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MEMORANDUM

TO: Mohsen Kourehdar – Department of Ecology

FROM: Matt Dalton

DATE: Final: May 5, 2014

SUBJECT: Results of Push-Probe Sampling and
Remedial Excavation Area
Former Arkema Wypenn Property

REF. NO: POT-001-01

CC: Scott Hooton – Port of Tacoma

This memorandum presents the results of supplemental push-probe soil sampling completed at the former Arkema Wypenn property located at 2920 Taylor Way (Figure 1). The purpose of the sampling was to define the excavation area with a high degree of confidence to expedite remedial construction and eliminate the need for time-consuming confirmational soil sampling and analysis. The interim action is described in the *Interim Action Work Plan* (DOF 2012) and in a technical memorandum prepared by Dalton, Olmsted & Fuglevand Inc. (DOF) titled *Results of Supplemental Testing, Interim Action Work Plan (IAWP),* Arkema Property (DOF 2013a). The objective of the interim action is to remove arsenic from shallow soil (less than 15 feet deep) so that remnant arsenic concentrations do not exceed industrial soil contact cleanup levels. Compliance with the soil Method C industrial cleanup level for arsenic was assessed using the procedures outlined in WAC 173-340-740(7)(d). To meet the cleanup objective determined based on WAC 173-340-740(7)(d), soils with arsenic concentrations greater than 176 mg/kg will be excavated and disposed off-site in a Subtitle D landfill.

The project sampling approach was outlined in a technical memorandum submitted to Ecology in early December 2013 (DOF 2013b). Comments were received during a phone call on January 7, 2014 and revisions to the approach were outlined in an e-mail to Ecology (Dom Reale) on January 8. Approval of the sampling approach was confirmed in an e-mail from Ecology to DOF on January 9, 2014. A draft of this memorandum reporting the results of testing was submitted to Ecology on April 28, 2014. Based on Ecology comments received on May 5, 2014 by e-mail, the memorandum was revised and finalized. The memorandum and approach to completing the interim action was approved by Ecology in an e-mail to Matt Dalton (DOF) on May 5, 2014.

FIELD SAMPLING AND ANALYSIS

Twenty-two supplementary push-probes were drilled to complement the twelve borings previously drilled for a total to thirty-four borings. Drilling depths ranged from 5 to 15 feet below ground surface. The work included the laboratory analysis of seventy-nine (79) soil samples and the supplemental field screening of two hundred and eight (208) soil samples by X-ray fluorescence (XRF). The density of the sampling locations and the numbers of samples collected provide a high degree of confidence that the 2,000 yards of soil identified for removal under this effort will achieve the goals of the interim action, and that additional sampling is not necessary or warranted.

Field Preparation. Preparatory activities included the following:

- Obtaining drilling permits in accordance with Washington State Chapter 18.104 RCW;
- Scheduling and coordinating field activities with subcontractors and other parties;
- Surveying underground utilities at the proposed sampling locations and notifying the Utility Notification Center in accordance with RCW 19.122; and
- Updating the previously prepared health and safety plan.

A Trimble GeoXH differential correcting GPS (DGPS) was used to locate and document push-probe locations. Previous boring/push-probe locations where arsenic concentrations above 176 mg/kg were previously detected were also field located. The new push-probe locations were located in general relation to the previous boring/existing well locations in accordance with the work plan.

Soil Sampling and Field Screening. Soil sampling was accomplished with a tracked push-probe rig (Geoprobe 7720DT) operated by Cascade Drilling LP using a barrel-type Macro sampler equipped with acrylic liners. Borings were sampled continuously and representative soil samples were collected based upon field screening and stratigraphy. Sample intervals were chosen to avoid sampling across any major stratigraphic units.

Soil samples were described in the field by David Cooper a licensed geologist with DOF, using ASTM D2488 as a general guide. Samples were field screened for visual indications of contamination and the presence of arsenic using XRF.

Prior to sample collection from the core barrel, field screening for arsenic was conducted using an INNOVIX Model 4000 hand-held XRF analyzer spectrometer. Direct measurements of the exposed core sample were made at both regular sample intervals and intervals with anomalous colors or staining. The sampling window of the unit was placed directly on the exposed core sample while shielded with a thin piece of cellophane from moisture. XRF instrument screening QA/QC procedures such as the use of blank standards and duplicates every 60 measurements were followed, in general conformance with EPA Method 6200 guidelines. The XRF screening results are presented on the geologic logs and in Table 1.

