2011 Annual Water Quality Report

Willow Creek Mine

Submitted to MOE
March 31, 2012

WALTER ENERGY
WESTERN COAL

1.1 Table of Contents

<u>LIST OF FIGURES</u>

LIST OF TABLES

APPENDICES

Section 1 – Introduction

1.1 COMPANY PROFILE

Walter Energy (WE) is a public company with shares traded on the TSX Stock Exchange using the symbol "WLT". Through its wholly owned subsidiary, Western Coal Corp. (hereafter referred to as Western) the company owns two groups of coal properties in northeast British Columbia, the Brazion Group (including the Burnt River Property, Brule), and the Wolverine Group (including the Wolverine, Mt Speiker and Hermann Properties). WE assumed management responsibilities of Falls Mountain Coal (Willow Creek Mine) in July 2007, under agreement with the owner, Cambrian Mining plc. Walter and Peace River Coal Limited Partnership also jointly own the Belcourt-Saxon Group of Properties south of Tumbler Ridge. Western Coal Corp also owns properties in West Virginia, USA and Wales, UK. The head office of Western Coal Corp. is located in Vancouver:

1000-885 Dunsmuir Street
Vancouver, British Columbia V6C 1N5
Telephone: 604-608-2692
Fax: 604-629-0075
Website: www.walterenergy.com

The Willow Creek Mine is operated from Chetwynd, B.C.:
Willow Creek mine
4804 47th Street
P.O. Box 537
Chetwynd, BC V0C 1J0
Telephone: 250.788.3619
Fax: 250-788-2172

The Willow Creek Mine is under the management of Bruce Donald, Mine Manager. Executive direction related to the Willow Creek Mine is provided by:

President & CEO	Walt Scheller
President, Canadian Operations	Dan Cartwright
Vice President, Environment and Community Affairs	Eric Christensen

Implementation and day-to-day direction of the on-site environmental programs is the responsibility of Mark Vancook, Environmental Coordinator under the direction of the Mine Manager, Bruce Donald.

1.2 PROPERTY LOCATION

The Willow Creek Mine is located in the eastern foothills of the Rocky Mountains (Peace River Regional District) approximately 45 km by road west of Chetwynd, BC. The Plant site is located at kilometer three on the Willow Creek FSR. The central pit area is accessed via the Willow Creek FSR at Kilometer 8.

1.3 PURPOSE OF REPORT

The purpose of this document, *2011 Annual Air Quality Report – Willow Creek Mine*, is to satisfy the annual reporting requirements under section 5.5 of Air Permit PA-17043.

Section 2 – Mining Program

2.1 SURFACE DEVELOPMENT TO DATE

Mining activities at the Willow Creek Mine resulted in a total disturbance of 175.8 hectares until October 2006, when the mine was placed under care and maintenance status. Total material moved prior to 2008 was 12.8 million bench cubic metres (BCM), with waste totaling 11.5 million BCM and coal totaling 1.3 million BCM.

During 2008, mining resumed in the 4C pit and the on the east side of the 7C pit in late August and continued until 25 November when the Willow Creek Mine was once again placed under care and maintenance status. During this period of active mining 1.09 million BCM of waste was moved in the 7C pit, which produced 20,000 BCM of coal. Additionally, 122,000 BCM of waste was mined from the 4C pit to produce another 17,000 BCM of coal. Overall, the total disturbance areas did not change from the previous year. Appendix A (Table 1) of the 2009 Annual Reclamation Report – Willow Creek Mine displays total areas moved in hectares.

Four main areas were used for soil stockpile purposes during 2008, three of these stockpiles were newly established at the top of north dump (0.7216 ha), the north side of south dump (0.5956 ha) and the south side of south dump (0.4638 ha), covering a total area of 1.781 ha (Figure 2-1).

The pile on the top of the north dump consists of 6,000m^3; the pile on the south face of the south dump consists of 4,800m^3 of soil and the soil pile on the north face of the south dump totals 6,500m^3. Additionally, 11,200m^3 of soil was added to the stock pile on the west side of the north dump.

No surface development occurred in the 2009 calendar year at the Willow Creek Mine site.

Calendar year 2010 saw the construction of the South sediment pond as well as the associated collector ditches and discharge structures. An extension of the south ditch of South pond was begun in 2010 and was completed prior to freshet in early 2011. 15,785,923 tonnes of waste rock was moved in 2010 (May to December), while 389,873 tonnes of clean coal were mined.

.

2.2 SURFACE DEVELOPMENT IN THE PAST YEAR

The North Sediment Pond construction began with the logging phase in March of 2011 and continued on with construction of the pond and associated areas for the remainder of the year creating a total area of disturbance of 43.13 ha; the project is expected to be completed in early 2012 to accommodate the north expansion mining plan. There are two soil stockpiles associated with this construction totaling 145, 951 bcm.

The North Haul Road (NHR), that was built to accommodate the coal haul for the north expansion, was constructed in 4 phases; the first two phases began in 2010 and involved constructing the road to light vehicle standards, the third phase consists of widening the road to accommodate the haul trucks this has an expected completion date of early 2012, the fourth phase will comprise of paralleling the FSR up to the ROM area as well as the ditch associated with the North Sediment Pond, the completion date is projected for May 2012. The total area of disturbance for the mine site roads in 2011 was 78.26 ha.

The expansion of the process plant began in May 2011 and has an expected completion date of February 2012. The expansion will increase the production capacity from 1.7 Mt/a to 3.8 Mt/a and will allow the processing of Brule coal at the Willow Creek plant site. The total area of disturbance for the plant was 20.30 ha.

The development of the 4N1 and 7N1 pits, in 2011, created 433, 560 m^3 of soil which has been stripped, 117, 000 m^3 was stored in run out lanes along the north haul road for future use in reclaiming the mine site while the remainder was temporarily stored until haulage to a more permanent area takes place.

5,454,083 BCM of waste rock was moved in, while 925,989 tonnes of coal were mined. The waste rock was placed in a combination of the Southeast Dump, North Dump and Saddle dump (in the East end of the 7 Pit), with some waste also being used to create the North Haul Road. Please refer to Table 3 of Appendix A for a complete breakdown of the volumes taken to each location

Please refer to figure 5.1 for a map of all the areas of disturbance in 2011.

2.3 SURFACE DEVELOPMENT OVER NEXT FIVE YEARS

WEWC is currently in the process of developing the life of mine plan for Willow Creek Mine, which will be influenced by future market conditions. Mining has extended into the north area and the disturbance area is approaching the planned limits in this section. Exploration of the south area will continue. All surface development will be authorized under Mine Permit C-153.

Section 3 – Water Quality Monitoring Program

3.1 ENVIRONMENTAL STAFF

The Environmental Department for WEWC dedicated to the Willow Creek mine site is comprised of the following staff:

- Environmental Coordinator
- Two Environmental Technicians
- Two Environmental Samplers

In addition to water quality monitoring and reporting, environmental staff at the Willow Creek Mine was responsible for a range of other activities, including but not limited to employee and contractor environmental orientations, air quality monitoring, ML/ARD sampling and reporting, overseeing defined reclamation activities, and the implementation of Environmental Management Plans.

3.2 SAMPLING PROGRAM

Table 3-1 outlines the locations of the Willow Creek Mine water quality monitoring sites. In addition to operational monitoring, a pit dewatering monitoring program was implemented throughout the duration of discharge (April – June) from pits 7C and 4C. This program followed the guidelines of Permit PE-17042. Sampling of the sediments and sampling for extractable petroleum hydrocarbons occurred on 14 September, 2011, at the plant site sediment pond, south pond and pond X.

Table 3-1. Willow Creek Mine Surface Water Quality Monitoring Sites

Site ID	Location Description	Former Site ID	GPS Location (NAD83 zone 10U)	Date Established
South Sediment Pond	North of Tr 2-1, discharges into ditch that enters Tr-2 directly u/s of Tr 2-1	Pond C	0550454 E 6160809 N	Aug 09 (re-established)
Pond X	Trib 1 u/s, directly d/s of dump road	Pond X	0549035 E 6161547 N	Jun-05
Tr 1-1	Trib 1 mouth, 15 m u/s from confluence with Willow Ck.	TR1-1	0549035 E 6161201 N	Oct-05
Tr 2-1	Trib 2 d/s, directly d/s of crossing	Trib 2 Downstream	0550472 E 6160537 N	Aug-11
Tr 2-2	Trib 2, control site u/s of mine	Trib 2 Upstream	0551351 E 6161829 N	Apr-02
WC-1	Willow Creek, d/s of Trib 1 & 2 and bridge, furthest d/s site on Willow Ck.	Willow Downstream	0546703 E 6164087 N	Jul-04
WC-2	Willow Creek, at bridge, d/s of Trib 1 & 2	Willow Upstream of Bridge	0550536 E 6162006 N	Aug-11
WC-3	Willow Creek, 50 m d/s of confluence with Trib 1	N/A	0548987 E 6161218 N	Oct-05
WC-4	Willow Creek, 50 m u/s of confluence with Trib 1	N/A	0549020 E 6161169 N	Oct-05
WC-5	Willow Creek, u/s control site on Willow Ck, d/s of Canfor crossing	Willow Upstream	0552491 E 6158306 N	Jul-04
WC-5a	Willow Creek, u/s control site on Willow Ck, d/s of Canfor crossing	Willow Upstream	0549938 E 6160339 N	Apr-08
PR-1	Pine River, d/s of Willow Creek confluence, furthest d/s site on Pine River.	Pine Downstream	0547417 E 6165206 N	Jul-04
PR-2	Pine River, immediately u/s of Willow Creek confluence	Pine Upstream	0546637 E 6164182 N	Jul-04
PR-3	Pine River, control, u/s of Trib 234-699000	PR-3	0545843 E 6162649 N	Dec-05

Section 4 – Field Methodology

4.1 FIELD SAMPLING METHODOLOGY

Water sampling conducted by WEWC in 2011 was done in accordance with the procedures described in the MOE "*British Columbia Field Sampling Manual: 2003 – For Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples".*

4.2 CONTROL AND COMPLIANCE SITES

WC-5 and WC-5a are designated as the background control sites for comparison with sites downstream of effluent discharge from the Willow Creek Mine. WC-5 is located on Willow Creek, upstream of mine-related inputs (from Tributary 1 and Tributary 2), approximately 2.4km upstream from the confluence of Tributary 2 and Willow Creek. WC-5a is also located on Willow Creek, approximately 100m upstream of the Trib 2 confluence. Like WC-5, WC-5a, allows for a background comparison and segregation of mine related effluent; however, this site is closer to Tributary 2 which removes any additional (non-mine related) input to Willow Creek associated with the reach between the two sites. When sampling at WC-5a occurs, the requirement to sample at WC-5 is superseded. WC-2 is designated as the compliance site as it is established downstream of the confluences of Trib 1 and Trib 2 (source streams) with Willow Creek and is located within fish habitat. PR-3, permitted as a control site on the Pine River, enables a valid background comparison as it is isolated from mine related influences as well as any of the aforementioned creeks and tributaries.

4.3 FIELD DUPLICATES AND TRAVEL BLANKS

Field duplicate samples are two samples collected at the same location and time, using the same equipment and procedures. Field duplicates are intended to evaluate the precision of the water quality results for each parameter analyzed. The observed variance between duplicates will be the sum of variance caused by the local environment, field methods, and analytical methods. A field duplicate sample was collected at one station during each water quality monitoring event. The field duplicate sample was submitted blind to ALS Environmental for analysis of the full suite of parameters routinely monitored. When the results are reported back from the laboratory, parameters from the duplicate and the actual sample are compared to confirm likeness or potential of sampling error/contamination.

Travel blanks, consisting of distilled de-ionized (DI) water, were exposed to the same conditions and treatments as the water samples collected, and are intended to monitor contamination that occurs during sample collection and handling (*e.g.* sample preservation or filtering). Travel blanks were prepared as follows; DI water was ordered in bulk from ALS, shipped in 4 L bottles, and decanted into the appropriate bottles for travel blanks in the WEWC environmental office on the day of sampling (immediately before going into the field), placed in a cooler with ice packs, and taken into the field by the sampling staff. The blank samples are returned unopened to the office, preserved with acids along with the other water samples (i.e., bottles for Total Organic Carbon, Ammonia, Total Metals analysis, as well as Dissolved Metals in the case of Groundwater sampling), and shipped to the analytical laboratory, with the remainder of the samples, for analysis.

Filter blanks are de-ionized water that is passed through the filtration apparatus in the same manner as the sample. Analysis of the filtrate provides an indication of the types of contaminants that may have been introduced through contact with contaminated filtration surfaces (filtration apparatus and the filters) or exposure to dust sources.

4.4 FILTRATION

In order to minimize the potential for oxidation artifacts during groundwater collection, samples are filtered in-field using a 45µm in-line filter. In this manner, the groundwater samples are filtered prior to exposure to atmospheric conditions. Such methods minimize the potential for the oxidation of reduced species which may be present in suboxic groundwater environments (e.g., Fe^{2+}, Mn^{2+}, ammonia, and nitrite).During the winter months (typically November through March) or if the groundwater well pump is not in working order, the samples for dissolved metals are filtered by the laboratory (ALS Environmental). In 2011 the manual groundwell pump was used in March, June and September due to equipment failure. In the unusual event that a sample cannot reach the lab within the appropriate time frame for filtering, environmental staff filters the samples in a clean location, using 45µm filter paper (the same size as that used by ALS Environmental), under clean dust-free and fume-free conditions. Filtration was required prior to shipment of samples in June and September of the 2011 sampling year.

4.5 FIELD PARAMETERS

Field meters used at the Willow Creek Mine during 2011 included turbidity (LaMotte 2020e, LaMotte 2020we/wi or LaMotte 2020we – the number of meters increased versus 2010 due to equipment malfunction and the subsequent use of rental equipment), multi-probe system (YSI 556 MPS) which analyzed conductivity, pH, oxidative-reductive potential, temperature and percent dissolved oxygen and a Sontek Flowtracker flow meter. Field turbidity measurements are conducted at surface water locations described in Table 3.2 and Section 5.1 of Permit PE-17042.

WEWC's environmental staff used a LaMotte 2020e, LaMotte 2020we/wi and LaMotte 2020we field turbidity meter at the Willow Creek mine site. In order to maintain accountability and monitor potential variations, the particular meter used is documented at time of sampling. Several meters were used because of repairing required of the LaMotte 2020we/wi. The field turbidity meters are calibrated regularly using the methods outlined in the manual. Calibration standards (Formazin 0.00, 1.00, and 10.00 NTU) are ordered annually and used prior to expiry dates.

The portable flow monitoring device used by WEWC at the Willow Creek mine site is a Sontek Flowtracker. This meter utilizes sonar to measure water flowing past the sensor and converts that into a flow measurement. Internal calibration and troubleshooting is performed using “Beamcheck” software, included with the instrument.

Section 5 – Quality Assurance/Quality Control (QA/QC)

A comprehensive quality assurance/quality control (QA/QC) program was incorporated into the field and laboratory components of the 2011 water quality program by WEWC. The full suite of QA/QC data is presented in Appendix A.

The purpose of a QA/QC program is to verify the reliability of field and laboratory monitoring data through the implementation of procedures for controlling and monitoring the collection and measurement processes. The QA/QC program provides information for the evaluation of the analytical procedures (precision and accuracy) and for the analysis of issues pertaining to contamination both in the field and in the analytical laboratory. The QA/QC program is conducted at all stages of the sampling program; sample collection, transport and analysis, both in field and in laboratory.

