Mount Polley Mining Corporation
IMPERIAL METALS CORPORATION

Annual Anaerobic Biological Reactor Review

2012

INTRODUCTION

In 2008, a partnership was established between Mount Polley Mining Corporation (MPMC) and Sue Baldwin of the University of British Columbia (UBC) Chemical and Biological Engineering Department, with support from Genome BC, to collaborate on the project: The development of genomic tools for monitoring and improving passive mitigation of mine drainage.

To implement this project, a 100 gallon per minute (GPM) anaerobic biological reactor (ABR) was commissioned and constructed at Mount Polley Mine in December 2009. The objective of this ABR is to passively reduce metal and sulphate concentrations through biological activity, thereby providing a better opportunity for meeting water quality discharge requirements. The ABR feed flow is the Main Toe Drain which collects seepage through the Main Embankment of the Tailings Storage Facility (TSF). From the ABR outflow, water passes through a retention pond before returning to the Main Embankment Seepage Collection Pond (MESCP), from where it is pumped back into the TSF.

TIMELINE

2009

The ABR was commissioned on December 16th, 2009. It was constructed by laying perforated inflow pipes on the bottom of the northwest half of the excavated pond. The pipes and the bottom of the pond were then covered with layers of organic material (manure, woodchips, and straw), which act as a carbon and energy source for microbes. The organic material was sealed in by rocks, which maintain the layer structure and provide microbe habitat, and the rocks were covered with water to act as an oxygen barrier. The system was activated with an inflow of approximately 100 GPM.

2010

The system was active with an estimated 100 GPM until August 11th 2010, when the system was shut down for just over one month. From September 20th to the end of October, approximately 10 GPM was allowed to report to the ABR, then through most of November 100 GPM was once again flowing into the ABR.

2011

The ABR continued to be active at 100 GPM until September when a propane heating system was commissioned at the ABR inflow, and the inflow was reduced to a rate of 4 GPM. Heat was applied to increase the temperature of inflow water from 7°C to 20°C in hopes of promoting the activity of remedial microbes. The heating system ran until mid-November before being winterized and shut off. After the heating system was shut off, inflow was increased to 50 GPM.

2012

The ABR flow rate was regulated at 50 GPM from January through May, at which point it was restored to 100 GPM until June. After signing on to Phase II of the project with UBC, MPMC began modifications on the ABR with the aim of improving metal and sulphate reduction performance. Phase II preparation work involved re-directing the toe-drain feed flow to the MESCP in July and pumping down the ABR in August and September. Upon conclusion of dewatering in October, Phase II modifications to the ABR were completed: a containment berm around the up-flow water intake system was constructed (to increase retention time); the ABR was filled with hay, gravel, woodchips and manure to replenish the microbial content and the corresponding availability of carbon. Re-filling of the ABR commenced in November at a flow rate of 100 GPM. A discussion of the 2012 monitoring and research program is included in the following section.

SAMPLING METHODOLOGY

To monitor any changes in the water quality after passing through the ABR, samples are taken at the inflow (ABR-IN), within the pond (ABR-INTERFACE), and at the outflow (ABR-OUT). In 2012, samples were also taken in the “Duck Pond” (retention pond) to see if additional passive treatment occurred after water passed through the ABR. Refer to Figure 1 for a map of sampling locations.

Since April 2011, ABR-IN has been sampled from an inflow port, providing more accurate inflow data then previous samples which were collected by drawing down the MESCP and sampling the toe drain input at the foundation drain location below the TSF Main Embankment.

During non-freezing periods ABR-OUT is accessed through the gate on the South East side of the ABR and the sample is taken in front of the outlet culvert. In the winter months, the sample is taken from the other side of the Gavin Lake Forest Service Road in the outlet ditch (for safety reasons).

ABR-Interface samples are taken at four locations within the body of water in the ABR in the area of the pond where the piping is situated (refer to Figure 2). In addition to samples, profiles are taken at interface locations to measure the changes in pH, conductivity, temperature, and dissolved oxygen from surface to bottom.

