Annexure 2:

Responses to s92 requests prepared by Bioresearches in respect of terrestrial ecology matters

Bioresearches
A Babbage Company

30 August 2024 Job No: 61130#BIO04

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MP4 CONSENT APPLICATION – S92 REQUESTS FOR ADDITIONAL INFORMATION FROM DCC AND WDC – HERPETOFAUNA & INVERTEBRATE RESPONSES

Dear Suzanne,

OceanaGold (NZ) Ltd has received a joint request for additional information (RFI) under section 92 of the Resource Management Act (RMA) 1991 from Dunedin City Council (DCC) and Waitaki District Council (WDC) (dated 24 July 2024)[1] relating to a resource consent application for the Macraes Phase IV Project. The joint RFI includes questions posed by E3 Scientific on behalf of the Otago Regional Council (dated 24 July 2024)[2].

This letter provides responses to questions *1 b), 3 a)–g); and 4 a).* The questions from DDC and WDC are shown in blue italics and responses shown in regular black text below.

1 b) Please update the assessment to include the Northern Gully WRS and Coronation pit lake spill channel.

The MP4 Project application includes reference to the construction of a spillway to drain overflow from the eventual infilling of the Coronation Pit into a tributary of Camp Creek. The herpetological values and effects were not considered in the Herpetofauna Assessment nor the Lizard Management Plan (LMP) at the time of the application. Accordingly, a summary of the herpetofauna values and effects related to the Coronation Spillway footprint is provided here and will be reflected in revised versions of the Herpetofauna Assessment and LMP.

The Coronation Spillway is situated on the northern Taieri Ridge in the south-eastern corner of the Coronation 6 Pit, and works will consist of a 1.27 ha excavation 370 m long cut to 33 m wide and down to 660m RL into bedrock. A portion of the spillway footprint is covered by existing consents; however, an area of 0.24 ha of tussockland (0.21 ha) and riparian vegetation (0.03 ha) falls outside of the consented area. Detailed descriptions of the proposed affected vegetation communities are provided by Whirika

[1] DCC LUC-2024-126, 482 Longdale Road, Hyde – and WDC 201.2024.2373. Request for further information regarding Macraes Phase 4 resource consent applications. Dated 24 July 2024.

[2] Request for further information under section 92(1) of the Resource Management Act 1991 (the Act) – Consent Application Number RM24.184", dated 24 July 2024.

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(2024)[3]. Considering the presence of tussockland and riparian habitats, lizard communities (likely McCann's, Tussock, and possibly herbfield skink, as well as korero gecko) are expected to occupy the unconsented spillway area. Skink population density information gathered during the April 2024 baseline monitoring programme (see the attached *Lizard Management Plan: Macraes Phase 4 Project,* report version 30 July 2024) was used to estimate the size of the skink population occupying the impact area. It is possible that approximately 290 (184–485)[4] skinks may be affected by the spillway construction. The size of the korero gecko population in the impact area is likely to be markedly smaller than (probably <10%) the skink population due to less habitat (rock tor) availability, and therefore, up to approximately 50 geckos may be expected to be affected.

While the unconsented Coronation Spillway area increases the number of lizards potentially affected by the MP4 Project, the overall magnitude of effect and proposed mitigation strategies (e.g., salvage and relocation numbers) remain largely unchanged. This is due to the following: lizard population estimates across all MP4 Project Components have broad confidence limits that accommodate the relatively small increase in lizard numbers estimated from inside the Coronation Spillway footprint and expected gains from mammalian predator eradication and control in the MEEA and surrounding buffer will adequately offset the loss of any additional individuals affected by the spillway construction. Adjustments to the number of lizards salvaged and relocated as part of the MP4 Project will be made to ensure that effort is invested in salvaging lizards from the Coronation Spillway footprint.

3 a) Please provide the additional documentation regarding the further lizard survey and adjusted population estimates. We expect this will cover the additional field survey methodology and detail of where the survey was undertaken.

Please refer to sections "4.3 Lizard population size estimates" and "6 Lizard monitoring programme" in the revised *Lizard Management Plan: Macraes Phase 4 Project,* report version 30 July 2024[5] (Attachment 1), for descriptions of the monitoring methods and refined population estimates. Figure 6.1 of the Lizard Management Plan (page 54) shows the locations of sites (pitfall traps) that were used to survey lizards over a consecutive nine-day period in April 2024. Also see the report produced by Proteus (2024), entitled *Analysis of Macraes Flat Lizard Monitoring Data* (Attachment 2), which describes the methods for estimating population size.

3 b) Detail any additional work intended to be undertaken over the coming warmer months to further define lizard distribution and population size.

A second round of lizard baseline monitoring is scheduled for the summer 2024/ 2025 period. This will involve a repeat of the nine-day survey across the six monitoring sites (Coronation 6 Pit, Back Road Waste Rock Stack, Golden Bar 2 Pit, Golden Bar Waste Rock Stack and extension area, Murphys Ecological Enhancement Area, and Murphys Buffer area). The data collected will be analysed in the same way as the

[3] Whirika (2024). Ecological values of planned Coronation spillway and mitigation of project effects. Technical note prepared for OceanaGold Limited. 11 p.

[4] Based on an average (lower & upper range) population size estimates, using data from N-mixture modelling and Capture-Mark-Recapture analyses.

[5] Bioresearches (2024). Lizard Management Plan: Macraes Phase 4 Project. Technical report prepared for OceanaGold. 93 p.

April 2024 data (i.e., using N-mixture models and capture-mark-recapture analysis) to estimate relative lizard abundance, detection probabilities, and lizard population sizes. Comparisons against the April 2024 data will allow further refinement of these estimates to better inform the effects management.

3 c) Provide comment on how the Zone of Impact buffer was determined taking into account known research into the home range and movement of the lizard species present.

The extent of the zone of impact buffer does not specifically consider home ranges of lizards but rather represents an area within which indirect mining effects (e.g., dust, rock fall, noise, vibration) may generally be expected to occur on a range of ecological aspects (e.g., plants, lizards, invertebrates, and birds). If one was to consider lizard home range size and movements for species identified in the MP4 footprint (McCann's and tussock skinks), then an average home range of 20.6 m^2 (range: 0.9–51.2 m^2)[6] would be apply (Patterson 1985[7]). The 100 m buffer, therefore, represents a highly conservative area over which potential effects on local lizards (covering the home ranges of many individuals) may be realised.

It is noted that a buffer zone width of 100 m has been applied at Macraes for previous terrestrial ecology effects assessments and has been accepted previously by Councils and their technical auditors. Where effect(s) is(are) expected to extend beyond 100 m then the full extent of the effect(s) is described in Section 6 of the IMP. Also refer to Section *4.2 Boundary of ecological impact of the project* of the Impact Management Plan (Ahika Consulting, 2024[8]) and see Whirika Consulting's s92 response to question *2c* for further details.

3 d) Regarding assessment of impact (Table 4.7 lizard survey doc) please outline your assessment of both local and regional impact in addition to the national impact.

The landscape scale assessment involved estimating both proportion of lizards and the extent of lizard habitat affected by the project compared to the lizard population size and lizard habitat extents on local (OGL Macraes landholdings), Ecological District (Macraes ED), and National (i.e., areas of New Zealand within the natural range of the species identified) scales. A regional-scale (i.e., Otago Region) assessment was not undertaken. Expert opinion, informed by published density estimates and more recently (April 2024), population estimates generated from the baseline monitoring work referred to in our response to Q 3a), was used to assess the number and proportion of lizards potentially affected and the Land Cover Database version 5.0, Mainland, New Zealand (LCDB v5.0) was used for a coarse assessment of affected lizard habitat at each of the landscape scales.

For clarity, the Magnitude of effect level as shown in Table 4.7 of the Herpetofauna survey report relates specifically to the magnitude at the local (OGL Macraes landholdings scale). Where local scale impacts

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[6] Average adjusted values based on Patterson (1985) (i.e., 7 captures/ m^2) and Christion & Waldschmidt (1984) (i.e., 16 captures/ m^2). Patterson (1985) indicated that home range sizes of McCann's and tussock skinks in his study probably lay between the adjusted area values for 7 and 16 captures, hence why the averaged value was used in the MP4 LMP.

[7] Patterson, G. B. (1985). The ecology and taxonomy of the common skink *Leiolopisma nigriplantare maccanni* in tussock grassland in Otago. Unpublished PhD thesis, University of Otago, Dunedin. 215 pp.

[8] Ahika Consulting (2024). Macraes Phase 4 Project: Ecology Impact Management Plan, March 2024. Report prepared for OceanaGold by Ahika Consulting Ltd (now known as Whirika Consulting Ltd).

were considered 'low' or 'negligible', then impacts across broader landscapes scales were typically considered to be lower, i.e., 'negligible'. Importantly, local scale impacts were used to describe the overall level of effect on lizards and their habitat, as this was the most conservative approach to the impact assessment.

Table 1 of this document provides an assessment of magnitude of effect on lizards (population size and proportion of total estimated population) and lizard habitat (hectares, ha) at different landscape scales, including local and regional (i.e., Otago Region) scales.

3 e) Please provide more information on the procedure for encountering unexpected populations of threatened lizards. We assume the impact of the activity on these lizards to be higher than on common or "at risk" species, resulting in stricter consideration of the effects management hierarchy and more specific and intensive management and monitoring considerations.

The inset box on p. 39 of the MP4 LMP, entitled "*Response to the detection of rare or threatened lizard species*" provides the basis for the approach to encountering 'Threatened' or 'At Risk' lizards other than those common lizards known to occur in the impact areas. Further to this, where such lizards are encountered, numbers will undoubtedly be low due to the paucity of high-quality habitat for 'Threatened' species (e.g., grand, Otago, and Otago green skinks) in the impact areas, failure to detect these species during the field surveys and recent (April 2024) baseline monitoring, and a general paucity of records of these species in the wider landscape over the past decade (refer to section "3.2.1 Desktop Assessment" of Herpetofauna Survey report for information on historical lizard survey efforts).

Because the number of 'Threatened' species will be small, the magnitude of any realised effect is unlikely to be more than 'moderate' and any potential adverse effects on these lizards will be addressed through a mitigation approach. Specifically, salvage and relocation to a protected, mammalian predator free area with suitable habitats (i.e., MEEA).

During the salvage operation, a shift in effort away from species with lower threat status to those with higher threat status will occur, to ensure all reasonable efforts are made to avoid impacts and recover each of the 'Threatened' individuals. 'Threatened' individuals would be relocated to the MEEA site where much higher quality habitat (e.g., complex rock tors, rocky screes, damp riparian gullies, etc) is present and where mammalian predation pressures will be removed (i.e., predator exclusion fence and on-going removal in response to threat incursion). The same conservation measures have been successfully applied historically for 'Threatened' lizards that may be encountered (i.e., relocation into fenced and pest free reserves which offers the best prospects for their survival) by the Department of Conservation and other conservation groups (Mokomoko dryland sanctuary). Thus, it is considered that the same approach can feasibly be applied as part of the MP4 Project.

Monitoring and management of any 'Threatened' species will be more intensive than that proposed for other species. This will involve targeted monitoring at the release sites including tor observations for grand and Otago skinks and specifically placed ACO grids in damper areas where Otago green skinks would be released. Monitoring will focus on establishing post-release survival and site fidelity, and longer-term monitoring over a 10-year period will measure establishment and expected population expansion in the MEEA. Should 'Threatened' species be encountered, the scale and specifications of the monitoring will be rapidly developed according to prevailing good practice[9] and in consultation with the Department of Conservation.

While the detection of 'Threatened' lizard species in the MP4 Project will raise the 'species' values of the impact areas, magnitude of effect is unlikely to be markedly changed because lizard numbers will be very low, and mitigation measures (e.g., salvage, relocation, and monitoring) will adequately reduce adverse effects.

3 f) Further information is required regarding the release site at MEEA

i. What is the current and expected carrying capacity of the various lizard species at the sites?

Based on the recent population modelling data[10], current skink densities within the MEEA area are on average around 350–880 individuals per hectare, or ~32,000–80,000 skinks (see section "*4.3 Lizard population size estimates*" of the LMP). Gecko densities are not known but are expected to be approximately 30–45% of that of the skinks (based on information from historical lizard salvages in similar habitats e.g., Deepdell North III). The current carrying capacity is also unknown and difficult to measure but considering that the environment is currently grazed by livestock, supports populations of feral pigs, deer, and goats, and is not subject to any mammalian predator control, it is expected that the site's lizard carrying capacity is below its potential.

The potential of the site to support greater lizard numbers is highlighted by the results of published research that have shown up to four-fold increases in lizard abundance in dryland tussock habitats where livestock exclusion and mammalian predator control are implemented (Reardon *et al.,* 2012; Norbury *et al.,* 2022). Furthermore, lizard densities in tussock/ dryland ecosystems of more than 2,000 lizards/ ha have been reported in the literature (Dixon 2005[11]) suggesting that the MEEA site has much greater potential to support additional lizards. It is likely that more than 2,000 lizards/ ha could be realised as a result of the mammalian predator exclusion/ control and habitat enhancement proposed for the MEEA. That is, a potential increase of 100,000–150,000 additional lizards in the MEEA (i.e., approximately 1–3 times the number of lizards affected by the MP4 mine extensions).

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[9] Roughton, C.M., 2005. Assessment of methods to monitor Otago skink and grand skink populations, New Zealand. Science & Technical Publishing, Department of Conservation.
Bogisch, M., 2014. Comparing the use of time-lapse photography and visual observations for post release monitoring of Otago Skinks. Otago University Wildlife Management Report (276).
Roughton, C.M. and Seddon, P.J., 2006. Estimating site occupancy and detectability of an endangered New Zealand lizard, the Otago skink (*Oligosoma otagense*). Wildlife Research, 33(3), pp.193-198.

[10] Proteus (2024). Analysis of Macraes Flat Lizard Monitoring Data. Client Report for [Bioreseerachers]. 30th July 2024.

[11] Dixon, K.M., 2005. Biodiversity along a gradient of modification: plant invertebrates and reptile diversity in mid-altitude tall tussock (*Chionochloa rigida*) grasslands, eastern Central Otago, New Zealand (Doctoral dissertation, University of Otago).

ii. How are the various actions of fencing, predator control, rocky habitat creation, planting going to impact the carrying capacity?

Native lizards, and their terrestrial invertebrate prey, are vulnerable to mammalian predators and are negatively affected by livestock grazing, which reduces vegetation cover (Didham *et al.* 2009; St Clair 2011; Ruscoe et al 2012[12]). Previous studies have shown that management interventions (e.g., livestock exclusion, then mammalian pest eradication/ control) can result in positive lizard and invertebrate population responses (Reardon *et al*., 2012; Norbury *et al*., 2022; Rufaut & Gibbs 2003; Towns et al. 2006; Watts et al. 2011[13]). For example, increases in abundance of lizards of up to four-fold have been demonstrated in areas subject to intensive mammalian predator control (e.g., excluding mouse control, Reardon *et al.,* 2012; including mouse control, Norbury *et al*., 2022[11]), up to 3-fold increases in wēta abundance occurred following rat control (Ruscoe *et al.* 2012[10]), and leaflitter invertebrate abundance was shown to be markedly higher (10–100-fold) in areas where livestock had been excluded (Didham *et al.* 2009[10]). In addition, habitat creation/ supplementation (e.g., addition of rock piles and native planting), coupled with mammalian predator management, is considered a viable strategy for restoring lizard communities (Herbert 2020[14]).

Population growth in response to management actions is proven by other New Zealand examples and this highlights the potential capacity of the landscape to support higher abundances of native fauna where management interventions are implemented. That is, landscapes not subject to management support populations below carrying capacity, and when management interventions are put in place, the capacity is increased, often dramatically. Accordingly, it is expected that the carrying capacity of MEEA and Murphys buffer areas (mitigation areas) will be markedly increased to align more closely with historical natural ecosystems following the proposed MP4 Project management interventions. For lizards, a 2–4-fold increase in population size could be expected in the MEEA as a result of the proposed MP4 management measures.

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[12] Didham *et al.* (2009). The interactive effects of livestock exclusion and mammalian pest control on the restoration of invertebrate communities in small forest remnants. New Zealand *Journal of Zoology*, 36 (2): 135-163.

St Clair, J.J.H. 2011. The impacts of invasive rodents on island invertebrates. Biological Conservation 144:68–81.

Ruscoe *et al.* (2013). Effects of spatially extensive control of invasive rats on abundance of native invertebrates in mainland New Zealand forests. *Conservation Biology*, 27 (1): 74-82.

[13] Reardon et al. (2012). Predator control allows critically endangered lizards to recover on mainland New Zealand. *New Zealand Journal of Ecology*, pp.141-150.

Norbury et al. (2022). Density-impact functions for invasive house mouse (*Mus musculus*) effects on indigenous lizards and invertebrates. *Biological Invasions*: 1-15.

Rufaut, C. G., & G. W. Gibbs. 2003. Response of a tree weta population (*Hemideina crassidens*) after eradication of the polynesian rat from a New Zealand Island. *Restoration Ecology* 11:13–19.

Towns, D., I. Atkinson, and C. Daugherty. 2006. Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions* 8:863–891.

Watts, C. H., D. P. Armstrong, J. Innes, and D. Thornburrow. 2011. Dramatic increases in weta (Orthoptera) following mammal eradication on Maungatautari – evidence from pitfalls and tracking tunnels. *New Zealand Journal of Ecology* 35:261–272

[14] Herbert, S. M. (2020). Is habitat enhancement a viable strategy for conserving New Zealand's endemic lizards? Unpublished PhD thesis, Victoria University of Wellington. 274 p.

iii. How has the expected stress and loss of individuals been accounted for in these calculations?

The lizard salvage and relocation programme only aims to capture a proportion of the total population affected by the project for reasons outlined in the LMP (see section "*5.3 Salvage programme parameters and strategy*"). These individuals will be relocated to the MEEA using accepted good practice methods that reduce stress (e.g., limiting the time between capture and release and releasing into areas with adequate cover, including created cover). The salvage and relocation methods described in the LMP typically accord with accepted good practice for lizard mitigation projects that occur across New Zealand, including those previously approved by DOC, iwi, and Regional/ District Councils.

The loss of individuals not salvaged from impact areas has been accounted for in the lizard offset model whereby management interventions (mammal exclusion fencing, mammalian predator eradication and control, habitat enhancement) will facilitate the growth of lizard populations above the current levels in the MEEA. The growth in lizard numbers in the management areas are expected to outweigh the number of lizards lost in the footprint over the medium- to longer-term (~10 years).

The loss of invertebrates and any stress will not be directly addressed, except for mitigation actions for proposed for the 'Threatened' moth *Orocrambus sophistes*. It is assumed that positive community-level and population responses in invertebrates will result from the management actions in the MEEA. Previous studies have demonstrated positive responses in wēta abundance following rat control (Ruscoe *et al.* 2012[11]) and overall, net positive benefits for all invertebrate groups are expected as a result of the MP4 Project.

3 g) What is the overall biodiversity gain for the lizard population and how has this been determined?

The MP4 biodiversity offset aims to achieve a 'No Net Loss' (NNL) and preferably 'Net Gain' (NG) outcome for all ecological values, including lizard populations, affected by the project. The MP4 Project offset modelling was undertaken by Ahika (now Whirika) Consulting and is described in the Impact Management Plan (Ahika Consulting 2024). Considering actual data on relative lizard population abundance in the impact and proposed mitigation sites is now available (see section *4.3 Lizard population size estimates* in the revised LMP, dated 30 July 2024), the offset models are being revised to determine the target required to result in NNL. The NNL target, plus a 5% buffer to this target, will deliver a NG result. In general, NG outcomes are expected to be realised as a result of the project considering up to four-fold increases in lizard abundance have been demonstrated at other sites where management actions identical to those proposed for the MP4 Project have been implemented (e.g., intensive mammalian predator control and fences) (Reardon *et al.* 2012; Norbury *et al*. 2022[11]).

4 a) The invertebrate assessment is clear that the survey effort was limited to short surveys in Autumn and Spring 2022. Given the presence of a nationally vulnerable species (*Orocrambus sophistes*) in the GBWRS and the recognition that it is likely other at risk species are present further detailed survey work is necessary to support the ecological impact assessment. Is further work scheduled to improve the robustness of the assessment?

Additional moth surveys to better understand the distribution and abundance of *Orocrambus sophistes* in the GBWRS/ GB2 Pit footprints are planned prior to any works commencing at these sites. Considering this species is an Autumn flier, moth surveys would only be undertaken in the months of March to May 2025. For other invertebrates, no additional invertebrate survey work is currently proposed other than the opportunistic terrestrial invertebrates that are recorded during the baseline lizard monitoring work.

Yours sincerely,

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Table 1. Assessment of magnitude of effect on lizards (population size) and lizard habitat (hectares, ha) at different landscape scales.

Project Component	Attribute	Value (lizard numbers and affected area)	Local (OGL Landholdings) ~13,000 ha	Ecological District (Macraes ED) ~113, 000 ha	Regional (Otago Region) ~3M ha	National (lower South Island) ~6M ha
CO6 Pit	Lizards	~945	<5% of population **Low**	<1% **Low**	<0.5% **Negligible**	<0.05% **Negligible**
	Lizard habitat	5.54 ha	<1% of available habitat **Low**	<0.5% **Negligible**	<0.5% **Negligible**	<0.5% **Negligible**
CN BF	Lizards	~10	<1% of population **Negligible**	<0.5% **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**
	Lizard habitat	0.2 ha	<0.05% of available habitat **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**
NGWRS	Lizards	~10,800*	<1% of population **Low**	<0.5% **Negligible**	<0.5% **Negligible**	<0.5% **Negligible**
	Lizard habitat	17.6 ha (low quality)	<0.5% of available habitat **Low**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**
GB2 Pit	Lizards	~11,600	<5% of population **Moderate**	<1% **Low**	<0.5% **Negligible**	<0.05% **Negligible**
	Lizard habitat	5 ha (high quality)	<1% of available habitat **Low**	<0.5% **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**
GB WRS	Lizards	~24,500	<5% of population **Moderate**	<1% **Low**	<0.5% **Negligible**	<0.5% **Negligible**

	Lizard habitat	72 ha (48 ha of high quality)	<1% of available habitat **Moderate**	<0.5% **Low**	<0.05% **Negligible**	<0.05% **Negligible**
IM 9 Pit	Lizards	~256*	<0.05% of population **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**
	Lizard habitat	~0.46 ha (low value)	<0.05% of available habitat **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
IM 10 Pit	Lizards	~1,995*	<5% of population **Low**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
	Lizard habitat	3.9 ha (low quality)	<0.05% of available habitat **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
Frasers BF/WRS	Lizards	0	N/A **Negligible**	N/A **Negligible**	N/A **Negligible**	N/A Negligible
	Lizard habitat	0 ha	N/A **Negligible**	N/A **Negligible**	N/A **Negligible**	N/A Negligible
GB RR	Lizards	~460	<1% of population **Low**	<0.5% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
	Lizard habitat	1.47 ha (low quality)	<0.5% of available habitat **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
GP BB	Lizards	~307	<1% of population **Low**	<0.5% **Negligible**	<0.05% **Negligible**	<0.05% Negligible
	Lizard habitat	0.6 ha (low quality)	<0.05% of available habitat **Negligible**	<0.05% **Negligible**	<0.05% **Negligible**	<0.05% Negligible

* Unlikely to be an accurate (reliable) estimate given the low-quality of the habitat.

ATTACHMENTS

Attachment 1. Lizard Management Plan: Macraes Phase 4 Project (30 July 2024).

Attachment 2. Proteus (2024). Analysis of Macraes Flat Lizard Monitoring Data. Client Report for Bioreseracher [*sic*]. 30th July 2024.

LIZARD MANAGEMENT PLAN

MACRAES PHASE 4 PROJECT

30 JULY 2024

LIZARD MANAGEMENT PLAN

MACRAES PHASE 4 PROJECT

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FOR: OCEANAGOLD LIMITED

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REVIEW & APPROVED FOR RELEASE BY:
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COVER ILLUSTRATION: KŌRERO GECKO (*WOODWORTHIA* "OTAGO/ SOUTHLAND LARGE"), MACRAES

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1 EXECUTIVE SUMMARY

- OceanaGold (New Zealand) Limited is proposing to extend the life of mine ("LOM") at its Macraes Gold Project ("MGP"). The Macraes Phase 4 ("MP4") Stage 3 Project is an extension to the existing consented projects and would extend the LOM to around year 2030. The MP4 Project is comprised of ten Project Components ("PCs"), each of which represents an area of mine that would be subject to development, including the construction of new haul roads, realignment of existing roads, mining pit and waste rock disposal area expansions.
- A herpetofauna survey between April and September 2022 confirmed the presence of at least three native lizard taxa (*Oligosoma maccanni*, *Oligosoma chionochloescens*, and *Woodworthia* "Otago/ Southland large") in areas either directly and/ or indirectly impacted by the proposed MP4 activities. All three taxa are legally protected, and the latter two species are listed at 'At Risk—Declining' under the New Zealand threat classification system.
- An assessment of herpetofauna values and effects[1] identified that in the absence of mitigation measures, a level of effect ranging from Very low to High depending on the nature of the PC could be expected on native lizards. To avoid and/ or reduce the level of effect, the mitigation hierarchy (avoid, remedy, mitigate, offset, or compensate) was applied and measures to mitigate effects on native lizards and their habitat were outlined.
- This Lizard Management Plan identifies and guides actions required to manage lizards (and their habitats[2]) during the MP4 Project activities. Its purpose is to ensure that impacts on native lizards are reduced as far as practicable to comply with environmental legislation. Activities outlined in the LMP will be implemented under a Wildlife Act 1953 Authority ("WAA"), issued by the Department of Conservation for the purpose of protecting native wildlife (e.g., lizards).
- Measures proposed by OGL to address adverse effects on native lizards:
    - Avoidance of higher value lizard habitat through project redesign and refinement, avoidance of indirect effects of mining operations on the immediately surrounding landscape, and prioritisation of previously disturbed land for siting new project infrastructure to avoid unnecessary effects on undisturbed lizard habitat.
    - Remediate and rehabilitate waste rock stacks and re-create rocky habitats for lizards through deposition of larger aggregate and boulders.
    - Mitigate impacts by salvaging a target of 2,100 lizards from the impact areas and relocating them into a 91 ha area where mammalian predators have been controlled or excluded by a combination of predator control and a pest-proof fence (surrounded by a 1 km buffer mammalian predator control area). The predator control operation will be two-phased to account for project timelines and will involve an interim intensive predator control programme over approximately 20 ha of land (surrounded by approximately 140 ha of buffer control), followed by the construction of the fence

[1] Bioresearches (2024). Herpetofauna Assessment: Macraes MP4. Unpublished technical report prepared for OceanaGold Limited. 68 p.
[2] The loss of vegetation and lizard habitat is largely addressed by the MP4 Impact Management Plan (Ahikā Consulting, 2024a).

and eradication of predators within. Also, mitigate any potential indirect effects of the MP4 activities on surrounding lizard habitat through site controls and operating practices.

- Offset and compensate for residual effects on native lizards and their habitat by applying an offset package (Ahikā Consulting, 2024a), that includes contingencies, adaptive management, and long-term lizard monitoring to ensure stated goals are achieved in specified timeframes. An initial no net loss target has been established, but this is to be refined/ confirmed following consultation with relevant stakeholders.

- A key component of the LMP is the robust lizard monitoring programme that will provide information crucial for the evaluation of the impact and successes or otherwise of enacted management measures. The monitoring programme will include baseline monitoring, buffer area monitoring, and post-release lizard monitoring, commencing in April 2024 and will continue for at least 10 years.
- A range of compensatory actions are provided for as contingency measures for unanticipated adverse effects on lizards resulting from the MP4 Project.

2 INTRODUCTION

OceanaGold is proposing to extend the life of mine ("LOM") at its Macraes Gold Project ("MGP"). The Macraes Phase 4 ("MP4") Stage 3 Project (hereafter "MP4 Project") is an extension of existing consented projects (e.g., Macraes Phase 3 [MP3]) and would extend the LOM to around year 2030. The primary development activities associated with the MP4 Project include open mining pit expansions (Coronation Pit Stage 6, Innes Mills Pit Stages 9–10, and Golden Bar Stage 2 Pit), waste rock disposal (in pit backfilling and extending the Golden Bar waste rock stack), rehandling waste rock from Northern Gully Waste Rock Stack, ore stockpiling, a minor road realignment of Golden Bar Road.

The MP4 Project covers a total area of approximately 537 ha (i.e., Zone of Impact; "ZOI"), which includes a 296 ha impact footprint area (where mining activities will take place) and a 240 ha buffer zone (a 100 m buffer area surrounding the impact footprint where indirect effects of mining activities may be realised). The 537 ha project area is divided into ten[3] Project Components ("PCs"), each of which represents an area of mine that would be subject to development. The PCs range in size and are distributed widely across the OGL landholdings (Figure 2.1). Existing resource consent (consented under Macraes Phase 3, "MP3") is held by OGL for mining activities over most (307 ha or 57%) of the 537 ha MP4 Project area. Stage 3 seeks to obtain resource consent for an extension of mining activities over the differential 229 ha of land, which includes 124 ha of land directly impacted by mining and 105 ha in a surrounding buffer zone where indirect effects are anticipated (i.e., some of the areas within the ZOI are already consented and therefore, effects on those areas have already been considered and addressed elsewhere) (Table 2.1; Figure 2.1).

The MP4 mining activities are expected to have potential adverse ecological effects on a range of biodiversity values within the ZOI (Ahikā Consulting, 2024a), including impacts on resident, protected native lizards (Bioresearches, 2024). Direct impacts on lizards are expected to occur over an area of approximately 90 ha of land that supports suitable lizard habitat. Accordingly, management measures for native lizards and their habitats are required to mitigate the adverse impacts resulting from the mine development (Bioresearches, 2024) and a Wildlife Act Authority ("WAA") is required to authorise lizard mitigation activities (i.e., lizard salvage and relocation). This Lizard Management Plan ("LMP") has been prepared to identify and guide actions required to ensure potential adverse effects on lizards resulting from the MP4 mine developments are appropriately managed and that any activity that potentially impacts native lizards complies with environmental legislation (notably the Wildlife Act 1953[4]).

[3] For the purposes of this document the Frasers Backfill and Frasers WRS are combined into a single Frasers BF/WRS project component as these features will have very similar effects (being earthworks associated with excavation or deposition of rock) with large areas of overlap.

[4] For MP4, mitigation measures required under the Resource Management Act (1991) to address impacts on vegetation and landscape features that provide significant habitat for indigenous biodiversity (including lizards) are outlined in the project wide MP4 Impact Management Plan (Ahikā Consulting, 2024a).

Areal extent measurements

Areal extent measurements (in hectares, “ha”) of Project Component footprints and buffer zones were taken from shape files supplied by OceanaGold Limited and using high-definition aerial photographs (i.e., LINZ aerial basemaps and high-definition drone images) in the GIS programme, QGIS (v. 3.34.3). Similarly, the areal extents of various identified habitat types were mapped based on the most recently available (2020–2023) aerial imagery.

While all measurements were regarded as accurate at the time of report delivery, it is acknowledged that variations in areal extents across this and other technical reports are expected due to mapping inconsistencies by authors. Any discrepancies will be minor and should be considered immaterial given the landscape scale of the MP4 Stage 3 project.

Table 2.1. Macraes Phase 4 Project Components (PCs) and their areal extents (in ha), total area inside the footprints and 100 m buffers of all PCs combined (non-overlapping), and the overall area of the Zone of Impact (ZOI) (i.e., all PCs combined excluding PC overlap). Note: that the extent of lizard habitat within each PC is markedly less than the total land area.

	Project Component name	Acronym	PC footprint area (ha)	PC buffer area (ha)	Unconsented PC footprint area (ha)	Unconsented PC buffer area (ha)
1	Coronation 6 Pit	CO6 Pit	25.0	27.1	5.5	7.1
2	Coronation North Backfill	CN BF	37.6	30.5	0.05	2.1
3	Northern Gully Waste Rock Stack	NGWRS	21.2	0[5]	21.2	0
4	Golden Bar Stage 2 Pit	GB2 Pit	22.7	20.1	22.7	20.1
5	Golden Bar Waste Rock Stack	GB WRS	48.0	32.8	48.0	32.8
6	Innes Mills Stage 9 Pit	IM9 Pit	5.6	15.6	5.6	6.1
7	Innes Mills Stage 10 Pit	IM10 Pit	5.9	16.3	5.9	8.2
8	Frasers Backfill/Waste Rock Stack	Frasers BF/WRS	91.1	47.1	0	0.4
9	Golden Bar Road realignment (indicative)	GB RR	1.2	16.6	1.2	16.6
10	Golden Point Backfill Buttress	GP BB	38.1	40.1	14.2	17.1
	Total area inside footprints and buffers (non-overlapping)		**296.4**	**240.2**	**124.3**	**105.3**
	Total area inside ZOI		**536.6**		**229.6**	

[5] It should be noted that the NGWRS footprint area is highly conservative. That is, the actual extent of the impact associated with the rehandling of waste rock will be smaller the PC outline. Therefore, the 100 m buffer has not been applied and instead, represents an estimate of the total area inclusive of a buffer zone.