Sample intervals were selected based on soil-type, field screening and visual indicators such as color or staining. Each representative soil sample was collected from the core-barrel as a "*grab sample*" using a stainless steel spoon and placed into a 4-ounce laboratory provided container. The samples represent an approximately 0.5-foot interval bracketing the depth indicated on the geologic logs. All samples were placed in chilled coolers and transported to the laboratory using standard chain-of-custody procedures.

Following sampling, each boring was backfilled with bentonite chip, in accordance with Chapter 173-160 WAC. The horizontal coordinates of the push-probe locations were established using a DGPS with +/- 1 foot accuracy. Based on the sample descriptions and field screening, geologic logs were prepared and are included in Attachment A.

Decontamination Protocol. All down-hole drilling equipment was steamed cleaned prior to use and between each boring to avoid cross contamination. Sampling equipment was decontaminated between each sample interval using soap (Liquinox) and water and double rinsed.

Investigation Derived Waste. Decontamination water and residual soils from sample cores were placed in sealed barrels and appropriately marked for later disposal.

Laboratory Analysis. Samples were delivered to Analytical Resources Inc. (ARI), Tukwila, WA for analysis or archival. Samples selected for analysis were based on field screening and relative location. The remaining soil samples were archived for possible later analysis as noted in Table 1. ARI analyzed forty-one supplementary soil samples for total arsenic using EPA method 3050B (preparation) and 6010C (analysis). The current results supplement the 38 earlier soil analyses. The analytical results are summarized in Table 1. Laboratory data sheets for the samples collected in March 2014 are included in Attachment B.

COMPARISON OF XRF AND LABORATORY ANALYSES

The XRF field measurements were compared to the laboratory results to assess the reliability of the XRF measurements for use in determining the final remedial excavation area. The XRF/laboratory measurements showed a very high correlation of R=0.95.

Regression analysis was used to "*convert*" the XRF field measurements to equivalent laboratory concentrations. The fitted regression trend is shown on Figure 2 with an R^2 of 0.90 (i.e. the fitted line accounts for 90% of the data variability). Also shown on Figure 2 are the Upper and Lower 95% regression trends (i.e. the actual regression trend likely falls within the indicated trends). Using the Upper 95% regression trend (y=1.656x+32) the XRF measurement equivalent to the CUL of 176 mg/kg was calculated to be 87 ppm. Comparison of the data indicated that the XRF measurements are biased low by approximately 50%.

The Upper 95% regression equation was used convert the XRF measurements to equivalent laboratory concentrations. Both the laboratory results and XRF converted concentrations are summarized in Table 1and were used to define the interim action remedial area as discussed below.

SHALLOW SOIL INTERIM ACTION AREA

Arsenic Concentration Plots. To define the interim action remedial area, arsenic soil concentrations were plotted on a site plan with depth. Data from available boring/push-probe locations and designations are shown on Figure 3 while soil arsenic concentrations are plotted on approximately two foot depth intervals on Figures 4 to 9. Converted XRF measurements are highlighted with a "*". Based on the soil arsenic concentration data, the proposed interim action remedial area was determined and highlighted on the figures. Exceedances most commonly occurred within the 8 to 10 foot depth interval (Figure 8).

Figure 9 shows arsenic concentrations in the 10 to 12+ foot depth interval, and provides uniform definition for the depth of arsenic exceeding the interim action goal of 176 mg/kg. This is also illustrated on Sections A-A' (Figure 10) and B-B' (Figure 11). Section trends are shown on Figure 3. Arsenic concentrations fall below 176 mg/kg at the top of the First Aquitard that is composed of silt to clayey silt.

Field Observations and Interpretations. Most of the higher arsenic concentrations were detected in samples that were observed to contain "*black silt*", "*white or orange precipitates*", or "*yellow flecks*". During the remedial excavation, the nature of the soils removed along the perimeter of the remedial area will be observed for evidence of high arsenic concentration (e.g. presence of precipitates and yellow flecks) to provide additional confidence that the goal of the interim action is being achieved.

Interim Remedial Area. The proposed interim action area and excavation depths are illustrated on Figure 12 and along the section trends on Figures 10 and 11. Most of the excavation would be completed to the top of the First Aquitard, a depth of 10 feet. Shallower excavations (3 to 4 feet) would be completed in two small peripheral areas and excavation would occur to a depth of 12 feet in one other small area.