In 2012, seven (7) samples were taken at ABR-IN and seven (7) samples were taken at ABR-OUT. Two (2) samples were taken from the bottom of the ABR at ABR-INTERFACE 4. Surface samples were collected by hand, and from the ABR bottom using a Van Dorn sampler. These samples were sent to an independent laboratory (ALS Laboratory Group (ALS)) for analysis.

In consideration of the theory that microbes may be converting sulphate into sulfides, but the sulphate is re-oxidizing upon exposure to oxygen, additional research was completed. 4 mL of zinc acetate to 250 mL water samples from ABR-OUT immediately upon collection to see if this

solution bound to sulphate before it re-oxidized. In March, when ice was still on the ABR (ensuring an anaerobic environment), additional attempts to precipitate sulphate from the water before it re-oxidized were completed with samples from ABR-INTERFACE-4-Bottom. 4 mL of zinc acetate was added and/or steel wool was secured in the Van Dorn sampler. Samples were sent to ALS and in situ sulphate readings were taken using a Hanna sulphate meter. The dilution required to use the Hanna meter, however, is a potential source of error.

On September 27th, 2012 (when the ABR was pumped down) the organic substrate was sampled 30 cm below the exposed surface at all four ABR-INTERFACE locations. These samples were sent to UBC for analysis of the microbial groups.

RESULTS

Water Quality Parameters

Results for individual samples taken in 2012 at ABR-IN and ABR-OUT are presented in Tables 1 and 2, respectively. A comparison of average results for key parameters at ABR-IN and ABR-OUT is presented in Table 3. Highlighted cells indicate an increase in a parameter, and red text indicates that a BC Water Quality Guideline (BCWQG) or Permit 11678 guideline has been exceeded. Note that results from the ABR-IN November sample were not used in the comparison, because the ABR was not active at this time. ABR-INTERFACE was sampled twice in 2012 and results for the key parameters are presented in Table 4. Parameters of concern are reviewed below to assess if the water quality is appropriate for discharge.

- Sulphate*:* Sulphate levels at ABR-INTERFACE and ABR-OUT were consistently lower than levels at ABR-IN. All results were above the maximum BCWQG.

- Nitrate: Nitrate levels were consistently higher at ABR-IN than ABR-INTERFACE and ABR-OUT. A significant decrease between the average results of ABR-IN and ABR-OUT was observed. All results were below the BCWQG.

- Phosphorus (Total): ABR-OUT and ABR-INTERFACE reported slightly higher values of total phosphorus. All results were below the BCWQG.

- Aluminum (Dissolved): Dissolved aluminum concentrations increased slightly through the system. All results were below the BCWQG.

- Cadmium (Total): Cadmium results were all below MDL and the fact that higher MDLs were generally used at ABR-IN caused the annual average decrease between ABR-IN and ABR-OUT. All results were below the BCWQG.

- Copper (Total): Copper levels were consistently lower at ABR-INTERFACE and ABR-OUT than ABR-IN. All results were below the BCWQG.

- Iron (Total): Average iron levels were lowest at ABR-INTERFACE and highest at ABR-OUT, resulting in an overall increase. All results were below the BCWQG.

- Molybdenum (Total): Molybdenum concentrations were consistently lower at ABR-INTERFACE and ABR-OUT than at ABR-IN. All results were below the BCWQG; however, molybdenum levels exceed the stringent discharge permit guideline of 0.05 mg/L which was implemented to protect livestock water sources.

- Selenium (Total): Selenium results were significantly lower at ABR-OUT and ABR-INTERFACE than ABR-IN, and decreased from above the BCWQG, to below the guideline through the system.

Comparison with 2010 and 2011 Results

Refer to Table 5 for a comparison of 2010, 2011 and 2012 ABR results. Over this period, reduction of some parameters has consistently improved, including arsenic, nickel (and the increase in iron through the system has drastically decreased). Other parameters show a similar level of removal (nitrate, cadmium, manganese, magnesium, molybdenum, selenium, and zinc). After showing an increase through the system in 2010, in 2011 and 2012, lead and copper have showed major reductions. Contrary to 2011, sulphate levels were reduced in 2010 and 2012, while manganese and phosphorus followed the opposite trend. For the first time in 2012, increases in dissolved aluminum were measured through the ABR.

