DALTON OLMSTED FUGLEVAND

January 19, 2017

Mr. Ed Jones
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Hazardous Waste and Toxics Reduction Program
Washington State Department of Ecology
3190 160th Ave SE
Bellevue, Washington 98008-5452

RE: ISB Phase I and ISCO Phase II Result and Downgradient Area Pilot Study Work Plan

Dear Ed,

This memorandum was prepared by Dalton, Olmsted and Fuglevand (DOF) on behalf of Stericycle Environmental Solutions (Stericycle) in response to the letter dated December 6, 2016 (Ecology, 2016) and a subsequent telephone conference held on Dec 19, 2016 to discuss Ecology's letter and next steps. This memorandum provides additional information requested by Ecology related to the results of the 2016 In-Situ Chemical Oxidation Pilot Study conducted to address 1,4-dioxane present in groundwater at the Stericycle Georgetown site. A Work Plan Addendum will be separately prepared to address remaining Ecology comments that related to work to be conducted in the future.

Comment 12 regarding Table 1

- Field records from the July 7, 2016 sampling of well CG-122-75 were reviewed and the redox value recorded during sampling was -42.8 mV (not +42.8 mV). This has been corrected in the revised Table 1, attached.
- Pre-Sept 2016 data for CG-161-60 (specific conductivity, oxidation reduction potential, and 1,4-dioxane for the preceding year) are summarized in the attached new Table 1a. The most recent monitoring event included significant change in both Redox and 1,4-dioxane trends, while specific conductivity remained consistent with past results. Given the large difference in results, another round of monitoring should clarify if these results are an outlier or a trend.

Comment 13 regarding Table 3 –

- DOF double checked Table 3 against field observations recorded on June 24, 2016 and made the following revisions:
  - IP-3 values were corrected to 18 and 16 pounds per square inch (psi) at 10:55 and 11:10, respectively.
  - Minor changes in flow totals were corrected (rounded to the same level of detail for each total).

A revised version of Table 3 is attached.

- The drop in pressure at IP-1 and IP-3 was due to a field adjustment. Injection valves were closed down to maintain a flow rate of 2 gallons per minute (gpm), as required in the work plan.
- It is accurate that the lower injection pressures of 8 psi equated to relatively little change in flowrate, as Ecology pointed out. Field personnel also recognized this at the time of injection and monitored actual volumes being injected to verify approximate flowrates in case meters were not reading accurately. Field personnel also checked pressure readings at multiple gauges across the system and found them to be consistent under a variety of flow conditions. Volumes confirmed average flowrates, though without the precision that real time meters provided because volumes could only typically be monitored across two injection points concurrently, rather than as discrete injection points. A problem with the flow meters is a possible source of error, but generally the field personnel did not observe major difference in flowrate when pressures were adjusted.
- The high pressures (28-30 psi) at IP-4 were inconsistent with the readings before and after, but we have no additional details to explain this difference from the other injection points. We agree that the well logs do not support any difference in lithology at that location. Clogging of the injection ports could have caused the higher pressures, as may happen during drilling in fine grained units (i.e similar to a silted screen when Geoprobing), though there were no direct field observations other than the higher pressures to indicate that situation had occurred or was more likely to occur at that specific interval at IP-4.

The information collected during the 2016 pilot study is useful in planning future treatment, though one of the major findings of the pilot was that predictability of results (spatially and over time) is challenging for this method of treatment.

Thank you,

Natasya DD Gray

Tasya Gray, LG
Senior Geologist
DOF

Patrick Hsieh, PE
Senior Engineer
DOF

Attachments:
Revised Table 1
New Table 1a – Groundwater Monitoring Data Summary – CG-161-60
Revised Table 3

cc: Tong Li

TABLE 1
GROUNDWATER MONITORING DATA SUMMARY
Stericycle Georgetown Facility
Seattle, Washington
(Revised January 2017)