QA/QC samples include field duplicates, blanks (filter, travel and laboratory (method) blanks), field/laboratory turbidity comparison and certified reference materials. Data relating to each of these components are discussed in turn below.

5.1 LABORATORY/FIELD DUPLICATES

Twelve full suite field duplicates were collected for the surface water sampling program in 2011. Field and laboratory duplicates were compared for the purpose of evaluating the precision of the methods used (i.e. combined precision of field methods, lab methods and the environmental variability between the samples). A Relative Percent Difference (RPD) of ±20% was used to identify significant differences between laboratory duplicate and sample, where the RPD is defined as: The difference between the values of the duplicates divided by the average of the two values. The lab RPD was defined as 20% variation, and as per section 3.6.6 of Permit PE-17042, field duplicates are allowed a ±40% variation.

RPD (%) = (Value 1 – Value 2)/mean X 100

RPDs are expected to be high at values near the detection limit. In such instances one or both values were less than one order of magnitude from the detection limit but RPD’s were > 40%, the samples were not considered to have exceeded their data quality objectives, and as a result, were omitted from the list below. The field replicates (Appendix A) showed generally acceptable precision with the following exceedences of the relative percent difference (RPD) of 40% for the surface water sampling program in 2011:

- April
    - D-Al (120.86%)
    - T-Cu (121.95%)
    - T-Ti (49.84%)
- May
    - T-Ti (49.84%)
- June
    - Nitrite (84.85%)
    - TKN (47.76%)
- July
    - T-Phosphorus (44.53%)
    - D-Al (82.88%)
    - D-Cr (52.63%)
    - D-Fe (51.80%)
- August
    - T-Cr (41.38%)
- September
    - TKN (102.82%)
- October
    - D-Al (128.02%)
    - D-Cr (47.06%)
- November
    - Acidity (123.53%)
    - TKN (57.81%)

Some degree of environmental variability can be expected in duplicate samples for parameters influenced by TSS (such as some metals). It is expected that turbulence and flow patterns will create small scale spatial differences in concentrations of TSS and other parameters, and therefore field duplicates may not be sampling water containing exactly the same proportions of parameters. While measures were taken to minimize this, it is not possible to completely alleviate this effect when sampling duplicates side by side in the field. No laboratory duplicates exceeded the 20% RPD for surface water in 2011.

The 2011 groundwater QA/QC program included 4 full suite field replicates Groundwater field duplicates were evaluated using the same data quality objectives described above for surface water samples. The field replicates (Appendix A.7) showed generally acceptable precision with the following exceedences of the relative percent difference (RPD) of 40% for the ground water sampling program in 2011:

- March
    - TSS (97.76%)
    - T-phosphorous (60.42%)
- September
    - TOC- (41.19%)

As discussed above, at concentrations near the detection limit, small variations in water chemistry can result in significant variability between duplicate samples. As a result, any instances in which one or both samples exhibited readings for a parameter that was less than two times the detection limit the duplicate comparisons were omitted from the above list. Also, as previously mentioned, some degree of environmental variability can be expected in duplicate samples for variables influenced by TSS (i.e. total metals). No laboratory duplicates exceeded the 20% RPD for groundwater in 2011.

5.2 LABORATORY/TRAVEL BLANKS

5.2.1 Laboratory Blanks

Laboratory blanks were prepared and analyzed at ALS in accordance with standard QA/QC protocols. There were no parameters that were found to be greater than the detection limit from the twelve laboratory blanks prepared for the surface water program in 2011, with the exception of pH, which remained within the target range.

As only one parameter was shown to be above detection limits in the laboratory blank (T-Mn in the laboratory blank associated with the July 4, 2011 surface water sampling set read 0.00128 mg/L, with a detection limit of 0.00005 mg/L), contamination associated with laboratory analysis and equipment is not predicted to have a significant effect on the surface water data quality.

An additional four laboratory blanks were prepared and analyzed as a part of the 2011 groundwater sampling program. For the groundwater program in 2011 there were no parameters that were found to be greater than the detection limit from the four laboratory blanks prepared.

Given the number and magnitude of detectable concentrations in laboratory blanks, contamination associated with laboratory analysis and equipment is not predicted to have a significant effect on groundwater data quality.

5.2.2 Travel Blanks

Travel blanks were prepared in the following way: A full suite of blanks using deionized water is prepared from 4 L jugs shipped to WEWC by ALS office site before traveling to the sampling locations. The sample bottles remain capped throughout the sampling process. Preservatives are then added at the same time as the samples themselves. Twelve travel blanks were submitted for monthly surface water analysis in 2011. There were no parameters that were found to be greater than the detection limit from the twelve travel blanks prepared, with the exception of pH for which an average of 5.69 ±0.09 was noted.

An additional four travel blanks were submitted as part of the groundwater sampling program in 2011. There were no parameters that were found to be greater than the detection limit from the four travel blanks prepared.

Given that there were no exceedences, contamination associated with sample collection and handling, or laboratory analysis and equipment is not predicted to have a significant effect on groundwater data quality.

Appendix A.1 and A.5 summarize total and dissolved metals and general parameters for surface water and groundwater travel blanks (respectively) in 2011.

5.3 CERTIFIED REFERENCE MATERIALS

Certified Reference Materials (CRMs) verify the accuracy and precision of instrumentation and analytical methods. CRMs are materials of which one or more property values are certified by a technically valid procedure and are traceable to a certificate or other documentation that is issued by a certified body. The sole purpose of the CRMs is to monitor and evaluate the accuracy of the analytical procedures and techniques used. The Data Quality Objectives (DQO) for CRMs is based on percent recovery, with an acceptable recovery given as 75% to 125%.

All reported surface water CRM values were within the acceptable level of accuracy. Total and dissolved metal recoveries for CRMs all fell within 75% and 125% of targets. All general parameters fell within the75% and 125% targets.

All reported groundwater CRM values were within the acceptable level of accuracy. Total metal recoveries for CRMs all fell within 75% and 125% of targets. All dissolved metal values were also found to fall within 75%-125%. The general parameters all fell within their expected targets of 75%-125%. pH was within the target range (6.9 and 7.1) on all occasions for 2011.

As there is no CRM exceedences noted for 2011, there is no concern that data being processed by ALS would be unreliable.

5.4 FIELD/LABORATORY TURBIDITY

Turbidity samples were collected weekly at surface water sites and analyzed for turbidity both in the field and in the laboratory (at ALS Environmental). Both the sample bottle (500 ml HDPE) and the cuvette used in the turbidimeter were primed (rinsed 3 times with sample water) before sample collection. It was acknowledged that the MoE was concerned with the usefulness of laboratory turbidity as a management tool. This topic was discussed by WEWC staff and MoE personnel in September of 2009. Although it was anticipated that laboratory turbidity would not be a monitoring requirement in the amended permit (PE- 17042 issued October 28, 2010) it will, in fact, continue to be analyzed. The DQO for laboratory turbidity was 75 to 125 %.

For field and laboratory turbidity analysis all values were included in comparison. Values that had a reading of less than 3 (<3.0) were included as 3.00. These values were included to prevent a substantial loss of data.

Appendix A displays field versus laboratory turbidity comparisons for 2011. These relationships are discussed in detail in section 7.1.12.

Section 6 – Flow Data

Flows were monitored at the Willow Creek Mine (TR2-1, Pond X and WC-2) through the use of staff gauges as well as with a Sontek Flowtracker flow monitoring device. Flows were monitored daily during dewatering for TR2-1, Pond X, and WC-2 and then weekly throughout the rest of the ice-free period.

6.1 STAFF GAUGES

There were four staff gauges in 2011 at Willow Creek Mine used for the surface water monitoring program. These gauges are located at Pond X, TR2-1, TR1-1 and WC-2. The staff gauge at Trib2-1 was monitored daily from April 29 to June 24. In late June there was flooding that removed the staff gauge from Trib2-1; the staff gauge was replaced at the end of August. From August onwards the staff gauge was monitored weekly until 7 November. The TR1-1 staff gauge was recorded monthly from May 25 to October 13 (sampling at TR1-1 ceased beyond this date due to unsafe conditions), except for June and July, when landslides precluded safe access to this site. WC-2 was monitored daily from April 15 to May 17. From May 18 to August 21 WC-2 staff gauge was washed out due high water levels and flooding. WC-2 staff gauge was read at least once per week from August 22 to November 10. Pond X staff gauge was read daily from May 3 to July 30, except for June 25 to July 3 when the mine was inaccessible due to flooding. Pond X staff gauge was read weekly from the beginning of August to Nov 10. Table 6-1 summarizes the staff gauge measurements at Trib2-1, TR1-1, WC-2, and Pond X. Additionally there was a staff gauge at PR-1 in 2009. However, it was destroyed during the freshet period in 2010. A new installation will occur when flows in the Pine River permit the job to be done safely. It was not replaced in 2011 due to major flooding and high water levels which created unsafe conditions for this job.

Table 6-1 Monthly Staff Gauge Averages at Willow Creek (m)

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
TR 2-1	Maximum	0.114	0.610	0.429	N/A	0.092	0.110	0.135	0.049
	Minimum	0.101	0.110	0.068		0.092	0.050	0.045	0.039
	Mean	0.108	0.333	0.209		0.092	0.087	0.061	0.044
	Std Dev	0.009	0.148	0.091		N/A	0.020	0.026	0.007
	N	2	29	24		1	10	10	2
TR 1-1	Maximum	Frozen	0.200	N/A	N/A	0.138	0.130	0.520	N/A
	Minimum		0.200			0.138	0.130	0.520	
	Mean		0.200			0.138	0.130	0.520	
	Std Dev		N/A			N/A	N/A	N/A	
	N		1			1	1	1	
WC-2	Maximum	0.390	Flood	N/A	N/A	0.279	0.331	0.297	0.258
	Minimum	0.260				0.252	0.228	0.258	0.235
	Mean	0.305				0.265	0.256	0.273	0.249
	Std Dev					0.009	0.030	0.015	0.010
	N	16				6	10	6	6
Pond X	Maximum	Frozen	N/A	0.215	0.360	0.169	0.160	0.049	0.048
	Minimum			0.001	0.17	0.148	0.139	0.035	0.039
	Mean			0.168	0.256	0.159	0.146	0.044	0.043
	Std Dev			0.053	0.040	0.009	0.008	0.008	0.005
	N			23	25	8	7	7	4

6.2 DISCHARGE MEASUREMENTS

Table 6-2 presents a summary of the discharges calculated for staff gauges at sites Trib2-1, WC-2 and Pond X in 2011. Please refer to Figure 6-1 for discharge curves for Trib2-1, WC-2 and Pond X. Graphs include data from previous years, but omit data from 8 May 2009 as these readings are erroneous. As a result of a flood event in May, the staff gauge at WC-2 was destroyed. It was re-established; however, a second, larger flood event (occurring in late June) resulted in the destruction of this new staff gauge as well. A staff gauge was established again, as close to the old site as possible, however, the second flood event had has cut a new channel through which Willow now flows. Likewise, the staff gauge at Tr 2-1 was also destroyed in the same event and was re-established. The addition of further data over time will serve to increase the accuracy of these curves. For the purpose of this report, discharge curves for WC-2 and Tr 2-1 contain data that encompasses pre-flood records, allowing for increased robustness and range of conditions while maintaining a strong R^2 value (11 Sep 09 to 28 Oct 11 for WC-2 and 5 Oct 07 to 31 Oct 11 for Tr 2-1) . A complete list of discharge measurements can be found in Appendix B. While discharge measurements from the current sedimentation ponds are required under PE – 17042, discharge from the majority of these sites is infrequent and minimal, making a flow measurement difficult, imprecise, and impractical. Furthermore, the only sedimentation ponds to directly discharge to the receiving environment are Pond X and South Pond where flow monitoring is achieved on a consistent basis, as is shown in Table 6-4. Below are Table 6-2 providing calculated discharge analysis and Table 6-3 showing measured discharge analysis for the 2011 year.

Table 6-2 Monthly Calculated Discharge Averages (m^3/s)

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
TR 2-1	Maximum	Frozen	0.618	0.284	N/A	0.007	0.008	0.015	0.004
	Minimum		0.009	0.003		0.007	0.002	0.002	0.003
	Mean		0.201	0.067		0.007	0.004	0.003	0.0022
	Std Dev		0.164	0.068		N/A	0.005	0.004	0.0004
	N		29	24		1	10	10	2
WC-2	Maximum	Frozen	5.324	N/A	N/A	0.051	0.121	0.070	0.036
	Minimum		0.411			0.032	0.023	0.036	0.025
	Mean		1.679			0.041	0.041	0.047	0.249
	Std Dev		1.241			0.006	0.029	0.013	0.249
	N		17			6	9	6	0.005
Pond X	Maximum	Frozen	0.059	0.059	1.436	0.009	0.007	0.0004	0.0004
	Minimum		0.004	0.000	0.009	0.005	0.004	0.00025	0.0003
	Mean		0.154	0.017	0.159	0.007	0.005	0.0003	0.0003
	Std Dev		0.017	0.019	0.269	0.002	0.001	0.000	0.000
	N		26	23	26	8	6	7	4

Table 6-3 Monthly Handheld Discharge Averages (m^3/s)

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
TR 2-1	**Maximum**	Frozen	0.147	0.045	0.157	0.018	0.004	0.004	N/A
	Minimum		0.016	0.01	0.038	0.006	0.001	0.002	
	Mean		0.093	0.034	0.096	0.011	0.002	0.003	
	Std Dev		0.05	0.016	0.059	0.006	0.002	0.0008	
	N		5	4	3	5	10	6	
WC-2	**Maximum**	Frozen	1.364	0.5994	1.031	0.160	0.046	0.101	N/A
	Minimum		0.448	0.4896	0.266	0.050	0.025	0.038	
	Mean		1.016	0.533	0.614	0.112	0.052	0.059	
	Std Dev		0.496	0.059	0.387	0.056	0.041	0.029	
	N		3	3	3	4	5	4	
Pond X	**Maximum**	Frozen	0.102	0.1292	0.147	0.006	0.008	0.003	0.0007
	Minimum		0.107	0.0012	0.070	0.003	0.001	0.001	0.0005
	Mean		0.030	0.055	0.109	0.004	0.004	0.002	0.0006
	Std Dev		0.040	0.056	0.038	0.001	0.003	0.001	0.0001
	N		5	4	3	5	4	4	2
South Pond	**Maximum**	Frozen	0.014	0.0185	0.147	0.0007	0.0006	0.009	0.001
	Minimum		0.014	0.0006	0.07	0.00003	0.00001	0.001	0.0009
	Mean		0.014	0.011	0.109	0.0003	0.0002	0.003	0.001
	Std Dev			0.009	0.005	0.003	0.0003	0.003	0.0004
	N		1	3	4	5	3	5	2

Note: Flows for South Pond for October calculated from upstream and downstream differences. Flows for South Pond for November were calculated from a five gallon pail by taking the time it took to fill the pail and repeating five times to get an average and then dividing the average time by the size of the pail (in litres).

