Blue Mountains Water Skink Research and Management Program

Springvale Coal Mine

October 2015

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Report Number: PR 129308 Rev 1
Version / Date: 12 October 2015

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1.0 Project Scope

RPS has prepared in accordance with condition 13 of the Commonwealth Approval Notice issued for the Project (EPBC 2013/6881) a Blue Mountains Research and Management Program. The requirements of consent SSD_5594, specifically, condition 10 h (iv) 'research and management' for the Blue Mountains Water Skink (*Eulamprus leuraensis*), has also been considered.

1.1 Overview

A research and management program for the Blue Mountains Water Skink (BMWS) is required under condition 13 of EPBC 2013/6881 and as part of a broader Biodiversity Management Plan to comply with consolidated consent SSD_5594. This Biodiversity Management Plan forms a component of the overarching Extraction Plan.

1.2 Program context

Commonwealth Approvals

The Approval Notice issued for the Project (EPBC 2013/6881) states the following for the BMWS:

Condition 13: The approval holder must prepare a management and research program for the BMWS at Carne West Swamp, including specific measures for monitoring that population and response measures to be implemented if a decline is detected. The approval holder must not commence undermining of Carne West Swamp before the approved management and research program has been approved in writing by the minister. The approved management and research program must be implemented.

This approval largely mirrors the State approvals although is specific to Carne West Swamp. While implied in the State approval, the need for monitoring is also specifically mentioned in the Approval Notice.

NSW Approvals

Project approval is contingent on a primary obligation being the minimisation of harm to the environment. In this respect, Centennial is obliged to:

- Meeting the specified performance measures and criteria established under the consent for SDD_5594; and
- Implement all reasonable and feasible measures to minimise harm to the environment that may arise from construction, operation and rehabilitation of the development.

Harm exceeding the subsidence impact performance measures specified in Schedule 3 of the consent (Table 1) would constitute a breach of the approval and may require offsetting requirements if remediation is not possible or feasible. The consolidated consent uses qualitative terminology to define the tolerable limits for harm (i.e. negligible impact); a subjective term that may prove difficult in demonstrating compliance with the consent.

In these situations it is desirous to minimise the subjectivity of terms such as 'negligible impact' as an ill defined interpretation may diminish the benefit of a management program. Circumstances such as these should consider the use of quantitative measures integrated with an adaptive management framework. An accurate appreciation of the Projects impact on the environment over time has the benefit of enhancing the effectiveness of restorative and/or management prescriptions, thereby substantially improving the likelihood of Centennial meeting its primary environmental obligation.

1.3 Approach

A prudent approach to addressing the inherent subjectivity expressed through the consent terminology is to establish a robust quantitative approach to the evaluation of harm on BMWS and its habitat. In this respect, it is recommended that a scientifically robust monitoring program be prepared as the centrepiece to the BMWS research and management plan. A Before After Control Impact (BACI) monitoring framework (Underwood 1992), a framework based on the principles of experimental design, is proposed due to its dual utility (i.e. effective monitoring framework and capacity to deliver research outcomes).

The BACI monitoring program would have functionality capable of achieving the following:

- Characterise a baseline dataset for impact and control sites thus define the natural pre-impact variation within BMWS populations;
- Define meaningful quantitative triggers that sequentially delineate increasing levels of harm such that a trajectory towards a breach in the 'negligible impact' harm threshold can be pre-emptively detected; and
- Support an adaptive management framework that matches targeted restoration focused management actions with pre-emptive harm thresholds, thereby minimising the potential incidence of a harm outcome exceeding the subsidence impact performance measures.

An experimental design is critical to protecting Centennial Coal from unwarranted claims that they have caused some impact on the BMWS and its habitat, when there is no biological evidence to support such a contention.

The proposed research and management objectives, approach, design and sampling methods are discussed in the following sections.