Duck Pond Sample Results

Water flowing out of the retention pond (Duck Pond), sampled at DUCK-2, shows a further reduction of all parameters except copper, iron, lead, and nickel which stay the same or increase (none of which exceed BCWQG or PE 11678 guidelines). While phosphorus levels are lower at the pond outflow, concentrations are increased compared to ABR-OUT in the ditches to and from the retention pond. The retention pond results are presented in Tables 6 and 7.

Zinc Acetate Preservation

Table 8 shows average results of adding zinc acetate to ABR-OUT samples (an average decrease of 37 mg/L). As shown in Table 9, the use steel wool and addition zinc acetate also resulted in a decrease in sulphate concentrations. The in situ results vary significantly, likely due to errors in dilution volumes, and the lab data provides a more accurate representation.

ABR-INTERFACE Profiles

Table 10 shows the results from a profile completed at interface location 4 in March 2012 through a hole augured in the ice. Conductivity was higher than in previous profiles, while pH was lower. Both parameters were approximately constant through the profiles, which is consistent with past years. This is the first time a profile has been completed under the ice, and significant reductions in dissolved oxygen were observed, indicating that when the ABR is not covered, the desired anaerobic environment is not being achieved. A “sulphur” odor was also noted when the profiles were being completed, indicating the presence of sulfides.

Organic Substrate Samples

Results have not yet been compiled by UBC, however chronomids and snail shells were observed in the substrate.

CONCLUSIONS AND RECOMMENDATIONS

All of the key parameters analyzed in this reports showed greater than 28% decreases in average concentration through the action of the ABR, except magnesium and sulphate which decreased less significantly, and phosphorus, dissolved aluminum, iron, and manganese, which increased in concentration. At the ABR outflow, sulphate is the only parameter exceeding BCWQG, while molybdenum exceeds the PE 11678 site specific guideline for the discharge receiving environment water quality.

In 2013, it is recommended that selenium be closely monitored, because in 2011 the ABR did not reduce levels to below BCWQG, and that ABR-INTERFACE-4 continue to be the preferred interface sample location to keep results consistent. Any changes that result from the 2012 design modifications should be examined.

It is also recommended that MPMC build upon 2012 research to develop methods to further sulphate concentration. Planned modifications include:

- Covering the water surface of the ABR with straw to promote plant growth and prevent oxygen from entering the system (creating an anaerobic environment similar to when ice forms over the system).
- Changing the ABR water source to the MESCP and complete filling. This water has higher metal concentrations and is expected to provide more metal ions, such as iron, to bind to sulphides, preventing re-oxidation into sulphate.
- Heating the inflow water to promote microbial activity (as a continuation of 2010 research which had positive results).

TABLES AND FIGURES

Figure 1: ABR sample locations

Table 1 ABR-IN 2012 sample results

Parameter	8-Feb-12	26-Apr-12	2-May-12	7-Jun-12	28-Jun-12	5-Jul-12	15-Nov-12
Conductivity (in situ) (µs/cm)	1180	1156	1310	1158	1143	1158	1160
pH (in situ)	7.86	8.01	7.05	7.84	8.07	8.20	8.14
Temperature (in situ) (°C)	2.4	3.4	2.5	8.3	9.4	7.7	6.5
Sulfate (SO_4) (mg/L)	458	448	554	475	471	472	481
Nitrate (as N) (mg/L)	0.76	0.864	0.025	1.22	1.18	1.36	1.33
Phosphorus (Total) (mg/L)	0.0605	0.0640	0.0616	0.0346	0.0380	0.0358	0.0342
Aluminum (Dissolved) (mg/L)	0.0015	0.0015	0.0015	0.0032	0.0033	0.0015	0.0015
Arsenic (Total) (mg/L)	0.00178	0.00183	0.00494	0.00171	0.0017	0.00168	0.00173
Cadmium (Total) (mg/L)	0.00006	0.00006	0.0001	0.0001	0.00005	0.000075	0.00006
Copper (Total) (mg/L)	0.00479	0.00395	0.00087	0.00454	0.00678	0.00491	0.00522
Iron (Total) (mg/L)	0.043	0.015	0.307	0.054	0.235	0.090	0.068
Lead (Total) (mg/L)	0.00101	0.000166	0.00007	0.000078	0.000293	0.000192	0.000073
Magnesium (Total) (mg/L)	21.4	20.8	22.7	21	20.8	21.8	20.9
Manganese (Total) (mg/L)	1.090	1.130	0.966	0.695	0.697	0.691	0.628
Molybdenum (Total) (mg/L)	0.182	0.196	0.158	0.202	0.197	0.162	0.214
Nickel (Total) (mg/L)	0.00061	0.00118	0.00064	0.00067	0.00202	0.00094	0.00102
Selenium (Total) (mg/L)	0.00146	0.00157	0.00025	0.00331	0.00385	0.00415	0.00424
Zinc (Total) (mg/L)	0.0015	0.0068	0.0061	0.0171	0.0077	0.0064	0.0056
Note: Values below MDL are represented as 0.5*MDL							

