BENTHIC INVERTEBRATE BIOMONITORING PROGRAM FOR THE OBED MOUNTAIN MINE

Prepared for: Coal Valley Resources Inc
November, 2011

PISCES ENVIRONMENTAL CONSULTING SERVICES LTD.

Benthic Invertebrate Biomonitoring Program for the Obed Mountain Mine

Submitted to:

Coal Valley Resources Inc.
November, 2011

Prepared by:

Pisces Environmental Consulting Services Ltd.
25J 37337 Burnt Lake Trail, Red Deer County, Alberta T4S 2K5

--this page left blank for printing purposes--

Table of Contents

--this page left blank for printing purposes--

1.0 INTRODUCTION

Coal Valley Resources Inc. (CVRI) operates the Obed Mountain Mine (OMM), an open pit coal mine, east of Hinton, Alberta. The OMM has been in operation since 1984 and recently received Environmental Protection and Enhancement Act (EPEA) Approval (10119-02-00) for ongoing operations extending to November 2021. One of the requirements of the EPEA Approval was submission of a Benthic Invertebrate Biomonitoring Program (BIBP) for Apetowun Creek, Baseline Creek, and Canyon Creek. This document presents the strategy that Pisces Environmental Consulting Services Ltd. (Pisces) would employ to conduct the BIBP.

2.0 OBJECTIVES

The proposed BIBP is designed to meet the terms and conditions of the EPEA Approval which state the that:

> *The Benthic Invertebrate Biomonitoring Program shall include, at a minimum, all of the following requirements:*
>
> a) *Conducted in the fall of every 4th year;*
>
> b) *Shall determine significant changes in the benthic invertebrate community which are attributable to the effects of the mine effluent and the length of impact along the creek;*
>
> c) *Shall quantify variables that include epilithic algae (i.e. chlorophyll a), substrate conditions, flow velocities, water levels, and effluent plume distribution;*
>
> d) *Follow the protocol set out in: Guidelines for Monitoring Benthos in Freshwater Environments, Environment Canada, January 1993 and;*
>
> e) *Be submitted to the Director by May 1st of the year following sampling.*

3.0 STUDY AREA

The proposed BIBP will include the establishment of *reference sites* (not expected to be affected by mining activity) and *test sites* (potentially influenced by mining activity) on Apetowun Creek, Baseline Creek and Canyon Creek, as well as several smaller unnamed watercourses. In some instances the mine infrastructure is located near the headwaters of these streams and there is no habitat that is suitable for the establishment of a *reference site* upstream of the potential mine influences. In these cases, additional reference sites would be established on adjacent streams that do not appear to be influenced by mining activity but possess similar habitat characteristics to the other sample streams.

Proposed *reference* and *test sites* are delineated on Figure 1. *Test sites* on Apetowun Creek are consistent with previous monitoring while *test sites* in the Baseline and Canyon Creek drainages are new. The location of these new sites is considered preliminary and will need to be refined based on information gathered from field reconnaissance of the area. This refinement may also result in a fewer or more *test sites* than is indicated on Figure 1. The exact location and number of *reference sites* shown on Figure 1 is also likely to change subject to the reconnaissance and analysis described below.