Well	**IMW-1**							**IMW-2**						
Parameter	6/21/2016	6/24/2016	6/30/2016	7/7/2016	7/14/2016	8/4/2016	9/29/2016	6/21/2016	6/24/2016	6/30/2016	7/7/2016	7/14/2016	8/4/2016	9/29/2016
initial water level (ft TOC)	8.6	--	8.69	8.76	8.85	9.19	9.85	8.73	--	8.8	8.87	8.94	9.26	10.0
pH (standard units)	7.4	--	7.6	7.4	7.4	7.2	7.22	7.3	--	7.4	7.4	7.4	7.2	6.93
Specific Conductivity (µs/cm)	1015	--	1024	989	1340	1714	1815	1040	--	1124	1068	1082	1890	3288
Temperature (°C)	15.9	--	17.6	16.8	16.9	16.4	16.7	15.9	--	17.2	16.8	16.9	16.1	16.65
Turbidity (NTU)	5	--	6.6	11.7	10.4	5.1	3	2.2	--	12.5	8.9	9	0.9	2.7
Dissolved Oxygen	0.4	--	0.5	0.2	0.1	0.1	0.01	0	--	0.4	0.1	0.1	0	0.02
Redox (mV)	-93.4	--	-100.8	-38.8	-48.7	-30.1	-3.6	-116.2	--	-103.6	-52.3	-56.9	-8.2	-4.2
Sulfate	0.69	--	0.68	73.6 J/ 192	301	457	454	0.46	--	0.37	0.39	27.2	519	1550
Sulfide	<0.05	--	<0.05	<0.05	<0.05	<0.05	0.031 J	0.031 J	--	<0.05	<0.05	<0.05	<0.05	0.035 J
1,4-Dioxane (µg/L)	210		300	290	300	240	160	370		330	340	380	310	220
Persulfate (ppm)	--	>70	0.5	0.5	0	0	0	--	>70	0.2	0.3	0	0	0
Arsenic	0.0004 J	--	0.0003 J	<0.0005	0.0003 J	<0.0005	--	0.0002 J	--	0.0003 J	0.0002 J	<0.0005	<0.0005	--
Cadmium	<0.000016	--	0.000015 J	<0.000020	<0.000010 J	<0.000020	--	<0.000025	--	0.00002 J	<0.000020	<0.000020	<0.000020	--
Chromium	0.00058	--	0.00064	0.00052	<0.00057	<0.00038	--	0.0005	--	0.00061	0.00058	<0.00057	<0.00047	--
Lead	<0.000031	--	0.000029	<0.000018 J	<0.000034	0.000012 J	--	<0.000032	--	0.000072	<0.000027	<0.000014 J	0.000009 J	--
Silver	<0.00002	--	<0.000020	--	--	<0.000020	--	<0.000020	--	<0.000015 J	--	--	<0.000020	--
Sodium	144	--	136	--	--	182	--	190	--	189	--	--	228	--
Selenium	<0.001	--	<0.00100	--	--	< 0.00100	--	<0.00100	--	< 0.00100	--	--	0.00054 J	--
Barium	0.015485	--	0.015064	--	--	0.027401	--	0.010919	--	0.011538	--	--	0.027709	--
Beryllium	<0.00002	--	<0.000020	--	--	<0.000020	--	<0.000020	--	<0.000020	--	--	<0.000020	--
Copper	0.00033	--	0.00023	--	--	0.0004	--	0.00018	--	0.00048	--	--	0.0005	--
Zinc	0.00164	--	0.00191	--	--	0.00089	--	0.00229	--	0.01022	--	--	0.0016	--
Nickel	0.00119	--	0.00098	--	--	0.0012	--	0.00123	--	0.00128	--	--	0.00161	--
Chromium (+3)	<0.024	--	<0.05 J	--	--	<0.05	--	<0.024	--	<0.05	--	--	<0.05	--
Chromium (+6)	<0.024	--	<0.05 J	--	--	0.004 J	--	<0.024 J	--	<0.05	--	--	0.005 J	--
Total Iron	--	--	--	--	--	--	9.9	--	--	--	--	--	--	37.4
Ferrous Iron	--	--	--	--	--	--	0.39	--	--	--	--	--	--	2.7
Iron (+2) field test	--	--	--	--	--	--	3.8	--	--	--	--	--	--	6.0

Notes:
1) metals are dissolved results, field filtered
2) units are in milligrams per liter (mg/L) unless otherwise noted

Definitions:
µg/L = micrograms per liter
°C = degrees centigrade
ppm = part per million
NTU = Nephelometric turbidity units
mV = millivolt
ft = feet
TOC = Top of casing
-- = not tested
µs/cm =microsiemens per centimeter
> = exceeds upper limit of test
< = not detected above reporting limit
J = the result is an estimated value