1.4 Management and research objectives

Documentation reviewed in preparing the program is listed below:

- All available documentation associated with the consolidated consent for SDD_5594;
- Approval Decision: EPBC 2013/6881 – Springvale Mine Extension Project
- Department of Sustainability Environment, Water, Population and Communities (2011) Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2011);
- Underwood T. (1992). Beyond BACI: The detection of environmental impacts on populations in the real, but variable, world. *L Exp. Mar. Biol. Ecol.* (1992) 145-178.

The regulatory context provides the following draft objectives for the BMWS research and management program:

- Develop an efficient monitoring program for the BMWS with the principle aim being the detection of subsidence related pre-harm change in a BMWS population;
- Determine meaningful, quantitative measurable triggers compatible with the monitoring program that define an acceptable threshold for 'negligible impact';
- Define restorative management actions linked to pre-harm trigger levels (i.e. adaptive management framework) to minimise the incidence of harm on the BMWS and its habitat; and
- Quantitatively show through the monitoring program that subsidence impacts have had a negligible impact on the BMWS and its habitat.

Considerable research opportunities exist in the course of performing works for the above objectives. Potential to add to the scientific knowledge published on this species is outlined below:

- Identification of a cost effective and efficient sampling method suitable for detecting and monitoring the elusive and cryptic BMWS within a remote setting;
- Characterisation of population demographics for a number of BMWS occurrences; and
- Testing of impact models that have been used to define pre-emptive harm thresholds used in the adaptive management framework.

1.5 Monitoring Design

Underwood (1992) outlined the key elements critical to the design of a BACI monitoring program. Key factors considered in such a monitoring design are:

- Singularity of the impact site: The impact area is noted as having a number of swamps harbouring or potentially harbouring the BMWS. The sampling of all known habitat areas impacted by the project is warranted to avoid problems associated with pseudosampling.
- Variance in space: Most natural populations oscillate in ways that are not concordant from one place to another. Thus, abundances of most species will fluctuate from time to time independently in any two sites (one potentially impacted and one control). As such, comparisons between one impact and one control site are not capable of demonstrating differences in temporal patterns should the only detectable/ measurable change in the environment be the consequence of longwall mining. As such multiple independent sampling sites are required to increase the power of any analysis that attempts to isolate subsidence as the causation of change.
- Variance in time: The numbers of organisms in a population are likely to vary over time, with the assumption that the population will remain constant generally unfounded. Monitoring timing and confounding factors need to be considered to minimise unrelated sources of variance

A balanced experimental design comprising at least five impact and five control sites independent of each other is considered the minimum for developing a robust statistically based monitoring program. The experimental design would need to carefully consider the following potentially confounding factors to reduce sources of 'noise' (i.e. unrelated data variance) in such a program:

- Swamp type;
- Past, present and future mining impacts;
- Past fire regimes;
- Proximity of non-natural land uses (e.g. forestry); and
- Elevation (i.e. minimise any confounding factors potentially related to climate change).

The influence of confounding variables need to be minimised through appropriate site selection, where ever possible, to avoid misleading/ inaccurate results. This is, of course, in addition to the identification of candidate swamps containing populations of the BMWS. Factors to be considered in this regard include, but not limited to, the following:

- Sampling of candidate swamps where there has been no prior incidence of BMWS to find new populations that may be suitable for inclusion in the monitoring program;
- Physical and tenure related access constraints (e.g. national park estate and/ or state forests); and
- Scientific licensing (conducting of research on a threatened species within national park estate).

1.6 Sampling

Three reptile sampling methods are proposed for consideration in the monitoring program to determine which is the most effective and efficient approach (i.e. pit fall trapping, arthropod trapping and tiling). Pit fall trapping is the only recommended approach (DSEWPaC 2011), although the other two methods are equally useful in detecting cryptic reptile species. These methods are outlined in the following sections, which is followed by the proposed rationale for testing sampling method efficacy then data collection protocols.

1.6.1 Sampling methods

1.6.1.1 Pitfall Traps

The most comprehensive survey technique used in the detection of the BMWS is pit fall trapping (DSEWPAC 2011). Pitfall trap lines will consist of three 10L buckets installed approximately 10m apart during the peak activity period of December to March. Each bucket will contain moist vegetation for protection of captured individuals. Although this technique is deemed the most successful, it requires a high survey effort as traps require morning and afternoon checks.