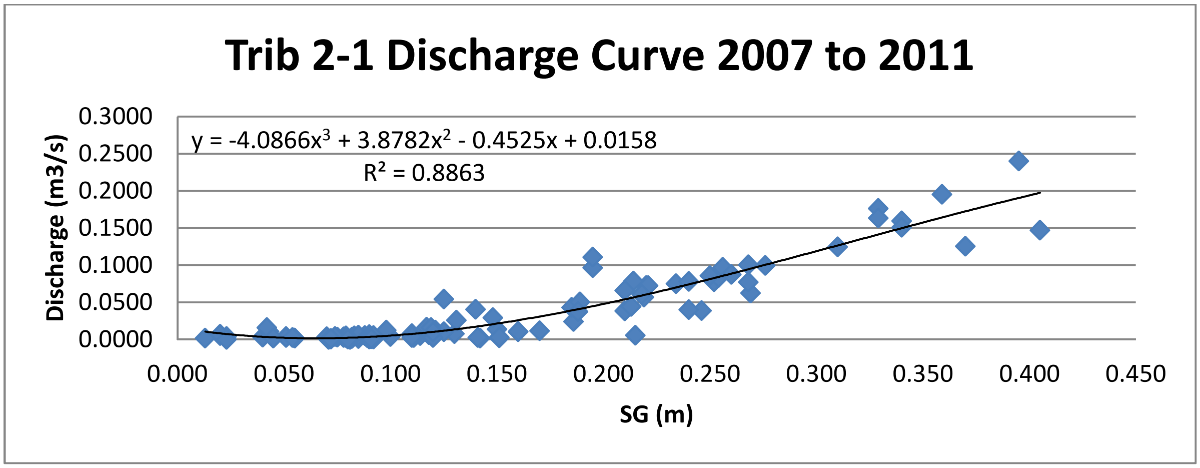
Table 6-4 Sediment Pond Discharge Date Summary

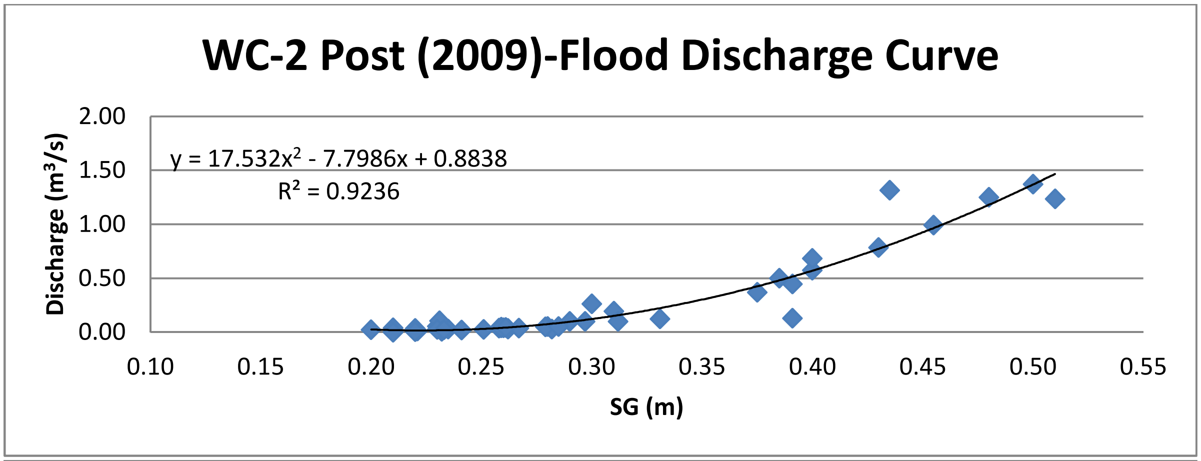
	Pond C		Pond E		Pond G	
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**
2008	05-May-08	10-Nov-08	19-May-08	07-Jul-08	07-Jul-08	21-Jul-08
2009	02-Sep-09	09-Nov-09	25-May-09	15-Jun-09	01-Jun-09	05-Jun-09
2010	N/A	N/A	N/A	N/A	15-Apr-10	15-Jun-10
2011	N/A	N/A	N/A	N/A	N/A	N/A

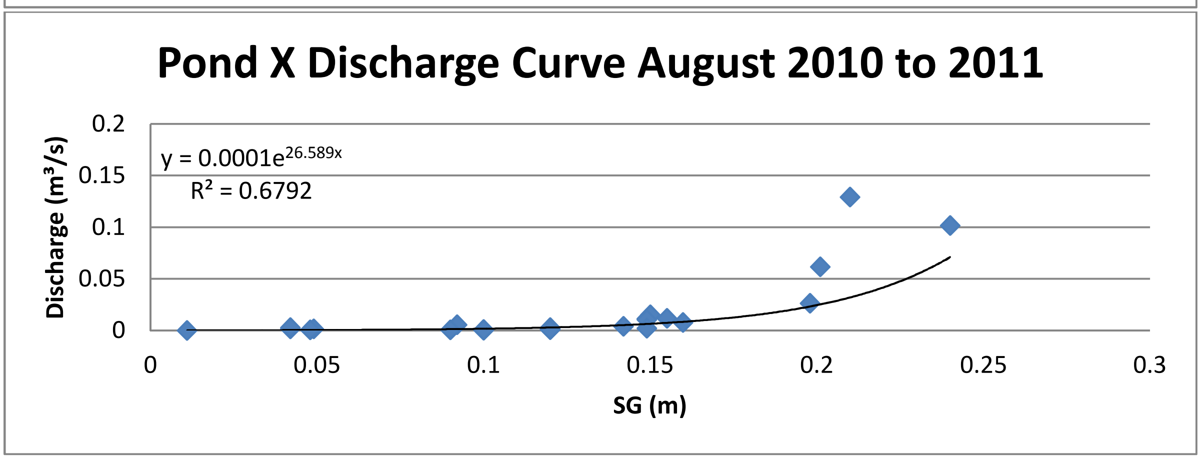
	Pond H		Pond J		Pond X	
	Start	**Stop**	**Start**	**Stop**	**Start**	**Stop**
2008	12-May-08	23-Jun-08	03-Jun-08	30-Jun-08	Continuous	
2009	04-May-09	08-Jul-09	04-May-09	11-May-09	Continuous	
2010	13-Apr-10	15-Jun-10	15-Apr-10	22-Jul-10	Continuous	
2011	13-Apr-11	26-Apr-11	N/A	N/A	1-Jan-11 7-Apr-11	7-Jan-11 Dec-11

	South Pond	
	Start	**Stop**
2011	1-May-11	Continuous

Figure 6-1: Stage Discharge Curves for WC-2, Trib2-1 and Pond X







Section 7 –Surface Water Quality

This section presents a discussion of the results of the 2011 water quality sampling program for parameters that either exceeded the BC Water Quality Guidelines (WQGL's), or were noted to exhibit trending. Water quality values for mine discharges and the receiving environment (Willow Creek and Pine River) were tabulated and graphed on a monthly basis, with comparisons against baseline data and previous years (Appendix B). For parameters in which the guideline is calculated based upon a different parameter (i.e. T-Zn is calculated based upon hardness), monthly average guidelines were calculated using the multi-year average for the required parameter (i.e. the average of the last 10 years of hardness readings for January at WC-2 were used to calculated the January T-Zn guideline for WC-2). Additionally, daily monitoring of turbidity in Willow Creek and its tributaries was implemented following any 1 in 10 year or 24 hour or greater rainfall events (resulting in field turbidity readings of 50 NTU or greater at WC-2).

All trace elements and general parameters have been tabulated and are presented in Appendix B. Graphed general parameters and trace elements have been limited to those parameters that show inter- or intra-annual trends or are above detection limits. The following general elements were not graphed due to lack of trending, or consistent results less than or equal to the detection limits: Br, D-Phosphate, Orthophosphate, T-Phosphate, TKN, TDS, and TOC. The following total metals were omitted from graphing and discussion for the same reasons: T-Sb, T-Be, T-Bi, T-P, T-K, T-Si, T-Ag, T-Na, T-Sn, T-Th, and T-Ti. Dissolved metals omitted from graphing and discussion due to lack of exceedences and trending are as follows: D-Sb, D-As, D-Ba, D-Be, D-Bi, D-B, D-Ca, D-Cr, D-Co, D-Pb, D-Mg, D-Mn, D-Mo, D-Ni, D-P, D-K, D-Se, D-Si, D-Ag, D-Na, D-Sr, D-Sn, D-Th, D-Ti, D-U, D-V, and D-Zn. It is also worth mentioning that many of the elements associated with TSS (*e.g.* Al, Cd, Fe, Mn, and Zn) experienced elevated concentrations spikes in May of 2011 due to naturally elevated levels of suspended solids due to freshet and flooding. Graphs are also presented in Appendix B.

7.1 General Parameters

7.1.1 Conductivity

Conductivity exhibits seasonal trends at all sites, with higher values observed in the months with low flow, and reduced levels detected during freshet. Such observations reflect seasonal changes in the relative proportion of groundwater (higher TDS) and surface runoff (lower TDS) contributing to the total surface flow.

Inter-annual trends are apparent at some surface water sites. At Pond X, increases in monthly values are noted between 2000 and 2011 with sharper increases from 2006 to 2011. The increase in conductivity over time at Pond X can be attributed to an increase in the proportion of mine-influenced flows entering this tributary (tributary 1). Discussions of alkalinity, hardness, and sulphate later in this section will further support this conclusion. There was an increase in conductivity at TR2-1 in comparison to previous years. Conductivity has increased at Trib 2-1. This can potentially be attributed to an increase in mine-related loadings entering this drainage between Trib 2-2 and Trib 2-1 (i.e. via south pond discharge). These levels initially rose during freshet but they continued to stay high in the post-freshet months, further supporting the hypothesis that South pond is the source of the elevated conductivity as it began to discharge on May 1, 2011.

Conductivity was observed to be increasing at WC-2 in 2011. This site is located downstream from Pond X and TR2-1. Accordingly, mine-related loadings may have contributed to the observed increase. WC-2 was shown to have average conductivity levels of 490.83, 429.92, 531.25 µg/L and (494 µg/L) in 2008, 2009, 2010 and 2011 respectively. WC-5a exhibited a slightly elevated conductivity relative to previous years, with an average conductivity of 285 µg/L in 2008, 308.08 µg/L in 2009, 373.42 µg/L in 2010, and (339 µg/L) in 2011.

7.1.2 Alkalinity

Alkalinity levels at all sites tend to follow a trend that shows higher levels during periods of low flow. There were two spikes recorded in alkalinity concentrations in 2011; one at WC-5A (control site) in January and one at WC-1, WC-2 and WC-5a in April. Given the fact that WC-1and WC-2 are downstream from the control site (WC-5a) and that the elevated concentrations at these sites occurred concurrently with elevated levels at the control, these concentrations can be said to be of natural origin.

7.1.3 Nitrogen Compounds

7.1.3.1 Ammonia

Ammonia concentrations at the Willow Creek mine were well below the water quality guidelines set out by the province of British Columbia for the protection of freshwater aquatic life. Pond X experienced elevated concentrations of ammonia in May (1.120 mg/L) and June (0.586 mg/L), while Trib 2-1 was shown to have a maximum of 1.450 mg/L ammonia in July. Elevated concentrations were noted during freshet for all sites with lower concentrations noted for the remainder of the year (often at levels less than or equal to the laboratory detection limit (0.02 mg/L).

7.1.3.2 Nitrate

Nitrate levels at all sites except Pond X and TR2-1 were shown to have remained well below the BC 30 day average water quality guideline of 3.0 mg/L. At Pond X, an intra-annual trend is present in 2011 where concentrations are relatively low from January to July and higher from July through to December. Pond X showed exceedences in January (3.35 mg/L) and from April to December, 2011 with a high of 6.96 mg/L in August. In general, 2011 values for Pond X were similar to 2010 values, and were lower than those reported for 2009 for most months. TR2-1 showed exceedences of the BC 30 day average water quality guideline in July (11 mg/L).In July there is an increased level of Nitrate at WC-1, WC-2, and TR 2-1 possibly due to increased precipitation and flooding. Pond X exceeded the 30 day WQGL for all months that it was sampled.

7.1.3.3 Nitrite

Nitrite levels were shown to exceed detection limits for TR 2-1, TR 2-2, Pond X, WC-2, WC-1 and WC-5a during freshet. This is likely due to increased amount of sediment load in the creeks associated with higher flows in the Creeks and Tributaries from melt water.

7.1.4 Chloride

Chloride concentrations were generally above the analytical detection limit (0.5 – 5.0 mg/L), however; all sites showed chloride levels well below BC 30 day average Water Quality Guidelines (150 mg/L) in 2011. The detection limits at Pond X and TR2-1 were raised to 5 mg/L due to interference by other parameters, but these chloride levels are still well below the BC WQGL.

7.1.5 Fluoride

Flouride concentrations were found to exceed the BC maximum WQGL (0.3 mg/L) only at two sites (Pond X and South Pond) during the latter half of 2011. It was also noted that many of the exceedences at these two sites (3 of 4 at Pond X and 3 of 6 at South Pond) were found to be values that were less than or equal to detection limits that had been elevated to concentrations greater than the WQGL. The analytical detection limit for samples from these two sites was higher than at other sites due to interference in the analysis from other parameters and direct mine effluence (fluoride analysis of these samples required dilution which, in turn, resulted in increased detection limits).Seasonal variations were apparent for fluoride, at most sites, with the lowest concentrations present during freshet and relatively constant concentrations during the remainder of the year.

7.1.6 Hardness

Hardness levels varied from month to month and site to site, with maximum values occurring during low-flow periods and minimum during freshet. Hardness, represented primarily by Ca and Mg, is a product of waste rock weathering and therefore tends to follow a pattern similar to that of sulphate and conductivity. Pond X receives a high portion of flows coming into contact with waste rock, hardness levels showed an increasing trend. This represents an inter-annual trend of increasing hardness. Similar to conductivity, the Pine River does not show any signs of increasing hardness due to mine-related loadings of TDS.

7.1.7 pH

PH samples were analyzed by ALS Environmental at their lab and were found to range between 7.86 and 8.46 for 2011. Previous years also show consistency within the 6.5 to- 9.0 provincial WQGL.

7.1.8 Sulphate

Given the relatively low background levels for sulphate, the high concentrations in mine-related flows, and its conservative behavior in aerobic streams (tends to be un-reactive), sulphate represents a very sensitive indicator of mine-related influences. Mine related sulphate signatures are evident at Pond X where the maximum water quality guideline of 100 mg/L was exceeded in each month during 2011. Sulphate levels at Pond X ranged from a low of 340 mg/L in January to a high of 875 mg/L in September. TR2-1 also showed high sulphate levels in comparison to 2010, with a low of 52.20 mg/L in May and a high of 550 mg/L in March. At the compliance point, WC-2, one exceedence was noted in April (114 mg/L). This indicates that, although exceedences were routinely recorded in Pond X and Trib 2, sulphate levels were sufficiently diluted at the control point so as to remain below the maximum WQGL. A trend towards increasing sulphate concentrations was noted for WC-2 year-over-year. (Appendix B).

7.1.9 Total Suspended Solids (TSS)

The BC WQGL states that TSS at any given site should not exceed:

- 5 mg/L above TSS at the upstream site, when the 30 day average upstream is ≤ 25 mg/L
- 25 mg/L above TSS at the upstream site, when downstream the 30 day average upstream is between 25 and 250 mg/L
- 10% of the TSS at the upstream site, when the 30 day average upstream is >250 mg/L

Table 7-1 summarizes the TSS values from WC-5a, WC-4, WC-3, WC-2 and WC-1 on a weekly and monthly basis and highlights results where TSS values exceeded the WQGL. The exceedences in February, April and May are thought to be from precipitation which would promote increases in TSS concentrations and elevated temperatures causing runoff to enter the streams and raise the concentrations of TSS. The elevated TSS readings at WC-2 and WC-1 in April and May are derived from a sediment release from the WC FSR on April 4, 2011. This incident was reported immediately to MoE personnel.