Table 2 ABR-OUT 2012 sample results

Parameter	5-Jan-12	8-Feb-12	14-Mar-12	3-Apr-12	7-Jun-12	28-Jun-12	5-Jul-12
Conductivity (in situ) (µs/cm)	1194	1180	1161	1010	1079	1074	1060
pH (in situ)	7.78	7.86	7.77		8.04	8.06	8
Temperature (in situ) (°C)	1.4	2.4	0.8	1.7	12.5	17.4	16.5
Sulfate (SO_4) (mg/L)	448	405	420	349	434	447	442
Sulfate (SO4) (mg/L) - Preserved with Zn-Acetate		380	392		400	361	
Nitrate (as N) (mg/L)	0.057	0.025	0.055	0.284	0.025	0.025	0.025
Phosphorus (Total) (mg/L)	0.0815	0.0907	0.0751	0.0551	0.0186	0.0148	0.0155
Aluminum (Dissolved) (mg/L)	0.0031	0.0015	0.0015	0.0038	0.0015	0.0047	0.0015
Arsenic (Total) (mg/L)	0.00174	0.0017	0.0015	0.00133	0.0014	0.00131	0.00143
Cadmium (Total) (mg/L)	0.00002	0.000025	0.000025	0.00006	0.00005	0.000025	0.000025
Copper (Total) (mg/L)	0.00421	0.00342	0.00154	0.00453	0.00176	0.00261	0.00187
Iron (Total) (mg/L)	0.245	0.409	0.095	0.113	0.038	0.03	0.015
Lead (Total) (mg/L)	0.00006	0.000061	0.000025	0.000052	0.000025	0.000025	0.000025
Magnesium (Total) (mg/L)	22.4	22.1	20.4	19.6	20.6	20.6	21.5
Manganese (Total) (mg/L)	1.60	1.52	1.34	1.12	0.50	0.24	0.29
Molybdenum (Total) (mg/L)	0.116	0.125	0.110	0.122	0.137	0.155	0.152
Nickel (Total) (mg/L)	0.00058	0.00057	0.00025	0.00025	0.00025	0.00025	0.00025
Selenium (Total) (mg/L)	0.00051	0.00054	0.00025	0.00140	0.00080	0.00158	0.00161
Zinc (Total) (mg/L)	0.0015	0.0015	0.0015	0.0067	0.0015	0.0102	0.0132
Note: Values below MDL are represented as 0.5*MDL							

