

City of Spokane

Golf Course Water Reuse Pilot Study – Phase I Report

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Phase I - Initial Sampling to Determine Baseline Levels of Heavy Metals of Soil and Water and Soil Nutrients at Two City of Spokane Golf Courses

Objective: To determine the baseline levels of heavy metals in the soil and irrigation water and soil nutrients prior to the application of effluent water at the 2 city of Spokane golf courses.

Soil samples were taken at 6 locations at the Creek at Qualchan and 4 at Downriver Golf Courses. The Qualchan tee effluent soil sample was not taken on 5/15/08 because the tee was under construction. The tee was sampled on 6/17/08 and analyzed for heavy metals. See table below for the location of each soil sample.

Location	Turf-site	Effluent H ₂ O irrigation	City H ₂ O irrigation
Downriver (DR)	Rough	Yes	
DR	Rough		Yes
DR	Tee	Yes	
DR	Tee		Yes
Qualchan (Q)	Tee (Under Construction)	Yes	
Q	Tee		Yes
Q	Green	Yes	
Q	Green		Yes
Q	Fairway	Yes	
Q	Fairway		Yes

Mercury levels at 4 of the Creek at Qualchan locations (2 fairway and 2 tees) were < 0.013 ppm (Table 1). However, on the 2 green locations mercury levels were up to 100 times higher. These high levels of mercury could be residual mercury left over from the use of mercurial fungicides for snow mold control years ago. Levels of mercury ranged from 0.033 to 0.270 ppm at the Downriver locations (Table 2).

Table 1. Initial heavy metal levels in the soil at the Creek at Qualchan Golf Course 5/15/08.

Analyte	15 Green Effluent	15 Green Pond	16 Fairway Effluent	16 Fairway Pond	16 Tee Effluent*	16 Tee Pond	Units	Detect Limit	Analysis Method	Prep Method
Beryllium	0.55	0.58	0.54	0.59	0.77	0.54	ppm	0.02	ICP-MS	3050B Digest
Chromium	18	16	14	15	16	14	ppm	0.38	ICP-MS	3050B Digest
Cobalt	4.8	4.2	6.8	6.6	4.6	6.7	ppm	0.02	ICP-MS	3050B Digest
Nickel	11	9.8	12	12	10	12	ppm	0.06	ICP-MS	3050B Digest
Copper	17	15	11	12	12	11	ppm	0.06	ICP-MS	3050B Digest
Arsenic	15	13	7.1	7.0	14	8.9	ppm	0.38	ICP-MS	3050B Digest
Selenium	< 0.38	< 0.38	< 0.38	< 0.38	<0.38	< 0.38	ppm	0.38	ICP-MS	3050B Digest
Molybdenum	0.33	0.34	0.31	0.29	0.25	0.26	ppm	0.02	ICP-MS	3050B Digest
Silver	0.60	0.61	0.58	0.53	0.097	0.47	ppm	0.08	ICP-MS	3050B Digest
Cadmium	0.10	0.11	0.057	0.11	0.086	0.13	ppm	0.04	ICP-MS	3050B Digest
Antimony	< 0.38	< 0.38	< 0.38	< 0.38	<0.38	< 0.38	ppm	0.38	ICP-MS	3050B Digest
Barium	71	74	100	110	85	97	ppm	0.04	ICP-MS	3050B Digest
Thallium	0.16	0.17	0.15	0.17	0.16	0.15	ppm	0.06	ICP-MS	3050B Digest
Lead	6.9	7.0	8.4	9.1	8.7	8.6	ppm	0.04	ICP-MS	3050B Digest
Mercury	1.0	1.4	0.0098	0.013	0.013	0.0082	ppm	0.008	CVAFS	Nitric/HCl Digest

*Sample taken 6/17/08 after tee was constructed and before effluent water applied.

Table 2. Initial heavy metal levels in the soil at Downriver Golf Course 5/15/08.