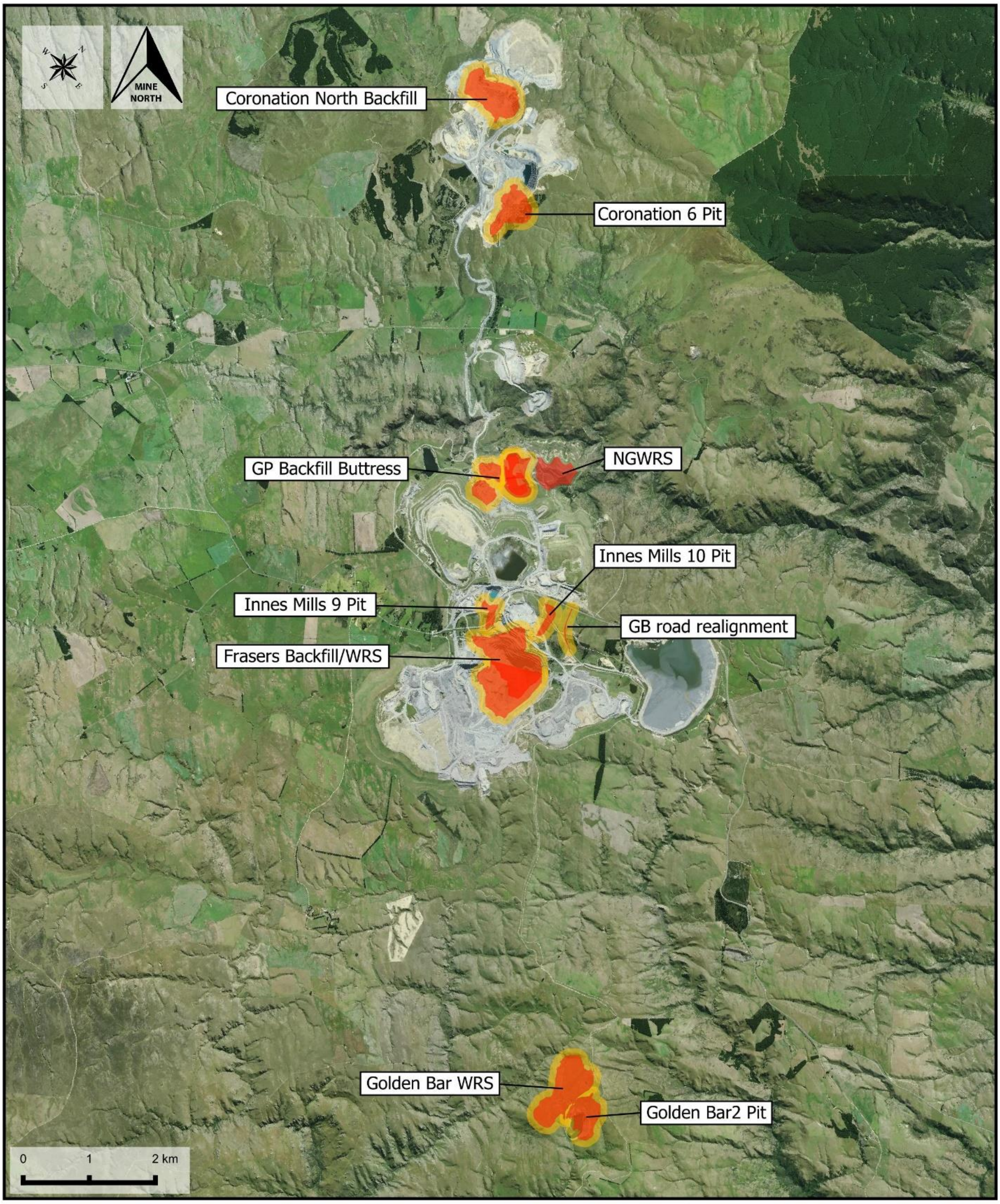

Figure 2.1
Macraes MP4 Stage 3: Zone of Impact (ZOI)

CLIENT / PROJECT
OceanaGold Limited

13 February 2024

MAP PROJECTION:
NZGD2000 / New Zealand Transverse Mercator 2000

SOURCES:
LINZ Basemap aerial

SCALE **@ A4 1:75,000**

61130#BEE09

Legend

MP4 Zone of Impact
Project Components

Impact areas (direct impact)

100 m buffer (indirect impact)

Bioresearches
A Babbage Company

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

3 CONTEXT OF THE LIZARD MANAGEMENT PLAN

Herpetofauna (reptiles and amphibians) comprise a significant component of New Zealand's terrestrial fauna. Mokomoko/ lizards (which includes skinks and geckos) are represented by 125 endemic taxa[6] (van Winkel *et al*., 2018; Hitchmough *et al.,* 2021; Purdie, 2022). Of these, more than 85% are classified as 'Threatened' or 'At Risk' of extinction under the New Zealand Threat Classification System (Townsend *et al.* 2008; Hitchmough *et al*. 2021). All native lizards are legally protected under the Wildlife Act 1953 ("WA") (and subsequent amendments) and significant habitats[7] of indigenous fauna (including lizards) are protected under the Resource Management Act 1991 ("RMA"). For Otago, the Proposed Otago Regional Policy Statement ("PORPS")[8] gives effect to the RMA through a variety of objectives and policies aimed at protecting, maintaining, and enhancing biodiversity values[9]. Thus, statutory obligations require the management of native lizards where they or their habitats are threatened by land disturbance or development.

A LMP is a site- or project-specific plan that is prepared to identify and guide actions required to manage lizards and their habitats when disturbance or modification to land is proposed. Lizard Management Plans aim to ensure that any activity that potentially impacts native lizards complies with environmental legislation. A LMP is typically implemented under a Wildlife Act 1953 Authority ("WAA") that is issued by the Department of Conservation ("DOC") for the purpose of protecting native wildlife (e.g. lizards).

3.1 PURPOSE OF THIS LMP

This Lizard Management Plan (LMP) has been developed to:

- Clearly document and describe the objectives, strategy, and actions that OGL will take to manage and mitigate adverse effects on native lizards arising from WAA and resource consent considerations relating the MP4 Project.

Objectives of the LMP include:

- Detail the actions to be followed by OGL to avoid and minimise adverse effects of mining activities on lizard populations occurring in the MP4 Project areas;
- Ensure as far as practicable, that the management of lizards during the pre-mining, operation, and post-mining phases of the mine complies with any conditions or statutory approvals imposed;

[6] The term "taxa" is used instead of "species" because many New Zealand lizards, including some present within the project area, have not been formally described to species level.
[7] The term 'significant' is not defined by the RMA but for the purpose of this assessment, "significant habitats" has been interpreted as habitat that provides all the necessary needs for persistence of lizard populations in an environment (i.e., food, shelter, areas for reproduction). It is weighted more heavily towards habitats for 'Threatened' or 'At Risk' species.
[8] The Proposed Otago Regional Policy Statement or PORPS is not yet operative. The hearings concluded in late 2023; however, it is not yet known when decisions will be issued.
[9] Under the PORPS, the following objectives and policies would apply to the Macraes Projects: Objectives ECO-01, ECO-02, and ECO-03 and Policies ECO-P1 (Kaitiakitaka), ECO-P2 (significant natural areas and taoka), ECO-P3 (protecting significant areas and taoka), ECO-P4 (provision for new activities), ECO-P6 (maintaining indigenous biodiversity), and ECO-P8 (enhancement). As well as APP2 – Significance criteria for indigenous biodiversity, APP3 – Criteria for biodiversity offsetting, and APP4 – Criteria for biodiversity compensation.

- Identify the methodologies that will be used to salvage and relocate lizards from affected areas to suitably protected and enhanced sites;
- Identify and implement measures to enhance populations of each lizard species in protected areas outside of the project impact areas (e.g., mitigation or offset sites) to achieve a no net loss (preferably net gain) outcome;
- Outline habitat enhancement measures relevant to lizards to be carried out within the MP4 mitigation site;
- Identify monitoring that will be undertaken to assess progress against the objectives of the LMP and targets set in the MP4 Impact management plan (Ahikā Consulting, 2024a); and
- Identification of compensatory actions to act as contingency measures for unanticipated adverse effects on lizards resulting from the MP4 Projects.

3.2 MANA WHENUA AND STAKEHOLDER ENGAGEMENT

OceanaGold Limited has (since May 2022) and continues its efforts to engage with mana whenua (Ngāi Tahu, via Aukaha) and relevant stakeholders (DOC, Otago Regional Council, and lease holders) regarding cultural perspectives, land-use, and ecological management proposals (e.g., salvage and relocation of mokomoko/ native lizards) related to the MP4 Project. Cultural, social, and ecological perspectives, including the management and care of taonga/ taoka species, have been considered and incorporated into the LMP. OceanaGold Limited recognise the importance of mana whenua engagement in all aspects of the management of mokomoko as part of the MP4 Project (e.g., LMP refinement, capture, relocation, and monitoring) and are actively pursuing engagement with mana whenua via Aukaha.

At the time of writing this LMP no formal feedback on lizards has been received from any stakeholders. Engagement in respect of the MP4 Project has thus far not raised any significant concerns regarding the management of mokomoko. However, it is anticipated that further refinement to the methods/ management actions proposed will occur through ongoing engagement with DOC, Waikato District Council ("WDC") and iwi and refinements.

3.3 PLAN STRUCTURE

This LMP addresses the management of effects related to the currently unconsented components of the MP4 Project for which mitigation, including salvage and relocation, and offsetting are required under both the RMA and the WA. The MP4 Project is comprised of several discrete project components across OceanaGold landholdings, and the effects management for all PCs are bundled together in one overarching Impact Management ('mitigation') Plan (Ahikā Consulting, 2024a). The LMP does not explicitly cover the management of effects on lizard habitats affected by MP4 (this is covered in the Impact Management Plan; Ahikā Consulting, 2024a), but the LMP does address habitat enhancement required to increase the probability of the survival and long-term persistence of salvaged and relocated lizards as part of the MP4 Project. To provide clarity around how this LMP and the WAA application sit within this structurally complex project, a flow chart has been developed (Figure 3.1).

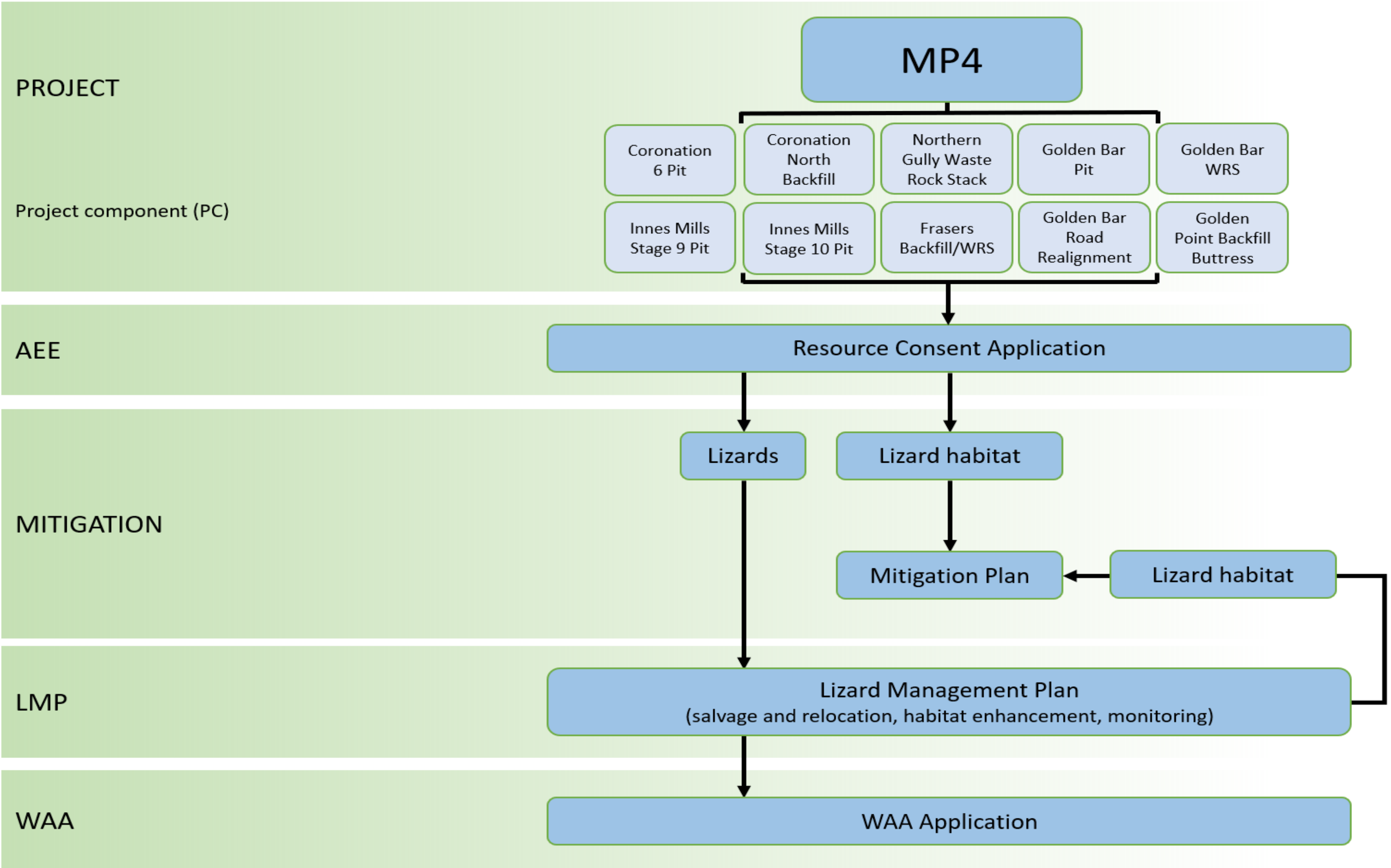

Figure 3.1. Flow diagram demonstrating how the different elements of the MP4 Project are related. Note: Only Project Components (PCs) mentioned in this LMP are shown (i.e., Northern Gully Waste Rock Stack has not been assessed as part of this report). AEE=Assessment of Ecological Effects; LMP=Lizard Management Plan; WAA=Wildlife Act Authority.

3.3.1 Consistent and informed approach

To ensure national consistency, this LMP generally adheres to the Department of Conservation guidance and key principles for lizard salvage and transfer in New Zealand (NZLizardTAG, 2019; Figure 2.2) though, some elements of the LMP have been adapted based on the expert opinion of the Project herpetologist.

Figure 2.2. The Department's nine key principles for lizard salvage and transfer:

1. Lizard species' values and site significance must be assessed at both the impact (development) and receiving sites.
2. Actual and potential development-related effects and their significance must be assessed.
3. Alternatives to moving lizards must be considered.
4. Threatened lizard species require more careful consideration than less-threatened species.
5. Lizard salvage, transfer and release must use the best available methodology.
6. Receiving sites and their carrying capacities must be suitable in the long term.
7. Monitoring is required to evaluate the salvage operation.
8. Reporting is required to communicate outcomes of salvage operations and facilitate process improvements.
9. Contingency actions are required when lizard salvage and transfer activities fail.

Pertinent to the current LMP are the recommendations that emerged from the Deepdell North III Project lizard salvage (LizardExpertNZ, 2021; Appendix I). Several important lessons learnt, including but not limited to the risk of underestimating salvage numbers, 'stopping rules'[10], and appropriate salvage season, have been taken into consideration in developing this LMP. Additionally, the LMP recommendations have been considered alongside a draft lizard management strategy for Macraes mine to ensure a consistent approach and alignment with OGL's overarching lizard management strategy.

Since this LMP forms part of a wider ecological assessment and effects management package, the Plan has been informed or guided by, the following documents where relevant:

1. The Macraes MP4 Herpetofauna Survey report (Bioresearches 2024);
2. MP4 Project: Assessment of Effects on Vegetation & Avifauna. (Ahikā Consulting 2024b);
3. MP4 Impact Management Plan (Ahikā Consulting 2024a); and
4. Draft lizard management strategy: OceanaGold Operations, Macraes Flat (in development).

[10] A stopping rule is a mechanism for deciding whether to cease a process based on the present position and past events. In the context of this LMP, a stopping rule is a trigger (e.g., amount of effort, number of lizards) that once reached, leads to the cessation of a lizard salvage programme.

3.4 Responsibilities and competencies

The roles and responsibilities for implementation of the LMP are set out as follows. OGL hold overall accountability and the environmental/ sustainability and project managers will be responsible for implementation and compliance with this part of the over-arching Impact Management Plan (Ahikā Consulting 2024a).

The Project herpetologist (Appendix V) takes a technical lead and must be suitably qualified and experienced in lizard handling, including salvage and relocation operations, and hold a current WAA to capture, handle and relocate protected native lizards. The Project herpetologist will liaise with the other roles through OGL's Project Manager. Supporting ecologists and/ or ecological sub-contractors that will contribute to the LMP protocols required before, during, and after mine development shall be suitably experienced in lizard surveys and handling and will act under the supervision of the lead Project herpetologist.

4 LIZARD EFFECTS ASSESSMENT OVERVIEW

A comprehensive effects assessment for the MP4 Project is provided by Ahikā Consulting (2024a) and Bioresearches (2024). These documents should be read in conjunction with this LMP; however, the effects assessments are briefly summarised below for convenience.

4.1 AREAS OF AFFECTED HABITAT

4.1.1 MP4 Project

The MP4 Project is comprised of ten PCs that are widely distributed across the OGL landholdings (Figure 2.1). Each PC represents an area of land that would be subject to the effects of mining development and all PCs combined form the ZOI. Detailed descriptions of the vegetation and lizard habitat values identified within each of the PCs is provided by Ahikā Consulting (2024a, b) and Bioresearches (2024), respectively.

Ten broad habitat types were identified in the ZOI and of these, eight were considered to provide habitat value for lizards. These included rock tors/ tor complexes, shrubland, tussockland, riparian vegetation, exotic grassland (including rank and grazed pasture), ephemeral wetlands, exotic treeland (e.g., pine plantation, shelterbelts), and felled pine (Figure 4.1). Project components or parts of PCs that occur within existing pit disturbance limits (e.g., mine workings) were not considered to hold values for native lizards (e.g., Frasers BF/WRS). The areal extents of each habitat type within each of the PCs is presented in Table 4.1.

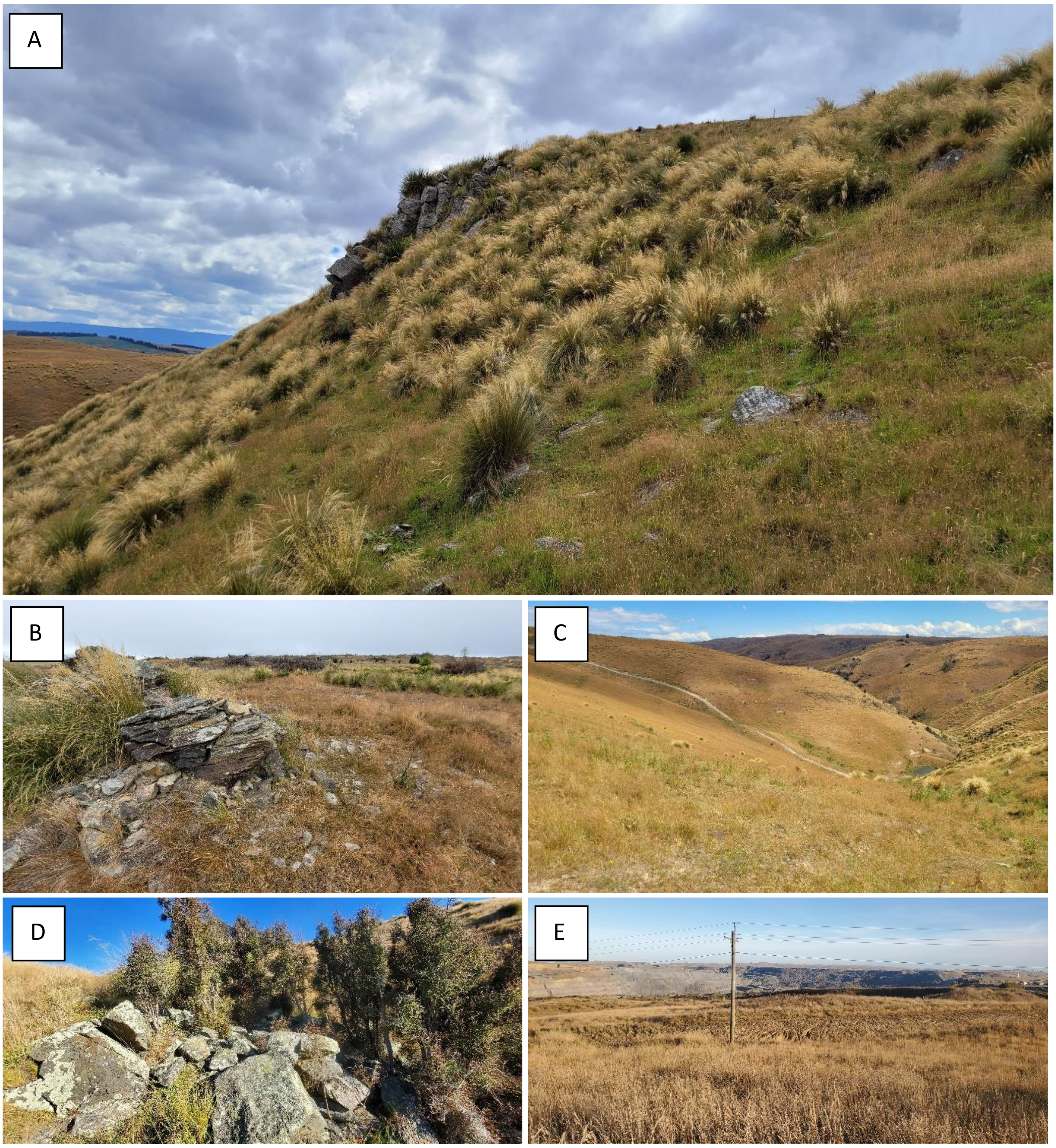

Figure 4.1. Selection of photographs showing some habitats considered suitable for lizards across the MP4 Project area (A, Golden Bar WRS; B, Coronation Pit; C & D, Golden Bar WRS; and E, Golden Bar Road Realignment).

Table 4.1. Areal extent (ha) of lizard habitat types directly impacted (i.e., within the footprint) in each Project Component (PC). Total values exclude PC/ habitat overlap. The number of tors is represented by a count. Green shaded squares indicate suitable lizard habitats. "Mine workings" and "Open water (ponds)" habitat categories do not provide suitable habitat for lizards.

Decreasing lizard habitat quality ↓

	Project Component										
Habitat type	**CO6 Pit**	**CN BF**	**NGWRS**	**GB2 Pit**	**GB WRS**	**IM9 Pit**	**IM10 Pit**	**Frasers BF/WRS**	GB RR	**GP BB**	**Total (Footprint)**
No. rock tors/ tor complexes	1	0	0	6	5	0	0	0	0	0	**12**
Rock tors	0.002	0	0	0.01	0.03	0	0	0	0	0	**0.04**
Shrubland	0	0	0	0	0.04	0	0	0	0	0	**0.04**
Tussockland	2.9	0	0	4.9	23.5	0	0.2	0	0.06	0	**31.6**
Riparian vegetation	0.02	0	0	0.03	0.3	0	0.1	0	0	0	**0.42**
Exotic grasses/pasture	0	0.02	17.6[11]	8.8	24.0	0.5	3.6	0	0.9	0.6	**38.37**
Ephemeral wetlands	0.02	0	0	0	0	0	0	0	0	0	**0.02**
Felled pine	2.6	0	0	0	0	0	0	0	0	0	**2.60**
Exotic treeland (incl. pine)	0	0	0	0	0	0	0	0	0	0	**0**
Mine workings	0	0.03	3.6	9.0	0	5.1	2	0	0.26	13.6	**30.0**
Open water (ponds)	0	0	0	0.05	0.1	0	0	0	0	0	**0.15**
Total (all suitable lizard habitat)	**5.5**	**0.02**	**21.2**	**13.7**	**48.0**	**0.5**	**3.9**	**0**	**0.9**	**0.6**	**90.7**
Total (all habitat types)	**5.5**	**0.05**	**17.6**	**22.8**	**48.0**	**5.6**	**5.9**	**0**	**1.2**	**14.2**	**124.4**

[11] The NGWRS habitat types are referred to as "Rehabilitated mine workings" in Ahikā Consulting (2024a).

4.2 Affected lizard species and populations

The Otago Region supports a high diversity and abundance of lizards due in part to the presence of rock outcrops and the nature of schist rock, which tends to form horizontal crevices and large flat pancake-like stacks of rock slabs that provide habitat and refuge for lizards. The region is known to support 30 native lizard taxa and two introduced frogs (DOC Herpetofauna database; *accessed November 2022*). The Macraes Ecological District ("Macraes ED"), which covers an area of 1.14 M ha, supports a much lower herpetofauna diversity; represented by seven (or eight[12]) lizard taxa (Table 4.2). Macraes ED is the strong hold for populations of 'Nationally Endangered' grand skink (*Oligosoma grande*) and Otago skink (*O. otagense*).

4.2.1 MP4 lizards

The diversity of lizards known from the MP4 Project ZOI includes three species, kōrero gecko (*Woodworthia* "Otago/Southland large", 'At Risk—Declining'), tussock skink (*Oligosoma chionochloescens*, 'At Risk—Declining'), and McCann's skink (*O. maccanni*, 'Not Threatened'). Not all taxa were recorded in each of the PCs. Where detected, the relative abundance of McCann's skink and kōrero gecko in rocky outcrop/ tor, shrubland, rough pasture, and tussockland was relatively high, and tussock skinks were found at moderate abundance in an isolated pocket of grassy habitat and damper ground at Golden Bar WRS. Indeed, Golden Bar WRS supported a much higher abundance of lizards relative to other PCs (Bioresearches, 2024).

The potential presence of other lizard species such as grand skink, Otago skink, Otago green skink, and herbfield skink in the PCs cannot be dismissed based solely on the results of the herpetological surveys (Bioresearches, 2024). Recent (2014) records of Otago skinks in the upper Murphys catchment on OGL landholdings (EcoGecko, 2015) and very recent records of Otago green skinks (January 2023) and grand skinks (December 2023) from the landscape immediately surrounding the MP4 Project area suggest that remnant populations of these large and rare lizards may persist in the parts of the MP4 Project area. Similarly, the existence of herbfield skink in the wider surrounding landscape suggests the possibility of this taxon being present in one or more PCs. The rocky outcrops and schist tors in the buffer zone of the Golden Bar WRS appear to offer highly suitable habitat for the large saxicolous[13] grand and Otago skinks and the damper riparian and seep/ wetland habitats at Coronation 6 Pit and Golden Bar WRS could harbour residual populations of herbfield skink, or even the rarer Otago green skink.

[12] There is one 'suspect' record of a *Naultinus* sp. gecko (likely *N. gemmeus*) from the southern extent of the Macraes ED. This record has largely been ignored for purpose of this assessment because of the high unlikelihood that *Naultinus* gecko populations currently exist in the ED (Jewell & McQueen, 2007).

[13] Living on or among rocks.

Table 4.2. Herpetofauna of the Macraes Ecological District, corresponding NZ threat status (Hitchmough *et al.*, 2021) and occurrence within 20 km of the MP4 Project area. 20 km distance arbitrarily chosen to reflect 'local' lizard populations.

	Common name	Scientific name	NZ threat status*	Date of most recent record	Recorded in Macraes ED	Reported within 20 km
Native	Otago skink	*Oligosoma otagense*	Nationally Endangered	2016	✓	✓
Native	Grand skink	*Oligosoma grande*	Nationally Endangered	2023[A]	✓	✓
Native	Korero gecko	*Woodworthia* "Otago/ Southland large"	At Risk – Declining	2023	✓	✓
Native	Jewelled gecko	*Naultinus gemmeus*	At Risk – Declining	2019[B]	?[A]	✓
Native	Tussock skink	*Oligosoma chionochloescens*	At Risk – Declining	2024	✓	✓
Native	Herbfield skink	*Oligosoma murihiku*	At Risk – Declining	2019	✓	✓
Native	Otago green skink	*Oligosoma* aff. *chloronoton* "eastern Otago"	At Risk – Declining	2023[C]	✓	✓
Native	McCann's skink	*Oligosoma maccanni*	Not Threatened	2024	✓	✓
Exotic	Whistling tree frog	*Litoria ewingii*	Introduced & Naturalised	2023	✓	✓

[A] In December 2023, two grand skinks (a juvenile and an adult) were observed on rock tors in the proposed Redbank Ecological Covenant on OceanaGold landholdings, approximately 6.5 km west of GB WRS and 4.5 km southwest of IM9 Pit (L. Sherwood, Ahikā Consulting; pers. obs., 01/12/2023).
[B] Single record from Waianakarua Scenic Reserve, located north of Shag River and approximately 17.5 km northeast of MP4 Project area.
[C] In January 2023, a tracking tunnel print believed to be from an Otago green skink was recorded in the base of a valley in Deepdell Station Ecology Covenant, approximately 5.6 km due west of the Coronation 6 Pit PC (M. Tocher, unpub. data). This record was later verified by the observation of a live Otago green skink close to the location of the tracking tunnel that recorded the print (M. Tocher, pers. comm. 31/01/2024).

4.3 LIZARD POPULATION SIZE ESTIMATES

Understanding the size of populations occurring in the impact areas is fundamental to accurately assessing potential effects of the proposed mining development. However, determining the size of a lizard population size is inherently difficult due to imperfect detection caused by ecological and behavioural traits such as their small size, cryptic (secretive) nature of many taxa (e.g., herbfield skink, Otago green skink), the complexity of the habitats in which they live (e.g., some habitats such as rock tors cannot be searched/ surveyed effectively), and the large size of the impact areas.

For this LMP, attempts were made to estimate lizard density and lizard population size in select PCs and across MP4 impact area as a whole. Three methods were used, including 1) literature informed lizard density (skinks/ ha) extrapolations, 2) N-mixture modelling, and 3) Capture-Mark-Recapture analyses. Each method is briefly explained below.

4.3.1 Density extrapolation (literature informed)

To estimate lizard population sizes, we synthesised data from multiple sources, including on-site survey results and both grey and peer-reviewed scientific literature.

Specifically, information was gathered from the following sources:

1. Systematic searches across areas of OceanaGold landholdings (including the MP3 Back Road Waste Rock Stack [“BRWRS”], unnamed tributaries of Deepdell Creek, and the MP4 impact areas) by a herpetologist (D. van Winkel) in September 2022 and February 2023 (Bioresearches, 2024);
2. Walkthrough and targeted Gee’s Minnow trapping surveys of BRWRS and unnamed tributaries of Deepdell Creek by a herpetologist (M. Tocher, Lizard Expert NZ) over March to April 2022;
3. Historical lizards survey and monitoring results from previous projects/ stages of the Macraes mining operation (Ecogecko, 2013a; 2013b; 2015; LizardExpertNZ, 2021);
4. Historical lizard salvage results from previously projects/ stages of the Macraes mining operation (Ecogecko, 2013b; LizardExpertNZ, 2021); and
5. Published literature on estimated population densities of lizards in similar habitat types in the Otago Region (Patterson, 1984; 1985; Dixon, 2004; Clark, 2006; Jones, 2013).

We retrieved estimated lizard density values for populations inhabiting similar habitat types in the Otago Region. The density values were then scrutinised by the Project herpetologist and professional judgment used to make predictions of expected population size ranges for each taxon within the MP4 impact area (“informed density range estimates”) (Table 4.3). The Project herpetologist’s field observations of habitat extent, quality, and relative lizard abundance across the impact areas, and professional experience implementing numerous lizard salvages nationally weighed heavily in considering the expected population size ranges for each species. Furthermore, previous Macraes mine lizard salvage numbers and densities provided by Ecogecko (2013b) and LizardExpertNZ (2021) provided ‘real-life’ data that assisted in refining the estimates.

The informed density estimates were then extrapolated to the PC and overall MP4 impact areas to approximate the likely lizard population sizes.

It is acknowledged that this method of population estimation is prone to subjectivity, uncertainty, and error, not in the least because lizards are not uniformly distributed across the landscape and extrapolation can result in misleading estimates. Furthermore, the absence of methods to accurately quantify population size for some lizard species (e.g., kōrero gecko) means that estimates of lizard population size using this method will underrepresentation true values.

Table 4.3. Lizard density estimates (# lizards/ hectare; indexed and modelled; refer to relevant 'Reference' for methods) for Otago species reported in the literature. Information on sampled sites and habitats is also provided for context. Note: population estimates generated from the baseline monitoring programme will refine or potentially replace the literature-based density estimates presented in the table.

	Densities (lizards/ ha) reported in the literature & reference										
Reference	**Patterson (1984)**	**Patterson (1985)**	**Dixon (2004)**	**Clark (2006)**	**Jones (2013)**	**Ecogecko (2013a)**	**Ecogecko (2013b)**	**Ecogecko (2013b)**	**Ecogecko (2015)**	**LizardExpertNZ (2021)**	**Informed density range estimate[A] (lizards/ ha)**
Habitat & site information	(Tussock; Rock & Pillar Range)	(Tussock; Rock & Pillar Range)	(Tall tussock; Macraes)	(Ridges & gullies; Alistair's Gully control site, ~29 ha)	(Tall tussock, Macraes)	(Deepdell QEII covenant, 110 ha)	(Tussock, rank grass, rock tors; FNWRS salvage, 5.24 ha)	(Tussock, rank grass, rock tors; FSWRS salvage, 4.91 ha)	(Rock outcrops, gullies; Green skink survey, Murphys, ~35 ha)	(Tussock, rank grass, rock tors; MPIII Deepdell North III salvage, 109 ha)	**For MP4 Project areas**
Species											
Tussock skink	-	769[B]	572–2250[C]	2–35[B]	683–777	1–8	3	13		5	**10–50**
McCann's skink	423				~300	-	11	0		14	**10–300**
Kōrero gecko	-	-	-	-	-	3–9	0.2	7		14	**5–50**
Herbfield skink	No available density data										**0–0.1**
Otago green skink	No available density data										**0–0.06**
Grand skink	No available density data										**0–0.06**
Otago skink									0.06		**0–0.06**

[A] Estimated density range informed by literature and by field experience/ expert opinion of the author (Project herpetologist).

[B] Figure includes tussock, McCann's, and cryptic (herbfield) skink combined.

[C] Figures include tussock and McCann's skink combined.

4.3.2 Modelled population estimates

Statistical methods (N-mixture modelling and Capture-Mark-Recapture) were used to estimate the size of lizard (skink) populations occurring within the MP4 impact area. This was achieved through a landscape scale lizard trapping and release programme involving repeated count and capture-mark-recapture data collection that was implemented in April 2024.

To provide confidence in data collection approach and analytical methods, the study design was reviewed and validated by an experienced biometrician from *Proteus*, an ecological statistical consulting company based in Mosgiel, New Zealand.

A stratified random sampling regime was used to select locations for pitfall trap arrays that were installed across representative areas[14] in the landscape. Sampling sites were selected by overlaying 20 m x 20 m grid squares on aerial maps and randomly selecting 30–40 grid squares in each representative area of the landscape (Figure 4.2; Table 4.4). A 20 m x 20 m grid was chosen as this encompassed the expected home range of target lizard species (i.e., estimate home range size of 20 m^2 for McCann's and tussock skinks; Patterson 1985); therefore, ensuring each sampling site was spatially independent. At each sampling site, a pitfall trap (covered by an *Onduline* ACO) was installed. The pitfall traps were activated (cleared of vegetation and fruit bait added) and inspected over nine consecutive days between 15th and 23rd April 2024. Lizard capture (and recapture) data were collected over this period. These data were modelled by a qualified biostatistician (see MacKenzie & Bratt 2024; Appendix VI) to generate estimates of skink[15] relative abundance and detection probabilities. These data were subsequently converted to skink density estimates, with confidence limits, and were used to estimate the overall population size of skinks occupying each of PCs and the overall MP4 impact area.

4.3.2.1 N-mixture modelling (Repeated counts)

N-mixture models (Royle 2004) are a type of statistical model used primarily in ecology to estimate the abundance of a species in each area while accounting for imperfect detection. These provide estimates of how many individuals of a species are present, even though not all individuals may be detected during a survey. The model uses repeated count data (i.e., number of skinks captured each night) from each trap location to estimate the expected number of skinks in the vicinity of each trap (i.e., 'per trap' metric) (MacKenzie & Bratt 2024). This estimate does not necessarily equate to an estimate of the unique number of individuals in the vicinity of a trap during the entire trapping session, but rather a measure of relative (c.f. actual) abundance. It also estimates a detection probability, which is the probability of detecting an individual during a survey. Detection probability is informed by the variability in the nightly counts at each trap, relative to the maximum count over all nights at the trap (noting that the total number of individuals may be greater than the maximum counted) (MacKenzie & Bratt 2024).

[14] Representative PCs (e.g., CO6 Pit, GB2 Pit, GB WRS, BRWRS, and Murphys EEA) were used in sampling regime as it was not feasible to operate pitfall traps across all 10 PCs in the nine-day sampling period.
[15] Kōrero geckos were excluded from the analysis due to very low captures.

4.3.2.2 Capture-mark-recapture (CMR)

Capture-mark-recapture (CMR) is a popular and powerful method in ecology used to estimate population size, survival rates, and other demographic parameters of animal populations. It involves capturing, marking, and releasing animals, then recapturing them later to gather data on the proportion of marked individuals in the population. Mark-recapture methods utilise the information in the frequency of capture of individuals to estimate the probability of capture, and hence the number of individuals that were in the population but never captured during the trapping session. A closed-population model was used (i.e., assuming no births, deaths, immigration, or emigration during the study period) and this was a valid approach considering the nine-day consecutive trapping period and the late April sampling period, when lizard activity would have been reduced and recruitment completed for the season.

The estimate of abundance from the CMR represented an estimate of the unique number of individuals in the vicinity of all traps during the sampling session (N-mixture models are at the scale of a single trap) (MacKenzie & Bratt 2024).

4.3.2.3 Skink density estimates from modelled data

Relative skink abundance values from the N-mixture modelling and CMR analyses (reported in MacKenzie & Bratt 2024) were converted to density estimates (skinks/ ha) to allow total population sizes within each PC and in the MP4 impact area to be calculated. Since the two approaches describe slightly different abundance metrics (i.e., N-mixture models provide a "per trap" abundance metric whereas CMR provides an estimate of the unique number of individuals in the vicinity of all traps during the sampling session), different calculations were required to estimate population densities for each of the approaches.

A key consideration common to both approaches was the exposure of skinks within each population to the pitfall trapping technique, specifically the size of the area around each trap that is effectively being sampled for skinks (MacKenzie & Bratt 2024). To inform the effective trapping area, average home range sizes for McCann's and tussock skinks ($\overline{x}$ = 20.6 m^2 as reported by Patterson 1985) were applied to the areas surrounding each trap, which allowed density estimates for each representative area of the landscape and for each modelling approach to be calculated.

To determine the expected density of skinks within MP4 PCs that did not have specific sampling data (e.g., CN BF, NGWRS, etc.) an average skink density from CO6 Pit, GB2 Pit, and GBWRS[16] (including upper and lower estimates) was calculated. The averaged skink density was extrapolated across the areal extents of each PC and the MP4 impact area in its entirety (~101.3 ha) to estimate affected lizard population sizes (Table 4.5).

[16] Other sampling areas (e.g., BRWRS, MEEA, MurphysBuffer) were excluded as they did not occur inside the MP4 impact area and were not considered representative of the MP4 PCs.

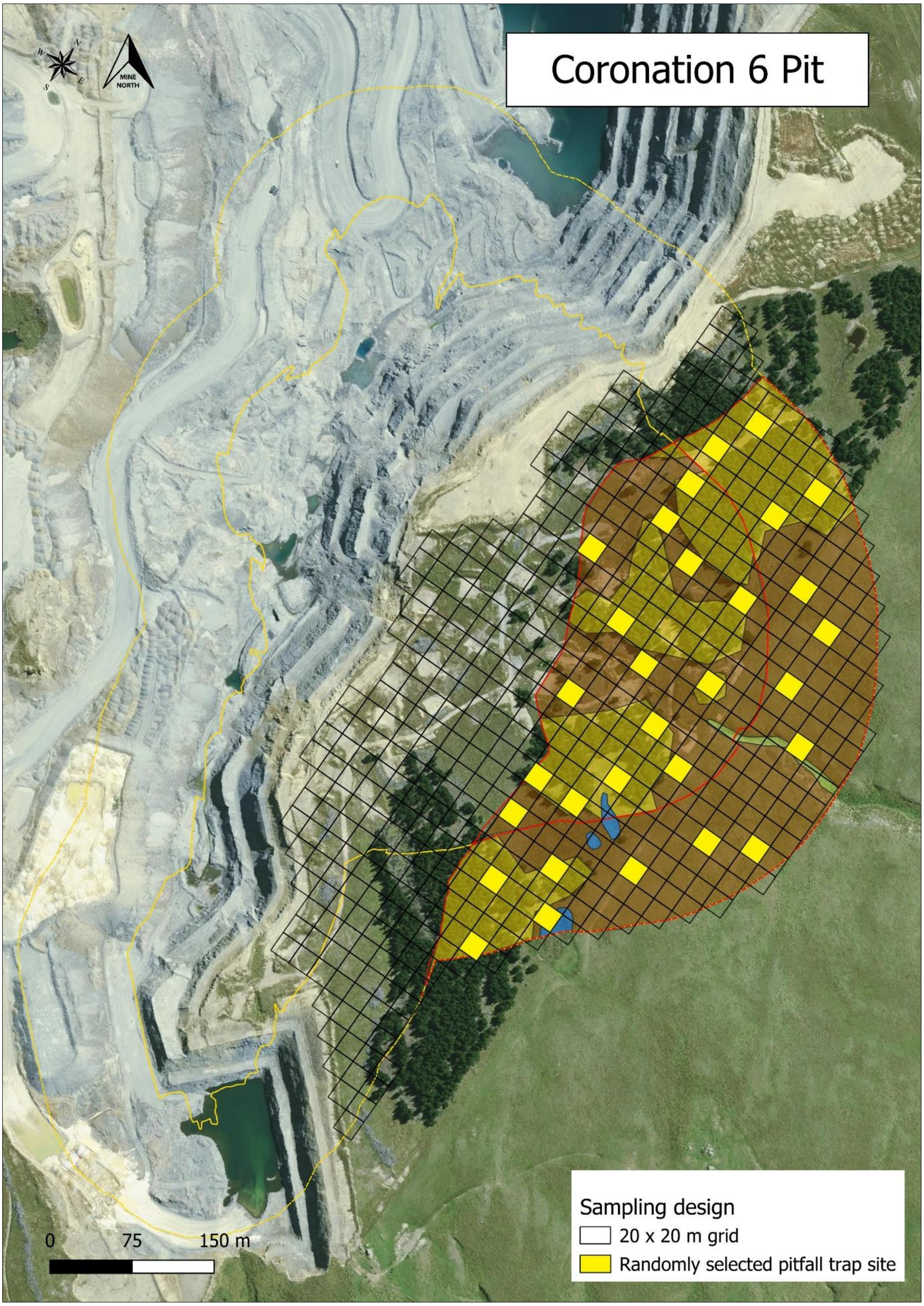

Figure 4.2. An example of random stratified sampling design for monitoring lizard populations at Coronation 6 Pit (CO6 Pit).

Table 4.4. The number of sites (pitfall traps) in each of the monitoring areas.

Monitoring area	Number sites (pitfall traps)
Back Road Waste Rock Stack[17]	40
Coronation Pit	29
Golden Bar Pit	36
Golden Bar WRS	40
MEEA	40
MEEA buffer	39
Total	**224**

4.3.3 MP4 affected lizard population size

Skink population size estimates for the MP4 impact area varied markedly across the three different methods, with the literature-informed density extrapolations producing the lowest estimates ($\overline{x}$ = 18,744 skinks), followed by CMR ($\overline{x}$ =26,387 skinks) and N-mixture models ($\overline{x}$ = 111,559 skinks).
In interpreting the population estimates, the following factors need to be considered.

- The N-mixture models revealed variation in the estimated relative abundance of skinks across different habitat types (e.g., exotic grass, shrubland, tussock, other), with relative abundance typically highest in tussock grassland habitat. In calculating skink population size in the MP4 impact area, habitat variation was not considered for simplicity but rather the average skink relative abundance across all habitats was used. Therefore, the population estimates may be overinflated in some PCs where tussock represents only a small component of the overall habitat, or where tussock is absent altogether.

- Environmental covariates (e.g., windspeed, relative humidity, habitat type) and survey day (time) explained some of the temporal variation in skink detection, but there was additional temporal variation in both models that remained unexplained.

- Estimates of abundance from the CMR results are likely to be an underestimate of the total number of skinks in each PC area due to the low trap density. CMR methods rely on lizards being available to be caught in more than one trap and because of the low density of traps in the PCs (i.e., less than one trap per skink home range[18]), 'gaps' in the trapping coverage are likely, meaning estimates will be underestimates.

- Lizard detection/ capture probabilities calculated from the CMR and N-mixture models were exceptionally low (0–0.24), and capture probability decreased markedly over the nine-day trapping period. This suggests that a very small fraction of skinks in the vicinity of a pitfall trap were caught each survey occasion.

- Extrapolating averaged skink densities from the literature-informed, CMR, and N-mixture methods across the overall MP4 impact area to estimate affected lizard population sizes is a

[17] Monitoring will include the MP3 consented Back Road Waste Rock Stack as a reference site, because the area is largely representative of the natural wider surrounding landscape and will not be mined as part of MP4 Stage 3.
[18] The low trap density was intentional and a function of the study design, which primarily focussed on N-mixture models. N-mixture models require independence between sampling units (e.g., pitfall traps).

relatively rudimentary technique and is subject to several assumptions. The most important being that it assumes a uniform distribution of lizards across all affected habitat types and PCs, and that lizard detection probability is relatively high. It is clear from the results that these assumptions do not hold true; thus, population size could be over- or underestimated.

- The population estimate methods did not include kōrero geckos (a species confirmed to be present in the impact area), nor did they include other species of skink that have not been recorded in the impact area but could potentially be present in low numbers (e.g., herbfield, grand, Otago, and Otago green skink). Based on direct observations (relative abundance) of kōrero geckos and availability of gecko habitat in some of the PCs (D. van Winkel, pers. obs.), it is estimated that the total lizard population (skinks and geckos) could be approximately 10–15% higher than those reported. With respect to other skinks, if present, the numbers are expected to be very low and the reported lizard population estimates are unlikely to noticeably change given the large confidence intervals surrounding the population size.

Ultimately, the overall lizard population size for the MP4 impact area is likely higher than the average literature-informed density extrapolation estimate of 18,744, and probably lies in between the CMR and N-mixture modelling estimates (i.e., between 26,387 and 111,559 lizards). Of the total number of affected lizards, it is estimated that most (~65–70%) will be represented by 'Not Threatened' McCann's skinks, with approximately 15–20% and 10–15% represented by 'At Risk—Declining' tussock skinks and 'At Risk – Declining' kōrero geckos, respectively. If present, herbfield, grand, Otago, and Otago green skinks combined are likely to contribute approximately 1% of the total population.

Table 4.5. Estimated skink population size based on literature-informed density extrapolations, Capture-mark-recapture, and N-mixture modelling methods for each of the MP4 Project Components. Mean population size is reported as well as the lower and upper ranges (in parentheses).

Project Component	Available lizard habitat (ha)	Estimated skink population size		
		Density extrapolation	CMR	N-mixture modelling
CO6 Pit	12.5*	2,313 (250 – 4,375)	1,032 (303 – 3,277)	3,164 (1,373 – 9,271)
CN BF	0.02	4 (0 – 7)	5 (3 – 10)	22 (13 – 40)
NGWRS	21.2	3,922 (424 – 7,420)	5,592 (3,122 – 10,428)	23,023 (13,881 – 42,064)
GB2 Pit	13.7	2,535 (274 – 4,795)	6,318 (3,857 – 10,441)	26,079 (16,351 – 44,268)
GB WRS	48	8,880 (960 – 16,800)	11,883 (6,524 – 21,670)	52,864 (31,370 – 95,016)
IM9 Pit	0.5	93 (10 – 175)	132 (74 – 246)	543 (327 – 992)
IM10 Pit	3.9	722 (78 – 1,365)	1,029 (574 – 1,918)	4,235 (2,554 – 7,738)
Frasers BF/WRS	0	0	0	0
GB RR	0.9	167 (18 – 315)	237 (133 – 443)	977 (589 – 1,786)
GP BB	0.6	111 (12 – 210)	158 (88 – 295)	652 (393 – 1,190)
MP4 impact area	**101.3**	**18,744 (2,026 – 35,462)**	**26,387 (14,678 – 48,728)**	**111,559 (67,211 – 202,365)**

*Includes 7 ha of land that was consented as part of MP3. Lizard salvage will be undertaken in this area during the MP4 CO6 Pit works.

4.4 POTENTIAL ADVERSE EFFECTS

The clearance of vegetation and habitat features used by native lizards can result in direct adverse effects such as significant injury or mortality and/ or loss of important resources (e.g., food and refuge sites) from the landscape. Potential indirect effects such as displacement of lizards into surrounding areas of lower habitat quality or the reduction in ecological linkages/ corridors in the landscape may also adversely impact local lizard communities.

These effects are not constrained to areas supporting moderate- or high-quality habitats. Ostensibly low value habitats such as dense weedy thickets, rank grassland, waste rock piles, and inorganic debris (e.g., corrugated iron, farming materials, etc.) are frequently used by native lizards, and these 'habitats' also need to be considered as part of any effects assessment. For this reason, all potentially suitable lizard habitat (see Table 4.1) was considered, not just the highest quality habitats (e.g., rock tors, shrubland).

For the MP4 Project areas, the potential effects on lizards from mining operations include:

- Injury or mortality as a result of vegetation clearance, land development, construction activities, and waste rock deposition;
- Permanent loss of important lizard habitats such as tussock, shrubland, riparian vegetation, and rock outcrops/ tors and associated resources (e.g., invertebrate prey, refuge structures);
- Displacement of resident native lizards into adjacent habitat that may be of lower habitat quality with lower carrying capacity or may already be at population carrying capacity; and
- Habitat fragmentation, isolation, and increased habitat edge effects.

Potential indirect and ongoing effects resulting from operation and maintenance of mining activities include:

- Decreased landscape and habitat connectivity through fragmentation;
- Population and genetic isolation;
- Anthropogenic disturbance effects (e.g., dust, noise, vibration, artificial lighting); and
- Lost opportunities for maintaining ecological corridors across the landscape.

4.5 MANAGING POTENTIAL ADVERSE EFFECTS ON NATIVE LIZARDS

The RMA, and associated planning instruments and policy statements (e.g., National Policy Statement for Indigenous Biodiversity or "NPSIB"), require that adverse effects on biodiversity, including protected native lizards, be managed by applying the effects management hierarchy (i.e., effects are avoided, remedied, or mitigated and where necessary, consideration given to offsetting and compensation to further redress residual adverse effects of activities). Specifically, the NPSIB sets out objectives, policies, and implementation requirements to manage natural and physical resources to maintain indigenous biodiversity (i.e., the maintenance and at least no overall reduction in biodiversity and where necessary, restoration and enhancement of ecosystems and habitats) under the RMA. Under the WA, the focus is on providing a protective benefit to wildlife (i.e., individuals or populations).

The measures proposed by OGL to address adverse effects on native lizards are outlined in Table 4.5. In addition, Ahikā Consulting have assessed wider project effects and advised OGL on the measures to address adverse impacts in the MP4 Impact Management Plan (Ahikā Consulting, 2024a), which should be read in conjunction with this LMP. A summary of the MP4 Impact Management Plan strategies are provided in Appendix II[19]. The excerpts in this Appendix are largely verbatim; however, there have been some minor amendments to improve readability and to focus the excerpts on lizards.

Table 4.5. Effects management proposed for the MP4 Project, with specific emphasis on native lizard related management measures. See Ahikā Consulting (2024a) for a description of the overall effects management package.

Avoid
1. Avoidance of higher value lizard habitat in the Round Hill and SPIM pit extension areas. These extensions were removed from the current project design as further work is required to understand potential ecological impacts and other technical uncertainties. 2. Avoidance of higher value lizard habitat (rocky tors and riparian vegetation) in the GBWRS footprint, through project redesign and refinement. 3. Avoiding indirect effects of mining operations on the immediately surrounding landscape through project footprint demarcation and barriers, where practicable (e.g., roadside windrows or fences, and rock intercept fences at the toe of waste rock stacks [WRSs]). 4. Prioritisation of previously disturbed land for siting new project infrastructure (roads, tailings storage facilities) to avoid unnecessary effects on undisturbed lizard habitat.
Remedy
1. Rehabilitation of WRSs via revegetation and re-creation of rocky habitats for lizards through deposition of larger aggregate and boulders. a. Revegetation of some WRS areas to narrow-leaved tussock grassland, including supplementation with fruit-bearing plants, to restore vegetation cover and enhance lizard habitat. b. Rock stacks (like the ones created as part of the Coronation Project; Ecogecko, 2019) and 'rock tors' (like those created at the Camp Creek research area; C. Rufaut unpub. data.), will be recreated across some of the flat or shallow sloping land on WRSs. It has been demonstrated that created rock stacks are colonised by three species of native lizard (McCann's skink, tussock skink, and kōrero gecko) (Ecogecko, 2019). Similarly, created 'rock tors' at Camp Creek have been colonised by kōrero gecko (D. van Winkel, pers. obs., February 2023). In addition, scree or talus slopes (slopes with accumulated loose rock of varying sizes) may be recreated on steeper sloping land (e.g., WRS embankments) to replicate complex sloped rocky habitat for lizards.

19 Details of the proposed offset and associated management measures have been designed by Whirika Consulting (previously Ahikā Consulting) and have been relied upon by the author.

Mitigate
1. Operational management plans and procedures to control the effects of dust, noise, disturbance, sediment, contaminant suppression, weed surveillance, and fire on areas of lizard habitat surrounding mining operations. 2. Implementation of a Lizard Management Plan that will include appropriate vegetation and habitat clearance protocols to reduce harm to lizards, a salvage and relocation programme, and relocation site management (see section 5 "Lizard salvage and relocation protocols" below).
Offset and Protective Benefit
1. An offset package that addresses the residual ecological effects of the MP4 Project and to provide a protective benefit to lizards has been prepared (Ahikā Consulting, 2024a; a summary is provided in Appendix II) and will be implemented. 2. The offset will address residual effects related to all aspects of terrestrial and wetland ecology, including lizards and their habitats (i.e., the loss of lizard habitat and any individuals not salvaged and relocated will be accounted for in the offset design as far as practicable). 3. The loss of lizard populations (individuals of lizards) will be addressed by a two-phase mammalian predator control operation in the Murphys Ecological Enhancement Area ("Murphys EEA" or "MEEA"; approximately 91 ha enclosed by a mammal exclusion fence) (Appendix III). The purpose of this site will be to protect and greatly enhance ecological (including lizard) values on OGL landholdings and will provide the primary recipient site for lizards salvaged as part of the MP4 activities (Harper & Thorsen 2023). Further detail surrounding the predator control programme, including a summary of longer-term management of the fenced population and biosecurity and maintenance (Harper & Thorsen 2023) are captured in Appendix II; the predator exclusion fence design and construction (Xcluder 2024; Appendix III) and the interim intensive predator control (Harper 2024 - Appendix IV). 4. There will be baseline monitoring of lizard populations and long-term monitoring to measure lizard response against management targets. 5. Contingency triggers and adaptive management procedures to ensure lizard response targets are achieved in the desired timeframes.
Compensation
1. Installation of ~35 created 'rock tors', made of locally sourced plate schist, in the MEEA. Tors to be positioned along the existing access road to minimise impact of tor construction activities on natural habitats. 2. Further compensatory actions are provided for in this LMP to act as contingency measures for unanticipated adverse effects on lizards. See section 7 "Compensatory/ Contingency Actions".

5 LIZARD SALVAGE AND RELOCATION PROTOCOLS

A lizard salvage and relocation programme will be carried out for the MP4 Project to mitigate adverse effects on native lizards. Salvage and relocation aims to reduce injury or mortality to individuals as far as practicable prior to, during, and after impacts occur. Post-impact management is concerned with ensuring the highest possible likelihood of relocation success, and will involve measures such as habitat enhancement, long-term monitoring, and where appropriate, contingency actions.

The salvage and relocation programme will primarily target the three lizard taxa known to occur in the project footprints (tussock skink, kōrero gecko, and McCann's skink) but will also include any other taxa that may be encountered (e.g., herbfield skink, Otago green skink, Otago skink, and/ or grand skink) (see callout box entitled "Response to the detection of rare or threatened lizard species" on page 28).

The salvage will utilise a variety of industry standard and proven lizard capture techniques (e.g., ACOs, pitfall traps, Gee's minnow traps, and systematic searches). These techniques are relatively indiscriminate in terms of their ability to detect and capture a range of lizard species. This means there will be opportunities to salvage other lizard species that may potentially occur but have not previously been recorded in the impact areas.

The lizard salvage and relocation programme is broadly categorised into three phases (Figure 5.1), each of which is discussed in detail below.

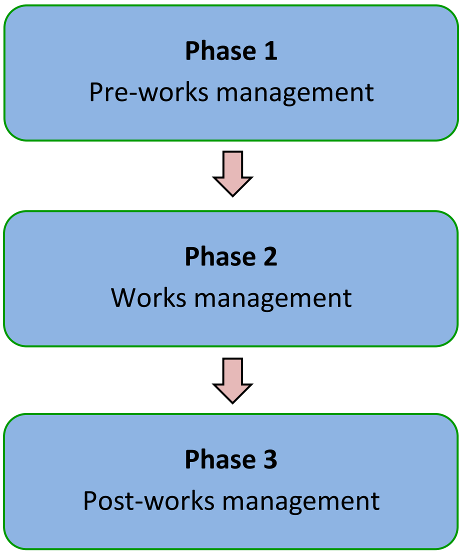

Figure 5.1. The three phases of the lizard salvage and relocation programme for the MP4 Project.

5.1 PROJECT STAGING AND TIMING OF SALVAGE OPERATION

The MP4 Project will be staged over several years (MP4: 2024–2030) and although the staging programme has yet to be finalised, the indicative timeframes for each project are shown in Figures 5.2. Full site rehabilitation is proposed to start in 2031.

The lizard salvage and relocation programme will align with the project staging, with relevant lizard management measures carried out in the months and weeks preceding and during each mining stage. The initial stage, involving stripping of CO6 Pit is scheduled to commence outside the existing consented area ca. mid-2025, requiring the capture and transfer of salvaged lizards in Q1 2025 to the MEEA relocation site (see section 5.2 "Relocation site selection"). The MEEA predator exclusion fence will not be constructed by the time CO6 Pit lizards need to be released and therefore, an area of approximately 20 ha on the true right of Murphy's Creek has been designated as an interim intensive predator control area to receive the initial propagule of relocated lizards (see section 5.6.2 "Lizards release strategy", inset box on pg. 47, and Appendices III and IV). The intensive predator control will be in place before any lizards are relocated and will continue to be maintained during the fence construction period and subsequent pest mammal removal. This strategy will provide the best chances of lizard survival following relocation.

Lizard salvage activities (i.e., capture, handling, and relocation) will only take place within the generally accepted South Island lizard season, from October to March, inclusive. The activities will be focussed when ambient temperatures range between 12–22°C. While the relocation of lizards will strictly occur only within this temperature range, salvage activities may take place during cooler or warmer temperatures where necessary. Seasonal and temperature limitations on the salvage period will ensure that any relocated lizards will be released at a time of year when activity is highest, allowing lizards to move and settle into new environments at the release site(s).

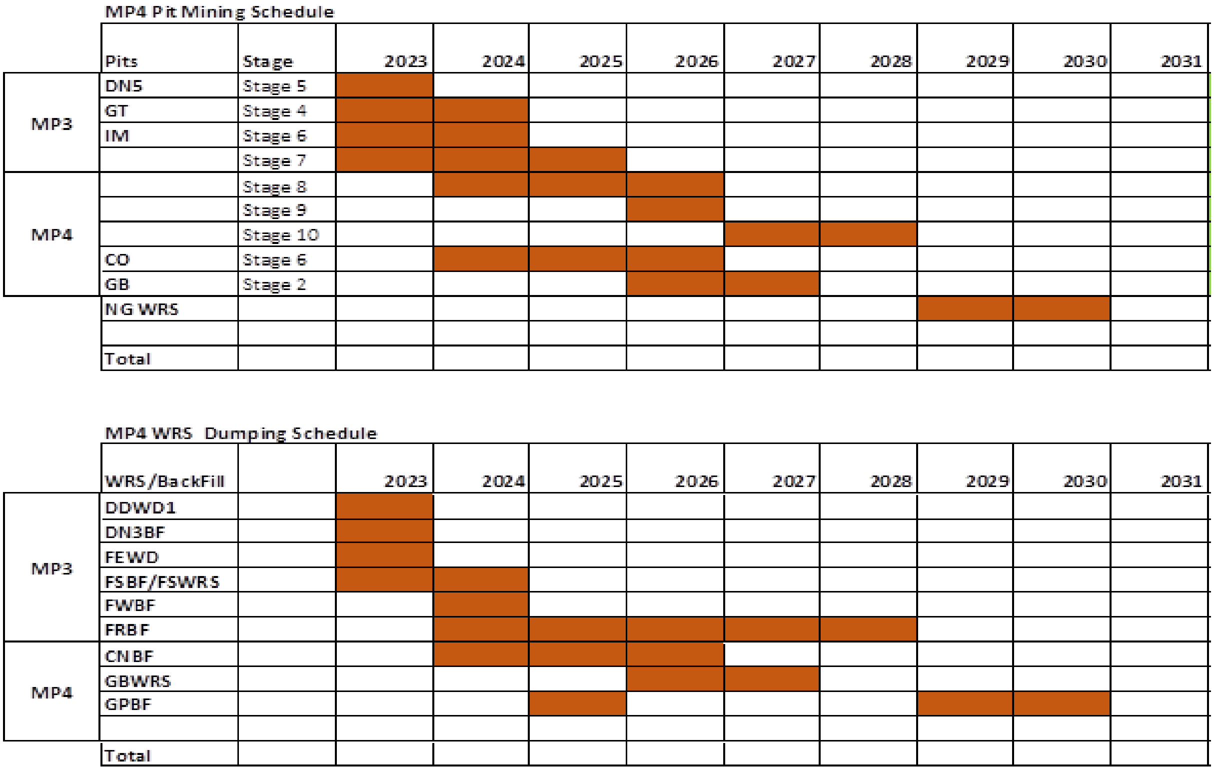

Figure 5.2. Indicative MP4 Project staging timeline. The main habitat disturbances are during the pit mining schedule when pit extents are increased (top) necessitating Golden Bar Road Realignment, and GBWRS expansion when the waste disposal areas are being expanded.

5.2 RELOCATION SITE SELECTION

The relocation site selection process involved a combination of predefined criteria, reviews of aerial imagery, deductive reasoning to determine the most appropriate recipient site for salvaged lizards, and at a local scale, a site visit to confirm the practicalities of constructing a mammalian predator exclusion fence.

To assist with site selection, the key principles for lizard salvage and transfer guidelines (NZLizardTAG, 2019) were reviewed, from which a set of site selection criteria were established. These criteria included:

1. The site(s) must be ecologically appropriate and have long-term security;
2. The habitat at the site(s) must be suitable for the salvaged species;
3. The site(s) must provide protection from predators;
4. The site(s) must be protected from future human disturbance (i.e. covenanted);
5. The distance between the receiving site(s) and the original population (i.e., capture site) should be minimised as far as practicable;
6. The site must not compromise future potential mining opportunities (i.e., the site must not occur on land that could be designated for mining); and
7. The views of mana whenua must be included in the site selection process.

Aerial imagery was reviewed to scope potential sites on OGL landholdings and within the wider landscape, with consideration given to size, topography, and variety of lizards habitat present. Preference was given to covenanted sites as these held existing land protection status. The process was also coupled with consultation with Ahikā Consultants ecologists regarding appropriate mitigation sites to address project-wide (including lizards) effects, including recognition of practical issues related to fencing and future maintenance.

Seven potential sites were considered in detail. Site information was tabulated, and the suitability of each site assessed against the site selection criteria (Table 5.1). A suitable relocation site was then selected through deductive reasoning (i.e., selecting sites that met the highest number of criteria). Other sites meeting a high proportion of the assessment criteria were considered potential options for contingency sites (i.e., 'spill-over' sites) (see section 7 "Compensatory/ Contingency Actions"), should they be required.