Overall, the available data reliably defines the area where soil excavation with off-site disposal will meet the objective of the interim remedial action; that is to remove soil with arsenic concentrations greater than 176 mg/kg from the Wypenn property. Based on the number of borings/push-probes sampled (N=34), the number of field XRF measurements (N=208), the number of laboratory analyses (N=79) and the modest remedial volume targeted for removal (2,000 cubic yards), it is our opinion, that sufficient sampling and analysis has been conducted and no additional confirmation sampling is needed to meet the remedial objective.

CLOSING

The services described in this memorandum were performed consistent with generally accepted professional consulting principles and practices. No other warranty, expressed or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk. Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this document.

REFERENCES

DOF (Dalton, Olmsted & Fuglevand, Inc.), 2012, *Interim Action Work Plan, Wypenn Property*, Former Arkema Manufacturing Plant, Tacoma, Washington, May 2012.

DOF, 2013a, *Results of Supplemental Testing, Interim Action Work Plan (IAWP)*, Arkema Wypenn Property, May 8, 2013.

DOF, 2013b, *Interim Remedial Action, Wypenn Site* (Technical Memorandum to Dom Reale), Draft: December 2, 2013.

ATTACHMENTS

Table 1 – Soil Analytical Data
Figure 1 – Site Vicinity Map
Figure 2 – Comparison of XRF and Laboratory Arsenic Concentrations
Figure 3 – Sample Locations – Greenhouse Area
Figure 4 – Arsenic in Soil – 0 to 2 feet, Greenhouse Area
Figure 5 – Arsenic in Soil – 2 to 4 feet, Greenhouse Area
Figure 6 – Arsenic in Soil – 4 to 6 feet, Greenhouse Area
Figure 7 – Arsenic in Soil – 6 to 8 feet, Greenhouse Area
Figure 8 – Arsenic in Soil – 8 to 10 feet, Greenhouse Area
Figure 9 – Arsenic in Soil – 10 to 12+ feet, Greenhouse Area
Figure 10 – Arsenic Soil Concentration Profile A-A'
Figure 11 – Arsenic Soil Concentration Profile B-B'
Figure 12 – Excavation Areas and Depths
Attachment A – Push-Probe/Boring Logs
Attachment B – Laboratory Data Sheets (March 2014 Sampling)

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
WP-B3	10/8/10	1-2	-----	<5	-----		
		5-6	-----	<5	-----		
		7.5-8	-----	<6	-----		
WP-B4	10/8/10	1-2	-----	<6	-----		
		5-6	-----	<5	-----		
WP-B5	10/7/10	1-2	-----	33	-----		
		4-5	-----	32	-----		
		8-9	-----	100	-----		
		11-12	-----	46	-----		
		14-15	-----	20	-----		
		17-18	-----	<7	-----		
WP-B6	10/7/10	1-2	-----	90	-----		
		4-5	-----	33	-----		
		8-9	-----	645	-----		
		12-13	-----	<10	-----		
WP-B7	10/7/10	0.5-1.5	-----	39	-----		
		4-5	-----	64	-----		
		8-9	-----	<7	-----		
WP-B8	10/7/10	0.5-1.5	-----	44	-----		
		4-5	-----	12	-----		
		8.5-9.5	-----	<6	-----		
		10-11	-----	10	-----		
WP-B15	10/19/12	0.5-1.5	-----	12	-----		
		8-9	-----	32	-----		
		11-12	-----	<8	-----		
WP-B16	10/19/12	1-2	-----	<5	-----		
		8-9	-----	12	-----		
		11-12	-----	<7	-----		
WP-B17	10/19/12	1-2	-----	122	-----		
		7-8	-----	667	-----		
		11-12	-----	10	-----		

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
WP-B18	10/19/12	1-2	-----	53	-----		
		7-8	-----	<6	-----		
		11-12	-----	<10			
WP-B19	10/19/12	0.5-1.5	-----	195	-----		
		7-8	-----	42	-----		
		11-12	-----	<9	-----		
WP-B20	10/19/12	2-3	-----	31	-----		
		7-8	-----	<6	-----		
		11-12	-----	<10	-----		
S-A	3/19/14	0.5	132	-----	251		
		1	237	-----	424		0-1.5 - Mottled black silt
		1.5	15	-----	57		
		2	<9	archive	<47	SA-2	
		3	<8	-----	<45		
		4	<10	archive	<49	SA-4	
		5	12	-----	52		
		6	61	archive	133	SA-6	
S-B	3/19/14	1	<13	-----	<54		
		2	40	-----	98		
		3	135	-----	256		
		4	34	-----	88		
		5	<9	-----	<47		
		6	418	634	-----	SB-6	6-9.5' - Black silt w/orange precipitate
		8	417	archive	723	SB-8	
		9	354	-----	618		
		10	38	50	-----	SB-10	
S-C	3/19/14	1	58	-----	128		
		2	11	archive	50	SC-2	
		3	<10	archive	<49	SC-4	
		5	16	-----	58		
		6	570	746	-----	SC-6	6-8' - Black silt w/green
		7	786	-----	1334		
		8	31	44	-----	SC-8	
		10	<10	archive	<49	SC-10	
		12	7	archive	44	SC-11	

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Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
S-D	3/19/14	1	<18	-----	<62		
		2	16	22	-----	SD-2	
		5	16	-----	58		
		6	15	31	-----	SD-6	
		8	40	76	-----	SD-8	No black silt but poor recovery
		10	<5	17	-----	SD-10	
		12	<7	-----	<44		
S-E	3/19/14	0.5	201	-----	365		
		1	41	-----	100		
		2	230	-----	413		
		3	14	-----	55		
		6	<10	-----	<49		
		8	<9	-----	<47		
		9	490	824	-----	SE-9	9-9.5 - black silt atop peat
		10	9	60	-----	SE-10	
		11	<8	archive	<45	SE-11	
		12	8	-----	45		
L1	3/19/14	1	14	-----	55		
		2	<9	20	-----	L1-2	
		3	<11	-----	<50		
		4	17	17	-----	L1-4	
		6	<9	archive	<47	L1-6	
		8	<8	12	-----	L1-8	
		10	<6	-----	<42		9.5-10' -Peat/silt generally
		12	<8	-----	<45		
L-B15	3/19/14	2	35	-----	90		Next to WP-B15 (as check)
		4	100	-----	198		
		6	80	archive	164	LB15-6	
		8	90	69	-----	LB15-8	6-10' - No black silt layer
		10	10	-----	49		

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
L2	3/19/14	1	18	-----	62		
		2	<21	archive	<67	L2-2	
		3	<30	21	-----	L2-4	
		6	<23	archive	<70	L2-6	
		8	37	56	-----	L2-8	Loose, slurry-like gravelly sand
		9	36	-----	92		
		10	<17	archive	<60	L2-10	
L3	3/19/14	1	70	-----	148		
		2	54	175	-----	L3-2	
		3	26	-----	75		
		4	<17	-----	60		
		6	<19	archive	63	L3-7	
		8	133	-----	252		
		9	216	495	-----	L3-9	8-9.5 - Black silt - sample 8.5-9.5
		11	<16	20	-----	L3-11	
L4	3/19/14	1	<19	-----	<63		
		2	327	441	-----	L4-2	Stepped out 10', sample L4A-2 (57 PPM) (Lab 134)+F112 - on 3-20-14
		3	<23	25	-----	L4-3	
		6	<15	archive	<57	L4-6	
		8	<15	-----	<57		
		9	<20	8	-----	L4-9	
		10	<16	-----	<58		
		12	<15	-----	<57		
L5	3/20/14	1	73	-----	153		
		1.5	42	-----	102		
		2	182	archive	333	L5-2	
		2.5	35	-----	90		
		3	<24	-----	<72		
		4	<5	-----	<40		
		6	<17	-----	<60		
		8	<14	-----	<55		
		9	128	-----	244		8-11' - Black w/trace yellow silt
		9.5	264	archive	469	L5-9	Sample 8.5-9.5
		11	<11	-----	<50		

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
L6	3/20/14	1	282	archive	499	L6-1	
		2	23	-----	70		
		4	<19	-----	<63		
		6	<14	-----	<55		
		8	<19	-----	<63		
		9	171	-----	315		8-9.5' - Mottled black silt w/white precipitate
		9.5	310	archive	545	L6-9.5	Sample 8.5-9.5
		10	<13	-----	<54		
		11	<11	-----	<50		
L7	3/20/14	1	<21	-----	<67		
		2	<20	archive	<65	L7-2	
		4	<16	16	-----	L7-4	
		6	<17	archive	<60	L7-6	
		8	<16	archive	<58	L7-8	
		9	271	410	-----	L7-9	9.4-9.5' thin 0.1' layer of black silt - sample 8.5-9.5'
		9.5	69	-----	146		
		11	<10	19	-----	L7-11	
		12	<16	-----	<58		
L8	3/20/14	1	130	182	-----	L8-1	Black/orange layer 0-1.5' stepped out 8 more feet.
		2	43	-----	103		
		4	30	72	-----	L8-4	
		6	<17	archive	<60	L8-6	
		8	16	archive	58	L8-8	
		9	24	-----	72		
		9.5	163	473	-----	L8-9.5	9-9.5 - Black silt atop peat
		10	75	100	-----	L8-10	
		11	<14	-----	<55		
		12	<11	-----	<50		
L9	3/20/14	2	<22	33	-----	L9-2	
		4	<26	archive	<75	L9-4	
		6	<18	9	-----	L9-6	
		8	<18	-----	<62		
		9	80	238	-----	L9-9	
		10	<17	21	-----	L9-10	
		12	<12	-----	<52		
		14	<17	-----	<60		

TABLE 1 - Soil Analytical Data

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
L10	3/20/14	2	<26	59	-----	L10-2	
		4	<23	archive	<70	L10-4	
		6	<18	5	-----	L10-6	
		8	<14	-----	<55		
		9	40	57	-----	L10-9	9-9.5' - Black silt atop peat
		10	<16	archive	<58	L10-10	
		12	<14	-----	<55		
L11	3/21/14	1	<20	-----	<65		
		2	<24	archive	<72	L11-2	
		4	<27	-----	<77		
		6	26	archive	75	L11-4	
		8	18	archive	62	L11-6	
		9	17	archive	60	L11-8	
		9.5	147	archive	275	L11-9	
		10	<14	archive	<55	L11-10	
		12	<15	-----	<57		
L12	3/21/14	1	36	-----	92		
		2	<22	-----	<68		
		3	39	archive	97	L12-3	
		6	<20	archive	<65	L12-6	
		8	<28	-----	<78		
		9	<26	archive	<75	L12-9	
		10	30	-----	82		
		10.5	60	-----	131		
		11	197	archive	358	L12-11	Sample 10'-11.5'
		12	<14	archive	<55	L12-12	
L13	3/21/14	1	37	-----	93		
		2	40	-----	98		
		3	35	47	-----	L13-3	
		6	63	archive	136	L13-6	
		8	44	-----	105		
		9	159	40	-----	L13-9	Sample 8-9'
		9.5	<14	-----	<55		
		10	<12	-----	<52		
		11	<13	archive	<54	L13-11	
		12	<14	archive	<55	L13-12	

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
L14	3/21/14	1	<20	-----	<65		
		2	<24	-----	<72		
		3	44	-----	105		
		4	72	-----	151		
		6	<27	-----	<77		
		8	306	-----	539		
		9	763	archive	1296	L14-9	
		10	336	-----	588		
		10.5	<14	archive	<55	L14-10.5	
		11	<12	-----	<52		
		12	<14	-----	<55		
L15	3/21/14	1	355	-----	620		
		2	28	-----	78		
		3	142	archive	267	L15-3	
		4	79	-----	163		
		5	<18	-----	<62		
		6	<15	-----	<57		
		7	<16	-----	<58		
		8	<18	-----	<62		
		8.5	571	-----	978		
		9	194	archive	353	L15-9	
		9.5	353	-----	617		
		10	31	archive	83	L15-10	
		11	<14	-----	<55		
		12	<16	-----	<58		
		14	<18	-----	<62		
D-B	3/20/14	1	33	-----	87		
		2	106	-----	208		
		3	166	-----	307		
		4	113	-----	219		
		6	<18	-----	<62		
		8	128	-----	244		
		9	161	-----	299		8-10' - Black/orange silt
		9.5	621	-----	1060		
		10	<15	21	-----	DB-10.5	Native silt at 10'
		11	<22	-----	<68		

TABLE 1 - Soil Analytical Data

Arkema Wypenn Property
Tacoma, Washington

Probe	Date	Depth (feet)	XRF As (ppm)	Lab As (ppm)	Est. Lab (ppm)	Sample No.	Comments
D-E	3/20/14	1	182	-----	333		
		1.5	382	-----	665		
		3	147	-----	275		
		4	63	-----	136		
		6	<19	-----	<63		
		8	292	-----	516		
		9	471	-----	812		7-10.5 - Black/orange silt
		10	401	-----	696		
		10.5	13	20	-----	DE-10.5	Native silt at 10.5'
		12	<12	-----	<52		

Notes: < - Not detected at indicated reporting limit.
----- - Not available