DOF

TABLE 1

GROUNDWATER MONITORING DATA SUMMARY

Stericycle Georgetown Facility

Seattle, Washington

(Revised January 2017)

Well	**CG-122-60**						**CG-122-75**					**CG-161-60**
Parameter	6/22/2016	6/30/2016	7/7/2016	7/14/2016	8/4/2016	9/29/2016	6/21/2016	6/30/2016	7/7/2016	7/14/2016	8/4/2016	9/29/2016
initial water level (ft TOC)	8.65	8.73	8.84	8.9	9.2	9.94	8.37	8.48	8.55	8.65	8.98	9.8
pH (standard units)	7.3	7.4	7.3	7.3	7.18	7.14	7.4	7.4	7.4	7.3	7.41	6.77
Specific Conductivity (µs/cm)	709	732	702	711	981	1170	576	590	580	578	591	968
Temperature (°C)	15.3	16.2	15.5	16	15.51	16.36	15	15.9	15.9	15.7	15.27	15.9
Turbidity (NTU)	1.6	2.5	2.5	5.9	0.83	1.3	1.3	1.3	1.5	6.3	0.8	2.6
Dissolved Oxygen	0	0	0	0	0.07	0.01	0	0.1	0	0.2	0.12	0.04
Redox (mV)	-80	-72.5	-35.9	-21.1	-10.3	5.3	-102.5	-82.4	-42.8	-11.2	-9.3	40.9
Sulfate	0.33	0.29	0.29	0.33	324	324	0.24	0.2	0.22	0.22	0.12 J	< 0.20
Sulfide	<0.05	<0.05	<0.05	<0.05	<0.05	0.053	<0.05	<0.05	<0.05	<0.05	<0.05	0.030 J
1,4-Dioxane (µg/L)	310	310	210	360	280/240	240	160	150	150	130	110	530
Persulfate (ppm)	--	0.7	0.3	0.3	0	0	--	0	0	0	0	0
Arsenic	0.0001 J	<0.0005	<0.0005	<0.0005	<0.0005	--	0.0002 J	0.0003 J	0.0003 J	0.0003 J	0.0002 J	--
Cadmium	<0.000017 J	0.000013 J	<0.000020	<0.000020	<0.000020	--	<0.000016 J	0.000025	<0.000020	<0.000020	<0.000020	--
Chromium	0.00048	<0.00045	0.00042	<0.00049	<0.00034	--	0.00061	<0.00058	0.00058	<0.00057	<0.0006	--
Lead	<0.000043	0.000026	<0.000017 J	<0.000023	0.000008 J	--	<0.000021	0.000036	<0.000017 J	<0.000023	0.000023	--
Silver	<0.000020	<0.000015 J	--	--	<0.000020	--	<0.000020	<0.000015 J	--	--	<0.000020	--
Sodium	116	120	--	--	146	--	115	113	--	--	103	--
Selenium	<0.00100	<0.00100	--	--	<0.00100	--	0.00033 J	0.00042 J	--	--	0.00063 J	--
Barium	0.005084	0.004726	--	--	0.020056	--	0.002914	0.002758	--	--	0.002456	--
Beryllium	<0.000020	<0.000020	--	--	<0.000020	--	0.000010 J	0.000008 J	--	--	0.000006 J	--
Copper	0.00013	0.00015	--	--	0.00036	--	0.00019	0.00023	--	--	0.0002	--
Zinc	0.00082	0.02177 J	--	--	0.00075	--	0.00122	0.0116	--	--	0.00065	--
Nickel	0.00106	0.00103	--	--	0.00132	--	0.00043	0.00047	--	--	0.00046	--
Chromium (+3)	<0.025	<0.05	--	--	<0.05	--	<0.039	<0.05	--	--	<0.05	--
Chromium (+6)	<0.025 J	<0.05	--	--	<0.05	--	<0.039 J	<0.05	--	--	<0.05	--
Total Iron	--	--	--	--	--	18.6	--	--	--	--	--	8.09
Ferrous Iron	--	--	--	--	--	3.8	--	--	--	--	--	1.3
Iron (+2) field test	--	--	--	--	--	4.8	--	--	--	--	--	3.8