Table 3: 2012 average results from ABR-IN and ABR-OUT

Parameter	BCWQG 30-day Average	BCWQG Max	ABR-IN	ABR-OUT	Decrease	% Reduction
Conductivity (in situ) (µs/cm)	-	-	1184	1108	76	6.4
pH (in situ)	6.5 - 9.5		7.84	7.92	-0.08	-1.0
Temperature (in situ) (°C)	<1°C deviation from optimum range for each life stage		5.6	7.5	-1.9	-34.0
Sulfate (SO_4) (mg/L)	-	100	480	421	59	12.3
Nitrate (as N) (mg/L)	3.0	32.8	0.902	0.071	0.831	92.1
Phosphorus (Total) (mg/L)	-	-	0.0491	0.0502	-0.0011	-2.2
Aluminum (Dissolved) (mg/L)	0.05	0.10	0.0021	0.0025	-0.0004	-20.7
Arsenic (Total) (mg/L)	-	5.0	0.0023	0.0015	0.0008	34.6
Cadmium (Total) (mg/L)	0.025 (annual mean)*		0.00007	0.00003	0.00004	55.7
Copper (Total) (mg/L)	0.007*	-	0.00431	0.00285	0.00146	33.9
Iron (Total) (mg/L)	-	1.0	0.124	0.135	-0.011	-8.9
Lead (Total) (mg/L)	0.020	0.445	0.00030	0.00004	0.00026	87.1
Magnesium (Total) (mg/L)	-	-	21.4	21.0	0.4	1.8
Manganese (Total) (mg/L)	2.25	4.5	0.878	0.945	0	-7.6
Molybdenum (Total) (mg/L)	0.05*	2.0	0.183	0.131	0.052	28.4
Nickel (Total) (mg/L)	-	-	0.00101	0.00034	0.00067	66.1
Selenium (Total) (mg/L)	-	0.0020	0.0024	0.0010	0.0015	60.7
Zinc (Total) (mg/L)	0.225	0.250	0.008	0.005	0.002	32.1

* Discharge permit PE-11678 guideline

Values below MDL are used in calculations as 0.5*MDL

Table 4: ABR-INTERFACE 2012 results

ABR-INTERFACE Location	4-Bottom	4-Bottom	4-Surface
Parameter	**20-Mar-12**	**28-Jun-12**	**20-Mar-12**
Conductivity (in situ) (µs/cm)	1154		924
pH (in situ)	7.683		7.807
Temperature (in situ) (°C)	3.8		1.3
Sulfate (SO_4) (mg/L)	432	477	
Sulfate (SO4) (mg/L)* - Preserved with Zn-Acetate	387	390	
Nitrate (as N) (mg/L)	0.025	0.025	
Phosphorus (Total) (mg/L)	0.0805	0.023	
Aluminum (Dissolved) (mg/L)	0.0031	0.0015	
Arsenic (Total) (mg/L)	0.00151	0.00143	
Cadmium (Total) (mg/L)	0.000025	0.00003	
Copper (Total) (mg/L)	0.00153	0.00193	
Iron (Total) (mg/L)	0.086	0.052	
Lead (Total) (mg/L)	0.000025	0.000025	
Magnesium (Total) (mg/L)	22.1	21.1	
Manganese (Total) (mg/L)	1.4	0.785	
Molybdenum (Total) (mg/L)	0.12	0.16	
Nickel (Total) (mg/L)	0.00025	0.00025	
Selenium (Total) (mg/L)	0.00025	0.00157	
Zinc (Total) (mg/L)	0.0032	0.0015	
Note: Values below MDL are represented as 0.5*MDL			

Table 5: Comparison of ABR results from 2010 to 2012

	2010		2011		2012	
Parameter (mg/L)	**Decrease**	**% Reduction**	**Decrease**	**% Reduction**	**Decrease**	**% Reduction**
Conductivity (In Situ) (uS/cm)	29.8	2.6	-89.8	-8.0	75.9	6.4
pH (In Situ)	0.18	2.3	0.00	0.0	-0.08	-1.0
Temperature (In Situ) (°C)	-7.3	-83.2	-2.9	-38.2	-1.9	-34.0
Sulphate (Dissolved)	71.0	14.9	-28.2	-6.0	59.0	12.3
Nitrate (as N)	1.9	98.4	1.2	97.9	0.8	92.1
Phosphorus (Total)	0.000	0.0	0.024	42.9	-0.001	-2.2
Aluminum (Dissolved)	0.0002	12.0	0.0004	19.6	-0.0004	-20.7
Arsenic (Total)	-0.0005	-32.2	0.0004	22.8	0.0008	34.6
Cadmium (Total)	0.00005	26.2	0.00004	63.8	0.00004	55.7
Copper (Total)	-0.0007	-23.3	0.0022	50.9	0.0015	33.9
Iron (Total)	-0.139	-929.3	-0.054	-119.6	-0.011	-8.9
Lead (Total)	-0.000003	-5.2	0.000263	91.3	0.000263	87.1
Magnesium (Total)	0.61	3.0	-1.76	-8.2	0.39	1.8
Manganese (Total)	-0.091	-13.3	0.310	28.5	-0.067	-7.6
Molybdenum (Total)	0.049	29.7	0.047	25.3	0.052	28.4
Nickel (Total)	-0.0013	-230.4	0.0005	54.8	0.0007	66.1
Selenium (Total)	0.0022	70.7	0.0008	44.8	0.0015	60.7
Zinc (Total)	0.0008	34.8	0.0021	44.9	0.0024	32.1