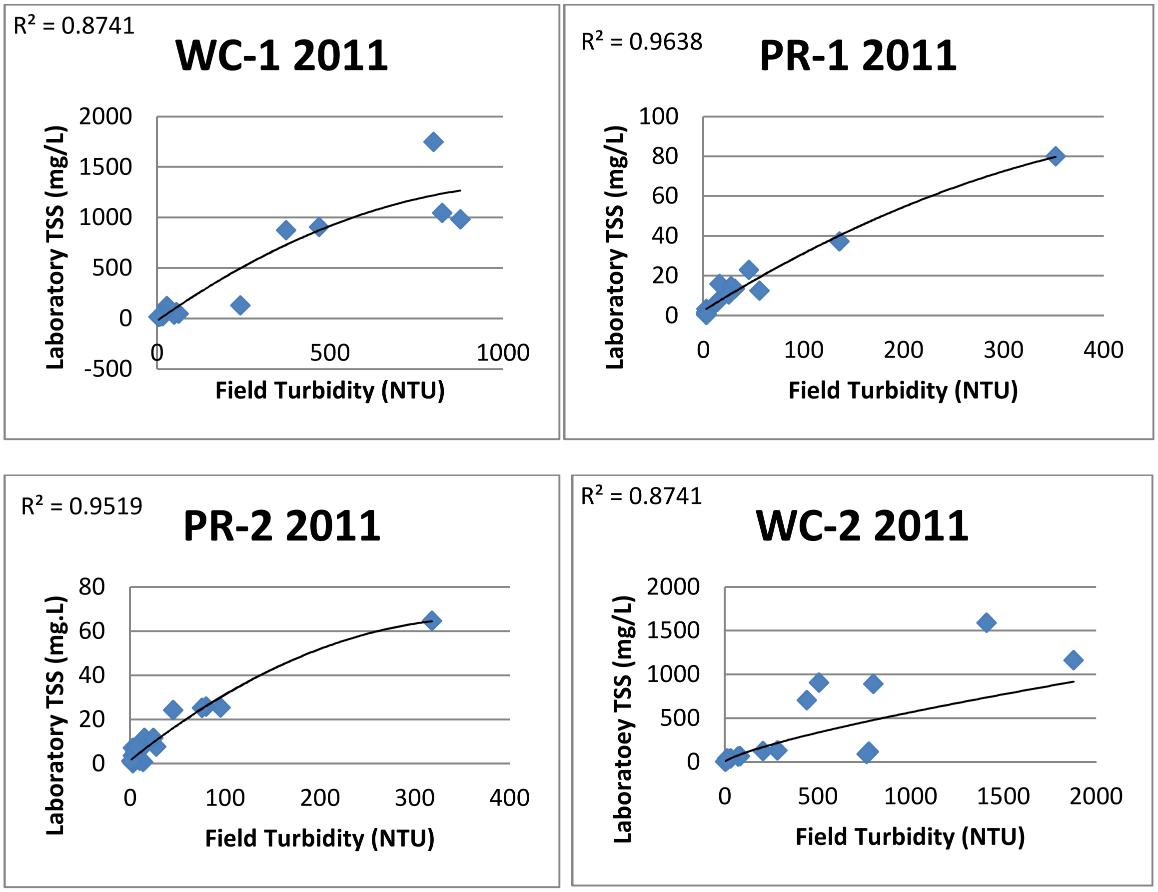
Table 7-1. Monthly TSS Results and the Weekly TSS Concentrations at WC-5a, WC-4, WC-3, WC-2, and WC-1 in 2011

Date	WC-5a	WC-4	WC-3	WC-2	WC-1
6-Jan-11	5.00	N/A	N/A	8.50	N/A
January	**5.00**			**8.50**	
22-Feb-11	<3.0	N/A	N/A	11.30	N/A
February	**<3.0**			**11.30**	
16-Mar-11	<3.0	N/A	N/A	6.00	N/A
17-Mar-11	N/A	N/A	N/A	N/A	N/A
March	**<3.0**			**6.00**	
7-Apr-11	3.70	N/A	N/A	1880.00	N/A
13-Apr-11	3.00	N/A	N/A	776.00	6510.00
20-Apr-11	7.16	N/A	N/A	764.00	6470.00
26-Apr-11	N/A	N/A	N/A	2840.00	5420.00
April	**3.23**			**1565.00**	**6133.33**
5-May-11	127.00	N/A	N/A	800.00	824.00
12-May-11	675.00	N/A	N/A	866.00	516.00
18-May-11	N/A	N/A	N/A	N/A	N/A
May	**401.00**			**833.00**	**670.00**
2-Jun-11	N/A	N/A	N/A	N/A	241.00
7-Jun-11	752.00	N/A	N/A	441.00	373.00
13-Jun-11	164.00	N/A	N/A	140.00	123.00
20-Jun-11	481.00	279.00	181.00	262.00	304.00
June	**465.67**	**279.00**	**181.00**	**281.00**	**260.25**
4-Jul-11	590.00	N/A	206.00	307.00	236.00
14-Jul-11	609.00	N/A	N/A	508.00	468.00
20-Jul-11	387.00	N/A	N/A	205.00	253.00
28-Jul-11	236.00	N/A	N/A	71.80	70.70
July	**455.50**	N/A	**206.00**	**272.95**	**256.93**

Date	WC-5a	WC-4	WC-3	WC-2	WC-1
3-Aug-11	181.00	137.00	78.60	54.70	46.00
9-Aug-11	54.90	N/A	N/A	32.20	49.50
18-Aug-11	60.30	N/A	N/A	13.00	15.70
24-Aug-11	116.00	N/A	N/A	14.40	11.80
August	**103.05**	**137.00**	**78.60**	**28.58**	**30.75**
1-Sep-11	65.10	23.70	19.70	14.40	8.40
8-Sep-11	26.80	N/A	N/A	5.50	N/A
15-Sep-11	32.00		N/A	<3.0	N/A
20-Sep-11	20.80	N/A	N/A	<3.0	N/A
23-Sep-11	N/A	N/A	N/A	N/A	N/A
24-Sep-11	N/A	N/A	N/A	50.00	39.00
25-Sep-11	68.00	N/A	N/A	21.00	20.00
28-Sep-11	52.70	N/A	N/A	10.70	16.00
September	**44.23**	**23.70**	**19.70**	**20.32**	**20.85**
4-Oct-11	225.00	N/A	N/A	41.70	33.00
13-Oct-11	178.00	N/A	N/A	27.10	21.10
19-Oct-11	7.50	N/A	N/A	6.20	9.50
26-Oct-11	25.10	N/A	N/A	7.10	4.40
October	**108.90**			**20.53**	**17.00**
8-Nov-11	25.30	N/A	N/A	4.50	N/A
16-Nov-11	13.30	N/A	N/A	<3.0	N/A
22-Nov-11	29.20	N/A	N/A	<3.0	N/A
November	22.60	N/A	N/A	4.50	N/A
8-Dec-11	11.20	N/A	N/A	3.80	N/A
December	**11.20**			**3.80**	

*Bold values denote monthly averages
Highlighted values indicate exceedences of TSS based on Section 3.1 of PE-17042

Figure 7-1. Field Turbidity as a Function of Laboratory TSS for Sampling Stations WC-1, WC-2, PR-1, and PR-2 in 2011



*Please note that values that had results of <3.0 Laboratory TSS were included in the graphs as 3.00. April 26, 2011 was omitted from WC-1 and WC-2 graphs due to erroneous values.

In 2011, TSS at WC-1 ranged from 4.40 to 6510 mg/L and field turbidity ranged from 13.3 to >4000 NTU. WC-2 exhibited a range in TSS of <3.0 to 1880 mg/L, while field turbidity ranged from 3.58 to 4082.0 NTU. At PR-1, TSS ranged from <3.0 to 352 mg/L while field turbidity ranged from 0.26 to 1004 NTU. PR-2 exhibited TSS ranging from ≤3 to 318 mg/L with field turbidities ranging from 0.24 to 64.7 NTU.

Field turbidity measurements were compared to laboratory measurements of TSS made on the same sample, in order to determine how closely these two parameters are related. Figure 7-1 shows best fit relationships for field turbidity plotted against lab TSS for two stations in the Pine River and two stations in Willow Creek. A strong correlation between laboratory TSS and field turbidity was noted for all sites PR-1 (R^2 = 0.9638), WC-1 (R^2 = 0.8741), WC-2 (R^2 = 0.8741) and PR-2 (R^2 = 0.9519), although there was a period in April and May when the field meter was not giving accurate readings (the meter was sent for repairs immediately upon discovery of this error and a rental meter was obtained.

7.1.10 Turbidity

As with TSS, turbidity values are typically higher during the spring freshet and after high rainfall events. Appendix B displays tabulated turbidity data, and summary graphs with maximum and mean values. Maximum laboratory turbidities were noted in May (all Pine River sites, WC-5a, WC-4, WC-3, WC-2 and Pond X), June (South Pond) and April (WC-1). The high turbidity levels occurred during freshet when both precipitation and flows increase substantially

For most stations, turbidities returned to stable levels shortly after the end of the spring freshet. Table 7-2 shows the monthly values for field turbidity.

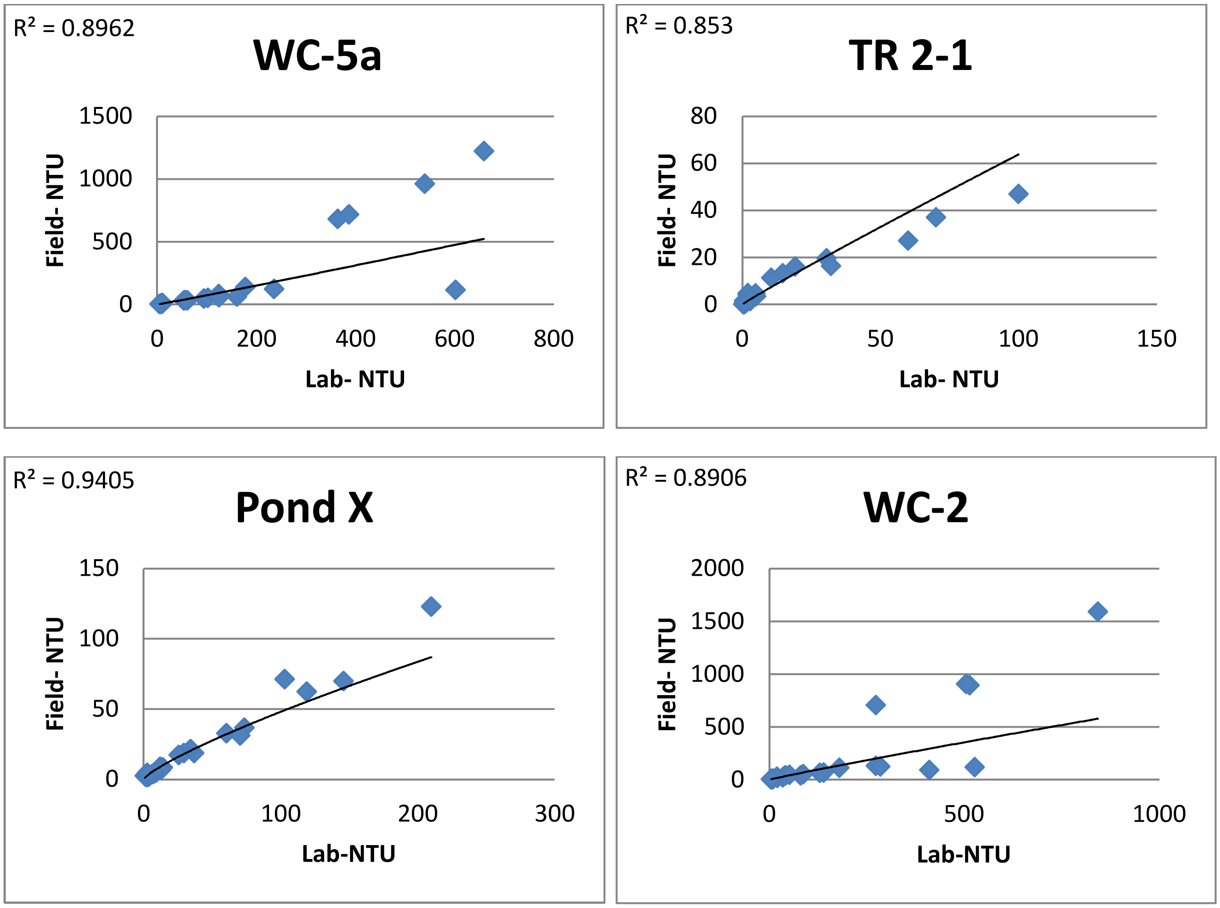
Table 7-2. Average Monthly Field Turbidity Values in Willow Creek for 2011

	WC-5a	WC-4	WC-3	WC-2	WC-1
January	5.92			3.99	
February	4.4			6.1	
March	3.97			17.28	
April	21.1			694.01	736.4
May	798.2	765.0	759.0	897.04	681.7
June	639.4	128.0	126.0	115.0	146.3
July	1276.5	128.0	665.0	811.0	673.9
August	94.9	66.1	72.3	40.8	48.8
September	47.23	37.70	40.30	14.69	24.90
October	95.40	119.0	93.0	43.2	52.7
November	41.1	22.7	21.8	9.6	13.3
December	18.3			5.24	

*On June 24, 2011 there were three sites that read over range: WC-5a, WC-1 and WC-2

Figure 7-2 illustrates the laboratory versus field turbidity comparisons at WC-5a, TR2-1, Pond X, and WC-2. A strong correlation between laboratory and field turbidity exists, with R^2 values of 0.8962 for WC-5a, 0.853 for TR2-1, 0.9405 for Pond X, and 0.8906 for WC-2.

Figure 7-2 Laboratory and Field Turbidity Comparison for Sampling Stations WC-5a, TR2-1, Pond X and WC-2 for 2011



*Please note that values that had results of <3.0 Laboratory NTU were included in the graphs as 3.00. April 26, 2011 was omitted from WC-2 graphs due to erroneous values.

7.2 Trace Elements

In the following sections, data are discussed for metals that exceeded their respective Water Quality Guidelines during the 2011 sampling period for all sites within the Willow Creek mine permit area. All data are presented in Appendix B, both in tabular and graphic form.

7.2.1 Total Aluminum

A seasonal trend is apparent in T-Al concentrations at most sites in and around the Willow Creek mine site, with the greatest concentrations found during freshet months (April to June) and July. The following sites showed elevated concentrations in the month of April: South Pond, Trib 2-1, WC-5a, WC-1 and WC-2 (maximum level was 20.9 mg/L at WC-5a). There were also elevated levels detected in June at WC-5 and in July at WC-5a and WC-2. Aluminum is a major component of silt and clay sediment fractions and therefore elevated levels tend to occur commensurately with elevated TSS during periods of high flow. The increase at WC-5a and WC-2 in July is likely due to flooding in late June and the associated increase in TSS in Willow Creek. Based upon the elevated levels recorded at WC-5a, T-Al can be attributed to natural processes rather than mine-related activities.