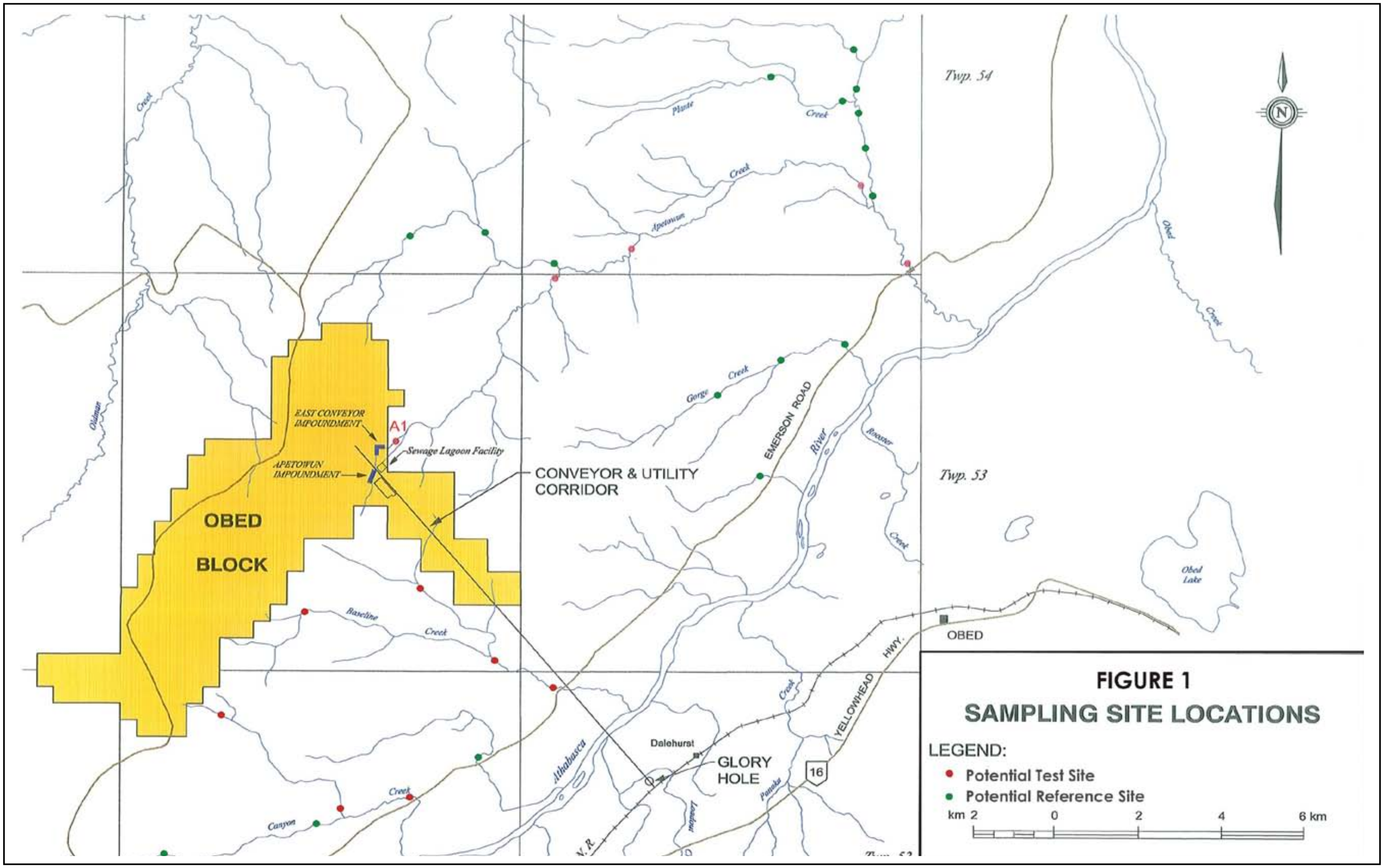

Figure 1. Proposed Benthic Invertebrate Monitoring Locations for the Obed Mountain Mine.

4.0 REVIEW OF PAST MONITORING

4.1 BACKGROUND

A biomonitoring program was initiated for Apetowun Creek in 1992 and implemented in 1994, 1996, 1998, 2002, 2006, and 2010 (Pisces 2011). The program used a control-impact (C-I) approach that consisted of a sampling erosional or depositional habitat for benthic invertebrates at established "control" sites as well as at potentially impacted "synoptic" sites and comparing results to determine if there were statistical differences.

4.2 SAMPLING LOCATIONS

Sample Benthic invertebrate samples were collected from a total of 8 sites; including 4 on Apetowun Creek, 2 on Plante Creek (a tributary to Apetowun Creek), and 2 on an unnamed tributary to Apetowun Creek (Table 4.1).