1.6.1.2 Tiling

This non-invasive technique is aimed at long-term data collection and has minor impacts on the surrounding environments. It involves A4 sized black rubber mats placed in suitable areas of habitat within each site that provides artificial habitat for the BMWS. At each control and impact site 5-20 tiles will be positioned. Intensive surveys are not required for this technique, thus, if this technique is the preferred option, a reduced survey effort is expected to occur for future monitoring for this program.

1.6.1.3 Arthropod Traps

Although arthropod traps have not been trialled for the detection of the BMWS (that RPS is aware of), this technique is used for other cryptic lizards including the Grassland Earless Dragon (*Tympanocryptis pinguicolla*) (DSEWPAC 2011). Arthropod traps are constructed of PVC piping inserted vertically into the substrate level with the opening level with the surface, an inner tube is placed into this to allow removal of trapped animals or debris, and inspection of tubes is carried out by torch. A metal roof is placed over each trap to shelter animals from sun and rain and to assist in locating tubes. This technique is also less labour intensive than pitfall trapping, and would be a cost and effort benefiting replacement of pitfall trapping.

1.6.2 Sampling method selection

DSEWPAC (2011) describes only one method for detecting the BMWS (i.e. pit fall trapping); an effective yet labour intensive and destructive method for determining incidence. The method is described below:

"*Appropriate survey methodology for detecting the presence of the Blue Mountains water skink would be targeted pitfall trapping in December to February when the species is most likely to be active, using a line of three 10 litre buckets each approximately 5 metres apart (although other pitfall trap arrays could be trialled). No drift fence would be required*" (DSEWPaC 2011).

Pit fall trapping techniques represent a reliable and repeatable sampling method well suited to monitoring programs. However, implementation in remote settings such as the Springvale study area can be expensive for practical and ethical reasons (i.e. repeated daily morning and evening checking of pit fall traps to minimise harm or death to trapped animals). While effective, pitfall trapping is unlikely to represent a cost efficient monitoring method for remote sites such as those at Springvale.

In addition to these considerations, the pit fall trap sampling rate recommended by DSEWPAC (2011) is oriented to detection (i.e. three buckets separated by 5 metres), not monitoring, and as such contrasts poorly with the sampling rigor required to adequately understand the spatial and temporal fluctuations of a given population. It is considered that many more pitfalls than those specified by DSEWPAC (2011) would be required to adequately understand population variance within a given habitat area.

In this respect, it is considered that a guideline complaint approach to BMWS monitoring using pit fall traps is likely to under sample habitat areas impacted by the project, thus potentially increase the risk of a false negative (i.e. data erroneously indicating or not indicating an exceedance of the negligible impact trigger). It is recommended that at least three separate sample locations comprising three buckets each within a single swamp monitoring site is required to improve the utility of data for the intended purpose (i.e. determine if a negligible impact has occurred). Thus, it is envisaged that at least nine pit fall traps per monitoring site would be required representing a significant cost investment (i.e. labour).

In determining the most suitable monitoring method (i.e. cost versus efficacy), it is considered that the comparison of the three methods itself addresses the research aspect of the consent conditions. The basis for considering alternative sampling methods is premised on broad similarities in habitat use by the BMWS, Lined Earless Dragon and burrowing reptiles in general. The Lined Earless Dragon is known to refuge in burrows constructed by wolf spider holes; a habitat feature that has been successfully replicated artificially using PVC pipes (i.e. spider tubes). Similarly, the BMWS is known to occupy borrows in peat and, as such, may use spider tubes in a manner similar to Lined Earless Dragons. Also, the BMWS may also utilise tiles as do other burrowing reptiles successfully sampled by this method.

If methodological trials successfully show one of the alternative sampling approaches as being superior to pit fall trapping, then it is considered that the alternate method may profoundly reduce the unit cost of monitoring (i.e. increased number of sampling points with fewer monitoring visitations), hence the cost of the program over the term of its implementation. These approaches would also reduce the indirect impacts of monitoring activity on the swamps hence habitat of the species. Moreover, the results obtained from these comparisons are likely to represent contributions to scientific knowledge and, as such, can be published in the scientific literature (i.e. represents research, hence addresses one aspect of the conditions of consent).