Table 6: Retention pond (Duck Pond) June 7, 2012 sample results

	07-Jun-12						
Parameter	**ABR-OUT**	**DUCK 1**	**Decrease**	**% Reduction**	**DUCK 2**	**Decrease**	**% Reduction**
Conductivity (in situ) (µs/cm)	1079	943	136	12.6	729	350	32.4
pH (in situ)	8.04	7.99	0.05	0.6	8.45	-0.41	-5.1
Temperature (in situ) (°C)	12.5	12.1	0.4	3.2	13.2	-0.7	-5.6
Sulfate (SO_4) (mg/L)	434	353	81	18.7	246	188	43.3
Nitrate (as N) (mg/L)	0.025	0.055	-0.03	-120.0	0.0025	0.0225	90.0
Phosphorus (Total) (mg/L)	0.0186	0.0334	-0.0148	-79.6	0.0163	0.0023	12.4
Aluminum (Dissolved) (mg/L)	0.0015	0.0046	-0.0031	-206.7	0.0015	0	0.0
Arsenic (Total) (mg/L)	0.0014	0.00147	-0.00007	-5.0	0.00129	0.00011	7.9
Cadmium (Total) (mg/L)	0.00005	0.00005	0	0.0	0.000047	3E-06	6.0
Copper (Total) (mg/L)	0.00176	0.00774	-0.00598	-339.8	0.00272	-0.00096	-54.5
Iron (Total) (mg/L)	0.038	0.729	-0.691	-1818.4	0.311	-0.273	-718.4
Lead (Total) (mg/L)	0.000025	0.000224	-0.0002	-796.0	0.000116	-0.000091	-364.0
Magnesium (Total) (mg/L)	20.6	19.3	1.3	6.3	16	4.6	22.3
Manganese (Total) (mg/L)	0.50	0.344	0.16	31.7	0.134	0.37	73.4
Molybdenum (Total) (mg/L)	0.137	0.1	0.037	27.0	0.0692	0.0678	49.5
Nickel (Total) (mg/L)	0.00025	0.00111	-0.00086	-344.0	0.00071	-0.00046	-184.0
Selenium (Total) (mg/L)	0.00080	0.00095	-0.00015	-18.8	0.00059	0.00021	26.3
Zinc (Total) (mg/L)	0.0015	0.0033	-0.0018	-120.0	0.0015	0.000	0.0

