Evaluating the effects of moving to a low maintenance ARD control strategy at the Victoria Junction coal tailings site

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Abstract The Victoria Junction Coal Preparation site near Sydney NS, Canada was a major source of ARD to Northwest Brook and surrounding wetlands. Attempts were made to capture and treat ARD generated by its refuse pile through various pump and treat schemes until a polymer cap was placed over the 26 ha pile in 2005. Cap placement coincided with a rapid improvement in stream and wetland health. The earlier water treatment system (WTS) remained in operation until 2009 when it was decided by site managers Enterprise Cape Breton Corporation to evaluate whether the WTS active treatment system was necessary to maintain water quality in Northwest Brook and the nearby wetlands. This paper summarizes the use of an acid base loading model to develop and evaluate a closeout plan for the WTS and reports on the first eight months of monitoring results. While preliminary, the results illustrate a method for isolating the effects of the WTS vs. capping by using a mass balance model. Preliminary results indicate that Northwest Brook has remained net alkaline through and downstream of Victoria Junction.

Key Words ARD, closeout, mass balance, water quality

Introduction

The Victoria Junction Coal Preparation Plant served a large mining complex near Sydney, NS, Canada. During 20 years of operation it generated a 40m high, 26ha pile containing coarse waste rock and tailings totaling about 8,000,000 tonnes. The pile was situated across the shallow valley of Northwest Brook and became a serious source of acid rock drainage (ARD) impairing the Brook and an adjacent wetland. Earlier hydrological studies (JWEL, 2002; AMEC, 2008) indicated that most of the ARD exited the pile through its foundation and seeped into the wetland/stream complex. The foundation consisted of peat overlaying glacio-fluvial sand lenses which, in turn overlaid compacted till and fractured bedrock. Much of the ARD generated over the previous twenty years was found in the upper bedrock zone.

Early remedial actions included a grout wall and wells to intercept the ARD plume and treat the contaminated water in a hydrated lime plant. This approach met with limited success until a polymer liner was installed over the entire pile in 2005. This resulted in rapid improvement in water quality and wetland vigor down gradient of the pile largely by head reduction. Ziemkiewicz (2009) studied the historical data and suggested that the pump and treat system was a minor component of the acid-base balance down gradient of the pile. The objective of this project was to minimize active treatment while ensuring that the integrity of Northwest Brook and the adjacent wetlands were maintained.

The WTS closeout plan was initiated in September 2009 to minimize active treatment requirements by evaluating which components of the WTS were necessary given the effect of capping and installation of passive treatment. The evaluation consists of progressive reduction of groundwater pumping rate from 227 L/min to zero over a five month period while monitoring the effects for 24 months. A surface and groundwater monitoring program was instituted in September 2009 to determine whether the legacy ARD plume would move into the wetland and stream or remain in the subsurface as the pumping rate was reduced.

Methods

The closeout plan had three components: staged WTS shut down, passive treatment system construction and water quality/flow monitoring.

WTS shutdown

The pre closure ARD treatment system consisted of six pump and treat (PT) wells completed to depths of about 25 m, a leachate collection system (LCS) collecting shallow ARD from underneath the cap and a French drain/pump at the east side of the pile known as the wet well (WW). Average flows from AECOM (2008) were: PT-116 L/s, LCS-9 L/s and WW-3 L/s. Flows in Northwest Brook varied seasonally and averaged about 680 L/s at its discharge from Grand Lake and 861 L/s downstream of the Victoria Junction site. The WW was turned off in September 2009 and an anoxic drain installed in its place in the fall of 2009. Three pump and treat (PT) wells were shut down in September 2009 with the final three taken off line on 18 Jan 10. The leachate collection system (LCS) remains in service. Installation of the open limestone channel in Smith's Brook (SBD) was completed in February 2010. An additional limestone leachbed is planned in Smith's Brook contingent on identification of the need for additional alkalinity.