TABLE 1
GROUNDWATER MONITORING DATA SUMMARY
Stericycle Georgetown Facility
Seattle, Washington
(Revised January 2017)

Well	**DP-1**	**DP-2**	**DP-3**	**DP-4**	**DP-5**	**DP-6**	**DP-7**	**DP-8**
Parameter	7/1/2016	7/1/2016	7/8/2016	7/8/2016	7/15/2016	7/15/2016	8/5/2016	8/5/2016
initial water level (ft TOC)	--	--	--	--	--	--	--	--
pH (standard units)	7.2	7.3	6.9	7.1	7.4	7.2	7.1	6.9
Specific Conductivity (µs/cm)	791	1077	366	403	989	1002	1307	429
Temperature (°C)	19.5	18.6	18.9	17	23.3	20	17.8	22.5
Turbidity (NTU)	170	>1000	345	18.1	279	363	160	102
Dissolved Oxygen	0.4	0.3	0.1	0.2	0.4	0.4	0.05	0.17
Redox (mV)	-84.2	-61.3	-20.2	-6.2	-12.1	-7.6	-1.2	63
Sulfate	35.2	0.51	2.77	1.93	5.9	6.3	143	1.9
Sulfide	2.4 J	11 J	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,4-Dioxane (µg/L)	180	250	3.7	8.7	380	280	18	5.3
Persulfate (ppm)	0	0	0.3	1.4	6	3.5	0.7	2.8
Arsenic	0.0005	0.0012	0.0025	0.0016	0.0006	0.0004 J	0.0004 J	0.0013
Cadmium	<0.000013 J	<0.000013 J	<0.000028	<0.000020	<0.000010 J	<0.00002	<0.000020	<0.000020
Chromium	<0.00066	<0.00067	0.00055	0.00051	<0.00062	0.00077	<0.00048	<0.00036
Lead	<0.000093	<0.000055	0.000098	0.000062	<0.000022	<0.00004	0.000057	0.000038
Silver	<0.000007 J	<0.000007 J	--	--	--	--	<0.000020	<0.000020
Sodium	--	--	--	--	--	--	120	32.8
Selenium	0.00042 J	<0.0010	--	--	--	--	<0.0010	<0.0010
Barium	0.009267	0.013166	--	--	--	--	0.019278	0.004786
Beryllium	0.000009 J	0.000006 J	--	--	--	--	<0.000020	<0.000020
Copper	<0.00105	<0.00083	--	--	--	--	0.00045	0.00049
Zinc	0.00528	0.03338	--	--	--	--	0.00134	0.00214
Nickel	0.00201	0.00608	--	--	--	--	0.0031	0.00358
Chromium (+3)	--	--	--	--	--	--	<0.05	<0.05
Chromium (+6)	<0.05	0.025 J	--	--	--	--	0.36	<0.05
Total Iron	--	--	--	--	--	--	--	--
Ferrous Iron	--	--	--	--	--	--	--	--
Iron (+2) field test	--	--	--	--	--	--	--	--

TABLE 1a

GROUNDWATER MONITORING DATA SUMMARY - CG-161-60

Stericycle Georgetown Facility

Seattle, Washington

(Prepared January 2017)

Well	**CG-161-60**						
Parameter (units)	2/19/2014	8/6/2014	2/11/2015	8/5/2015	2/3/2016	8/3/2016	9/29/2016
Specific Conductivity (µs/cm)	862	968	876	957	881	949	968
Redox (mV)	-114	-75	-92	-89	-96	-80	40.9
1,4-Dioxane (µg/L)	460	410	450	520	640	740	530

Notes:

µg/L = micrograms per liter

µs/cm =microsiemens per centimeter

mV = millivolt

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TABLE 3
INJECTION TIMING, PRESSURE, AND FLOW DETAILS
Stericycle Georgetown Facility
Seattle, Washington
(Revised January 2017)

