent recoveries for the NIST SRM 2704 were 97.1% for batch 603 and 86.9% for batch 604, both of which meet data quality objectives.
E10263A	34 Field Samples 2 Field Blanks 38 Field Samples 2 Field Blanks	607 608	Percent recoveries for NIST SRM 1646 were 94% for batch 607 and 86% for batch 608. Percent recoveries for NIST SRM 2704 were 104% for batch 697 and 98% for batch 608. All of these results meet data quality objectives.
E11303A[2]	5 Field Samples 0 Field Blanks 2 Field Samples 0 Field Blanks	617 607[3]	Percent recoveries in batch 617 were 87.3% for the NIST SRM 1646 and 87.4% for NIST SRM 2704. Both of these results meet data quality objectives.

(1) One sample preparation batch was divided into two instrument analysis batches.
(2) This instrument analysis batch consisted of five carpet samples and four window samples.
(3) Two samples from sample prep batch 607 were reanalyzed due to dilution problems in the original analysis.

Table D-3b. Summary of Conclusions Made in Analysis of Laboratory QA/QC Samples in the Window Replacement Phase

Instrument Analysis Batch	Total Number of Field Samples Analyzed	Sample Preparation Batch	Notes
Personal and Ambient Air (MCE Filter) Cassettes			
V11223A V11233A[1]	26 Field Samples 4 Field Blanks 1 Field Sample	610	The percent recovery for NIST SRM 1646 was 78.1%, which falls between the lower warning and control limits. For NIST SRM 2704 the percent recovery was 104.1%, which meets the data quality objectives.
V02034A	10 Field Samples 0 Field Blanks	621	Percent recovery for NIST SRM 1646 was 78.2%, which fall between the lower warning and control limits. For NIST SRM 2704 the percent recovery was 87.6%, which meets the data quality requirements.
Paint Chip Samples			
E11173A	19 Field Samples 3 Duplicates 1 Field Blank	615	Percent recoveries for NIST SRM 1579 were 97.6, 93.4, and 99.7%, meeting the data quality objectives. Percent recoveries for AIHA SRMs were 103, 95, and 105% for AIHA 1 and 101, 93, and 102% for AIHA 2. All of these results meet the data quality objectives.
Dust Vacuum Samples			
E11153A	49 Field Samples 3 Field Blanks	612 614	Percent recovery for NIST SRM 1646 was 87.3% for batch 612 and 78.1% for sample batch 614. The result for bath 614 fall between the lower warning and control limits. Percent recoveries for NIST SRM 2704 was 97.6% for batch 612 and 88.22% for batch 614, both of which meet data quality objectives.
E11163A[2]	39 Field Samples 0 Field Blank	613 614	The percent recovery for the NIST SRM 1646 was 100% for batch 613, and for NIST SRM 2704 it was 102%. Both of these results meet the data quality objectives.
E11303A[3]	8 Field Samples 1 Duplicate	617 618	The percent recovery for the NIST SRM 1646 was 87.3% for batch 617 and 83.6% for batch 618. The recoveries for NIST SRM 2704 were 87.4 and 93.7% for batches 617 and 168, respectively. All of these results meet the data quality objectives.
E02254A	31 Field Samples 1 Field Blank	619 622	The result for the NIST SRM 1646 was 99.0% for batch 619 and 96.7% for batch 622. The percent recoveries for NIST SRM 2704 were 102 and 95.3% for batches 619 and 622, respectively. All of these results meet the data quality objectives.

(1) The samples from instrument batches V11223A and V11233A were combined when assessing data quality objectives.
(2) Instrument analysis batch E11163A included the reanalysis of one sample from sample prep batch 614.
(3) Instrument analysis batch E11303A included two samples from the carpet removal phase.

Table D-3c. Summary of Conclusions Made in Analysis of Laboratory QA/QC Samples in the CED Phase