The outcome of this process identified the Murphys Ecological Enhancement Area ("Murphys EEA" or "MEEA") (Figures 5.3 & 5.4) as the most appropriate site for both broad-scale ecological mitigation and as a highly suitable relocation site for lizards. The MEEA location was adjusted to provide a suitable setback (a minimum of approximately 500 m) from a potential gold resource target known as "Ounce Prospect". The proposal for the MEEA site is to construct a mammalian predator exclusion fence around 91 ha of land encompassing part of the Murphys Creek catchment and to establish a network of mammalian predator control around the fence to buffer predator pressure. Further details of the MEEA are outlined by Ahikā Consulting (2024a), Harper & Thorsen (2023), Xcluder (2024) and Harper (2024) (see Appendices II, III & IV).

5.2.1 Selected lizard release site(s)

Considering the site selection criteria, capacity to receive high numbers of native lizards, and the proposal for extensive ecological enhancement, MEEA will be used as the receiving site for native lizards salvaged as part of the MP4 Project. Deepdell Station Ecology Covenant rated highly as a suitable site for native lizards; however, the active lizard monitoring and research programme at the site precluded it as a contingency relocation site for the MP4 Project. The other highly rated site was Island Block Ecology Covenant, with its extensive areas of highly suitable rock tors, shrubland, and tussockland. It is recommended that this site be chosen as a contingency or 'spill-over' site for the salvage-relocation programme (see section 7 "Compensatory/ Contingency Actions").

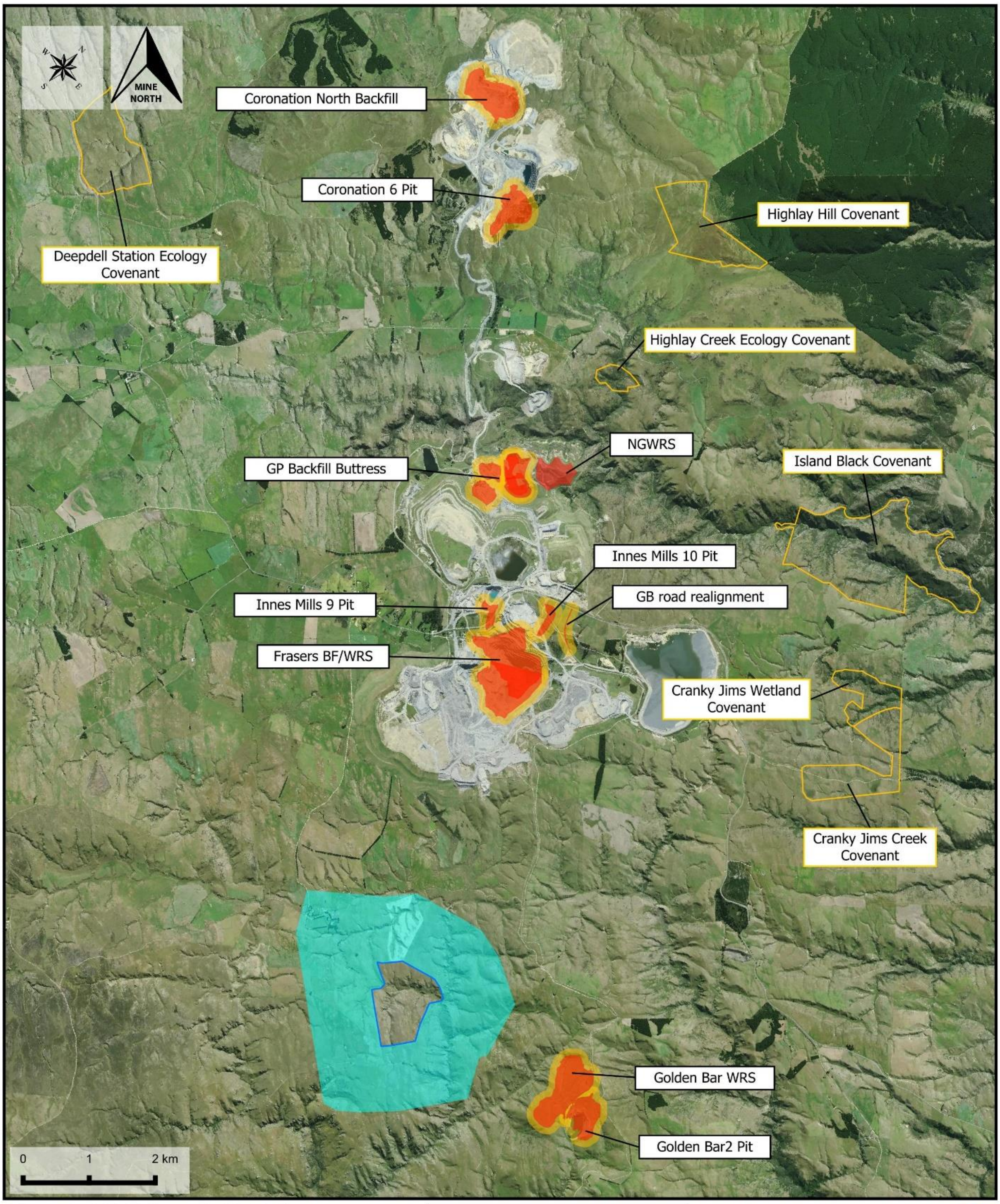

Figure 5.4 MP4 Stage 3: MEEA & Ecology Covenants

CLIENT / PROJECT
OceanaGold Limited

13 February 2024

MAP PROJECTION:
NZGD2000 / New Zealand Transverse Mercator 2000

SOURCES:
LINZ Basemap aerial

SCALE **@ A4 1:75,000**

61130#BEE09

Legend

- MEEA fence boundary
- MEEA pest control buffer (indicative)
- Macraes Ecology Covenants

MP4 Zone of Impact
Project Components

- Impact areas (direct impact)
- 100 m buffer (indirect impact)

Bioresearches
A Babbage Company

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

Table 5.1. Assessment of potential lizard relocation sites within OceanaGold landholdings and wider surrounding landscape. Criteria definitions provide in text above.

Site name	Areal extent	Land status	Distance from centre of project area	Brief description	Criteria						
					1	2	3	4	5	6	7
Deepdell Station Ecology Covenant	110 ha	QEII covenant	~8.8 km	An area of indigenous tussock grassland intersected by gullies containing a diverse range of native vegetation. A considerable number of rock tors and bluffs are present. Lizard surveys and monitoring have been undertaken, which have identified the presence of four species (McCann's skink, tussock skink, herbfield skink, and kōrero gecko). All but herbfield skink occur in high abundance (Ecogecko, 2013a, c). An active monitoring/ research programme is currently underway at this site (M. Tocher, pers. comm.). Mammalian pest control is being carried out at this site. The site is also grazed by stock, although areas subject to intensive lizard monitoring are in the process of being fenced.	?	✓	✓	✓	✓	✓	?
Highlay Creek Ecology Covenant	16.9 ha	Covenant	~3.9 km	A deep gully system dominated by indigenous scrub and tussocks. Rocky outcrops, tors, slabs, and boulders are present in abundance. Lizard surveys and monitoring have been undertaken in Highlay Creek Ecology Covenant, which have identified the presence of three species (McCann's skink, tussock skink, and kōrero gecko); all species occurred at low to moderate abundance (Ecogecko, 2013a, c). Mammalian predator control is not currently operational.	✓	✓	x	✓	✓	✓	?

Highlay Hill Covenant	100 ha	Covenant	~6.2 km	A higher elevation site predominantly covered by grassland (tussocks) and supporting a basalt rock cone. No information is available on the lizard species or numbers present at the site. Mammalian predator control is not currently operational.	?	?	x	✓	✓	✓	?
Cranky Jims Creek Ecology Covenant	47 ha	Covenant	~5.4 km	Cranky Jims Creek Ecology Covenant supports an area of high value native bush, scrub and bracken, tussocks, and grassland. There is a considerable amount of steep rock bluffs lining the gullies, with some rock tors on the plateau. Lizard surveys and monitoring undertaken in Cranky Jims Creek Ecology Covenant identified the presence of three species (McCann's skink, tussock skink, and kōrero gecko) but all species occurred at very low abundance (Ecogecko, 2013a, c). The low lizard abundance was attributed to the structure of the rock at Cranky Jims not providing an abundance of suitable crevices or thin rock plates for lizards to refuge and the extensive forest cover having a cooling effect on the surrounding rock, shading out potential lizard habitat (Ecogecko, 2013a, c). Kōrero geckos (N = 843) were relocated into Cranky Jims Creek Ecology Covenant as part of the Deepdell North III project. Lizard monitoring was established on-site in February 2023, but no monitoring results are currently available.	?	x	x	✓	✓	✓	?

Cranky Jims Wetland Open Space Covenant	49 ha	Covenant	~5.3 km	Cranky Jims Wetland Open Space Covenant is an area of open tussock and grassland, supporting sparse rock tors. No lizard surveys or monitoring have been carried out at the site. Mammalian predator control is not currently operational.	✓	?	x	✓	✓	✓	?
Island Block Covenant	291 ha	Covenant	~4.8 km	A deeply incised gully system along the margins of Deepdell Creek. The area supports an abundance of mixed native and exotic shrubland, extensive areas of tussock and grassland, and an abundance of rocky outcrops and tors. No lizard surveys or monitoring have been carried out at the site, presumably because of the treacherous and largely inaccessible terrain. Mammalian predator control is not currently operational.	✓	✓	x	✓	✓	✓	?
Murphys Ecological Enhancement Area (Murphys EEA)	~91 ha	Proposed covenant	~5 km	A series of steep gullies along the margins of Murphys Creek. The area supports an abundance of mixed native and exotic shrubland, extensive areas of tussock and grassland, and an abundance of rocky outcrops and tors. Part of the site was surveyed for lizards in 2014, during investigations into the presence of Otago green skink (Ecogecko, 2015). Four lizard species were recorded (McCann's skink, tussock skink, Otago skink, and kōrero gecko). A preliminary site investigation and cursory lizard survey was undertaken in February 2023, which recorded McCann's skink, tussock skink, and kōrero gecko and noted an abundance of suitable habitat for native lizards (including Otago, grand, and Otago green skink).	✓	✓	✓	✓	✓	✓	?

				The site is currently grazed and not subject to mammalian pest control; however, an extensive and intensive pest control programme is proposed as part of the Impact Management Plan for the MP4 Project. Habitat restoration and enhancement also forms part of the proposed package.							

Figure 5.4. Photographs of the vegetation and habitat features present in Murphys EEA. Photographs provided by Ahikā Consulting.

5.3 SALVAGE PROGRAMME PARAMETERS AND STRATEGY

A lizard salvage programme of the scale associated with the MP4 Project presents several challenges, including but not limited to the type and intensity of salvage methods employed, managing potentially very high numbers of lizards, and selecting a suitable relocation site(s) that can accommodate potentially high numbers of lizards. The lizard salvage operation undertaken as part of the 109 ha Deepdell North III Project between November 2020 and March 2021, where approximately 1,500[20] lizards were captured and relocated, was subject to many of these challenges (LizardExpertNZ, 2021). In particular, the difficulty of managing large numbers of lizards was hightlighted. The salvage numbers were 50% greater than anticipated, which meant lizards had to be held in temporary captivity—a relatively stressful situation for the lizards—and an additional relocation site had to be organised to accept the 'surplus' individuals. Several recommendations emerged from the Deepdell North III salvage-relocation, including taking a highly conservative approach to estimating lizard numbers in the salvage footprint, that future large-scale salvages strive to avoid unexpected outcomes as far as practicable, and having flexibility in 'stoppings rules' (LizardExpertNZ, 2021; Appendix I).

[20] 1,500 lizards was considered an underestimate of the total lizard population size in the affected area given that not all lizards were able to be captured and relocated (LizardExpertNZ, 2021).

For the MP4 lizard salvage operation, both an attempt to identify inherent challenges upfront and learn from the outcomes of previous salvages have been incorporated into the programme design. Initially, two primary limitations to the prospective programme were identified. These were 1) the number of lizards that can feasibly be managed under a salvage programme (i.e., how many lizards can be physically captured and relocated without compromising the success of the relocation programme), and 2) population capacity limitations associated with the release site(s) (i.e., what is the upper limit number of lizards that can be relocated into a site(s) that already supports native lizard populations). Understanding and addressing these limitations is fraught with difficulty, due to a paucity of relevant exemplars to base decisions on and high levels of uncertainty.

5.3.1 Lizard salvage recovery rate

The approach taken in this LMP has been to set an upper limit (+ 5% contingency) for the number of lizards of all encountered taxa that will be captured and relocated (recovered), and appropriately managed at the release site. The upper limit value has been informed by a combination of

1) learnings from the Deepdell North III salvage project;
2) the physically ability of herpetologists to manage the number of lizards expected to be salvaged;
3) the expert opinion and experience of the author based on previous lizard salvage-relocation projects; and
4) predictions of the lizard population size and capacity (based largely on lizard population recovery rates in similar environments and under similar management regimes, e.g., mammalian pest control) at the selected relocation site.

The number of lizards proposed to be salvaged during the MP4 Project has been set at 2,100 individuals[21] (though, see inset box entitled "Response to the detection of rare or threatened lizard species" on page 47). This figure is largely based on the physically ability of herpetologists to adequately manage the expected number of salvaged lizards to the extent that lizard welfare is not compromised and that relocated lizards are afforded the highest chances of survival. Considering the large population size estimates for the MP4 impact area, the capture and relocation of 2,100 lizards (i.e., the recovery rate or percentage of the total estimated population to be salvaged) will be very low (e.g., approximately 2–7% of lizard population estimated to occur in the MP4 impact area).

The establishment of a salvage limit (i.e., up to 2,100 lizards) requires a set of parameters (or 'stopping rules') that will guide the salvage effort invested in each of the affected PCs. That is, for each stage of mine development, an indicative timeframe, dedicated level of effort, and number of lizards will be allocated (Table 5.2). For example, during the salvage if time, effort, or the number of lizards, whichever comes first, has been reached in a specific PC then the salvage operation for that PC ceases (though, see inset box entitled "Response to the detection of rare or threatened lizard species" on page 39). All captured lizards will be relocated into the mitigation/ offset site (MEEA) and any lizards remaining in the impact areas will be left in situ and the impacts on them considered residual effects

[21] This figure may be subject to refinement following consultation with OceanaGold and the Department of Conservation.

that will be addressed through offset and compensation measures as outlined in the MP4 Impact Management Plan (Ahikā Consulting, 2024a).

The salvage parameters are subject to refinement following consultation with relevant experts from the Department of Conservation, Otago Regional Council, and mana whenua. Additionally, adaptive management will be applied throughout the delivery of this LMP to improve management practices incrementally over the years. Therefore, the salvage parameters detailed below should be interpreted as indicative only and are likely to be revised and amended over time.

Response to the detection of rare or threatened lizard species.

The current lizard salvage and relocation protocols are largely designed to target 'Not threatened' and 'At Risk' species known to be present in the impact areas. Though it is acknowledged that rarer (e.g., herbfield and Otago green skink) or more threatened (e.g., grand and Otago skinks) species could potentially be present in affected areas. Where such species are detected during the salvage operation, a diversion of some salvage effort will take place to target areas supporting these rare or threatened lizards. The Department of Conservation would be notified and consulted with upon the detection of threatened lizards in the impact areas. Targeted capture effort would then be invested and maintained at sites supporting threatened species until such time that the Project herpetologist was confident that all rare or threatened lizards had been captured at the specific site. The effort to salvage 'Not threatened' and 'At Risk' species would not cease entirely during this time, and the numbers of more threatened lizard species would be in addition to the cap of 2,100 lizards set by the salvage programme.

5.3.2 Relocation site (MEEA) carrying capacity

Ensuring the relocation site has sufficient carrying capacity for resident and relocated lizards is also critical to the success of the relocation programme. The carrying capacity of a site is determined based on the size site, the estimated size of the resident lizard population, and expected lizard population response to proposed management.

For the MP4 Project, the 91 ha MEEA site has been selected as the most appropriate lizard release site. An estimate of the current resident lizard population size in the MEEA, based on the data collected during baseline monitoring in April 2024 and the methods described section 4.3.2.3 "Skink density estimates from modelled data" is between approximately 160,000–2.4M lizards. It has been demonstrated that a four-fold (possibly more) increase in lizard numbers can be achieved in areas subject to intensive mammalian predator control (Reardon *et al*., 2012; Norbury *et al*., 2022). Therefore, it is expected that a substantial increase in the resident lizard population in the MEEA would occur as a result of the proposed MEEA mammalian predator exclusion, and consequently, the carrying capacity of the site is expected to be very high and much greater than the existing lizard population levels.

The anticipated relocation of 2,100 lizards as part of MP4, would equate to a release of ~23 lizards/ hectare or <1 lizard per 20 m x 20 m area into the MEEA. This density is very low in comparison to the reported lizard densities in Otago Region (see Table 4.3) and the number of lizards is significantly below the estimated density of lizards currently in the MEEA (i.e., ~1700–26,000 lizards/ ha; see section 4.3.2.3 “Skink density estimates from modelled data”). It should be recognised that the number of lizards salvaged and relocated at any point in time will be markedly lower than 2,100 (e.g., ≤1,000 lizards) due to the MP4 Project schedule requirements (see section 5.1. “Project staging and timing of salvage operation”). Furthermore, the exclusion of stock and removal of mammalian predators from the MEEA (see Ahikā Consulting, 2024a) will greatly enhance the capacity of the relocation site to support growing lizard populations. Therefore, the relocation of 2,100 lizards is not considered to have measurable effects on the lizard populations already resident in the MEEA.

Table 5.2. Indicative lizard salvage parameters ('stopping rules') for the MP4 footprint (~90 ha of lizard habitat), including staging, timeframes, salvage effort, and estimated number of salvaged lizards. Parameters to be refined as the salvage programme progresses.

Project Component	Salvage timeframe	Indicative salvage effort	kōrero gecko	tussock skink	McCann's skink
CO6 Pit	3 weeks	• 500 pitfall trap nights, • 300 funnel trap nights, and • 240 search hours.	80	150	200
CN BF	2–4 days	• 16 search hours.	0	10	20
NGWRS	1 week	• 16 search hours, and • 100 pitfall/ funnel trap nights.	0	0	70
GB2 Pit	3 weeks	• 800 pitfall trap nights, • 400 funnel trap nights, and • 480 search hours.	150	200	250
GB WRS	3 weeks	• 800 pitfall trap nights, • 400 funnel trap nights, and • 480 search hours.	150	200	250
IM 9 Pit	1 week	• 16 search hours, and • 100 pitfall/ funnel trap nights.	0	20	40
IM 10 Pit	1 week	• 250 pitfall trap nights, • 250 funnel trap nights, and • 160 search hours.	0	50	60
Frasers BF/WRS	N/A	N/A	N/A	N/A	N/A
Golden Bar Road Realignment	1 week	• 500 pitfall trap nights, • 300 funnel trap nights, and • 240 search hours.	10	50	100
Golden Point Backfill Buttress	2–4 days	• 16 search hours, and • 100 pitfall/ funnel trap nights	0	20	20
			390	**700**	**1,010**
			2,100		

5.4 DEMARCATION OF THE WORKS FOOTPRINT

Salvage effort will be invested in all suitable lizard habitats throughout areas directly affected by mining activities. Buffer areas not proposed to be directly affected will not be subject to salvage.

Prior to any vegetation clearance or land disturbance, lizard salvage areas will be clearly demarcated to ensure everyone involved clearly understands the work extents and that works do not encroach into peripheral habitat areas.

An interactive GIS application, showing the works footprint boundary, aerial imagery, and other relevant overlays will be carried in the field by the Project herpetologist to assist with orientation and boundary recognition.

5.5 PHASE 1 – PRE-WORKS LIZARD MANAGEMENT

Pre-works lizard management will involve activities undertaken by the Project herpetologist and salvage team prior to commencement of vegetation clearance or habitat disturbance in the affected areas. Refer to the inset box on page 42 ("Timing of mammalian predator management") for details of the staged predator control to be implemented during the pre-works phase.

A variety of reliable and proven live trapping and capture techniques will be employed to increase the probability of lizard capture. Techniques will include, but may not be limited to, pitfall traps, layered *Onduline* artificial cover object (ACOs), Gee's Minnow traps, and systematic searches (both diurnal and nocturnal).

The indicative level of salvage effort for each project component and stage of the mine development is outlined in Table 5.2. The information presented in this table may change adaptively as the programme progresses through time and alterations to the salvage programme would be at the discretion of the Project herpetologist, with approval from OGL and other relevant stakeholders.

All native lizards captured during the pre-works period would be relocated to the approved relocation site (see section 5.2 "Relocation site selection").

Once the pre-works salvage programme has been satisfactorily delivered in accordance with this LMP, the Project herpetologist will consult with/ notify OGL and the next phase of the salvage will commence.

5.5.1 Lizard capture methods

5.5.1.1 Pitfall traps

Pitfall trapping is a standard and effective technique for capturing terrestrial lizards in New Zealand (Hare, 2012a). Pitfall trapping will involve the installation of 4 litre plastic pails, dug into the ground with the top of the bucket flush with ground level, and covered with a lid (e.g., wooden board or *Onduline* ACO) wider than the aperture of the pail. A small amount of soil and leaf litter is placed in the bottom of the traps to provide cover for captured lizards, and traps will be activated by adding a lure (e.g., soft fruit or protein-based lure).

Both the existing 'monitoring' pitfall traps and newly installed arrays of pitfall traps (their specific locations determined by the Project herpetologist) will be used throughout the staged impact areas. The locations of all pitfall traps would be recorded on a GPS and traps would be inspected at least every 24 hours for the duration of the pre-works salvage operation.

5.5.1.2 Gee's Minnow traps (funnel traps)

Gee's Minnow traps or funnel traps are small fish traps that typically consist of two funnel-shaped entrances at either end of a mesh cylinder. Funnel traps are a passive sampling method because they rely on lizards to willingly encounter and enter the trap. They can be used to capture lizards in a wide range of habitats because they can be positioned on or above ground, can be nestled among dense vegetation, and can easily be relocated without disturbing the soil (Hare, 2012b).

Arrays of funnel traps will be installed throughout the staged impact areas; their specific locations determined by the Project herpetologist. Each funnel trap would be half-filled with vegetation matter and baited with a lure (e.g., soft fruit or protein-based lure). The locations of all funnel traps would be recorded on a GPS and traps would be inspected at least every 24 hours for the duration of the pre-works salvage operation.

5.5.1.3 Artificial cover objects (ACOs)

Artificial cover objects (ACOs) are at standard (best practice) tool for detecting, surveying, capturing, and monitoring lizards in New Zealand (Lettink & Cree, 2007; Wilson *et al.*, 2007; Lettink *et al.* 2011; Lettink, 2012; Lettink & Hare, 2016).

The ACOs used will constitute single- or double-layered, 400 mm x 475 mm corrugated *Onduline* sheets. *Onduline* is a bituminous corrugated roofing material that has heat retention properties, providing refuge and thermoregulatory benefits for lizards.

ACOs require a period of settlement following installation to allow any scent to equalise, and lizards to find and become familiar with the devices. It is recommended that at least 2–3 months of settling is required before ACOs can be inspected for lizards (Lettink, 2012). ACOs are then repeatedly inspected, and all lizards found beneath are captured. To assist in the capture of lizards, a portable plastic or metal shroud will be used to enclose the ACOS and prevent lizards from escaping during inspections.

Lizard use of ACOs is dependent on environmental factors such as proximity to dense, complex vegetation and weather conditions, as well as disturbance frequencies (Lettink *et al*. 2011). These factors will be taken into consideration during the placement and inspections of ACOs, to increase lizard detection probability.

Arrays of ACOs will be installed throughout the staged impact areas; their specific locations determined by the Project herpetologist. The locations of all ACO would be recorded on a GPS and ACOs would be inspected at least every 24 hours for the duration of the pre-works salvage operation

5.5.1.4 Systematic searches

Systematic searches are a commonly used method for herpetofauna surveys (Hare, 2012c) and are frequently used during salvage operations to find and capture lizards. Both diurnal and nocturnal systematic searches will be carried out across the staged impact areas.

5.5.1.4.1 Diurnal searches

Diurnal visual and hand searches will be carried out by the lizard salvage team who will move through the landscape searching for active sun-basking lizards and searching habitat features (e.g., lifting rocks and debris, searching crevices in rock outcrops) to reveal refuging lizards. Accessible areas of dense vegetation such as fern clumps or vegetation overhanging rocky outcrops will be physically searched for lizards by lifting, moving aside, or removing foliage. In addition to systematic searches, opportunistic searches[22] will be carried during all salvage activities in the impact areas.

5.5.1.4.2 Nocturnal spotlight searches

Nocturnal searches of gecko habitats (rock outcrops ad tors) will be undertaken to target night-active kōrero geckos. The lizard salvage team would progressively move over or along rocky outcrops after dusk, aided by headlamps/ torches, searching the rock faces and overhangs, and rock crevices for emerged geckos, or partially retreated geckos. Diurnal lizard species may also be encountered in rocky habitats at night, and these too will be targeted. Binoculars may be used to assist with detecting active geckos (i.e., gecko eye-shine) from afar before approaching the specific rock feature.

5.6 PHASE 2 – WORKS MANAGEMENT

Phase 2 of the lizard salvage will involve targeted and opportunistic capture of lizards during vegetation and habitat clearance activities. Site preparation for mining activities involves the stripping of vegetation and topsoil and removal of unstable rock tors to create a uniform and structurally stable surface for excavation or deposition of waste rock. It is during this pre-mining process that the Project herpetologist and salvage team will work directly with machine operators to progressively dismantle habitat features and clear vegetation to facilitate the capture of lizards.

These activities will not be carried out across the entire site due to the extensive areas of clearance required but rather, key areas of habitat would be identified by the Project herpetologist and salvage team prior to commencing the searches.

5.6.1 Physical vegetation and habitat removal methodology

It is crucial that there is clear coordination and communication between the herpetologists and machine operators to ensure effective capture of lizards and to minimise health and safety risks. The Project herpetologist and machine operator(s) would discuss the methodology and agree on processes and activities prior to commencing this work in the field.

[22] Opportunistic searches are considered 'non-dedicated searches' that will be undertaken while walking between sites or during other activities in the impact area. Effort associated with opportunistic searches will not necessarily be recorded/ quantified.

For areas that support abundant and dense vegetation cover such as shrubland, riparian, and tussockland habitats, clearance will be carried out by an excavator, fitted with a toothed bucket or root raker attachment, and supervised by the Project herpetologist and/ or salvage team. Lizards will be captured by hand during the vegetation stripping process.

In instances where debris, rocks, or rock outcrops/ tors cannot be physically moved or searched by the salvage team, an excavator(s) dedicated to the lizard salvage would be used to lift or dismantle the feature to reveal lizards for hand capture. It is recommended that the excavator(s) use a grapple attachment to allow precision lifting of objects (e.g., rocks, schist rock slabs) and to reduce scraping or shearing of rock surfaces, which may injure or kill lizards. In some instances, a toothed bucket attachment may be used to lift or roll large heavy objects (Figure 5.3).

Recoverable material (e.g., schist rock slabs) will be sourced and transferred to the lizard mitigation site(s) to be used to recreate rocky habitat features (see section 5.6.3 "Lizard Habitat Enhancement").

Figure 5.3. Machine-assisted dismantling of a rock tors during the Deepdell North III Project. Image by M. Tocher.

5.7 PHASE 3 – POST-WORKS MANAGEMENT

Post-works management is concerned with the selection of a suitable lizard relocation site(s), provision of habitat enhancement, and lizard monitoring to ensure the best possible outcome for salvaged individuals and to measure lizard population level response to enacted management.

5.7.1 Lizards release strategy

A direct wild-to-wild release of lizards is proposed for the MP4 Project. Lizards will be 'hard released' (*versus* penned) into habitats suitable for each species (e.g., kōrero released into rocky habitats, tussock skink released into damper grassland/ tussock habitats). Lizards salvaged as groups (e.g., kōrero tor community or family groups) will be released together into the same area to preserve group structure. Lizards will not be marked (neither temporarily nor permanently) nor will photographic identification techniques be used. The reason being the relatively high 'cost to reward' ratio of mark-recapture programmes involving large populations (i.e., for large populations, high effort is required to mark or photo-identify individuals, yet the probability of recapture is typically very low) (further details on lizard population monitoring are outlined in section 6 "Lizard Monitoring Programme").

The proposed salvage and relocation programme does not include provisions for captive holding of lizards. The reasons being that captivity can lead to stress, injury or mortality in lizards and captive holding is resource intensive, which can divert resources away from other activities. There are also no tangible benefits of holding lizards in captivity prior to release though, it is acknowledged that survival probability may be increased by holding lizards in captivity temporarily when the weather conditions are deemed unsuitable for release (e.g., when temperatures are low and compromise lizard activity/ movement).

The release of lizards at the recipient site will be guided both by selection of appropriate and suitable habitat for each species and the monitoring programme design (see section 6 "Lizard Monitoring Programme"). The inherent staging of the MP4 Project will reduce the number of lizards released at any point in time and accurate records of release locations and release numbers during each stage will eliminate the risk of 'overstocking' areas of the recipient site.

Based on the preselected number of salvage individuals (~2,100 of all species) and the potential size of the MEEA relocation site (~91 ha), a relocation 'stocking density' of ~23 lizards/ ha (2,100/ 91 = ~23) will be realised. It must be re-emphasised that not all 2,100 lizards will be relocated at once, and it is more likely that 150–500 lizards will be released at any one time (i.e., 'stocking density' of ~1.6–5.5 lizards/ ha). Since the lizard population carrying capacity in MEEA will be increased (potentially fourfold or more) as a result of the mammalian predator control programme (Reardon *et al.,* 2012; Norbury *et al.,* 2022) and lizard habitat enhancement (see section 5.7.2 "Lizard habitat enhancement"), it is considered that the site could comfortably accommodate relocated lizards at the aforementioned 'stocking density'. That is, the anticipated increase in capacity of MEEA to support additional lizards (of all species) as a result of the mammalian predator control programme, is far greater than number of salvaged lizards that would be released at the site.

Timing of mammalian predator management

To meet the lizard salvage timing required by the MP4LOM schedule, the fence will need to be established in H2 2025, once a Resource Consent and Wildlife Act Authority are granted.

Acknowledging that lizards will need to be relocated in Q1 2025 from Coronation6 Pit, prior to construction of the fence, a two-phase predator control strategy is proposed. Phase 1 will involve intensive predator control (trapping and toxins) over approximately 20 ha area on the slopes of Murphy's Creek tributary where lizards will be relocated and a larger area (~140 ha) having extensive large-predator removal infrastructure to intercept cats and mustelids (Figure 5.6). Further details of Phase 1 are outlined in Harper (2024) (Appendix IV).

Intensive predator control will be carried out approximately 6 months prior to lizards being released to ensure mammalian predator numbers have been sufficiently knocked down/ suppressed (confirmed using dedicated mammalian predator monitoring tools).

Upon receiving Resource Consent and a WAA for MP4, the mammalian predator exclusion fence will be constructed and the complete predator control package, as outlined by Ahikā Consulting (2024a), implemented.

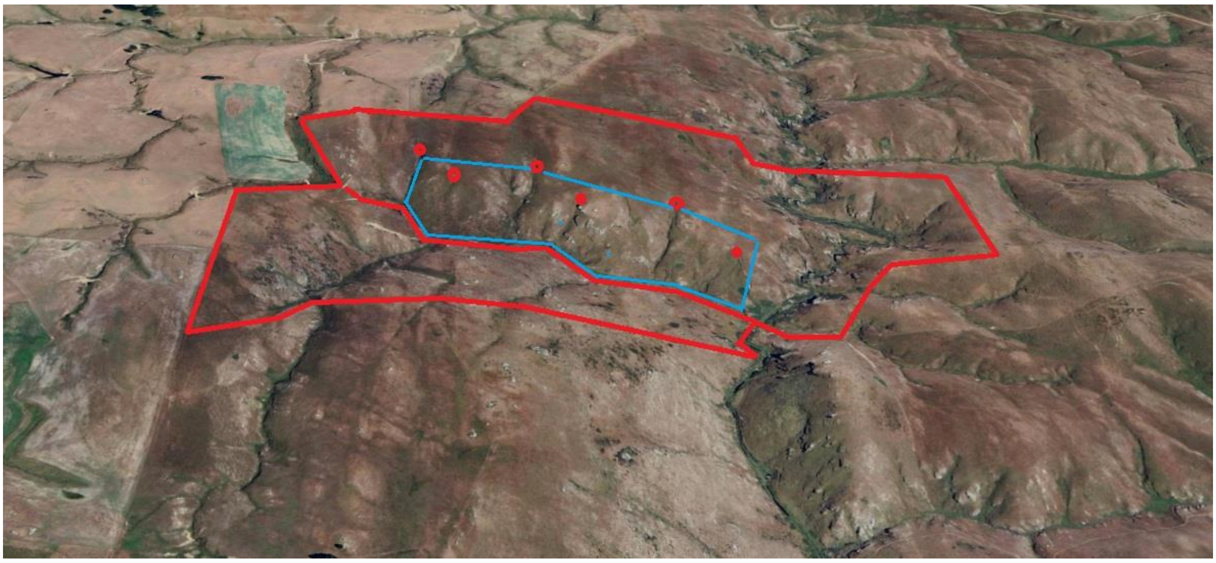

Figure 5.6. Oblique aerial view of Murphy's Creek showing indicative locations of the lizard transfer fenced site, and the large predator trapline and trap sites. Source: Harper (2024).