Sample sites were established in water bodies that could potentially be impacted by the discharge of impoundments. Control sites were established upstream of impoundments and major mining activities or on adjacent "undisturbed" streams while synoptic sites were established at various locations downstream of impoundments. Sample sites were generally consistent between monitoring years. Habitat at sites A1 to A4 was depositional and habitat at sites A5 to A8 was erosional.

Table 4.1. Existing Benthic Invertebrate Sample Sites on the Obed Mountain Mine.

Habitat Type	Site	Description
Depositional	A1	Apetowun Creek downstream of settling pond
	A2	Control, headwaters of unnamed tributary to Apetwun Creek
	A3	Apetowun Creek, upstream of confluence with unnamed tributary
	A4	Control, unnamed tributary to Apetowun Creek
Erosional	A5	Apetowun Creek, downstream of confluence with unnamed tributary
	A6	Apetowun Creek, upstream of confluence with Plante Creek
	A7	Control, Plante Creek upstream of mouth of Apetowun Creek
	A8	Plante Creek, downstream of confluence withApetowun Creek

4.3 METHODS

4.3.1 Field Sampling

Field sampling protocols were based largely on methodology described by Alberta Environment (1990) which included collection of five random, replicate samples at each location using Neil-Hess Cylinder with a 250 micron mesh. Sampling was conducted in the fall with all samples preserved with a minimum 80% ethanol prior to shipment.

General habitat conditions including substrate type, size, water velocity, and bankfull and wetted width were characterized at each site.

In addition, at each site, basic water quality parameters including conductivity, water temperature, pH, dissolved oxygen and turbidity were recorded.

4.3.2 Data Analysis

Samples were processed by an independent taxonomist following standard procedures. The techniques used to analyze the data included: examination of the community structure, estimates of diversity, and statistical comparison of densities of major taxonomic groups.

4.4 RESULTS

Results of early surveys (1994, 1996, 1998) suggested that effluent was affecting the benthic invertebrate community immediately downstream of settling pond discharge into upper Apetowun Creek. This was most apparent in the relatively high densities of Oligochaeta at synoptic sites compared to reference sites (Pisces 2011). However, this trend has not continued in recent years as results have generally indicated that there were no differences in benthic communities between synoptic sites and control sites (Pisces 2011).

5.0 PROPOSED BENTHIC INVERTEBRATE BIOMONITORING PROGRAM

5.1 GENERAL APPROACH

The proposed monitoring program will employ the Reference Condition Approach (RCA) whereby *test sites*, suspected of potentially being impacted are compared to an appropriate *group* of *reference sites* (that represent the normal condition) to determine if there is an impact. The degree of impairment is determined by how far the benthic communities at the *test sites* depart from those at *reference sites*. Key elements of the proposed approach include:

1. Selection of a pool of candidate *reference sites* that may include:
    a. sites that have been sampled previously (either during monitoring or baseline investigations);
    b. new sites that could be sampled in the future.

2. Selection of *test sites* (based on mine plans). Generally one *test site* will be established in the immediate vicinity of an effluent discharge point and additional *test sites* will be established at locations downstream (depending on the size of the water body) to determine the linear extent of an impact.

3. Review and analysis of existing regional benthic data that OMM has accumulated during previous monitoring and baseline investigation to determine if it can be used to:
    a. Develop a preliminary model that explains the natural variability of the benthic populations in the region.
    b. Determine (through statistical analysis described in Section 5.2.1), the number of *reference sites* (from the candidate pool) that need to be sampled in a given monitoring year.
    c. Identify data gaps (it will likely be necessary to some obtain additional reference information to ensure the model is accurate).

4. Implementation of monitoring program whereby:
    a. *test sites* will be sampled.
    b. a number of reference sites (# determined as described in Section 5.2.1) will be sampled and included in the model to account for effects of natural temporal variation.
5. Employment of statistical analysis to match *test sites* with the appropriate group of *reference sites* (*Reference Group*) for comparison and assessment of effects.