Instrument Analysis Batch	Total Number of Field Samples Analyzed	Sample Preparation Batch	Notes
Personal Air (MCE Filter) Cassettes			
V03314A	39 Field Samples 2 Field Blanks	629	Data quality objectives met.
V04134A	22 Field Samples 1 Field Blank	630	Percent recovery for NIST SRM 1646 was 75.4%, which falls between the lower warning limit and lower control limit as published in the QAPjP.
V05264A	29 Field Samples 2 Field Blanks	635	Percent recovery for NIST SRM 1646 was 72.7%, which falls below the lower control limit as published in the QAPjP. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary.
Dust Wipe Samples			
V04264A E04254A E04214A	4 Field Samples 9 Field Samples 6 Field Samples 2 Field Blanks	631	Percent recovery for NIST SRM was 77.2%, which falls between the lower warning limits and the lower control limit as published in the QAPjP.
E05254A	14 Field Samples 2 Field Blanks	638	Percent recovery for both NIST SRM 2704 and NIST SRM 1646 were 63.2% and 50.7%, respectively, which does not meet the data quality objectives. Historical data continued to be monitored throughout the study, and no further corrective action was deemed necessary.
Paint Chip Samples			
E03294A V04264B[1]	39 Field Samples 4 Duplicates 2 Field Blanks 2 Field Samples	628	Data quality objectives met.
E05264A	22 Field Samples 3 Duplicates	636	Data quality objectives met.
Dust Vacuum Samples			
E04044A	79 Field Samples 13 Duplicates	624 625	Percent recovery for NIST SRM 1646 was 78.5% for batch 624, which falls between the lower warning limit and the lower control limit as published in the QAPjP. The result for batch 625 was 65.6%, which does not meet the data quality objectives. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary.
E04134A E04184B[2] V04264A[2]	83 Field Samples 12 Duplicates 1 Field Blank 1 Field Sample 1 Duplicate 1 Field Sample 1 Duplicate	626 627	The result for the NIST SRM 1646 was 67.3% for batch 626, which falls below the lower control limits as published in the QAPjP. Historical data continued to be monitored through the study, and no further corrective action was deemed necessary. The result for the NIST SRM 2704 was 75.3% for batch 626, which falls between the lower warning limit and the lower control limit as published in the QAPjP.
E05264B E06014B[3]	75 Field Samples 5 Duplicates 4 Field Blanks 2 Field Samples	633 634	The result for the NIST SRM 1646 was 78.4% for batch 634, which falls between the lower warning limit and the lower control limit as published in the QAPjP.

(1) Rerun samples from Instrumental Analysis Batch No. E03294A (over range).
(2) Rerun samples from Instrumental Analysis Batch No. E04134A.
(3) Samples moved from Instrumental Analysis Batch No. E05264B.

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA 747-R-96-008	2.	3. Recipient's Accession No.
4. Title and Subtitle Lead Exposure Associated with Renovation and Remodeling Activities: Environmental Field Sampling Study Volume II: Appendices			5. Report Date May 1997 6.
7. Author(s) Menkedick, J.R., Menton, R.G., Constant, P., Lordo, R.A., Strauss, W.J.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201-2693 and Midwest Research Institute, 425 Volker Boulevard, Kansas City, Missouri 64110			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) 68-D5-0008 (G)
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics 401 M Street, S.W. Washington, D.C. 20460			13. Type of Report & Period Covered Technical Report – Appendices 14.

15. Supplementary Notes

In addition to the authors listed above, the following key staff members were major contributors to the study: Halsey Boyd, David Burgoon, Beth Burkhart, Paul Feder, Pam Hartford, Mary Kayser, Steve Naber, Nick Sasso, and Shawn Shumaker of Battelle; and Jack Balsinger, Derrick Bradley, John Jones, and Gary Wester of MRI.

16. Abstract (Limit 200 words)

The U.S. Environmental Protection Agency, in response to the Residential Lead Based Paint Hazard Reduction Act of 1992 (Title X), conducted a study of lead exposure associated with renovation and remodeling (R&R) activities. This report presents the results of a literature review and one of the principle data collection efforts of the study: the Environmental Field Sampling Study (EFSS). The EFSS collected 90 personal air samples and 556 settled dust samples to assess potential exposure to workers and occupants from selected R&R activities. Task length average exposures measured by personal air samplers on R&R workers were greater than 100 $\mu g/m^3$ for paint removal, interior demolition, and sawing, and greater than 49 $\mu g/m^3$ for interior surface preparation and central heating system maintenance/repair. Lead loadings from stainless steel dust collectors were measured as indicators of the amount of lead disturbed and made available by the R&R activity for exposure to occupants. With the exception of carpet removal and drilling into plaster, all activities monitored in the EFSS deposited significant amounts of lead, ranging from 218 $\mu g/ft^2$ for sawing lead-painted plaster to 42,900 $\mu g/ft^2$ for paint removal. Other exposure modifiers, as well as sampling methodology issues, are discussed in the report.

17. Document Analysis

a. Descriptors
   Lead-based paint, lead hazards, renovation and remodeling, field study, wipe and vacuum dust-lead sampling, dust-lead, personal exposure samples, worker certification, dustfall sampling
b. Identifiers/open-ended Terms
   Lead, renovation and remodeling, worker exposure, Title X, dustfall
c. COSATI Field/Group

18. Availability Statement Release Unlimited	19. Security Class (This Report) Unclassified	21. No. of Pages 135
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-239.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce