Lord Howe Island

Rodent Eradication Project

NSW Species Impact Statement

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				Name/Position	Signature
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Executive Summary

Introduction

The Lord Howe Island Board (LHIB) is proposing to undertake the Lord Howe Island Rodent Eradication Project (LHI REP) which aims to eradicate introduced rodents: the Ship Rat (*Rattus rattus*) and the House Mouse (*Mus musculus*) from the World Heritage listed Lord Howe Island Group (LHIG).

The sub-tropical LHIG, comprised of Lord Howe Island (LHI) and its associated islands and rocky islets, is located 780 kilometres north-east of Sydney and is part of the State of New South Wales. It supports a diverse flora and fauna with a high degree of endemic species and communities and numerous threatened and migratory species.

A settlement of approximately 350 inhabitants is located in the northern section of LHI and covers about 15% of the island. The rest of the island, all outlying islands, islets and rocks are protected under the Permanent Park Preserve (PPP), which has similar status to that of a national park.

Tourism is the most significant industry and major source of income on the Island and is heavily focused around the world heritage values of both the terrestrial and marine environments. Export of the Lord Howe Kentia Palm has also been a major industry since the late 1800s.

Since their arrival on LHI, introduced rats and mice have had and continue to have a significant impact on the World Heritage, biodiversity, community and economic values of the island. Mice probably arrived on LHI by the 1860s; rats arrived in 1918 with the grounding of the SS Makabo.

Project Need and Benefits

The devastating impacts of introduced rodents on offshore islands around the world are well documented. The presence of exotic rodents on islands is one of the greatest causes of species extinction in the world. Ship rats alone are responsible for the severe decline or extinction of at least 60 vertebrate species and currently endanger more than 70 species of seabird worldwide. They suppress plants and are associated with the declines or extinctions of flightless invertebrates, ground-dwelling reptiles, land birds and burrowing seabirds. Mice have also been shown to impact on plants, invertebrates and birds.

Predation by exotic rats on Australian offshore islands of less than 1000 km2 (100,000 ha) is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). *Predation by the Ship rat on Lord Howe Island* is listed as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995* (TSC Act)

On LHI, rats are implicated in the extinction of five endemic bird species, at least 13 species of endemic invertebrates, and two plant species. Rodents are also a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities, and seven species of threatened invertebrates on LHI. Rodents have therefore not reached equilibrium with native species on LHI.

The LHIB currently maintain a rodent control program that aims to keep the negative effects of rodents under control, but its ongoing nature brings with it a constant financial burden and potential human health and environmental risks from ongoing presence of poison in the environment. Under the current control program, neither the rat or mouse population is being reduced to a level that reduces landscape scale ecological impacts.

Globally, eradication has become a powerful tool to prevent species extinctions and to restore damaged or degraded ecosystems. The biodiversity benefits of removing rodents from islands are well recognised and have been shown to be both significant and immediate. Benefits include:

- significant increases of seeds and seedlings of numerous plant species on islands after the eradication of various rodent species
- rapid increases in the number of ground lizards (e.g. geckos, skinks) following removal of rats – including a 30-fold increase in one case
- dramatic increases in the numbers of breeding seabirds and fledging success
- rapid increases in forest birds and invertebrates.

After completing a Feasibility Study in 2001, the LHIB has carefully considered and evaluated the eradication of rats and mice on the LHIG. Due to developments in eradication techniques during the past 20 years, particularly the refinement of aerial baiting methods, the eradication of both rats and mice on the LHIG in a single operation is now feasible and achievable. The eradication of rodents will also present an opportunity to simultaneously eradicate the introduced Masked Owl.

Eradication (rather than ongoing control) is expected to provide the following benefits:

- Removal of a key threat to many island species resulting in significant biodiversity improvement including threatened species recovery and reintroduction
- Removal of ongoing poison in the environment and associated control costs. It also removes the risk of rodent resistance to poisons
- Long term positive impacts for tourism through protection and enhancement of World Heritage values and improved visitor experience
- Increased productivity for the Kentia Palm industry
- Elimination of current health and amenity impacts from rodents.

The eradication of rodents is consistent with numerous local, state, commonwealth and international plans and obligations. Eradication of exotic rodents from high priority islands (including LHI) is the first objective in the Commonwealth *Threat Abatement Plan to Reduce the Impacts of Exotic Rodents on Biodiversity on Australian Offshore islands of Less than 100 000 Hectares*. The action is in accordance with the principles of ecologically sustainable development.

Failure to proceed with the REP will result in continuing adverse consequences to biodiversity, World Heritage and socio-economic values through:

- Ongoing impacts to biodiversity (including potential population decreases and extinctions) as a result of rodent predation and competition.
- Continuation of the current rodent control program (and the continuous presence of poison baits in the environment) essentially in perpetuity. This presents an ongoing risk of poisoning for non-target species and potential for development of rodent resistance to poison.
- Potential further degradation of World Heritage values (including endemic and threatened species) and the potential for the LHIG to be inscribed on the “World Heritage in Danger List”.
- Ongoing socio-economic impacts associated with rodents.

Project Description

The one-off eradication proposes to distribute a cereal-based bait pellet (Pestoff 20R) containing 0.02g/kg (20 parts per million) of the toxin, Brodifacoum across the LHIG (excluding Balls Pyramid). Methods of distribution will be dispersal from helicopters using an under-slung bait spreader bucket in the uninhabited parts of the island (most of the LHIG) and by a combination of hand broadcasting and the placement of bait in trays and bait stations in the settlement area. In the outdoor areas of the settlement baits will be dispersed by hand and/or placed into bait stations. In dwellings (e.g. in ceiling spaces or floor spaces) bait trays and bait stations will be used. Bait stations will also be used around pens for any remaining livestock.

The bait will be distributed at a nominal dose rate of 20 kg (12 kg + 8 kg) of bait (or 0.4 g of poison) per hectare. At this rate, a maximum of 42 tonnes of bait (containing 840 g of Brodifacoum) will be required to cover the total island group surface area of 2,100 ha. The proposal is for aerial and hand baiting to be carried out twice, the applications separated by about 14 -21 days (depending on the weather).

The baiting is planned to occur in winter (June - August) of 2018 but may extend into September if there are problems such as unfavourable weather conditions. June - August is preferred because this is the time of the year when the rodents are at their most vulnerable due to the relatively low abundance of natural food. Many of the seabird species are also absent from the island at this time of year. This is also the low season for tourists on LHI. The operation will take place in a single year, targeted for winter of 2018 (June to August) however, to allow operational flexibility and to account for unforeseen delays, approval is sought for at least a two year period, June 2018 to December 2019.

Post eradication, a rodent detection monitoring network including the use of detector dogs will be established to allow detection of any potentially surviving rodents. If the network does not detect any rodents within two years, the eradication will be declared a success.

To prevent reinvasion from rodents and to improve Biosecurity on the island more generally, the LHIB is updating the Island’s Biosecurity system concurrently with the proposed REP although upgrades will occur regardless of whether the REP goes ahead. Surveillance monitoring and rodent prevention measures will be on going post eradication as part of the island’s permanent rodent detection and prevention system.

As a result of the proposed rodent eradication, there is also an opportunity to concurrently eradicate the Masked Owl, which was introduced to LHI to controls rats in the 1920s and 1930s. Rodents currently make up the Masked Owl’s main prey base on the Island, and during the rodent eradication it is expected that most owls are likely to succumb to secondary Brodifacoum poisoning by ingestion of poisoned rodents. To avoid any remaining owls switching to a diet of solely native species in the absence of rodents, it is proposed to eradicate remaining owls via hunting or trapping before, during and after the baiting proposal.

A range of mitigation will be put in place to minimise impacts to the environment and the community. This includes captive management of at risk species (LH Woodhen and LH Pied Currawong), an extensive suite of environmental monitoring and monitoring for non-target species impact.

A Biodiversity Benefits monitoring program associated with the rodent eradication project has been established to assess and document the biodiversity benefits of removing rats and mice from the World Heritage Lord Howe Island. The program provides a measure of the return on investment. It also allows an evaluation of status of species prior to and following the eradication so any impacts of the eradication of rodents on key non-target species can be tracked during their recovery. Over time, results from the various monitoring components can be integrated to identify and explore changes to ecosystem processes

The REP is currently in the planning and approvals stage. The final decision by the LHIB to proceed with the eradication or not will be informed by the technical, social and financial feasibility. This will include the status of approvals, level of community support and recommendations from the Independent Human Health Risk Assessment.

Alternatives Considered

Systematic techniques for eradicating rodents from islands were first developed in New Zealand in the 1980s. Since then techniques have improved significantly, and eradications are now being attempted and achieved on increasingly larger and more complex islands, including those with human populations.

Aerial broadcasting of bait using helicopters has become the standard method used in eradications, particularly those on large islands with steep topography. This method has proven to be a more reliable and more cost-effective option than the previous ground based techniques. The majority of successful eradications on large islands have used aerial baiting with Brodifacoum in cereal pellets. Rat eradications on islands over the period 1997- 2014 using this bait and method have been 98% successful (37 of 39 attempts). The success rate for mouse eradications on NZ islands using aerially applied Pestoff 20R with 20ppm Brodifacoum (the bait to be used on Lord Howe) from 1997 - 2014 is 100% or 11 from 11 attempts.

A range of alternatives for eradicating rodents were considered for LHI including alternate techniques and mortality agents. Many were considered to have fatal flaws and were unsuitable for use for eradication on LHI either because the technique was not suited to the terrain or size of the island, they did not ensure that all individuals would be killed or they were too experimental. The method chosen proposes to distribute highly palatable bait pellets containing Brodifacoum using a combination of aerial and hand broadcasting together with bait stations and trays. This approach will maximise chances of success whilst minimising risks to non-target species and the community and was considered the only method capable of removing every rat and mouse on LHI. Whilst Brodifacoum is the preferred toxicant because it is has been well tested and proven successful in numerous rodent eradication projects throughout the world. The eradication techniques proposed for LHI are neither novel nor experimental. They are the culmination of more than 30 years of development and implementation involving more than 380 successful rodent eradications worldwide.

Threatened Species and Ecological Communities

A wide range of threatened species and ecological communities listed under the TSC Act either reside on LHI or are considered regular or irregular visitors to the LHIG.

Threatened species occurring or with the potential to occur in the project area include 30 birds, 7 invertebrates, 2 land reptiles, 10 plant species, 6 marine mammals and 3 marine reptiles. Two threatened ecological communities are recorded.

Many of these bird species and marine animals are considered irregular visitors or vagrants that are present in very low numbers or not present at all during the proposed eradication period. Many of the listed threatened seabirds have only been observed at sea in the waters of the LHIG.

Potential Impacts to Threatened Species and Ecological Communities

The potential impacts arising from the proposed REP were assessed. These included:

- Pollution of soil, air or water
- Bioaccumulation
- Mortality of non-target species due to primary poisoning from consumption of bait pellets
- Mortality of non-target species due to secondary poisoning from consumption of poisoned rodents, fish or invertebrates

- Bird strikes and collisions from helicopter activity
- Disturbance from helicopter activity
- Potential impacts as a result of handling and captive management during the captive management program
- Long term changes to ecological relationships affecting threatened species following the eradication of rats, mice and owls.

Potential impacts to Air, Soil or Water and Bioaccumulation

Based on evidence from similar eradications on other islands, the physical and chemical properties of the bait and toxin and the relatively small quantity used in a one-off eradication, the risk of pollution impacts to soil, air or water were considered to be very low. Similarly whilst bioaccumulation could occur, the risk of impacts was considered low. In the unlikely event that impacts occurred they would be highly localised and short term in nature

Potential Impacts to Threatened Bird Species

Risks to non-target bird species during an eradication programme are a function of the species present on the island group and their behaviour, susceptibility of those species present to the poison, composition and delivery method of the bait and the probability of exposure to the poison either directly or indirectly.

Land Birds

Many land bird species are not expected to consume pellets or sufficient numbers of invertebrates to be at risk from primary or secondary poisoning.

The REP poses a significant risk to the LH Pied Currawong (LHPC) from secondary poisoning and the LH Woodhen (LHW) from primary and secondary poisoning. To mitigate potential impacts to these species, large numbers: up to 80% of the LHW population and 50-60% of the LHPC population will be taken into captivity during the eradication period. Both species have previously been held in captivity before with no observable ill effects.

In the absence of mitigation, a significant impact to woodhens is likely to occur from the LHI REP. However with the mitigation proposed in place, it is considered unlikely that either long term population decrease or major disruption to a breeding cycle will occur. Impacts are likely to be temporary. It is therefore considered unlikely that the REP will have a significant impact on woodhens

In the absence of mitigation, a significant impact to LHPC is likely to occur from the LHI REP. With the proposed mitigation in place, it is considered possible that the REP will still have a significant impact on LHPC through the temporary disruption of a breeding cycle, although it is unlikely that a long-term population decrease will occur. Any potential impacts will be temporary.

Non-seabird migrants

The number of individuals of each of the regular migrant shorebird species on the LHIG is insignificant at a regional, state, national and international scale as the timing of baiting operations coincides with a period when the abundance of these species on the LHIG is lowest. Therefore, the proposed REP is highly unlikely to have a significant impact on these species.

Irregular or vagrant non-seabird migrants

Many of the listed non-seabird species occur as irregular migrants or vagrants on LHIG have been recorded on five or fewer occasions since ornithological records commenced in the early 1900s. The other species have recorded dates outside of the proposed bating operation. None of the species have been recorded breeding on the LHIG and the small number of individuals of each species that have been recorded indicate the LHIG population is not significant at a regional, state, national or international scale. A significant impact of the REP to these listed species is therefore assessed to be highly unlikely.

Seabirds

All listed seabird species are carnivorous and obtain all their prey at sea; they are not known to consume any food on land and as such they are highly unlikely to consume cereal bait pellets distributed on land or poisoned rodent carcasses.

As many of the threatened seabird species are either not present during the eradication period or not present in significant numbers they will not be exposed to either primary or secondary poisoning or helicopters. The risk to many species was considered negligible.

Only two seabird species occur regularly on or around the LHIG in winter when baiting operations will be undertaken: Masked Booby and Providence Petrel. Breeding colonies of both species will be baited using a helicopter; as such they are not at risk of disturbance from human presence within the colonies. Records of helicopter strikes or disturbance from aerial eradication operations are very rare. Nonetheless, mitigation measures will be in place to minimise disturbance and the risk of collision. Specifically, helicopter flight times over Masked Booby colonies will be restricted to periods when birds are less likely to be leaving or arriving at the colony (movements are greatest shortly after dawn and in the late afternoon) and helicopters will be restricted to flying at a height of >30 m above colonies. Providence petrels breed principally in the southern mountains, particularly the two mountain summits. From March to November annually they arrive at LHI from mid-afternoon onwards to display in the airspace above the breeding sites, find mates and visit burrows. Helicopter strike with Providence Petrels involved in courtship and incubation will be avoided by restricting helicopter flights around the southern mountains to before midday on each day of baiting. The majority of returns from foraging to provision chicks occur after early July (Marchant and Higgins 1990) avoiding any overlap with proposed helicopter movements. The risk of absorption of Brodifacoum via contact with the skin is extremely low for birds as almost all of their external body surface is covered by a thick layer of feathers (particularly seabirds) or cornified keratinocytic tissue, thereby virtually eliminating contact with the skin.

Potential Impacts to Threatened Marine Species

Potential impacts to TSC Act Listed threatened marine species are limited to accidental bait entry into the water (either through aerial distribution or a spill) leading to pollution of water, primary or secondary poisoning.

Pollution of marine water resulting in impacts to threatened marine species is considered extremely unlikely considering the minimal amount of bait likely to enter the water, the low solubility of Brodifacoum and the huge dilution factor.

There is no realistic pathway by which threatened marine mammals can be significantly exposed to rodenticide at the LHIG as a result of the proposed aerial baiting with Pestoff® 20R. The combination of Brodifacoum being practically insoluble in water, the infinitesimal amount of Brodifacoum that may land in the sea and the huge dilution factor preclude any significant effect upon marine mammals. Marine mammal species are also rare visitors to LHI waters, passing through on the annual migration and are therefore unlikely to encounter the bait.

Marine reptiles are also very unlikely to have significant exposure to bait directly or prey items that have ingested rodenticides.

Potential Impacts to Threatened Invertebrates

The only potential to impact on TSC Act listed terrestrial invertebrates is through direct consumption of bait (primary poisoning). From other studies around the world, most snail species studied have been shown to either not consume bait or have little mortality associated with bait consumption as they have different blood clotting systems to mammals and birds.

Negligible risk posed to *Placostylus bivaricosus* by the proposed eradication operation as the probability of a significant proportion of the Placostylus bivaricosus population consuming and dying from toxic baits in the wild is extremely unlikely. Three of the critically endangered land snails, minute to small leaf litter-dwellers with small activity ranges (*Mystivagor mastersi*, *Peudocharopa ledgbirdi*, *P. whiteleggei*) were considered at moderate risk of exposure to bait placed (i.e. some but not all individuals may get in contact with baits). Susceptibility to Brodifacoum was unknown. The fourth species *Gudeconcha sophiae magnifica*, a large ground-dwelling species with large activity ranges was considered to be at high risk of exposure to bait.

The one endangered snail (*Placostylus bivaricosus)* and four species of critically endangered land snails on LHI: Masters' charopid land snail, Mount Lidgbird charopid land snail, Whitelegge's land snail and *G. sophiae magnifica* are highly threatened by rat predation and it is likely that if rats are not removed these species will become extinct; some may already be extinct. The extreme rarity of these species precludes any testing of their susceptibility to Brodifacoum, or capturing the species to safeguard them in captivity. Whilst it is possible that some individuals of these species may be at risk of poisoning, this possibility must be weighed up against the threats associated with not removing rodents including almost certainty that predation by rats will result in the extinction of these species. Therefore a significant impact to these species is not expected from the REP when compared to not proceeding with the eradication.

The LHI earthworm and the wood feeding cockroach are not considered susceptible to poisoning but are however highly impacted by rodent predation.

Potential Impact to Threatened Reptiles

There are two native species of terrestrial reptiles on LHI, the LHI Skink *Oligosoma lichenigera* and the LHI Gecko *Christinus guentheri*, both listed a Vulnerable under the TSC Act. Both species occur on the offshore islets around LHI but were once widespread across the main island. Predation by introduced rodents is regarded as the major threat to these species. REP activities with the potential to impact on TSC listed terrestrial reptiles include distribution of the bait through primary poisoning (direct consumption) and secondary poisoning (consumption of poisoned invertebrates). Each species is considered to be at low risk of poisoning, and both are likely to substantially increase in abundance following the removal of rodents.

Potential Impacts to Threatened Terrestrial Plants

REP activities with the potential to impact on threatened plants are: works associated with building the captive management facility and bait distribution (through potential uptake of Brodifacoum by plants).

The captive management facility construction will occur through modification of existing greenhouses structures at the nursery site. If needed, previously cleared land at the nursery within the lowland settlement area will be used. No clearing of land is proposed.

Brodifacoum is not herbicidal, is highly insoluble and binds strongly to soil particles, therefore it is not likely to be transported through soils and taken up by the roots of plants into plant tissues. There is no identified chemical process that would allow Brodifacoum to impact on plants. No evidence of Brodifacoum uptake or impact to any plants species was identified in the available literature.

Therefore no impact is expected to listed plant species. Conversely removal of rodents is expected to significantly benefit individual species (such as the Little Mountain Palm and Phillip Island Wheat Grass) and many vegetation communities through reduced predation on seeds, seedlings and stems of palm-leaf fronds.

Potential Impacts to Threatened Ecological Communities

Potential impacts to threatened ecological communities are considered unlikely as there are not expected to be impacts to component flora or fauna species. In contrast the Mossy Cloud Forest community is threatened by rodents as rats eat the seeds and leaf stems of the two of the dominant species, the endemic palms *Hedyscepe canterburyana* and *Lepidorrhachis mooreana*, and also the seeds of other species.

Potential Long Term Ecological Changes

While it is difficult to predict the long term ecological changes that are expected to occur on LHI following successful rodent eradication, evidence from rodent eradication projects elsewhere has shown that a wide range of taxa benefit from the eradications of invasive mammals. Where rodent eradications have been reviewed, they have demonstrated benefits included population recoveries, re-colonisations and re-introductions, and increases to vegetation cover. It is expected that LHI populations of seabirds, land birds, invertebrates and vegetation would similarly benefit in the long-term from the eradication of rodents.

Whilst some negative impacts on native populations have also been reported following rodent eradications, most negative impacts are due to poisoning either from consumption of baits or through secondary poisoning following consumption of poisoned rodents. Such impacts are usually short term and populations recover once the baiting operations have ceased. Species at risk of being affected by bait consumption or secondary poisoning that occur in the LHIG include the Lord Howe Woodhen and the Lord Howe Pied Currawong. Risk to both species will be managed through captive management.

