northgate
environmental management, inc.

MEMORANDUM

From: Deni Chambers, Northgate
Renee Kalmes, Exponent

DATE: February 19, 2010/
Revised May 14, 2010

To: Brian Rakvica, NDEP

RE: Protocol: Bioaccessibility Method for Dioxin/Furans in Soil

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As requested by NDEP in their February 9, 2010 memorandum, the following protocol presents an *in vitro* bioaccessibility extraction test for dioxin/furans in soil to be implemented at the Tronox Henderson, Nevada Site (Site). The *in vitro* extraction method generally follows that reported in Ruby et al. (2002) and further described in Finley et al. (2009). The objective of this study is to provide site-specific information that will allow for an understanding of the likely relative bioavailability of dioxins/furans from site soils (on a TEQ basis). The data that emerge from this study will be evaluated to elucidate the nature of dioxins/furans in soils at the site, and will be interpreted in the context of available studies on the bioavailability of dioxins/furans, as has been presented in recent publications, including but not limited to Budinsky et al. (2008) and Finely et al. (2009).

As requested by NDEP, the dioxin/furan congener profile for relevant Site soil samples is presented in Attachment 1, because it provides the basis for identifying one dioxin/furan type at the Site.

Soil Sample Collection and Analysis

Soil sample collection will be targeted in areas of the Site where prior data indicate dioxin/furan TEQ concentrations generally between 1,000 and 3,000 parts per thousand and include a representative range of organic carbon content, while also considering the site conceptual model. Soil samples (0-1 feet below ground surface [bgs] in depth) will be collected from ten different locations at the Site, as follows:

Sample Location	Total Dioxin TEQ (ppt)	Fraction of Organic Carbon (%)
Two samples from Area 4		
SA 169	2,000	0.145
Near SA 84	1,200	0.629
Four samples from Area 2		
Near SA 41	2,237	1.25
Near SA 114	2,522	7.18
Near SA 150	3,052	0.274
Near SA 167	2,027	0.073
Four samples from Area 1		
Near SA 75	1,265	0.063
Near RSAH3	1,360	0.15
Near RSAL3	1,141	0.895
Near RSAK4	1,556	0.166

At each of these locations, one additional sample will be collected and archived in the event that additional analysis is needed (10 for initial analysis and 10 archived samples). Samples will be homogenized in the field prior to being transferred to appropriate sample containers. Samples will be collected in accordance with procedures outlined in the Quality Assurance Project Plan (QAPP) (AECOM 2009), including use of sample containers, preservatives, and holding times as specified in Table B-1 of the QAPP[1]. Standard Operating Procedures (SOPs) presented in BRC SOP-06 (Sample Management Procedures) and SOP- 34 (Investigated Derived Waste Management) will be followed.[2]

All bioaccessibility extractions and dioxin/furan analytical work (for soils and extraction fluid) will be conducted by Vista Analytical at their laboratory:

1100 Windfield Way
El Dorado Hills, CA 95762-9622
(916) 673-1520

In the lab, the soils will be air-dried and sieved to the <250-µm particle size prior to being analyzed for dioxin/furan. All soil samples and extraction fluid samples will be analyzed for dioxins/furans by EPA Method 1613. (This method is technically identical to EPA Method 8290, but with different quality control limits. Method 1613 is generally recommended for use on biological tissue samples, and therefore was deemed more appropriate for evaluation of simulated gastric fluid, although the distinction is insignificant, given the similarities in the methods.) Data will be reported as individual congeners to allow for reporting of results in toxicity equivalency (TEQ). All samples will

[1] Quality Assurance Project Plan, Tronox LLC Facility Henderson Neveda. AECOM 2009. Revised July 20.
[2] Basic Remediation Company Standard Operating Procedures, BMI Common Areas, Clark County Neveda. SOP -06 and SOP -34. December 2008.

be analyzed for dioxin/furan content using isotope dilution gas chromatography-mass spectrometry, to ensure that the collected soils represent an appropriate dioxin/furan TEQ range for use in the bioaccessibility study. All 10 samples (and any additional archived samples) will also be analyzed for organic carbon content according to United States Environmental Protection Agency (USEPA) Method Lloyd-Kahn 9060.

Bioaccessibility Extraction Method

The extraction will be carried out in 1-liter (L) amber glass bottles with Teflon®-lined screw caps. The bottles will be partially immersed in a water bath to maintain a temperature of 37 °C throughout the extraction procedure. Slow mixing will be provided by a stainless-steel paddle stirrer mounted in a rheostat-controlled motor (Arrow Engineering Model 1750®), or on a shaking water bath. A stirring/shaking rate of 30 revolutions per minute (rpm) will be maintained during the *in vitro* extraction.

The method generally follows that published by Ruby et al., (2002), but scaled back to 90% to allow for the use of 1-L bottles. The test procedure involves extraction of 9 grams (g) of test soil (<250-µm size fraction) in 0.9 L of extraction fluid (1:100 soil:solution ratio[3]), using a sequential extraction procedure that simulates a stomach phase (pH 1.5 with various enzymes, proteins, and fatty acids for 1 hour) followed by a small-intestinal phase (pH 7.2 with additional enzymes for 4 hours). Subsequent to the small-intestinal incubation, the extraction solution will be centrifuged (to remove any soil particles), and the extraction fluid will be submitted for analysis according to USEPA Method 1613. The resultant data, in combination with the total concentrations of the target analyte(s) for each soil, will be used to calculate the fraction of chemical that is liberated from each test soil (i.e., fraction that is bioaccessible).

The extraction procedure will be conducted according to the following method:

- Stock solutions should be mixed as specified in Ruby et al. (2002) (and modified in Finley 2009). Text below provides the basic steps in mixing these solutions. The attached Table 4 provides a scale-up to provide adequate solution for the full suite of extractions to be undertaken in this effort, and the contents of each extraction vessel.

[3] The 1:100 soil:fluid ratio was initially implemented in bioaccessibility testing for metals in soil. Lower soil:fluid ratios (e.g., 1:5 or 1:25) were found to limit dissolution from soils, most likely by constraining dissolution kinetics. Insufficient data are available to accurately estimate the soil:fluid ratio that might occur in a child following inadvertent soil ingestion, although some have suggested that higher ratios (e.g., 1:1000) are representative of the ratio of total daily soil ingestion to total daily fluid production in the gastrointestinal tract (Richardson 2006). High soil:fluid ratios have potentially adverse impacts on detection limits as well as creating larger waste streams. Therefore, it is generally believed that the ratio needs to be adequately high to avoid constraints on dissolution kinetics. For lead, in vitro extraction methods using a 1:100 soil:fluid ratio result in bioaccessibility estimates that are directly predictive of the relative oral bioavailability of lead. The ratio of 1:100 was selected for use in this method (Ruby 2002), based on precedent and logistical considerations.

- Prepare 4 L of buffered stomach fluid by adding 60.06 g glycine (0.2 M; Sigma UltraPure®) to 4 L of Type II deionized (DI) water, and adjust to pH 1.5 with concentrated HCl (requires approx. 240 mL)
- Add 35.2 g of sodium chloride (NaCl, concentration of 150 mM in stomach fluid)
- Add 4.0 g of pepsin (activity of 800–2,500 units/mg, final concentration of 1.00 g/L in stomach fluid)
- Add 20 g bovine serum albumin (BSA; minimum 98 percent, final concentration of 5 g/L in stomach fluid)
- Add 10 g mucine (Type III, purified from porcine stomach; final concentration of 2.5 g/L in stomach fluid)
- Place 0.9 L of the stomach solution in each reaction vessel
- Add 5.4 mL of oleic acid (90%; Aldrich Chemical) to each extraction vessel
- Add 9 g of soil (<250 μm size fraction) to each reaction vessel
- Stir for 1 hour with paddle stirrer at 30 rpm to simulate stomach-phase extraction
- Bring reaction fluid in each vessel to pH 7.2 by adding sodium hydroxide (NaOH; 50 percent w/w, approximately 9 mL)
- Add 540 mg porcine pancreatin to each extraction vessel (activity equivalent to 8× U.S.P. specifications)
- Add 3.6 g of bovine bile (50 percent bile acids, mixture of free and conjugated acids) to each extraction vessel
- Stir for 4 hours with paddle stirrer at 30 rpm
- After 4 hours of small-intestinal extraction time, allow the solids to settle, and decant all of the fluid from each reaction vessel into four 250-mL centrifuge tubes. Centrifuge at 3,000 Gs for 10 minutes and collect the supernatant in a 1-L amber glass bottle. Record the volume of extraction fluid collected.

Mass Balance Testing

As a check on the recovery from the *in vitro* extraction, a mass balance test will be performed on the replicate extraction samples by adding the two following steps (outlined below) to the extraction protocol:

- Using DI water, wash the post-extraction soil from the reaction vessel onto a 1.0-μm glass-fiber filter. Wash any soil pellets in the centrifuge tubes onto the filter. Wash the filtered soil with 20 mL DI water. Add the filtrate to the extraction supernatant (in the 1-L amber glass bottle), and measure the volume of extraction fluid.

- Collect the post-extraction soil, and remove 2 g for determination of percent moisture. Ship the remaining post-extraction soil (wet) to the analytical laboratory for analysis.

Quality Control

In addition to the 10 site soils, a set of samples will be included to allow for an assessment of data quality. These will include (at a minimum):

- Triplicate testing of one site soil
- Extraction blank
- Extraction spike (to be representative of the congener mix found in site soils)

ATTACHMENT

1 Vista Analytical Services Dioxin/furan Analytical Results for Soil Samples

TABLES

1 Dioxin/Furan Congener for Select Soil Samples a)

2 Dioxin/Furan Congener Percentage of TEQ for Select Soil Samples a)

3 Dioxin/Furan Congener Percentage of TEQ for Select Supplemental (Depth) Soil Samples a)

4 Stock Solutions for Bioaccessibility Testing

Profile Set 1

Profile Set 2

ATTACHMENT 1: DIOXIN CONGENER PROFILE ANALYSIS

To evaluate the potential similarities or differences among dioxin/furan congener profiles from Site soils, a congener profile analysis was conducted for 37 soil samples collected from Areas I, II, and IV. Most of these samples represent concentrations of dioxin/furan TEQ within the approximate range of 1,000 to 3,000 ppt, which is the range of interest. However, for comparison purposes, some additional congener profiles for samples with higher reported dioxin/furan concentrations are included, and four (4) dioxin/furan samples collected near the former effluent pond berms SA 201-0.5B, RSAJ6-0.5B, RSAJ7-0.5B, RSAK3-0.5B) are included. Dioxin fingerprinting was not conducted for Area III samples, because all dioxin/furan TEQ results are below the BCL screening level of 1000 ppt.

Table 1 provides the dioxin/furan TEQ for the 37 samples and the individual congener results, while Table 2 presents the congener data as a percentage of the total TEQ for the 37 samples. Total organic carbon content of the samples is also presented in Table 2. As shown in the first set of fingerprint profile figures (Set 1), the congener fingerprints of all the samples are fairly consistent. With the exception of one sample (SA-129), dioxins generally account for less than 6% of the total TEQ and 2,3,7,8-TCDD constitutes a very minor component of each soil sample (less than 0.3%). In all samples, the hexa, hepta, and octa furans account for the vast majority (at least 75%) of the total dioxin/furan TEQ in each sample, with OCDF accounting for at least 40% of the total TEQ concentration. This pattern is essentially identical to that reported by Finley et al. (2009) for a magnesium facility in which chloride and metals were separated via an electrolytic process.

Table 3 provides the congener data as a percentage of the total TEQ for a set of supplemental soil samples in which dioxin/furan samples were collected at a depth of 1.0–1.5 ft bgs and 1.5–2.0 ft bgs. The second set of fingerprint profiles (Set 2) also shows that the fingerprint profiles for these samples are fairly consistent with depth.

Based on this evaluation, the dioxin/furan samples of interest have similar “fingerprints,” and there is little variability in this pattern among samples collected in Areas I, II, and IV, within high and low dioxin/furan TEQ concentrations or by depth. The fingerprint profiles will be confirmed based on the data collected as part of the bioaccessibility study.

TABLE 1
Dioxin/Furan Congener Data for Select Soil Samples a)

Area	Grid ID	System Sample Code	2,3,7,8-TCDD (ng/kg)	1,2,3,7,8-PeCDD (ng/kg)	1,2,3,4,7,8-HxCDD (ng/kg)	1,2,3,7,8,9-HxCDD (ng/kg)	1,2,3,6,7,8-HxCDD (ng/kg)	1,2,3,4,6,7,8-HpCDD (ng/kg)	OCDD (ng/kg)	2,3,7,8-TCDF (ng/kg)	1,2,3,7,8-PeCDF (ng/kg)	2,3,4,7,8-PeCDF (ng/kg)	1,2,3,4,7,8-HxCDF (ng/kg)	1,2,3,7,8,9-HxCDF (ng/kg)	1,2,3,6,7,8-HxCDF (ng/kg)	2,3,4,6,7,8-HxCDF (ng/kg)	1,2,3,4,6,7,8-HpCDF (ng/kg)	1,2,3,4,7,8,9-HpCDF (ng/kg)	OCDF (ng/kg)	Total TEQ (ng/kg)
1 - Near Berm	I-3	SA201-0.5B	407	1630	1080	2560	2610	9370	8930	11400	19800	10000	60300	6390	38700	21300	135000	62300	363000	22,243
1 - Near Berm	J-6	RSAJ6-0.5B	990	1590	3440	7840	7090	20500	23000	29600	23000	11400	198000	22400	130000	69000	459000	210000	941000	60,611
1 - Near Berm	J-7	RSAJ7-0.5B	1020	2790	2020	4430	4040	15200	14600	27400	51200	24000	123000	12800	76000	9340	220000	91200	725000	41,935
1 - Near Berm	K-3	RSAK3-0.5B	1880	2880	2680	5840	5290	17000	22700	11700	40700	20200	122000	15200	79300	43400	315000	148000	821000	45,635
1	H-3	RSAH3-0.5B	21.7	99.1	75.4	158	137	462	491	601	1780	739	3630	281	2480	1150	7600	2740	16000	1,360
1	J-2	RSAJ2-0.5B	156	485	350	559	461	1360	1670	1860	3030	1240	10200	913	6740	1440	20800	10500	52900	3,699
1	J-5	RSAJ5-0.5B	118	389	251	675	602	1450	1860	1700	2870	1230	10400	439	6130	1570	17100	7600	52900	3,417
1	J-6	SA127-0.5B	32.6	85.4	56.6	129	105	334	364	615	1420	560	3870	307	2460	333	7270	3460	16100	1,232
1	K-4	RSAK4-0.5B	32.1	118	100	221	178	514	527	1430	1300	581	4410	296	3060	734	10000	3840	21300	1,556
1	K-8	RSAK8-0.5B	38.5	117	91.7	194	153	791	686	2240	1620	692	5450	361	3440	424	10900	5350	26900	1,826
1	L-3	RSAL3-0.5B	23.9	83.8	67.4	152	138	534	917	1100	1330	388	4150	179	1920	286	4680	2170	12500	1,141
1	L-4	SA189-0.5B	25.9	73.5	59.2	120	103	369	413	2000	1140	499	2770	164	1840	318	6170	2600	16500	1,117
1	L-7	SA75-0.5B	24.3	91.3	67.8	145	127	380	448	1970	1750	897	2720	222	1580	797	3960	1700	13200	1,265
2 - Ditch	M-7	SA155-0.5B	139	482	408	844	766	2490	2770	2430	6110	2990	16800	1390	10700	5790	29800	13400	85000	6,097
2	L-5	SA167-0.5B	41.5	151	143	271	264	850	1040	621	1960	882	6930	432	4100	1140	7580	3100	18800	2,027
2	M-5	SA104-0.5B	51	195	143	248	227	742	1250	2650	1970	934	4950	473	2810	1640	8600	4150	35700	2,045
2	M-5	SA129-0.5B	22.6	68	282	212	141	633	5390	4850	1480	1050	2290	60.9	677	587	2780	1530	30700	1,420
2	M-6	SA175-0.5B	159	429	414	698	626	1850	2510	6540	4350	2050	13100	1330	7130	4170	25700	11700	86500	5,154
2	M-7	SA63-0.5B	155	493	480	871	763	2310	3290	6100	4710	2350	15500	1550	8450	4840	31000	13700	111000	5,854
2	M-7	SA86-0.5B	185	619	528	835	786	2790	3860	3320	7250	4130	14400	1370	7560	4420	24900	11000	75100	5,993
2	M-7	SA92-0.5B	18.8	89.7	53.9	130	112	377	377	1690	1460	506	3460	266	2210	1230	6410	3050	17600	1,323
2	N-5	SA58-0.5B	28.2	67.5	55.8	119	96.4	376	385	1750	1380	713	3650	372	2390	1480	5360	2660	18700	1,432
2	N-6	SA105-0.5B	50	84.3	54.9	140	118	422	456	2050	1390	682	3320	391	2090	1200	5000	2490	17900	1,402
2	N-6	SA150-0.5B	76.8	283	227	448	367	965	1450	4170	2430	1170	7620	722	4330	2530	14000	6190	50800	3,052
2	N-6	SA60-0.5B	101	304	216	353	366	1370	2810	6030	4030	2120	11400	1380	6500	4020	21500	10700	85100	4,550
2	N-7	SA49-0.5B	114	383	271	546	445	1270	1970	4290	4090	2020	9070	1140	5930	3510	16100	8130	56000	4,018
2	N-7	SA107-0.5B	67.7	227	143	333	282	1080	757	4240	3830	1800	7780	837	4770	2670	11400	5310	32200	3,243
2	O-5	SA114-0.5B	73.5	263	213	417	356	1250	1780	881	2150	1150	6930	651	3710	2210	14600	6710	43200	2,522
2	O-5	SA187-0.5B	64.6	254	192	386	374	1060	1470	1060	2060	1140	6380	448	3570	1890	9410	4080	39200	2,310
2	O-5	SA41-0.5B	50.1	167	112	239	200	740	875	1180	2000	918	6460	574	3890	2070	13700	5420	43000	2,237
2	O-6	SA200-0.5B	13.9	52.1	42.8	88.1	77.3	297	376	1100	816	366	2940	212	1730	1030	6470	3060	22700	1,027
2	O-6	SA51-0.5B	24.1	78.9	53.8	121	105	407	813	1410	972	508	3210	244	1890	1090	6040	3050	20600	1,198
4	Q-3	RSAQ3-0.5B	720	2200	1000	1100	1400	5600	5200	12000	19000	7800	30000	2100	15000	2300	47000	19000	140000	13,000
4	Q-3	RSAQ3009-0.5B (dup)	230	760	530	1000	880	3300	3500	3700	6900	2300	15000	1700	8400	1900	28000	16000	110000	5,700
4	Q-3	SA169-0.5B	79	210	140	220	240	870	820	1400	2300	1200	4700	450	2900	680	9900	4600	30000	2,000
4	Q-4	SA84-0.5B	22	64	59	130	100	450	690	770	1400	650	3500	390	2000	540	9100	3800	31000	1,200
4	Q-5	SA156-0.5B	74	150	76	150	140	480	750	2100	1200	820	2500	170	1600	400	5500	2100	15000	1,300

Note: All Area 4 data are unvalidated

[a)] For use in Set 1 profiles

TABLE 2
Dioxin/Furan Congener Percentage of TEQ for Select Soil Samples a)

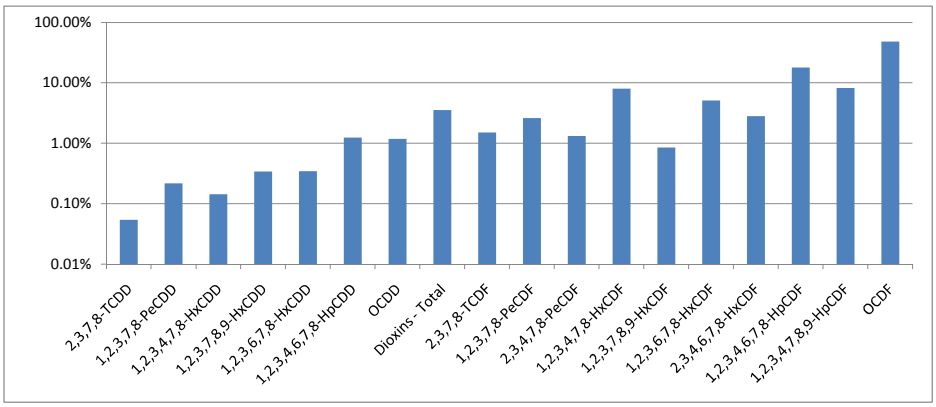
Area	Grid ID	System Sample Code	FOC (%)	Total TEQ (ng/kg)	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	Dioxins - Total	2,3,7,8-TCDF	1,2,3,7,8-PeCDF	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,6,7,8-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF	Furans - Total
1 - Near Berm	I-3	SA201-0.5B	0.664	22,243	0.05%	0.22%	0.14%	0.34%	0.35%	1.24%	1.18%	3.52%	1.51%	2.62%	1.32%	7.99%	0.85%	5.13%	2.82%	17.89%	8.25%	48.09%	96.48%
1 - Near Berm	J-6	RSAJ6-0.5B	0.566	60,611	0.05%	0.07%	0.16%	0.36%	0.33%	0.95%	1.07%	2.99%	1.37%	1.07%	0.53%	9.18%	1.04%	6.02%	3.20%	21.27%	9.73%	43.61%	97.01%
1 - Near Berm	J-7	RSAJ7-0.5B	0.249	41,935	0.07%	0.20%	0.14%	0.32%	0.29%	1.08%	1.04%	3.14%	1.95%	3.65%	1.71%	8.76%	0.91%	5.41%	0.67%	15.67%	6.50%	51.64%	96.86%
1 - Near Berm	K-3	RSAK3-0.5B	0.485	45,635	0.11%	0.17%	0.16%	0.35%	0.32%	1.02%	1.36%	3.48%	0.70%	2.43%	1.21%	7.28%	0.91%	4.73%	2.59%	18.81%	8.84%	49.02%	96.52%
1	H-3	RSAH3-0.5B	0.15	1,360	0.06%	0.26%	0.20%	0.41%	0.36%	1.20%	1.28%	3.76%	1.56%	4.63%	1.92%	9.44%	0.73%	6.45%	2.99%	19.77%	7.13%	41.62%	96.24%
1	J-2	RSAJ2-0.5B	2.25	3,699	0.14%	0.42%	0.31%	0.49%	0.40%	1.19%	1.46%	4.40%	1.62%	2.64%	1.08%	8.90%	0.80%	5.88%	1.26%	18.14%	9.16%	46.13%	95.60%
1	J-5	RSAJ5-0.5B	1.58	3,417	0.11%	0.36%	0.23%	0.63%	0.56%	1.35%	1.73%	4.98%	1.58%	2.68%	1.15%	9.69%	0.41%	5.71%	1.46%	15.94%	7.08%	49.31%	95.02%
1	J-6	SA127-0.5B	0.079	1,232	0.09%	0.23%	0.15%	0.34%	0.28%	0.89%	0.97%	2.95%	1.64%	3.79%	1.49%	10.32%	0.82%	6.56%	0.89%	19.39%	9.23%	42.93%	97.05%
1	K-4	RSAK4-0.5B	0.166	1,556	0.07%	0.24%	0.21%	0.45%	0.37%	1.06%	1.08%	3.47%	2.94%	2.67%	1.19%	9.07%	0.61%	6.29%	1.51%	20.56%	7.89%	43.79%	96.53%
1	K-8	RSAK8-0.5B	0.174	1,826	0.06%	0.20%	0.15%	0.33%	0.26%	1.33%	1.15%	3.48%	3.77%	2.73%	1.16%	9.17%	0.61%	5.79%	0.71%	18.34%	9.00%	45.25%	96.52%
1	L-3	RSAL3-0.5B	0.895	1,141	0.08%	0.27%	0.22%	0.50%	0.45%	1.74%	2.99%	6.26%	3.59%	4.34%	1.27%	13.55%	0.58%	6.27%	0.93%	15.28%	7.09%	40.82%	93.74%
1	L-4	SA189-0.5B	0.142	1,117	0.07%	0.21%	0.17%	0.34%	0.29%	1.05%	1.17%	3.31%	5.69%	3.24%	1.42%	7.88%	0.47%	5.23%	0.90%	17.55%	7.39%	46.92%	96.69%
1	L-7	SA75-0.5B	0.063	1,265	0.08%	0.30%	0.23%	0.48%	0.42%	1.26%	1.49%	4.27%	6.55%	5.82%	2.98%	9.04%	0.74%	5.25%	2.65%	13.17%	5.65%	43.88%	95.73%
2 - Ditch	M-7	SA155-0.5B	0.324	6,097	0.08%	0.26%	0.22%	0.46%	0.42%	1.37%	1.52%	4.33%	1.33%	3.35%	1.64%	9.22%	0.76%	5.87%	3.18%	16.35%	7.35%	46.62%	95.67%
2	L-5	SA167-0.5B	0.073	2,027	0.09%	0.31%	0.30%	0.56%	0.55%	1.76%	2.15%	5.71%	1.29%	4.06%	1.83%	14.35%	0.89%	8.49%	2.36%	15.69%	6.42%	38.92%	94.29%
2	M-5	SA104-0.5B	0.202	2,045	0.08%	0.29%	0.21%	0.37%	0.34%	1.11%	1.87%	4.28%	3.97%	2.95%	1.40%	7.42%	0.71%	4.21%	2.46%	12.89%	6.22%	53.50%	95.72%
2	M-5	SA129-0.5B	1.33	1,420	0.04%	0.13%	0.53%	0.40%	0.27%	1.20%	10.22%	12.79%	9.19%	2.81%	1.99%	4.34%	0.12%	1.28%	1.11%	5.27%	2.90%	58.20%	87.21%
2	M-6	SA175-0.5B	0.149	5,154	0.09%	0.25%	0.24%	0.41%	0.37%	1.09%	1.48%	3.95%	3.86%	2.57%	1.21%	7.74%	0.79%	4.21%	2.46%	15.18%	6.91%	51.11%	96.05%
2	M-7	SA63-0.5B	0.199	5,854	0.07%	0.24%	0.23%	0.42%	0.37%	1.11%	1.59%	4.03%	2.94%	2.27%	1.13%	7.47%	0.75%	4.07%	2.33%	14.94%	6.60%	53.48%	95.97%
2	M-7	SA86-0.5B	0.642	5,993	0.11%	0.38%	0.32%	0.51%	0.48%	1.71%	2.37%	5.89%	2.04%	4.45%	2.53%	8.83%	0.84%	4.64%	2.71%	15.27%	6.75%	46.06%	94.11%
2	M-7	SA92-0.5B	0.153	1,323	0.05%	0.23%	0.14%	0.33%	0.29%	0.97%	0.97%	2.97%	4.33%	3.74%	1.30%	8.86%	0.68%	5.66%	3.15%	16.42%	7.81%	45.08%	97.03%
2	N-5	SA58-0.5B	0.145	1,432	0.07%	0.17%	0.14%	0.30%	0.24%	0.95%	0.97%	2.85%	4.42%	3.49%	1.80%	9.22%	0.94%	6.04%	3.74%	13.54%	6.72%	47.24%	97.15%
2	N-6	SA105-0.5B	0.276	1,402	0.13%	0.22%	0.15%	0.37%	0.31%	1.12%	1.21%	3.50%	5.42%	3.67%	1.80%	8.77%	1.03%	5.52%	3.17%	13.21%	6.58%	47.31%	96.50%
2	N-6	SA150-0.5B	0.274	3,052	0.08%	0.29%	0.23%	0.46%	0.38%	0.99%	1.48%	3.90%	4.26%	2.49%	1.20%	7.79%	0.74%	4.43%	2.59%	14.32%	6.33%	51.95%	96.10%
2	N-6	SA60-0.5B	0.513	4,550	0.06%	0.19%	0.14%	0.22%	0.23%	0.87%	1.78%	3.49%	3.81%	2.55%	1.34%	7.20%	0.87%	4.11%	2.54%	13.58%	6.76%	53.76%	96.51%
2	N-7	SA49-0.5B	0.255	4,018	0.10%	0.33%	0.24%	0.47%	0.39%	1.10%	1.71%	4.34%	3.72%	3.55%	1.75%	7.87%	0.99%	5.14%	3.04%	13.97%	7.05%	48.58%	95.66%
2	N-7	SA107-0.5B	2.25	3,243	0.09%	0.29%	0.18%	0.43%	0.36%	1.39%	0.97%	3.72%	5.46%	4.93%	2.32%	10.01%	1.08%	6.14%	3.44%	14.67%	6.83%	41.43%	96.28%
2	O-5	SA114-0.5B	7.18	2,522	0.08%	0.30%	0.25%	0.48%	0.41%	1.44%	2.06%	5.03%	1.02%	2.48%	1.33%	8.01%	0.75%	4.29%	2.55%	16.87%	7.75%	49.92%	94.97%
2	O-5	SA187-0.5B	2.94	2,310	0.09%	0.35%	0.26%	0.53%	0.51%	1.45%	2.01%	5.20%	1.45%	2.82%	1.56%	8.74%	0.61%	4.89%	2.59%	12.88%	5.59%	53.67%	94.80%
2	O-5	SA41-0.5B	1.25	2,237	0.06%	0.20%	0.14%	0.29%	0.25%	0.91%	1.07%	2.92%	1.45%	2.45%	1.13%	7.92%	0.70%	4.77%	2.54%	16.79%	6.64%	52.70%	97.08%
2	O-6	SA200-0.5B	0.186	1,027	0.03%	0.13%	0.10%	0.21%	0.19%	0.72%	0.91%	2.29%	2.66%	1.97%	0.88%	7.11%	0.51%	4.18%	2.49%	15.64%	7.40%	54.87%	97.71%
2	O-6	SA51-0.5B	0.36	1,198	0.06%	0.19%	0.13%	0.30%	0.26%	1.00%	2.00%	3.95%	3.47%	2.39%	1.25%	7.90%	0.60%	4.65%	2.68%	14.87%	7.51%	50.72%	96.05%
4	Q-3	RSAQ3-0.5B	0.421	13,000	0.23%	0.71%	0.32%	0.35%	0.45%	1.80%	1.67%	5.53%	3.85%	6.10%	2.50%	9.63%	0.67%	4.82%	0.74%	15.09%	6.10%	44.96%	94.47%
4	Q-3	RSAQ3009-0.5B (dup)	0.327	5,700	0.11%	0.37%	0.26%	0.49%	0.43%	1.62%	1.71%	5.00%	1.81%	3.38%	1.13%	7.35%	0.83%	4.12%	0.93%	13.72%	7.84%	53.90%	95.00%
4	Q-3	SA169-0.5B	0.145	2,000	0.13%	0.35%	0.23%	0.36%	0.40%	1.43%	1.35%	4.25%	2.31%	3.79%	1.98%	7.74%	0.74%	4.78%	1.12%	16.31%	7.58%	49.42%	95.75%
4	Q-4	SA84-0.5B	0.629	1,200	0.04%	0.12%	0.11%	0.24%	0.18%	0.82%	1.26%	2.77%	1.41%	2.56%	1.19%	6.40%	0.71%	3.66%	0.99%	16.65%	6.95%	56.71%	97.23%
4	Q-5	SA156-0.5B	0.539	1,300	0.22%	0.45%	0.23%	0.45%	0.42%	1.45%	2.26%	5.48%	6.32%	3.61%	2.47%	7.53%	0.51%	4.82%	1.20%	16.56%	6.32%	45.17%	94.52%

Note: All Area 4 data are unvalidated

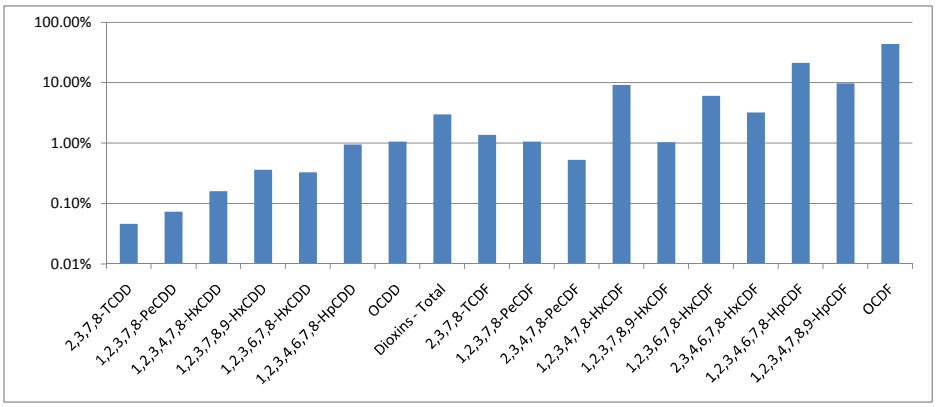
[a] For use in Set 1 profiles

SET 1
Dioxin/Furan Profiles for Select Soil Samples

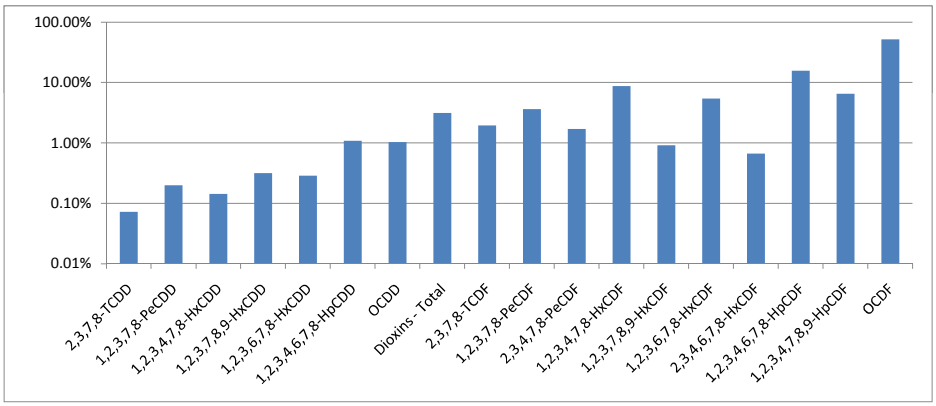
Area	1 - Near Berm
Grid	I-3
Sample	SA201-0.5B
TTEQ (ppt)	22,243



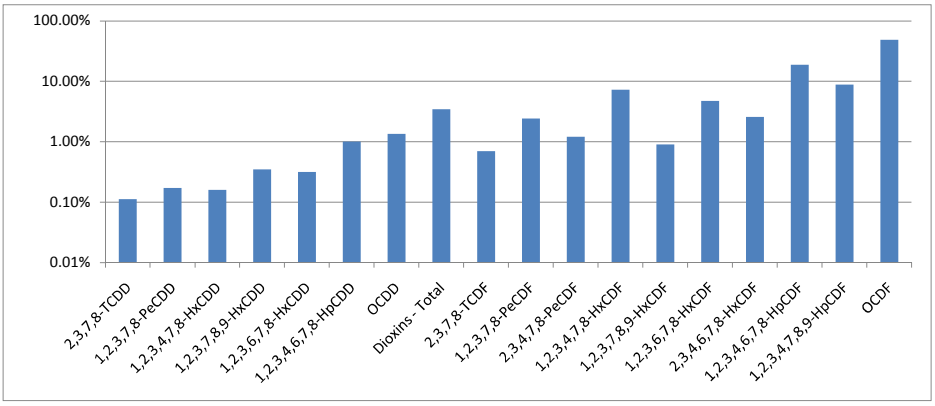
Area	1 - Near Berm
Grid	J-6
Sample	RSAJ6-0.5B
TTEQ (ppt)	60,611



Area	1 - Near Berm
Grid	J-7
Sample	RSAJ7-0.5B
TTEQ (ppt)	41,935

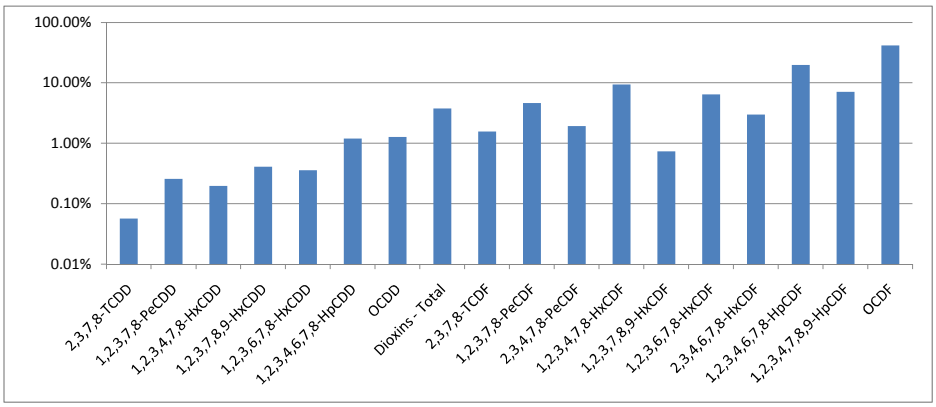


Area	1 - Near Berm
Grid	K-3
Sample	RSAK3-0.5B
TTEQ (ppt)	45,635

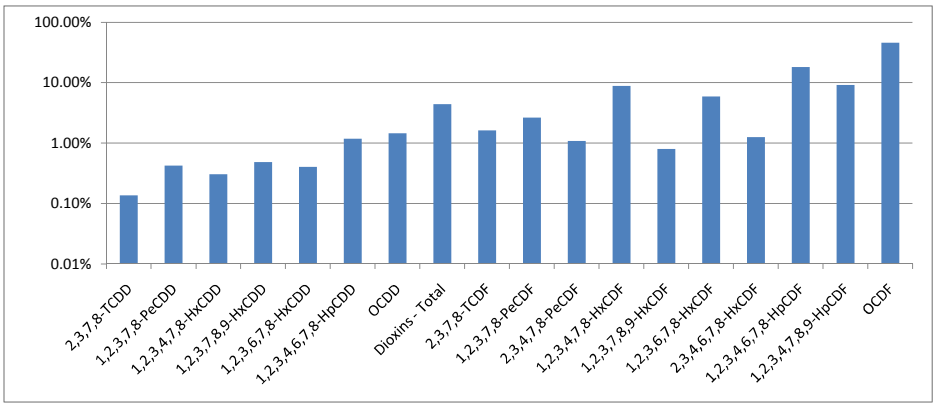


SET 1
Dioxin/Furan Profiles for Select Soil Samples

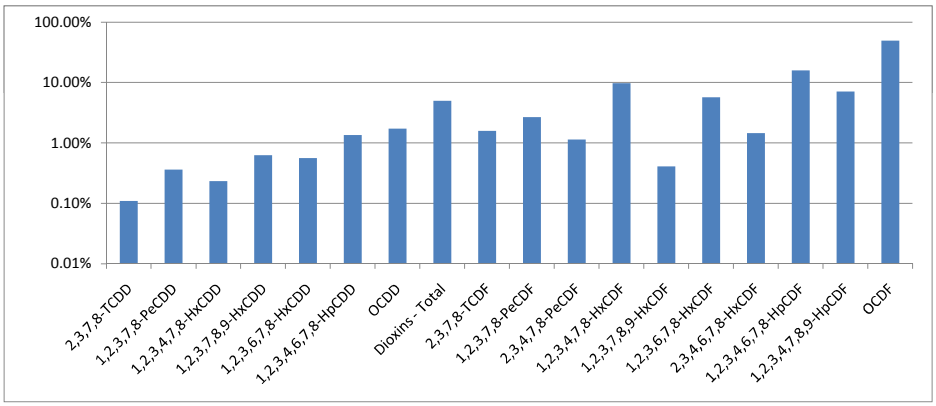
Area	1
Grid	H-3
Sample	RSAH3-0.5B
TTEQ (ppt)	1,360



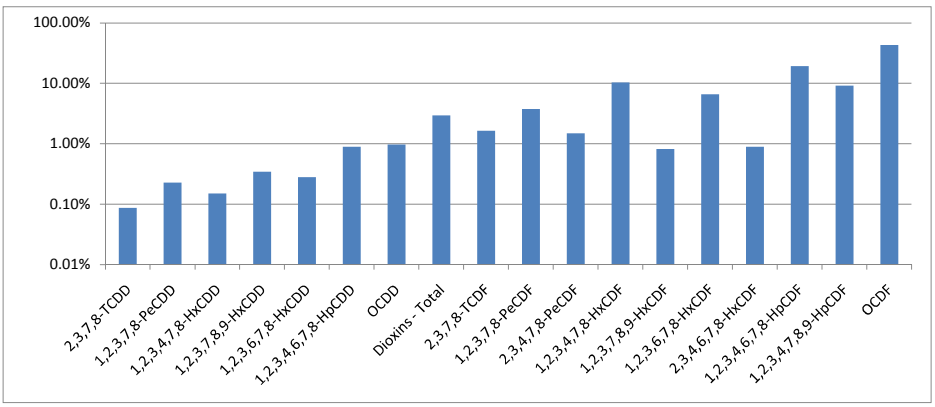
Area	1
Grid	J-2
Sample	RSAJ2-0.5B
TTEQ (ppt)	3,699



Area	1
Grid	J-5
Sample	RSAJ5-0.5B
TTEQ (ppt)	3,417

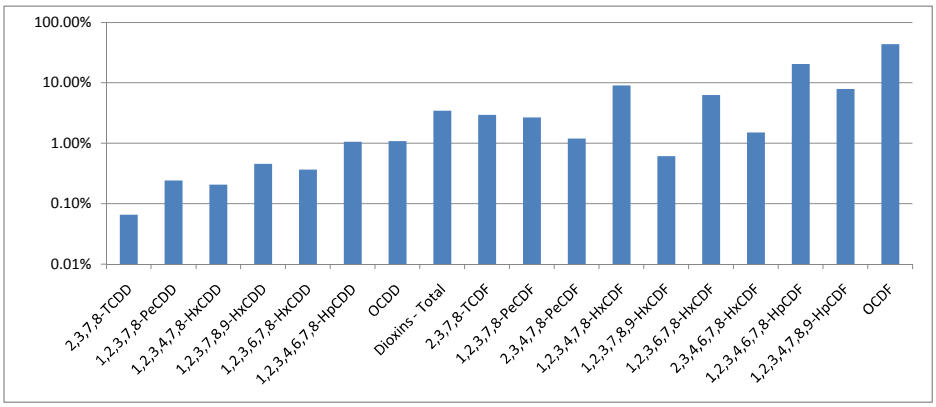


Area	1
Grid	J-6
Sample	SA127-0.5B
TTEQ (ppt)	1,232

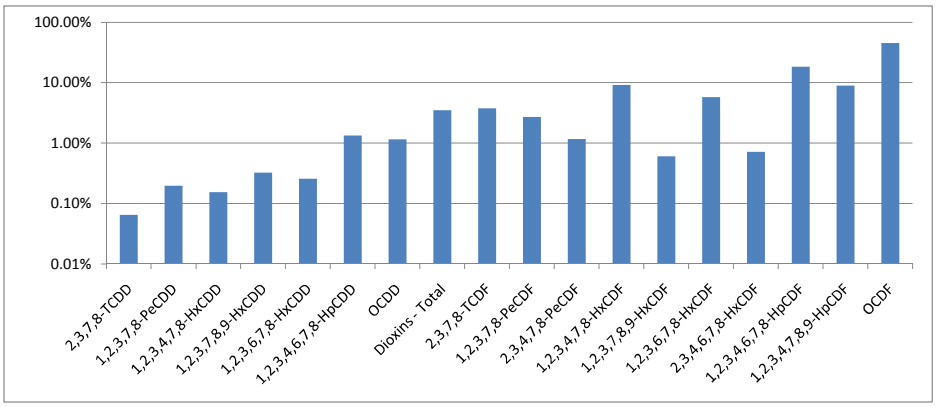


SET 1
Dioxin/Furan Profiles for Select Soil Samples

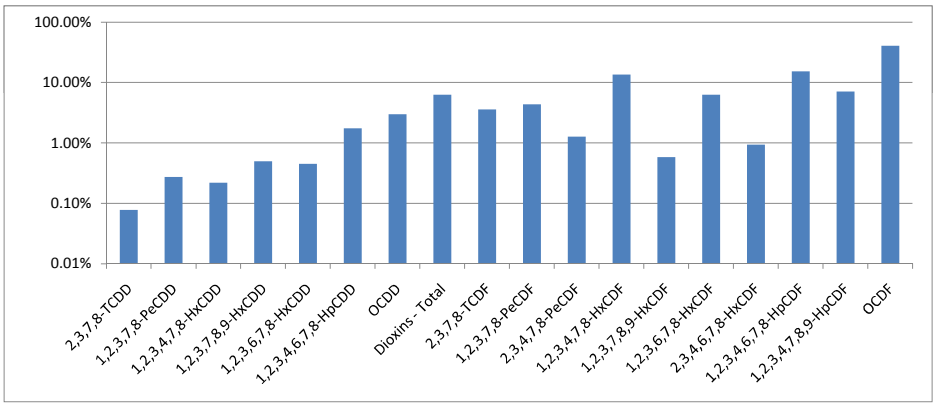
Area	1
Grid	K-4
Sample	RSAK4-0.5B
TTEQ (ppt)	1,556



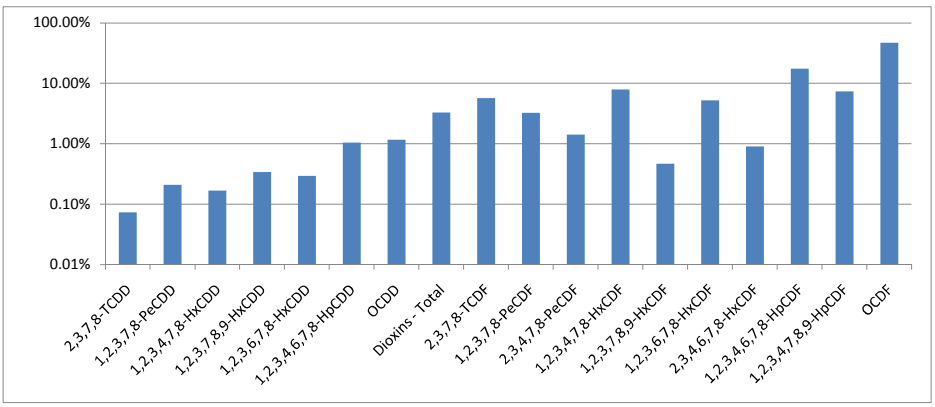
Area	1
Grid	K-8
Sample	RSAK8-0.5B
TTEQ (ppt)	1,826



Area	1
Grid	L-3
Sample	RSAL3-0.5B
TTEQ (ppt)	1,141

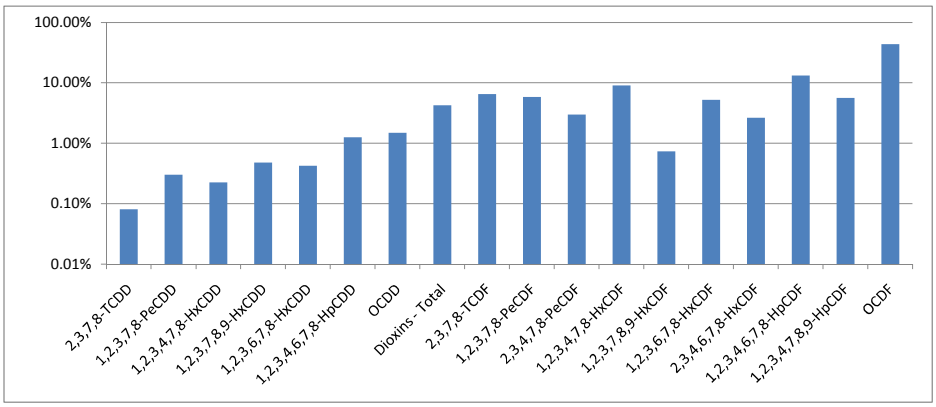


Area	1
Grid	L-4
Sample	SA189-0.5B
TTEQ (ppt)	1,117

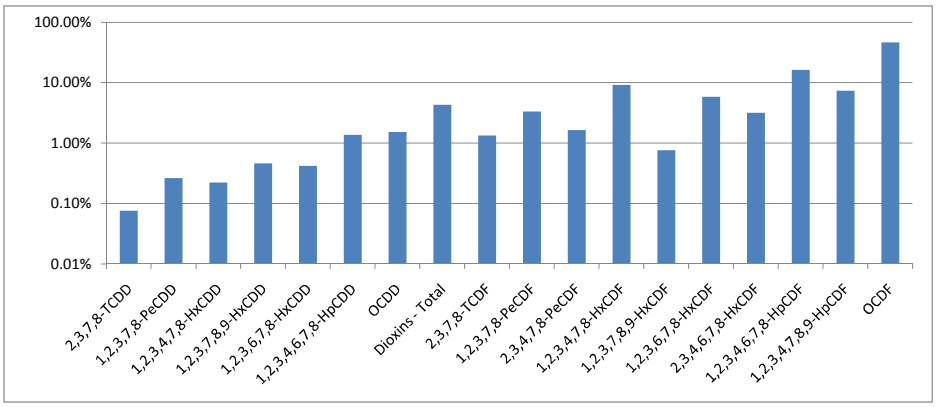


SET 1
Dioxin/Furan Profiles for Select Soil Samples

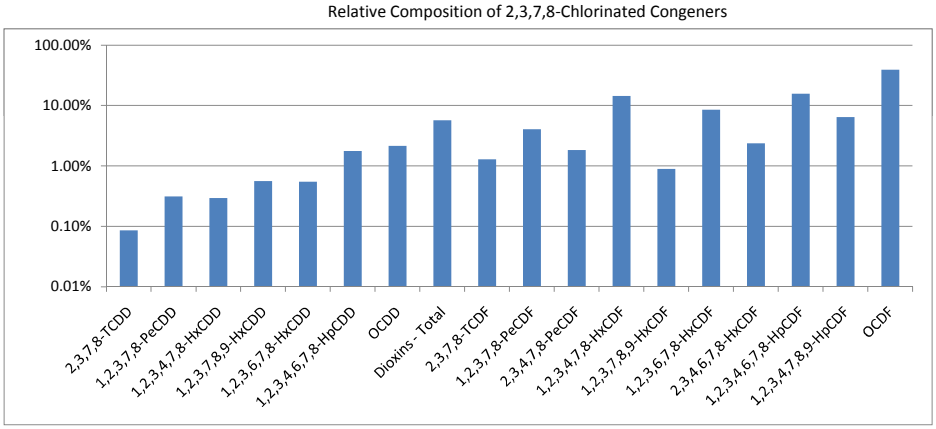
Area	1
Grid	L-7
Sample	SA75-0.5B
TTEQ (ppt)	1,265



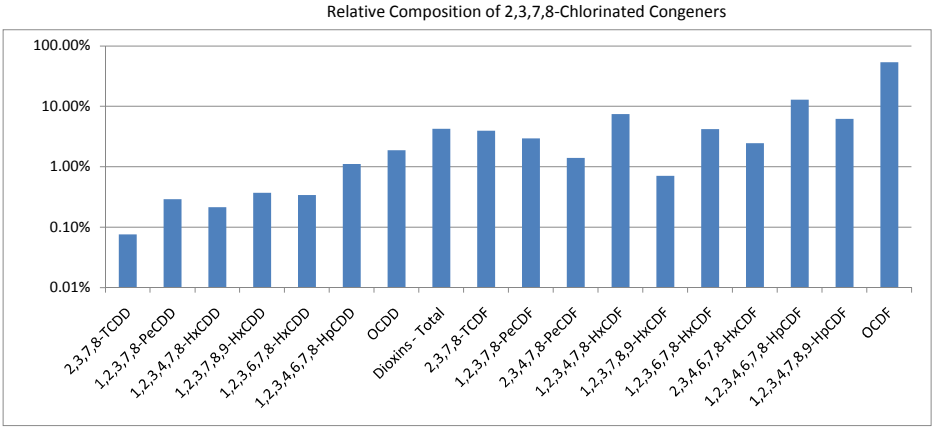
Area	2 - Ditch
Grid	M-7
Sample	SA155-0.5B
TTEQ (ppt)	6,097



Area	2
Grid	L-5
Sample	SA167-0.5B
TTEQ (ppt)	2,027

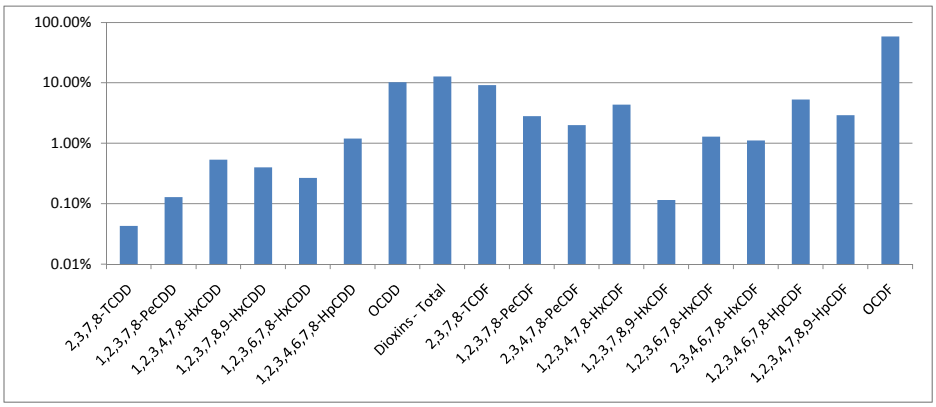


Area	2
Grid	M-5
Sample	SA104-0.5B
TTEQ (ppt)	2,045

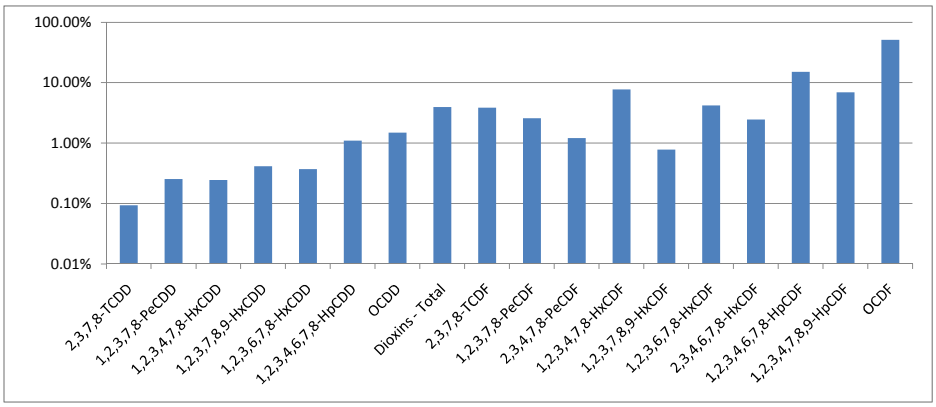


SET 1
Dioxin/Furan Profiles for Select Soil Samples

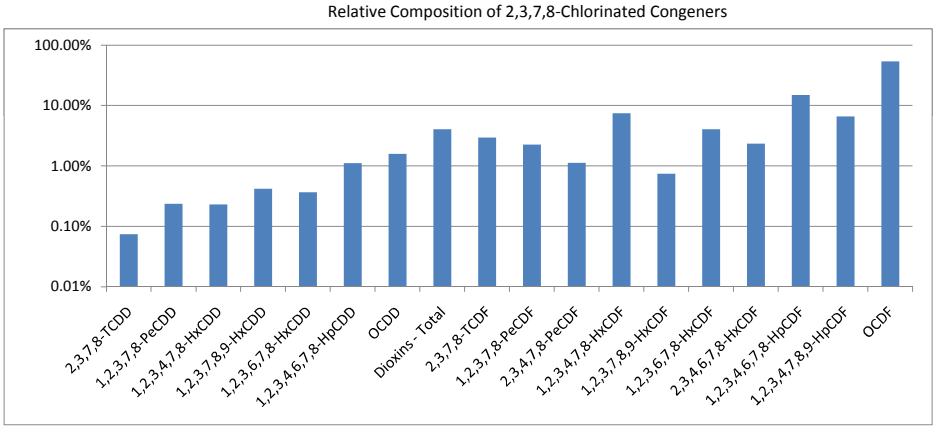
Area	2
Grid	M-5
Sample	SA129-0.5B
TTEQ (ppt)	1,420



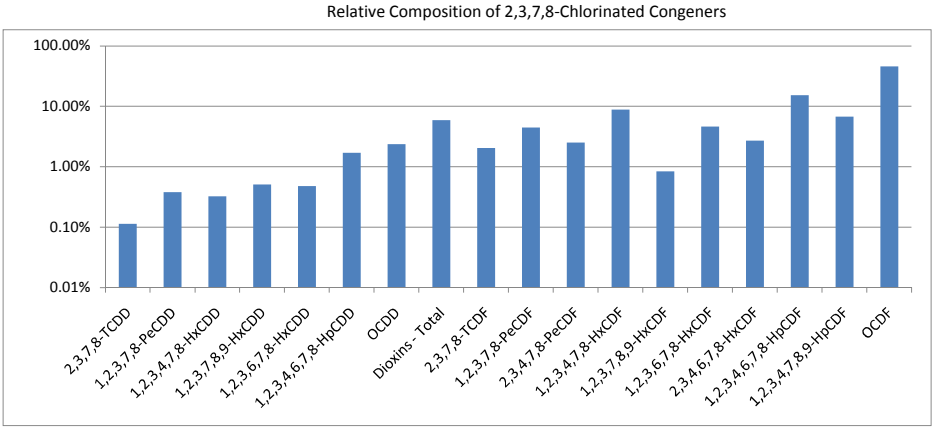
Area	2
Grid	M-6
Sample	SA175-0.5B
TTEQ (ppt)	5,154



Area	2
Grid	M-7
Sample	SA63-0.5B
TTEQ (ppt)	5,854

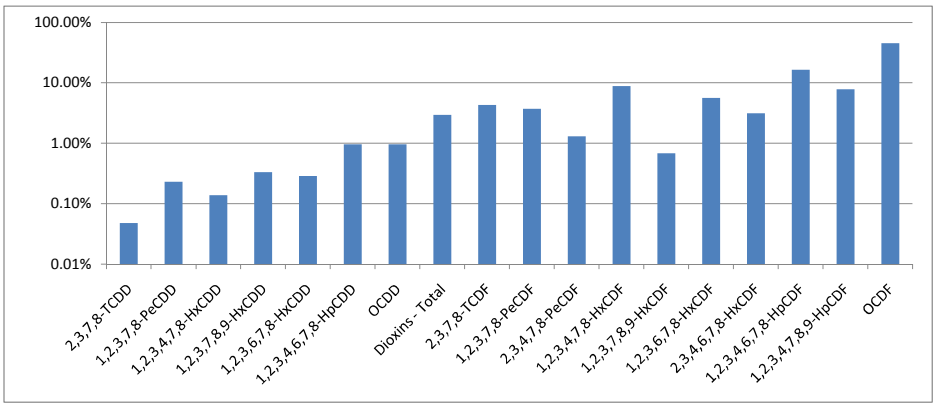


Area	2
Grid	M-7
Sample	SA86-0.5B
TTEQ (ppt)	5,993

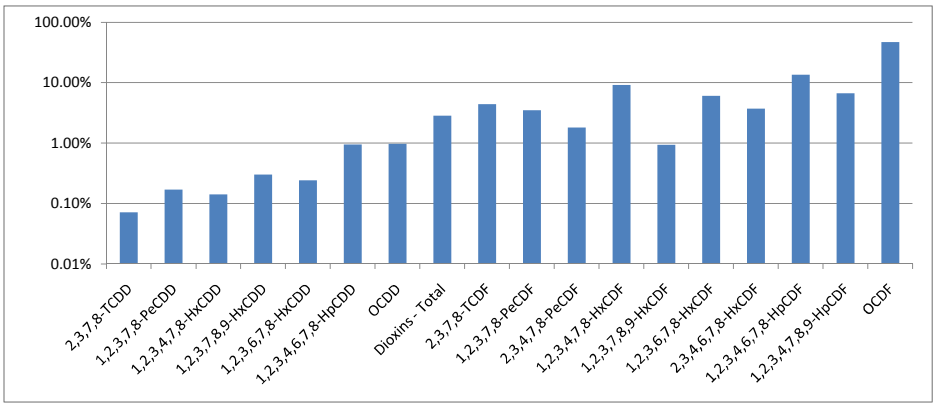


SET 1
Dioxin/Furan Profiles for Select Soil Samples

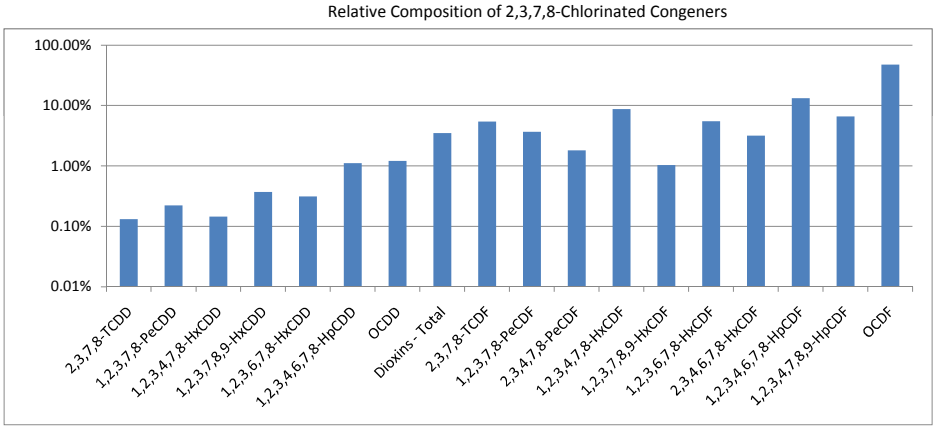
Area	2
Grid	M-7
Sample	SA92-0.5B
TTEQ (ppt)	1,323



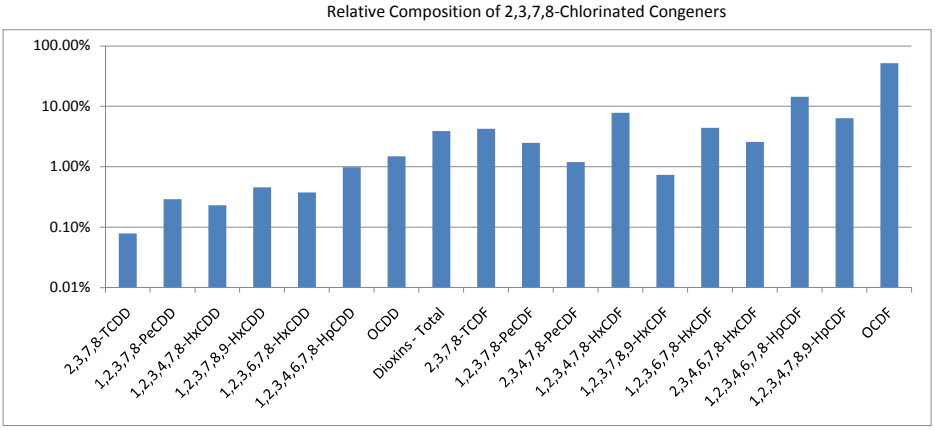
Area	2
Grid	N-5
Sample	SA58-0.5B
TTEQ (ppt)	1,432



Area	2
Grid	N-6
Sample	SA105-0.5B
TTEQ (ppt)	1,402

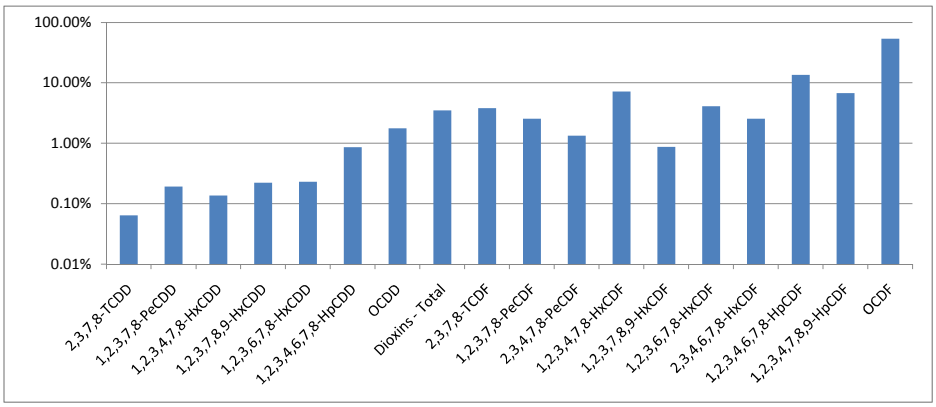


Area	2
Grid	N-6
Sample	SA150-0.5B
TTEQ (ppt)	3,052

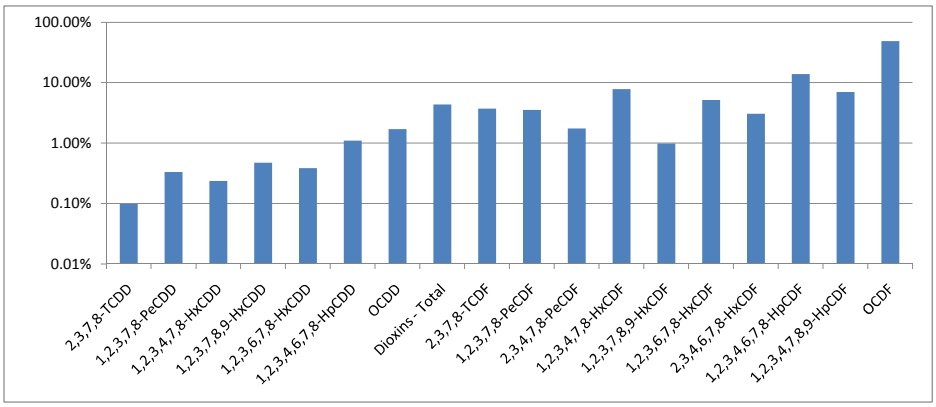


SET 1
Dioxin/Furan Profiles for Select Soil Samples

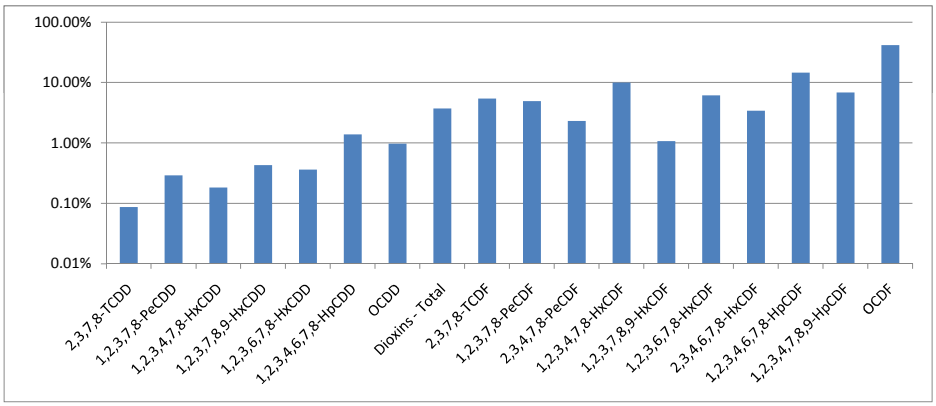
Area	2
Grid	N-6
Sample	SA60-0.5B
TTEQ (ppt)	4,550



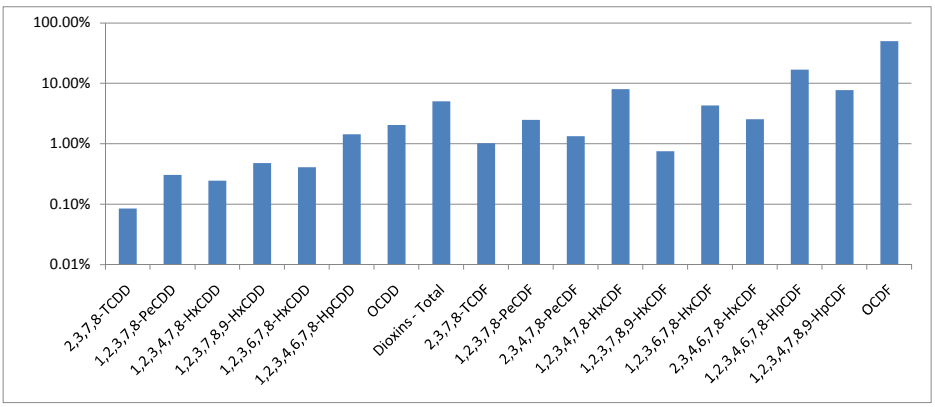
Area	2
Grid	N-7
Sample	SA49-0.5B
TTEQ (ppt)	4,018



Area	2
Grid	N-7
Sample	SA107-0.5B
TTEQ (ppt)	3,243

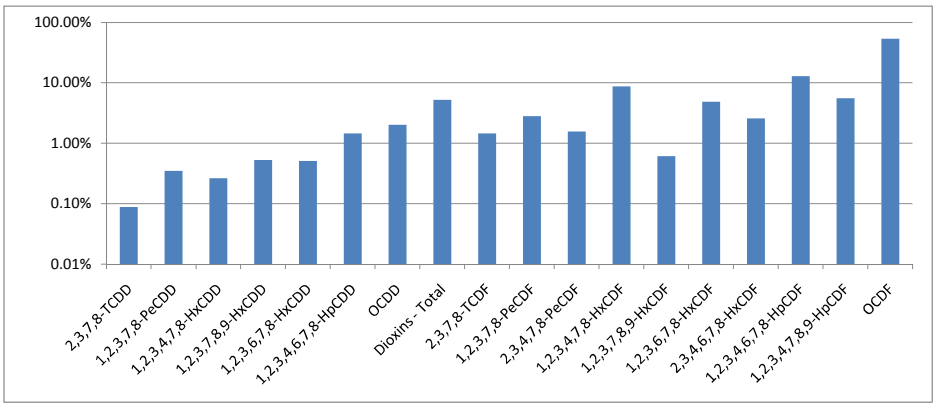


Area	2
Grid	O-5
Sample	SA114-0.5B
TTEQ (ppt)	2,522

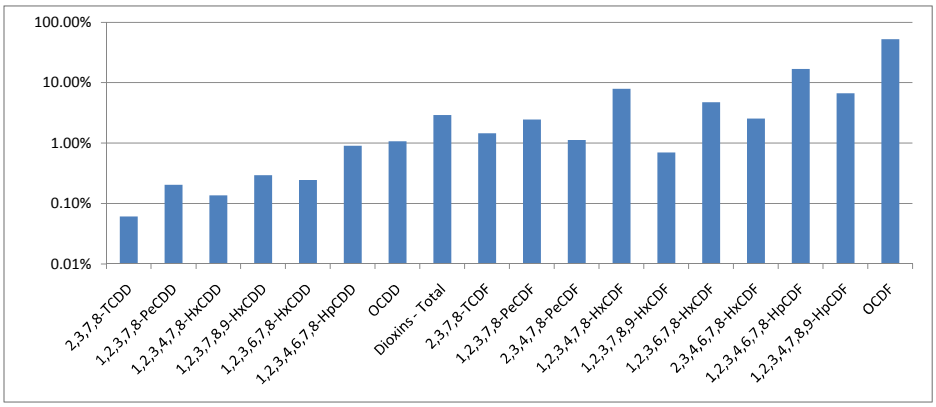


SET 1
Dioxin/Furan Profiles for Select Soil Samples

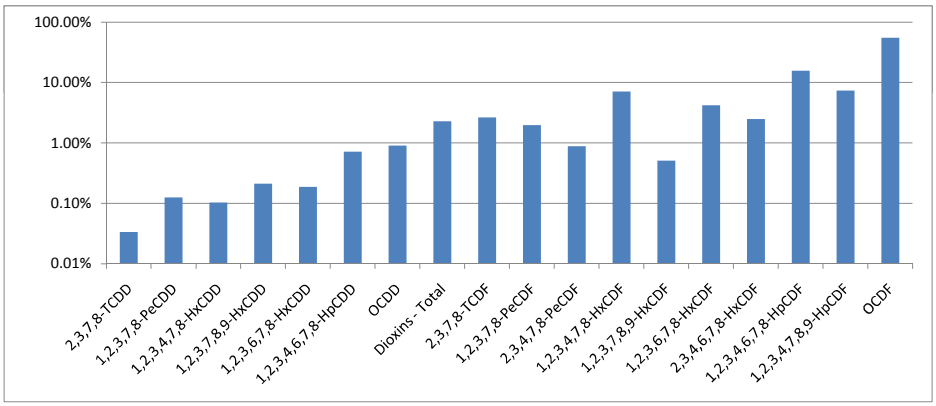
Area	2
Grid	O-5
Sample	SA187-0.5B
TTEQ (ppt)	2,310



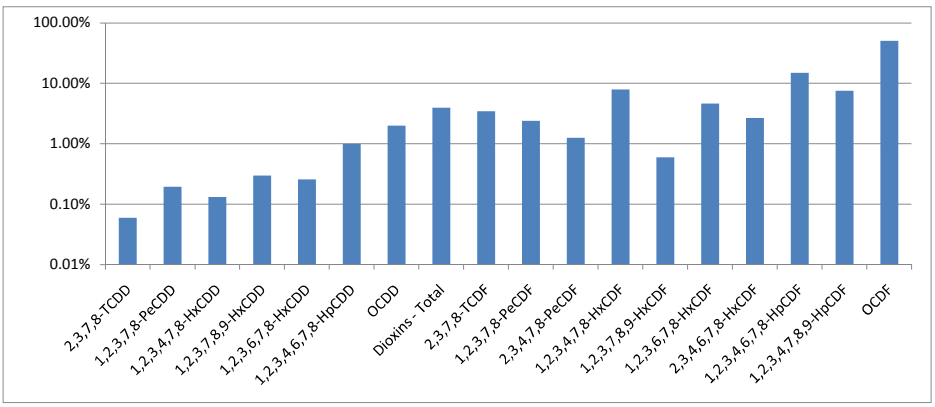
Area	2
Grid	O-5
Sample	SA41-0.5B
TTEQ (ppt)	2,237



Area	2
Grid	O-6
Sample	SA200-0.5B
TTEQ (ppt)	1,027

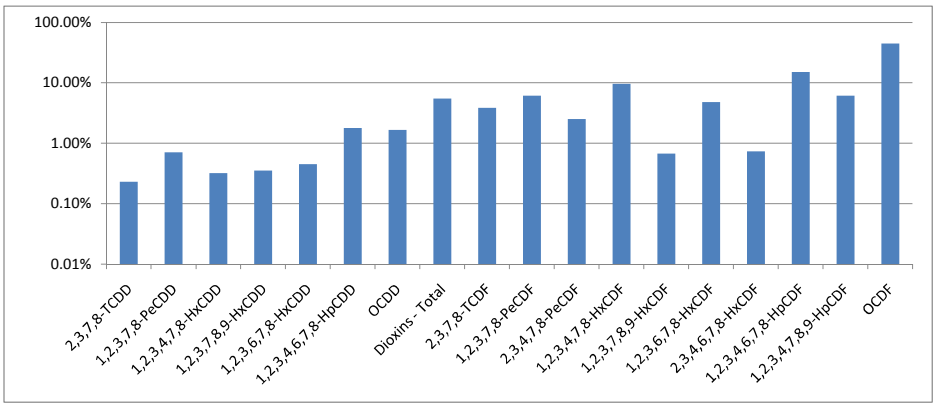


Area	2
Grid	O-6
Sample	SA51-0.5B
TTEQ (ppt)	1,198

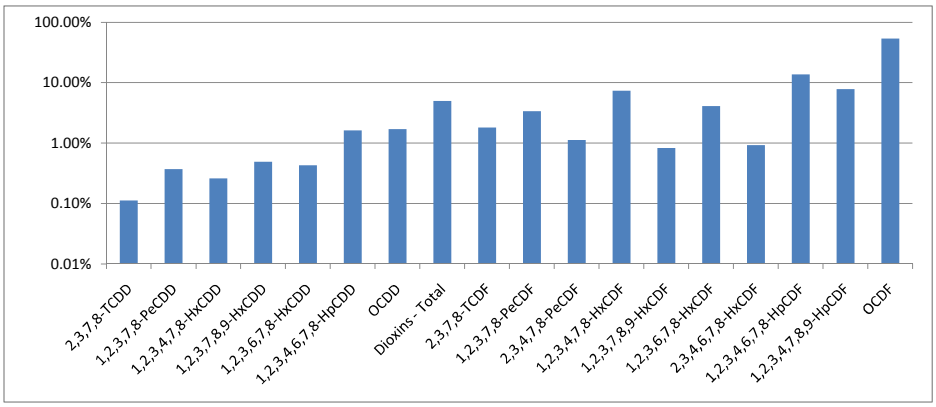


SET 1
Dioxin/Furan Profiles for Select Soil Samples

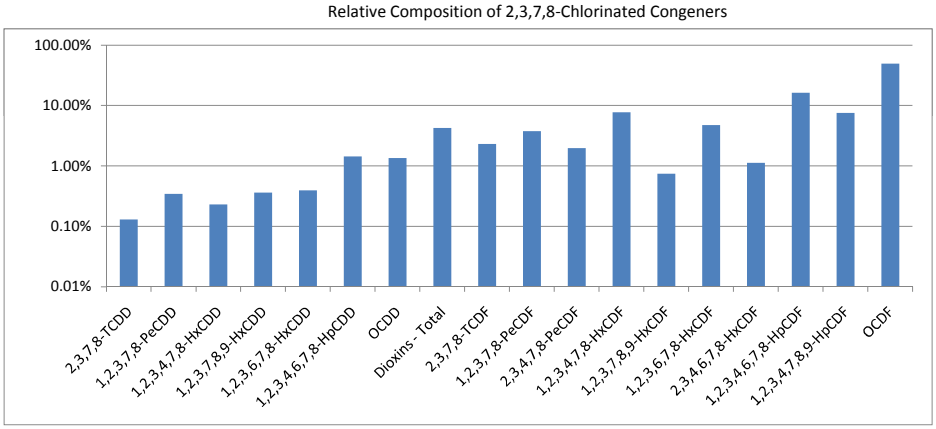
Area	4
Grid	Q-3
Sample	RSAQ3-0.5B
TTEQ (ppt)	13,000



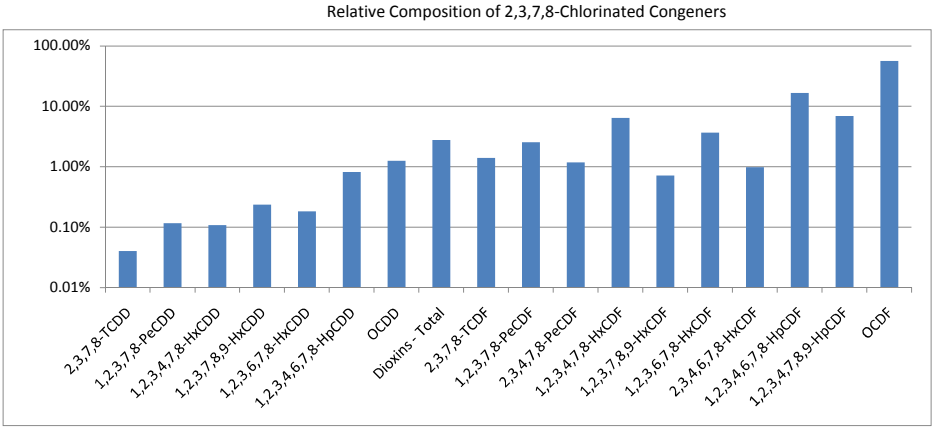
Area	4
Grid	Q-3
Sample	ΔQ3009-0.5B (dup) duplicate
TTEQ (ppt)	5,700