7.2.2 Dissolved Aluminum

Monitoring of dissolved aluminum (D-Al) in 2011 indicated elevated concentrations during the freshet and summer months at the Willow Creek when there was increased precipitation and associated higher flows and increased sediment load. For the fall and winter months D-Al was below the analytical detection limit of 0.001 mg/L at most sites and during 2011. Mean concentrations of D-Al in Pond X, TR2-1 and WC-2 were found to be less than the mean detected at WC-5a, indicating that D-Al is not significantly elevated in, or affected by, mine site drainage. The highest D-Al concentration measured (0.925 mg/L) was at WC-2 in August, exceeding the BC maximum guideline for the protection of freshwater aquatic life (0.1 mg/L). There were also spikes at TR 2-2, TR 1-1, WC-1 and WC-2 during freshet and summer months. As discussed in the 2007 Annual Report, a large fraction of the "dissolved" component of aluminum is actually represented by colloidal forms (i.e. amorphous Al hydroxides) which are small enough to pass through a 0.45µm filter membrane and are thus picked up in the test for dissolved Al. Higher levels of these colloids will be present during periods of high flow due to greater bank erosion and stream re-suspension leading to higher particulate loadings at these times. Accordingly, it is likely that the fraction of aluminum contained in particles smaller than 0.45 µm contributes to an overestimate of the truly dissolved Al fraction (Lorax Environmental, 2006). Furthermore, as the WQGL was exceeded at the upstream control site, it is apparent that this concentration represents naturally occurring D-Al and is thus not due to mine-related activities.

7.2.3 Total Arsenic

T-As was found to be low in samples taken from Pond X and TR2-1 in 2011, indicating that T-As is not elevated in mine site drainage (mean of 0.00039 mg/L at Pond X and 0.0003 mg/L at Tr 2-1). T-As was below the BC WQG of 5 µg/L for all 2011 surface water monitoring samples, with the exception of WC-2 and WC-1 in April (0.00525 and 0.0363 mg/L, respectively). T-As was shown to exhibit a degree of seasonal trending similar to other metals associated with suspended sediments. The greatest concentrations occurred during freshet with lower levels during the lower-flow periods. In April, increases occurred throughout Willow Creek and the Pine River which coincided with elevated TSS.

7.2.4 Total Barium

As in previous years, seasonal trending was shown for T-Ba concentrations, with the freshet months (April, May and June) exhibiting lower values in comparison to the lower flow months. T-Ba levels in 2011 were on average below those of 2010. It would appear again, based upon higher concentrations at control sites and decreases at Pond X (except for freshet months; Pond X increased), that mine-related flows are not altering natural T-Ba concentration patterns.

7.2.5 Total Boron

Total boron was well below the BC WQGL of 1.2 mg/L at all stations monitored in 2011. Concentrations of T-B in Trib 2 were not elevated downstream of mine drainage relative to upstream levels. Similarly, T-B in Pond X (0.02 – 0.079 mg/L) had a similar range as at WC-5a (0.024 – 0.054 mg/L), indicating that boron is not significantly elevated above background in mine effluent. For Pond X, the detection limit for T-B was raised to 0.05 mg/L.

7.2.6 Total Cadmium

T-Cd was shown to have a strong seasonal signature, with the highest concentrations coinciding with elevated TSS during high flow periods. Exceedences of the hardness-based maximum BC WQGL for T-Cd (0.02 to 0.06 µg/L) were recorded at all stations except for the Pine River sample sites. Loadings from Willow Creek have no bearing on cadmium levels in the Pine River, and thus levels in the Pine are governed largely by flow conditions and associated TSS levels.

The seasonal effects of TSS on cadmium are illustrated by the 2011 data for WC-5a, with exceedences in T-Cd WQGL's observed in May (0.508 µg/L), June (0.280 µg/L), July (0.409 µg/L), August (0.181 µg/L), September (0.081 µg/L) and October (0.144 µg/L). WC-2 had five exceedences in April (1.480 µg/L), May (0.379 µg/L), June (0.249 µg/L), July (0.252 µg/L) and October (0.076 µg/L).

Examination of the time series record for WC-2 does not reveal any obvious mine-related influences or any inter-annual trends; except for in April when there was a sediment release incident. 2011 T-Cd values for Pond X continued to show a mine-related signature, with values exceeding the working BC WQGL-max in all months except for August and peaking during freshet in May (0.397 µg/L). Monthly values for Pond X were typically greater in 2011 compared to 2010.

In general, exceedences of T-Cd typically occurred during periods of high flow and increased rainfall, when elevated TSS levels were observed. This indicates that these values can be attributed (at least in part) to particulate-bound metals, particularly during the freshet (in the case of the Pine River sites) and following a major rainfall event in May and the end of June (for Willow Creek sites) where significant runoff and high rainfall lead to high TSS and turbidity.

7.2.7 Dissolved Cadmium

No significant trends in the concentrations of D-Cd were noted at any sites along the Pine River and Willow Creek; however there are notable increases of concentration in freshet and summer months, likely due to increased snowmelt and precipitation events resulting in increased sediment load. WC-5a had a maximum concentration of May 2011 of 0.000082 mg/L. South Pond had highest levels in April and May. Trib 1-1 also depicted a maximum concentration in May of 0.000243 mg/L. WC-2 recorded its highest level in July of 0.000376 mg/L. Pond X remained fairly static, but exhibited slightly higher levels than those recorded in previous years.

7.2.8 Total Calcium

Consistent with other parameters already discussed, T-Ca exhibited seasonal trending with the lowest concentrations occurring during the periods of highest flow (i.e. freshet). The generally increasing concentrations of T-Ca at Pond X and Trib-2-1 in 2008-2011 parallels increases in hardness. As a similar trend was also noted that WC-5a (outside of mine related influences), it is not possible to attribute, at least solely, the increases at Pond X and Trib 2-1 to mine related influences. Inter-annual variations in T-Ca in the Pine and upper Willow Creek will relate in part to changes in the annual water balance (precipitation cycles), with higher values expected during low-flow years. In 2011 we received high rainfall in freshet and July this is reflected in the slight decreases in calcium in these months when compared to 2010.

7.2.9 Total Chromium

Baseline data indicated occasional exceedences of the BC Max WQGL for T-Cr in the Pine River, Willow Creek, and Tributaries 1 and 2. Observations made during the baseline sampling program indicate that elevated concentrations of T-Cr occur concurrently with elevated TSS levels. At these times, the elevated T-Cr levels can be attributed almost entirely to Cr being bound to suspended particles. During 2011, there were no exceedences for T-Cr recorded in the Pine River. WC-5a and WC-2 had exceedences for all months except for January 2011 for WC-2. Exceedences for Pond X occurred during freshet months. Trib 2-1 and South Pond had exceedences in April and May for the BC Max WQGL.

7.2.10 Total Cobalt

T-Co shows an inter-annual trend of higher concentrations during higher flow periods such as freshet. Pond X, WC-5a, WC-2 and all of the Pine River sites exhibit this trend. There were no exceedences of the BC WQGL-max. However, the exceedences for the Water Quality Guideline-30 day of 4.0µg/L occurred at WC-5a in May (5.41 µg/L) and July (5.88 µg/L), at WC-2 in April (6.2 µg/L) and May (4.42 µg/L) and at WC-1 in April (40.90 µg/L) and May (4.38 µg/L). Pond X and South pond each exhibited one exceedence in May (4.97 µg/L) and July (6.12 µg/L) respectively. This represents a t natural background signature associated with elevated TSS during freshet months. Except for April the high results were from a large sediment release incident

7.2.11 Total Copper

T-Cu levels in the Pine River are not affected by mining activities and were below the BC 30 day WQGL of 0.008 mg/L at all three sites. Elevated levels of T-Cu occurred in 2011 during periods of elevated TSS. Values exceeded the BC 30 day WQGL of 0.0100 mg/L at WC-5a in April, May and July owing to the effects of elevated TSS (0.0182 mg/L, 0.0172 mg/L and 0.0163 mg/L). This coincided with exceedences for WC-2 in April, May and July owing to the effects of elevated TSS (0.0458 mg/L, 0.014 mg/L and 0.0149 mg/L). As the WQGL was exceeded at the upstream control site each time there was an exceedence at WC-2 (with the exception of April), it is apparent that, from May onward, this concentration represents naturally occurring T-Cu and is thus not due to mine-related activities. The exceedences in April at WC-2 and WC-1 may be attributable to the sediment release event. TR2-1 showed no apparent trending; however there was one exceedence of the BC 30 day WQGL (0.0100 mg/L) in April of 0.0148 mg/L

7.2.12 Dissolved Copper

D-Cu concentrations have been increasing in the Pine River from year to year since 2006; although not due to mine activities (PR-3 shows this increasing trend and is upstream of mine influence).It was also shown that Willow Creek is experiencing an increase in D-Cu over time. Again, as this increase has been shown to occur at WC-5a, it can be stated that this increase is natural in origin. Neither Pond X nor TR2-1 (the two sites closest to, but downstream from, the mine site) show any significant trending at all.

7.2.13 Total Iron

T-Fe exhibits similar behavior to other metals, with a pronounced increase in concentration corresponding with periods of high flow and TSS. During such periods, TSS is predominantly associated with suspended particles. 22 exceedences of the maximum BC Water Quality Guideline of 1.0 mg/L for total iron occurred in 2011 (compared to 20 in 2008, 8 in 2009 and 6 in 2010), eight of which occurred in areas outside those impacted by mining activity. In all months except April, exceedences of the T-Fe WQGL at WC-2 and WC-1 coincided with exceedences at WC-5a. In April, the exceedences were likely due to particulate-bound iron, with levels elevated as a result of the sediment release event. Of the remaining exceedences, only June showed greater levels at WC-2 and WC-1 than at the upstream control (WC-5a). There were no exceedences in the Pine River. WC-5a exhibited the greatest concentration of T-Fe with 15.7 mg/L in April. Historical Fe levels in both Willow Creek and the Pine River have exceeded water quality objectives. Therefore concentrations within these systems are naturally occurring, not mine related.

7.2.14 Dissolved Iron

Three exceedences occurred for D-Fe in 2011, one occurred in May 2011 at WC-5a at a concentration of 1.1 mg/L and two occurred at WC-2 at a concentration of 1.49 in July and 0.916 in August. Seasonal trending was noted with the greatest concentrations occurring during freshet for the Willow Creek sites. Higher levels in May and July were likely due to increased colloidal Fe associated with TSS and high flows. As all sites located upstream of any mine influences experienced similar increases as those subject to mine influences, it can be said that these elevated concentrations are due partially to natural, rather than mine-related, factors.

7.2.15 Total Lead

T-Pb preferentially associates with suspended particulars and therefore shows similar trends to T-Fe, with elevated concentrations observed during periods of elevated flows and TSS concentrations. Seven BC maximum WQGL exceedences occurred for T-Pb, two at WC-5a in May (6.860 µg/L) and July (7.590 µg/L); two occurred at WC-1 in April (53.500 µg/L) and May (95.640 µg/L); and three occurred at WC-2 in April (7.610 µg/L), May (5.540 µg/L) and July (4.030 µg/L). The exceedences of the maximum WQGL (4.00 µg/L) in Willow Creek coincided with periods of increased suspended sediments (in April, this coincides with the sediment release), in our background sample site due to the freshet and flooding conditions in 2011.

7.2.16 Total Lithium

Seasonal trending has been observed for T-Li with concentrations being highest during periods of high flows (e.g., freshet) and lower during drier months, indicating that Li behaves analogous to TDS (i.e., enriched in groundwater recharge). In this regard, inter-annual variations are predicted to be governed by year-to-year changes in precipitation, with higher values predicted during higher-flow periods. At all sites, T-Li has remained well below the maximum guideline for the preservation of aquatic life (0.87 mg/L). The highest concentration of T-Li was in February 2011 at Tr 2-2 with a concentration of 0.0625 mg/L; this exceeded the 30 day water quality objective, but did not exceed any other guidelines.

7.2.17 Total Magnesium

Although most sites did not show any inter-annual trending for T-Mg, WC-5a and Pond X have shown annually ascending trends; however at WC-5a concentrations were lower than last year. Both Pond X and South Pond show greater concentrations September through December. Pond X has shown a notable increase from previous years during the months of August through December. This site has showed a generally increasing trend. The maximum recorded concentration of T-Mg was 121 mg/L, recorded at South Pond in both November 2011.

7.2.18 Total Manganese

In oxygenated stream environments, concentrations of T-Mn are governed by particulate Mn fractions (mostly Mn oxides), with elevated values occurring commensurately with high TSS. No evidence of mine-related loading was evident from the time series data for Willow Creek and its tributaries. No exceedences of the hardness-based WQGL were noted, with the greatest concentration of 2011 occurring in April at WC-1 (1.11 mg/L).

7.2.19 Total Molybdenum

Like sulphate and selenium, molybdenum occurs predominantly as dissolved oxyanions in stream environments. This can explain the higher values of T-Mo occurred during low-flow months (maximum recorded value of 0.0115 mg/L at Pond X in June).

7.2.20 Total Nickel

T-Ni reveals a seasonal trend in which the greatest concentrations are present during the periods of highest flow and associated increased TSS. WC-5a showed higher levels of T-Ni in comparison to previous years from April through December. The greatest concentrations of T-Ni recorded in Pond X were 0.0755 mg/L in June and 0.0607 mg/L in July, in general the remainder of the months showed higher concentrations than previous years. TR2-1 showed higher concentrations in January through April 2011, while remaining fairly consistent with the previous year's concentrations for the remaining months. WC-2 showed higher concentrations during periods of higher flows such as freshet, with an increase in April of 0.0909 mg/L. No exceedences of the 150 µg/L WQGL were noted in 2011 at the Willow Creek mine site.

7.2.21 Total Selenium

Exceedences in the concentrations of the T-Se guideline of 0.002 mg/L were recorded in all samples from Pond X, TR 1-1 and TR2-1 in 2011, with the highest concentration recorded at Pond X in August (0.083 mg/L). Pond X T-Se concentrations in 2011 were greater than 2010 for all months except January, July and December. TR2-1 showed more variation and higher levels than most other sites, peaking at 0.0219 mg/L in April. As Tr 2-1 and Pond X contribute only a portion of the flow of Willow Creek, T-Se levels are diluted upon entering the larger system. Thus there were fewer exceedences in Willow Creek. Exceedences in Willow Creek were noted at WC-1 in April (0.0051 mg/L), August (3.39 µg/L), September (0.0045 mg/L), October (0.0028 mg/L) and November 0.0028 mg/L) and at WC-2 in all months throughout the year except March, May and June (maximum of 0.0045 mg/L in September). Overall, concentrations at WC-2 in 2011 were similar to those in 2010.

A comparison of total and dissolved Se fractions demonstrates that selenium is present in this system primarily as filterable species (i.e. dissolved selenate). Also, elevated Se levels observed at WC-2 are consistent with sulphate values and demonstrate that mine-related influences affect this downstream location.

Although selenium concentrations in water serve as a reliable proxy for mine-related influences, water concentrations do not prove an adequate indicator for selenium toxicity to fish and water birds. In order to address the potential for selenium toxicity at Willow Creek Mine, a fish-tissue selenium program is being carried out. The data from this program are included in Appendix B.

7.2.22 Total Strontium

Strontium substitutes for Ca in carbonate rocks, and therefore tends to follow a pattern similar to hardness, Ca and sulphate. Analysis of T-Sr reveals both seasonal and inter-annual trending with the lowest concentrations being seen during the periods of highest flow. In 2011 Pond X exhibited higher concentrations relative to the same months in 2010 for all months except July. WC-5a showed similar concentrations of T-Sr for all months in 2011 compared to 2010, comparable to downstream (WC-2) which also showed similar levels for all twelve months relative to 2010; with the exception of one increased value in April of 0.394 mg/L.

7.2.23 Total Uranium

T-U exhibits a similar pattern of seasonal trending as observed for T-Ca, T-Sr, hardness and sulphate, with the lowest concentrations being found during the periods of highest flow. The relationship of U with these other parameters can be related to its common occurrence in carbonate rocks, and its increased solubility in the presence of dissolved carbonate (CO_3^{2-}). Most sites sampled under PE-17042 were found to exhibit increasing annual trends, including WC-5a, which is not impacted by any mining activities. This trend in the Willow Creek is also evident for other parameters (Ca and Li), and may indicate a regional trend associated with climate conditions in the region.