Potential Cumulative Impacts

Potential cumulative impacts from the REP were considered with:

- Other potential actions - the proposed wind turbines and ;
- Other key threatening processes on the island such as weeds, habitat clearing and degradation, other human related threats and anthropogenic climate change.

As the LHI currawong is the only species on which the REP will have a potential significant impact (temporary disruption to one breeding cycle) and the wind turbine is unlikely to have an impact on currawongs, no significant cumulative impacts are expected from the wind turbines and REP.

When potential impacts of the REP are considered with other threats, no significant cumulative impact is expected. This is due to the localised and short term nature of potential impacts from the REP and expected long term benefits to species and ecosystem recovery in the absence of rodents.

When considered as one action out of many related conservation and recovery actions currently being implemented or planned by the LHIB, the REP will add significant contribution to net positive cumulative impacts for species and biodiversity for the LHIG.

In contrast, not proceeding with the REP would allow continued impacts from predation and completion by rodent on a range of species, increasing cumulative impacts with other threats.

Proposed Mitigation

A range of mitigation measures are proposed to mitigate potential impacts of the REP.

Mitigation of risks has been considered through planning and development of the operation though choice of methodology, toxin and bait; through proposed timing of the operation; through the combination of bait delivery methods selected; and through the development of baseline monitoring programs and trial programs.

During the operation, mitigation will include captive management of at risks species; extensive environmental and non-target species monitoring and collection of carcasses where possible.

Post operational monitoring will track predicted species recovery (or potential impacts)

Conclusion

This Species Impact Statement provides a demonstrated need for the REP based on documented evidence of significant impacts of rodents both globally and on LHI. It presents evidence of ongoing impacts at the species and ecosystem level on LHI even in the presence of ongoing rodent control. It demonstrates support for the REP through a range of legislative instruments, recovery plans and the like and outlines the unacceptable consequences of failing to proceed. It also provides evidence of expected benefits.

Detailed consideration of alternatives assessed is provided together with justification of why continuing with the current control program is unacceptable. It provides evidence of why other methods were considered unsuitable for an eradication on LHI and why the toxin, bait and delivery methods were selected based on over 30 years of lessons and experience globally.

It outlines the project details and mitigation and considers in detail, potential risks to threatened species based on results from numerous similar eradications around the world.

It concludes that significant impacts are highly unlikely for most threatened species. Species considered most at risk are the LH Woodhen and the LH Pied Currawong (LHIPC). In the absence of mitigation, a significant impact to woodhens is likely to occur from the LHI REP. However with the mitigation proposed in place, it is considered unlikely that either long term population decrease or major disruption to a breeding cycle will occur. Impacts are likely to be temporary. It is therefore considered unlikely that the REP will have a significant impact on woodhens

In the absence of mitigation, a significant impact to LHPC is likely to occur from the LHI REP. With the proposed mitigation in place, it is considered possible that the REP will still have a significant impact on LHPC through the temporary disruption of a breeding cycle, although it is unlikely that a long-term population decrease will occur. Any potential impacts will be temporary.

The REP is essential and beneficial. Risks have been addressed through proposed mitigation to the point where they are considered to be very low. Any potential impacts are localised and short term and far exceeded by the benefits that will be provided by implementation of the REP. Potential impacts of the REP are also considerably less than the ongoing impact of failing to proceed.

Glossary, Definitions and Abbreviations

Abundance	A quantification of the population of the species or community
Activity	Has the same meaning as in the EP&A Act.
Affected Species	Subject species likely to be affected by the proposal.
Aerial Broadcast	Distribution of the pelletised bait by helicopter with an underslung bait spreader bucket.
Anticoagulant	Having the effect of inhibiting the coagulation of the blood
APVMA	Australian Pesticides and Veterinary Medicines Authority
Bait Station	A contained compartment housing for distributing rodenticide
Biosecurity	Procedures or measures designed to protect Lord Howe Island against harmful biological or biochemical substances
Brodifacoum	A second generation rodenticide and the active ingredient present in the proposed bait
Conservation Status	Regarded as the degree of representation of a species or community in formal conservation reserves
Control	To regulate, restrain, or hold in check
DA	Development Application Number
Development	Has the same meaning as in the EP&A Act.
Director General	The Director General of the Department of Premier and Cabinet, Office of Environment & Heritage (OEH).
DP	*Deposited Plan* which is the Plan number given to a subdivision that is registered by the Land Property Information.
EPA	Environment Protection Authority (formerly part of the OEH
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
ESD	Ecologically Sustainable Development
Eradication	The intentional total extermination of a species or population
Hand Broadcast	The scattering of Pestoff20R pellets by hand or machine rather than aerial distributing via helicopter
IUCN	International Union for Conservation of Nature
LGA	Local Government Area.
LHI	Lord Howe Island
LHIB	Lord Howe Island Board
LHIG	Lord Howe Island Group
Locality	The area within a 5 km radius of the study area.
NES	Matters of National Environmental Significance
OEH	NSW Office of Environment and Heritage
PER	Public Environment Report
Pestoff 20R	The proposed cereal based bait to be used during the proposed Rodent Eradication Project. Manufactured by Animal Control Products Ltd as either a 10mm or 5mm pellet containing the active Ingredient

	Brodifacoum at a concentration of 20 parts per million (20 milligrams per kilogram)
ppm	Parts per million
PPP	Permanent Park Preserve
Region	Same meaning as contained in the TSC Act.
Resistance	The ability not to be affected by something, especially adversely like rodenticides
REP	Rodent Eradication Project
Significant Species	Species not listed in the TSC Act but considered to be of regional or local significance.
Study Area	Subject site and any other additional areas which are likely to be affected by the proposal either directly or indirectly.
Subject Site	The area which is proposed for development/ activity.
Subject Species	Threatened and significant species, populations and ecological communities which are known or considered likely to occur in the study area.
Threatening Process	Same meaning as contained in the TSC Act; the definition is not limited to key threatening processes.
TSC	NSW Threatened Species Conservation Act 1995
World Heritage Area	An area recognised as being as of outstanding international importance and therefore deserving special protection.

1 Form of the Species Impact Statement

The Lord Howe Island Board (LHIB) is proposing to undertake the Lord Howe Island Rodent Eradication Project (LHI REP) which aims to eradicate introduced rodents: the Ship Rat (*Rattus rattus*) and the House Mouse (*Mus musculus*) from Lord Howe Island (LHI) and its associated islands and rocky islets (excluding Balls Pyramid), hereafter referred to as the Lord Howe Island Group (LHIG).

As part of the approvals for the project, a Species Impact Statement (SIS) is required under the NSW *Threatened Species Conservation Act 1995* (TSC Act). The form and content of the SIS has been determined though the Director General's Requirements (DGRs) issued for the project on 27 June 2016 (included as Appendix A). The DGRs set out the information required so that the Chief Executive of the Office of Environment and Heritage (OEH) can gauge the effect of the LHI REP on the environment. DGRs are prepared in accordance with Sections 109 and 110 of the TSC Act, which describe the form and content of a Species Impact Statement. Pursuant to Section 111(3) of this Act, the form and content of some Species Impact Statement requirements have been limited or modified.

The purpose of this Species Impact Statement (SIS) is to:

- identify and ameliorate possible harm to the listed *threatened* species of Lord Howe Island and its associated islands and islets resulting from the proposed eradication of introduced rodents from these islands using the anti-coagulant Brodifacoum in cereal baits that will be dispersed over the islands from the air, broadcasted by hand and deployed in bait stations and bait trays; and
- assist the Chief Executive of the OEH in the assessment of Section 91 Licence applications lodged under the TSC Act.

This SIS addresses the DGRs for the project. A checklist to ensure all matters are addressed is provided in Appendix B – DGRs Checklist. Names, qualifications and input of authors of this SIS are provided in 9.1.

1.1 Declaration

Section 109 (1) and (2) of the TSC Act states that:

*1.1 A species impact statement must be in writing (*Section 109 (1))*;*

1.2 A species impact statement must be signed by the principal author of the statement and by:

(a) the applicant for the licence, or

*(b) if the species impact statement is prepared for the purposes of the Environmental Planning and Assessment Act 1979, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires) (*Section 109 (2))*.*

Accordingly, the following declarations are made:

I, Andrew Walsh, (being the principal author of this Species Impact Statement) declare that it is, to the best of my knowledge, true and correct.

Signature: A. Walsh

Date: 15 February 2017

I…Andrew Logan, (on behalf of the Lord Howe Island Board, and acting in the capacity of Chief Executive Officer of the Lord Howe Island Board), of Bowker Avenue Lord Howe Island, being the proponent of the proposed eradication of introduced rodents from the Lord Howe Island Group using the anti-coagulant Brodifacoum, have read and understood this Species Impact Statement. I understand the implications of the recommendations made in the statement and accept that they may be included as concurrence conditions for the proposal.

Signature: A.H. Logan

Date: 15 February 2017

2 Contextual Information

Rodents are currently having significant impacts on World Heritage values including impacts to a range of TSC Act listed species. The eradication of rodents will also present an opportunity to simultaneously eradicate the introduced Masked Owl.

The one-off eradication proposes to distribute a cereal-based bait pellet (Pestoff 20R) containing 0.02g/kg (20 parts per million) of the toxin, Brodifacoum across the LHIG (excluding Balls Pyramid). Methods of distribution will be dispersal from helicopters using an under-slung bait spreader bucket in the uninhabited parts of the island (most of the LHIG) and by a combination of hand broadcasting and the placement of bait in trays and bait stations in the settlement area. In the outdoor areas of the settlement, baits will be dispersed by hand and/or placed into bait stations. In dwellings (e.g. in ceiling spaces or floor spaces) bait trays and bait stations will be used. Bait stations will also be used around pens for any remaining livestock (e.g. the remaining dairy herd, goat or horse containment areas).

Given the size and rugged terrain of the LHIG, the exclusive use of baits stations is not feasible for the eradication.

The operation is targeted for winter of 2018 (June to August) however to allow operational flexibility and to account for unforeseen delays, approval is sought for at least a two year period, June 2018 to December 2019.

2.1 Project Background

2.1.1 Proponent Details

Proponent	Lord Howe Island Board
ABN	33 280 968 043
Address	PO Box 5, Lord Howe Island, NSW 2898
Phone	02 65632066
Contact Details	Mr Andrew Walsh Project Manager – Rodent Eradication Project andrew.walsh@lhib.nsw.gov.au

The LHI REP has received significant funding ($9M) in 2012 for planning and implementation from the Federal Government's former Caring for Our Country Program (now National Landcare program) $4,500,000 and the NSW Environment Trust $4,542,442.

2.1.2 Project Objectives

The primary objectives of the proposed project are to:

- Eradicate (see box below) all ship rats and house mice from the LHIG to permanently remove the impacts of rodents on biodiversity, World Heritage and socio-economic values of the LHIG.
- Ensure safety of humans and the environment.
- Provide a secure environment for populations of threatened and endemic plants and animals currently present on the LHIG
- Minimise impacts to non-target species, livestock and pets.
- Eliminate the current ongoing rodent control program and therefore eliminate the need for ongoing use of rodent poison on LHI.

Control = to regulate, restrain or hold in check

Eradicate = the intentional total extermination of a species or population

There are five principles to achieving eradication that must be met in every case, for all target species (Parkes, 1990, Bomford and O'Brian, 1995):

1. All individuals can be put at risk by the eradication technique(s);
2. They can be killed at a rate exceeding their rate of increase at all densities;
3. The probability of the pest re-establishing is manageable to near zero;
4. The project is be socially acceptable to the community involved;
5. Benefits of the project outweigh the costs.

Secondary objectives are to:

- Eradicate Masked Owls from the LHIG and permanently remove their impacts on the fauna of the island
- Establish a sustainable and robust biosecurity system to prevent the reinvasion of rodents and other biosecurity risks. Strengthened biosecurity measures for the Island will protect and enhance LHI's World Heritage status and continue to increase tourism interest for this unique pest free environment.

2.1.3 Project History

Lord Howe Islanders and the LHIB have been involved in the control of rodents (rats and mice) on LHI since about 1920, highlighting both the long recognised impacts of rodents and difficulty in achieving outcomes through ongoing control on the island. Methods included a bounty on rat tails, hunting with dogs, introduction of cats and owls and the use of various poisons including barium chloride, diphacinone, and warfarin. Further detail on previous control efforts is found in Section 2.8.2.

Internationally (particularly in New Zealand), eradication of rodents from islands started to gain momentum following the successful eradication of rats from Maria Island/Ruapuke Island in 1959 and the invasion by rats on Big South Cape Island in 1963 (Russell and Broome, 2016). Incremental work over many decades, starting with small islands and gradually increasing scale and building capacity led to the desire and ability to tackle larger, more complex islands (ibid). The breakthrough which allowed these advances was the development of slow acting second generation anticoagulants in the late 1970s. For the first time rodents could eat a lethal dose in a single or many small meals yet not feel the effects for several days. Poison shyness, which hampered earlier eradication attempts with toxicants, was eliminated. The first successes from deliberate attempts in the 1980s opened the minds of many to the conservation possibilities. The old adage 'success breeds success' held true for rodent eradications with a surge of projects in New Zealand in the 1990s (ibid).

This led to a chain of events, both locally on LHI and within state and federal Government in Australia that would lead to development of the idea of rodent eradication on LHI. These are summarised below.

In 2000, the NSW Scientific Committee, made a Final Determination to list *Predation by the Ship Rat* Rattus rattus *on Lord Howe Island* as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995* recognising the impact of rats to species and biodiversity on LHI. It recommended augmentation of the existing control program and to investigate long term impacts of ongoing control.

A proposal to eradicate rodents was submitted to the LHIB in 2001. The proposal called for LHIB support and funding to undertake a feasibility study and further support for the eradication, subject to findings of the feasibility study.

In 2001, the LHIB commissioned a feasibility study (Saunders and Brown, 2001) that looked at a long-term solution to the rodent problem on LHI, through a program of total eradication. The study concluded that rodents were having a significant impact on LHI particularly to biodiversity and the palm industry and that control of rodents was unsustainable. It also concluded that eradication on LHI was feasible using a combination of aerial broadcast, hand broadcast and bait stations using a Brodifacoum based product. The study identified additional further gaps that needed to be addressed and risks to be mitigated and recommended key next steps.

A Cost Benefit Analysis (Parkes *et al.* 2004) which looked at additional feasibility, risks and benefits of eradication on LHI again confirmed that eradication was feasible and highly beneficial, provided risks (non-target impacts, bait palatability and efficacy, and community support) could be appropriately managed and funding and approvals obtained.

In March 2006, the Commonwealth Minister for the Environment listed *Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha)* as a Key Threatening Process under *the Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The listing advice (TSSC, 2006) provided examples of rodent impacts on LHI species in support of the listing. It also recommends that eradication of rodents, where feasible, was a preferred outcome to ongoing control.

In 2007 the *Lord Howe Island Biodiversity Management Plan* (BMP) (DECC, 2007) was developed as a key overarching document providing holistic management of key threats and protection of the island's biodiversity. It also constitutes the formal recovery plan for many threatened species. The eradication of rodents is one priority conservation management action listed in the BMP.

In 2007, a non-toxic bait uptake trial (DECC, 2007a) was undertaken on LHI that examined rodent and non-target species uptake of the bait pellets, bait breakdown in the environment and spread of the bait using helicopter. The study concluded that bait was highly palatable to both rats and mice and that sufficient bait would be available for both species to receive a lethal dose under eradication conditions. It found bait breakdown in the environment was approximately 100 days. It also found that four bird species (the LH woodhen, buff banded rail and two introduced species) consumed bait along with some invertebrates.

A further study in 2008 (DECC, 2008) examined bait sizes. Both small (5.5 mm) and large (10 mm) baits were shown to be palatable to rats and mice. Consequently, either baits would be appropriate for use in an eradication operation on LHI, however large baits are recommended for aerial operations, and small baits for hand broadcasting where it is critical to increase bait encounter rates for mice.

The early studies on LHI and growing government recognition of wide spread rodent impacts, led to development of a Draft LHI Rodent Eradication Plan in 2009. The Draft Plan was externally peer reviewed by the Island Eradication Advisory Group (IEAG) of the New Zealand Department of Conservation; the Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union; the Worldwide Fund for Nature (WWF), Australia; Birds Australia; Landcare Research, New Zealand; CSIRO and Professor Tim Flannery. Public comment on the Draft Lord Howe Island Rodent Eradication Plan was sought in November 2009 and 83 submissions were received.

A Human Health Risk Assessment was undertaken in 2010 (Toxikos, 2010). The study found the risks to human health from the eradication are negligible with the proposed mitigation in place.

The LHIB received significant funding to implement the REP from the New South Wales Government's Environment Trust and the Australia Government's Caring for Our Country Program in 2012.

A range of additional studies and consultation have been undertaken since then that provide the basis for the current rodent eradication proposal and this PER. These include:

- Baseline biodiversity benefits monitoring (see Section 2.2.1.7)
- Additional studies on key species such as Currawong (Carlile and Priddel, 2006), LHI *Placostylus (*Wilkinson and Hutton, 2013)*,* Masked Owl (Milledge, 2010 and Hogan *et al.* 2013) and Land Snails (Kohler *et al.* 2016)
- Captive management trials in 2013 (Taronga Conservation Society Australia, 2014) that showed woodhen and currawongs could be successfully held in captivity for extended periods of time (see section 2.2.1.2
- Rat and mice bait toxicity trials in 2013 (Wheeler and Carlile, 2013) and 2016 (O'Dwyer *et al.* 2016) that showed rats and mice on LHI would be able to receive a lethal dose of poison on eradication conditions (see section 2.11.2.1).

2.1.4 Related Actions

LHI has a demonstrated history of positive environmental management and conservation actions to protect the unique values of the island. The proposed REP is essentially an extension of an integrated and much broader conservation and ecological restoration program on the LHIG. Historic related conservation actions included:

- Control of rodents from as early as the 1920s. Methods tried included a bounty on rat tails, hunting with dogs, introduction of cats and owls and the use of various poisons including barium chloride, diphacinone, and warfarin
- Eradication of feral pigs in the early 1980s
- Eradication of feral cats in the 1980s as part of the Lord Howe Woodhen recovery program
- Eradication of feral goats in 2002 (a small number of non-reproductive animals remain as pets)
- Culling of introduced masked owls.

Current environmental management and conservation programs underway include:

- The Lord Howe Woodhen recovery program implemented since the 1980s
- The Lord Howe Island *Placostylus* recovery program
- The Lord Howe Phasmid recovery program
- African Big Headed Ant eradication
- Eradication of over 60 priority weeds from the LHIG including Weeds of National Significance such as Ground Asparagus, Bridal Creeper, African Boxthorn, Tiger Lilly, Bitou Bush, Ochna and Cherry Guava

- Ongoing rodent control program using coumatetralyl
- Strict biosecurity policies and protocols to prevent incursion and establishment from a range of biosecurity risk species.

The *Lord Howe Island Biodiversity Management Plan* (BMP) (DECC, 2007) is the key overarching document related to management of key threats and protection of the island's biodiversity and it constitutes the formal recovery plan for many species. It is a holistic management document, encompassing many of the programs listed above to protect the islands biodiversity with particular focus on rare and significant species. The eradication of rodents is therefore one of many related conservation actions and is listed as a priority action in the BMP.

More directly related to the proposed REP is the *Pilot Study for captive management of LHI Woodhen and LHI Currawong* which was referred to the Commonwealth Department of the Environment under the EPBC Act in 2013). This action was declared "not a Controlled Action" in June 2013. The pilot study showed that woodhens and currawongs could be held in captivity in large numbers for prolonged periods with no observable impact (Taronga Conservation Society Australia, 2014). All 20 woodhens and 10 currawongs that were in the trial were successfully released at their individual capture sites after the trial and monitored.

2.1.5 Project Status

The Project is broken into logical phases as shown in Figure 1 below. The Project is currently in Phase 2. Further detail on each phase is provided in Table 1.