Area	4
Grid	Q-3
Sample	SA169-0.5B
TTEQ (ppt)	2,000



Area	4
Grid	3773
Sample	SA84-0.5B
TTEQ (ppt)	1,200



SET 1
Dioxin/Furan Profiles for Select Soil Samples

Area	4
Grid	Q-5
Sample	SA156-0.5B
TTEQ (ppt)	1,300

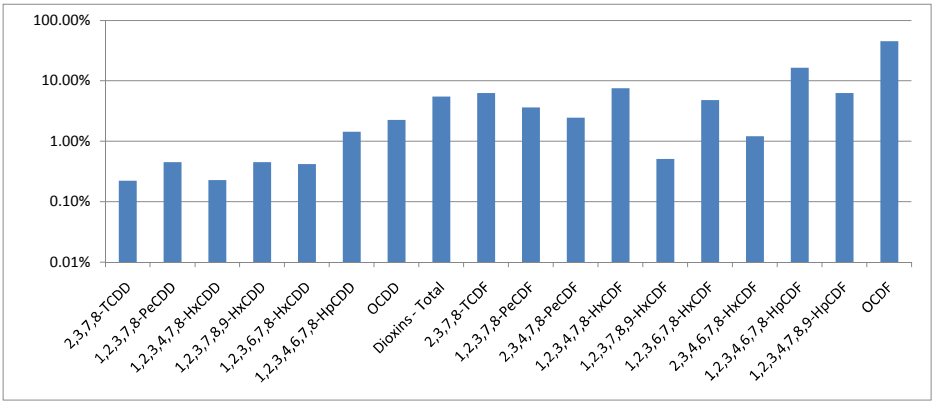


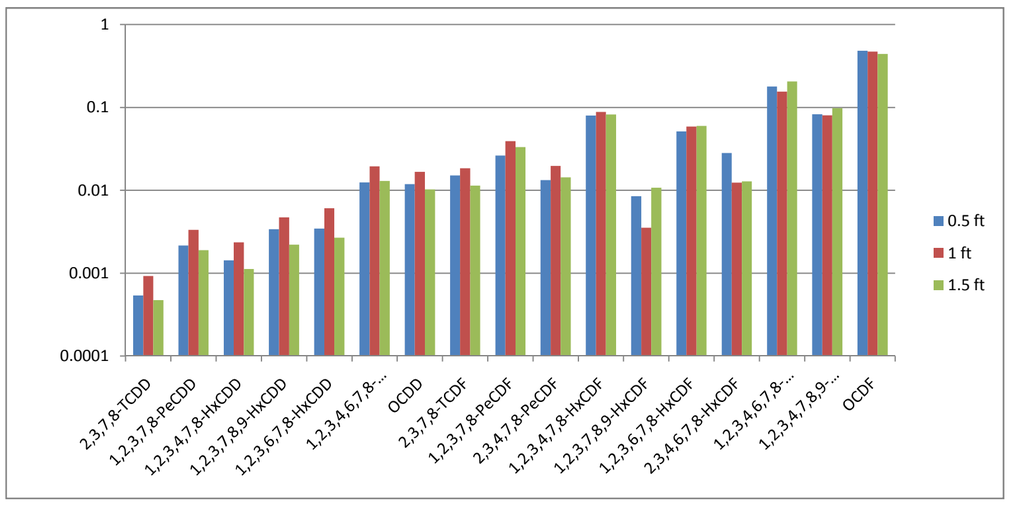
TABLE 3
Dioxin/Furan Congener Percentage of TEQ for Select Supplemental (Depth) Soil Samples a)

System Sample Code	Start Depth	Area	Grid ID	2,3,7,8- TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	2,3,7,8-TCDF	1,2,3,7,8-PeCDF	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,6,7,8-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF	
SA201-0.5B	0.5 ft	1 - Near Berm	I-3	0.05%	0.22%	0.14%	0.34%	0.35%	1.24%	1.18%	1.51%	2.62%	1.32%	7.99%	0.85%	5.13%	2.82%	17.89%	8.25%	48.09%	
SA201-1BR	1 ft	1 - Near Berm	I-3	0.09%	0.33%	0.24%	0.47%	0.61%	1.94%	1.67%	1.84%	3.92%	1.96%	8.83%	0.35%	5.89%	1.24%	15.50%	8.04%	47.08%	100.00%
SA201-1.5BR	1.5 ft	1 - Near Berm	I-3	0.05%	0.19%	0.11%	0.22%	0.27%	1.29%	1.02%	1.14%	3.31%	1.43%	8.20%	1.07%	5.99%	1.28%	20.50%	9.78%	44.15%	100.00%
RSAH3-0.5B	0.5 ft	1	H-3	0.06%	0.26%	0.20%	0.41%	0.36%	1.20%	1.28%	1.56%	4.63%	1.92%	9.44%	0.73%	6.45%	2.99%	19.77%	7.13%	41.62%	
RSAH3-1BR	1 ft	1	H-3	0.08%	0.27%	0.17%	0.39%	0.37%	1.25%	1.26%	2.02%	4.38%	2.02%	7.91%	1.03%	5.55%	1.13%	16.83%	6.56%	48.80%	100.00%
RSAH3-1.5BR	1.5 ft	1	H-3	0.07%	0.27%	0.16%	0.33%	0.34%	1.19%	1.11%	2.05%	4.52%	2.13%	7.94%	1.02%	5.63%	1.19%	17.07%	7.17%	47.79%	100.00%
RSAL3-0.5B	0.5 ft	1	L-3	0.08%	0.27%	0.22%	0.50%	0.45%	1.74%	2.99%	3.59%	4.34%	1.27%	13.55%	0.58%	6.27%	0.93%	15.28%	7.09%	40.82%	
RSAL3-1BR	1 ft	1	L-3	0.11%	0.50%	0.29%	0.18%	1.08%	3.79%	3.21%	3.50%	6.13%	2.48%	9.92%	0.58%	5.54%	1.14%	15.17%	5.54%	40.84%	100.00%
RSAL3-1.5BR	1.5 ft	1	L-3	0.34%	0.38%	0.25%	0.92%	0.53%	2.26%	3.39%	3.77%	5.47%	2.45%	8.30%	0.85%	4.71%	1.13%	14.71%	7.17%	43.37%	100.00%
SA155-0.5B	0.5 ft	2 - Ditch	M-7	0.08%	0.26%	0.22%	0.46%	0.42%	1.37%	1.52%	1.33%	3.35%	1.64%	9.22%	0.76%	5.87%	3.18%	16.35%	7.35%	46.62%	
SA155-1BR	1 ft	2 - Ditch	M-7	0.08%	0.30%	0.25%	0.45%	0.45%	1.40%	1.03%	1.92%	4.02%	2.20%	8.42%	1.31%	5.14%	1.03%	17.77%	9.35%	44.88%	100.00%
SA155-1.5BR	1.5 ft	2 - Ditch	M-7	0.08%	0.15%	0.19%	0.31%	0.44%	1.46%	1.90%	1.68%	3.45%	1.86%	6.20%	0.71%	5.31%	0.97%	19.48%	7.08%	48.70%	100.00%
SA104-0.5B	0.5 ft	2	M-5	0.08%	0.29%	0.21%	0.37%	0.34%	1.11%	1.87%	3.97%	2.95%	1.40%	7.42%	0.71%	4.21%	2.46%	12.89%	6.22%	53.50%	
SA104-1BR	1 ft	2	M-5	0.10%	0.21%	0.12%	0.25%	0.34%	1.17%	1.64%	2.38%	3.57%	2.08%	6.24%	0.65%	5.05%	1.26%	19.33%	6.54%	49.06%	100.00%
SA104-1.5BR	1.5 ft	2	M-5	0.28%	0.27%	0.24%	0.17%	0.42%	1.67%	8.67%	2.17%	2.00%	0.27%	6.17%	0.85%	4.50%	1.00%	16.67%	8.00%	46.66%	100.00%
SA200-0.5B	0.5 ft	2	O-6	0.03%	0.13%	0.10%	0.21%	0.19%	0.72%	0.91%	2.66%	1.97%	0.88%	7.11%	0.51%	4.18%	2.49%	15.64%	7.40%	54.87%	
SA200-1BR	1 ft	2	O-6	0.05%	0.20%	0.13%	0.23%	0.27%	1.07%	1.12%	1.47%	3.56%	1.88%	8.14%	0.71%	4.68%	1.22%	16.27%	8.14%	50.85%	100.00%
SA200-1.5BR	1.5 ft	2	O-6	0.06%	0.20%	0.08%	0.23%	0.36%	1.01%	1.09%	5.79%	5.07%	3.62%	7.97%	0.47%	4.71%	1.63%	15.93%	8.33%	43.45%	100.00%

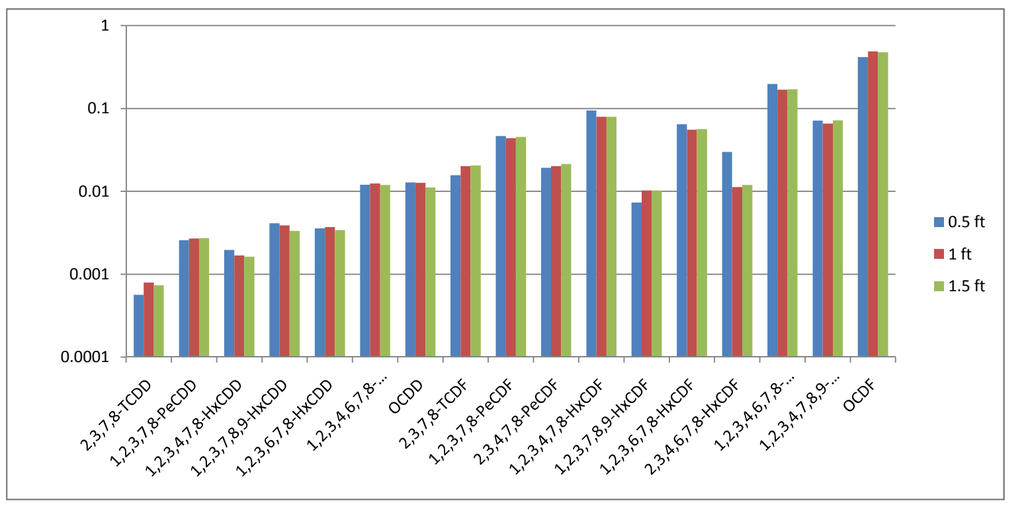
a) For use in Set 2 profiles

SET 2
Dioxin/Furan Congener Profiles for Select Supplemental (Depth) Soil Samples

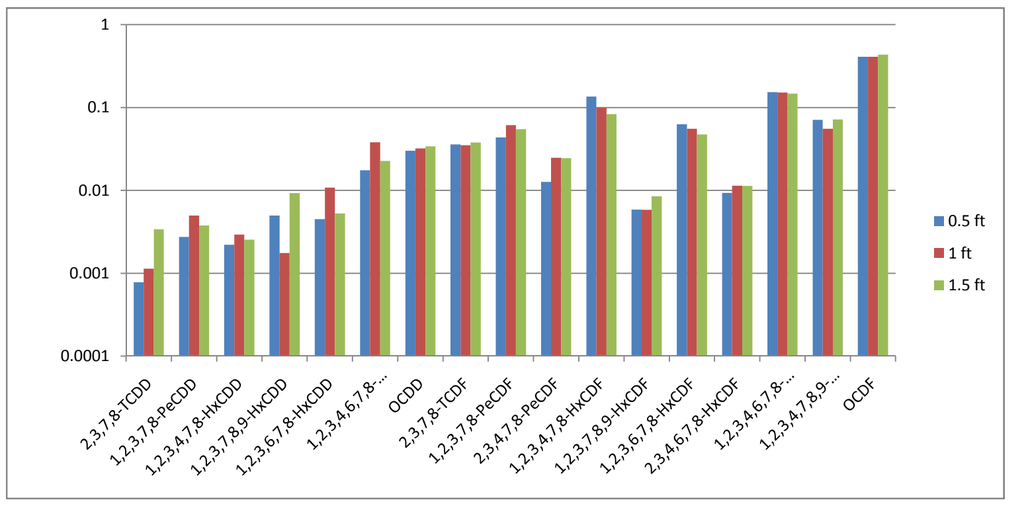
Location SA201-0.5B
Area 1 - Near Berm
Grid I-3



Location RSAH3-0.5B
Area 1
Grid H-3



Location RSAL3-0.5B
Area 1
Grid L-3



Location SA155-0.5B
Area 2 - Ditch
Grid M-7

Location SA104-0.5B
Area 2
Grid M-5

Location SA200-0.5B
Area 2
Grid O-6