Analyte	7 Rough Effluent	7 Rough City	6 Tee Effluent	6 Tee City	Units	Detect Limit	Analysis Method	Prep Method
Beryllium	0.71	0.60	0.47	0.49	ppm	0.02	ICP-MS	3050B Digest
Chromium	21	45	13	14	ppm	0.38	ICP-MS	3050B Digest
Cobalt	6.8	5.5	4.0	4.3	ppm	0.02	ICP-MS	3050B Digest
Nickel	12	12	8.4	8.9	ppm	0.06	ICP-MS	3050B Digest
Copper	14	14	18	16	ppm	0.06	ICP-MS	3050B Digest
Arsenic	6.7	7.0	12	13	ppm	0.38	ICP-MS	3050B Digest
Selenium	< 0.38	< 0.38	< 0.38	< 0.38	ppm	0.38	ICP-MS	3050B Digest
Molybdenum	0.51	1.0	0.38	0.37	ppm	0.02	ICP-MS	3050B Digest
Silver	0.63	0.70	1.2	0.96	ppm	0.08	ICP-MS	3050B Digest
Cadmium	0.19	0.59	0.10	0.11	ppm	0.04	ICP-MS	3050B Digest
Antimony	< 0.38	< 0.38	< 0.38	< 0.38	ppm	0.38	ICP-MS	3050B Digest
Barium	140	130	88	94	ppm	0.04	ICP-MS	3050B Digest
Thallium	0.21	0.19	0.15	0.16	ppm	0.06	ICP-MS	3050B Digest
Lead	33	41	10	11	ppm	0.04	ICP-MS	3050B Digest
Mercury	0.074	0.27	0.033	0.042	ppm	0.008	CVAFS	Nitric/HCl Digest

Table 3. Initial soil nutrient levels at the Creek at Qulachan on 5/15/08.

	15 Green Effluent	15 Green Pond	16 Fairway Effluent	16 Fairway Pond	16 Tee Effluent*	16 Tee Pond	Units	Analysis Method
pH	7.2	7	6.7	6.3	No Data	6.4		
Organic Matter	1.47	1.54	2.43	1.40	No Data	2.25	%	
NO3-N	1.3	1.8	0.5	0.5	No Data	0.5	ppm	
NH4-N	2.3	2.3	8	5.3	No Data	5.5	ppm	
Phosphorous	28	34	8	16	No Data	22	ppm	Bicarb
Potassium	99	78	182	178	No Data	168	ppm	Bicarb
SO4-S	19	17	9	12	No Data	13	ppm	
Boron	0.27	0.33	0.22	0.28	No Data	0.25	ppm	
EC (SS)	0.26	0.23	0.21	0.18	No Data	0.17	mmho/cm	Sat. Ext.
Zinc	1.2	1.8	2	1.8	No Data	3.6	ppm	DPTA
Calcium	60.1	38.1	33.4	19.2	No Data	31.8	ppm	Sat. Ext.
Magnesium	12.0	10.9	20.4	12.9	No Data	13.1	ppm	Sat. Ext.
Sodium	3.3	5.8	5	7.3	No Data	5.5	ppm	Sat. Ext.
SAR	0.10	0.21	0.17	0.32	No Data	0.21		
*Tee was under construction when study began, therefore, no soil sample was taken.								

Table 4. Initial soil nutrient levels at Downriver Golf Course on 5/15/08.

	7 Rough Effluent	7 Rough City	6 Tee Effluent	6 Tee City	Units	Analysis Method
pH	6.3	6.1	6.7	6.5		
Organic Matter	6.14	6.36	2.08	1.91	%	
NO3-N	10.3	16.3	1.5	0.5	ppm	
NH4-N	8.5	14.8	4.5	3.5	ppm	
Phosphorous	20	22	78	72	ppm	Bicarb
Potassium	210	227	170	138	ppm	Bicarb
SO4-S	17	16	20	23	ppm	
Boron	0.97	0.88	0.38	0.38	ppm	
EC (SS)	0.25	0.32	0.38	0.42	mmho/cm	Sat. Ext.
Zinc	11	10.8	5	5	ppm	DPTA
Calcium	15.7	19.4	44.6	31	ppm	Sat. Ext.
Magnesium	21.2	29.7	17	18.9	ppm	Sat. Ext.
Sodium	10.8	8.5	7.9	9.1	ppm	Sat. Ext.
SAR	0.42	0.28	0.25	0.32		

Table 5. Initial heavy metal levels of irrigation water at the Creek at Qualchan Golf Course 5/15/08.