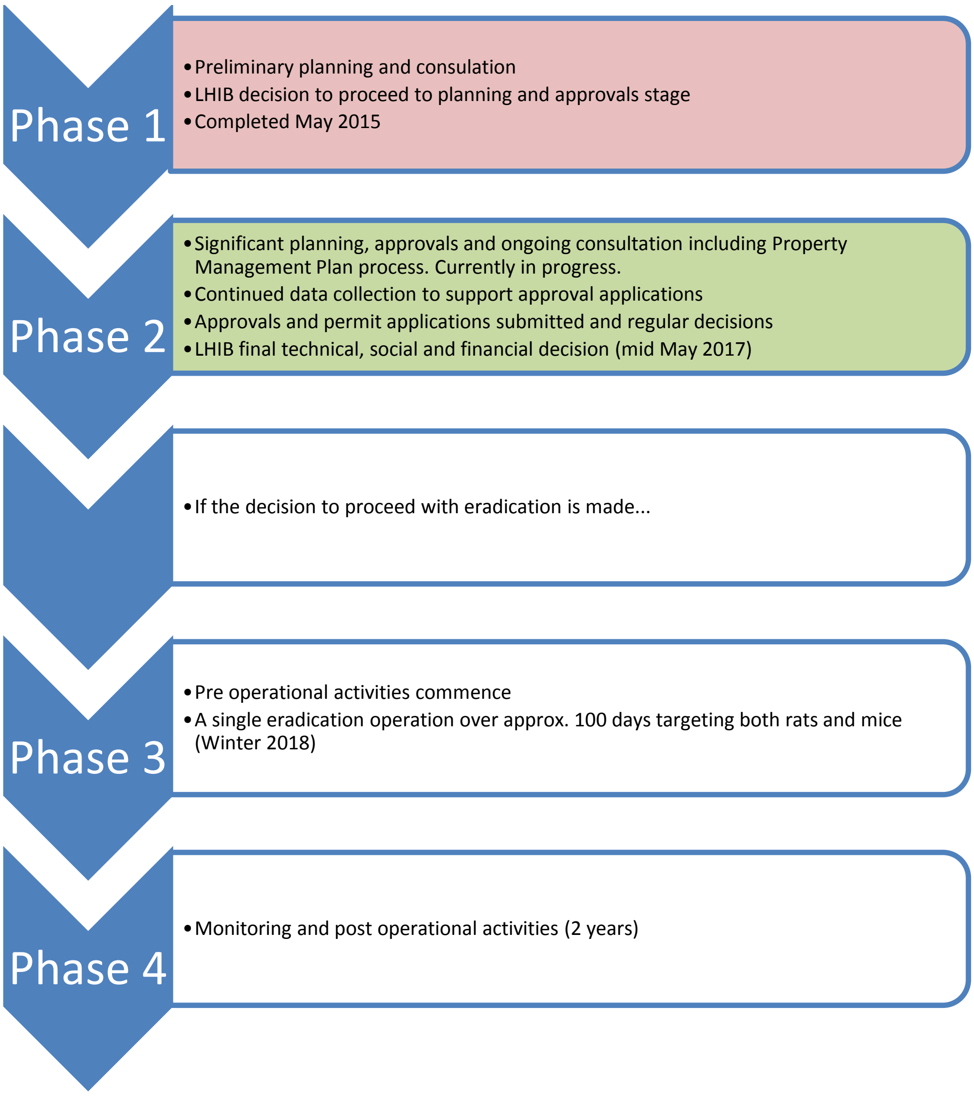


Figure 1 Project Phases Summary

Table 1 Project Phases

Project Phase	Keys Tasks	Proposed Timing
Phase 1 - Preliminary Planning and consultation	Feasibility studies in 2001 and further cost benefit and risk assessment in 2004 2006 - 2008 non-toxic trials including non-target uptake and initial community consultation 2009 Draft Eradication Plan drafted and presented to community Ongoing and divided community response Project funded in 2012 ($9M over four years) Steering Committee set up consisting of funders (State and Federal) LHIB and technical advisor Community liaison group formed in 2013 to attempt to resolve issues 2014 LHIB decision to put project on hold to further consult with community. Process for resolution developed (see below) May 2015 community referendum on expanded control vs. eradicate. Result was 48% (98 respondents) chose expanded control and 52% (106 respondents) chose to proceed with eradication. LHIB decision to proceed to Planning and Approvals Stage	Complete
Phase 2 - Planning and Approvals	Ongoing community extension process and Community Working group (CWG) consultation Development of Property Management Plans Livestock Valuations and Tenders Prepare and submit approval submissions to various regulatory bodies including APVMA, EPBC CASA, and NSW EPA. Human Health Assessment Review Mice resistance toxicity trials to be undertaken to define lethal dose rates and efficacy Recruitment and Training procedures Contractor and Supplier Early Engagement and Tendering EOI Final technical, Social and Financial Feasibility assessments to be undertaken Proceed to Final Go / No Go Decision by the LHIB (see below)	Nov 2015- May 2017 Nov 2015- May 2017 Jan 2016- May 2017 Apr 2016 – Feb 2017 Mar – Apr 2016 Sep 2016 Dec 2016 - May 2017 Feb 2017- May 2017 May 2017
Phase 3 – Implementation	Finalise PMPs and ongoing community consultation Aviary construction for captive management species Finalise supply contracts order baits, shipping, customs checks and quarantine checks. Helicopter logistics, fuel delivery storage facility Completion of livestock removal and poultry Recruitment undertaken. Advertising selection relocation training and preparation Capture of woodhens an currawong	May 2017- Jun 2018 June 2017- Oct 2017 May 2017 -June 2018 Feb-June 2018 May 2017- June 2018 Feb-May 2018 May – Jun 2018

	Undertake baiting campaign Bait Drop 1 Aerial, hand broadcasting and bait stations, community notification ongoing consultation, Meteorology information, Bait station placement and monitoring. Undertake dead rodent's collection through settlement areas. Bait Drop 2 Bait station monitoring and hand broadcasting. Collection of dead rodents continuing. Monitor bait breakdown. Ongoing community consultation and media updates Bait Break down monitoring Release of currawongs and woodhens	Jun 2018 Jul 2018 Jun – Nov 2018 Aug – Nov 2018
Phase 4 – Monitoring and Evaluation	Continuing monitoring for rodent presence including detector dog arrival and implementation. Continuing community information updates. Biodiversity Benefits monitoring	Sep 2017- Oct 2019

The final decision by the LHIB to proceed with the eradication or not (end of Phase 2) will be informed by the technical, social and financial feasibility. This will include the status of approvals, level of community support and recommendations from the Independent Human Health Risk Assessment as per the agreed process for resolution that was an outcome of ongoing community consultation in 2015.

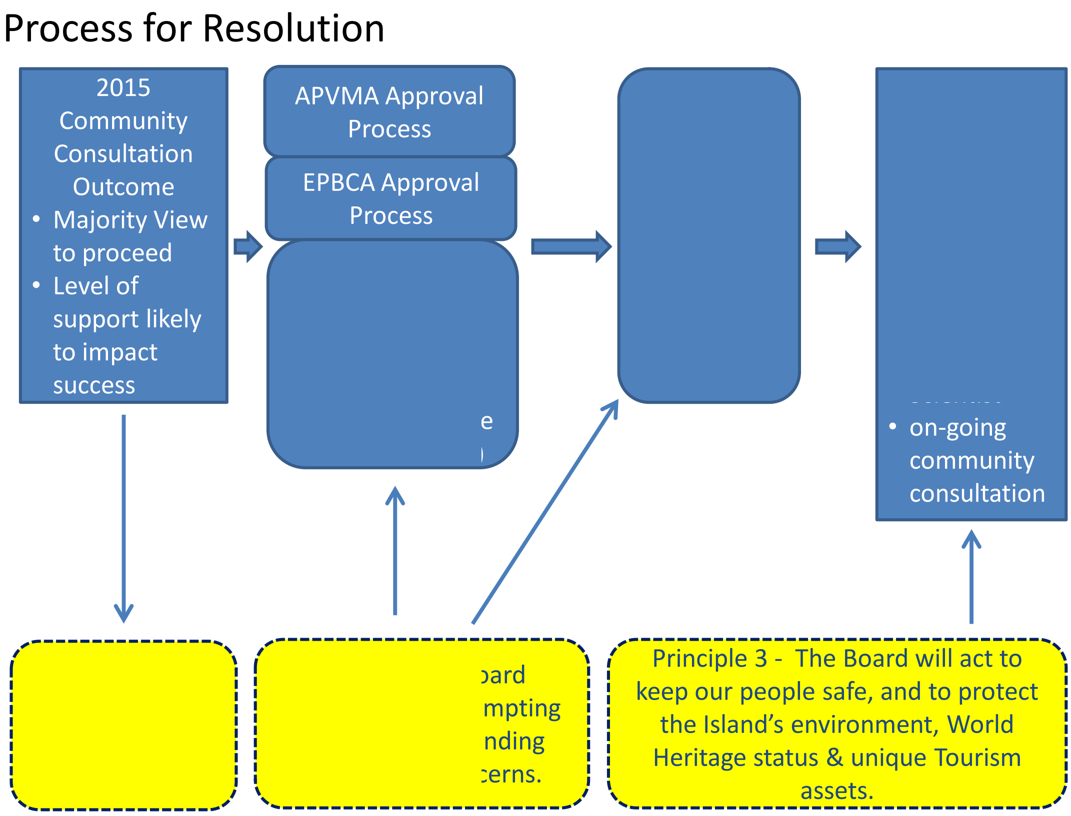


Figure 2 Process for Resolution

2.2 Description of Proposal, Subject Site and Study Area

2.2.1 Description of Proposal

The following operational elements of the proposed REP are described below.

- Removal of livestock
- Captive management of at risk species
- Bait application methods, product storage and disposal and spill response
- Environmental monitoring
- Masked owl eradication
- Rodent detection monitoring
- Improved Biosecurity
- Ongoing biodiversity benefits monitoring

2.2.1.1 Removal of Livestock

Having livestock present during the eradication poses a substantial risk to the success of the operation. Consequently, the proposal is to as far as possible de-stock the island prior to the eradication. Stock feed provides an ideal harbour and food source for rodents. If rodents have access to this feed or any spillage they may not take baits. There is also a risk that livestock may consume baits reducing coverage of bait and availability to rodents.

De-stocking of beef cattle in the 12 months prior to the eradication will be done largely through orderly culling and butchering. Cost of replacement stock and associated costs of returning stock to the island will be met by the LHIB through agreement with livestock owners. Replacement breeding stock will then be brought to the island when the breakdown of bait in paddocks is complete. Most stock-owners on the island have indicated their willingness to cooperate in this process, subject to satisfactory compensatory arrangements being put in place. Breeding stock will be gradually replaced, beginning 100 days after the eradication.

With the proposed mitigation measures in place there is little likelihood of Brodifacoum entering the human food chain via milk from the dairy herd. As such, it will be safe for the dairy herd (approximately 14 animals) to remain on the island throughout the operation, if requested by the owners. Animals will be confined to a small paddock and will receive supplementary feed during the period that bait is present (approximately 100 days). Baiting within the holding paddock will use cattle-proof bait stations

Similar arrangements will be made for remaining goats (approximately three) and horses (approximately three) confined during the risk period. All confined livestock will be fed with fresh-cut grass from unused paddocks, alleviating the need to store food which may provide an alternative food source for rodents. If required, grass will be raked before being cut to remove any bait pellets.

Poultry will be exposed to the risk of primary poisoning from baits spread around the settlement area. More significantly, the presence of poultry poses a major risk to the success of the operation as the presence of large amounts of feed grain has the potential to distract rodents from consuming the bait. As many chickens as possible will be removed from the island or culled at least one month prior to the eradication. Once all bait has disintegrated and no longer poses a threat, disease-free day-old chicks will be brought to the island to replace those birds removed. Residents will be compensated for lost poultry and egg production resulting from the eradication programme.

2.2.1.2 Captive Management

The LHI Woodhen (*Hypotaenidia sylvestris*) and LHI Currawong (*Strepera graculina crissalis*), both of which are listed as Vulnerable under the EPBC Act, are at risk of being poisoned, the former from eating baits and poisoned rodents, the latter from preying on poisoned rodents during the rodent eradication.

In order to protect these two bird species, it is proposed that concurrently with the rodent baiting, a large proportion of the population of the woodhens and currawongs will be taken into captivity on LHI.

The period of captivity will start from approximately two months before baiting commences until baits and rodent carcasses have broken down (or for a total period of up to nine months). The time that baits are available is estimated to be 100 days although the rate of bait breakdown will be monitored to ensure birds are not released at a time which may put them at risk. Up to approximately 85% of the island's woodhen population will be taken into captivity. For the currawong, the proportion will be about 50-60%. This will also ensure genetic diversity is maintained.

Significant experience has been gained in managing woodhen populations in captivity on LHI. During a recovery program for the species (1981-1983), protocols for capturing and housing woodhens were established (Gillespie, 1993). The highly successful captive breeding and release program resulted in the release of 82 birds bred from just three breeding pairs originally captured (NPWS, 2002). Prior to the commencement of the program it was estimated that only 37 individuals remained in the wild.

In preparation for the LHI REP, a captive management pilot study that was conducted in 2013 for woodhen and currawongs on LHI (Taronga Conservation Society Australia, 2014) has also added significant knowledge on the captive management of the two species. The pilot study showed that woodhens and currawongs could be held in large groups for prolonged periods with no observable impact. All 20 woodhens and 10 currawongs were successfully released at their individual capture sites. The trial report is included inAppendix C – Captive Management Package.

	
Figure 3 Woodhens in 2013 Captive Trial	**Figure 4 Currawongs in 2013 Captive Trial**
	
Figure 5 Woodhen Aviary in 2013 Captive Trial	**Figure 6 Currawong aviaries in 2013 Captive Trial**

Bird capture

Only experienced staff will be involved in the capture of both species. These include rangers on LHI who are involved in the capture of woodhen for banding as part of the annual monitoring of the population and Office of Environment and Heritage (OEH) scientific officers (with assistance from the LHIB rangers) that have been catching and banding currawongs since 2005 to determine their population status and movements. Hand-nets will be used to capture woodhen, and clap-traps will be used for currawongs. Upon capture, birds will be placed into cloth bags or ventilated cardboard boxes (one bird per bag or box) and taken to the holding facility where they will be checked by a veterinarian. A veterinarian with bird experience will be on site during all capture and release operations. A scientific licence issued by the NSW OEH under Section 132C of the National Parks and Wildlife Act 1974 is required to capture woodhen and currawongs on Lord Howe Island. LHIB staff have the relevant licence for capturing LHI Woodhen and OEH staff involved in the project have the same licence for the capture of LHPC.

Birds will be collected from across the island including Mt Gower which will be accessed by helicopter to minimise stress to the birds. The Woodhen Survey Manual (Harden, 1999) provides details around how to capture woodhens.

Captive Housing Design and Location

The design plans for the holding pens used for each species during the 2013 trial were prepared by an experienced team of aviculturists from Taronga Zoo considering knowledge gained from previous facilities built to house these birds (both at Taronga Zoo and on LHI) as well as advice from New Zealand where the Weka, a species similar to the woodhen, had been kept in captivity during rodent-eradication operations undertaken in that country. These, together with recommendations from the pilot study will be used to inform the detailed design of the larger facility needed during the REP. Woodhens will be held in enclosed paddocks 14 m by 14 m (see Figure 7), holding approximately 20 birds each. For the currawongs, aviaries 1.5m wide x 3m high x 6m long aviaries, will be constructed, holding 2 birds per aviary (see Figure 8). Indicative plans from the 2013 pilot study are shown below.

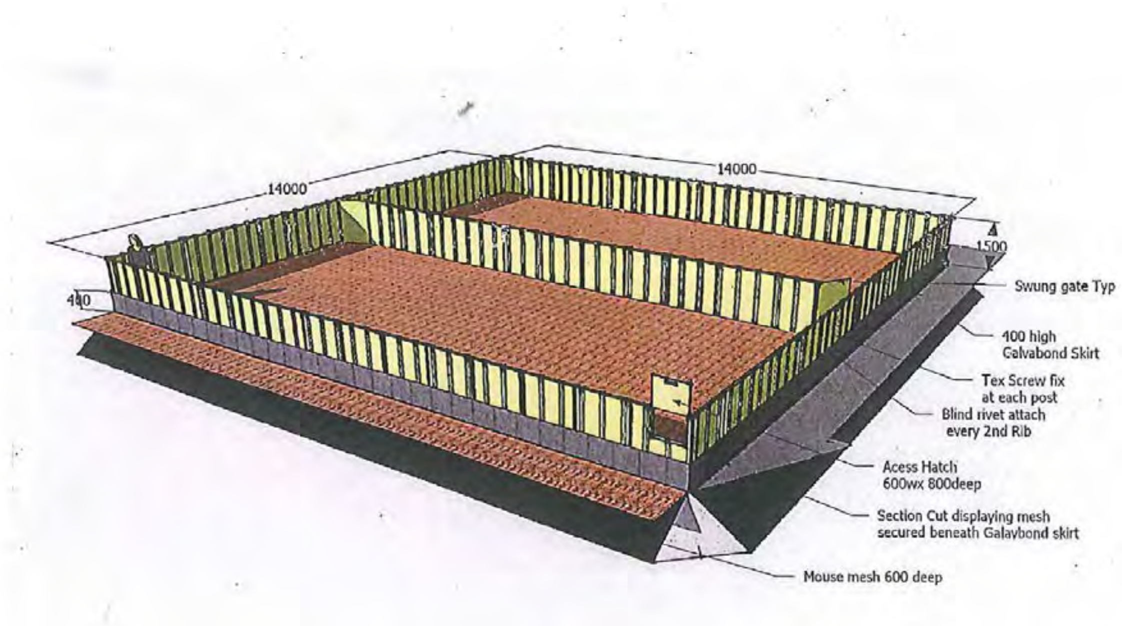


Figure 7 Indicative Woodhen Aviary

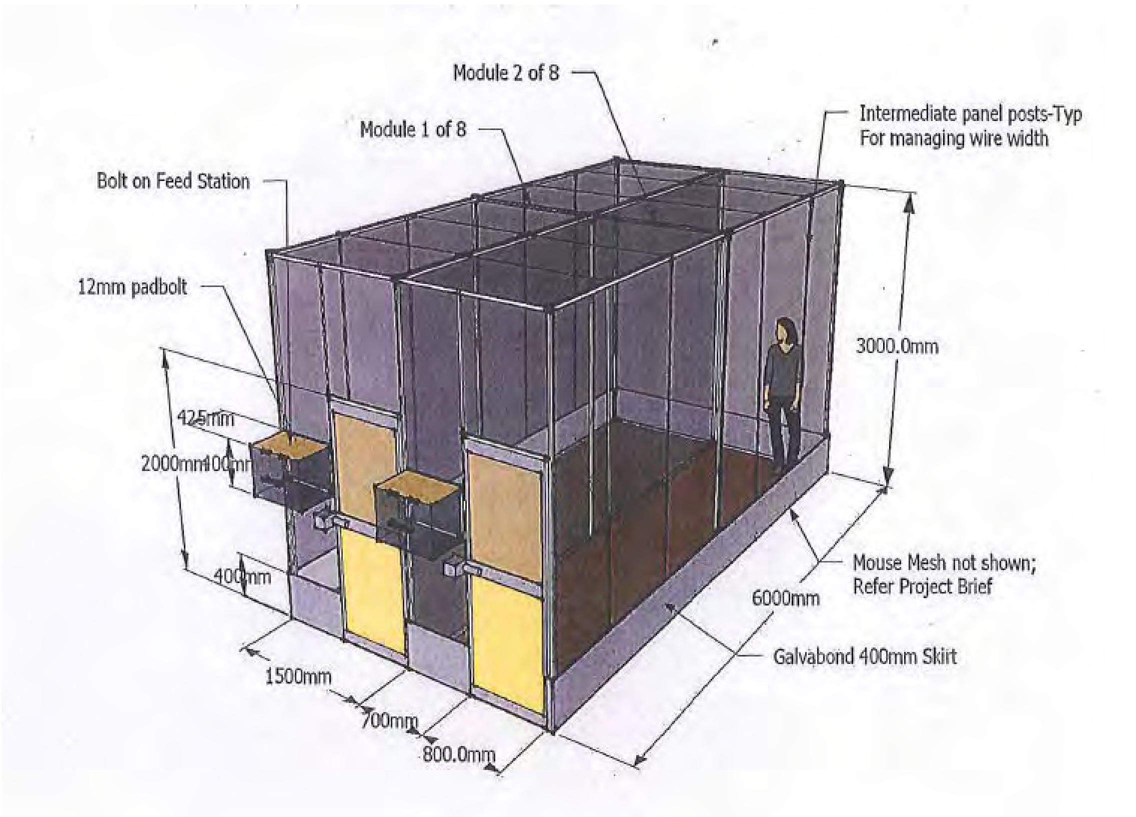


Figure 8 Indicative Currawong Aviary

The required number of aviaries will be accommodated for by reuse of the 2013 aviaries that are still in place at the Nursery site and through modifying existing greenhouses at the Nursery site used in 2013. The existing footprint of the 2013 aviaries and greenhouses should prove sufficient space (see Figure 9). In the unlikely event that additional space is required, expansion may occur on previously cleared and grassed land at the nursery site. No additional vegetation clearing would occur.