5.7.2 Lizard habitat enhancement

Lizard habitat enhancement in the form of intensive mammalian pest control/ exclusion; vegetation restoration via stock exclusion, weed management and native revegetation; land covenanting, and provision of supplementary refuge structures would be provided for the MEEA site.

The mammalian pest control/ exclusion and vegetation restoration components of the proposed habitat enhancement as outlined in the Impact Management Plan (Ahikā Consulting, 2024a), and are not described here.

Supplementary refuges, in the form of constructed rock tors and rock stacks, will be provided at the lizard relocation site, partly to partially replace rock tors lost in the impact areas but also to provide additional habitat for resident and relocated lizards. The constructed rock tors and rock stacks will follow the designs of C. Rufaut (unpub. data) and Ecogecko (2019), respectively (Figure 5.7). These two designs will be used because they have proven effective in attracting and supporting up to three species of native lizard (McCann's skink, tussock skink, and kōrero gecko) (Ecogecko, 2019; D. van Winkel, pers. obs.).

It is proposed that 35 rock tors and/ or rocks stacks will be installed in Murphys EEA, primarily on the ridges close to access roads to avoid disturbance to existing habitat by machinery required to install the rock features. The number of created rock tors/ rock stacks equates to a rock tor replacement ratio of 3:1 (i.e., 12 rock tors will be lost as part of the MP4 Project and approximately 35 rock tors/ rocks stacks will be created). Low-growing, fruit-producing, and divaricating or vine-type native plants (all appropriately sourced, see Ahikā Consulting, 2024b) will be planted around the rock features to provide additional cover and food sources for lizards once the plants establish.

In the instance where excess salvaged lizards are released into Island Block, no supplemetary refuges (constructed rock tors, rock stacks, or otherwise) would be provided due to the significant abundance of existing rocky habitat features at this site (D. van Winkel, per. obs.).

Figure 5.7. Example of rock tors and rocks stacks that will be created and installed in Murphys EEA to enhance lizard habitat. A, C. Rufaut (unpub. data) design and B, Ecogecko (2019) design.

5.8 LIZARD CAPTURE AND HANDLING

Native lizards will be captured and handled by a DOC-authorised herpetologist only (Appendix V). All native lizards captured prior to and during vegetation clearance operations will be placed immediately into containment boxes and held temporarily for release. Captured lizards will be measured, sexed, weighed, and photographed, prior to being released.

The retention of lizards in captivity for periods longer than 24 hours will be avoided as far as practicable, but it is recognised that unsuitable weather conditions may delay the release of lizards. In this instance, lizards will be held in ventilated containment boxes in a cool room, out of direct sunlight, until release can occur. Water and substrate will be provided, and food provision (e.g., invertebrates) will be necessary if lizards are held for longer than 48 hours.

If any individual(s) of the larger, rare lizard species (Otago green skink, Otago skink, grand skink) are found during the salvage operation, the individual(s) will be managed in the same way as other species and will be released into suitable habitat within the intensive mammalian predator control area of MEEA (see section 6 “Lizard Monitoring Programme”). The Department of Conservation will be notified of these finds and will be consulted on any additional management, should it be required.

5.9 INADVERTENT LIZARD INJURY OR DEATH

Considering the extensive area of habitat impacted by the projects and some of the destructive habitat methods employed during the salvage(s) (e.g., machine-assisted searches), injuries to and deaths of native lizards are expected.

The following steps will be implemented when an injured or deceased lizard(s) is(are) found during the salvage:

- The Project herpetologist will record, for each species, the number of injured and deceased lizards encountered throughout the salvage and will report these figures to the Department at the conclusion of each stage of the salvage operation.
- Any injured ‘Not Threatened’ and ‘At Risk’ lizard assessed as having severe life-threatening injuries, will immediately be humanely euthanized via blunt force trauma to the cranium, followed by cranial pithing, at the capture site. The Department will need to agree to this method of euthanasia, or recommend another appropriate method, prior to commencement of the salvage operation.
- Any injury or death of a ‘Threatened’ lizard species will be reported to the Department within 24 hours (preferably immediately) of the observation.
- All injured ‘Threatened’ species will be taken to a suitably qualified veterinarian as soon as possible, or if deemed appropriate by DOC, sent to the Dunedin Wildlife Hospital for treatment and care. Injured lizards will be kept in an appropriate portable enclosure (a well-ventilated plastic container with substrate) under the direction of the project herpetologist to ensure the animal is handled appropriately until the lizard can be assessed and treated by a veterinarian.

- Any 'Threatened' lizard assessed by a veterinarian as uninjured, or otherwise in suitable condition for release, will be transported to the relocation site in the portable enclosure and released.
- If any lizard is injured or killed, appropriate measures will be undertaken to minimise further injuries or deaths as the salvage progresses. Measures include but are not limited to adjusting the salvage strategy, ensuring additional support personnel are present to assist with the salvage, and conversing with or replacing machine operators.
- All deceased lizards will be retained and stored in preservative (70% ethanol) inside labelled vials. The samples will be submitted to the Department or under the guidance of the Department, submitted to the Museum of New Zealand Te Papa Tongarewa for accessioning into their collection.

5.10 Data recording and analysis

During both the pre-works and works periods, environmental and lizard catch data will be accurately recorded, and will include:

- Standard weather variables such as temperature, cloud cover, wind speed and direction, humidity, rainfall, etc.
- The number of lizards for each species caught using each salvage technique;
- The effort employed per day (e.g., number of trap nights or systematic search effort);
- The number of missed individuals and number of individuals found dead or injured.

Lizard catch data will be live plotted during the pre-works and works periods to visualise progress towards 'cease salvage' parameters. The decline in trapped lizard numbers (depletion rate), where observed, will also be explored using regression. Extending the regression line to its x-axis intercept can provide a crude estimation of the residual population size based on the proportion of un-trapped individuals for each species remaining in the salvage area. This coarse analysis will be useful for validating, or otherwise, both the initial population estimates for each impact area and the estimated proportion of the population that is salvaged.

6 LIZARD MONITORING PROGRAMME

Lizard monitoring is an important component of the project-wide lizard management and will provide information crucial for the evaluation of the success or otherwise of enacted management measures. Importantly, the purpose of the proposed monitoring is not to measure the survival of relocated lizards (individuals) nor the overall success of the salvage-relocation per se. Rather, its purpose is to measure lizard population change over time in response to enacted management (mammalian predator control and habitat enhancement) at MEAA and to track progress towards the biodiversity offsetting targets (see Ahikā Consulting, 2024a).

Relocated lizards will not be permanently marked nor photo identified, and it is assumed that the response of salvaged-relocated and resident lizards to management will be similar (e.g., an increase in resident lizards in response to mammalian pest suppression will similarly be demonstrated by salvaged-relocated lizards at the same site). Acknowledging a level of uncertainty in this assumption, the monitoring programme makes provisions for monitoring the contribution of salvage-relocated lizards to the resident lizard population, and the effect of such contributions on population level response compared to areas where no salvaged lizards are released (see section 6.4. "Monitoring programme design").

All lizard monitoring activities will be carried out under a valid Wildlife Act Authority (e.g., 98006-FAU).

To measure lizard response to management, population level monitoring needs to occur both before and after management intervention, and monitoring needs to continue over a sufficient period to allow measures of success or failure to be confidently determined.

For this project, three levels of lizard monitoring are proposed, including:

- Baseline monitoring (commenced April 2024);
- Buffer area monitoring (commenced April 2024); and
- Post-release monitoring.

The details of each type of monitoring are described below.

6.1 BASELINE MONITORING

The baseline monitoring programme commenced in April 2024, and sampled select impact sites (e.g., CO6 Pit, GB2 Pit, GBWRS, etc.) and the mitigation (lizard relocation) site (e.g., MEEA and the surrounding buffer pest control area; see Ahikā Consulting, 2024a) (Figure 6.1). Baseline monitoring serves the purpose of providing data on lizard populations (i.e., species diversity and population size) prior to the commencement of impact and prior to enacted management. The baseline data has assisted with refining the population range estimates of species occurring in potentially affected PCs and will establish reference points against which population change or trends (e.g., in response to management) can be measured over time.

Monitoring was also undertaken at the Back Road Waste Rock Stack site ("BRWRS"), even though this site is not required for the MP4 Project. The information gathered from the BRWRS site has provided both additional data on lizard abundance in the wider surrounding landscape and valuable baseline data on lizard populations should the site be considered for mine development in future.

Two rounds of the baseline monitoring for each select impact site will be implemented to account for temporal variation. That is, two years (e.g., Year 1 [April 2024] and Year 2) of baseline monitoring, and where practicable, repeated monitoring in spring (e.g., October/ November) and late summer (e.g., March/ April) each year would be undertaken to provide robust population data. It is important to highlight that reducing the number of sampling events may reduce the accuracy and robustness of the baseline data.

6.2 PROJECT COMPONENT BUFFER AREA MONITORING

The 100 m PC buffer zones (i.e., areas that may be indirectly affected by activities) surrounding some of the MP4 PCs (e.g., CO6 Pit, GB2 Pit, and GBWRS) will continue to be monitored post-impact. The initial (April 2024) baseline monitoring has already provided pre-impact data on the estimated number of lizards occurring inside the 100 m buffer zones (see section 4.3 “Lizard population size estimates”). Continued monitoring inside the buffer zones post-impact on an annual basis for three subsequent years will allow any in indirect effects on lizard abundance over time to be monitored.

6.3 POST-RELEASE AND ON-GOING MONITORING

Repeated annual monitoring of lizard populations in the MEEA and surrounding buffer pest control area will occur following the release of salvaged lizards and will continue for 10 years. The purpose of this monitoring is not to measure the survival of relocated individuals, nor the overall success of the salvage-relocation itself, but rather measure lizard population change over time in response to enacted management. Baseline lizard abundance estimates at Murphy’s EEA (where mammalian predators will be eradicated) and the wider buffer predator control area (where predators will be suppressed) has been collected in April 2024. Repeat annual monitoring of lizard abundance at these sites once pest control operations are in place will allow lizard population responses to be measured and evaluated against management targets [Ahikā Consulting, 2024a]), ultimately allowing positive ecological outcome (‘no net loss/ net gain’) claims to be validated or to trigger adaptive management where expected outcomes are not met.

In addition, the post-release monitoring will also allow the monitoring of relocated lizard influx (i.e., count or number of individuals of each species rather than unique individuals, which would require permanent marking) into the MEEA, compared to other areas where lizards will not be released.

Bioresearches
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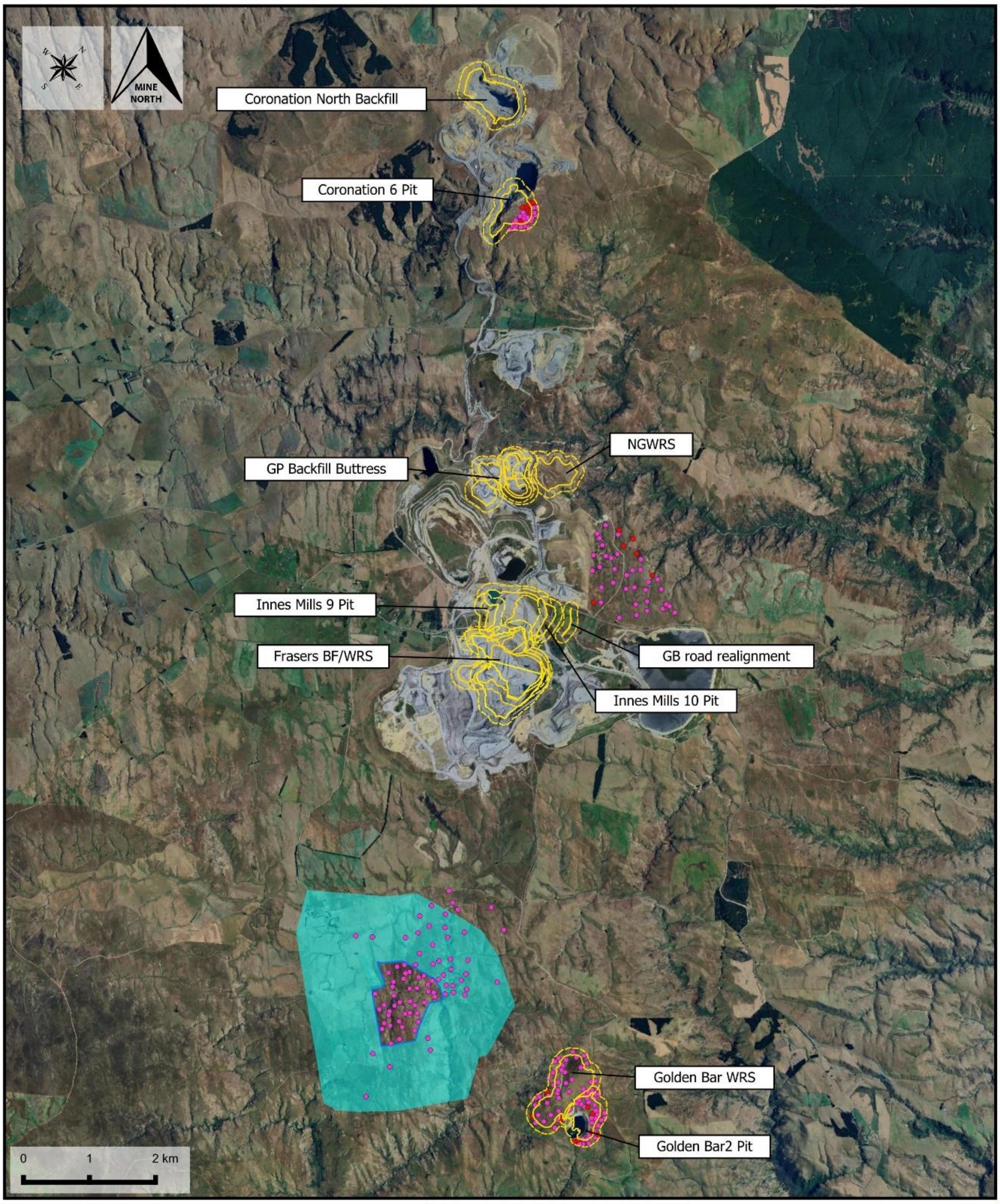

Figure 6.1 MP4 Stage 3: Lizard monitoring sites

CLIENT / PROJECT
OceanaGold Limited

30 July 2024

MAP PROJECTION:
NZGD2000 / New Zealand Transverse Mercator 2000

SOURCES:
LINZ Basemap aerial

SCALE **@ A4 1:75,000**

61130#BEE09

Legend

MP4 Project Components

- Impact footprint
- 100 m buffer
- MEEA fence boundary
- MEEA pest control buffer (indicative)
- Lizard pitfall trap

Bioresearches
A Babbage Company

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

6.4 MONITORING PROGRAMME DESIGN

All lizard monitoring undertaken as part of MP4 Project will primarily focus on skink (*versus* kōrero gecko) populations because effective monitoring of geckos in dryland landscapes where geckos use tors, is unreliable or not possible. As both skinks and geckos in the Otago landscape are vulnerable to the same or similar pressures (e.g., habitat degradation and mammalian predators), it is expected that any skink responses will provide a proxy for kōrero gecko response; recognising that gecko response will lag due to the difference in reproductive biology between skinks and geckos.

The monitoring design has been outlined in section 4.3.2 "Modelled population estimates" but is repeated here for convenience. The design employs stratified random sampling to establish a defined number of independent sites[23] across the monitoring areas. Sampling is achieved by overlaying 20 x 20 m grid squares on the monitoring areas and randomly selecting a representative number of grid squares ('sites') that will be subject to monitoring (Figure 4.2). The number of randomly selected sites varies between, and is related to, the size of monitoring areas (Table 4.4).

To discern the effect of relocated lizards on population level response within MEEA, the lizard release will be strategically implemented to ensure that some monitoring sites occur in areas where salvaged lizards will be released while other sites will aim to monitor only resident lizards (i.e., these sites will not receive salvaged lizards).

At each site, a pitfall trap (covered by an *Onduline* ACO) has been installed and will sample lizards at that specific site. Pitfall traps will be activated at least annually, preferably biennially, over a 10-day period during the months of November to April, inclusive, with 'lizard species' and 'count' (*versus* mark-recapture) data recorded.

Models for estimating abundance from repeated counts of a closed population (e.g., Royle's (2004) N-mixture model) will be used to generate lizard population estimates for each of the monitoring areas. Population estimates (with confidence intervals) generated from the April 2024 monitoring session provide the baseline reference points for each affected area prior to impact and for the mitigation site (MEEA) prior to pest management and lizard release. The same monitoring sites and data analyses will be used following the release of salvaged lizards to monitor lizard response to management over time. Where appropriate, an open population model (e.g., open population generalization of Royle's (2004) N-mixture model; Dail & Madsen, 2011) will be used to explore population trend data across years. Alternatively, a series of closed-population models (Royle's (2004) N-mixture model) for each year will be compared[24]. Covariates (e.g., temperature, relative humidity, habitat type, etc.) will be used to account for the influence of an outside variables that may affect the model results.

Lizards captured in pitfall traps will also be temporarily marked with non-toxic (xylene-free) marker pens so that individual capture histories over the period of the monitoring sessions can be recorded. Understanding individual capture histories will assist in testing both the independence of monitoring

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[23] Independent sites are considered sites that are sufficiently spatially distributed to eliminate the possibility of the same individual(s) being detected more than once during a sampling period. For this monitoring programme, a minimum distance of 20 m between sites has been set.

[24] Decisions to use closed or open population models will be informed by a biostatistician.

sites (i.e., individual pitfall trap sites) and the closed-population assumptions of each annual monitoring period. Population demographic information will also be collected for all species encountered. Captured lizards will be measured (snout-vent and vent-tail length), weighed, and sexed prior to release.

To provide confidence in the recommended lizard monitoring approach and analytical methods, the monitoring design was reviewed and validated by an experienced biometrician from *Proteus*, an ecological statistical consulting company based in Mosgiel, New Zealand.

6.5 MONITORING LONG-TERM MANAGEMENT BENEFITS

Introduced mammalian predators (especially rodents, hedgehogs, mustelids, and cats) are a driving factor in the population decline of native lizards. Where these predators are supressed or eliminated, positive lizard response occurs (Reardon *et al.,* 2012; Romijn, 2013; Norbury *et al.,* 2022).

Quantitative information on the degree of lizard population response to release from mammalian predators is limited to a few studies, but published information indicates fourfold increases in lizard abundance can be achieved where predators are suppressed to ≤ 5–10% residual catch rates (i.e., 5–10% of the predator population remains in the landscape) and even higher (e.g., sixfold) where mammalian predators are eradicated (Reardon *et al.,* 2012; Norbury *et al.,* 2022).

For the MP4 Project, a no net loss target (to be refined/ confirmed following consultation) inside MEEA over a predefined timeframe (to be refined/ confirmed following consultation) has be set (Ahikā Consulting, 2024a). The baseline and on-going monitoring will provide data that will be used to measure and track lizard response against the target. Where this target is achieved, positive ecological benefit claims for native lizards, as outlined in the Impact Management Plan (Ahikā Consulting, 2024a) will be realised. It should be emphasised that meeting the target will not result in reductions to management (e.g., mammalian pest suppression) efforts and effort will remain constant for the duration of the timeframe set out in the Impact Management Plan.

In instances where population growth trajectories are not tracking towards desired targets, adaptive management will be applied (e.g., increased level of mammalian predator control) in an attempt to bolster lizard population size back to the desired level to meet targets.

6.6 REPORTING

Following each annual monitoring period (post-lizard release), a report detailing the results of the monitoring will be prepared and copies provided to OceanaGold Ltd., the Department of Conservation, Otago Regional Council, iwi, and other relevant stakeholders. The results reported will include but not be limited to survey conditions, estimated population abundances, population demographics, and measures against management targets. Any recommendations for adaptive management would also be provided.

All records of lizards encountered would be compiled and submitted to the Department of Conservation, for inclusion in the Amphibian and Reptile Distribution Scheme (ARDS) database (*BIOWEB Herpetofauna database*).

6.7 Wildlife Act Authority and compliance reporting

Reporting requirements outlined in the Wildlife Act Authority and resource consent will be adhered to.

Lizard capture and relocation data will also be compiled, summarised, and submitted to the Department's national data repository for herpetofauna records (Bioweb ARDS Herpetofauna database) annually. As a minimum, the report will include the following information:

- DOC Wildlife Act Authority number and Project name and location;
- A summary of the species, numbers and age/ sex classes of lizard captured;
- Locations of lizards captured; and
- Summary of salvage method, effort, and success.

7 COMPENSATORY/ CONTINGENCY ACTIONS

Compensatory actions are provided for as contingency measures for unanticipated adverse effects on lizards resulting from the MP4 Project.

These include:

1. If any individual(s) of the larger, rarer lizard species (Otago green skink, Otago skink, grand skink) are found during the salvage operation, the following actions will occur:
    a. Salvage effort will be targeted at sites where rarer or threatened lizard species are detected. The degree and duration of salvage effort will be determined by the Project herpetologist, in consultation with OGL and the DOC, but will be maintained until there is a high level of confidence that all rare or threatened lizards have been removed from the affected area(s).
    b. The lizard(s) will be released into suitable habitat within the fenced and intensively predator-controlled area of MEEA; and
    c. A dedicated and localised monitoring programme will be developed and implemented by the Project herpetologist to monitor the survival of the individual(s) over time (e.g., photo-sight-resight) at and near their point(s) of release.
2. If the overall lizard salvage numbers are unexpectedly exceeded by more than 5% of the anticipated number, during any one of the staged salvage operations[25], all 'excess' individuals will be released into the existing Island Block Covenant site and/ or other suitable area, without any habitat enhancement or follow up monitoring requirements. While high numbers of 'excess' lizards are not expected from the salvage programme[26], an upper limit of no more

[25] Such a situation may arise if large numbers of lizards are captured in the final day of the salvage or where more individuals are captured during the dismantling of targeted rock tors.

[26] The salvage programme has been designed with 'stopping rules' (see Section 4.2) to reduce the likelihood of ending up with high numbers of excess lizards.

than 20 lizards/ ha (of any species) would be released into the Island Block Covenant[27] and/ or other suitable area. Where excess lizards are salvaged, the species and number of individuals will be clearly reported to the Department of Conservation.

3. If any individual(s) of a threatened species (Otago or grand skink) is killed as a direct result of the project activities, compensation could be provided through a contribution to a lizard conservation project focussed on protecting threatened native lizards. The type or value of the contribution will be determined through conversations between OGL, the Project herpetologist, Department of Conservation, and any other relevant stakeholders. The contribution will be commensurate to the effects and sufficient to ensure that tangible benefits for threatened lizard conservation are being realised.
4. Where the post-impact buffer monitoring detects declines in one or more lizard species at rates greater than expected for a species across their national range (i.e., decline rates assigned to species under the NZTCS framework), then more intensive monitoring and investigation into the cause of decline would be carried out. Where necessary, mitigative or compensatory actions would be explored in consultation with relevant stakeholders, including but not limited to OceanaGold and the Department of Conservation.

[27] 20 lizards/ ha is significantly lower than the expected density of lizards already present in Island Block Covenant, as inferred by the abundance of high-quality lizard habitat present at the site and the author's experience with lizard densities in the wider surrounding landscape.

Lizard Management Plan (LMP) Checklist. OceanaGold Limited = OGL, Otago Regional Council = ORC, Department of Conservation = DOC.

Project start-up	**Required of:**	**Completed**
Lizard Management Plan approval	OGL, ORC, DOC, mana whenua.	
Approved lizard release sites	DOC, ORC, mana whenua.	
Pre-start meeting	OGL, ORC, Project herpetologist, salvage team, relevant contractors.	
Demarcation of works footprint	OGL surveyors & engineers, vegetation clearance personnel.	
Pre-works management (prior to vegetation clearance and earthworks)		
Pre-works lizard capture and site preparation	Project herpetologist, salvage team, mana whenua.	
Works lizard management		
Machine assisted lizard capture	Project herpetologist, salvage team, mana whenua, contractor, clearance personnel.	
Lizard relocation	Project herpetologist, salvage team, mana whenua.	
Post-works		
Works completion report and lizard records to OGL, ORC, DOC, and relevant stakeholders.	Project herpetologist.	
Mitigation site management (protection, pest control, revegetation)	OGL, ORC, DOC, Project ecologists.	
Habitat creation at lizard relocation site	Project herpetologist, salvage team, mana whenua, contractor, clearance personnel.	
Post-release monitoring (annually)	Project herpetologist and ecologists.	

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9 APPENDICES

Appendix I. Lessons from the DDNIII Salvage and Recommendations (LizardExpertNZ, 2021)

The extent and duration of the DDNIII Project Impact Area ("PIA") lizard salvage resulted in several lessons for future large-scale salvage operations:

- Based on the predicted number of lizards in the LMP, versus actual numbers of lizards salvaged, a significant upward calibration is required when estimating lizard populations over a similar range of habitats at Macraes Flat. The exact nature of the upward scaling will become clearer once expert index counts over sixteen stage 3 salvage rock tors are compared with actual captures (see Section 3 "Calibration over Sixteen Rock Tors").
- Salvage stopping rules in LMPs need to be flexible, with a feed-back process established between DOC/OGL when the Wildlife Act permit is issued. Salvages of the scale carried out over DDNIII PIA are rare in New Zealand, and as such, stopping rules are still being developed and require real-time adjustment as the salvage progresses.
- Salvage of tussock skinks, at least in the Macraes Ecological District, is best carried out in spring when ground temperatures are relatively low, and skinks are still living in and around overwintering sites. As the season progresses skinks and in particular females, apparently become less catchable. This observation was not relevant to kōrero geckos that were present and catchable year around in most habitats.
- The salvage team were unable to keep ahead of mining works over stage 2 & 3 salvage, highlighting a need to ensure better coordination of OGL mining works schedules with lizard management tasks over any future projects involving salvage.
- Any future LMPs at Macraes Flat, or indeed anywhere in New Zealand where a large-scale lizard salvage project is permitted, need to explicitly provide for any lizards salvaged above and beyond numbers anticipated.

Appendix II. Summary of the MP4 Impact Management strategies for native lizards (Extracted and summarised from Ahikā 2024a).

Compensation

Due to uncertainty in the affected lizard population estimate, compensation is planned for the effects on reptile populations.

Predator control

Pest control or predator removal will be one of the main tools employed at the relocation site to address the effect on lizard and bird populations under the Wildlife Act and the Resource Management Act 1991 (and will also benefit the vegetation offsets and supports the lizard salvage actions described in this LMP).

The focus of the proposed predator control will be based on predator removal within a predator-proof fenced area (Murphys EEA).

Lizard Enhancement Project

The effect of the MP4 project on lizard populations will be addressed under both an offset framework for lost tussock and shrubland habitat (to replace the inherent value of these ecosystems, including as habitat for lizards but also as habitat for plants, invertebrates and other organisms), and predator control. A similar approach to that used in an offset will be employed in designing a Lizard Enhancement Project, which will consist of the predator control described above to achieve a target lizard population size of Net Gain. The lizard population target incorporates several components: addressing uncertainty, measuring the impact on affected populations, measuring baseline and measuring change, and averted loss. Together these are part of the lizard offset calculation.

Rock tor replacement

While the effectiveness of rock tor creation is unknown, it is currently the only technique available to address the loss of rock tor habitat of lizards (and also invertebrates and birds to a degree). At least two rock tor designs are currently being trialled at Macraes (Camp Creek and Deepdell North). The initial results of these trials will be used to inform the best design for replacement rock tors. It is proposed to use locally sourced plate schist to create ~35 replacement rock tors to the agreed design at Murphys EEA along the existing access road (to minimise impact of rock transport).

Site selection for Offsets and Compensation

The Murphys Ecological Enhancement Area (Murphys EEA – Figures 9.1 & 9.2) has been selected on the basis of its proximity to the Golden Bar and Innes Mills pits, the similarity of vegetation to that being affected, and also because it best fulfils site selection criteria for lizard salvage or translocation activities[28]. It is an area of farmland that retains areas of semi-natural vegetation that has been degraded by grazing, weed invasion (particularly by gorse), and a recent fire that severely damaged

[28] NZ Lizard Taxon Advisory Group, 2019

the shrublands and tussock grassland. The tussocks have recovered to about 50% of their probable pre-fire stature and there has been some loss in extent.

The site is comparable in elevation (except to the higher elevation of Coronation 6 area) and general ecological character to the sites within the project area, though there is a greater predominance and greater size of rocky outcrops and tors (a positive attribute).

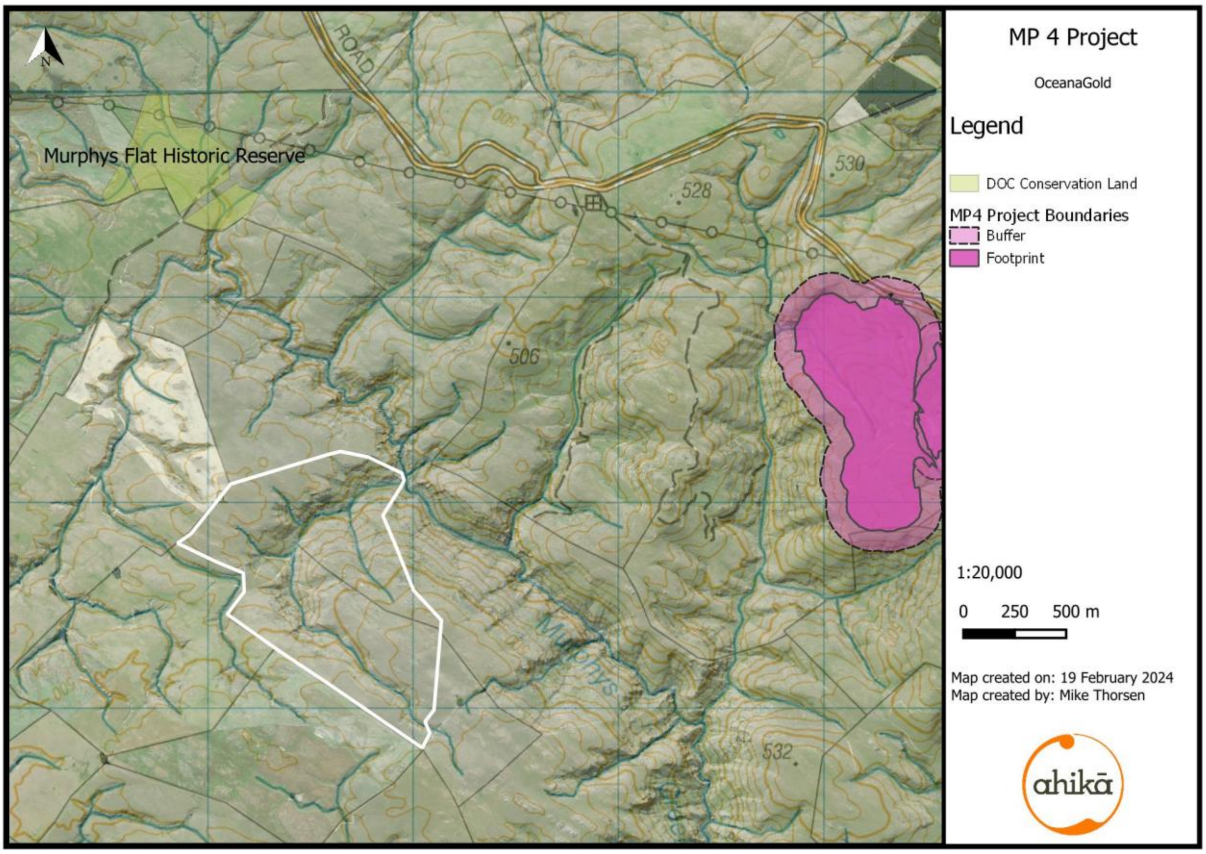

Figure 9.1. Location of Murphys EEA. Note: the white outline indicates the practicable fence line of a predator-proof Xcluder® fence.