7.2.24 Total Vanadium

Seasonal trending is apparent for T-V with the greatest concentrations being found during periods of high flow. No inter-annual trending was found in the Pine River, TR2-2, or Pond X. Examination of the Pond X time series reveals no indications of mine-related influences. There were ten total exceedences of T-V in 2011. At WC-5a there were four exceedences in April, May, June and July; 46.9 23 µg/L, 31.6 µg/L, 20.7 2µg/L, 62.8 µg/L sequentially. At the downstream site WC-2 there were also four exceedences in April, May, June and July of 11.3 µg/L, 21.6 µg/L, 20.3 µg/L and 48.7 µg/L sequentially. Further downstream at WC-1 there were two exceedences in April and May of 26.2 µg/L and 31.2 µg/L. As WC-5a is located in an area upstream of mine-related impacts, and as the exceedences downstream were found to be less than those at the control site, it can be said that this increase in concentrations relative to previous years is due to natural processes.

7.2.25 Total Zinc

T-Zn concentrations were shown to vary seasonally with the greatest concentrations occurring during periods of highest flow. Inter-annual trending analysis revealed that most sites experienced greater concentrations in 2011 relative to 2010 during freshet months; however, no exceedences of the hardness-based WQGL were observed. In comparison to baseline values, T-Zn values for Pond X may show a slight mine-related signature. However, this input is minor in comparison to the natural variability in Willow Creek which is governed by natural variations in flows.

Section 8 – Groundwater Quality

The following in an excerpt from the *2006 Groundwater Monitoring Program for the Willow Creek Coal Mine* report by EDI Environmental Dynamics Inc, commissioned by Pine Valley Coal (November 2007, p.1-2).

> *In mid-November 2005, Pine Valley Coal Ltd. initiated a groundwater monitoring program. This program was implemented to fulfill previous permit requirements and produce supplemental information in support of future permit amendments. The initial groundwater monitoring program was designed in accordance with the November 3, 2005 Ministry of Energy and Mines (MEM) permit amendment (C-153) authorizing the use of the temporary coal refuse dump.*
>
> *At the inception, eight groundwater monitoring wells were drilled, fitted, developed and sampled in coordination between Water Management Consultants (WMC), SRK Consulting, Allnorth Consultants Ltd., KP and EDI Environmental Dynamics Inc. (EDI) with input from MOE and MEM. Baseline monitoring data from these sites were collected and the laboratory results received from samples collected on November 10th and 24th, and December 7th and 20th 2005. The groundwater from well GWW-7 was only sampled twice since December 7th, 2005, as it was not constructed until the end of November. Under Permit PE-17042, the number of monitoring wells was reduced to seven for the 2006 groundwater monitoring program, with the elimination of GWW-7 (see Table 8-1).*
>
> *Five wells have been monitored to detect potential changes to the groundwater resource resulting from the operations of the coal refuse dump. One groundwater monitoring well is located up-gradient of the proposed coal refuse facility (GWW-4), one well is temporary and located within the proposed site (GWW-8) and three are located down-gradient (GWW-1, GWW-2 and GWW-3).*

Table 8-1 – Groundwater Monitoring Wells

Name	Location	Sampling Start Date
GWW-1	Coal Refuse – Northwest corner	10-Nov 2005
GWW-2	Coal Refuse – North centre	10-Nov 2005
GWW-3	Coal Refuse – Dump centre	10-Nov 2005
GWW-4	Coal Refuse – Southeast corner	10-Nov 2005
GWW-5	Plant Site – North of plant	10-Nov 2005
GWW-6	Northeast near mine access road	10-Nov 2005
GWW-7	North side of Pine River – Across from Coal Refuse	7-Dec 2005
GWW-8	Coal Refuse – Dump Southeast Centre	10-Nov 2005

In 2011, groundwater monitoring was conducted monthly at seven wells (GWW-1 to GWW-6 and GWW-8), except in November (the amended Permit 17042 which was received in October now defines groundwater monitoring as a quarterly requirement rather than a monthly one as it was previously). GWW-4 was only sampled once in 2011 as it was found to contain no water during the other sampling months. No sample was obtained for GWW-8 in March of 2011 as the well cap could not be removed, despite the best efforts of environmental personnel. Sampling at GWW-7 was not conducted at any time in 2011. The following discusses the locations of the groundwater wells sampled in relation to the direction of groundwater flow.

- GWW-1 is located to the West of the Coarse Coal Rejects (CCR) pile footprint. Groundwater movement in that area of the mine lease is to the northwest and so it might be expected that, although not directly in the path of most groundwater flow from beneath the CCR pile, some influence may be detected in GWW-1.

- GWW-2 is located 200 m to the northwest from the CCR pile. As it is located to the northwest of CCR materials, and as the groundwater flow is in a northwest direction, it is possible that water sampled at this location may be influenced by infiltration from the CCR pile into groundwater.

- GWW-3 is located immediately to the north of the center of the northern edge of the CCR pile footprint. As groundwater flow is to the northwest in this section of the mine lease, it is possible that there is some impact at GWW-3 due to infiltration from the CCR pile into groundwater.

- GWW-4 is located to the southeast of the CCR pile footprint. As groundwater flows to the northwest in this section of the mine lease, GWW-4 should be located up gradient of any CCR influences.

- GWW-5 is located approximately 500 to 600 m to the north-northeast of the CCR footprint, on the opposite side of Willow Creek. Given that Willow Creek represents a hydrologic boundary, and due to the fact that groundwater in this area is moving due north, the CCR pile should not have any impact on water quality at GWW-5. However, as GWW-5 is located directly north of the Plant Site and rail load out, water quality may be impacted due to infiltration into groundwater from either or both of these sources.

- GWW-6 is located approximately 1.5 km to the east of the CCR pile, across Willow Creek, next to the Willow Creek FSR . As the groundwater in this area moves to the north towards the Pine River, it is very unlikely that water taken from GWW-6 will show any impact due to infiltration from either the CCR pile or the plant site/load out.

- GWW-8 is located within the CCR pile footprint, directly adjacent to the pile itself (at a distance of approximately 2 m from the toe of the pile). The elevated sulphate concentrations detected at GWW-8 since 2005 suggest that CCR-related drainages are currently having an effect on groundwater quality in this location.

Both general parameters and dissolved metals have been tabulated and graphed and are presented in Appendix C. Those parameters or elements that do not show trending or are below detection limit values have been omitted from discussion. These consist of the following: Br, TOC, TDS, total Kjeldahl nitrogen, orthophosphate as P, and total phosphate as P.

8.1 GENERAL PARAMETERS

8.1.1 Alkalinity

Alkalinity levels in 2011 remained fairly consistent with 2006, 2007, 2008, 2009 and 2010 values. GWW-3 showed slight but consistent decreases in alkalinity when compared to previous years. GWW-4 reported the lowest alkalinity levels of 201 mg/L CaCO3. The highest levels reported were at GWW-1, with a mean of 326.6 mg/L. The remainder of the sites showed similar averages, from 242.6 mg/L at GWW-3 to 266.0 mg/L at GWW-2.

8.1.2 Ammonia

Ammonia nitrogen levels in 2011 were fairly consistent with those of previous years; however there is a slight decreasing trend in 2011 throughout all sites during most months. The greatest concentration of ammonia (0.469 mg/L) was detected in water sampled from GWW-1 in December of 2011.This represents a slight increase relative to previous years (0.417 mg/L in 2010 as compared with 0.40 mg/L in 2009, 0.42 mg/L in 2006, 0.36 mg/L in 2007 and 0.39 mg/L in 2008). GWW-2 exhibited a significant decrease in September 2011 in comparison to last year's results. GWW-3 exhibited similar levels to those found in 2008 and 2009, which are significantly lower than in 2006. GWW-4, GWW-5, GWW-6 and GWW-8 reported lower mean values overall with most values below the detection limit of 0.0050 mg/L.

Ammonia is a redox-sensitive species which is more stable in suboxic groundwater environments. Data for other redox-sensitive parameters (Mn and Fe) demonstrate that the higher ammonia values at GWW-1 and -2 can be attributed to the presence of suboxic (low redox potential) conditions in these wells. GWW-1 and -2 were shown to contain the highest concentrations of dissolved Fe and Mn. In the neutral pH conditions of these wells, the elevated concentrations of Fe and Mn are strong indicators of groundwater suboxia where elevated levels are sustained through the reductive dissolution of Fe and Mn oxides.

8.1.3 Chloride

Low chloride levels are at most sites in 2011 this are consistent with 2008, 2009 and 2010 levels. There were increased concentrations of Cl at GWW-2 and GWW-6 in September; 2.51 mg/L and 1.99 mg/L. Chloride levels were found to be within an order of magnitude of the detection limit at all wells during 2011, and at no time were chloride levels found to be close to the BC water quality guideline of 150 mg/L (highest recorded value was 2.51 mg/L in September at GWW-2).

8.1.4 Conductivity

The highest consistent levels of conductivity were recorded at GWW-1 and GWW-5 in 2011, with means of 581.5 and 602.5 µS/cm, respectively. Lowest levels overall were recorded at GWW-3 and GWW-4, with averages of 484.2 µS/cm and 392 µS/cm, respectively. A slight increasing trend in conductivity over time was noted for GWW-1, with annual averages increasing yearly from 543 µS/cm in 2005 to 580.2 µS/cm in 2011.

8.1.5 Fluoride

Flouride concentrations had no significant trending, either seasonal or inter-annual, was noted for fluoride. The highest recorded F concentrations were seen at GWW-3 (0.117 mg/L, in September).

8.1.6 Hardness

Hardness was relatively stable across the seven wells in 2011, with slightly higher values at GWW-1 and GWW-5 with means of 329.2 mg/L and 340.8 mg/L, respectively. Hardness appears to be increasing slowly from 2006 to present.

8.1.7 Nitrate

Nitrate-N concentrations for 2011 at all sites (except GWW-6) were similar to 2010 for all months. At GWW-1, the concentrations were at or below the detection limit (<0.0050 mg/L) for all months sampled. GWW-2 showed higher concentrations in September (0.263 mg/L) relative previous years (0.218 mg/L in September 2010). For GWW-3 Nitrate levels were similar to previous years with slightly elevated concentrations in January (0.0743 mg/L) and March (0.0952 mg/L) 2011. In 2010 GWW-3 concentration levels in January were 0.0254 mg/L and GWW-3 was not sampled in March of 2010. GWW-4 was only sampled in June and showed similar concentrations to previous years, with an average value of 0.180 mg/L. GWW-5 showed similar levels to previous years with a slight decrease from 2010. With the exception of February 2011 (0.657 mg/L) which shows a slight increase from previous years (0.408 mg/L for February 2010 and 0.392 mg/L for February 2008). GWW-6 showed an increasing trend with elevated levels in February (0.657 mg/L), June (0.0388 mg/L) and December (0.0247 mg/L) 2011, when compared to previous years. Values at GWW-8 showed values comparable to previous years.

8.1.8 Nitrite

Nitrite levels did not show any trends in 2011 for GWW-1, -2, -3, -4, -5, -6 and -8. All values were below the detection limit except for in December (GWW-2 (0.0034 mg/L), GWW-3 (0.0018 mg/L) and GWW-8 (0.0016)). These samples showed a slight increase when compared to previous years.

8.1.9 pH

The pH values remained similar at all wells, with well means ranging from 7.65 (GWW-1) to 8.27 (GWW-4). This range is similar to previous pH levels. No trending is apparent in pH for any of the groundwell sites.

8.1.10 Sulphate

As with nitrate levels, sulphate is a strong indicator of mine-related activities: The 2011 groundwell monitoring program reveals increasing sulphate concentrations at all sites over time, with GWW-5 exhibiting the highest concentration in 2011 (72 mg/L in December).

GWW-1 was sampled once in June 2011 (6.31 mg/L); this is lower than the 2010 value (10.0 mg/L). GWW-1 was found to have notable increases of sulphate concentrations in the summer of 2010. GWW-2 exhibited a trend towards increasing concentrations from June through September with the highest level being 49.6 mg/L in September. Comparing GWW-3 from 2011 to 2010 there is a slight decrease throughout the year with the exception of March; however, there is an increasing trend since 2006. GWW-4 was sampled once in June and was dried up for the remainder of the year. GWW-5 shows an overall increasing trend; two months were shown to have greater concentrations in 2011 than 2010 these were March and December, with a maximum value of 72 mg/L (recorded in December). GWW-5 values exhibited an ascending trend from January to July, followed by a trend towards decreasing sulphate concentrations. GWW-5 shows an increasing sulphate trend potentially due to the close proximity to the plant sediment pond. GWW-6 exhibited greater concentrations for September and December in 2011 relative to 2010 but, for March and June concentrations were lower. GWW-6 shows an overall increasing trend from 2006 onwards. GWW-8 had a similar trend to GWW-5 for all months but the maximum noted value was only 28.8 mg/L (December).

8.1.11 TSS

TSS and turbidity are used to provide a general indicator of well quality, since excessive TSS can result in the overestimation of parameters that may be associated with colloidal fractions that may be included in the “dissolved” fraction. TSS concentrations were shown to be greater in 2010 relative to the same months of 2011. The yearly average for quarterly months at GWW-2 is lower in 2011 (24.55 mg/L) in comparison to 2010 (75.78 mg/L). GWW-3 revealed lower concentrations with a yearly average of 33.13 mg/L in 2011 (compared to 49.1 mg/L in 2010); however in 2006 the values were considerably higher than all of the remaining years (2005-2010). GWW-4 was only sampled for one month (June - 3.00 mg/L), however, it has showed a general descending trend relative 2009 through 2011. GWW-5 and GWW-6 do not exhibit any trending of note. GWW-8 didn’t exhibit any significant trending; however, an increase in comparison to 2010 levels was noted in September (11.80 mg/L in 2010 to 95.80 mg/L in 2011). The higher TSS concentrations are likely due to low water levels present in the wells necessitating the placement of the pump closer to the bottom of the well and further increasing sediment suspension at the time of sampling, despite following proper purging protocols.

8.1.12 Turbidity

When 2011 data is compared to the 2010 data, the majority of turbidity samples averages in 2011 were lower than 2010 at all sites except GWW-1, GWW-6 and GWW-8. GWW-1 exhibited an increased annual average of 391.8 NTU in 2011 compared to 375 NTU average for the coinciding months in 2010. GWW-1 has higher turbidity than other groundwells potentially due to low water depths at this site, which can subsequently result in more bottom disturbance and therefore elevated turbidity. GWW-2 had an annual average of 17.8 NTU in 2011 compared to 39.1 NTU in 2010 for the corresponding months. GWW-3 had a yearly average of 33.07 NTU in 2011 compared to 76.78 NTU in 2010 for the months sampled. GWW-4 was only sampled once in June and had a turbidity reading of 0.10 NTU which is significantly lower than this month in 2009 which had a turbidity reading of 201 NTU (This month was not sampled in 2010). GWW-5 had an average of 7.48 NTU in 2011 compared to 15.93 NTU in 2010 for corresponding months. GWW-6 increased in 2011 with an annual average of 12.29 NTU compared to a 1.27 NTU in 2010 for the corresponding months. GWW-8 also increased in 2011 with an average of 35.39 NTU in 2011 compared to an average of 24.0 NTU in 2010. The ground water wells showed concentrations in 2010 to be greater than those of 2009, with a few exceptions of lower monthly turbidity values. Higher turbidity levels in 2010 are likely due to lower water levels within the ground water wells as explained in section 8.1.11.