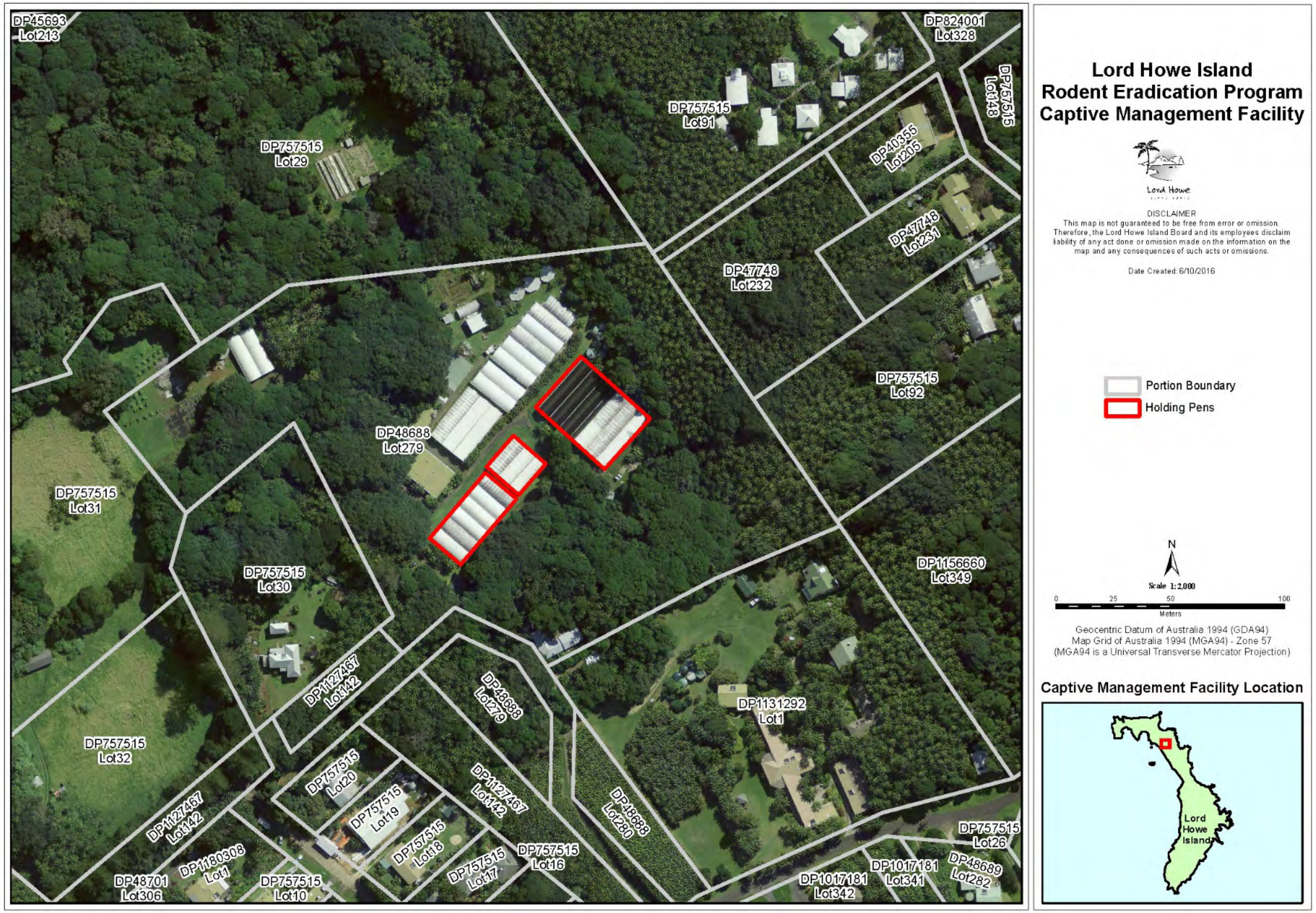


Figure 9 Captive Management Facility Location

Guiding principles used in designing and determining the location of aviaries have included

- Locating the aviaries away from areas frequented by people;
- Providing adequate shade and protection from inclement weather and avian predators;
- Ensuring the birds feel secure by the provision, if need be, of screens between pens containing antagonistic con-specifics;
- Providing cover within pens in which the birds can shelter;
- Ensuring the pens can be effectively cleaned;
- Ensuring drainage is adequate;
- Ensuring internal structures are without sharp surfaces and pointed edges;
- Ensuring that rodents cannot gain access to the aviaries.

A Construction Management Plan for construction of the aviaries was developed in 2013 and will be updated to consider the expansion required for the REP. The 2013 Construction Management Plan is attached as part of Appendix C – Captive Management Package.

Captive Husbandry and Disease Management

At the commencement of the captive period each bird will be examined by a veterinarian from Taronga Zoo who is experienced in avian medicine. The initial health status of individual birds will be determined by detailed physical examination. Measurements such as body weight, an assessment of endoparasitic burden, and faecal examination for intestinal parasites will be taken. While in captivity on LHI, the birds will be under the care and authority of Taronga Zoo. A team of aviculturists will be employed to manage the holding facility for the period that the birds are held.

During the captive period the birds' behaviour and food intake will be monitored daily by experienced keepers and body weight will be monitored regularly. Parasite loads will be monitored by faecal examination.

At the end of the captive period each bird will undergo another physical examination by a veterinarian to ensure that it is fit for release.

Previous health assessments conducted on the Lord Howe Woodhen and other avian species on the island have not identified infectious diseases causing illness (Curran, 2007). During the 2013 husbandry trial, 20 Woodhen and 10 Currawong underwent detailed physical examination to assess their health on arrival into care and on release. Birds were continuously monitored for signs of disease and for endoparasite loads. Low levels of coccidia were identified in the Woodhen. This parasite has potential to cause disease in other ground dwelling birds, if allowed to build to high levels, but was successfully controlled at very low levels through precautionary treatment. No signs of disease were noted in any Woodhen during the trial. Intermittent upper respiratory noise was heard in two Currawong. No disease cause was identified and all the birds were considered healthy at the time of release. No intestinal parasites of concern were identified in the currawong

The most likely disease or injury scenarios that may arise in the captive trial period include trauma due to con-specific aggression, parasitism especially coccidiosis, and outbreak of stress induced disease due to opportunistic environmental organisms such as salmonellosis and aspergillosis.

Facilities will be available for isolation of sick birds. Basic veterinary diagnostic investigation of any ill birds will be undertaken on the island while samples for more detailed diagnostic testing including histopathology and more complex haematology and serum biochemistry will be sent to Taronga Zoo for processing

The capture or housing of birds can result in the injury or death to individuals. Measures taken to reduce the likelihood of injury or death to birds in the program are:

- Experienced staff will be involved in the capture of both species
- A bird-specialist veterinarian will be on site during capture and release operations
- Experienced aviculturists from Taronga Zoo have designed the holding facilities to be sited on LHI
- Experienced aviculturists from Taronga Zoo will manage and care for birds through their period in temporary captivity
- Advice on captive management has been sought from, and will continue to be refined with, specialist aviculturists. Central to this process has been the examination of the successful captive-breeding programme for woodhen undertaken on LHI in the 1980s, the 2013 pilot study, as well as captive trials undertaken in New Zealand with Weka (a species similar to the Woodhen)
- Exclusion of rodents from the facility

- If the holding facilities are found to be inadequate after birds have been taken, attempts will be made to rectify any problems. As a last resort, should the welfare of the birds be at serious risk, the birds can be released back into the wild until deficiencies in the procedure are rectified.

Notwithstanding these precautions, a very small number of birds are likely to die in captivity due to natural mortality (e.g., due to old age) because birds captured for the trial will reflect the age structure and general health of birds on LHI.

Mainland Populations

In discussions with Taronga Zoo (and other zoos), the REP Steering Committee, LHIB Manager Environment /World Heritage and the OEH Science Manager, the risks and benefits of mainland insurance populations for woodhens and currawongs as part of the REP have been extensively considered.

In addition to captive management on LHI during the REP, options considered for insurance populations, addressing the risks for both species included:

- temporary mainland populations for the relevant holding periods of the two species during implementation of the REP
- permanent mainland populations starting during implementation of the REP
- maintaining all birds on Lord Howe Island for the relevant holding periods of the two species, during implementation of the REP with appropriate contingency measures to address potential risks such as disease, fire and natural weather events.

Off island captive management of Currawongs was considered unnecessary given it is considered very unlikely that all free ranging currawong would succumb to secondary poisoning (see section 5.2.3).

Options considered for wooden are summarized below in Table 2. Risk assessment of the events requiring mitigation for an on island only captive population is provided in Table 3.

Following an assessment of the risks, proposed mitigation strategies and emergency procedures and anticipated likelihood of these events occurring, the REP Steering Committee agreed that the option to maintain on island populations only was the preferred approach.

Whilst an off island population provides better risk management, we feel the risks posed by having only an island captive population of both species can be sufficiently managed and are acceptable through development of comprehensive captive management plans including a contingency plan to remove a portion of the on island population to safety on island (or even to the mainland) at very short notice if required.

Table 2 Woodhen Insurance Population Options Summary

	Benefits	Constraints	Recommendation
Permanent Mainland Population (Breeding)	Provides short term (REP) and long term insurance population for conservation of the species	Requires significant investment, planning, infrastructure, establishment of partnerships, consultation on display and potential exhibits, ownership, husbandry training, development of long term management plans and breeding programs Will permanently remove approximately 10-15% of the population from the wild and requires ongoing supply of woodhen from LHI to maintain genetic robustness of captive population	Whilst this option is considered the best option for long term conservation of the species, it is considered well beyond the scope and resources of the REP. The LHIB to continue to pursue this option separate to the REP.
Temporary Mainland Populations	Provides short term insurance population for the REP Birds can be returned to LHI on completion of the REP (provided disease risks are manageable)	Does not provide long term insurance population for conservation of the species Still requires substantial investment, planning, infrastructure, establishment husbandry training	Requires significant increase in planning and investment than an on island only option without similar increase in mitigation of risks
On Island Population (with contingency plan)	Provides acceptable mitigation of identified risks during the REP Birds can be released to wild on completion of the REP Investment and planning more commensurate with REP project size and scale	Does not provide long term insurance population for conservation of the species Provides a lower level of protection than the other options	Recommended as preferred option for the REP

Table 3 Risk Assessment of On Island Only Woodhen Population Option

Event	Event Comments	Consequence	Likelihood	Unmitigated Risk	Proposed Mitigation	Mitigated Likelihood	Residual Risk
Disease	No known disease in the LHI woodhen from previous testing	All these events could potentially result in loss of entire captive management population on LHI in a worst case scenario leading to possible extinction of a species and are therefore considered as Major consequence	Unlikely	Medium	Disease management procedures Trained staff form Taronga Zoo	Rare	Medium
Fire	Only 3 bushfire events in 20 years Bushfires considered unlikely in LHIB EMP Settlement area considered medium fire risk but rainforest with low vulnerability and low fuel load surrounding the facility Winter highest rainfall period		Possible	High	LHIB emergency procedures Rural Fire Service situated within 2 minutes of aviaries Fire fighting equipment on site Safe house contingency	Unlikely	Medium
Cyclone	No known cyclone events on LHI during winter period. Unlikely during winter.		Unlikely	Medium	Weather monitoring LHIB emergency procedures Safe house contingency	Rare	Medium
Severe Storm	Winter is highest wind period.		Likely	High	Maintenance pruning around facility Weather monitoring LHIB emergency procedures Safe house contingency	Unlikely	Medium
Tsunami	Unknown for LHI given surrounding deep water. Considered unlikely. Captive management facility is >10m above sea level and is considered safe		Unlikely	Medium	Weather monitoring LHIB emergency procedures Safe house contingency	Rare	Medium

Risk Assessment Matrix					
Likelihood Rating	Consequence Rating				
	Severe	Major	Moderate	Minor	Negligible
Almost Certain	Very High	Very High	High	Medium	Low
Likely	Very High	High	Medium	Medium	Low
Possible	High	High	Medium	Medium	Low
Unlikely	High	Medium	Medium	Low	Low
Rare	High	Medium	Low	Low	Low

2.2.1.3 Bait Application

The method chosen for the LHI REP is to eradicate rats and mice by distribution of the toxin Brodifacoum at a concentration of 20 ppm in the cereal based product Pestoff 20R. Justification for this methodology, toxin and bait is provided in Section 2.9.

Baiting Protocol

The bait will be distributed at a nominal dose rate of 20 kg (12kg first application + 8kg second application of bait (or 0.4 g of poison) per hectare on average over the island. At this rate, a maximum of 42 tonnes of bait (containing 840 g of Brodifacoum) will be required to cover the total island group surface area of 2,100 ha. Bait will be distributed by a combination of aerial and hand broadcast and through the use of bait stations/trays.

Area to be baited

Rats and mice occur throughout LHI, including the settlement. LHI is the only island in the LHIG that is known to contain rodents. However, ship rats are able to swim over 500 m and both rats and mice are difficult to detect at low densities. It is therefore possible that either species may occur on offshore islands and islets close to the main island or may invade those islands prior to the implementation of the operation. To minimise the risks of operational failure, the main island and all nearby islands and islets, other than Balls Pyramid and its associated islets, will be baited. The 23 km distance between Balls Pyramid and the main island renders the chances of invasion by rodents very low.

Number of bait drops

The proposal is for aerial and hand baiting to be carried out twice only, the applications separated by about 14-21 days (depending on the weather) although the number of applications in and around dwellings may be more as it is dependent on the rate of removal by rodents of distributed baits. This will maximise the exposure of rodents to the bait. The proposed application rate for the first bait drop is 12 kg of bait per hectare, and 8 kg per hectare for the second drop. These application rates relate to the actual surface area of the islands. Most rodents will be killed by bait from the first bait drop. However, it is beneficial to carry out a second bait drop to eliminate the likelihood of any gaps in the distribution of baits, ensure bait is available long enough to ensure that all individuals receive a lethal dose and to target:

- individuals that may have been denied access to bait distributed in the first application (by more dominant individuals that will now be dead), and
- any surviving young that have recently emerged from the nest.

Timing

The operation is programmed to take place in winter 2018 (June-August), when the availability of natural food for rodents is low, rodent breeding is greatly reduced or absent and the rodent populations are likely to be at their seasonal lowest. This is also a period when most non-target seabirds are absent from the LHIG. Bait drops will be timed to avoid periods of predicted heavy rainfall (as this may prematurely dissolve the bait) and cannot take place in high winds or in the presence of low cloud. Therefore weather will influence the actual timing of the two bait drops. Weather forecasts of rainfall and wind speeds will be obtained from the Bureau of Meteorology station on LHI from June onwards. A forecast of less than 15 knots and four fine days (three fine nights) without significant rainfall (less than 6 mm daily) is preferred for each drop but the decision to apply bait will be taken by the operations manager at the time when all relevant factors are known.

Given the possibly limited operational window, approval is sought for at least a two year period to account for unforeseen delays beyond winter 2018, however the operation would only occur once during that period.

Aerial baiting

Aerial baiting will be conducted throughout the LHI PPP and other areas of the main island excluding the settlement area and identified buffer zones. In all areas baited aerially, 10 mm baits (approximately 2 g each) will be broadcast at a density of 12 kg/ha (one bait every two square metres) for the first drop and 8kg/ha for the second drop on average over the island.

The bait will be dispersed using a purpose built spreader bucket (see Figure 10) slung below a helicopter. A rotating disc typically throws the bait 360º to 35 m (note outlier pellets may be thrown to 45 m); enabling a swathe of up to 70 m to be baited in a single pass.

Overlapping (50%) each swathe will ensure that there are no gaps in the distribution of baits (see Figure 11). Application rates out of the bucket are calculated to account for the 50% overlap (i.e. for the first drop 6 kg/ha on each swathe with 50% overlap will be applied to achieve a 12kg/ha application rate on the ground). Each bait drop will take approximately two days to complete dependant on weather.

Figure 10 Custom built spreader bucket being prepared and in use on LHI during 2007 trials.

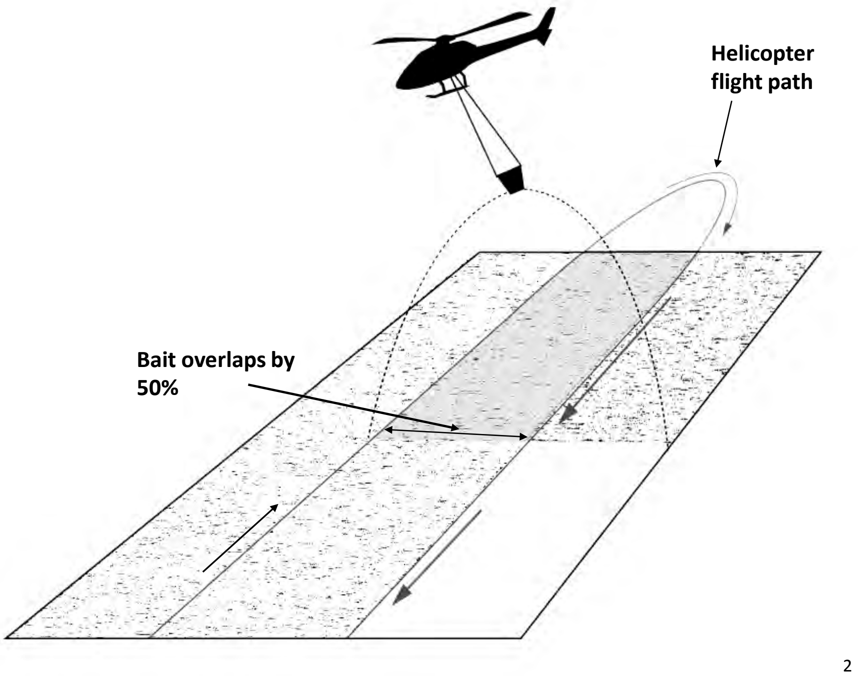


Figure 11 Aerial Application Method

In order to achieve the required baiting density on the cliffs and steep slopes (particularly around Mt Gower and Mt Lidgbird) several horizontal flight lines will be flown at approximately 50 m vertical spacing along these areas to ensure adequate bait coverage. Baiting around the coast line will occur above the mean high water mark to minimise bait entry into the marine environment. A deflector arm can be attached to the spreader bucket to restrict the arc of the swathe to 180° and will be used particularly when baiting the edge of buffer zones and to minimise bait entry into the marine environment when baiting coastal areas including cliffs. The sowing rate, bait direction and swathe width can all be controlled within set limits and will be adjusted as required for specific requirements for different types of flight lines (inland, coastal or buffer zone). Other aerial dispersal options include the idling or turning off of the spinning motor on the spreader bucket which will result in bait trickling vertically below the helicopter for narrow areas if required. The combination of techniques will enable all terrains on the LHIG to be effectively baited. The exact methodology of distributing bait aerially on LHI will be finalised in consultation with the helicopter contractors.

Buffer zones for aerial application to individual properties will be agreed with the relevant occupiers and in accordance with relevant regulations and considering outliers from the bait swath. The LHIB has committed that this would be no closer than 30 m to dwellings, by agreement or if agreement to the contrary is not reached, then the buffer zone will be 150 m. In these buffer zones bait will be applied by hand, or in bait stations. This will be covered in a Property Management Plan for each property. 30 m buffer zones will also be established around containment areas for the dairy herd.

GPS will be used to guide the helicopter along a set of pre-determined flight lines designed to ensure that all areas are adequately baited. Computer-generated plots of the actual path flown will be inspected at predetermined times during and at the completion of the flight to confirm that this has been done. Any identified gaps will be treated. Flight-path height will be set at an altitude that ensures effective and safe baiting. It will be determined in discussion with the baiting operator, and take into account topography, weather conditions, aircraft safety and the need to avoid significant disturbance to roosting birds.

This baiting methodology is similar to (and is based on) established techniques for other island pest eradications undertaken worldwide. In Australia this technique has been used on islands such as Montague (2007) and Broughton (2009) islands in New South Wales and Hermite Island (1996) in Western Australia. It was also used on World Heritage listed Macquarie Island in Tasmania over autumn and winter 2011.

The aerial baiting technique has been trialled on LHI with non-toxic bait and a custom built spreader bucket (DECCa, 2007). The trials have shown aerial baiting to be an effective technique that could be utilised in an operation on Lord Howe Island. The trial report is included in Appendix D – LHI Trials Package. The trial provided an opportunity to establish the correct flight configuration: air speed and settings to produce the required flow rate to achieve the on ground density of bait during operations. Methodologies for loading procedures, and determination of bait usage on flight runs were developed for use in future baiting operations.

Further detailed calibration of the equipment with non-toxic baits (i.e. helicopter, spreader bucket, GPS equipment etc.) will be undertaken immediately prior to the operation as part of an operational readiness check overseen by an international eradication expert most likely from the New Zealand Department of Conservation’s Island Eradication Advisory Group.

Hand broadcasting of bait

Hand broadcasting of bait will be conducted concurrently with aerial baiting. It will be undertaken throughout the settlement area where agreed by residents under individual Property Management Plans and in buffer and exclusion zones (i.e. the lagoon foreshore and Ned’s Beach). In the settlement area, either 10mm (2 g each) or 5.5 mm Pestoff baits (0.6 g each) will be hand-broadcast at a density of 12 kg/ha (one bait every two square metres for the 10mm pellet or one bait every half square metre for the 5.5 mm pellet on average) for the first application of bait and at 8 kg/ha for the second application.