The site is near an area known to recently harbour Otago skinks at two sites and these may still be present[29]. A number of other ecological features are present in the site (depending on its final boundary) including populations of other rare plants. The boundary is located to give at least 500 m clearance of a nearby area of potential future mining interest.

Murphys EEA will comprise an area of around 90 ha with the ability to create or enhance 80 ha of tussock grassland, and will be established under the Conservation Act, or other appropriate legal mechanism, in a major tributary mid reach on the west side of Murphys Creek. This area contains biodiversity that is of similar character to that being lost, and visually appears to be of better quality and a higher diversity of species together with other inherent ecological values (such as a developing kanuka shrubland).

[29] Knox, C. 2015. Survey for green skink (*Oligosoma chloronoton* Clade 3b) on the Oceana Gold (NZ) Limited estate at Macraes Flat, Otago. Unpub. Report. EcoGecko Consultants.

Figure 9.2. Overview of Murphys EEA looking SE down valley to Murphys Creek showing habitat variation. Tussock in foreground recovering after a fire.

The covenanted area will be fenced as a primary means of predator control, and to exclude stock. The predator removal/ intensive control area will extend over at least 71 ha in Murphys EEA (Table 9.1) within which the populations of all target pests will be eradicated and maintained at zero (this may require episodic control of mice within the area).

Table 9.1. Estimate of expected quantity of area required to meet a Net Gain scenario under a predator fence lizard management scenario.

	Predator fence
Initial estimate of population response	75% increase from baseline
Correction figure required to reach 147% increase in population size per impacted hectare	1.96
Extent required to meet 36.3 ha of lost habitat	71.1

The planned tussockland, riparian vegetation and shrubland offsets and a large part of the lizard compensation will occur within the Murphys EEA. The vegetation offsets will also address the impact on the matagouri (Declining) and some components of the invertebrate and bird communities through protecting areas inhabited by these species.

Fence detail

A feasibility assessment for the pest-proof fence is provided by Xcluder® in Appendix III. This provides detail on and images of the proposed design, fence and material specifications and construction.

Fence design

The fence design proposed by Xcluder® to meet the needs of the Macraes project is the Xcluder® "All-Pest" fence. This fence is designed to exclude all mammalian pests known to be present at the site.

The basic configuration and dimensions of this fence has proven to be very successful at exclusion of all target pests over several years.

The design has evolved over the last 25 years to improve several historical design elements, and has now been in successful practical service. Xcluder® have significant experience in designing and building pest-proof fences at sites where water management and erosion protection are critical for successful pest exclusion.

Construction

The fence should be constructed on a stable 5 m-wide platform that controls the movement of water through the base of the fence. The platform will accommodate the fence, provide room on the outside of the fence for a vehicle to pass for fence inspections and maintenance, and room on the uphill side for the construction of a water table to entrap and channel all runoff. Formation typically involves earthworks to create a fence line track, similar to a high-quality farm track or rural road, with water tables and culverts used to pass water under the fence (Figure 9.3).

Culverts

One square box culvert 1.5–2 m in diameter (or equivalent volume) and a water gate will be needed at the tributary mouth. Up to 10 small under-fence water management culverts will pass though the fence at various places.

Pest proofing

For pest proofing, the fence employs 6 mm x 25 mm ss316 stainless steel welded mesh and a mesh skirt is pinned into the substrate with stainless steel geotextile pins (typically galvanised), is covered with earth or metal and then re-grassed.

Gates

Secure, vehicle and ATV/pedestrian gates will be built into the fence perimeter for maintenance and monitoring access.

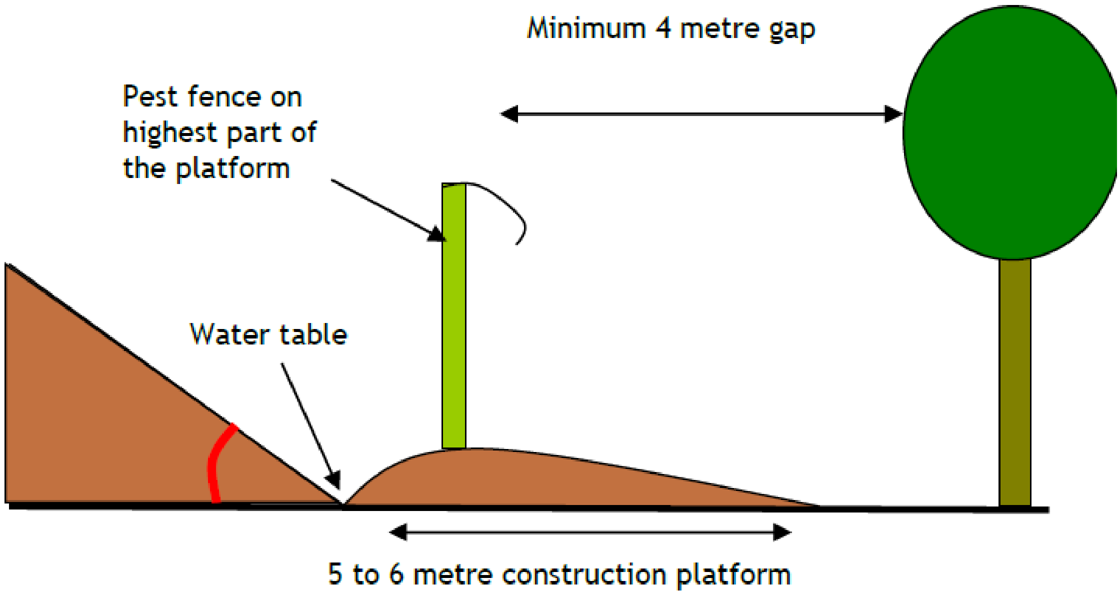

Figure 9.3. Standard fence platform used on steeper sections of the fence

Biosecurity and monitoring

Potential breach points of the predator fence (particularly where the fence crosses ephemeral stream channels) will be reinforced using 1 ha blocks of permanently set Ka Mate traps paired with permanent bait stations restocked 6-monthly on a 10 m spacing to keep mice at very low densities in these vulnerable areas.

An annual inspection and monitoring programme will be developed for the life of the Murphys EEA as part of the Ecological management Plan. It will monitor ecology and habitats covering lizard, bird, invertebrate, and vegetation responses, as well as weed and predator incursions and their removal.

Monitoring

A monitoring programme will be a key part of the project Impact Management Plan. Monitoring will cover the following:

1. Documenting long-term changes in lizard populations within the Murphys EEA, particularly in areas where salvaged lizards have been released.
2. Documenting long-term changes in bird populations, particularly of uncommon or taoka species, in the Murphys EEA.
3. Long-term monitoring of invertebrate communities in the Murphys EEA and Golden Bar WRS tussock rehabilitation in comparison with un-managed site(s) utilising pitfall trapping and light trapping.
4. Monitoring the quality and type of vegetation (community composition, ground cover, structure, weediness, pest damage) in the Murphys EEA, wetland and ephemeral wetland offset sites in comparison with un-managed site(s) (where possible) using permanent plots.
5. Monitoring of establishment and survival of rescued plants.

6. Monitoring of re-establishment of tussock grassland at Golden Bar WRS measuring community composition, ground cover, structure, weediness, pest damage.
7. Environmental weed survey and monitoring.
8. Annual inspections of Murphys EEA to increase knowledge of the biodiversity at the site.
9. Pest animal removal effectiveness.

Long term MEEA management and maintenance

Important components of the Murphys EEA site over the long term include the following:

- Legal protection of site and provision in perpetuity (via a covenant)
- Be of sufficient size to compensate for uncertainties in ecological outcomes
- Will have ecological oversight
- Will have funding to support the Murphys EEA over the term of the offset (35 years)
- Development of a Murphys EEA management plan
- The Murphys EEA will be maintained by dedicated personnel, and the facility will include site buildings to house personnel and equipment

Initial Intensive Predator Control

A preliminary stage of intensive predator control (“IPC”) will occur during Q4 2024 in the northern part of Murphys EEA to facilitate salvaging of CO6 lizards in Q1 2025. IPC will be undertaken prior to fence construction. Fence construction will follow during H2 2025. Predator removal within the fenced perimeter will be completed once all consents are obtained. The planned IPC is outlined in Appendix IV.

APPENDIX III. FEASIBILITY ASSESSMENT AND COST ESTIMATE FOR XCLUDER® PEST-PROOF FENCE AT MACRAES, OTAGO.

Feasibility Assessment and Cost Estimate for an Xcluder® Pest-Proof Fence at Macraes, Otago

February 2024

CONTENTS

1. INTRODUCTION

Ahika Consulting director, Mike Thorsen, has requested a feasibility assessment and cost estimate for an Xcluder® Pest-proof Fence around 90 hectares (four kilometres) to protect the Otago skink (*Oligosoma otagense)* at Macraes. The land is owned by OceanaGold Corporation. Currently two Xcluder fences are currently *in situ* at Macraes to protect Otago skink.

The project brief for this assessment is:

- Look at the feasibility of constructing a full-height pest-proof fence at this location to a standard sufficient to exclude rodents, mustelids, cats and dogs, hedgehogs, lagomorphs, and ungulates.
- Provide a cost estimate for construction of the fence.
- Look at the culvert requirements where the fence will need to cross streams and the possibility of flood impacts on the fence at these sites.

2. PROTECTION OF INDIGENOUS SPECIES

Aotearoa New Zealand has been geographically isolated from other land masses for *c.*80 million years. Over this period the only terrestrial mammals found here were three species of bats. Without exposure to mammalian predators most of the fauna of Aotearoa New Zealand did not evolve the ability to recognise these mammalian predators or life-history strategies to cope with them. Consequently, the arrival of introduced mammalian predators coupled with human modification of habitats has led to many indigenous species becoming endangered, with marked reductions in their geographic range, or extinct.

Predator-proof fences have proven to be an effective tool for protecting biodiversity, because they enable protected sites to be kept at or near zero pest density. In the absence of pests, species once extinct on the mainland can be successfully reintroduced. Examples of mainland fenced sites where species have been returned are Sanctuary Mountain Maungatautari, Brook Waimarama Sanctuary, Otorohanga Kiwi House, and Wairakei International Golf Course.

3. XCLUDER® PEST PROOF FENCES

As part of their efforts to protect and restore Macraes from ongoing threats posed by introduced pest animals, Ahika Consulting commissioned Xcluder® to assess the feasibility of installing a pest-proof fence around the reserve area. A pest-proof fence would provide a visible demonstration of a long-term commitment to protect the endangered Otago skink.

Xcluder® is a New Zealand-based company that specialises in the design and construction of scientifically proven pest-proof fences. Xcluder® fences are able to exclude all mammalian pests found in New Zealand, from juvenile mice to deer. Several years of scientific trials and nearly 25 years of testing and practical experience in the field have shown that Xcluder® fences are effective at excluding all target pests: to date no pests have climbed over, or got through our fences except as a result of nature-induced conditions or damage, human error, or inadequate fence maintenance.

Xcluder® only recommends fences when there is evidence to demonstrate that they will exclude all of the target pest animals and will not build 'operational' novel fence designs unless they have been scientifically tested to be effective. It is critical that a chosen fence design is proven to work in the field, as even the best design will fail to exclude pests if not constructed to precise standards.

Experience

Xcluder® has built over 100 kilometres of pest-proof fence for a wide variety of clients in Aotearoa New Zealand, Australia, Hawaii, Mauritius, and the Azores, and provides animal exclusion advice to clients all over the World. We are proud to have provided the benchmark standard for effective pest-proof fencing in Aotearoa New Zealand, and internationally, over the last 25 years and we strive to continue providing the highest quality and best value fences and exclusion solutions. Our estimate is that we have erected more than 80% of the pest-proof fence built in Aotearoa New Zealand over the last 10 years, and have erected ALL fences at sites where multi-species pest animal eradication has been achieved and subsequently maintained.

We have significant long-standing partnerships with a range of customers, consultants, fencing contractors, suppliers, machinery operators, builders, ecologists, and engineers. We use a construction model which ensures that any new staff or contractors we use in projects are fully trained and competent to achieve rigorous quality and exclusion standards.

Xcluder's® principals and key staff are arguably the most experienced pest-proof fence designers, builders and researchers in the World. Xcluder is focused on developing scientifically-sound, and highly practical, on-the-ground solutions. Published research associated with our projects is typically used as the starting point for anyone embarking on a new fence project or concept. The ongoing success of Xcluder® fences is a result of combining sound scientific research and knowledge with nearly 25 years of practical field-based experience and high-quality project management.

Xcluder's® most significant points of difference from other providers relate specifically to the experience of our team, our ongoing investment in research and development, and the wide range of pest-proofing project types and scales we have implemented:

- We live and breathe pest exclusion.
- We are the only full-time commercial builders of exclusion fencing technology in Aotearoa New Zealand, and probably internationally.
- Our track record and experience is unmatched.
- Partnerships and collaboration. We regularly form successful collaborative partnerships with our customers that allow the best value exclusion solution to be developed and implemented in a manner that best suits the customer.
- Project management experience. We have a proven track record in management and oversight of sub-contractors - earthworks contractors and fencers/builders - to achieve pest-proof quality standards within agreed budgets and timeframes.
- We are outcome-focused. Although most of our projects involve standard construction contracts for an agreed length of fence, gates, and water crossings (and sometimes

earthworks), we are focused on working with clients to deliver a complete exclusion solution rather than just a fence of a given specification.

- Research and development. Key staff have personally been involved in all of our exclusion fence development and research, including testing of the physical and psychological abilities of pests to cross barriers. As such, we know, first-hand, what it takes to effectively exclude target species, and to ensure that this is implemented successfully on-the-ground.
- Value and effectiveness. We strongly believe that Xcluder fences represent the best life-cycle value and most comprehensive solution in the market.

Track Record

Examples are set out below of recent Xcluder® pest exclusion projects that have used fencing technology and components very similar to those likely to be used at MacRaes:

- Brook Waimarama Sanctuary, Nelson: 14,500 metres of Xcluder 'all pest' fence with many stream crossings, six vehicle access points, pedestrian access, and very steep terrain.
- Lake Serpentine: National Wetland Trust wetland site, 1,380 metres of Xcluder® 'all pest' fence, with one sliding door pedestrian access gate, two vehicle entrance gates, and an 84 metre section of attached boardwalk across an unstable wetland peat substrate.
- Wairakei International Golf Course: 6,500 metres of Xcluder® 'all pest' fence, with two manual vehicle entrances, two automated vehicle entrances, ATV gates and integrated buildings.
- Maungatautari Ecological Island: 48km of Xcluder® 'all pest' fence, with ten manual vehicle entrances, pedestrian entrances, and integrated buildings.

Other Xcluder projects within the last five years that have used elements of the same technology, but with different exclusion barriers, materials, or design solutions include the following:

- Shakespear Open Sanctuary: 1,750 metres of Xcluder® 'all pest' fence with three sliding door pedestrian access gates, one manual vehicle entrance, two automated vehicle entrances, two specialised coastal fence ends, substantial earthworks and culverts.
- National Kiwi Hatchery Aotearoa, Rotorua - 241 metres of Xcluder® 'all pest' exclusion fence.
- Brook Valley, Nelson – 14km of Xcluder® 'all pest' fence.
- Various maintenance projects for existing clients, e.g. sea-end replacements at Rapanui Point, using high-grade anodised pipe and stainless-steel materials.
- Various private domestic and rural fencing projects.
- Commercial and industrial pest-proof fences in urban and heavy commercial areas, with close proximity to and integration with roads, traffic, buildings and other infrastructure, and pedestrians.

Xcluder® has the intellectual property, human capital, supplier relationships, facilities, vehicles, machinery, and specialist tools and equipment required to complete this project.

We have the specific expertise and experience to design an effective exclusion system that will work in the environment at Macraes.

4. ON-SITE FEASIBILITY EVALUATION

Xcluder® Pest-proof Fencing Ltd undertook an on-site feasibility evaluation at MacRaes on 12 December 2023. The objectives of this site evaluation were to:

- Undertake a physical inspection of all potential fence construction routes.
- Identification of any potentially difficult areas for fence construction.
- Consideration of fence platform construction and the requirements for water management on the site.
- Consideration of neighbouring land uses and any potential issues relating to pest exclusion.
- Options for vehicle and pedestrian access.
- Provide a quote for the proposed fence construction.
- Prepare a report presenting finding and outlining options and costs for construction of a pest-proof fence.
- Provide Ahika Consulting with sufficient information to enable development of a contract or tender process for fence construction.

5. PROPOSED FENCE ALIGNMENT

It is feasible to construct an effective pest-proof fence around the MacRaes site.

Selection of the fence alignment took account of the following factors:

- Terrain, including topography and ground conditions.
- Management of water and earthworks requirements.
- Vegetation cover and fence alignment.
- Pedestrian and vehicle access.
- Other site factors.

These factors are discussed further below.

Terrain

The terrain along the proposed fence alignment is moderately steep hillslopes with a rocky substrate. There is evidence of rock at shallow depths beneath the surface around the entire fence perimeter.

Management of Water and Earthworks Requirements

All of the streams on site are low volume unless there is a significant storm event. The main stream adjacent to the fence, Murphy's Creek, would be outside the fence line but is fed by a side catchment. The proposed fence line would cross the gully before it leads into Murphy's Creek.

Where the gully feeds into Muphys Creek the crossing will require a 1.5-2m square box culvert. The water crossing at the bottom of the gully is marked in blue (Figure 1).

The gully has permanent year-round low level water flow, but there was evidence that the water level can rise significantly after heavy waterfall. Any water flows through the fence needs to be managed to avoid erosion that could compromise pest-proof integrity.

During the site assessment there was little evidence of significant water flow through the proposed fence line other than the gully flowing into Murphy's Creek.

A vehicle gate should be installed near the crossing for maintenance in case of damage during storm events. The location of the vehicle gate is marked in yellow (Figure 1).

Up to 10 small 525 mm culverts with a box screen would be required around the fence line perimeter with most of them being located leading up the left-hand side of the gully. Water must be controlled on the steeper slopes.

The red line (Figure 1) is an option to go right around the top of the gully and not go across the dam with extra water pipes and screens. This has not been costed in this report but we would be happy to provide a costing if this was required.

Vegetation Cover and Fence Alignment

Land use outside of the proposed fence alignment is predominantly pasture with some low scrub and tussock on the left-hand face.

Land cover inside the proposed fence line is regenerating scrub and tussock which would require minimal earthworks. This will be left to continue to recover and provide habitat for the skinks. The surrounding land is leased to a local farmer and the top of the catchment is already fenced with a farm fence and the Xcluder fence should be placed parallel to that, approximately 5-6 metres from the existing fence. Existing farm fences that will be inside the new pest-exclusion fence should be removed. These can be rebuilt outside the pest-proof fence where there are currently no fences. Two hot wires should be placed on the outside of the farm fence to keep cattle away from the fence. Sheep would not pose a threat to the pest-proof fence and could be allowed to graze up to the margins.

In some areas the existing fences may need to be adjusted to allow the proposed pest fence to go around the top gully and maintain a six-metre buffer to protect it from damage by cattle/deer.

Figure 1: Proposed alignment of the pest-proof fence.

Pedestrian and Vehicle Access

For regular maintenance a vehicle gate would be recommended to enable a digger to get in near the gully in case of potential flood damage to the crossing in the event of a storm. This would need to be placed on the left-hand side looking up the stream beside the bottom crossing. Alternatively, a panel could be put in the fence that can be unscrewed and provide access for a digger. This would need to be resealed when the digger is on site.

Two ATV gates would be installed, at the locations marked in red (Figure 1).

Other Site Factors

Other features that need to be taken into account for fence design and construction are:

If high winds are an issue then an additional bracket should be placed over the hood join to strengthen the hood. This helps hold the hood when gusts are resulting in extreme wind speeds. These only need to be placed on the high exposed parts of the ridge.

The rocky substrate, at shallow depths, will require drilling for the placement of fence posts. One digger will be required with a auger drill for line clearance and the drilling of strainer holes. Two tractors with auger drills will also be on-site to drill the post holes.

During the site visit the fence line was only partially walked due to time constraints and the more difficult aspects of the fence were focused on. There may be other issues which have not yet been identified.

6. FENCE DESIGN AND CONSTRUCTION METHODOLOGY

The Macraes site is predominantly medium to steep hill country with light friable soil. Rainfall in winter can be significant.

Xcluder have significant experience in designing and building pest-proof fences at sites where water management and erosion protection are critical for successful pest exclusion. The Brook Waimarama Sanctuary project and the Maungatautari project in the Waikato are excellent examples of projects where construction of a stable platform on which to build the fence was essential. Selection of an experienced provider who can deliver an effective solution will be a key component of this project.

The construction programme will follow a systematic approach, consisting of:

- Consents and approval process.
- Earthworks and water treatment.
- Base fencing.
- Pest-proofing.
- Gates and Surveillance.
- Quality assurance and sign off.

The consent and approval process sits outside the scope and costing provided in this assessment.

The fence design we propose to meet the needs of the Macraes project is the Xcluder® "All-Pest" fence. This fence is designed to exclude all mammalian pests known to be present at the site, and we see no reason why complete exclusion of all pest species should not be feasible at Macraes. The basic configuration and dimensions of the Xcluder® "All-Pest" fence have been proven to be very successful at exclusion of all target pests over a number of years.

The design proposed has durable and aesthetically pleasing design. The design has evolved over the last 25 years to improve several historical design elements, and has now been in successful practical service at Lake Serpentine, Omaha Spit, Corvo (Azores), Shakespear Peninsula, and Wairakei International Golf Course (see Figures 2-1 and 2-2 in Appendix 2), and Otorohanga Kiwi House. This design has also been constructed more recently at the Brook Waimarama Sanctuary in Nelson and is described below.

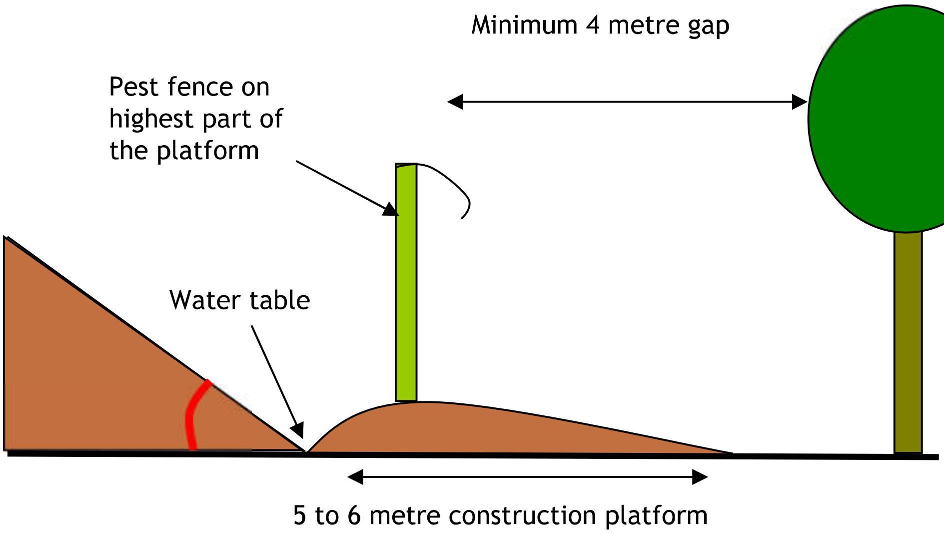

Figure 2: Standard fence platform used on steeper sections of the fence.

6.1 Earthworks and watercourse treatments

The Xcluder® fence should be constructed on a stable platform that controls the movement of water through the base of the fence. This typically involves earthworks to create a fence line track, similar to a high-quality farm track or rural road, with water tables and culverts used to pass water under the fence.

We have allowed for up to 10 culverts though the fence at various places. Most of them would be on the left-hand side leading up from Murphy's Creek.

The formation of the platform for the fence is a critical stage in the construction of a pest-proof fence. Xcluder® normally uses a standard farm-track/roading earthworks prescription for protection of the fence base from erosion and providing a stable long-term base. The platform must be at least five metres wide. A platform of this width is necessary to accommodate the fence, provide room on the outside of the fence for a vehicle to pass for fence inspections and maintenance, and room on the uphill side for the construction of a water table to entrap and channel all runoff (see Figure 2). Surface water runoff tends to bounce off the mouse-proof (6 mm × 25 mm) mesh that we use, and can result in accelerated erosion; for this reason we must prevent water flowing through the line of the fence in any concentrated way by mounding of the fence platform, creating water tables, and drawing surface runoff under the fence through screened culverts. Longer steeper sections of fence require greater numbers of cut-out culverts.

Small Culverts

Most of the under-fence water management culverts required will be concrete, steel or plastic round pipes, of specifications typically used in roading applications, with appropriate water containment and directional structures on the inlet and/or outlet ends of the pipes, e.g. headwalls. There would also be facility for the use of square or rectangular culverts where these were better suited to a particular site.

For small water table culverts (up to 525 mm in diameter), we suggest the use of proprietary culvert mesh cubes (with lockable lift-out screens) (Figure 1-1 in Appendix 1) on the culverts. Our experience from other sites has shown that these cubes will cope better with the occasionally large flows and associated debris than a flat screen alone. The cubes and screens are typically fully galvanised. Stainless steel equivalent cubes can also be used where there are corrosive influences.

Large Culverts

One square box culvert 1.5-2m in diameter (or equivalent volume) and a water gate will be needed. This culvert will require a swinging screen that releases under loading from water or debris and is self-closing. Xcluder® has built swinging water gate systems to suit each situation, but almost all involve the use of a square concrete box structure, in which there is a fully galvanised swinging pest-proof screen (Figure 1-2 in Appendix 1). These gates have to be manually checked after heavy rain events to ensure that they have closed property. Alternatively, electronic monitoring can be put in place for all swinging screens.

6.2 Xcluder® "All Pest" fence and materials specifications

Base Fence

- The base fence consists of a two-metre-tall framework of 135 mm quarter-round 3 metre long wooden posts and 185 mm round 3.6 metre long strainers, spaced two metres apart (see Figure 1-3 in Appendix 1).
- Fence sections in unstable ground (or soft ground) are stabilised using various techniques, including longer posts, additional bracing, and additional design structures, to provide a stable base for exclusion fencing.
- The base fence is built to the highest NZ fencing industry standards.
- The base fence provides a clean aesthetic 'look' while being an exceptionally strong framework using high-grade materials that have been proven over many years to be suitable for high-quality fencing in rural and agricultural landscapes.

Pest-Proof Components

- **Mesh:** We would use proprietary Xcluder® 6 mm × 25 mm ss316 stainless steel welded mesh, coated with a karaka green epoxy resin finish. Every batch of mesh is independently tested, inspected, and verified to assure uncompromised quality. This mesh is proven to exclude all species, including mice, and has been used successfully in over 100 km of pest-exclusion fence erected to date. The mesh extends from the top of the fence all the way down the face to form a horizontal mesh skirt below ground-level. Unlike woven or chain-link meshes, welded mesh has fixed wire spacing's and no inter-wire movement or fretting (a corrosion risk), thereby providing a more robust pest-proof barrier.
- **Mesh skirt:** the mesh skirt is pinned into the substrate with stainless steel geotextile pins (typically galvanised), is covered with earth or metal and then re-grassed. At the Macraes there is a large area, approximately 1km, where the skirt line is directly on rock and concrete would be required along the edges. The bags of rapid set concrete are poured on the edge of the mesh to seal it and topsoil can then be placed over the top.

- **Horizontal mesh joint:** karaka green 50 × 3 mm 6061 grade Aluminium flat bar and karaka green 50 × 25 × 3 mm aluminium channel (riveted with structural aluminium rivets).
- **Hood structure:** The proprietary Xcluder® hood structure consists of three parts: (1) an aluminium channel (top rail) suspended between posts that carries the hood; (2) an aluminium right angle section that sandwiches the mesh against the channel, sealing it in two dimensions; and (3) the Xcluder® hood, made with "low-sheen" karaka green long-run zinc-alum roofing, which seals the right angle and channel in the third dimension, providing secure mouse exclusion.
- **Hood expansion and contraction:** Hood sections naturally expand and contract with thermal heating and cooling and this movement must be allowed for.
- **Hood brackets:** Strong proprietary karaka green powder-coated aluminium hood brackets are used to secure the outside rolled edge of the hood to the fence posts.
- **Fastenings/fixings:** Coated steel, aluminium and stainless steel screws, rivets and wire ties (ss316 grade). All fastenings are designed to be of appropriate strength and metallurgically compatible with the materials they are fixing.

Figure 3: Panel view of Xcluder® "All-Pest" fence.

6.3 Gates

Vehicle Access Gates

Xcluder® builds a range of vehicle or maintenance gates, seamlessly integrated into our fences. The vehicle gates required at Macraes will be similar to that shown in Figure 1-5 in Appendix 1.

ATV Gates

Xcluder® build a variety of ATV and pedestrian access gates to suit the needs of different projects. These can be fitted retrospectively if required as shown in Figures 1-6 and 7 in Appendix 1.

7. PROJECT TIMELINE

The timeline for a project of this scale set out below:

- Preparation including consent process 6-12 months.
- Fundraising (unknown).
- Earthworks up to 1 month.
- Base fencing and predator-proofing 4-5 months, starting shortly after earthworks commences. Due to the nature of the rocky substrate the build time would be approximately one month longer than usual.

It is expected that the fence would take approximately four to five months to complete. Variables which would determine this are weather, materials availability, and labour availability.

8. COST ESTIMATE

The following cost estimate is for the materials and construction of an Xcluder® pest-proof fence at Macraes. Prices are GST exclusive.

	Units	Rate	Cost Estimate
Materials	4,000m		[redacted]
Labour/sub-contractors and project management	4,000m		[redacted]
Location costs including equipment hire	4,000m		[redacted]
Vehicle gate (larger mechanical)	1	[redacted]	[redacted]
ATV gate (manual)	2	[redacted]	[redacted]
Specialty Xcluder components			[redacted]
Total		[redacted]	[redacted]

Notes

- One mainstream crossing has been identified and will require a large box culvert and screen. The line may require up to 10 525 mm culverts, boxes, and screens to control the flow of the water from the inside of the fence line to the outside.
- The cost above includes one Xcluder fencing manager who will spend approximately 20 days on-site, travel, and location costs, but no other Xcluder staff.
- An estimated labour costs for up to six staff to be sourced locally are provided below.
- One digger and two tractors with augur drills would be required to drill the holes.
- This estimate does not include costs associated with pre-fencing works, including but not limited to:
  - Consultation and planning- feasibility studies, environmental, cultural, and social impact assessments.
  - Site clearance and preparation for fencing.
  - Engineering input and design permits and consents.

- Earthworks costs are included at an estimated [redacted] An earthworks contractor will need to visit and assess the cost of bulldozing the preferred alignment and provide a quote.
- There will be a requirement for a road up the fence line on the left-hand side of the valley from the fence line to control the water going through the fence. A road could be designed to go all the way up from Murphys creek on the left-hand side. A 200-300m section of roading or benching would be required on the right hand of gully.
- Earthworks should only be done on the line as required.
- Material and equipment will need a secure storage area for the duration of the project.
- Note also that this is an estimate only. We are more than happy to discuss any aspect of the proposed project, and to provide a detailed quote if the project was to proceed. Costs of materials will need to be confirmed at the time of a quote.
- The clearance margin from the outside edge of the fence to the nearest vegetation will be four metres but the clearance line to create the platform could be up to 6-10 metres wide.
- We have made allowance for up to 10 medium culvert crossing (525 culvert pipe with box screens) and one large culvert at 1.5-2m. If more are required there will be an increase in costs.

Local Labour

Item	Units	Cost Estimate (GST exclusive)
A South Island based fencing company, Greg Oliver Fencing, has the staff and equipment that would be required to undertake this project under Xcluder's supervision. We have provided an estimated cost for eight staff for 150 days.		[redacted]

Appendix 1

Xcluder® Componentry

Figure 1-1: Galvanised mesh culvert cubes to provide pest-proofing on water table pipes.

Figure 1-2: Xcluder® swinging water gates mounted in concrete box culverts.

Figure 1-3: Section of base fence prior to installation of pest-proof components.

Figure 1-4: Xcluder® “up-and-over” structure for an abutting fence.

Figure 1-5: Xcluder® vehicle access gate installed in an Xcluder® “All-Pest” fence.

Figure 1-6: Xcluder® pedestrian access gate at Shakespear Peninsula, featuring interlocked, self-shutting sliding doors in a 3 × 2 metres aluminium cage.

Figure 1-7: Xcluder® self-shutting ATV access gate under construction at the Agrodome.