Table 7: Retention pond (Duck Pond) July 5, 2012 sample results

	05-Jul-12									
Parameter	**ABR-OUT**	**DUCK 1**	**Decrease**	**% Reduction**	**DUCK 2**	**Decrease**	**% Reduction**	**DUCK 3**	**Decrease**	**% Reduction**
Conductivity (in situ) (µs/cm)	1060	900	160	15.1	744	316	29.8	671	389	36.7
pH (in situ)	8	7.98	0.02	0.2	8.79	-0.79	-9.9	8.09	-0.09	-1.1
Temperature (in situ) (°C)	16.5	15.8	0.7	4.2	17.1	-0.6	-3.6	16.7	-0.2	-1.2
Sulfate (SO_4) (mg/L)	442	337	105	23.8	280	162	36.7	280	162	36.7
Nitrate (as N) (mg/L)	0.025	0.025	0	0.0	0.0125	0.0125	50.0	0.0125	0.0125	50.0
Phosphorus (Total) (mg/L)	0.0155	0.025	-0.0095	-61.3	0.0127	0.0028	18.1	0.0187	-0.0032	-20.6
Aluminum (Dissolved) (mg/L)	0.0015	0.0015	0	0.0	0.0015	0	0.0	0.0015	0	0.0
Arsenic (Total) (mg/L)	0.00143	0.0013	0.00013	9.1	0.00135	0.00008	5.6	0.00131	0.00012	8.4
Cadmium (Total) (mg/L)	0.000025	0.00002	0.000005	20.0	0.000015	0.00001	40.0	0.000015	0.00001	40.0
Copper (Total) (mg/L)	0.00187	0.00433	-0.00246	-131.6	0.00227	-0.0004	-21.4	0.00301	-0.00114	-61.0
Iron (Total) (mg/L)	0.015	0.271	-0.256	-1706.7	0.061	-0.046	-306.7	0.238	-0.223	-1486.7
Lead (Total) (mg/L)	0.000025	0.000128	-0.0001	-412.0	0.000025	0	0.0	0.000081	-5.6E-05	-224.0
Magnesium (Total) (mg/L)	21.5	19.2	2.3	10.7	17.6	3.9	18.1	17.7	3.8	17.7
Manganese (Total) (mg/L)	0.29	0.172	0.12	41.1	0.0488	0.2432	83.3	0.054	0.238	81.5
Molybdenum (Total) (mg/L)	0.152	0.116	0.036	23.7	0.0826	0.0694	45.7	0.0813	0.0707	46.5
Nickel (Total) (mg/L)	0.00025	0.00072	-0.00047	-188.0	0.00025	0	0.0	0.00063	-0.00038	-152.0
Selenium (Total) (mg/L)	0.00161	0.00145	0.00016	9.9	0.0008	0.00081	50.3	0.00077	0.00084	52.2
Zinc (Total) (mg/L)	0.0132	0.0015	0.0117	88.6	0.0015	0.0117	88.6	0.0015	0.0117	88.6

Table 8: ABR-OUT sulphate sample results with and without zinc acetate additions

ABR-Out	
Sulphate	421
Sulphate + ZN-Acetate	383
Reduction (mg/L)	37
Reduction (%)	8.9

Table 9: ABR-INTERFACE-4-Bottom sulphate sample lab and in situ results with and without zinc acetate and steel wool additions

Sample	**Sulphate (mg/L)**	
	Lab Result	**In Situ Result**
ABR-INTERFACE-4-BOTTOM	477	610
ABR-INTERFACE-4-BOTTOM (Zn-Acetate)	390	360/490
ABR-INTERFACE-4-BOTTOM (steel wool)	360	740

Table 10 ABR-INTERPHASE-4 2012 profile results

Parameter	Depth (m)	ABR-INTERFACE-4				
		14-Jun-10	08-Jun-11	05-Jul-11	02-Aug-11	20-Mar-12
pH	0.0	6.4	8.3	8.84		7.807
	0.5		8.28	8.85		7.700
	1.0		8.28	8.87		7.691
	1.5		8.26	8.81		7.685
	2.0	5.7	8.11	8.1		7.684
	2.5		8.1	8.12	7.54	7.683
	3.0					
	3.5	5				
	4.0					
	4.5					
Conductivit	0.0	195.9	750	835		924
(uS/cm)	0.5		749	835		1156
	1.0		749	825		1153
	1.5		748	815		1153
	2.0	198	717	770		1153
	2.5		693	738	515	1154
	3.0					
	3.5	196.9				
	4.0					
	4.5					
Temperatu	0.0	15.71	14.9	15.6		1.3
(°C)	0.5		14.7	15.6		3.6
	1.0		14.6	15.5		3.7
	1.5		14.5	14.1		3.7
	2.0	12.88	11.9	11.2		3.7
	2.5		10.3	9.5	16.1	3.8
	3.0					
	3.5	7.7				
	4.0					
	4.5					
DO (mg/L)	0.0	1	7.73	9.7		0.90
	0.5		7.71	9.43		0.50
	1.0		7.71	10.13		0.31
	1.5		7.06	8.62		0.18
	2.0	0.66	4.36	2.51		0.11
	2.5		3.94	2.16	3.72	0.04
	3.0					
	3.5	1				
	4.0					
	4.5					
DO (%)	0.0		76.6	97.9		7.7
	0.5		76.4	95		4.3
	1.0		76	100.6		2.5
	1.5		69	83.9		1.6
	2.0		40.6	22.9		0.9
	2.5		35.3	18.9	37.9	0.4
	3.0					
	3.5					
	4.0					
	4.5					