Provisional areas to be hand-baited are subject to completion of individual Property Management Plans and collation into a revised operational plan.

Trained personnel will move through such areas and apply bait at the designated rate. All personnel will carry a GPS unit capable of continuously tracking their path. Computer-generated plots of their paths will be used to check baiting coverage. The aim will be to distribute baits in garden beds and other areas of vegetation around dwellings, rather than broadcast on lawns. These details will be contained in the individual property management plans which will be established between property occupiers and the LHIB.

It is essential that all hand-broadcast bait be out in the open so it is subject to degradation by weathering. No bait will be hand-broadcast directly in or under buildings where it will not be subject to weathering.

Bait stations

Commercially available or specifically designed bait stations (see Figure 12) will be used where aerial or hand broadcasting cannot be undertaken. Bait stations will also be placed within all areas containing livestock (i.e. dairy herd, horses and goats). The bait stations used in livestock areas will be designed specifically to be able to withstand interference and trampling by stock. Where practicable, and with the agreement of householders, small amounts of bait in open containers (‘bait trays') similar to commercial products currently available, will be placed within buildings including kitchens, pantries, pet food storage areas etc. Where possible, bait trays will also be put in accessible roof spaces and under-floor cavities.

Note: there is a potential for currently registered Brodifacoum products to be used in accordance with label conditions by residents in some dwellings. This will be considered on a case by case basis assessing higher palatability of pellets vs. higher dosage, quality control and resident acceptability. However, a major drawback in using commercially available baits is that these baits contain bitrex which is a bitter-tasting compound and is meant to deter children and pets from eating the bait; there is some evidence that some rodents will avoid baits with bitrex.

All bait trays and bait stations will be monitored regularly and bait replenished as necessary for approximately 100 days after the second baiting (this could be longer if surviving rats or mice are detected). Bait uptake will provide an indication of rodent activity, along with other detection techniques such as detector dogs, chew blocks and tracking tunnels. Bait in these locations will not be exposed to weathering, and so any remaining bait will be removed once project staff are confident all rodents have been eradicated from the island.

When using bait stations or trays it is important that they are set close enough together that individual rats and mice encounter at least one station during their nightly movements. Rats are wide-ranging and can be eradicated using a grid spacing of 25 m -50 m. Mice, however, are not as wide-ranging, and require a grid spacing as close as 10 m.

It is expected that the combination of hand broadcasting and setting and arming of bait stations will take approximately 5 days each application (coinciding with the aerial application) dependant on results of the property management plan process and actual staff numbers.

Indicative areas to be treated using the three methods above are shown in Figure 13 and Figure 14.

Custom made bait stations (currently in use)	Commercial bait stations

Figure 12 Bait Station Examples

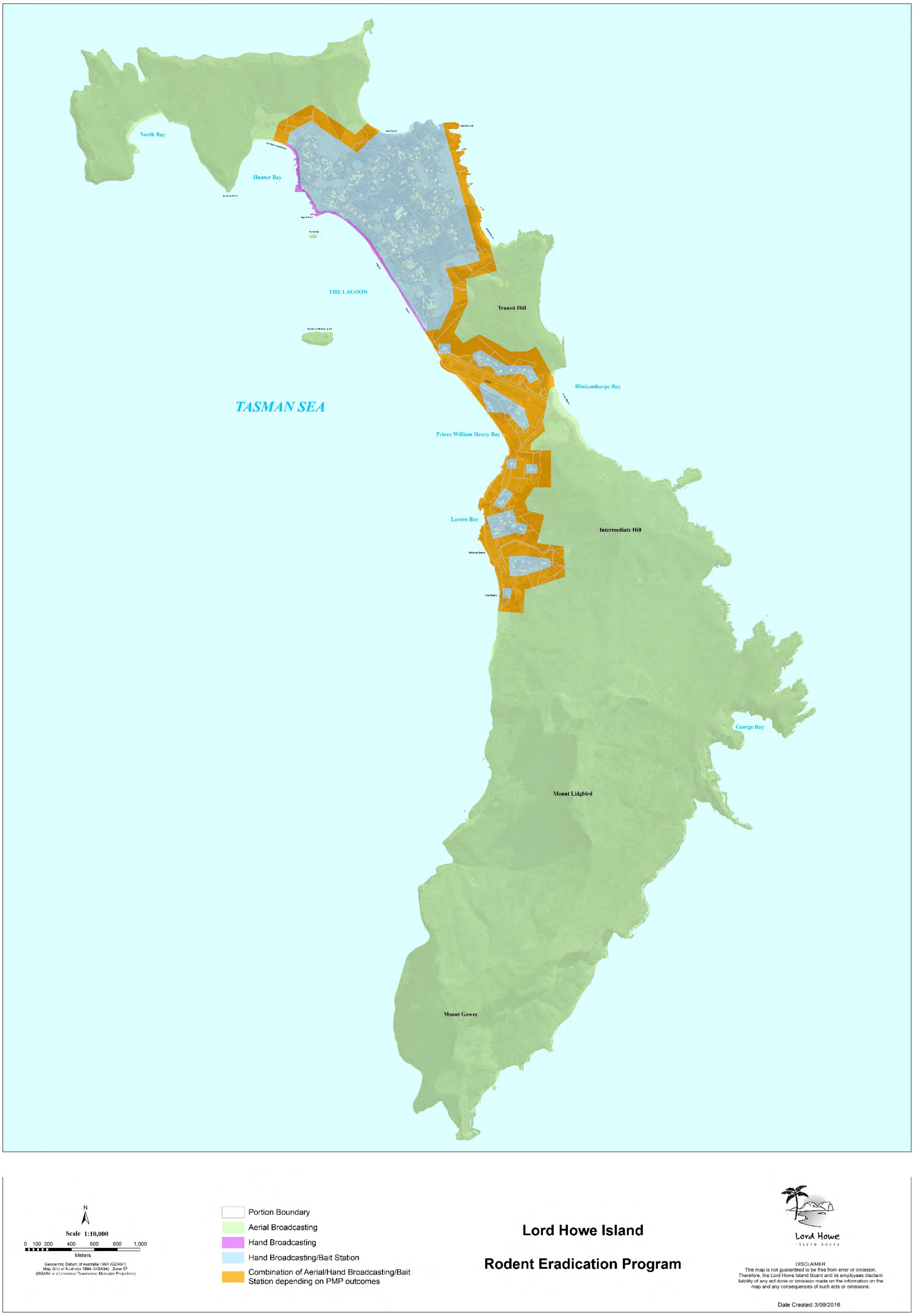


Figure 13 Indicative Treatment Areas by Method

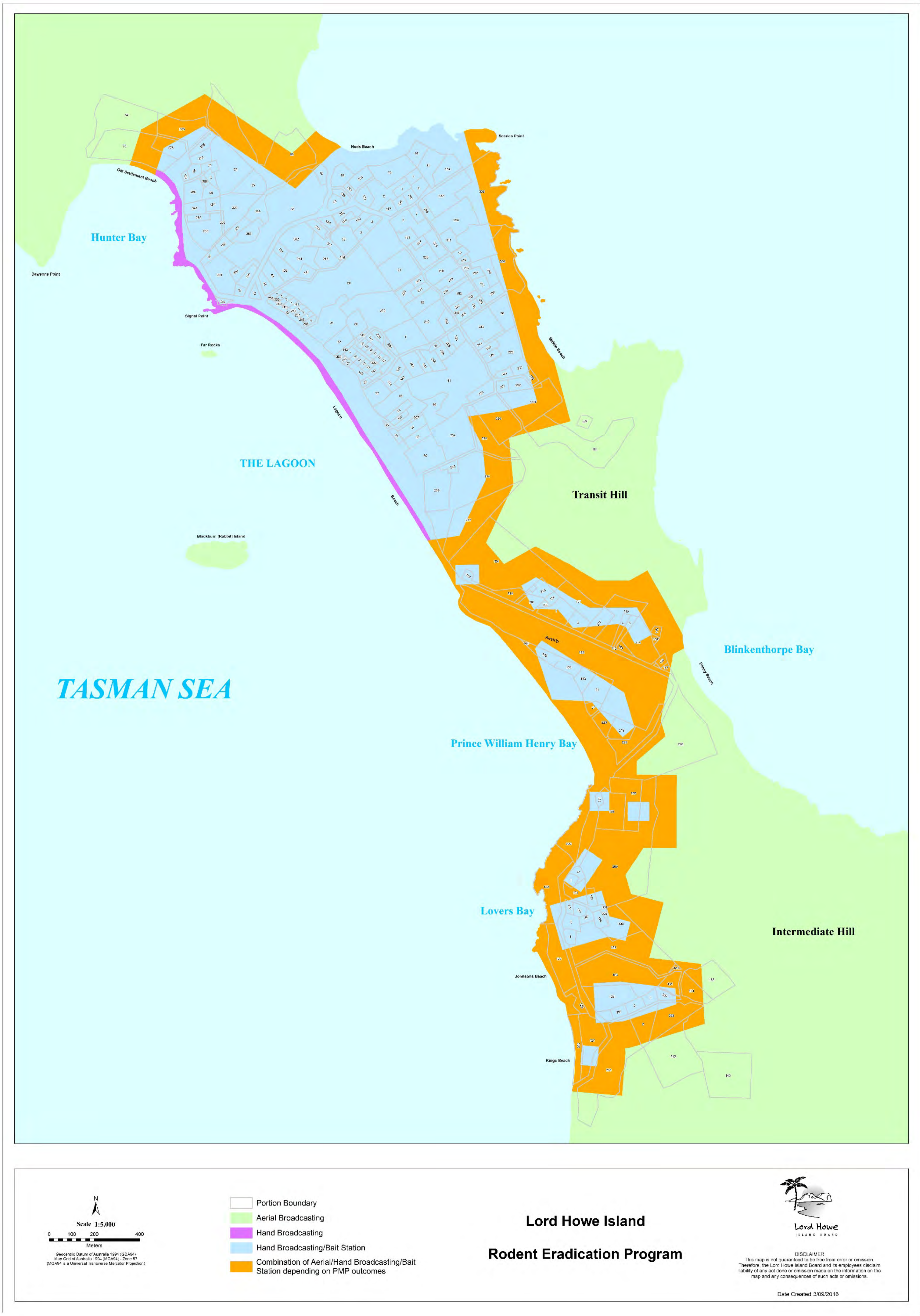


Figure 14 Indicative Treatment Areas by Method - Settlement Area detail

Property Management Plans

The LHIB has been consulting with all property owners and residents on the island to develop individual Property Management Plans (PMPs) as part of the REP. The PMPs include the agreed baiting methods for each lease on the Island, including the settlement area. This can include the desired combination of hand broadcast and bait stations on individual properties and if properties are on the edge of the settlement area, the appropriate buffer distances for aerial distribution.

The PMPs are confidentially discussed and negotiated with the leaseholders / residents individually and consider mitigation of specific risks and areas of concern on individual properties and in accordance with any regulatory approvals or conditions received. The PMPs will only need to be signed once all government approvals have been received and the final decision to proceed with the eradication project has been made by the LHIB. The PMPs will not impact on the tenure of the leases.

Product storage

At the manufacturing plant in New Zealand, the bait will be packaged into 25 kg bags and loaded in approximately 1 tonne weatherproof bait pods for transport by ship to mainland Australia. After customs and quarantine clearance in Australia, the bait will be shipped to LHI. On arrival on LHI, bait will continue to be stored in the weatherproof bait pods in a secured premise most likely at the LHI Airport.

Product Disposal

A limited amount of contingency bait will be purchased as part of the order in case of physical damage including weathering or bait loss so it is anticipated that there will be bait remaining at the end of the operation.

Unused Pestoff 20R is likely to be retained in case it is needed for follow up or incursion response. It may also be transported back to the mainland for sale to other similar projects or for disposal at an appropriately licensed facility. Unusable spillage will be collected and transported to the mainland for disposal. Emptied Pestoff bags may be disposed of in a similar manner as discarded bait pellets or they may be incinerated on LHI in accordance with all legal requirements.

Rodent and non-target carcasses will be collected wherever possible by ground staff during and immediately after the operation, particularly in the settlement area, however due to the large size of the island and rugged and inaccessible terrain this will not be possible across most of the island. It is proposed that carcasses collected will be buried, incinerated on island or transported back to the mainland for disposal at an appropriately licensed facility.

Accidental Release

In the event of a spill, the area will be isolated and all practicable steps taken to manage any harmful effects of the spillage including preventing baits from, as far as practical, entering streams or waterways. Spilled baits will be collected and put into secure containers. Fine material will be swept up and placed into bags for disposal as above.

2.2.1.4 Environmental and Impact Monitoring

An extensive environmental monitoring program will be conducted during and after the REP. This includes

- Monitoring of weather in the lead up to and during the REP.
- Monitoring breakdown of baits after distribution. Bait breakdown will be monitored at random sites using the Craddock Condition Index described below in Section 2.7 at approximately 30 day intervals until complete disintegration.
- Soil monitoring after distribution. Post operational soil samples will be collected to monitor residues of Brodifacoum in the soil. Representative samples will be collected from directly below some toxic bait and at control sites away from bait pellets. Soil samples will be collected approximately 30 days after bait disintegration and approximately every two months (if required, dependant on results). All tests will be conducted at a NATA accredited analytical laboratory.
- Random sampling will be conducted on water bodies (both freshwater and estuary inlets) on the island to monitor Brodifacoum levels after the bait drop. Water samples will be collected within 2 days of each bait drop and approximately weekly (if required, dependant on results). All tests will be conducted at a NATA accredited analytical laboratory. Rain water tanks and groundwater bores will be sampled if requested by residents.
- Monitoring for sick and dead non-target species. All individuals will be treated with Vitamin K where possible. Carcasses of rodents and non-target species will be collected if found, however previous studies have shown that the vast majority of rodents that are poisoned die in burrows underground (Vercauteren et

al.2002). Some analysis of non-target carcasses will be considered where poisoning is considered a likely cause.

- Analysis of milk samples pre and post baiting.

Full details of the monitoring program are provided in the Non-target Species Mitigation Plan in Appendix E – Non-target Impact Management Plan.

2.2.1.5 Masked Owl Eradication

As a result of the proposed rodent eradication, there is also an opportunity to concurrently eradicate the Masked Owl, which was introduced to LHI (along with 5 other Australian and North American owl species) to controls rats in the 1920s and 1930s. The Masked Owl on LHI were until recently believed to be the Tasmanian race *(Tyto novaehollandiae castanops),* however genetic testing has found significant divergence of the LHI population with *T. n. castanops,* suggesting hybridisation with the Mainland race *(Tyto novaehollandiae novaehollandiae) (*Hogan *et al.* 2013). This hybridisation and loss of genetic integrity would exclude translocation of the LHI Masked Owl to Tasmania or NSW.

A recent study (Milledge, 2010) has shown that rodents currently form the Masked Owl’s main prey on the Island, supplemented by occasional predation on other native birds. During the rodent eradication it is expected that most owls are likely to succumb to secondary Brodifacoum poisoning by ingestion of poisoned rodents. To avoid any remaining owls switching to a diet of solely native species in the absence of rodents, it is proposed to eradicate remaining owls via hunting or trapping before, during and after the baiting proposal.

Details of the various components of the Masked Owl eradication are provided below.

Pre- and Post-REP Population Estimates

Pre-REP surveys will be performed to estimate the current distribution and size of the owl population and to provide a measure of the number of owls, general location of roost sites and key areas that will be required to be targeted in the subsequent shooting programme. Simultaneous point triangulation surveys (point surveys) will follow the methods performed previously by Milledge (2010). Briefly, locations of point surveys will be selected to cover the slopes of the southern mountains and the northern hills of the island. The aim of the point surveys will be to provide a measure of owl density in two important areas of habitat. Measures of owl density will be then be extrapolated to the remainder of the island to inform an overall estimate of population size. The survey method will comprise a 45 minute listening period from dusk (with an agreed start time prior to the survey) followed by playback of a recorded sequence of owl calls and then a 5 minute listening period. The playback sequence will then be repeated, followed by a further 5 min period of listening. Prior to the REP, the simultaneous point surveys will be performed every three months until baiting occurs, with the first survey to be performed as soon as is practicable. Surveys will then continue to be performed once every three months for two years in line with the post-eradication rodent monitoring.

Acoustic Monitoring

Remote acoustic monitoring devices will be used to constantly monitor owl calls in remote areas of the island. The deployment and recovery of three units in selected locations throughout 2017 can inform both the population monitoring and eradication effort. Acoustic monitoring devices would be rotated throughout the island on a monthly basis (for recovery of recordings and refreshing of power source). The recovery of information from the recordings can either be through intensive replaying or the application of call-recognition software.

Timing and Personnel

A total of sixteen people will be required to perform point surveys at eight locations across the island. Each team of two will have at least one person who is familiar with the triangulation survey method, call playback technique and the calls of the Masked Owl. Volunteers from within the Lord Howe community will be sought to perform these surveys where possible but people from off the island may also be involved.

Trapping with goshawk-type traps using live rats as bait will not be possible once the REP commences, as using live rats cannot be risked due to the possibility of their escape. However live trapping may need to be employed as an alternative to shooting post-REP, for example where a particular owl has become too wary to be lured in by call playback or where an owl has been detected in an area of terrain too difficult to allow shooting. In these cases alternative live baits such as guinea pigs or young chickens may be considered.

Masked Owl Eradication Methods

Secondary Poisoning and Trapping Programme

There is the potential for a number of owls to succumb to secondary poisoning during the REP as a result of preying on rodents that have consumed Brodifacoum. However, it cannot be presumed that all owls will die in this manner; poisoned rodents may be unavailable in some areas, and because rodenticides are currently used on Lord Howe Island to control rats and mice, prolonged exposure to poisons may have allowed the owls to evolve some tolerance. Milledge (2010) had only limited success trapping owls using drop-nets (Dho-Gaza net). Therefore, trials will be performed prior to the eradication programme to explore the suitability of ‘goshawk-type traps', which will need to be set after dark and closed prior to dawn to avoid the capture of non-target species such as currawongs. All owls caught during this trial will be destroyed.

Timing and personnel

Trapping of owls for removal (if shown to be an effective method) will continue from three months before and for up to three months after the REP or longer if necessary until all owls not eliminated by shooting have been removed. Owls will be trapped with goshawk-type traps in two teams of two people.

Trapping with goshawk-type traps using live rats as bait will not be possible once the REP commences, as using live rats cannot be risked due to the possibility of their escape. However live trapping may need to be employed as an alternative to shooting post-REP, for example where a particular owl has become too wary to be lured in by call playback or where an owl has been detected in an area of terrain too difficult to allow shooting. In these cases alternative live baits such as guinea pigs or young chickens may be used.

Shooting programme

The proposed method of removing owls that are not eliminated through secondary poisoning and trapping is through a systematic shooting programme. Because it is inevitable that owls will begin preying on native fauna once rats and mice are removed, it is intended that the shooting programme begins as soon as possible after the REP begins without compromising the trapping programme.

Locations across the island will be chosen to provide clear vantage points and suitable overhead perches to enable the shooting of owls. Call playback will be used at these stations to attract owls, at which time they will be shot by experienced, qualified shooters who will be engaged to perform the shooting component. All shooters will be appropriately licensed in accordance with any New South Wales and Lord Howe Island Board requirements. The shooting programme (locations and expected number of owls to be targeted) will be informed by the pre-REP point surveys and acoustic monitoring results.

The shooting programme will cover all accessible habitat across the island. However, the first priority should be to target areas that will be difficult for shooters to access on foot. It is proposed that the helicopter(s) used for spreading bait be used to transport shooters to these inaccessible areas either, during the period between the first and second bait drops, or immediately after the second bait drop. It should be noted that the rodent eradication should be prioritised for helicopter use. When being transported to remote areas by helicopter during the day, shooters will carry adequate equipment to enable them to stay overnight as it will be unlikely that they can be picked up that night and inclement weather or other factors may also delay the return of the helicopter.

Timing and personnel

The shooting schedule will be informed by the population surveys and acoustic monitoring and it is proposed that two teams comprising two persons will perform shooting operations. Shooting in remote areas will begin as soon as is practicable after the first bait drop. The duration and timing of these forays will be dictated by weather and helicopter availability. Shooting forays in areas accessible by foot will also begin soon after the first bait drop once owls have had an opportunity to consume poisoned rodents. These forays will be performed at a frequency of three hours per night three nights per week. Shooting forays may need to continue at this frequency for six months after the REP and should include the period when owls are most responsive to calls (winter and spring, Milledge 2010)). After six months it should be possible to make an assessment of the necessity to continue at the same frequency or reduce either the number of shooting parties or the number of forays. The shooting schedule will be flexible throughout, however, to allow for breaks if, for example, owls become unresponsive to call-play back; previous culling programme found that, following a break, owls responded better to calls.