8.2 TRACE ELEMENTS

The following dissolved metals have also been omitted from discussion and graphs as per request from the Ministry of the Environment (Carmicheal, B. pers comm. 2010): Sb, As, Be, Bi, Cr, Co, Pb, Mo, P, K, Si, Ag, Na, Sr, Tl, Sn, Ti, U, V, and Zn. For a complete tabular representation of groundwater trace elements, please see Appendix C.

8.2.1 Dissolved Aluminum

In general, most sites were shown to contain similar concentrations of D-Al in 2011 relative to 2010. The detection limit from 2010 (0.0010 mg/L) has increased in 2011 (0.0030 mg/L). ALS increased the detection limit threefold for better accuracy to avoid false positive results (Langlais, A. pers comm., 2012). There was only two times that the concentration of D-Al exceeded the detection limit, these include; GWW-1 in March (0.0044mg/L) and GWW-5 in March (0.0039); otherwise all other concentrations were below the 0.0030 mg/L detection limit. Unlike in 2010, there were no spikes in the ground well D-Al concentrations in 2011. In 2010 during June there were spikes in the concentration at GWW-1 (1.94 mg/L), GWW-2 (0.191 mg/L) and GWW-3 (0.118 mg/L).

8.2.2 Dissolved Barium

Dissolved barium exhibited a slight increase in concentrations from 2010 to 2011 at GWW-1, GWW-2, GWW-3, GWW-5 and GWW-8. However the data was somewhat consistent with 2008 and 2009 data sets. GWW-2 and GWW-5 show slightly higher concentration levels than all other previous years' data sets.

8.2.3 Dissolved Boron

No notable trends for dissolved boron have been noted. The highest recorded concentrations of D-B in 2011 were 0.022 mg/L which occurred three times at GWW-1 (March), GWW-2 (March) and GWW-4 (December). GWW-2 and GWW-5 seem to have slightly higher concentrations than previous years during most months.

8.2.4 Dissolved Cadmium

The highest recorded levels of dissolved cadmium occurred at GWW-6 in 2011 (0.620 µg/L in March). GWW-2 showed no inter-annual trending (a notable spike of 0.117µg/L was noted at GWW-2 in September) for D-Cd while GWW-1, 3, 4, 5, 6 and 8 exhibited no trending.

8.2.5 Dissolved Calcium

No significant trends were noted for D-Ca in the 2011 groundwater sampling program, except at GWW-6, where D-Ca concentrations have been increasing since 2007. As noted earlier for surface water, calcium concentrations can increase from weathering of exposed waste rock and pit walls, and therefore can be a signature of mine related changes to water quality. Parameters that are strong indicators of mine related inputs are nitrate, sulphate, and selenium. Sulphate has increased at GWW-6 over time, but not to the magnitude it has at GWW-4 and GWW-5. Nitrate and selenium have increased above their detection limit at GWW-6; therefore the trend of increasing D-Ca concentration may be an indicator of mine related inputs at GWW-6.

8.2.6 Dissolved Copper

A slight seasonal trend is apparent in concentrations of D-Cu present in groundwater at the Willow Creek mine site with concentrations being lower during periods of high surface flow and higher during periods of lower flows. Inter-annual trend towards increasing concentrations was noted at GWW-2 in all months sampled. This is also the case for GWW-3 for all months sampled.

8.2.7 Dissolved Iron

GWW-1 had a mean D-Fe concentration of 17.29 mg/L in 2011 which is higher than 2010's concentration of 7.3 mg/L, however; 2011 concentration is lower than 2009 that had a mean concentration of 27.2 mg/L. The highest concentration for 2011 for GWW-1 was in June with a concentration of 25.6 mg/L. Most ground wells have higher average concentrations in 2011 than 2010. GWW-2 average concentration for 2011 was 0.38 mg/L, which is higher when compared to 2010 average concentration of 0.160 mg/L. GWW-3 had a lower average in 2011 (0.08 mg/L) than 2010 (0.0909 mg/L). GWW-4 average concentration for 2010 was 0.0242 mg/L; 2011 had a slightly higher average concentration of 0.03 mg/L. GWW-5 and GWW-6 had the same averages for 2010 and 2011 sites; with an average concentration of 0.0267 mg/L for 2010 and an average concentration of 0.03 mg/L for 2011. GWW-8 had an average concentration of 0.028 mg/L in 2010 and a higher average concentration of 0.0310 mg/L in 2011. There is a slight increase in concentration levels from 2010 to 2011, however, all the 2011 average concentration levels are the same or lower than 2009 average concentration levels.

8.2.8 Dissolved Lithium

A slight seasonal trend was observed for D-Li, with lower concentrations observed during months of higher surface flow. D-Li concentrations at GWW-6 were shown overall to have increased yearly since 2007. Ground water wells 1,2,3,4 and 8 all showed an increasing trend in 2011 for the majority of the months except September (GWW-1, GWW-2, and GWW-3) and June (GWW-4). GWW-6 was shown to contain lower concentrations of D-Li relative to 2010.

8.2.9 Dissolved Magnesium

D-Mg showed a slight increase in GWW-1, GWW-2 and GWW-5 in 2011, with GWW-1 and GWW-2 increasing from June through December while GWW-5 increased in March, June and December. The maximum concentration for GWW-1 was 24.20 mg/L, 25.4 mg/L for GWW-2 and 21 mg/L for GWW-6. GWW-3 also showed an increase in 2011; compared to all corresponding months sampled in 2010. There was no notable trending for any of the remaining sites in 2011. As both Ca and Mg are released together from waste rock, a similarity in trending was expected.

8.2.10 Dissolved Manganese

No consistent inter-annual trending was noted for D-Mn across the Willow Creek mine site ground water wells.

8.2.11 Dissolved Nickel

In general, dissolved Ni concentrations remain low in groundwater. GWW-1, GWW-2 and GWW-3 were found to contain D-Ni concentrations primarily less than or equal to the detection limits (0.5 µg/L), however; there was one notable increase at GWW-1 in

June (1.54 mg/L). GWW-6 has showed an increasing trend since 2008, however; June, September and December were lower this year than 2010. GWW-4 was only sampled one time in June and was fairly consistent with last year's result. GWW-5 showed concentrations slightly above the detection limit during the entire year, concentration levels were in the 0.5 µg/L – 1.0 µg/L range.

8.2.12 Dissolved Selenium

D-Se in groundwater shows generally low values. Concentrations in GWW-1, 2, 3, 6 and 8 concentrations all remain at or below 1.0 µg/L, with about half of these values being below the DL of 0.1 µg/L. Slightly higher concentrations are evident at GWW-4 and GWW-5 and it there is generally an increasing trend since 2006. Concentrations increased in 2011 relative to 2010 for GWW-4. For GWW-5; 2011 concentrations decreased slightly from 2010 concentrations for the corresponding months. GWW-5 shows an increasing selenium trend potentially due to the close proximity to the plant sediment pond.The greatest concentrations recorded in 2011 were 1.68 and 2.19 µg/L these were observed at GWW-4 (June) and GWW-5 (December) respectively. The higher D-Se values in these wells are consistent with elevated sulphate concentrations, confirming a mine-related influence.

Section 9 – Pit Dewatering

Pit dewatering in 2011 occurred from April 4st to June 20th.

9.1 Quality Assurance/Quality Control

9.1.1 Field/Lab Duplicates

RPDs are expected to be high at values near the detection limit. At concentrations near the detection limit values, small variations in water chemistry can result in significant variability between duplicate samples. In such instances where the values were less than one order of magnitude from the detection limit but RPD's were > 20%, the samples were not considered to have exceeded their RPD's and as such were omitted from the list below. Some degree of environmental variability can also be expected in duplicate samples for parameters influenced by TSS. In order to maintain proper QA/QC protocols, 11 full suite field replicates were also collected for the pit dewatering sampling program for 2011. The field replicates (Appendix A) showed generally unacceptable precision with the following exceedences of the relative percent difference (RPD) of 40% for the pit dewatering sampling program in 2011:

- 4April
  - T-P (79.85%)
- 13 April
  - T-Sb (91.67%)
  - T-Cu (56.76%)
  - T-N (42.55%)
- 28 April
  - TSS (175.3%)
  - Turbidity (128.08%)
  - TKN (79.48%)
  - T-P (165.67%)
  - TOC (73.66%)
  - T-Al (170.50%)
  - T-As (157.65%)
  - T-Ba (78.02%)
  - T-Cd (156.35%)
  - T-Cr (167.52%)
  - T-Co (150.84%)
  - T-Cu (177.48%)
  - T-Fe (184.20%)
  - T-Pb (185.63%)
  - T-Mn (184.39%)
  - T-Ni (94.61%)
  - T-Si (95.81%)
  - T-Ag (88.11%)
- 9 May
  - Acidity (55.56%)
- 16 May
  - T-Ti (80.31%)
- 25 May
  - D-Al (45.93%)
- 18 July
  - Al-T (148.80%)
  - Sb-T (50.85%)
  - As-T (131.61%)
  - Ba-T (78.46%)
  - Be-T (95.89%)
  - B-T (60.32%)
  - Cr-T (149.98%)
  - Co-T (99.71%)
  - Cu-T (78.37%)
  - Fe-T (135.57%)
  - Pb-T (88.73%)
  - Li-T (64.05%)
  - Mo-T (53.22%)
  - Ni-T (95.08%)
  - Si-T (132.46%)
  - Ag-T (159.26%)
  - Tl-T (137.84%)
  - Ti-T (142.45%)
  - V-T (141.75%)
  - T-Z (120.67%)
  - Al-D (124.60%)

- As-D (90.20%)
- Ba-D (66.16%)
- Cd-D (175.68%)
- Cr-D (81.36%)
- Co-D (141.57%)
- Cu-D (80.28%)
- Fe-D (170.88%)
- Pb-D (186.11%)
- Mn-D (175.27%)
- Ni-D (65.99%)
- Tl-D (85.71%)
- V-D (106.98%)

It is expected that, although sampled side by side, field duplicates may have different turbidity, TSS and metals values due to disturbances by one bottle resulting in increased sediment loading in the other. Also, turbulence and flow patterns mean that although sampled next to each other at the same time, the side by side samples may not be uniform. While measures were taken to minimize this contamination, it is not possible to completely alleviate this effect when sampling duplicates side by side in the field. No Laboratory duplicates were shown to exceed the 20% RPD for pit dewatering in 2011.

9.1.2 Laboratory/Travel blanks

Eleven laboratory (method) blanks were analyzed during the 2011 dewatering period. The following results were noted above detection limits:

- 13 April
  - D-Mn (0.000076 mg/L) exceeded the ALS DQO (0.00005 mg/L)
- 28 April
  - Total B (0.0051 mg/L) exceeded the ALS DQO(<0.001 mg/L)
  - Total Cr (0.00015 mg/L) exceeded the ALS DQO (<0.0001 mg/L)
  - Dissolved B (0.0016 mg/L) exceeded the ALS DQO (<0.001 mg/L)
- 7 June
  - D-Pb (0.000112 mg/L) exceeded the DL of <0.00005 mg/L

The majority of detected values in the laboratory blanks were within a factor of two of the detection limit values and thus, it is not expected that any contamination associated with laboratory blanks (and therefore laboratory equipment and procedure) will have a significant effect on data quality.

Eleven travel blanks were submitted for analysis during pit dewatering in 2011. The following result was noted above the detection limit:

- 9 May
  - Ammonia (0.0058 mg/L) exceeded the detection limit of 0.0050 mg/L

The detected value in travel blanks was within a factor of 2 of the detection limit value and thus, given the number and magnitude of detectable values for all parameters, contamination associated with travel blanks is not predicted to have a significant effect on data quality and by association not on the actual samples either. Appendix A summarizes Total Metals and Dissolved Metals for travel blanks in 2011.

9.1.3 Certified Reference Materials

There were no CRM exceedences for the 2011 year. Total and dissolved metal recoveries for CRMs mostly fell within 90% and 110% of targets. Sulphate recoveries were all 102-106%, indicating a high level of accuracy, while the rest of the general parameters were within 86% and 110% of targets. Laboratory error is not thought to be a significant source of error in analysis.

9.1.4 Laboratory TSS/Field Turbidity Comparison

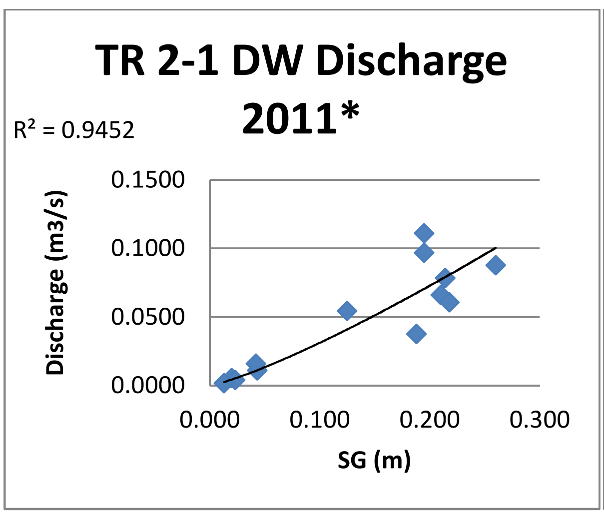
In 2011, TSS at Pond X ranged from 10.80-139.00 mg/L and field turbidity ranged from 4.84-2737.00 NTU. South Pond exhibited a range in TSS of <3.0-179 mg/L, while field turbidity ranged from 0.6-124.00 NTU. At WC-2, TSS ranged from 81.7-3180 mg/L while field turbidity ranged from 17.70-3883.0 NTU. The extremely high TSS/NTU's were due to the sediment release incident in April not due to dewatering. WC-5a exhibited TSS ranging from 3.00-752 mg/L with field turbidities ranging from 4.65-1115.0 NTU. A strong correlation exists between laboratory TSS and field turbidity. See appendix D.1 for the actual representation via correlation graphs.

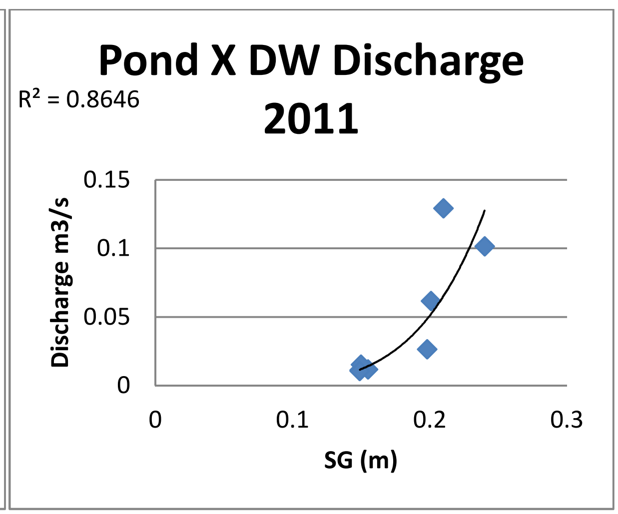
9.2 Flow Data

During the 2011 pit dewatering program, flows were measured weekly (estimated daily based on the staff discharge curves shown in figure 9.1) at TR2-1, WC-2 and Pond X (P1-1, discharge pipe 1) and P 2-1 (discharge pipe 2 – into the south pond collector ditch). Pump rates were monitored daily. Appendix D contains the full suite of flow data gathered during the 2011 dewatering program sites, data from the other sites can be found in Appendix B.

Figure 9.1 depicts the relationships between staff gauge and manual flow measurements made during the 2011 dewatering program. Strong correlations were established at P1-1 (R^2 = 0.8646) and TR2-1 (R^2 = 0.9452). P1-1 was discharged directly into Pond X and as a result, the discharge curve for Pond X is artificially high during the dewatering period (flow determined by subtracting the calculated upstream flow from the calculated downstream flow).