5.1.1 Benefits of the RCA Approach

The use of the RCA Approach is becoming more common and is recommended by The Canadian Aquatic Biomonitoring Network (CABIN) developed by Environment Canada. The RCA offers several benefits over the previously used C-I monitoring approach including:

- It is conducive to regional effects monitoring in that site testing and analysis for a relatively large area (multiple streams) can be completed relatively quickly compared to other approaches (Beatty *et al.* 2006) which allows for early identification of effects and/or areas that require additional follow-up.
- It allows for assessment of impact when a suitable reference site on a particular stream does not exist (Bowman and Somers 2005) (as is the case for the mine area i.e. Apetowun Creek, Baseline Creek, and possibly Canyon Creek).
- It allows for an assessment of the severity of impairment.
- It has been developed along with rapid assessment protocols which allows for reduced sampling effort in the field and laboratory.
- It can make use of existing data.
- Once an RCA model has been established for the region the monitoring program is more flexible and can be adapted to accommodate changes in mining plans or surface water management plans.

5.2 SAMPLING LOCATIONS

Proposed sample sites are delineated on Figure 1. As previously indicated the location and number of sites will be subject to revision based on information gathered during a field reconnaissance as well as the analysis described in Section 5.2.1. However once established, the *test site* locations are unlikely to change over the course of the monitoring program. The proposed location and number of *reference sites* is preliminary at this time. The number of *reference sites* will be determined by statistical analysis described in Section 5.2.1 while the location of the sites will depend on local habitat characteristics, accessibility, and proximity to potential disturbances. Sites may be established in erosional or depositional habitat.

5.2.1 Reference Sites

Reference Groups

As indicated above, *test sites* will be compared with a *reference group* (group of *reference sites*) to determine effects. Therefore, the number of *reference sites* required to complete the monitoring program will depend on the number of *reference groups* need to accurately depict the natural stream environment (Bowman and Sommers 2005, Environment Canada 2010). As such, descriminant analysis (Environment Canada 2010) can be used to determine the number of necessary reference groups based on habitat attributes at sites as well as existing community composition data. Given our current knowledge of the potential study streams it is expected that one or two *reference groups* will be required; one *group* may include erosional habitat and one *group* may include depositional habitat.

Reference Sites

A power analysis (as suggested by Environment Canada 2010) will be applied using the following formula to estimate the likelihood of detecting effects with the chosen number of *reference sites* per *reference group*.

$$N = 2(t_\alpha + t_\beta)^2(SD/ES)^2$$

> where, n is the number sites per *group*, t_α and t_β are the critical t values at significance levels for Type 1 and Type 2 error rates respectively, SD is the within reach standard deviation, and ES is the critical effect size (where ES is the mean reference condition ± 2 SDs assuming that effects exceeding ±2 DDs are of interest)

In the absence of a power analysis, Environment Canada (2010) suggests that there be a minimum of 10 *sites* within each *reference group* which would translate to 20 *sites* if there were two *reference groups* (as described above). It should be noted that this requirement represents the number of "data points" required to characterize the reference group and not necessarily the number of "reference sites required per monitoring year". As such, historical data from suitable sites may also be utilized to characterize the reference group.

As indicated above, information from the pool of candidate *reference sites* (Table 5.1) will be used to develop the model that describes the natural variability of benthic invertebrate populations in the region. It may be possible for this model to be based on existing information that the mine has obtained during previous baseline work in the area.

5.2.2 Test Sites

The proposed program will consist of approximately 12 *test sites* on up to 4 different water bodies. The location of existing synoptic (*test*) sites on Apetowun Creek will remain essentially unchanged from previous monitoring. In addition to these sites, new *test sites* will be established on an unnamed tributary to Canyon Creek, Baseline Creek, and an unnamed tributary to Baseline Creek (provided tributaries are of sufficient size to obtain samples).

5.2.3 Number of Sub-Samples (Replicates) per Site

With the RCA approach, replication is at the sample site scale and, since variation within a site is often much lower than among sites, a single sample can be taken at each site and variation among sites is used to describe the reference condition (Environment Canada 2010). However, additional sub-samples or *site replicates* may be required to accurately reflect organism abundance and species richness. If required, the following formula (Environment Canada 2010) will be applied to existing benthic invertebrate data (from the previous monitoring program) to determine the number of sub-samples needed to provide confidence that a representative number of animals has been captured.

$$N=s^2/D^2\ \bar{X}^2$$

where, $\bar{X}$ is equal to the sample mean, n is equal to the number of field sub-samples, s^2 is equal to the sample variance and D is equal to the index of precision.