Firearms

Two firearms with different capabilities will be used in the shooting programme; likely a 12-guage shotgun for close range and a .17 HMR rifle for longer range shots. Longer-range capabilities will be required for occasions when owls do not closely approach the call play-back station. All necessary licensing and shooting operations will be overseen by the LHIB Firearms Officer.

Translocation

As indicated above, genetic analysis has found that the ancestry of Lord Howe Island Masked Owls indicates a mixture of Tasmanian and mainland Australian Masked Owl individuals (Hogan *et al.* 2013). These owls are thus unsuitable for translocation into wild populations elsewhere in the species' range. Nevertheless, the owls are valued by some members of the Lord Howe Island community and the opportunity to transport some individuals to zoos or wildlife parks to maintain captive populations may be explored. Taronga and Melbourne zoos have been approached but these organisations are not able to accept live owls. However, other organisations, such as smaller zoos could be approached to investigate the potential for some owls to be relocated.

A more detailed plan for the eradication of Masked Owls and supporting studies is attached to this PER (in Appendix F – Masked Owl Package).

2.2.1.6 Rodent Detection Monitoring

Following an eradication attempt it is necessary to confirm the success of the operation and to prevent reinvasion. The level of confidence in determining whether an eradication was successful or not, and detecting new invasions is dependent on the type and density of detection devices, duration of deployment, along with the density of rodents present.

Traditional approaches (particularly for aerial eradications) for declaring success have been to wait until at least two rodent breeding seasons (i.e. two years) have passed before undertaking monitoring (Russell and Broome al, 2016). This period allows rodent densities to build up to detectable levels in the event that the operation failed. If no surviving rodents are found after at least two breeding seasons (roughly two years), then the eradication is declared a success. This traditional approach has potential downfalls in that it does not facilitate rapid response to early detection of survivors, and thus obligates repeating the eradication from scratch. An alternative “Rapid Eradication Assessment” approach is to monitor the island at some fixed time soon after the eradication and quantitatively estimate, whether the eradication was successful or not through a spatial-survey model (Samaniego-Herrera et al., 2013). This approach facilitates the early detection and removal of localised survivors in comparison to a complete repeat of the eradication operation. Additionally, if confidence in eradication success is determined earlier, restoration plans can be implemented before the traditional two year mark (Russell and Broome al, 2016).

The differences in scale and topography on LHI for areas treated by aerial application compared to the areas treated by ground based methods (i.e. hand broadcast or bait stations), present an opportunity to implement a combination of the above methods to maximise any chances to remedy a possible failure and increase confidence in eradication success. Therefore rodent detection monitoring will be undertaken in different areas at different scales and intensities on LHI. Monitoring in the following phases is described in more detail below.

- Initial follow up monitoring
- Monitoring to declare eradication success
- Ongoing monitoring for detection of reinvasion from rodents

A range of tools are available for trying to detect rodents at low density however they all have their limitations so in order to maximise the chances of detecting any survivors it is desirable to use a mixture of techniques. Details of these tools are provided further below.

On site trials need to be undertaken to test the local effectiveness and suitability of the various proposed techniques for Lord Howe, particularly the interaction of non-target species with the devices but also the effectiveness of the devices with detecting the target species i.e. rats and mice preferably at low density. Full details of the suite of tools to be used on LHI are yet to be finalised, as is the development of a detailed rodent monitoring plan.

Initial Follow up Monitoring

Due to the scale and topography of most of the areas on LHI that are to be treated by aerial broadcast, it is not realistic to try and detect with a sufficient degree of confidence any rodents surviving the eradication in those areas immediately after eradication. A failure in areas treated aerially means that there has been some failure in planning or implementation, and the ability to undertake any meaningful immediate response if survivors were detected in those areas is limited. Therefore very limited monitoring will be undertaken immediately after the eradication (restricted to some easily accessible areas) in areas treated aerially. This will be best achieved after several breeding seasons have passed allowing potentially surviving rodents to build up to detectable numbers.

However, the area around the settlement does offer an opportunity to undertake a high standard of rodent monitoring and to respond promptly to any survivors detected. This is due to the logistical feasibility of the area i.e. size, topography and access. Importantly, this area warrants the extra attention as it has the highest likelihood of failure given it will be treated by a combination of ground methods.

Russell *et al.* (2016) have tested a statistical model developed for the Rapid Eradication Assessment approach by Samaniego-Herrera *et al.* (2013) for assessing the probability of detecting surviving rodents and their offspring, using a grid of detection devices to predict eradication success. They found that spacing of detection devices and number of monitoring nights provided the best predictors for eradication success.

Preliminary modelling for LHI undertaken by Samaniego-Herrera and McClelland (2016) using the Rapid Eradication Assessment approach has suggested that a detection device network grid spacing of 30 m x 30m in the settlement area immediately after eradication would produce a median Confidence Interval of 100% (lower CI 99.1% and upper CI 100%) of detection when monitored for at least 30 nights.

Based on the modelling, the settlement area and other easily accessible areas of LHI will be monitored intensively for the presence of rodents throughout the 100-day period of the baiting operation (at least 30 days commencing 3-4 weeks after the second bait drop). Focus will be applied to areas that may have had restricted bait stations, and where techniques have overlapped (bait station and hand broadcast or hand broadcast and aerial). Detection of surviving rodents will be assessed by a combination of detection tools described below. All detection devices will be checked frequently – at least every second day and preferably daily, so that a targeted response can rapidly be undertaken, i.e. to maximise the likelihood of any rodents that is detected being in the same area so that it can be targeted with the preferred technique –traps or toxicants. Residents will also be asked to report any evidence of rodent activity to the project team. In addition, trained detector dogs and handlers will be deployed throughout the settlement area approximately 3-4 weeks after the eradication to search for signs of and locate any surviving rodents.

This approach will give a high level of confidence that eradication success has been achieved for the settlement area.

Declaring Eradication Success

During the period immediately following the eradication and in the lead up to declaring eradication success, the monitoring network implemented above will be adjusted in the following ways.

- The network within the settlement area will most likely be maintained but checked at reduced frequency potentially weekly or fortnightly.
- The network will be expanded to include accessible areas of the island. Additional modelling will be undertaken to confirm network spacing and trap nights required.
- The permanent rodent detector / biosecurity dog based on the island will sporadically undertake targeted searches of high risk areas.
- The declaration will be preceded with a thorough search using an additional contract team of rodent detector dogs and handlers to search all accessible areas of the island for rodents.

This methodology will give a high level of confidence to allow declaration of eradication success which will be declared after two years of monitoring with no rodent activity.

Ongoing Rodent Detection Monitoring

The eradication investment will be protected through ongoing rodent detection monitoring on the island aimed at detecting any possible reintroductions. This will form part of the island's permanent rodent detection and prevention system initiated as an integral part of the island's Biosecurity program which will be upgraded in parallel with the REP. The monitoring network developed for the initial follow-up monitoring and declaration of success will be modified to allow targeted monitoring of high risk reinvasion points. It will include:

- A grid network of detection tools at high risk reinvasion points such as the wharf and airport and potential areas for initial recolonisation. This will be checked at a frequency commensurate with arrivals (i.e. daily at the airport and fortnightly at the wharf coinciding with cargo vessel arrivals)
- The permanent rodent detector / biosecurity dog based on the island will routinely screen all incoming cargo and luggage
- The permanent rodent detector / biosecurity dog based on the island will sporadically undertake targeted searches of high risk and random areas

This methodology will allow a high level of confidence that any reinvasion would be detected. Genetic testing on LHI rodents has been undertaken. In the event that rodents are detected post REP, the genetic samples will allow determination of whether the eradication failed or the detection was a reinvasion.

Detection Response

In the unlikely event that rodents are detected, remedial action will be considered to eliminate them.

In the event that possible sign is detected, trail cameras with a variety of baits will be deployed in the area to try and confirm if a rodent is present. At the same time an array of other detection devices chew cards, wax block, tracking tunnels, bait stations and traps will be deployed in the vicinity and any rodent dogs available will be focused on that area. Any response will need to be carefully planned and implemented as previous experience has shown that if not done properly there is a risk of not locating the animal or even scaring it away from the known area.

Due to the wide number of situations that could involve a rodent being detected /confirmed e.g. unconfirmed sign, single confirmed individual, multiple individuals, animals around in buildings etc., it is not realistic to develop comprehensive response scenarios. Instead a Technical Advisory Group (TAG) will be set up who will be on immediate standby to provide consensus advice on how to respond to any specific situation. The TAG will consist of selected experts in eradication techniques, rodent detection and rodent behaviour.

Additional detection and response devices will be held on island to facilitate a rapid response if one is required.

A second eradication attempt using aerial techniques is not part of this proposal.

Detection Tools

Bait stations

There will be a network of bait stations present around much the settlement as part of the eradication. However any rodents surviving the initial eradication operation have for some reason avoided eating bait to which is likely to mean they haven't entered a bait station either because they have avoided the stations (neophobia) or they haven't had a station within their territory. The only way to use bait stations to detect rodents would be to put additional stations in any possible gaps in coverage i.e. reduce the spacing between stations. It is more effective simply to make sure that the initial coverage is adequate.

While the stations can, depending on the design, be used for the deployment of other devices e.g. tracking tunnels or to protect wax blocks this would assume that the rodents are not avoiding the stations themselves possibly due to inter or intra species competition. Unless other devices are placed in the stations the only likely rodent activity that will be recorded in the bait stations will be bait being eaten i.e. tooth marks. If there is still bait take continuing at any bait stations then the response is effectively part of the eradication, i.e. keeping the stations topped up.

Rodent Detection Dogs

Trained rodent dogs are a highly effective tool for locating rodents. They have the benefits over all other tools that they actively seek out the rodent rather than requiring the rodent to come to them. Also the rodent and dog do not need to be in the same place at the same time as the dog will, within limits, detect where the rodent has been. Detector dogs can also cover an area once to get a result whereas all other techniques need to be set up and then ongoing checking.

Detector dogs on LHI will be used in the following ways:

- A team of contract specialist rodent detector dogs and handlers will be deployed to actively search accessible areas (particularly the settlement area) to provide immediate detection capability for any surviving rodents in these areas. This will be undertaken within 3-4 weeks of the second bait drop. The exact number of dogs and handlers will be determined in consultation with the selected tenderer for this service.
- An ongoing rodent detection and general biosecurity dog (and handler) will be trained and permanently based on the island prior to implementation of the REP. This dog will provide a rodent detection capability at the border (airport and wharf) as well as generalised biosecurity capability.
- A team of contract specialist rodent detector dogs and handlers will be deployed to actively search all accessible areas (particularly the settlement area) to provide evidence for the declaration of eradication success. This will be undertaken approximately 2 years after the eradication. The exact number of dogs and handlers will be determined in consultation with the selected tenderer for this service.
- If the dogs indicate the current or recent presence of any rodents other techniques will be used to try and confirm it and to refine and hopefully kill the individual(s).

Minimum training, accreditation and ongoing certification requirements for both dogs and handlers will be developed prior to implementation of the REP. This will include

- Ability to identify target scent and avoidance of non-target species and scent
- High level obedience and control
- Good temperament around people and other dogs
- Initial and ongoing assessment and certification of dog and handler

Rodent Detection Dog Gadget on Ulva Island Photo: detectorgadget.blogspot.com	Rodent Detection Dog Cody on Macquarie Island Photo: Meg McKeown	Dog trainer Steve Austin with Rabbit Detection Dogs Gus and Ash Photo:K9 Wildlife Conservation

Figure 15 Rodent Detection Dog Examples

Trail Cameras

Trail cameras / remote cameras come in a variety of specifications e.g. natural light / infrared, stills or movie and are widely used to detect various species of wildlife around the world. Trail cameras have been shown to be very effective for confirming the presence of rodents but are of limited use for the LHI operation due to the cost ($300 + per camera), the time required to set up and maintain them i.e. to check all photos, and the limited range of the cameras without having any initial direction on where to set them up. As such cameras are best used when there is a preferred location e.g. a major food source, a high risk area e.g. the waste management facility or where the presence of a rodent is suspected in an area but unable to be confirmed.

Chew blocks / Wax tags

Chew blocks/wax tags are peanut butter flavoured wax blocks with a smooth surface. When an animal bites one it leaves incisor tooth marks which can usually be identified to species (mouse/rat). Chew blocks are cheap to purchase or can be made on site and are easy to deploy and check. However while they have proved very useful for locating rats and have been widely used for mice, potential issues have been raised with identifying mouse chew sign which warrant further investigation. Their low cost and ease of use means that they have potential to be a very useful detection tool in the Lord Howe situation.

Chew blocks can be bought commercially from Pest Control Services in New Zealand (NB only peanut butter flavoured tags should be used for rodents) or they can be made by project staff . Blocks should be placed 4 cm above the ground to facilitate access by mice.

There can be issues with non-target interference which need to be checked for the site, however with the absence of other mammal species on Lord Howe this is considered to be a very low concern .

Chew cards are pieces of corflute cardboard with peanut butter pressed into the holes. The standard design is a 9 x 18 cm card made of 3 mm white plastic corflute. When the rodent attempts to get to the peanut butter it leaves distinctive chew marks on the corflute which can be identified as rat or mouse. Chew cards are cheap, effective for both target species although somewhat less for mice than rats. Depending on the specifics of the devices used it can also include an ink card to try and get footprints.

Mice and rats have similar bite marks that are mainly distinguished on size. They leave pairs of incisor marks, nearly straight lined on top and more curved underneath. Incisor pairs are about 1 mm across for mice (less than half the width of the corflute channels) and about 2 mm across for rats (more than half the width of a corflute channel). Look for individual bites clear of continuous chewing along card edges. Rats frequently chew large chunks out of the cards leaving a relative cleanly cut edge. Mice usually chew small amounts, sometimes making just small scattered nicks along the edge, or chew short channels between card partitions on just one surface. Continuous mouse chewing along the card edge also tends to be less cleanly cut than for rats, with a short chewed flange attached to the remaining card with numerous light tooth impressions beyond that, as opposed to cleanly cut edges frequently made by rats.

Figure 16 Chew Block

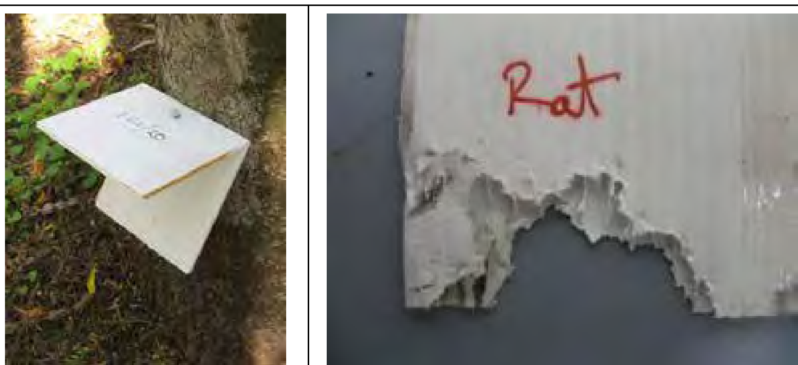


Figure 17 Examples of Chew Cards and Evidence of Rodent Damage

Traps

Traps have the major advantages over the other technique of both killing the survivor and providing a body which can then be examined for species, age, sex and breeding status i.e. a female that has bred is of far more concern than a lone male. However they have several disadvantages:

- They are labour intensive, both to set up and to monitor – NB every trap has to be set with care as each one needs to be considered as THE trap that will catch the rodent.
- They are much more expensive to purchase.
- They are generally species specific i.e. rat versus mouse, so you need to effectively set pairs of traps.
- There is a non-target risk with kill traps, particularly with rat traps i.e. they need to be set under covers to reduce the risk.

Traps are divided between kill traps – most commonly snap traps, and live or cage traps which come in a variety of designs.

	
Figure 18 Example Snap Trap	**Figure 19 Example Live Traps**

Live traps- the only advantage of using live traps on Lord Howe is that they largely eliminate the non-target risk as any non-targets which are caught can be released. However this requires at least daily checks for animal welfare reasons. The benefit of reduced non-target risk has to be balanced against the greater cost of the trap and the possible risk of neophobia i.e. rodents avoiding a new object especially one where they have to enter a box and the intensive servicing required. Also many live traps are more reliable for rats than mice i.e. the larger body size facilities the traps operation.

Kill traps, the most common and simplest kill traps are snap traps which are lightweight and relatively cheap. There are concerns that some rats may escape from snap traps and where feasible other designs e.g. the DOC 150 and 200 series are the preferred option in most situations. However most of the concerns relate to large Norway Rats (*Rattus norvegicus*) so are not a significant issue for LHI. The DOC series traps need to be placed in a purpose built wooden box mean they are not feasible for this task.

There are multiple variations of the snap trap and care should be taken to select the most suitable one – the Victor treadle trap with a yellow plastic treadle is the preferred option as unlike most other traps the rodent only needs to inspect the bait to set it off whereas for most snap traps the animal needs to actively chew on the bait. The double spring on the rat trap also gives greater killing power.

When used inside, as long as there is no risk to children, the traps can be set without a cover, however it is important to use a cover when setting kill traps outside to minimise the risk to non-targets. The cover can be made from a range of materials including corflute, plastic sheet, sheet metal or wood. Woodhen, currawong and banded rail are particularly likely to interfere with traps in order to access the bait so that even if they are not caught they will make the trap non-functional until it is reset. Also it is likely that once any of these birds learns that the traps are a food source they will target them.

Bait for the traps is highly variable but peanut butter with fish oil and rolled oats to bind it is the standard bait.

There is currently a self-resetting trap available (Good nature A24) however while these have major benefits when targeting multiple individuals as they don't need to be reset. These will be investigated for suitability on LHI.

Tracking tunnels

Tracking tunnels come in a variety of designs from semi-permanent wooden structures to lightweight plastic. Rodents are known for entering tunnels but the tracking tunnels are usually baited/lured to act as an added attractant. Inside the tunnel is a plain card with an ink source- either inked card or an ink tray set up so that any animal that walks through it will leave footprints on the card which can then be identified to species. To reduce the risk of neophobia the tunnels, minus tracking cards should be put in place a couple of weeks prior to the planned activation period.

There is a likelihood of currawong, rail and any woodhen interfering with the tunnels to access the bait after they have been released from captivity. The design of the tunnel should be set to reduce non-target interference while still allowing easy access to rodents, this is important as making the entrance small enough to prevent entry by non-targets may effectively deter the target species.

The cost of using tracking tunnels is in a large part dependent on the servicing regime as they can be left for several days between checks if required, however this reduces the likelihood of being able to mount an effective response to any detection as the individual may have moved prior to detection.

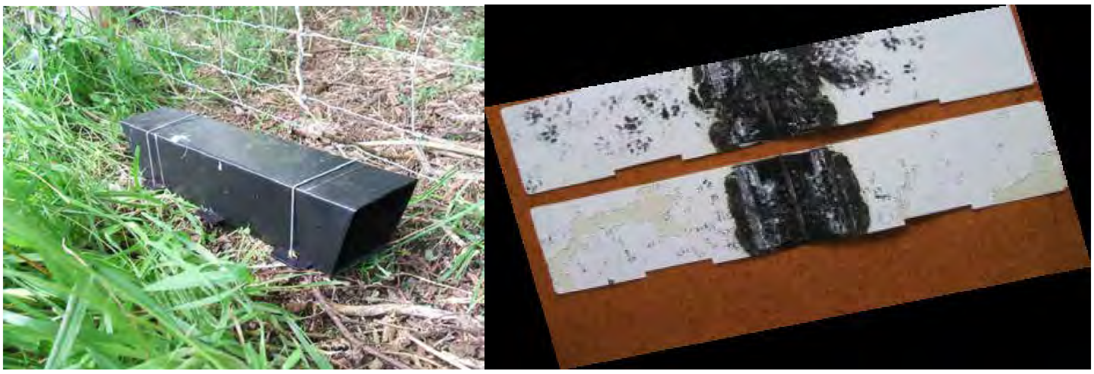


Figure 20 Example Tracking Tunnel and Foot Print Evidence

Implementation

Trials

On site trials need to be undertaken to test the local effectiveness and suitability of the various proposed techniques for LHI, particularly the interaction of non-target species with the devices but also the effectiveness of the devices with detecting the target species i.e. rats and mice preferably at low density. The latter is particularly an issue with mice which are generally more difficult to detect but are also more likely to be an issue for the eradication i.e. have a higher likelihood of failure to eradicate with the initial techniques.

It is possible that birds especially currawongs and woodhens will interfere with the devices (noting that it is likely that all Woodhen from the settlement area will be in captivity). It is also useful to see what if any invertebrate activity may confuse the results. Some insect marks are easily confused with the small marks made by mice.

A trial protocol will be developed separately which, along with the level of resources available for the monitoring and logistical constraints e.g. access to sites, will be used to develop the final monitoring plan.

Trial results will determine the final configuration of the monitoring network.