APPENDIX IV. INTENSIVE PREDATOR CONTROL PLAN FOR NORTHERN MEEA (BIODIVERSITY RESTORATION SPECIALISTS, JUNE 2024)

Proposed Interim Pest Control for lizard-transfer site – Murphy’s Creek 2024-2025 (Oceana Gold), Otago

BRS
BIODIVERSITY RESTORATION SPECIALISTS
027 498 6433

Proposed Interim Pest Control for lizard-transfer site –

Murphy's Creek 2024-2025 (Oceana Gold), Otago

GA Harper

Citation: Harper GA (2024). Proposed Interim Pest Control for lizard-transfer site – Murphy's Creek 2024-2025 (Oceana Gold), Otago. Biodiversity Restoration Specialists Ltd. Unpublished report. 5 pp.

Cover photo: Upper Murphy's Creek, Macraes, Otago (G. Harper)

Version History:

Version	Date	Author(s)	Reason for change
1.0	July 2024	G Harper	1st draft for review

Summary

A 30ha site in Murphy's Creek, Macraes, has been suggested as the receiving site for lizards transferred from the Oceana Gold mine. The site will be a holding location in the interim, until a predator-proof fence is constructed. There are a suite of mammalian predators requiring intensive control to protect the lizards and this is work is complicated by the area's current use for pastoral farming. In order for the control regime to work effectively care will need to be taken to reduce stock interference with the pest removal tools. A two-tier control regime is suggested, with one tier covering a larger area targeting the larger predators (cats, mustelids), and a more intense tier within a stock fenced lizard-release site for smaller predators (hedgehogs, rats, mice).

Introduction

Due to delays in implementation of proposed predator-proof fencing of the Murphy's Creek catchment (Harper 2023) and the need to transfer lizards from a portion of the Oceana Gold opencast mine, a 30ha site on the true right of Murphy's Creek has been suggested as a receiving site for the lizards. In order that the lizards stand the best chance of surviving the transfer, the site will need to have intensive predator control in place before and during the fence construction period and subsequent pest mammal removal.

Targeted Mammalian Predators

Feral cats

Cats are the largest wild terrestrial predator in New Zealand (♂: ~3.5kg, ♀: ~2.5kg) Their home ranges in rural areas can range from 50-400ha with their ranging behaviour and home range size being inversely related to principal prey abundance, i.e. when prey is scarce, cat home ranges enlarge. Introduced mammals are usually the most common prey item for cats, with rabbits being preferred, followed by rodents. Cat removal success tends to be inversely related to prey density, so reduction in prey animal abundance will significantly improve cat eradication efforts.

Ferrets

Ferrets are large mustelids (♂: ~1.1kg, ♀: ~650g). Ferrets prey on rabbits and hares in pasture. They will prey-switch if rabbits become rare, so the currently low rabbit population densities at Macraes are likely to exacerbate the predation pressure on alternative prey such as rodents, and native lizards and birds. Home ranges range from 45-760ha depending on sex and breeding season.

Stoats

Stoats are small mustelids (♂: ~320g, ♀: ~220g). Prey includes rabbits, rodents, birds and lizards. During the breeding season the home range of female stoats can be as small as 9ha, whereas males can retain much larger home ranges of ~ 300ha

Hedgehogs

Hedgehogs (~650g) are mainly insectivorous, but will eat slugs, snails and earthworms, and will prey on mice, lizards, and the eggs and chicks of ground-nesting birds. They are highly seasonal, spending most of the winter largely hibernating, with intense activity related to breeding occurring in spring. Hedgehogs do not hold territories and have overlapping home ranges ranging in size from 3-90ha,

Rabbits

Rabbits (~1.3-1.7kg) are likely the primary prey of cats and mustelids in Macraes, so their population abundance will largely drive the predator-prey dynamics in the area. Breeding can occur year-round but can be curtailed by food shortages. Females can produce up to 45 young per year but population growth can be curtailed by high mortality in young rabbits. Population densities can reach 20+/ha.

Implementation

The predator control programme will, to a degree, depend on rabbit population numbers. At high rabbit abundance predators will, as a general rule, be less interested in traps or bait. An additional consideration is that the upper Murphy's Creek catchment is grazed, mainly by sheep, on a lease from Oceana Gold. This presents a problem with implementation of a predator removal programme as sheep are likely to interact with the pest removal and monitoring tools (standing on/rubbing) which can damage them and reduce their effectiveness. One option is to fence the 30ha receiving site to remove the sheep. This will likely reduce rabbit numbers within a fenced site as they generally prefer short grass habitat. However, rodent numbers are likely to increase, as thick grass provides cover from predators, along with food from increased arthropod numbers and seeds. Similarly, long grass provides cover for lizards when moving between rock tors. Therefore, on balance, fencing the 30ha site appears the better option, with the added advantage of not having sheep interference, although the required rodent control will need to be intensive and sustained to reduce the predation risk for lizards.

A two-tier predator removal regime is proposed, with a larger area (~140ha) surrounding the 30ha lizard receiving site having extensive large-predator removal traplines to intercept cats and stoats before they enter the lizard transfer site. The lizard receiving site would have intensive predator control in place with a mix of traps and bait stations to knock-down and maintain the population of hedgehogs, rats and mice at low numbers. Figure 1 provides an indicative location of the large-predator traplines and trapping sites (in red) and the lizard fenced site (actually ~20ha, in blue).

Where possible any boundaries, whether natural (e.g. streams/grass-shrubland) or artificial (e.g. roads, culverts, fences) should be used for the large-predator traplines. The fence around the lizard transfer site provides a good boundary to set traps against, and there are farmland fences, 4WD roads, culverts, small streams and shrubland edges within the larger control catchment area that will increase trapping effectiveness.

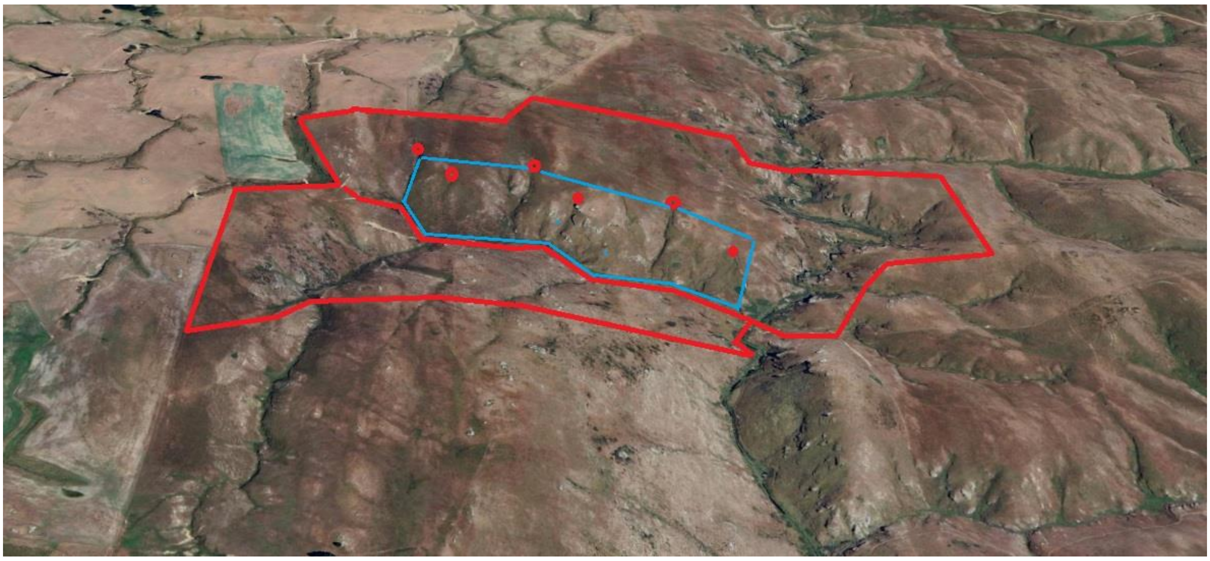

Figure 1. Oblique aerial view of Murphy's Creek showing indicative locations of the lizard transfer fenced site, and the large-predator trapline and trap sites.

A suite of traps should be used on the large-predator trapline, including soft-jaw leghold traps, walk-through traps, Timms traps, DOC 200s (stoats/hedgehogs), and bait stations for PAPP. The outer trapline is about 4.3km long, with the internal trapline being about 1.2km, with a 1km line along the ridgeline of the fenced site, or some 6.5km in total. Traps and bait stations will be established at 200m intervals. Trail cameras will be used for monitoring, placed on the trap lines at every 3rd trap/bait station.

Within the fenced lizard transfer site and 20 x 20 grid of 600 bait stations and 100 traps (DOC200s) will be established on a 20 x 20m grid. This tight grid spacing will be required to target mice with their small home ranges, and will remove rats and hedgehogs with their larger territories, and any stoats that enter the site. Tracking tunnel transects (10 x 25m between TTs) will be used for monitoring.

It is proposed that a knock-down of the predator populations, using toxins, is carried out about 2-3 weeks before the lizard transfer takes place (planned for about March 2025). This will provide enough time to fence the site and establish the traps and bait stations before the knock-down. It will also allow time to monitor the existing predator populations to provide a baseline to gauge the effectiveness of the predator removal effort once implemented.

For the large-predator trap line, bait stations should be in place by the end of 2024 to habituate the large predators to them. Non-toxic pre-baiting for 2-3 weeks prior to knock down is suggested, in order to key the target animals into feeding at the bait station. Baits should be checked and replaced daily. PAPP, or 1080-laced baits are likely the best toxins to use for the knockdown. Toxic baits should be checked and re-baited daily to remove any additional animals that may also be visiting bait stations. Toxic bait replacement should continue until bait take reaches zero.

Similarly, for the fenced site, the bait stations need to be in place for at least 3 months prior to being baited to allow for habituation. Baiting should start 6 weeks before the lizards are transferred. No pre-baiting is required. Two brodifacoum block baits should be placed in each bait station and then checked every 3 days and baits replaced until bait take reaches zero. Trapping should begin 2 weeks before the lizards are transferred.

Monitoring should be carried out every 3 months, and for the fenced site, baiting repeated once tracking rates exceed 10%.

It is assumed that the Lizard Transfer Site will be in operation for about 12 months until the new Predator-proof fence is constructed and activated.

[redacted]

Reference

Harper GA (2023). The feasibility of long-term removal of pest mammals from Macraes (Oceana Gold), Otago. Biodiversity Restoration Specialists Ltd. Unpublished report. 56 pp.

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APPENDIX V. CERTIFICATE VITAE: DYLAN VAN WINKEL

Dylan van Winkel

Technical Director –

Terrestrial ecology/ Herpetology

M.Sc. (Hons) Conservation Biology

B.Sc. Zoology & Physiology

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Personal profile

Dylan has over 15 years of experience in the fields of ecology, herpetology, and conservation. More specifically, his focus has been on herpetofauna survey and monitoring, translocation, threatened species management, in situ conservation, and invasive herpetofauna eradication. Dylan is a consultant herpetologist to the Ministry for Primary Industries (Biosecurity New Zealand), a member of the IUCN Skink Specialist Group (SSG), council member of the Society for Research of Amphibians and Reptiles of New Zealand (SRARNZ), a herpetological advisor to the Endangered Species Foundation, and an external member of the New Zealand Lizard Technical Advisory Group. He is also an assessor for both the National and Tāmaki Makaurau/ Auckland regional reptile threat conservation status assessments and reptile assessments for IUCN Red List.

Career summary

2009–present	Senior ecologist/Herpetologist: Bioresearches (Babbage Consultants)
2006 – 2009	Independent ecologist.

Current Wildlife Act Authorities

- 37604-FAU: National herpetofauna capture, handling and holding in temporary captivity, & small-scale relocations.
- 98006-FAU: Auckland capture, handling and holding in temporary captivity, & small-scale relocations.
- 102041-CAP: Holding protected lizards in captivity.

Featured herpetofauna experience

- **Department of Conservation: Lizard monitoring programme for Rangitoto and Motutapu Islands (2008/2009):** Implementation of monitoring programme for Department of Conservation. Management and delivery of pre-eradication assessment of lizard diversity, spatial distribution, and abundance.

- **Waka Kotahi/NZTA: Ara Tūhono Pūhoi to Wellsford RoNS (2012–2015) & Northland Bridges Kaeo (2019–2020):** Native lizard surveys and provision of management recommendations to mitigate potential adverse effects.

- **Auckland Council: Gecko monitoring programme for Regional Parks (2010–2017):** Collaborative development and implementation of a long-term region-wide monitoring to determine the spatial and temporal distribution and abundance of indigenous geckos.

- **Auckland Council: Muriwai gecko monitoring (2020–2024):** Development and implementation of a long-term population monitoring to determine the spatial and temporal distribution and abundance of Muriwai gecko and tātahi skink.

- **Tonkin & Taylor: Technical herpetofauna field assistance Mt Messenger & Ara Tūhono Pūhoi to Wellsford RoNS (2017–2018):** Provided technical field expertise to assist survey identification of lizard species and spatial distribution at Mt. Messenger. Provided technical field and logistical expertise to capture for relocation, native geckos from the Puhoi to Warkworth motorway Project.

- **Royal Forest & Bird Society: Reptile survey and monitoring programme (2021–ongoing):** Reptile survey of the Hibiscus Coast and design and management of a long-term reptile monitoring programme across the Whangaparaoa Peninsula.

- **Rotoroa Island Trust: Rotoroa Island lizard translocations (2014–2015):** Preparation of translocation proposals, stakeholder liaison, logistics and release-site management advice, and collection of moko skinks.

- **Tonga Power: Tongatapu wind generation feasibility study (2014–2015):** Assessments of reptiles for an Environmental Impact Assessment.

- **Biosecurity New Zealand (MPI): Alpine newt and plague skink eradications (2013 to present):** Technical herpetological advice on the trapping, monitoring and eradication of an exotic amphibian and skink in New Zealand.

- Biosecurity New Zealand (MPI): Foreign herpetofauna determinations (2014 to present): Primary herpetologist: Species determinations and risk-assessments on foreign reptiles and amphibians detected at, or post-, New Zealand border. Provision of expert advice on amphibian incursion programmes and legal compliance issues.

- General herpetofauna survey & salvage: Managed or coordinated over 75 herpetofauna surveys and salvage relocation programmes across New Zealand.

APPENDIX VI. ANALYSIS OF MACRAES FLAT LIZARD MONITORING DATA (MACKENZIE & BRATT 2024).

Proteus

YOUR ECOLOGICAL STATISTICAL EXPERTS

Proteus Client Report: 192

Analysis of Macraes Flat Lizard Monitoring Data

Darryl I. MacKenzie and Abby E. Bratt

Client Report for Bioreserachers

30th July 2024

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Citation: MacKenzie, D. I., and Bratt, A.E. (2024). Analysis of Macraes Flat Lizard Monitoring Data. Report for Bioreserachers, Proteus Client Report: 192. Proteus, Outram, New Zealand.

Front cover photo: Cover Image (Proteus).

Contents

1. Introduction

Lizard monitoring was conducted in six project components (referred to as populations hereafter) at Macraes Flat, Otago, near the current OceanaGold mine site. Overall, 224 pitfall traps were used, with each trap inspected daily over a period of nine days (i.e., nine inspections of each trap). Trap locations were randomly selected within each population by overlaying a 20m x 20m grid squares and squares to deploy a trap within were selected using a random number generator. A 20m x 20m area was chosen as this was expected to be a typical McCann's/Tussock skink home range. Pitfall traps were therefore expected to be spatially independent. Forty pitfall traps were intended to be deployed in each population, although the final number varied due to traps being lost or damaged.

2. Methods

2.1 Data preparation

Capture and environmental data were supplied as two separate files, and merging of the datasets was required for the analyses. The potential influence of environmental factors on skink detection and capture probabilities were of interest, and required temporal alignment of the data values. If environmental conditions did influence the likelihood of skinks being caught in pitfall traps, the relevant conditions would be those that preceded the capture event. A time of capture was not supplied, therefore for captures recorded on day x, the associated value for each environmental variable was the mean of the hourly-values for the 24-hour period from 1200 on day $x-1$ to 1200 on day x.

2.2 Data analysis

The skink capture data was analysed using two approaches,

1. N-mixture models, and
2. closed-population mark-recapture.

Both methods account for imperfect detection of skinks in pitfall traps, although in fundamentally different ways. N-mixture models (Royle, 2004) use the repeated count data (i.e., number of skinks captured each night) from each trap location to estimated the expected number of skinks in the vicinity of each trap. Detection probability is informed by the variability in the nightly counts at each trap, relative to the maximum count over all nights at the trap (noting that the total number of individuals may be greater than the maximum counted). Mark-recapture methods utilise the information in the frequency of capture of individuals to estimate the probability of capture, and hence the number of individuals that were in the population but never captured during the trapping session. An important distinction is the that mark-recapture methods require that individuals are identifiable (once marked) during the trapping session, while N-mixture models do not require individual identifiability. Further details on each analysis approach are provided below.

2.2.1 N-mixture modelling

The N-mixture model assumes that the number of individuals in the vicinity of a trap is a random value from a Poisson distribution, where the expected abundance is denoted as λ. The physical area in the vicinity of a trap is unknown and depends on the movement of individuals. Furthermore, when trapping is conducted across multiple days, λ is the expected abundance per trapping occasion. Whether these are regarded as the same or different individuals on each trapping occasion (i.e., each day) also depends on the movement of individuals. Thus, an estimate of λ does not necessarily equate to an estimate of the unique number of individuals in the vicinity of a trap during the entire trapping session, only the number per occasion. An assumption of no animal movement is required to interpret the estimate in the former sense. This is unlikely to hold for skinks; therefore, it is recommended to interpret λ as a measure of relative abundance rather than actual abundance.

The detection parameter (r) is the probability that an individual in the vicinity of a trap on a given trapping occasion will be captured into the pitfall trap. Therefore, it is expected that the number of individuals in the vicinity of a trap will be greater than the number actually trapped. Information to estimate this parameter comes from the repeated count data. For example, if the repeated counts of 0, 3, and 1 are observed on three trapping occasions, assuming there are at least three individuals available to be captured on each occasion (an assumption of the model), at least three individuals are not captured on occasion one, and at least two individuals are not captured on occasion three. Furthermore, there may be more than three individuals in the vicinity of the trap, where the actual number is assumed to be a random value from the Poisson distribution (as above).

Expected skink abundance at a trap (λ) was modelled as a function of population component (PComp) and habitat type (Habitat), where the habitat types *Felled Pine*, *Riparian*, and *Rock* were combined into an *Other* category due to the low number of traps located in those habitat types. Specifically the following combination of these covariates were considered for λ:

- none ($\sim$ `1`)
- population ($\sim$ `PComp`)
- habitat type ($\sim$ `Habitat`)
- population and habitat type ($\sim$ `PComp + Habitat`)

The second parameter type estimated in N-mixture model is the probability of detecting an individual in a survey, given the individual is present in the vicinity of a trap during the survey period (r). Detection probability was modelled as a function of the covariates:

- habitat type
- average temperature within the previous 24 hours
- average rainfall within the previous 24 hours
- average relative humidity within the previous 24 hours
- average windspeed within the previous 24 hours
- bait type

The covariates associated with environmental conditions explain temporal variation in detection probability, and are the same across all traps as all traps were surveyed simultaneously. Therefore, models were also considered where detection probability varied between surveys as a comparison to the covariate models to assess how much temporal variation the covariates are explaining. Note that relative humidity was highly correlated with both temperature and rainfall, therefore models that included relative humidity and temperature, or relative humidity and rainfall, were not considered.

A total of 168 N-mixture models were fit to the data, each containing different combinations of covariates for λ and r. Models were compared on the basis of Akaike's Information Criterion (AIC) and the highest-ranked models used for inference. AIC is a metric for estimating the relative amount of information lost by representing truth with a model, where models with smaller AIC values are preferred. All analysis were conducted using the `RPresence` package in `R`.

2.2.2 Mark-recapture modelling

The mark-recapture data was analysed using the `RMark` package in `R`, with the Huggins-type (Huggins, 1991) model being used to estimate capture probabilities (p) and abundance (N). Note that in the Huggins model, abundance is not estimated directly from the data, but is calculated from the estimated capture probabilities and number of animals caught. Hence covariate effects were only considered on capture probability, and only univariate models for p were considered due to the low number of recapture events. Capture probability (p) was considered to be constant across all surveys, or a function of:

- relative humidity
- rainfall
- temperature
- windspeed
- survey occasion

Models were compared on the basis of AICc, which is a variation of AIC commonly used for mark-recapture models, with a correction based on the number of parameters relative to the sample size.

Unlike N-mixture models, the estimate of abundance from the mark-recapture is an estimate of the unique number of individuals in the vicinity of all traps during the sampling session (N-mixture models are at the scale of a single trap). Although, as for the N-mixture models, the effective area around traps that is being sampled is uncertain and depends on animal movement. Trap densities of four traps per species home-range have been recommended for closed-population mark-recapture models (Otis et al., 1978) to ensure sufficient coverage of a region of interest. As the trap density used here is much lower than that, the estimates of abundance reported here are likely to be an underestimate of the total number of skinks in each population component area.

3. Results

3.1 N-mixture modelling

Table 3.1 summarises the results of the AIC model selection, which indicates strong evidence for λ differing between populations, and detection probability varying between surveys. That *SURVEY* is included for detection probability in the highest-ranked models provides evidence that the environmental covariates explain some temporal variation in detection, but there is substantial additional temporal variation unexplained by these covariates. The highest-ranked model includes a habitat effect on λ, although the second-ranked model has a similar AIC model weight but does not include the habitat effect. This suggests some evidence for variation in relative abundance between habitats, but not overly strong evidence. Population specific estimates are given in Table 3.2.

Table 3.1: Ten highest AIC-ranked N-mixture models fit to the skink data. Given in is the relative difference in AIC (ΔAIC), the AIC weight (w), number of parameters (NPar) and twice the negative log-likelihood ($-2ll$).

Model	ΔAIC	w	NPar	$-2ll$
λ(PComp+Habitat), r(SURVEY)	0.00	0.50	18	3 199.13
λ(PComp), r(SURVEY)	0.43	0.41	15	3 205.55
λ(PComp), r(Habitat+SURVEY)	4.93	0.04	18	3 204.06
λ(PComp+Habitat), r(Habitat+SURVEY)	5.19	0.04	21	3 198.32
λ(PComp+Habitat), r(Windspeed+RH+Bait)	9.31	0.00	13	3 218.44
λ(PComp), r(Windspeed+RH+Bait)	9.81	0.00	10	3 224.93
λ(PComp), r(Habitat+Windspeed+RH+Bait)	14.14	0.00	13	3 223.27
λ(PComp+Habitat), r(Habitat+Windspeed+RH+Bait)	14.48	0.00	16	3 217.61
λ(Habitat), r(SURVEY)	33.76	0.00	13	3 242.88
λ(1), r(SURVEY)	35.35	0.00	10	3 250.48

Table 3.2: Estimated λ value for each population from the second-ranked N-mixture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Population	Estimate	SE	Lower	Upper
BRWRS	1.94	0.39	1.30	2.88
CN	0.17	0.10	0.05	0.54
GBWRS	0.51	0.16	0.28	0.93
GBP	0.95	0.24	0.58	1.57
MEEA	0.97	0.24	0.60	1.56
ML	1.53	0.33	1.01	2.32

Table 3.3: Estimated λ value for each population and from the two highest-ranked N-mixture models. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals. Habitat-specific estimates are from the top-ranked model and 'Overall' estimates are from the second-ranked model.

Population	Habitat	Number traps	Estimate	SE	Lower	Upper
BRWRS	**Overall**	**40**	**1.94**	**0.39**	**1.30**	**2.88**
BRWRS	Exotic grass	24	1.83	0.41	1.18	2.85
BRWRS	Other	2	2.48	0.97	1.15	5.33
BRWRS	Shrubland	14	2.13	0.54	1.30	3.49
BRWRS	Tussock	**NA**	NA	NA	NA	NA
CN	**Overall**	**29**	**0.17**	**0.10**	**0.05**	**0.54**
CN	Exotic grass	NA	NA	NA	NA	NA
CN	Other	14	0.14	0.09	0.04	0.49
CN	Shrubland	NA	NA	NA	NA	NA
CN	Tussock	15	0.21	0.13	0.06	0.69
GBP	**Overall**	**36**	**0.95**	**0.24**	**0.58**	**1.57**
GBP	Exotic grass	17	0.64	0.20	0.35	1.20
GBP	Other	NA	NA	NA	NA	NA
GBP	Shrubland	NA	NA	NA	NA	NA
GBP	Tussock	19	1.30	0.35	0.76	2.21
GBWRS	**Overall**	**40**	**0.51**	**0.16**	**0.28**	**0.93**
GBWRS	Exotic grass	13	0.31	0.12	0.14	0.65
GBWRS	Other	NA	NA	NA	NA	NA
GBWRS	Shrubland	NA	NA	NA	NA	NA
GBWRS	Tussock	27	0.62	0.19	0.33	1.14
MEEA	**Overall**	**40**	**0.97**	**0.24**	**0.60**	**1.56**
MEEA	Exotic grass	25	0.91	0.23	0.55	1.49
MEEA	Other	3	1.22	0.50	0.55	2.70
MEEA	Shrubland	11	1.05	0.31	0.59	1.87
MEEA	Tussock	1	1.82	0.66	0.89	3.71
ML	**Overall**	**39**	**1.53**	**0.33**	**1.01**	**2.32**
ML	Exotic grass	25	1.33	0.30	0.84	2.08
ML	Other	4	1.79	0.67	0.86	3.71
ML	Shrubland	6	1.54	0.46	0.86	2.76
ML	Tussock	4	2.66	0.83	1.45	4.90

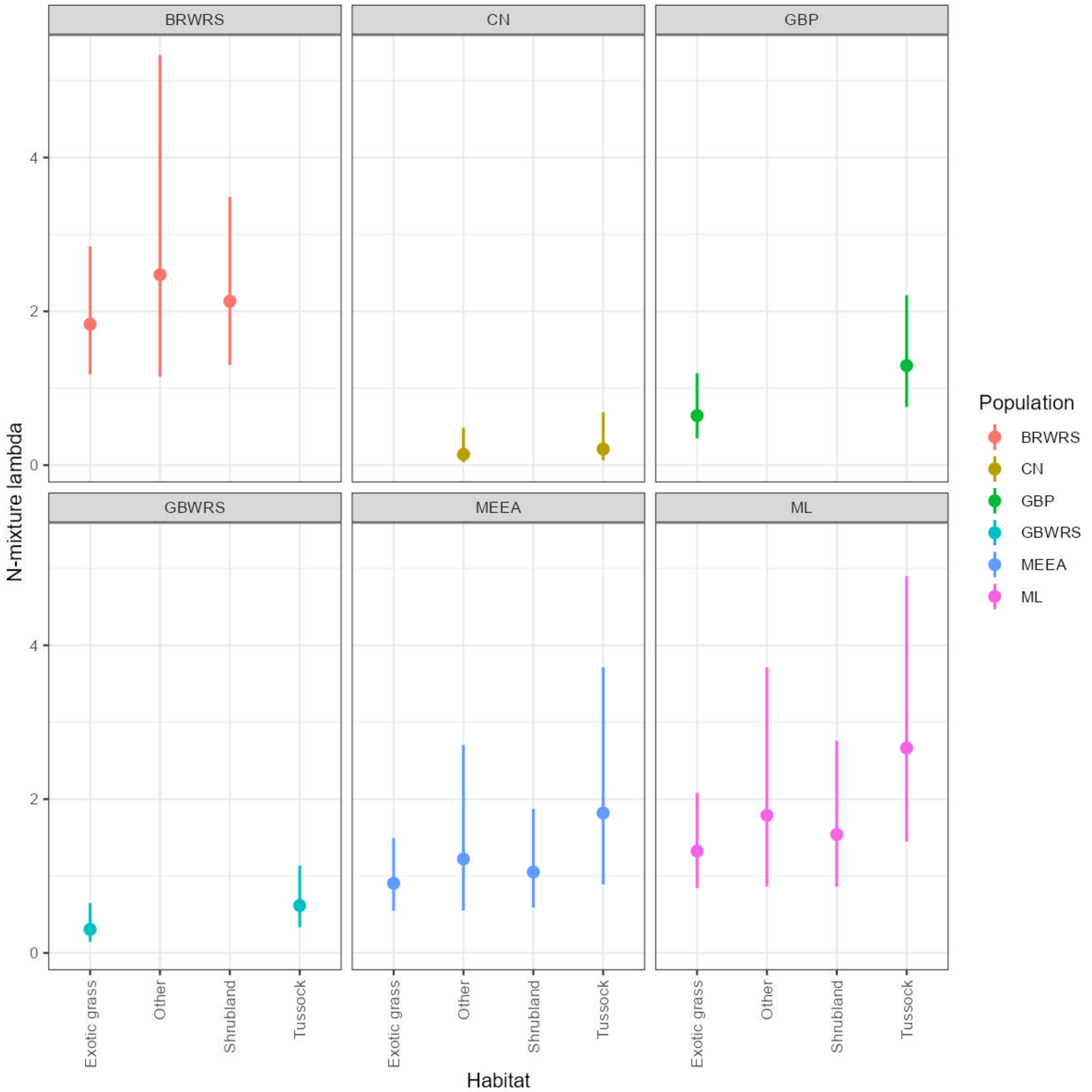

Figure 3.1: Habitat-specific estimates of λ, and 95% confidence intervals, for each population.

The estimated probability of detecting individual skinks with a pitfall trap (r), from the highest-ranked N-mixture model, are highly variable across survey occasions (Table 3.4). Estimates range from 0.02 - 0.24, which may be associated with variation in skink activity patterns. As noted above, there is evidence that some of this variation can be explained by the inclusion of environmental covariates, however there is substantial additional variation.

Table 3.4: Estimated probability of detecting individual skinks (r) given presence in the vicinity of a trap, per survey occasion. Results are from the highest-ranked N-mixture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Survey	Estimate	SE	Lower	Upper
1	0.24	0.04	0.17	0.34
2	0.14	0.03	0.09	0.21
3	0.07	0.02	0.04	0.11
4	0.15	0.03	0.10	0.22
5	0.05	0.01	0.02	0.09
6	0.02	0.01	0.01	0.05
7	0.11	0.03	0.07	0.17
8	0.12	0.03	0.07	0.18
9	0.03	0.01	0.01	0.06

3.2 Mark-recapture modelling

Table 3.5 summarises the results of the AICc model selection for the mark-recapture modelling, which indicates strong evidence for capture probability varying between surveys. That the models including windspeed, bait and relative humidity are ranked above the constant capture probability model (p(1)) indicates those environmental covariates explain some temporal variation in capture probability, but there is substantial additional temporal variation unexplained by these covariates. Population specific abundance estimates are given in Table 3.6.

Table 3.5: AICc model selection table for closed population mark-recapture models fit to the skink data. Given in is the relative difference in AIC (ΔAIC), the AIC weight (w), number of parameters (NPar) and twice the negative log-likelihood ($-2ll$).

Model	ΔAICc	w	NPar	$-2ll$
p(time)	0.00	1	9	1 262.40
p(Windspeed)	77.03	0	2	1 353.52
p(Bait)	82.23	0	2	1 358.73
p(RH)	85.50	0	2	1 361.99
p(1)	86.54	0	1	1 365.04
p(Temp)	88.07	0	2	1 364.57
p(Rainfall)	88.21	0	2	1 364.71

Table 3.6: Estimated abundance for each population from the top-ranked Huggins model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Population	Estimate	SE	Lower	Upper
BRWRS	337.79	77.29	223.47	535.64
CN	15.12	8.39	6.56	44.31
GBWRS	90.75	26.45	54.47	163.11
GBP	141.17	37.09	88.51	239.63
MEEA	161.33	41.27	102.25	270.11
ML	262.16	61.93	171.38	421.98

Estimated capture probabilities (p) are very low, and indicate a high level of relative variation (i.e., from near 0, to 0.06), with a similar pattern to the estimated detection probabilities from the N-mixture modelling. This would suggest that a very small fraction of skinks in the vicinity of a pitfall trap are getting caught each survey occasion, and that deploying pitfall traps for short survey periods (e.g., 3-6 survey occasions) is unlikely to yield quality data for abundance estimation, using trap spacing similar to those used here. Increasing trap density will increase overall capture probabilities, making shorter survey periods more feasible.

Table 3.7: Estimated probability of capturing a skink (p) given presence in the vicinity of a trap per survey occasions, from the highest-ranked mark-recapture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Survey	Estimate	SE	Lower	Upper
1	0.06	0.01	0.04	0.09
2	0.03	0.01	0.02	0.06
3	0.02	0.01	0.01	0.03
4	0.03	0.01	0.02	0.06
5	0.01	0.00	0.01	0.02
6	0.00	0.00	0.00	0.01
7	0.03	0.01	0.02	0.05
8	0.03	0.01	0.02	0.05
9	0.01	0.00	0.00	0.01

3.3 Comparison

Figure 3.2 presents a simple comparison of the estimated λ values (from the second-ranked N-mixture model) to abundance estimated from the closed population mark-recapture model, for each population. There is a very high degree of correlation in the estimates from the two methods for the populations, although note the difference in the scale of the metrics is due to the difference in their spatial scale (trap-level for N-mixture and population for abundance). Figure 3.3 is similar, although both metrics are on a per-trap scale.