6/23/2016						
Injection Location	**Time**	**Depth (ft bgs)**	**Injection Rate (gpm)**	**Pressure (psi)**	**Volume Injected (gallons)**	**Average Injection Rate (gpm)**
IP-1	12:35	51-53	start [1]	start	60	1.0
	12:45	51-53	2.0	8		
	12:50	51-53	1.5	8		
	13:05	51-53	pause	pause		
	14:28	50-52	2.0	10		
	15:00	50-52	final	final		
	15:00	52-54	start	start	60	2.1
	15:28	52-54	final	final		
	15:40	54-56	start	start	60	1.0
	15:50	54-56	--	12		
	15:54	54-56	--	14		
	16:03	54-56	1.4	--		
	16:10	54-56	--	14		
	16:25	54-56	0.2	--		
	16:30	54-56	--	18		
	16:41	54-56	final	final		
	16:51	56-58	start	start	50	1.3
	16:59	56-58	1.3	--		
	17:09	56-58	1.3	--		
	17:11	56-58	0	0		
	17:26	56-58	--	8		
	17:30	56-58	final	final		
IP-3	12:35	50-52	start	start	60	1.2
	12:45	50-52	2.0	8		
	12:50	50-52	1.5	8		
	13:25	50-52	1.3	5		
	15:40	52-54	start	start	60	1.0
	15:50	52-54	--	12		
	15:54	52-54	--	14		
	16:03	52-54	1.4	--		
	16:25	52-54	--	14		
	16:25	52-54	0.2	--		
	16:30	52-54	--	18		
	16:41	52-54	1.00	16		
	16:51	54-56	start	start	50	1.3
	16:59	54-56	1.3	--		
	17:09	54-56	1.3	--		
	17:11	54-56	0	0		
	17:26	54-56	--	8		
	17:30	54-56	final	final		

Notes:
1) Injection start and stop as well as breaks for troubleshooting (pause) are noted rather than pressures or flows.
2) There was no flow at 45 psi. Pressure was increased to 65 psi to achieve 2 gpm, but pressure stayed elevated followed by leak at surface seal. No flow at next injection depth.

Definitions:
ft bgs = feet below ground surface
gpm = gallon per minute
psi = pound per square inch
'--' = No reading taken

TABLE 3
INJECTION TIMING, PRESSURE, AND FLOW DETAILS
Stericycle Georgetown Facility
Seattle, Washington
(Revised January 2017)

6/24/2016						
Injection Location	**Time**	**Depth (ft bgs)**	**Injection Rate (gpm)**	**Pressure (psi)**	**Volume Injected (gallons)**	**Average Injection Rate (gpm)**
IP-1	10:20	56-58	0.5-2.0	10-20	10	2.0
	10:25	56-58	0.5-2.0	10-20		
	10:40	58-60	1.8	22	60	2.1
	10:55	58-60	2.0	8		
	11:08	58-60	2.0	10		
IP-3	10:20	54-56	0.5-2 .0	10-20	10	2.0
	10:25	54-56	0.5-2.0	10-20		
	10:40	56-58	2.0	22	60	2.0
	10:55	56-58	2.0	18		
	11:10	56-58	2.0	16		
	11:12	58-60	2.0	11	60	2.1
	11:18	58-60	2.0	11		
	11:23	58-60	2.0	11		
	11:33	58-60	2.0	11		
	11:40	58-60	2.0	11		
IP-4	12:48	48-50	start	start	60	2.0
	12:55	48-50	2.0	--		
	13:00	50-52	2.0	5		
	13:18	50-52	final	final		
	13:20	52-54	start	start	60	2.1
	13:30	52-54	2.00	30		
	13:36	52-54	2.00	28		
	13:42	52-54	2.00	28		
	13:50	52-54	final	final		
	13:51	54-56	start	start	60	2.4
	14:00	54-56	2.0	8		
	14:05	54-56	2.0	7		
	14:10	54-56	2.0	--		
	14:18	54-56	2.0	8		
	14:18	56-58	start	start	60	2.2
	14:20	56-58	2.0	10		
	14:25	56-58	2.0	8		
	14:30	56-58	2.0	6		
	14:47	56-58	2.0	6		
	14:59	58-60	start	start	60	2.1
	15:28	58-60	2.0	7		
IP-2	13:51	50-52	start	start	60	2.2
	14:00	50-52	2.0	32		
	14:05	50-52	2.0	36		
	14:10	50-52	2.0	--		
	14:18	50-52	2.0	34		
	14:18	52-54	start	start	56	1.9
	14:20	52-54	2.0	22		
	14:25	52-54	2.0	30		
	14:30	52-54	2.0	34		
	14:47	52-54	2.0	22		
	14:59	54-56 [2]	2.0	65	7	1.2
	15:05	55-57	--	--		