1.6.3 Sample size

A balanced monitoring design comprising five impact and five control sites is proposed. At least nine samples would be collected from each site (pitfall traps) totalling 90 samples, but may be more if alternate methods are used. A power analysis would be completed following the first round of sampling to determine if the sample size is sufficient to adequately test for difference between impact and control sites. A type I error rate of 0.05 is assumed in this analysis.

1.6.4 Data collection

Mark-capture-recapture data is to be collected to estimate the BMWS population size at each monitoring site using the Lincoln Index. This involves the capture and marking of a portion of the population followed by release. Later, another portion is captured and the number of marked individuals within the sample is counted. Since the number of marked individuals within the second sample should be proportional to the number of marked individuals in the whole population, an estimate of the total population size can be obtained by dividing the number of marked individuals by the proportion of marked individuals in the second sample.

This method is proposed as a cost efficient approach to estimating population size (rather than counting all individuals). Population size will be estimated on the basis of a ‘closed’ population (i.e. no immigration, emigration or recruitment within the monitored period). For this assumption to hold true, monitoring must occur after the birth of individuals (i.e. February-April).

Other useful population data that should be obtained is listed below:

- Male/ female ratios (i.e. weigh marked animals before and after January to estimate sex);
- Deaths (i.e. absence of recaptures); and

- Dispersal between swamps (i.e. captures from one swamp are detected elsewhere).

Sex determination among captured BMWS individuals typically requires an invasive procedure (i.e. internal sex organs), which is not proposed in this sampling program. Rather, the sexing of BMWS individuals is to be inferred by weighing marked adult individuals captured immediately before and after the January birthing period. As such, pre-birth monitoring events are also proposed with sex determination inferred from a differentiation in the weight of marked individuals.

1.6.5 Survey timing

The BMWS is active from September to March (April), although is reliably active during the summer months. Females bear live young in January. On this basis, it recommended that monitoring typically span the summer months for the following reasons:

- Maximise capture potential (i.e. minimise the effect of weather on sampling);
- Obtain capture data prior to and after breeding events.

Additional considerations for survey timing are outlined in the above sections. In sum, the proposed sampling regime comprises three separate occasions as listed below:

- Survey 1 ‘initial capture and marking’ (November);
- Survey 2 ‘recapture’ (December); and
- Survey 3 ‘post birth’ (February).

The first two surveys permit the assumption that the population is closed, thus allowing for a population estimate to be calculated. The third survey allows for the characterisation of male/ female ratios and number of births; this being population demographic data important in population viability analysis and potentially the setting of trigger levels.

1.7 Analysis

At least three types of analyses are proposed as part of the management and research program. These are outlined in the following sections.

1.7.1 Population estimates

The Lincoln Index is proposed to estimate population size at each monitoring site. At least two samples per year are required to make this estimate as per the timing specified in Section 1.6.5 (i.e. closed population). Populations for each site will be tallied for impact and control treatments.

1.7.2 Population Viability Analysis

This analysis has the potential to be of great utility in the modelling of subsidence impacts, in advance of the impacts, hence potentially identify factors that might lead to population decline (i.e. detection of an impact exceeding the ‘negligible’ threshold). Information obtained from the mark-capture-recapture analysis is critical to performing a population viability analysis.

Vortex software is initially proposed to be used for this analysis although will be reviewed for its suitability during the commission. A summary of this software is provided as follows:

Vortex is an individual-based simulation of deterministic forces as well as demographic, environmental and genetic stochastic events on wildlife populations. It can model many of the extinction vortices that can threaten persistence of small populations. Vortex models population dynamics as discrete, sequential events that occur according to probabilities that are random variables following user-specified distributions. Vortex simulates a population by stepping through a series of events that describe an annual cycle of a typical sexually reproducing, diploid organism: mate selection, reproduction, mortality, increment of age by one year, dispersal among populations, removals, supplementation, and then truncation (if necessary) to the carrying capacity. The simulation of the population is iterated many times to generate the distribution of fates that the population might experience.