Sampling

Both ground and surface stations are sampled monthly. Groundwater was sampled at 20 wells, many completed to multiple levels resulting in 42 sample points, sampling was conducted down gradient of the Victoria Junction site to identify whether pollutants were rising toward the surface during implementation of the closure plan. To the extent that closure involved shutting down the pump and treat wells, the worst case scenario would involve a rise in ARD from depth and extending through the wetland to Northwest Brook. All sampling was conducted by ADI Ltd. Sydney, NS. All chemical analyses were carried out by Maxxam Analytical of Sydney, NS.

The surface water monitoring program consists of three sampling points in Northwest Brook: ST 100-exit of Grand Lake, ST 2017 Northwest Brook upstream of Victoria Junction and ST 2016 Northwest Brook downstream of the project area. Flowing into Northwest Brook are Smith's Brook on the north side of the waste rock pile and numerous seeps originating along the north side of the pile and the adjacent wetland. They are captured by sampling stations SBU (upper Smith's Brook) and SBD (lower Smith's Brook). WWT-3 is the discharge of the polishing pond which flows into Smith's Brook upstream of SBD.

Mass Balance Model

The acidity mass balance model used flow and net acidity to calculate loadings according to the formula:

$$\text{net acid load (tpy)} = \text{net acidity (mg/L)} \times \text{flow (L/s)} \times 0.0317$$

Net acidity represents the mass of pure base expressed as calcium carbonate equivalent that are needed to neutralize that acid load. It is a convenient way to 'weight' the influence of different sources of acidity and alkalinity in a single metric that can then be added and subtracted to yield an acid/base balance. Acidity was calculated based on pH and metal concentrations while alkalinity was determined by titration. Figure 1 illustrates the key components of the acid base model used in this study. Figure 1A represents the pre-closeout status of the drainage system. The large arrow at the bottom indicates Northwest Brook flowing from left to right. Its source is Grand Lake, roughly 1 km upstream of the project area. Smith Brook accounts for about 23% of the flow in Northwest Brook while the water treatment system accounts for less than 1%. Figure 1B projects the post closeout acid base balance if all of the ARD presently being treated by the water treatment system reports to Smith's Brook. In fact, if the ARD groundwater plume rises to the surface much of it would report to the wetland down gradient of Smith's Brook but it would reach the downstream sampling point on Northwest Brook. If most of the ARD plume stagnates in the subsurface then the alkaline load in lower Northwest Brook will improve.

Conclusions

Surface Water

The effect of shutting down the water treatment system has been monitored for eight months. During that period, the net acidity in Northwest Brook downstream of Victoria Junction remained stable at about -7 mg/L representing net alkaline conditions. The depression in alkaline load during the winter reflects decreased flow. There was only one occasion when the Victoria Junction site exported net acid water to Northwest Brook. That event occurred in January 2010. On the other seven sampling dates, Victoria Junction exported net alkaline water (table 1). Net alkaline load in Northwest Brook downstream of Victoria Junction averaged 202 tpy. The pre-project acid

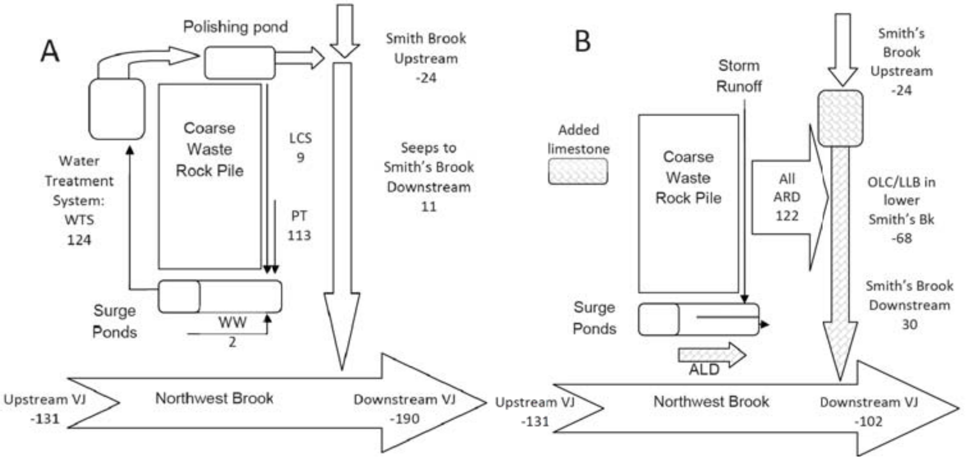

Figure 1 *This schematic diagram shows the relationship between the principal components of the Victoria Junction (VJ) flow system. LCS: leachate collection system, PT: pump and treat wells, WW: wet well, ALD: anoxic limestone drain. The numbers represent alkaline (negative values) or acid load. A represents the pre closeout situation while B represents the post closure projection if all of the ARD that had been treated in the WTS reports to Smith's Brook. The direction of groundwater flow is to the right*