Timing

Timing of when the monitoring commences is important so as to not waste resources detecting and then targeting walking dead i.e. animals that will die from the delayed action of the toxicant, but there is a need to detect animals as early as possible to facilitate a fast and targeted response. It is proposed to commence the monitoring approximately 4 weeks after the first baiting operation as this is likely to have given all animals which have eaten the bait time to have died. It also means that the monitoring can be tied in with the eradication work e.g. checking of monitoring devices can be linked to the ongoing servicing of bait stations.

To reduce the risk of neophobia reducing the value of any detection tools, any tools which are suitable e.g. tracking tunnels or traps will be deployed well in advance of when they will need to be activated.

Training and Data recording

It is important that the location of all detection devices is accurately recorded and detailed records of all checks and any changes to the plan recorded. Failure to do so can lead to major issues with interpreting results later in the programme. All personnel involved in implementing the plan will be properly trained in deploying the devices and in identifying rodent sign – not just on the devices but also any incidental sign they may encounter.

2.2.1.7 Improved Biosecurity

To improve Biosecurity on the island more generally and to protect the rodent eradication investment, the LHIB is updating the Island's Biosecurity system concurrently with the proposed REP although upgrades will occur regardless of whether the REP goes ahead. In 2015 a consultant was engaged to review and update the LHI Biosecurity Strategy. Recommendations from the updated Strategy (AECOM, 2015) include:

- reducing risk at the Port Macquarie wharf

- increasing education and awareness for residents and visitors pre arrival to LHI
- Increasing inspection regimes for all pathways
- pursuing legislative declaration of LHI as a Special Biosecurity Zone under the Biosecurity Act 2015
- increasing residents' awareness of biosecurity risks of plants, animals and diseases both before and after import
- being prepared to react quickly to new incursions through early detection and rapid response
- continuing with on ongoing management and eradication programs
- ensuring biosecurity is adequately resourced with realistic cost and resource estimates

Specifically in relation to rodents and in addition to the ongoing rodent detection measures described in Section 2.2.1.6, the following measures will be applied:

- Employment of a dedicated on island biosecurity officer who will have primary responsibility for the ongoing rodent detection network. This role may be combined with the rodent / biosecurity detector dog handler
- Upgrades to the shipping contract to increase emphasis on rodent prevention including requirements to:
    - have in place a Biosecurity Management Plan
    - maintain rodent baiting at the point of mainland departure
    - maintain rodent baiting and De-ratting certificates on the cargo vessel
    - report biosecurity risk cargo and incidents prior to arrival.

2.2.1.8 Biodiversity Benefits Monitoring

A Biodiversity Benefits monitoring program associated with the REP has been established to assess and document the biodiversity benefits of removing rats and mice from LHI. The program is predominantly run through the NSW OEH – Science Division. The program provides a measure of the return on investment and also allows an evaluation of status of species prior to and following the eradication so any impacts of the eradication of rodents on key non-target species can be tracked during their recovery in the absence of rodents. Over time, results from the various monitoring components can be integrated to identify and explore changes to ecosystem processes.

Monitoring has and will continue to be undertaken to collect baseline data to determine the short-, medium- and long-term trends and changes in the distribution and abundance of key species and taxa following the removal of exotic rodents from LHI. Monitoring reports to date are provided in Appendix G – Biodiversity Benefits Monitoring Package.

Currently the biodiversity benefits monitoring program has developed a Plan of Action until the point of implementation of the REP. Additional monitoring in the short medium and long term post eradication will be developed if the final decision to proceed with the eradication is made. To fully assess the long-term biodiversity benefits of eradication, monitoring will need to continue for at least three years after the eradication and preferably up to 10.

Monitoring previously undertaken and monitoring planned but not yet implemented as part of the program is described below.

LH Pied Currawong

Population size of the LH Pied Currawong *Strepera graculina crissalis* (LHPC) has been estimated previously using trapping, banding and mark-recapture analysis (Carlile and Priddel 2007). Full monitoring will recommence in Spring-Summer of 2016. Techniques are well established. With OEH consultation, birds can be attracted to designated locations across the island with food, and any unbanded birds caught, banded and released in early spring. A second round of surveys can then take place. Birds individually marked with coloured leg bands can be observed and the band combinations recorded. Population abundance can then be determined by mark-recapture analysis, and the size of the population tracked over time. Data will then be available to compare the survival of (i) the population prior to rodent eradication, (ii) birds left in the wild during the period of risk (i.e., during and in the period immediately following the baiting operation), and (iii) birds held captive during the period of risk.

Prior to the end of 2016-17 year and with an expectant commencement of Phase 3 of the rodent eradication program (baiting) it will be necessary to bring into captivity a proportion of the LHPC population. The capture process will target breeding pairs close to the settlement and from Mount Gower to cover the range of birds from the island during an intensive 3-week program including helicopter transport (from Mount Gower) in conjunction with Woodhen activities.

Land birds

Land birds are highly visible to the community and some species may suffer short-term declines as a result of the baiting. Consequently it is important to have robust baseline data for this faunal group. Surveys of the distribution and abundance of land birds were undertaken annually in spring of 2013, 2014 and 2016. This sampling will be replicated in 2017. Replicated sampling will be undertaken at randomly selected points from a grid covering all readily accessible parts of the island (i.e., excluding the southern mountains). At each sampling point, standard 10-minute counts of bird abundance will be recorded. In addition, a series of transects along roads will be counted to gather data on those birds that tend to inhabit more open areas and are not well represented in the sample points. Methodology has been scientifically validated using preliminary data and is detailed in the 2013 census report (Fullagar *et al.* 2014). This monitoring program will be undertaken by volunteers from the Canberra Ornithologists Group with the assistance of Ian Hutton and any other interested members of the local community. Data from the BirdLife Australia transects established by the LHIB will also be analysed, although because of the non-systematic nature of these data, they are unlikely to demonstrate changes or trends in the short term.

Seabirds

Monitoring the impact of rodents on seabirds needs to focus on the loss of eggs and chicks, as these are the life stages most vulnerable to rat predation. The time of egg laying, hatching and fledging varies among the species of vulnerable seabirds present on LHI. Consequently, monitoring several species requires numerous trips. Thus, during this project (2015-16 and 2016-17 focus has been on two species only—the Little Shearwater P*uffinus assimilis* and Black-winged Petrel *Pterodroma nigripennis*.

Initial research in 2014-15 indicated that these small burrowing seabirds are vulnerable to rat predation of nestlings (Carlile, *et al.* 2015). For both species, the distribution and abundance of nests or burrows within a delineated sub-colony will be monitored using surveillance cameras from just after egg laying to the fledgling of any young. This will allow the determination of hatching success (the proportion of eggs that hatch), fledging success (the proportion of chicks that fledge) and breeding success (the proportion of eggs that produce fledglings). Where such information is available, breeding success in the presence of rodents will be compared with that on rodent-free islands. Monitoring of Little Shearwaters began in July 2016 with the installation of 28 surveillance cameras on active burrows. A further 35 active burrows are being monitored to measure breeding success. A large part of the colony has also been assessed for burrow occupancy and density which will allow any changes in these parameters to be assessed post-eradication.

Reptiles

There are two native reptile species on LHI, the LHI Gecko *Christinus guentheri* and the LHI Skink *Oligosoma lichenigera.* Both species are likely to increase considerably in distribution, and abundance following the removal of rodents. Average body size may also increase as the survival of larger animals improves. The gecko was recently surveyed (Bray *et al.* 2013), providing some coarse baseline data from which to assess changes in distribution and abundance after the eradication, particularly if, as expected, the animal were to expand across basalt soils. The skink was monitored during the 2014-15 season (Wheeler and Madani 2015). This monitoring made several recommendations for a post- rodent environment and sufficient information was collected from which to monitor changes in their populations.

Land snails

Baseline data of the distribution and abundance of the LH Placostylus *Placostylus bivaricosus* were collected in 2006-07 (Hutton 2007) and 2010 (Hutton and Hiscox 2010) where permanent survey plots were established in representative habitats, focussing on those areas where snails had been recorded previously.

Surveys of the LH Placostylus are best conducted after rain, so are problematic to plan, and consequently are best done in collaboration with residents on the island. Existing plots will be resurveyed to detect snails foraging on the surface at night in 2016-17. Similar species are more active on wet, warm nights, between 0200 and 0300 hours (Brescia *et al.* 2008), so surveys are best done late on summer nights after rain. All animals will be measured and marked. 'Dead' shells will also be counted. Population number and body size (as determined by shell size of both live and dead animals) can then be compared before and after the eradication.

Other invertebrates

It is expected that the biomass of invertebrates on the island will increase sharply after the eradication of rodents. General abundance of ground-dwelling and tree-dwelling invertebrates will immediately benefit from the removal of a major predator. To capture this gross change in the biota several monitoring programs have been established. In June 2016, 20 invertebrate monitoring sites were established across the island. Sites have been positioned on both major soil types (calcarenite and basalt) and a number of sampling techniques have been utilised, including collection of leaf litter and the installation of artificial habitat designed to mimic ground cover, exfoliating bark, and tree crevices. Material collected will be sorted to Order and weighted over four 3-month periods prior to the eradication. The repeating of this sampling post eradication will, along with flora monitoring of seedling survival, give the most immediate response of the biota to a rodent-free environment.

Big and Little mountain palms

Rats severely reduce seedling recruitment of the Little Mountain Palm *Lepidorrhachis mooreana* and Big Mountain Palm *Hedyscepe canterburyana auld* (Auld *et al.* 2010). This was repeated in 2014-15 and confirmed the earlier results (Auld *et al.* 2015). Fruiting and seedling establishment in both these species has been measured over a number of years, with almost no seedling establishment evident where there is no rat baiting occurring. Further studies are need to confirm the initial results from the slopes of Mt Gower, where baiting is minimal. Monitoring of these species using established plots, once rats are removed from LHI, is likely to demonstrate a marked change in seedling recruitment. This work will be undertaken by Dr Tony Auld (OEH).

Fruiting plants

From monitoring carried out in 2014-15 there was evidence that rats were consuming fruits or seeds in all 16 species examined (Auld *et al.* 2015). In summary, seed or fruit losses were apparent in all study species, at least at some sites. Losses were very high for six study species (H*owea forsteriana, Olea paniculata, Baloghia inophylla, Jasminium simplicifolium, Smilax australis* and *Geitonoplesium cymosum*); potentially very high but variable for one species (Ochrosia elliptica); moderate for three species (*Syzygium fullagarii, Chionanthus quadristamineus, Dietes robinsoniana*) (the actual losses may be higher as the trials only ran for a short period); generally low in 4 species (*Sarcomelicope simplicifolia, Psychotria carronis, Dysoxylon pachyphyllum, Coprosma putida)* (but the actual losses may be higher where the trials only ran for a short period); and low-moderate in two species (*Sophora howinsula, Drypetes deplanchei*).

Further work on examining the impact of fruit losses on the ecology of the study species would assist interpretation of these data. Given that losses are occurring in all tested species, sampling will be extended to additional species as many other species are also likely to be impacted by rats. This work will be undertaken by Dr Tony Auld (OEH).

Woodhen

Annual surveys of woodhen conducted by the LHIB will continue in November / December each year. Data from these surveys can be analysed to track the population and identify changes in population abundance as a result of the eradication program.

Prior to the end of 2016-17 year and with an expectant commencement of Phase 3 of the rodent eradication program (baiting) it will be necessary to bring into captivity the entire woodhen population from surveyed areas in an intensive 3-week program. This process will require both LHIB employees familiar with trapping techniques and the breeding areas frequented by woodhen as well as OEH and Taronga Zoo staff. Ideally the Mt Lidgbird population should be targeted but logistical constraints may not make this possible.

The monitoring reports undertaken to date are provided in Appendix G – Biodiversity Benefits Monitoring Package.

2.2.2 Definition of SIS Study Area

Lord Howe Island (LHI) is located 780 kilometres north-east of Sydney (See Figure 21). It covers 1455 ha, is 12 km long, 1.0–2.8 km wide and formed in the shape of a crescent, with a coral reef enclosing a lagoon on the western side (see Figure 22, Figure 23 and Figure 24). Mount Gower (875 m), Mount Lidgbird (777 m) and Intermediate Hill (250 m) form the southern two-thirds of the island; the northern end of the island is fringed by sea cliffs of about 200 m in height (See Figure 22, Figure 23 and Figure 24). A settlement of approximately 350 inhabitants is located in the northern section of LHI and covers about 15% of the island. Approximately 75% of LHI plus all outlying islands, islets and rocks are protected under the Permanent Park Preserve (PPP), which has similar status to that of a national park. The LHIG has been placed on the Register of the National Estate and was listed as a World Heritage Area in 1982. It is also located within the Lord Howe Island Marine Park (NSW) out to 3 nautical miles (under NSW jurisdiction) and the new Lord Howe Commonwealth Marine Reserve (under Commonwealth authority), a further area of 110 000 km^2). Coordinates for the project area boundary are provided below.

Table 4: Project Area Coordinates

Location point	Latitude			Longitude		
	degrees	minutes	seconds	degrees	minutes	seconds
1	-31	28	53	159	4	23
2	-31	31	31	159	0	38
3	-31	36	18	159	4	8
4	-31	33	47	159	8	3

The 2 dimensional area of LHI is 1,455 ha. The 3 dimensional area when considering the rugged topography is approximately 2,100 ha.

The Proposed REP will occur over the entire LHIG, excluding Balls Pyramid which therefore is defined as the study area.

Potential impacts to the Lord Howe Island Marine Park (NSW) under the NSW *Marine Estate Management Act 2014* and threatened species listed under the NSW *Fisheries Act* 1994 have been addressed in a separate application to the NSW Department of Primary Industries.

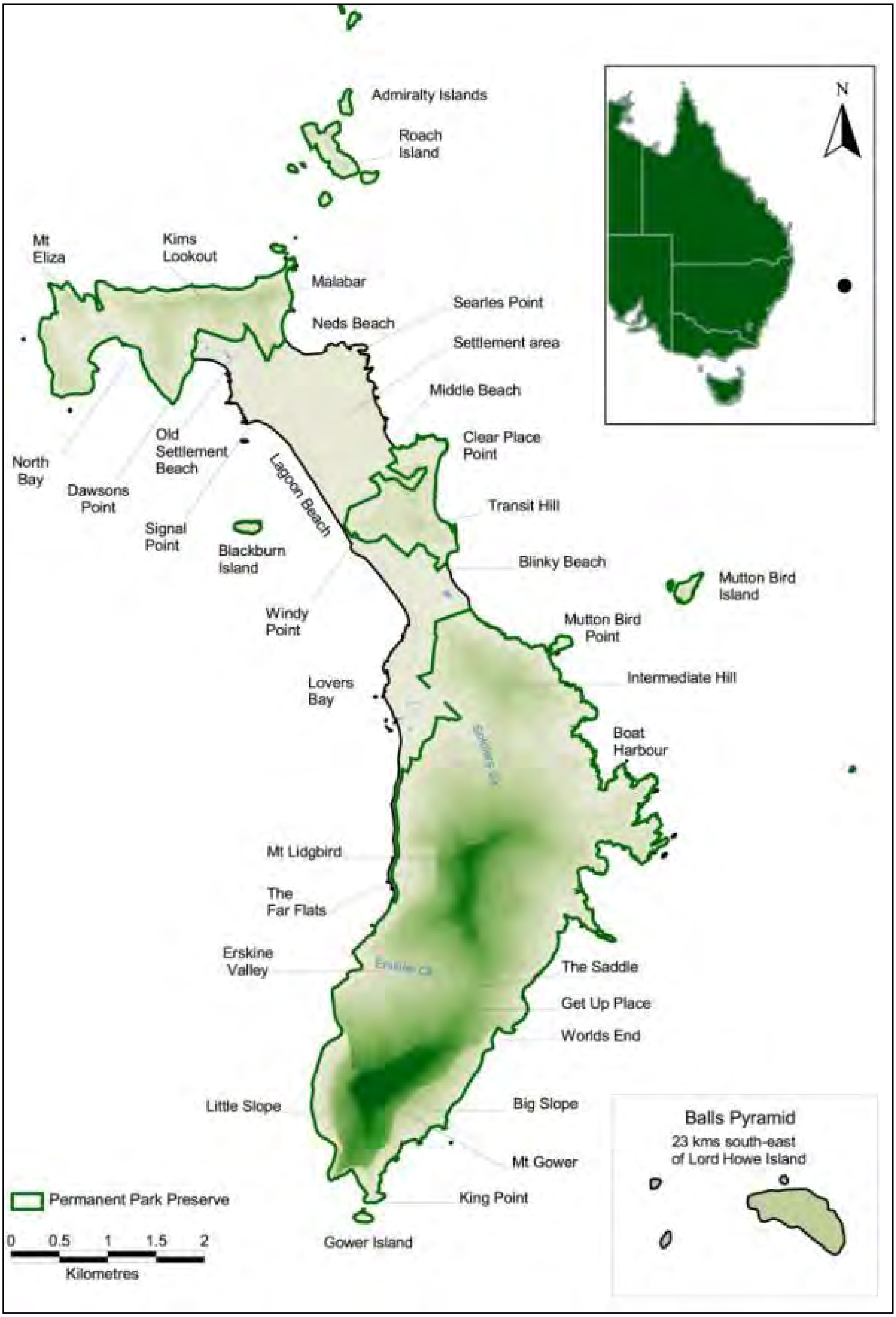


Figure 21 Lord Howe Island Locality (DECC, 2007)

Figure 22 Lord Howe Island overview (DECC, 2007).

Figure 23 Lord Howe Island as seen from the North

(Image courtesy Dave Kelly)

Figure 24 Lord Howe Island as seen from the South

(Image courtesy Ian Hutton)

2.2.3 Description of Study Area

The LHIG supports a diverse terrestrial flora and fauna with a high degree of endemic species and communities. Many biogeographical relationships are discernible, with components of the terrestrial flora and fauna exhibiting affinities with eastern Australia, New Zealand, Norfolk Island and New Caledonia (DECC, 2007). The biodiversity of the island has been well studied over a long period of time. A summary of relevant studies is found in section 4.

2.2.3.1 Flora

There are currently believed to be approximately 240 native species of vascular plants in the LHIG (DECC, 2007). While the vegetation has affinities with the flora of northern New South Wales, southern Queensland, New Zealand, Norfolk Island and New Caledonia, there is a high level of endemism (113 species (47%)). The high degree of endemism is illustrated not only at the species level, but also at the generic level, where there are five endemic vascular plant genera including three endemic palms (DECC, 2007).

Approximately 270 species of vascular flora have naturalised (introduced species that are reproducing in the wild) on the LHIG since settlement.

The non-vascular flora of terrestrial and freshwater habitats (bryophytes, lichens and freshwater algae) is less well known, but is also considered to be diverse with many endemic species. For example, 105 species of mosses are known, 21 (20%) of which are endemic.

2.2.3.2 Fauna

Birds

Similar to other oceanic islands, the terrestrial fauna of the LHIG is dominated by birds. The LHIG forms one of the major seabird breeding sites in the Tasman Sea and is thought to be home to the most diverse and largest number of seabirds in Australia (DECC, 2010). Many of these species are believed to have important breeding populations on the LHIG; they are the only major breeding locality for the Providence Petrel, and contain one of the world's largest breeding concentrations of Red-tailed Tropicbird.

182 species have been recorded from the LHIG of which 20 are resident land birds, 14 are breeding seabirds, 17 are regular visitors and 120 are vagrants (DECC, 2010). 34 species have been recorded as regularly breeding on the islands. Many of the breeding seabirds found on the islands are listed migratory species.

The LHIG is the only known breeding locality in the Australasian region for the grey ternlet and Kermadec petrel, and is the southernmost breeding locality in the world for the masked booby, the sooty tern and common noddy.

Endemic land birds on the islands include the Lord Howe Woodhen, Lord Howe golden whistler and Lord Howe currawong. Nine land birds are believed extinct, five of which have been at least partially attributed to the presence of rats.

Mammals

The only known native mammal on the LHIG is the large forest bat (*Vespadelus darlingtonii*) (DECC, 2010). The Lord Howe Long-eared Bat (*Nyctophilus howensis*) is thought to be extinct (DECC, 2007).

Reptiles

There are two native reptiles, the LHI skink and LHI gecko (DECC, 2010). Both are now severely reduced in their range and abundance on the main island due to predation by rats; however both are present on Blackburn Island, the Admiralty group, Mutton Bird Island and Balls Pyramid. Until recently it was believed that both species also occurred on Norfolk Island, although recent genetic work indicates they are separate species.

Invertebrates

The LHIG has a very complex and biogeographically interesting invertebrate fauna, characterised by relatively high species richness (>1600 species recorded) and high endemism (DECC, 2010). This includes 157 land and freshwater snails, 464 beetles, 27 ants, 183 spiders, 21 earthworms, 137 butterflies and moths and 71 springtails. The rate of discovery of new species remains high, indicating that numerous endemic species are yet to be discovered (DECC, 2007).