In the event that the background data is unusable, three sub-samples (*site replicates*) will be collected at each site as recommended by Environment Canada (2010).

5.3 METHODS

5.3.1 Field Sampling

Field sampling will be carried out in the fall as is the general convention (Alberta Environment 1990). Consistent with previous monitoring, sites will likely be established in erosional and depositional habitat.

Samples at erosional sites will be obtained using one of two methods:

- Neil-Hess Cylinder with a 250 micron mesh.
    - Is consistent with previous monitoring work so would likely allow for the use of existing data (from previous monitoring) in determining the reference condition.
    - More samples per site would be required compared with kick-net sampling.
- Kick-net
    - Not consistent with previous monitoring work but is the recommended approach for CABIN. However, cannot use existing data in determining the reference condition so more reference sites would need to be sampled.
    - Would require only one sample per site.

Samples at depositional sites will be obtained using and Eckman Grab which is consistent with previous monitoring work.

All samples will be preserved in the field with ethanol and shipped to an independent taxonomist for sorting, counting, and identification.

General habitat conditions including habitat type, substrate (type, size and compactness), water velocity, and bankfull and wetted width will be characterized at each site.

In addition, at each site, basic water quality parameters including conductivity, water temperature, pH, dissolved oxygen and turbidity will be recorded.

Epilithic algae will be sampled at each site by randomly scraping a 2X2 cm area on randomly selected rocks. A composite sample will be sent to an independent laboratory for analysis of total chlorophyll *a*.

5.3.2 Data Analysis

Data provided by the taxonomist will be used to calculate several metrics (for each site) that describe the community. These metrics will include the following:

- Total Abundance
- Total Richness
- % Ephemeroptera, Plecoptera, and Trichoptera (EPT)
- Simpson's Diversity Index
- Simpson's Evenness

Multivariate analysis as described by Environment Canada (2010, CABIN) will be used to characterize normal variability of habitat (and differentiate reference groups), match test sites with reference sites (determine which reference group a test site will be compared with), and compare test sites and reference sites to determine the level of impairment.

5.4 MONITORING CHRONOLOGY

The proposed monitoring program will be implemented every 4 years once the number and location of sample sites has been determined based on field reconnaissance and statistical analysis described above.

6.0 ADAPTIVE MANAGMENT

It is expected that some information gaps will be identified during the program and that there will be ongoing refinement of the model as monitoring progresses. If, through the course of monitoring, a water body is determined to be impaired, then additional measures will be implemented to:

- determine the cause of the impact and/or,
- further refine the level of impact and/or,
- further refine the zone of impact.

7.0 REFERENCES

Beatty, J. M., McDonald, L. E., Westcott, F. M., and C. J. Perrin. 2006. Guidelines for sampling benthic invertebrates in British Columbia streams. Prepared for British Columbia Ministry of Environment.

Bowman, F. M. and K. M. Somers. 2005. Considerations when using the Reference Condition Approach for bioassessment of freshwater ecosystems. Water Quality Resources Journal of Canada. Vol 40, n3, 347-360.

CABIN. Canadian Aquatic Biomonitoring Network website. (http://www.ec.gc.ca/rcba-cabin/default.asp?lang=En&n=72AD8D96-1)

Alberta Environment 1990. Selected methods for monitoring benthic invertebrates in Alberta rivers. Alberta Environmental Protection, Surface Water Assessment Branch.

Environment Canada. 2010. Pulp and paper EEM guidance document. Environment Canada, National EEM Office, Gatineau, Quebec.

Pisces 2008. Benthic invertebrate monitoring on streams on and adjacent to the Coal Valley Mine 2008. Report of Pisces Environmental Consulting Services to Coal Valley Resources Inc. Edson, Alberta.