Table 1 *Summary of net acid loads during the first eight months of the monitoring period. Negative values indicate net alkalinity. * this parameter was generated via subtraction, a. All other parameters were calculated based on observed flow and aqueous phase concentration. VJ: Victoria Junction site; NWB: Northwest Brook; US/DS: upstream and downstream respectively*

sampling date	Grand Lk outlet	NWB US VJ site	upper Smith Bk.	lower Smith Bk	Net from VJ site	NWB DS VJ site
Net acid load (tons per year)						
1-Sep-09	-203	-158	-8	-17	-139	-314
15-Oct-09	-240	-150	-33	-31	-23	-205
11-Nov-09	-205	-175	-20	-6	-160	-340
9-Dec-09	0	-56	-19	-42	-9	-107
13-Jan-10	-93	-53	-19	-100	110	-42
3-Feb-10	-83	-52	NF	NF		NF
10-Mar-10	-66	-49	-40	-64	-146	-258
19-Apr-10	-92	-16	-123	-47	-200	-263
field pH						
1-Sep-09	6.1	6.6	7.1	6.7		6.2
15-Oct-09	7.1	7.4	7.2	7.6		6.8
11-Nov-09	6.0	6.4	7.6	6.6		8.5
9-Dec-09	8.5	5.9	8.5	7.6		8.5
13-Jan-10	7.5	6.5	6.9	6.3		7.9
3-Feb-10	6.9	6.7	6.7	6.7		6.6
10-Mar-10	6.4	6.2	7.1	7.1		7.1
19-Apr-10	6.6	7.5	6.9	6.2		7.3
disolved Fe (µg/L)						
1-Sep-09	150	150	1,200	150		310
15-Oct-09	240	200	250	610		310
11-Nov-09	200	190	1,100	340		240
9-Dec-09	50	190	180	520		0
13-Jan-10	170	150	540	50		170
3-Feb-10	150	130	370	2,600		210
10-Mar-10	180	130	50	50		180
19-Apr-10	50	50	210	150		50

NF=frozen, no flow determination possible base load model predicted that if all of the ARD that was being pumped and treated in the WTS surfaced and entered Northwest Brook, its alkaline load would average about102 tpy. The results suggest that, thus far, the closeout plan is exceeding expectations.

Groundwater

In September 2009 27 of 34 wells were alkaline, by April 2010 26 of 34 were alkaline. While some wells changed from acid to alkaline five became substantially more acidic. Four of those were the original pump and treat wells. The other well that became more acidic after shut down of the WTS was PN10D, a 3m deep well nested with three others at increasing depth. All of those wells became more alkaline. The four PT wells and well PN10D are located at the down gradient toe of the coarse waste rock pile. The PT wells are completed to depths between 13 and 55 m while PN10D is completed to only 3 m. When pumping ceased one of the PT wells became artesian. It had no measurable flow, was net alkaline with 1.7 mg/L total iron and 0.037 mg/L dissolved iron. It will ultimately be plugged at depth if the decision is made to permanently shut down the PT well system. Seven wells are sampled in the coarse waste rock pile. Three of them became more alkaline, one was unchanged and three became more acidic.

The data suggest that the closure plan is functioning somewhat better than planned. More alkalinity is being produced at Victoria Junction than planned with only two of three passive treatment units constructed. The mass balance model somewhat underestimated the alkalinity produced on site. While this report covers only the first eight months of a planned twenty four month monitoring program, as of late April 2010, the site is a net alkalinity generator and there was no indication that major deterioration of water quality was imminent.

Acknowledgements

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