1.7.3 Analysis of Variance

Yearly population estimates for impact and control sites will be statistically compared to determine if a significant difference exists. A parametric analytical method would be used in the first instance (i.e. analysis of variance (ANOVA)). If assumptions pertaining to normally distributed data do not apply, then non-parametric techniques would be used (e.g. Kruskal-Wallis).

An interim level of significance is benchmarked at 5% or p=0.05.

1.8 Research

Research grade scientific knowledge can be obtained from the monitoring program. It is proposed to publish on one or more of the following aspects of the monitoring results in a scientific journal:

- Sampling methods;
- Population demographics; and
- Population viability.

1.9 Risk management

A number of risks are inherent in the undermining of threatened species habitat, particularly in circumstances where subjective low tolerance impact thresholds are applied to measure performance (and restorative action). In this project, the main risks identified are:

- Lack of quantitative parameters that clearly define a universally acceptable definition for a ‘negligible impact’ threshold (i.e. trigger levels).
- Limited knowledge and data on BMWS in the area of impact; and
- Limited knowledge of the BMWS response to subsidence impacts.

These represent significant risks as the consequence of an impact exceeding ‘negligible’ constitutes a breach of the consent conditions and may necessitate the need for offsetting. Offsetting would not only be considerably difficult to achieve for the BMWS, it is likely that any such offsetting requirements would be expensive.

The program provides an empirical consultative approach to manage the above identified project risks. Scientific rigor is not only embraced for the purposes of delivering ‘research’ outcomes, it is also necessary for increasing the accuracy and reliability of impact detection. Consultation at the start and midway through the program has the purpose of managing regulatory expectations.

2.0 Methodology

The underlying aim of the BMWS research and management program is to manage the impacts of subsidence such that a negligible impact on the species eventuates as a consequence. A BACI monitoring designed comprised within an adaptive management framework is proposed with research outcomes arising from the adoption of an experimental design. An eight stage program is proposed to deliver against the objectives of the program. |These stages are outlined in the following sections.

2.1 Stage 1 – Site Selection and initial consultation

Candidate monitoring sites would be identified using the guiding principles outlined in Section 1.2.3, consultations with Centennial Coal and other relevant stakeholders (e.g. NPWS) and additional parameters listed below:

- Large swamps in close proximity to other large swamps;
- Swamps with a high diversity of plant species (200+);
- Swamps with deep leaf litter; and
- Swamps with known presence of *Tetrarrhena turfosa* and *Baeckea linifolia*.

In relation to control sites, access and survey permission will need to be obtained prior to commencing works as these sites as they are outside the Springvale Project Area. Monitoring site section would be narrowed to five control sites external to the Springvale Project Area and five impact sites within the Springvale Project Area following site inspections to determine presence.

Initial consultations with regulatory authorise are also proposed thereby communicating the proposed approach to the research and management of the BMWS. Monitoring design, methods and analysis would be discussed and fine tuned, where appropriate. Anticipated research outcomes will also be discussed.

2.2 Stage 2 – Methodology trials and first round of monitoring

Trials of each proposed monitoring method would be completed at the five control and impact sites. Methods trailed at these sites are outlined in Section 1.6. Data obtained will be initially used to determine the best monitoring method. Animals trapped will be marked in preparation for the second monitoring round.

2.3 Stage 3 – Second round of monitoring

Data obtained from the trial monitoring surveys would be supplemented with additional capture data obtained from the second monitoring round. 'Inferior' sampling methods would be repeated then decommissioned.

2.4 Stage 4 – Third round of monitoring

Monitoring would be conducted following the birth of new recruits (i.e. post January). Additional population demography data would be obtained including male/female sex rations (inferred) and number of recruited animals. This information would be collated and made ready for data analysis including population viability analysis.