Figure 9.1. Flow as a Function of Staff Gauge Readings for the 2011 Pit Dewatering Program .





* July 13, 2011 data not included because of missing staff gauge.

There was not enough data to graph the WC-2 dewatering discharge curve for 2011 because the staff gauge was flooded out twice and subsequently there was not enough information.

9.3 Water Quality

This section presents the results of the 2011 pit dewatering sampling program. Water quality values for mine discharge and the receiving environment (Willow Creek and Pine River) have been tabulated and graphed and are presented in Appendix D.

All trace elements and general parameters have been tabulated and graphed and are presented in Appendix D. Discussed general parameters and trace elements have been limited to those parameters that were found to be above detection limits.

9.3.1 General Parameters

9.3.1.1 Conductivity

All conductivity measurements for the 2011 pit dewatering program were processed at ALS Environmental lab in Vancouver. Water discharged from the pits via P1-1 and P2-1 exhibited the greatest conductivity (average of 1037 and 1489 mg/L $CaCO_3$, respectively) relative to other sample sites.

9.3.1.2 Alkalinity

The highest alkalinity readings detected during the 2011 dewatering program were found in pit discharges (averages of 251 and 230 mg/L $CaCO_3$ at P1-1 and P2-1, respectively). These values are comparable to the 2011 average observed at WC-2 (147.91 mg/L). Alkalinity levels were greatest in P1-1 and P2-1 (averages of 251 and 230 mg/L $CaCO_3$, respectively) and lowest in Willow Creek (66 mg/L $CaCO_3$ for WC-5a on 25 May 2011).

9.3.1.3 Ammonia

Ammonia concentrations for all sites at the Willow Creek mine typically remained well below both the maximum and 30 day average guidelines set out by the province of British Columbia for the protection and preservation of freshwater aquatic life (averages of 6.22 mg/L and 1.2 mg/L (respectively) based on temperature of 4.0 ºC and pH of 8.0) during pit dewatering. South Pond had the highest concentration of ammonia on 25 July 2011(2.72 mg/L – on this date at South Pond, pH was 7.9. P2-1 and P1-1 had averages of 0.8051 mg/L and 1.3134 mg/L, respectively. While WC-2 and WC-5a showed averages of 0.0688 mg/L and 0.0108 mg/L, during the pit dewatering program. As the average concentration of ammonia at the compliance site (WC-2) is less than that of the control site (WC-5a), it is possible to conclude that the dewatering program did not result in large changes to ammonia concentrations in the Willow Creek.

9.3.1.4 Chloride

All sites showed chloride levels well below BC Water Quality Guidelines for chronic exposure (150 mg/L) in 2011. Sites P1-1 and P2-1 were above the detection limit for all samples taken; WC-2, TR 2-1, WC-5a and TR 2-1 u/s were all at the detection limit or slightly above. No trending is apparent.

9.3.1.5 Fluoride

Fluoride levels only exceeded the 0.3 mg/L water quality guideline at P1-1 and P 2-1 locations, this occurred at P1-1 on May 25 (0.320 mg/L), on June 7 (0.320 mg/L) and on July 25 (0.340 mg/L). All fluoride concentrations were exceeded at the P2-1 site. Fluoride levels averaged 0.293 mg/L at P1-1 and 0.374 mg/L at P2-1. Dewatering was shown to have had no deleterious effect on F concentrations in Willow Creek as WC-2 averaged 0.137 mg/L, while WC-5a (background) averaged only 0.166 mg/L during the dewatering period.

9.3.1.6 Hardness

Hardness levels were decreasing over the freshet period for P1-1, P 2-1, WC-2, and WC-5a. P1-1 hardness is primarily due to levels of calcium and magnesium dissolved in the water, therefore increases to hardness are indicators of the weathering of minerals rich in these elements (e.g. dolomite and calcite) exposed by mining operations

9.3.1.7 Nitrate

There were exceedences of the 30 day max, but not the BC WQGL max for nitrate. From the beginning of freshet April to the end of July there is an overall increasing trend in nitrate at P1-1, P2-1, TR 2-1 u/s and WC-2. There are no trends apparent at TR 2-1 and WC-5a. WC-5a exhibited the lowest average of 0.111 mg/L while P1-1 exhibited the highest, 7.657 mg/L. P1-1 and P2-1 exceeded the 30 day water quality guideline of 3.0 mg/L for all dates sampled during dewatering. The exceedences for BC WQGL-30 day for Nitrate for P1-1 were: 8.170 (16 May), 4.920 (25 May), 8.190 (7 June), 8.34 (20 June), 7.83 (18 July) and 9.02 (25 July). The exceedences for BC WQGL-30 day for Nitrate for P2-1 were: 3.25 (16 May), 5.94 (25 May). 4.28 (7 June), 3.93 (13 June), 6.58 (20 June), 9.97 (18 July) and 12.00 (25 July). The elevated levels seen in WC-2 relative to WC-5a are due to the nitrate concentrations in P1-1 and P2-1 discharge; however, given the low nitrate concentrations in the Pine River, as discussed in section 7.1.7, it can be concluded that dewatering is having no impact on the nitrate concentrations in the Pine River.

9.3.1.8 Nitrite

Exceedences of the 30 day average BC WQGL and the max BC WQGL (Cl-based) were observed at all dates at P1-1 (Pond X discharge water) during the dewatering period of 2011. TR 2-1 was at the BC WQGL on July 25 at a concentration of 0.040 mg/L. No other sites exhibited exceedences during this period. While WC-5a was shown to be at or below detection limits on all occasion during the dewatering program, WC-2 was shown to contain nitrite concentrations above detection limits on 6 of 11 occasions. The difference between WC-5a and WC-2 is attributable to the dewatering of the 4C pit through P2-1 (South Pond); however, as discussed in section 7.1.8, it is apparent that nitrite levels in the pit water are not having an appreciable impact on the receiving environment.

9.3.1.9 pH

PH samples were analyzed by ALS Environmental at their lab and were found to range between 7.97 and 8.37 for the pit dewatering program. This is within the provincial water quality guideline of 6.5 to 9.0.

9.3.1.10 Sulphate

Given the low background levels for sulphate, the high sulphate concentrations in mine-related flows, and its conservative behavior in aerobic streams (tends to be unreactive), sulphate represents a very sensitive indicator of mine-related influences. During dewatering, the pit discharge concentrations at P1-1 and P2-1 surpassed the 100 mg/L WQGL at every sampling date for P1-1 and P2-1 (average of 347.5mg/L and a range of 243 mg/L to 418 mg/L for P1-1 and an average of 723.29 mg/L and a range of 460 mg/L to 1000 mg/L for P2-1). WC-2 showed an overall decreasing trend throughout the pit dewatering program for 2011 with two exceedences of the 100 mg/L guideline on April 4 and April 13. The annual average for WC-2 was 54.35 mg/L. No exceedences were recorded in the Pine River, as discussed in section 7.1.10. Dewatering was shown to affect sulphate levels in Willow Creek: WC-2 had an average of 54.35 mg/L with a range of 15.70 to 155.0 mg/L. The upper limit of the range occurred on April 4 2011 during the sediment release incident. The average at WC-5a was 7.50 mg/L, with a range of 4.12 to 25.0 mg/L; the Pine River doesn't seem to be negatively impacted by these elevated concentrations – as discussed in section 7.1.8.

9.3.1.11 Total Suspended Solids (TSS)

For downstream sites, Section 2.1 of Permit PE-17042 states that TSS should not exceed:

- 5 mg/L above TSS at the upstream site, when the 30 day average upstream is ≤ 25 mg/L

- 25 mg/L above TSS at the upstream site, when the 30 day average upstream is between 25 and 250 mg/L

- 10% of the TSS at the upstream site, when the 30 day average upstream is >250 mg/L

Table 9-1 summarizes the TSS values in Willow Creek during the pit dewatering program.

Table 9-1. TSS Concentrations (in mg/L) in the Willow Creek during Pit Dewatering in 2011

2011	P1-1	P2-1	WC2	WC-5a
4 Apr 11			2530	<3.0
13 Apr-11			1100	3.6
28 Apr 11			1210	39.8
9 May 11			501	
16 May 11	23.3	8.0	434	395
25 May 11	140	6.4	402	589
7 Jun 11	55.3	<3.0	424	740
13 Jun 11	11.8	<3.0	100	170
20 Jun 11	16.7	<3.0	227	290
18 Jul 11	12.7	30.0	384	502
25 Jul 11	4.7	24.0	191	489

Highlighted values indicate exceedences of TSS based on Section 3.1 of PE-17042

There were three noted TSS exceedences during the 2011 dewatering program. These occurred at WC-2 on the 4 April (2530 mg/L), 13 April (1100 mg/L) and 28 April (1210 mg/L) and were the result of the sediment release event that occurred on 4 April 2011.

During the 2011 pit dewatering program, TSS at WC-2 ranged from 191 to 2530 mg/L. P1-1 exhibited at laboratory TSS range of 5.3 to 210 mg/L. P2-1 laboratory TSS was shown to exhibit a range of <3.0 to 198 mg/L. WC-5a, which is the control site, outside of influence of the mine, was shown to have TSS concentrations ranging from <3.0 to 740 mg/L.

9.3.1.12 Turbidity

Turbidity levels during dewatering ranged from a low average of 0.6 NTU at P2-1 to >4000 NTU at WC-5a. P2-1 had an average NTU of 48.5 NTU with a range of 1.1 NTU to 70.4 NTU. WC-2 levels varied throughout the dewatering period, going from a high of 1880 NTU on 7 April to a low of 140 NTU on 13 June with an average of 539.68 NTU. WC-5a turbidity levels varied from 7.24 to 659 NTU (on 20 April and 14 July, respectively). For April and May WC-2 was higher than WC-5a; for these months it is apparent that the sediment release incident was having an impact on Willow Creek. For June and July the high turbidities were shown at WC-5a and that turbidities were always lower at WC-2 (compliance site which includes all mine-related inputs), it is apparent for June and July that mine influences are not resulting in increased turbidities in the Willow Creek.

9.3.2 Trace Elements

The following sections discuss any trace elements that exceeded their respective Water Quality guidelines during the 2011 dewatering program at any of the sites within the Willow Creek mine permit area. All data are presented in tabular and graphic format in Appendix D.

9.3.2.1 Total Chromium

Baseline data indicated some exceedences of the maximum BC working WQGL (0.001 mg/L) at the pump discharges (P1-1 and P2-1) and in Willow Creek. P1-1 experienced exceedences on May 16 (0.00212 mg/L), May 25 (0.00411 mg/L), June 7 (0.00147 mg/L) and June 20 (0.00189 mg/L). P2-1 had two exceedences on 25 May (0.00103 mg/L) and July 18 (0.00109 mg/L); the remainder of the samples for these two sites had levels which were at or below the detection limit. WC-2 exceeded the maximum working water quality guideline for the majority of the dewatering program for 2011 with an average of 0.001002 mg/L. WC-5a exceeded on each sampling occasion with an average for the 2011 dewatering program of 0.01501 mg/L. The concentrations at WC-5a support the hypothesis that natural factors are primarily responsible for the T-Cr concentrations found at WC-2.

9.3.2.2 Total Iron

As was seen with T-Cr, T-Fe exhibited multiple exceedences of the maximum WQGL of 1 mg/L at WC-5a (average of 8.43 mg/L) and at WC-2 (average of 12.09 mg/L). The average at WC-2 is higher due to the sediment release incident at the beginning of April: increased sediment is associated with increased iron concentrations. The concentration of total iron from WC-5a to WC-2 is slightly higher; the exceedences at WC-2 are due to the sediment release incident that occurred in April.

9.3.2.3 Total Lead

Total lead concentrations exhibited only one exceedence in the 2011 pit dewatering program for the BC 30 day average WQGL (0.016 mg/L). The exceedence occurred on April 4 at WC-2 with a concentration of 0.022 mg/L. Exceedences of the maximum hardness-based WQGL (the range for this WQGL in 2011 at Willow Creek Mine was 0.08 mg/L to 0.33 mg/L, dependent upon the month) noted at WC-2 are as follows: April 4 (0.022 mg/L), April 13 (0.00968 mg/L), April 28 (0.0128 mg/L), May 9 (0.00497 mg/L), May 16 (0.00497 mg/L), May 25 (0.005510 mg/L), June 7 (0.00544 mg/L)m June 20 (0.003350 mg/L), July 18 (0.00602 mg/L) and July 25 (0.00303 mg/L). There were six exceedences of the maximum BC WQGL at the WC-5a control site: May 16 (0.00434 mg/L), May 25 (0.00907 mg/L), June 7 (0.0083 mg/L), June 20 (0.004440 mg/L), July 18 (0.0063 mg/L) and July 25 (0.00562 mg/L). Given the fact that WC-5a is not within mine influence, these T-Pb concentrations in Willow Creek are due to natural processes, with the exception of April and early May, which were due to the previously described sediment release event.

9.3.2.4 Total Selenium

As per the mitigation plan for pit dewatering (Mitigation Plan, 2008), the concentrations of selenium were predicted to be 0.011 mg/L at WC-2. This concentration was agreed to by both WEWC and the MOE to have minimal effect on the aquatic receptors, based on the short duration of exposure. Based on this prediction WC-2 did exceed this concentration once due to the sediment release incident in the creek, with a maximum concentration of 0.0168 mg/L recorded on 6 April. No exceedences of the predicted T-Se concentration were noted due to the dewatering program.

Section 10 – Conclusion

This report represents the findings of the 2011 Water Quality Monitoring Program for the Willow Creek Mine. By analyzing the data collected in 2011, WEWC was able to compare the results from those obtained during previous years, including baseline monitoring, and observe any trends that appear to be developing as a result of mine effluent. Sulphate and selenium were shown to exhibit mine-related signatures in P2-1, P1-1, Trib 1 (including Pond X), Trib 2, South Pond, and Willow Creek during certain periods.

Occasional exceedences of BC Water Quality Guidelines occurred at the aforementioned sites during baseline data collection or at control sites; therefore, mine related input is either unlikely to have influenced these sites or verification of whether mine effluent has contributed to exceedences is difficult to ascertain. A lack of control site in Tributary 1 can create difficulties when comparing downstream sites that may be subject to mine influence.

Exceedences during the freshet period (April, May and June) were experienced at some sites and can be associated with higher TSS and sediment loading in water ways due to the aforementioned sediment release from the Willow FSR.

With the development of the Willow Creek Mine in future years, an increase in the mine footprint is expected to increase the overall loadings in Willow Creek and the Pine River. Continued observations and analysis of the sampling results will help to identify trends early on and enable WEWC to prepare and employ management and contingency plans.

Section 11 – References

Carmichael, Bruce. Personal communication., 2010

EDI Environmental Dynamics Inc. 2007, *2006 Surface Water Quality Report Willow Creek Mine.*

EDI Environmental Dynamics Inc. 2007, 2006 *Groundwater Monitoring Program for the Willow Creek Coal Mine*.

Langlais. Andre 2012. Personal communication (February 8, 2012).

Lorax Environmental 2006, *Dillon Mine Aluminum Speciation Results- Implications for Residual Effects Analysis for Brule Project*. Technical memorandum prepared for Kathy Pomeroy. Prepared by Alan Martin, Lorax Environmental Services Ltd., June 30, 2006.

Ministry of the Environment 2006, Effluent Permit PE-17042.

Mitigation Plan Willow Creek Mine Pit Dewatering. Prepared by Falls Mountain Coal Ltd., April 22, 2008.