Analyte	Effluent	Pond	Units	Detect Limit	Analysis Method	Prep Method
Beryllium	< 0.13	< 0.13	ppb	0.13	ICP-MS	
Chromium	< 1	< 1	ppb	1	ICP-MS	
Cobalt	< 0.25	< 0.25	ppb	0.25	ICP-MS	
Nickel	1.3	< 0.5	ppb	0.5	ICP-MS	
Copper	7.8	2.5	ppb	0.5	ICP-MS	
Arsenic	1	2.2	ppb	0.5	ICP-MS	
Selenium	< 1	< 1	ppb	1	ICP-MS	
Molybdenum	2.3	1	ppb	1	ICP-MS	
Silver	< 0.25	< 0.25	ppb	0.25	ICP-MS	
Cadmium	< 0.25	< 0.25	ppb	0.25	ICP-MS	
Antimony			ppb	0.38	ICP-MS	
Barium	12	22	ppb	0.5	ICP-MS	
Thallium			ppb	0.06	ICP-MS	
Lead	0.37	1.2	ppb	0.25	ICP-MS	
Mercury	< 0.05	< 0.05	ppb	0.05	CVAFS	BrCl Digest
Vanadium	0.42	< 0.25	ppb	0.25	ICP-MS	
Manganese	8.8	8.3	ppb	0.25	ICP-MS	
Zinc	67	18	ppb	2.5	ICP-MS	

Table 6. Initial heavy metal levels of irrigation water at Downriver Golf Course 5/15/08.

Analyte	Effluent	City	Units	Detect Limit	Analysis Method	Prep Method
Beryllium	< 0.13	< 0.13	ppb	0.13	ICP-MS	
Chromium	< 1	< 1	ppb	1	ICP-MS	
Cobalt	< 0.25	< 0.25	ppb	0.25	ICP-MS	
Nickel	1.3	< 0.5	ppb	0.5	ICP-MS	
Copper	7.8	< 0.25	ppb	0.5	ICP-MS	
Arsenic	1	2.4	ppb	0.5	ICP-MS	
Selenium	< 1	< 1	ppb	1	ICP-MS	
Molybdenum	2.3	1.1	ppb	1	ICP-MS	
Silver	< 0.25	3.1	ppb	0.25	ICP-MS	
Cadmium	< 0.25	< 0.25	ppb	0.25	ICP-MS	
Antimony			ppb	0.38	ICP-MS	
Barium	12	23	ppb	0.5	ICP-MS	
Thallium			ppb	0.06	ICP-MS	
Lead	0.37	0.35	ppb	0.25	ICP-MS	
Mercury	< 0.05	< 0.05	ppb	0.05	CVAFS	BrCl Digest
Vanadium	0.42	< 0.25	ppb	0.25	ICP-MS	
Manganese	8.8	< 0.25	ppb	0.25	ICP-MS	
Zinc	67	170	ppb	2.5	ICP-MS	

Time-line:

- Task 1.** Soil sampling and analysis (Basic soil test and SAR).
Summer (15 July) and Fall (15 October) 2008
- Task 2.** Soil sampling and analysis (Trace Element Screen, Mercury, and Physical Properties).
Fall (15 October) 2008
- Task 3.** Water sampling and analysis.
Summer (15 July) and Fall (15 October) 2008
- Task 4.** Tissue testing.
Monthly throughout growing season until Fall 2008
- Task 5.** Turfgrass evaluation.
Monthly throughout growing season until Fall 2008
- Task 6.** Fertilizer program nutrient balance.
Fall 2008
- Task 7.** Phase II data analysis and 2008 report.
March 2009

Budget:

Sample analysis	\$7093
Travel	\$900
Materials & supplies	\$140
Labor	\$5200
Indirect cost (5%)	\$667

Phase II TOTAL \$14,000