2.5 Stage 5 – Data analysis and Trigger level determination

Data collated through stage 1-4 would be digitised and put into a form suitable for analysis. A preliminary baseline dataset would be established from the analysis and reviewed for suitability in future monitoring events. Population estimates using the Lincoln Index method would be produced.

A population viability analysis would also be performed with multiple scenarios. Scenarios would include existing and reduced population conditions to evaluate response to falling population numbers. Interim performance thresholds would be deduced from the modelling, thus providing insight into the derivation of meaningful trigger levels suitable for the activation of restorative management actions prior to the breaching of a 'negligible impact' threshold.

2.6 Stage 6 – Consultation with regulatory authorities

RPS would seek to consult with relevant regulatory authorities following the completion of summer surveys and data analyses to convey the findings and discuss proposed trigger levels. Consultation with the NSW Office of Environment and Heritage and Commonwealth Department of Environment would be performed. Refinement of proposed research outcomes would also be discussed.

2.7 Stage 7 – Annual report

A draft and final report would be submitted to Centennial Coal comprising the methodology for the monitoring program, management regime including trigger levels and results of the first round of monitoring.

2.8 Stage 8 – Scientific publication

Key findings obtained from the monitoring program would be synthesised into at least one scientific paper ready for peer review. Research topics considered for publication include:

- Efficacy of three survey methods for the BMWS;
- Population demographic patterns of the BMWS; and
- Utility of population viability analysis modelling in determining realistic trigger levels suitable for implementation in an adaptive management program for impacted populations.

2.9 Indicative delivery schedule

It is difficult to estimate the specific time to undertake activities, particularly when establishing new research programs. Unknowns include time to travel from one site to another, site accessibility and complexity of survey sites. However, the following schedule has been put forth to address the required survey technique, and proposed alterative survey techniques.

Stage	Project Item	Timing	Lifecycle
Stage 1	Site selection for BACI monitoring program. Install tiles, pit fall and arthropod traps at control and impact sites.	October – November 2015 – 4 weeks	Adults and previous season recruits active
Stage 2	Perform first round of trapping to obtain data describing population demography at these sites and evaluate sampling method. Compile data and determine most successful sampling method. Mark individuals.	November 2015 – 4 weeks	Adults and previous season recruits active Mating?
Stage 3	Repeat Stage 2 monitoring surveys	December 2015 – 3 weeks	Adults active
Stage 4	Perform monitoring event after live birthing to obtain additional population demography data	February 2016 – 2 weeks	Follows live birthing in January
Stage 5	Define population demographics for each swamp and determine trigger levels. Perform data analysis including population viability analysis.	March – June 2016 – 4 weeks	Adults and juveniles active to April
Stage 6	Consultation with regulatory authorities	July – August 2016	BMWS inactive

Stage	Project Item	Timing	Lifecycle
Stage 7	Annual Report Due (Baseline)	September 2016	BMWS inactive?
Stage 8	Prepare a scientific paper for publication in a scientific journal and submit for peer review	September – December 2016	Adults and previous season recruits active

3.0 Project Team

3.1 The Project Team

RPS has assembled an experienced project team of specialist consultants to deliver the project objectives and outputs envisioned by the project brief.

Arne Bishop (Senior Ecologist/Project Manager) will be the primary contact responsible for the coordination and delivery of this project. Monitoring field work will be undertaken by suitably qualified Ecologists and Senior Ecologists of the RPS Ecology team.

3.2 Personnel

Personnel	Position
Arne Bishop	Senior Ecologist
Mark Aitkens	Senior Ecologist
Lauren Vanderwyk	Ecologist
Daniel Watts	Field Ecologist
Rhys Osborne	Field Ecologist
Joe May	Field Ecologist

4.0 Conclusion

RPS has been involved in the preparation of a number of ecological assessments and flora and fauna monitoring reports for coal mines and quarry operations in the Hawkesbury-Nepean Catchment Area and is well situated to deliver the above in a timely manner. RPS has a highly skilled team who understand the issues, have extensive experience in the locality, have the relevant inductions, and are well placed to undertake the works associated with the BMWS.