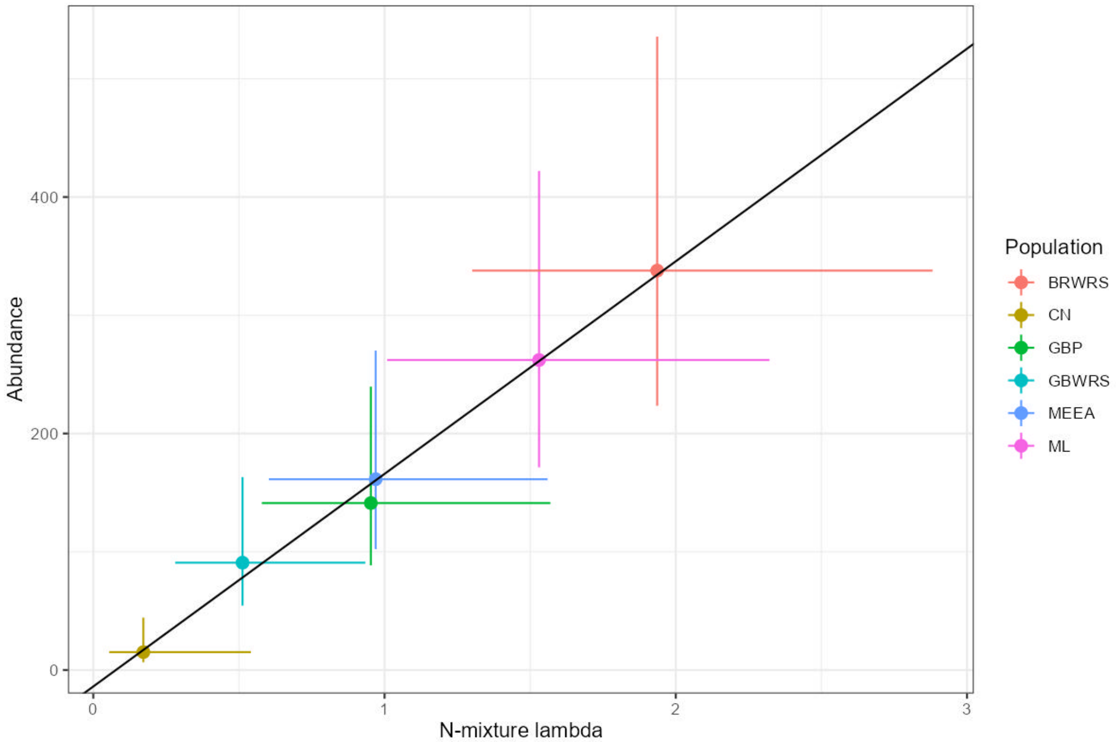

Figure 3.2: Comparison of N-mixture λ estimates and closed population mark-recapture abundance estimates. The difference in the scale of the metrics is mainly due to the difference in their spatial scale (trap-level for N-mixture and population for abundance).

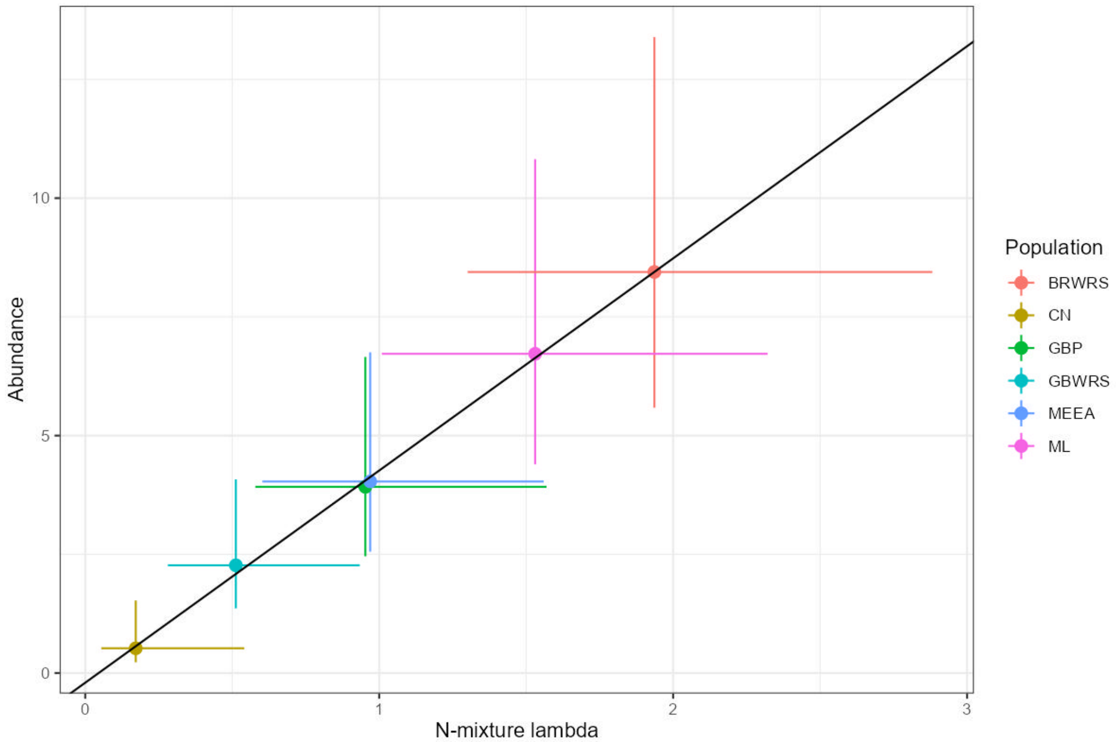

Figure 3.3: Comparison of N-mixture λ estimates and closed population mark-recapture abundance estimates divided by number of traps.

4. Discussion

A key consideration in interpreting the above results is the exposure of skinks within each population to the pitfall trapping technique, specifically the size of the area around each trap that is effectively being sampled for skinks. This consideration is particularly important for interpreting the closed population mark-recapture abundance estimates. Abundance estimates using mark-recapture provide an estimate of the number of individuals within the population that are exposed to the survey methods. When individuals have small home ranges relative to the trap spacing, there may be "gaps" in the trapping coverage within the nominal population of interest, meaning the effective area being trapped may be smaller than the nominal area. This is particularly true when the trapping density is relatively low, with only one or two devices located within an individual's home range, if any. In such cases, abundance estimates may be more proportional to density, as each pitfall trap effectively surveys a similar (but unknown) sized area around each trap. As noted previously, a trap density of 4 traps per home range has been suggested as a suitable intensity level (Otis et al., 1978).

While the number of traps is similar for each population, is not the same. Therefore the effective area associated with the abundance estimates is also different for each population. Given an estimate of the effective area around a trap that is being sampled during the survey period (i.e., 9 days), a correction factor could be determined to rescale the abundance estimates provided here to the population-level.

The λ parameter from N-mixture models is a "per trap" metric, and hence, more like a density estimate. However, it is a metric that represents the maximal-count in a single survey occasion (i.e., a single day) due to the contiguous and open nature of the environment around traps. Skinks are not physically restricted to be near traps and may be away from the immediate area around a trap on some survey occasions. Therefore, estimated λ values should not necessarily be interpreted as an estimate of abundance at a pitfall trap.

There was a high-level of correlation between the N-mixture λ estimates and mark-recapture abundance estimates (Figure 3.2), and even higher correlation when abundance was standardised to the per-trap scale (Figure 3.3). This correlation will be due:

- both analyses are derived from the same data source,
- given the trap spacing, recapture events of individuals were always at the same trap, and
- the number of individuals caught at each trap per day was always low.

Therefore, while the two analyses are using the data in different ways to estimate model parameters there is possibly some equivalency in the underlying calculations given the sparse data. This aspect has not been explored further, but this result should not be interpreted as evidence of equivalency of abundance estimation from N-mixture and mark-recapture models in general. Although in this particular case, it does appear that both statistical approaches would yield similar inferences about relative abundance among populations.

5. References

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Analysis of Macraes Flat Lizard Monitoring Data

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Client Report for Bioreserachers

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Contents

1. Introduction

Lizard monitoring was conducted in six project components (referred to as populations hereafter) at Macraes Flat, Otago, near the current OceanaGold mine site. Overall, 224 pitfall traps were used, with each trap inspected daily over a period of nine days (i.e., nine inspections of each trap). Trap locations were randomly selected within each population by overlaying a 20m x 20m grid squares and squares to deploy a trap within were selected using a random number generator. A 20m x 20m area was chosen as this was expected to be a typical McCann's/Tussock skink home range. Pitfall traps were therefore expected to be spatially independent. Forty pitfall traps were intended to be deployed in each population, although the final number varied due to traps being lost or damaged.

2. Methods

2.1 Data preparation

Capture and environmental data were supplied as two separate files, and merging of the datasets was required for the analyses. The potential influence of environmental factors on skink detection and capture probabilities were of interest, and required temporal alignment of the data values. If environmental conditions did influence the likelihood of skinks being caught in pitfall traps, the relevant conditions would be those that preceded the capture event. A time of capture was not supplied, therefore for captures recorded on day x, the associated value for each environmental variable was the mean of the hourly-values for the 24-hour period from 1200 on day $x-1$ to 1200 on day x.

2.2 Data analysis

The skink capture data was analysed using two approaches,

1. N-mixture models, and
2. closed-population mark-recapture.

Both methods account for imperfect detection of skinks in pitfall traps, although in fundamentally different ways. N-mixture models (Royle, 2004) use the repeated count data (i.e., number of skinks captured each night) from each trap location to estimated the expected number of skinks in the vicinity of each trap. Detection probability is informed by the variability in the nightly counts at each trap, relative to the maximum count over all nights at the trap (noting that the total number of individuals may be greater than the maximum counted). Mark-recapture methods utilise the information in the frequency of capture of individuals to estimate the probability of capture, and hence the number of individuals that were in the population but never captured during the trapping session. An important distinction is the that mark-recapture methods require that individuals are identifiable (once marked) during the trapping session, while N-mixture models do not require individual identifiability. Further details on each analysis approach are provided below.

2.2.1 N-mixture modelling

The N-mixture model assumes that the number of individuals in the vicinity of a trap is a random value from a Poisson distribution, where the expected abundance is denoted as λ. The physical area in the vicinity of a trap is unknown and depends on the movement of individuals. Furthermore, when trapping is conducted across multiple days, λ is the expected abundance per trapping occasion. Whether these are regarded as the same or different individuals on each trapping occasion (i.e., each day) also depends on the movement of individuals. Thus, an estimate of λ does not necessarily equate to an estimate of the unique number of individuals in the vicinity of a trap during the entire trapping session, only the number per occasion. An assumption of no animal movement is required to interpret the estimate in the former sense. This is unlikely to hold for skinks; therefore, it is recommended to interpret λ as a measure of relative abundance rather than actual abundance.

The detection parameter (r) is the probability that an individual in the vicinity of a trap on a given trapping occasion will be captured into the pitfall trap. Therefore, it is expected that the number of individuals in the vicinity of a trap will be greater than the number actually trapped. Information to estimate this parameter comes from the repeated count data. For example, if the repeated counts of 0, 3, and 1 are observed on three trapping occasions, assuming there are at least three individuals available to be captured on each occasion (an assumption of the model), at least three individuals are not captured on occasion one, and at least two individuals are not captured on occasion three. Furthermore, there may be more than three individuals in the vicinity of the trap, where the actual number is assumed to be a random value from the Poisson distribution (as above).

Expected skink abundance at a trap (λ) was modelled as a function of population component (PComp) and habitat type (Habitat), where the habitat types *Felled Pine*, *Riparian*, and *Rock* were combined into an *Other* category due to the low number of traps located in those habitat types. Specifically the following combination of these covariates were considered for λ:

- none ($\sim$ `1`)
- population ($\sim$ `PComp`)
- habitat type ($\sim$ `Habitat`)
- population and habitat type ($\sim$ `PComp + Habitat`)

The second parameter type estimated in N-mixture model is the probability of detecting an individual in a survey, given the individual is present in the vicinity of a trap during the survey period (r). Detection probability was modelled as a function of the covariates:

- habitat type
- average temperature within the previous 24 hours
- average rainfall within the previous 24 hours
- average relative humidity within the previous 24 hours
- average windspeed within the previous 24 hours
- bait type

The covariates associated with environmental conditions explain temporal variation in detection probability, and are the same across all traps as all traps were surveyed simultaneously. Therefore, models were also considered where detection probability varied between surveys as a comparison to the covariate models to assess how much temporal variation the covariates are explaining. Note that relative humidity was highly correlated with both temperature and rainfall, therefore models that included relative humidity and temperature, or relative humidity and rainfall, were not considered.

A total of 168 N-mixture models were fit to the data, each containing different combinations of covariates for λ and r. Models were compared on the basis of Akaike's Information Criterion (AIC) and the highest-ranked models used for inference. AIC is a metric for estimating the relative amount of information lost by representing truth with a model, where models with smaller AIC values are preferred. All analysis were conducted using the `RPresence` package in `R`.

2.2.2 Mark-recapture modelling

The mark-recapture data was analysed using the `RMark` package in `R`, with the Huggins-type (Huggins, 1991) model being used to estimate capture probabilities (p) and abundance (N). Note that in the Huggins model, abundance is not estimated directly from the data, but is calculated from the estimated capture probabilities and number of animals caught. Hence covariate effects were only considered on capture probability, and only univariate models for p were considered due to the low number of recapture events. Capture probability (p) was considered to be constant across all surveys, or a function of:

- relative humidity
- rainfall
- temperature
- windspeed
- survey occasion

Models were compared on the basis of AICc, which is a variation of AIC commonly used for mark-recapture models, with a correction based on the number of parameters relative to the sample size.

Unlike N-mixture models, the estimate of abundance from the mark-recapture is an estimate of the unique number of individuals in the vicinity of all traps during the sampling session (N-mixture models are at the scale of a single trap). Although, as for the N-mixture models, the effective area around traps that is being sampled is uncertain and depends on animal movement. Trap densities of four traps per species home-range have been recommended for closed-population mark-recapture models (Otis et al., 1978) to ensure sufficient coverage of a region of interest. As the trap density used here is much lower than that, the estimates of abundance reported here are likely to be an underestimate of the total number of skinks in each population component area.

3. Results

3.1 N-mixture modelling

Table 3.1 summarises the results of the AIC model selection, which indicates strong evidence for λ differing between populations, and detection probability varying between surveys. That *SURVEY* is included for detection probability in the highest-ranked models provides evidence that the environmental covariates explain some temporal variation in detection, but there is substantial additional temporal variation unexplained by these covariates. The highest-ranked model includes a habitat effect on λ, although the second-ranked model has a similar AIC model weight but does not include the habitat effect. This suggests some evidence for variation in relative abundance between habitats, but not overly strong evidence. Population specific estimates are given in Table 3.2.

Table 3.1: Ten highest AIC-ranked N-mixture models fit to the skink data. Given in is the relative difference in AIC (ΔAIC), the AIC weight (w), number of parameters (NPar) and twice the negative log-likelihood ($-2ll$).

Model	ΔAIC	w	NPar	$-2ll$
λ(PComp+Habitat), r(SURVEY)	0.00	0.50	18	3 199.13
λ(PComp), r(SURVEY)	0.43	0.41	15	3 205.55
λ(PComp), r(Habitat+SURVEY)	4.93	0.04	18	3 204.06
λ(PComp+Habitat), r(Habitat+SURVEY)	5.19	0.04	21	3 198.32
λ(PComp+Habitat), r(Windspeed+RH+Bait)	9.31	0.00	13	3 218.44
λ(PComp), r(Windspeed+RH+Bait)	9.81	0.00	10	3 224.93
λ(PComp), r(Habitat+Windspeed+RH+Bait)	14.14	0.00	13	3 223.27
λ(PComp+Habitat), r(Habitat+Windspeed+RH+Bait)	14.48	0.00	16	3 217.61
λ(Habitat), r(SURVEY)	33.76	0.00	13	3 242.88
λ(1), r(SURVEY)	35.35	0.00	10	3 250.48

Table 3.2: Estimated λ value for each population from the second-ranked N-mixture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Population	Estimate	SE	Lower	Upper
BRWRS	1.94	0.39	1.30	2.88
CN	0.17	0.10	0.05	0.54
GBWRS	0.51	0.16	0.28	0.93
GBP	0.95	0.24	0.58	1.57
MEEA	0.97	0.24	0.60	1.56
ML	1.53	0.33	1.01	2.32

Table 3.3: Estimated λ value for each population and from the two highest-ranked N-mixture models. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals. Habitat-specific estimates are from the top-ranked model and 'Overall' estimates are from the second-ranked model.

Population	Habitat	Number traps	Estimate	SE	Lower	Upper
BRWRS	**Overall**	**40**	**1.94**	**0.39**	**1.30**	**2.88**
BRWRS	Exotic grass	24	1.83	0.41	1.18	2.85
BRWRS	Other	2	2.48	0.97	1.15	5.33
BRWRS	Shrubland	14	2.13	0.54	1.30	3.49
BRWRS	Tussock	**NA**	NA	NA	NA	NA
CN	**Overall**	**29**	**0.17**	**0.10**	**0.05**	**0.54**
CN	Exotic grass	NA	NA	NA	NA	NA
CN	Other	14	0.14	0.09	0.04	0.49
CN	Shrubland	NA	NA	NA	NA	NA
CN	Tussock	15	0.21	0.13	0.06	0.69
GBP	**Overall**	**36**	**0.95**	**0.24**	**0.58**	**1.57**
GBP	Exotic grass	17	0.64	0.20	0.35	1.20
GBP	Other	NA	NA	NA	NA	NA
GBP	Shrubland	NA	NA	NA	NA	NA
GBP	Tussock	19	1.30	0.35	0.76	2.21
GBWRS	**Overall**	**40**	**0.51**	**0.16**	**0.28**	**0.93**
GBWRS	Exotic grass	13	0.31	0.12	0.14	0.65
GBWRS	Other	NA	NA	NA	NA	NA
GBWRS	Shrubland	NA	NA	NA	NA	NA
GBWRS	Tussock	27	0.62	0.19	0.33	1.14
MEEA	**Overall**	**40**	**0.97**	**0.24**	**0.60**	**1.56**
MEEA	Exotic grass	25	0.91	0.23	0.55	1.49
MEEA	Other	3	1.22	0.50	0.55	2.70
MEEA	Shrubland	11	1.05	0.31	0.59	1.87
MEEA	Tussock	1	1.82	0.66	0.89	3.71
ML	**Overall**	**39**	**1.53**	**0.33**	**1.01**	**2.32**
ML	Exotic grass	25	1.33	0.30	0.84	2.08
ML	Other	4	1.79	0.67	0.86	3.71
ML	Shrubland	6	1.54	0.46	0.86	2.76
ML	Tussock	4	2.66	0.83	1.45	4.90

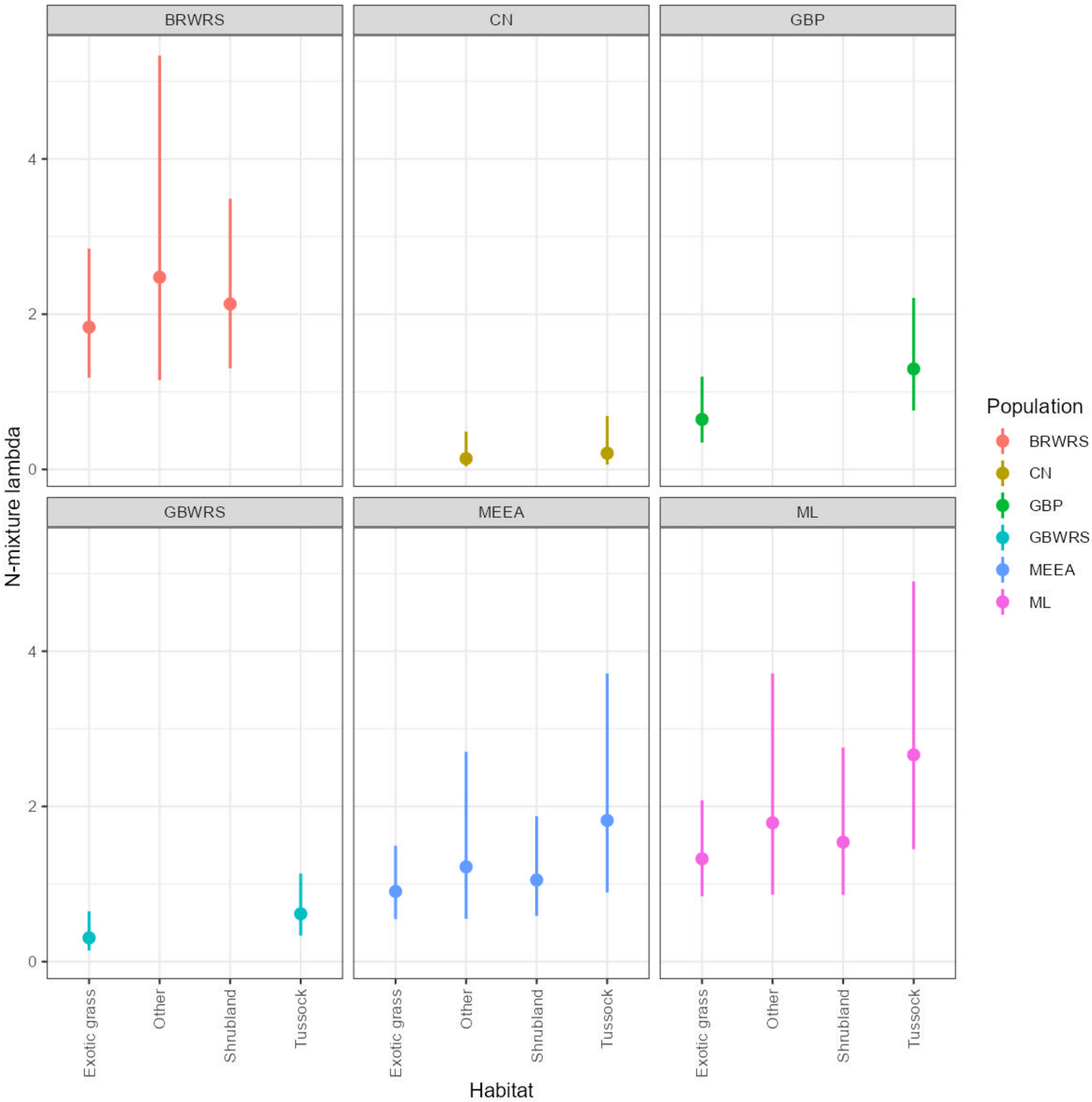

Figure 3.1: Habitat-specific estimates of λ, and 95% confidence intervals, for each population.

The estimated probability of detecting individual skinks with a pitfall trap (r), from the highest-ranked N-mixture model, are highly variable across survey occasions (Table 3.4). Estimates range from 0.02 - 0.24, which may be associated with variation in skink activity patterns. As noted above, there is evidence that some of this variation can be explained by the inclusion of environmental covariates, however there is substantial additional variation.

Table 3.4: Estimated probability of detecting individual skinks (r) given presence in the vicinity of a trap, per survey occasion. Results are from the highest-ranked N-mixture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Survey	Estimate	SE	Lower	Upper
1	0.24	0.04	0.17	0.34
2	0.14	0.03	0.09	0.21
3	0.07	0.02	0.04	0.11
4	0.15	0.03	0.10	0.22
5	0.05	0.01	0.02	0.09
6	0.02	0.01	0.01	0.05
7	0.11	0.03	0.07	0.17
8	0.12	0.03	0.07	0.18
9	0.03	0.01	0.01	0.06

3.2 Mark-recapture modelling

Table 3.5 summarises the results of the AICc model selection for the mark-recapture modelling, which indicates strong evidence for capture probability varying between surveys. That the models including windspeed, bait and relative humidity are ranked above the constant capture probability model (p(1)) indicates those environmental covariates explain some temporal variation in capture probability, but there is substantial additional temporal variation unexplained by these covariates. Population specific abundance estimates are given in Table 3.6.

Table 3.5: AICc model selection table for closed population mark-recapture models fit to the skink data. Given in is the relative difference in AIC (ΔAIC), the AIC weight (w), number of parameters (NPar) and twice the negative log-likelihood ($-2ll$).

Model	ΔAICc	w	NPar	$-2ll$
p(time)	0.00	1	9	1 262.40
p(Windspeed)	77.03	0	2	1 353.52
p(Bait)	82.23	0	2	1 358.73
p(RH)	85.50	0	2	1 361.99
p(1)	86.54	0	1	1 365.04
p(Temp)	88.07	0	2	1 364.57
p(Rainfall)	88.21	0	2	1 364.71

Table 3.6: Estimated abundance for each population from the top-ranked Huggins model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Population	Estimate	SE	Lower	Upper
BRWRS	337.79	77.29	223.47	535.64
CN	15.12	8.39	6.56	44.31
GBWRS	90.75	26.45	54.47	163.11
GBP	141.17	37.09	88.51	239.63
MEEA	161.33	41.27	102.25	270.11
ML	262.16	61.93	171.38	421.98

Estimated capture probabilities (p) are very low, and indicate a high level of relative variation (i.e., from near 0, to 0.06), with a similar pattern to the estimated detection probabilities from the N-mixture modelling. This would suggest that a very small fraction of skinks in the vicinity of a pitfall trap are getting caught each survey occasion, and that deploying pitfall traps for short survey periods (e.g., 3-6 survey occasions) is unlikely to yield quality data for abundance estimation, using trap spacing similar to those used here. Increasing trap density will increase overall capture probabilities, making shorter survey periods more feasible.

Table 3.7: Estimated probability of capturing a skink (p) given presence in the vicinity of a trap per survey occasions, from the highest-ranked mark-recapture model. Given is the estimate, standard error, lower and upper bounds of 95% confidence intervals.

Survey	Estimate	SE	Lower	Upper
1	0.06	0.01	0.04	0.09
2	0.03	0.01	0.02	0.06
3	0.02	0.01	0.01	0.03
4	0.03	0.01	0.02	0.06
5	0.01	0.00	0.01	0.02
6	0.00	0.00	0.00	0.01
7	0.03	0.01	0.02	0.05
8	0.03	0.01	0.02	0.05
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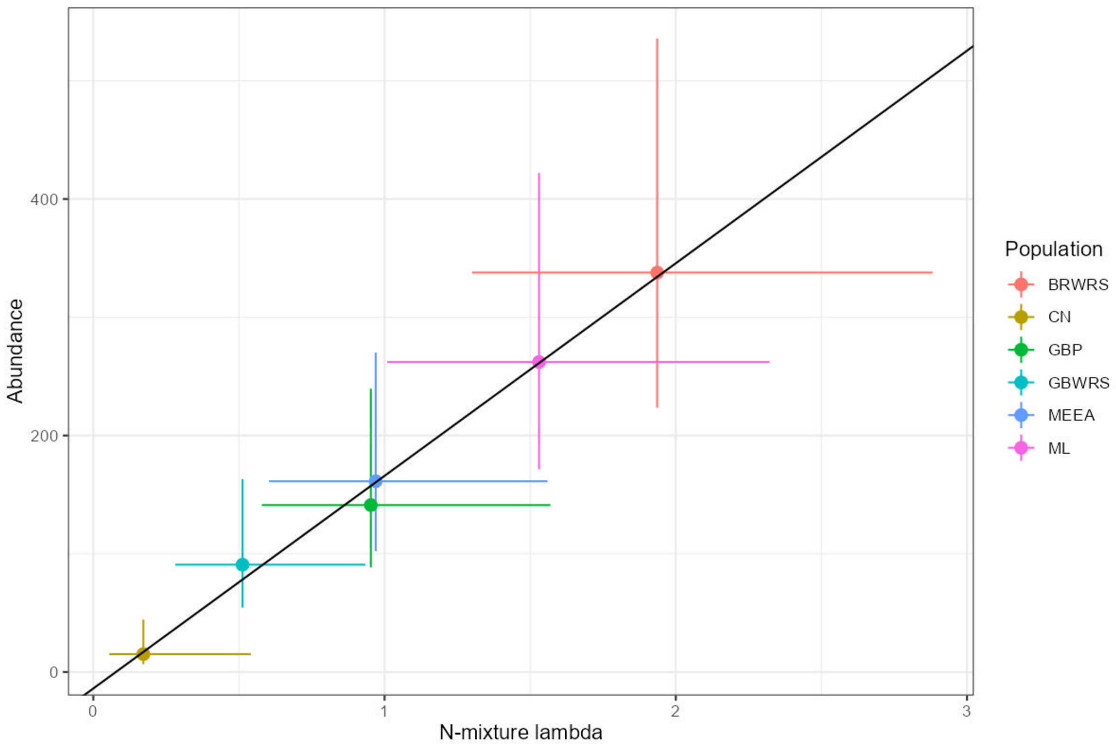
3.3 Comparison

Figure 3.2 presents a simple comparison of the estimated λ values (from the second-ranked N-mixture model) to abundance estimated from the closed population mark-recapture model, for each population. There is a very high degree of correlation in the estimates from the two methods for the populations, although note the difference in the scale of the metrics is due to the difference in their spatial scale (trap-level for N-mixture and population for abundance). Figure 3.3 is similar, although both metrics are on a per-trap scale.



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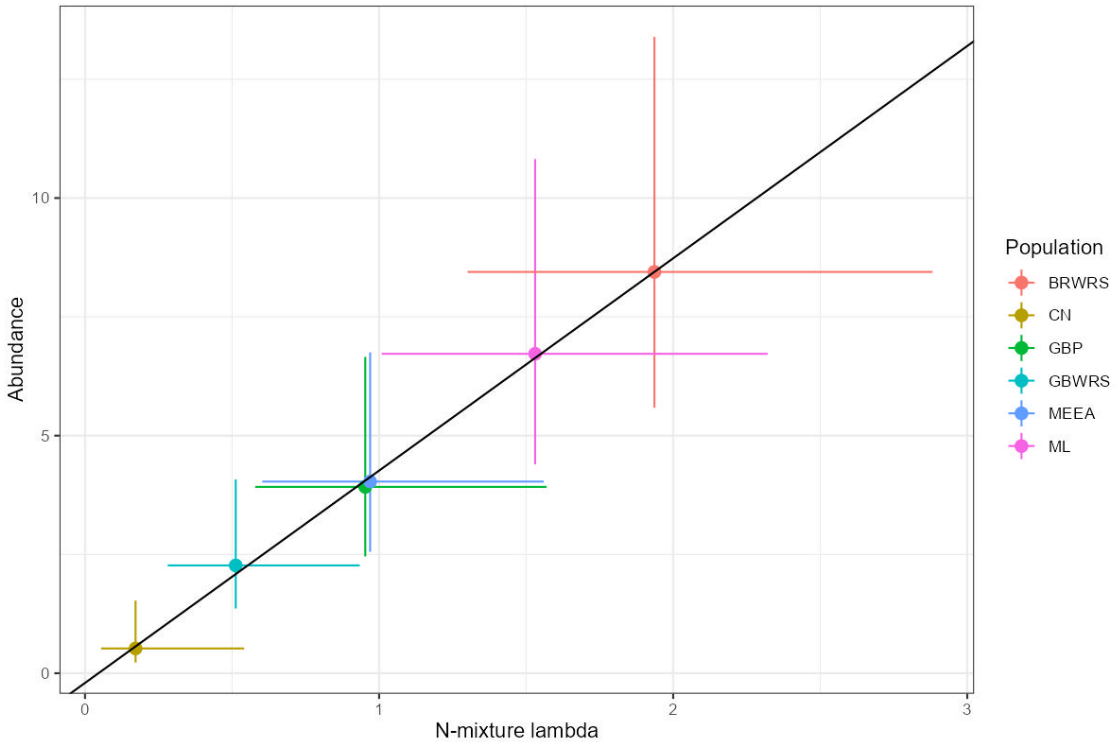

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4. Discussion

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- both analyses are derived from the same data source,
- given the trap spacing, recapture events of individuals were always at the same trap, and
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Therefore, while the two analyses are using the data in different ways to estimate model parameters there is possibly some equivalency in the underlying calculations given the sparse data. This aspect has not been explored further, but this result should not be interpreted as evidence of equivalency of abundance estimation from N-mixture and mark-recapture models in general. Although in this particular case, it does appear that both statistical approaches would yield similar inferences about relative abundance among populations.

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