Of particular note are the Lord Howe Island phasmid, which was previously thought to be extinct, the wood-feeding cockroach, and the darkling beetle which are no longer found on the main island, but are restricted to outlying, rodent-free islands (DECC, 2007).

There are more than 50 endemic species of land snails found in the island group. One large species, *Epiglypta howinsulae*, has already become extinct and another large species, the Lord Howe placostylus (*Placostylus bivaricosus*), is endangered with one of its subspecies presumed extinct (DECC, 2010). A new species of

Phasmid *Davidrentzia validus* was discovered in 1988, with only 12 records of the species been detected since then. The species is considered at risk from predation by rodents.

It is believed that numerous invertebrate extinctions have occurred including one endemic ant and ten endemic beetles (DECC, 2007).

Freshwater Fishes

Three species of freshwater fish (two eels and a galaxias) occur on the LHIG (DECC, 2007).

2.2.3.3 Hydrology

A small number of ephemeral streams are found on LHI. It is anticipated that a small amount of pellets may fall into these streams as part of the aerial distribution where they will sink and disintegrate rapidly. The Brodifacoum from these pellets will settle and bind strongly to sediments.

LHI has very limited groundwater which is predominantly used by a small number of accommodation providers to supplement rainwater for toilet flushing, washing, gardens. Some properties occasionally use bore water for drinking and stock watering. Several of the properties have desalination plants for treatment of groundwater before use.

The low-moderate application rate of Brodifacoum (0.4 g/ ha) for the LHI REP and one off eradication means that any environmental contamination would be of a sufficiently low magnitude as to not present a significant risk. Any potential impacts are likely to be very localised and temporary in nature.

2.2.3.4 Soil and Vegetation

The LHIG is a volcanic remnant characterised by volcanic basalt outcrops and sedimentary calcarenite (mostly coral fragment) formations in the low slopes and low lying areas. Soil profiles are limited across the island.

Soil on the island is unlikely to be impacted by the proposal. Fate of the bait and the toxin in soil is described in Section 5.2.1. The pellet will degrade in approximately 100 days. Manner of use of Brodifacoum baits and physical and chemical properties of Brodifacoum suggests little accumulation of Brodifacoum in soil, with concentrations of Brodifacoum in soil predicted to be negligible/low and occurring only sporadically according to bait treatment timings. Brodifacoum is strongly bound to soil particles, and radio-labelled Brodifacoum was found to be effectively immobile (i.e. not leached) in four soil types (World Health Organisation 1995). It is broken down by soil micro-organisms to its base components, carbon dioxide and water, the half-life being 12-25 weeks (Soil Degradation for 50% of the compound (DT_{50}) – typical 84 days: Field – 157 days; Shirer 1992). Any potential impacts are likely to be very localised and temporary in nature. The rodent eradication project will lead to an overall reduction in rodenticide use in the long term.

2.2.3.5 Gradient

The LHIG is a sea mount chain. The lagoon, which is approximately 6 kilometres by 1.5 kilometres at its widest point, has an average depth of just 2–3 metres, although its deeper holes can be up to 10 metres deep. The lagoon fringing reef is pierced by four principal passages: Erscotts Passage, South Passage and Erscotts Blind Passage to the south; and North Passage, the latter constituting the main entrance and being 4–6 metres deep (Allen *et al.*1976). On the seaward edge of the lagoon, the shoreline drops off steeply to depths of 15–20 metres and then gradually slopes to deeper water (Allen *et al.*1976). Around other parts of the island, the shorelines are steep, with rocky cliffs extending to the water's edge adjacent to water depths of 10–20 metres (MPA, 2010).

2.2.3.6 Current State of the Environment

The LHIG is a World Heritage property and is often considered pristine. The LHIG however has not escaped significant impacts due to human activity and introduced species. Current and historical key threats (DECC, 2007) include:

- habitat clearing and modification particularly for accommodation and farmland in the settlement area
- vegetation windshear and associated canopy dieback
- trampling, browsing and grazing from introduced cattle and horses and historically goats
- weed invasion from 270 plant species that have become naturalised including 68 declared noxious weeds
- predation by rodents
- predation and competition from other introduced animals including:

- 18 land bird species and five sea bird species that have established populations on the LHIG since human settlement
- Cats, goats and pigs that have now been eradicated
- African Big-headed Ant *Pheidole megacephala*. Number on the island have been significantly reduced and an eradication program is well commenced (expected eradication 2018)
- Approximately 100 other species of introduced invertebrates
- Bleating Tree Frog *Litoria dentata* and Grass Skink *Lampropholis delicate*

Other threats include sea bird ingestion of plastic, by catch from fishing, traffic impacts to shearwaters and woodhens, *Phytopthora* infestation, habitat fragmentation and climate change.

Threats are managed under the LHI Biodiversity Management Plan (DECC, 2007) and through significant investment in conservation from the LHIB and numerous funding partners.

A 2014 World Heritage property outlook assessment undertaken by the IUCN considered that overall management of the LHIG World Heritage property was “Good”, the highest rating (IUCN, 2016). It stated:

“Good management is in place and provided resourcing and commitment to addressing the key threats to World Heritage values are sustained the values should remain preserved. The outstanding scenic values are likely to remain in good condition and subject to funding and effective program implementation the significant natural habitat; rare plants and threatened wildlife are likely to persist in their current or an improved condition”

The assessment recognised the threat to the LHIG World Heritage values from rodents as a “High Threat” and recommended implementation of the rodent REP to address the threat (IUCN, 2016).

2.2.3.7 Indigenous Heritage Values

No indigenous groups or indigenous heritage values are found on the LHIG.

2.2.3.8 Other Important or Unique Values of the Environment

Approximately 75% of LHI plus all outlying islands, islets and rocks above the high water mark are protected under the Permanent Park Preserve (PPP), which has similar status to that of a national park. The PPP area is managed by the LHIB.

2.2.3.9 Climate

The LHIG is considered to have a sub-tropical climate moderated by oceanic air currents and mild sea temperatures. Winters are wet and cool whilst summers have less rainfall and are mild or warm. A summary of key climate statistics during the proposed operational period is shown below (BOM, 2016).

Table 5 Lord Howe Island Climate

Key Climate Statistics	Jun	Jul	Aug	Sep
Mean maximum temperature (°C)	19.9	18.9	19.0	20.0
Mean minimum temperature (°C)	14.9	13.9	13.5	14.5
Mean rainfall (mm)	171.2	144.0	108.8	114.0
Mean number of days of rain ≥ 1 mm	17.2	17.8	15.0	11.9
Mean 9am relative humidity (%)	66	67	65	68
Mean 9am wind speed (km/h)	21.9	21.8	21.5	21.0
Mean 3pm relative humidity (%)	66	66	64	68
Mean 3pm wind speed (km/h)	22.5	23.9	23.0	22.4

2.3 Relevant Plans and Maps

A plan of the project area including land tenure is found in Figure 25 below.

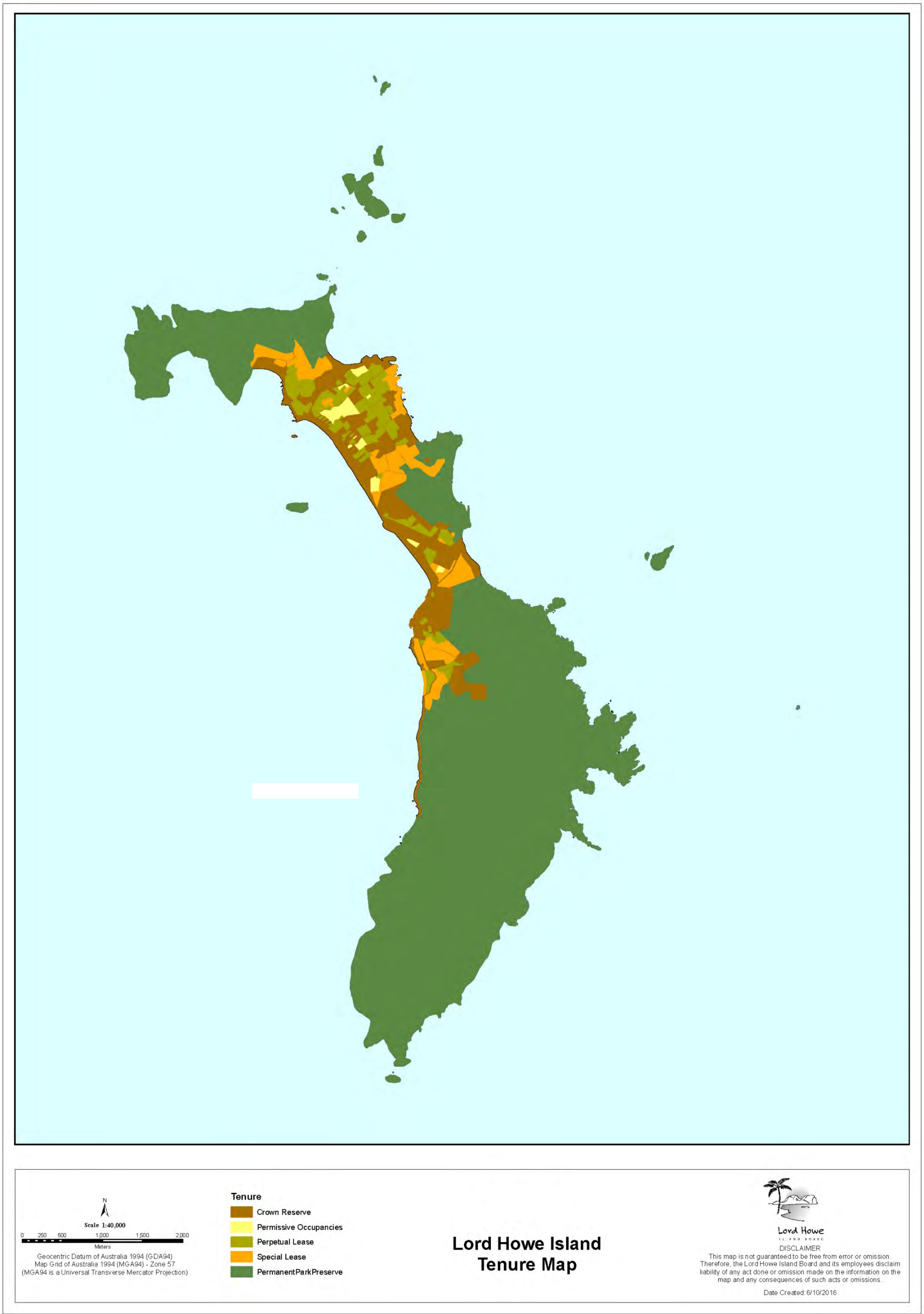


Figure 25 LHI Tenure Map

2.4 Land Tenure Information

2.4.1 Local Government Area

The LHIG is part of the State of New South Wales and, for legal purposes, is regarded as an unincorporated area administered by the LHIB, a statutory authority established under the provisions of the *Lord Howe Island Act, 1953* (the Act). The LHIB is directly responsible to the NSW Minister for the Environment and comprises four Islanders elected by the local community and three members appointed by the Minister. It is charged with the care, control and management of the Island's natural values and the affairs and trade of the Island. It is also responsible for the care, improvement and welfare of the Island and residents.

The LHIB carries out all local government functions on behalf of approximately 350 Island residents. It controls all land tenure on the island and administers all residential and other leases in accordance with the Act. The LHIB manages the Island PPP and the protection and conservation of the Island's fauna and flora.

The LHIB also undertakes the role of the relevant Local Government Authority and Consent Authority under the NSW *Environment Planning and Assessment Act, 1979*. Relevant Contact is Dave Kelly, Manager Environment and Community Development P.O. Box 5, LHI, 2898. Telephone 02 6563 2066.

2.4.2 Land Tenure

The LHIG consists of the following lease types:

- The Permanent Park Preserve
- Crown Land
- Permissive Occupancy
- Perpetual Leases
- Special Leases

Lease Boundaries are shown on Figure 25.

2.4.3 Land Use

A settlement of approximately 350 inhabitants occurs in the northern section of LHI and covers about 15% of the island; approximately 400 hectares. The settlement area is used predominantly for residential, pastoral/agricultural and commercial uses.

Ocean waters from the high water mark to three nautical miles offshore are protected under the NSW Lord Howe Island Marine Park (approximately 47,000 hectares) and are the responsibility of the New South Wales Marine Park Authority.

Tourism is the most significant industry and major source of income on the Island and is heavily focused around the world heritage values of both the marine and terrestrial environments. Key tourism activities include:

- Marine activities in the Marine Parks such as beach and reef walking, swimming, snorkelling, scuba diving, fish feeding, surfing, underwater photography, windsurfing, sea-kayaking, fishing, sightseeing cruises and eco tours, and other water sports and beach activities
- Terrestrial activities such as hiking, bird watching, golf, walking, bike riding, sightseeing and eco tours, lawn bowls.

Export of the Lord Howe Kentia Palm and to a lesser extent, three other palm species endemic to LHI, has been a major industry since the late 1800s. The species is now one of the most popular decorative palms in the world. Seed is collected from natural forest and plantations and then germinated in soil-less media and sealed from the atmosphere to prevent contamination. After testing, they are picked, washed (bare-rooted), sanitised and certified then packed and sealed into insulated containers for export. The industry has suffered a decline on LHI as a result of increased global competition from foreign plantations and to a lesser extent, rodent impacts. The Kentia Palm Nursery formerly managed by the LHIB was bought by a private consortium in 2014 who are re-establishing the industry. The nursery currently exports 400,000 seedlings year.

2.5 Vegetation

2.5.1 Vegetation Communities

Over thirty vegetation communities have been described from the LHIG and many of these are endemic or have highly restricted distributions. Eighteen of these communities are considered to be of particular conservation concern (DECC, 2007).

The dominant vegetation on the island is Closed Forest, the major sub-formations of which—Rainforest, Megaphyllous Broad Sclerophyll Forest (mainly palms) and Gnarled Mossy Forest—cover 54%, 19% and 2% of the island respectively. A full description of the vegetation was compiled by John Pickard of the National Herbarium of NSW, Royal Botanic Gardens, and published in the journal *Cunninghamia* in 1983 (Volume 1, pages133-265) (Pickard, 1983). The methods he used involved transects, the examination of aerial photographs and subsequent ground truthing. He discounted the structural classification of Specht for that of F.R. Fosberg (1967, A classification of vegetation for general purposes. In *Guide to the Checklist for IBP Areas*, G.F. Peterken, editor; pp. 55-120; IPB Handbook 4). Pickard describes the physiography, community structure and floristics, and history of disturbance for each plant association. Although published in 1983, little has changed in the intervening years because the island was declared a World-Heritage site in 1982. A summary is included in the LHI Biodiversity Management Plan (DECC, 2007) which is included as Appendix H – LHI Biodiversity Management Plan.

2.5.2 Remnant native vegetation

Most of the island (87%) is considered remnant vegetation (DECC, 2007). Closed forest is the most extensive remnant vegetation, covering over half of the main island and extending from the lowlands to the mountain tops. The remaining natural vegetation cover consists of scrubs, herbfields, grasslands and the vegetation of exposed cliff and littoral terrains. Thirty four vegetation communities are defined for the LHIG (DECC, 2007) and many of these are endemic or have highly restricted distributions. Eighteen of these communities are considered to be of particular conservation concern (DECC, 2007) due to threatening processes that are causing, or likely to cause their decline including impacts from introduced rodents.

The proposal is unlikely to impact on remnant vegetation. In contrast, if the proposal proceeds and rodents are eradicated, significant improvement is expected for remnant vegetation communities.

2.6 Consequences of Not Proceeding with the Project

Introduced rats and mice are currently having a significant impact on the biodiversity, World Heritage and socio-economic values of LHI (DECC, 2007). The LHIB currently implements a rodent control program (covering approximately 10% of the island) aimed at reducing rodent impacts but even with this in place, neither the rat or mouse population is being reduced to a level that reduces landscape scale ecological impacts. Even with the current control program in place rodent population estimates from the entire island range from 63,000 to 150,000 rats and 140, 000- 210,000 mice (30 -74 rats per hectare and 67-100 mice per hectare (DECC, 2007a and 2008)).

Failure to proceed with the REP will result in continuing adverse consequences to these values through:

- Ongoing impacts to biodiversity including population declines and potential extinctions as a result of rodent predation and competition.
- Continuation of the current (or expanded) rodent control program (and the continuous presence of poison baits in the environment) essentially in perpetuity. This presents ongoing risks of poisoning for non-target species and high probability that rodents will develop a resistance to poison.
- Potential further degradation of World Heritage values (including endemic and threatened species) and the potential for the LHIG to be inscribed on the “World Heritage in Danger List”.
- Ongoing socio-economic impacts associated with rodents.

A one off, planned eradication will eliminate these risks. Further detail is provided in the following sections.

2.6.1 Failure to Mitigate Rodent Impacts to Biodiversity

Globally the introduction and spread of invasive species is a leading cause of biodiversity loss. Invasive species are particularly destructive to island species and ecosystems. Nearly two-thirds of recent extinctions (Jones *et al.* 2016) and 75% of all recorded terrestrial vertebrate extinctions occurred on islands and most were caused fully or in part by invasive species (McCreless *et al.* 2016). Currently, 40% of species threatened with global extinction are from islands. Eradication of invasive mammals has recently been modelled as having the potential to prevent up to 75% of extinctions of threatened species on islands (ibid).

Exotic rodents, particularly ship rats and perhaps mice, have been a key (and often the critical) cause of extinction, extirpation (local population loss) and decline of many native species, adverse changes to island ecosystems, as well as economic damage to island peoples' livelihoods and potentially to their health (DEWHA, 2009). Ship rats alone are responsible for the severe decline or extinction of at least 60 vertebrate species (Towns *et al.* 2006), and currently endanger more than 70 species of seabird worldwide (Jones *et al.* 2008). They suppress plants and are associated with the declines or extinctions of flightless invertebrates, ground-dwelling reptiles, land birds and burrowing seabirds (Towns *et al.* 2006). Mice have also been shown to impact on plants, invertebrates and birds (Angel *et al.* 2009).

On LHI, rodents are implicated in the extinction of at least five endemic birds and at least 13 invertebrates (DEWHA, 2009). They are also recognised in the LHI Biodiversity Management Plan (DECC, 2007) as a threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates on the island (ibid) including TSC listed species shown below in Table 6 . Further detail on rodent impacts on LHI is provided in Section 2.8.

Table 6 TSC Act Listed Species Currently Impacted by Rodents on the LHIG (from DECC, 2007 and Carlile et al. 2016)

CE = Critically Endangered, E = Endangered, V = Vulnerable

	Common name	Scientific Name	Endemic	TSC Act
Birds	Black-winged petrel	*Pterodroma nigripennis*	-	V
	Flesh-footed shearwater	*Ardenna carneipes*	-	V
	Grey ternlet	*Procelsterna cerulea*	-	V
	Kermadec petrel	*Pterodroma neglecta*	-	V
	Little shearwater	*Puffinus assimilis*	-	V
	Lord Howe woodhen	*Hypotaenidia sylvestris*	Yes	V
	Masked booby	*Sula dactylatra*	-	V
	Providence petrel	*Pterodroma solandri*	-	V
	White-bellied storm petrel	*Fregetta grallaria*	-	V
Reptiles	Lord Howe Island gecko	*Christinus guentheri*	-	V
	Lord Howe Island skink	*Oligosoma lichenigera*	-	V
Invertebrates	Lord Howe Island phasmid	*Dryococelus australis*	Yes	CE
	Lord Howe placostylus	*Placostylus bivaricosus*	Yes	E
	Whitelegge's land snail	*Pseudocharopa whiteleggei*	Yes	CE
	Masters' charopid land snail	*Mystivagor mastersi*	Yes	CE
	Mt Lidgbird charopid land snail	*Pseudocharopa lidgbirdi*	Yes	CE
	Magnificent Helicarionid land snail	*Gudeoconcha sophiae magnifica*	Yes	CE
	LHI Earthworm	*Pericryptodrilus nanus*	Yes	E
	LHI Wood feeding Cockroach	*Panesthia lata*	Yes	E
Plants	Little mountain palm	*Lepidorrhachis mooreana*	Yes	CE
	Phillip Island Wheat Grass	*Elymus multiflorus var. kingianus*	-	CE

Impacts of rodents on some species on LHI and subsequent consequences if the REP did not proceed are demonstrated in both *Key Threatening Process* and *Threatened Species listings* under the *EPBC* Act and TSC Act.

Predation by exotic rats on Australian offshore islands is listed a Key Threatening Process under the *EPBC* Act (DEWHA, 2009). The eligibility criteria for a process to be listed as a key threatening process under the EPBC Act are:

a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent; or

b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment; or

c) it adversely affects 2 or more listed threatened species (other than conservation dependent species) or 2 or more listed threatened ecological communities.

Exotic rodents on islands were considered by the commonwealth Threatened Species Scientific Committee (TSSC, 2006) in their eligibility assessment to meet all three of the above criteria. Specific examples provided by the TSSC in their assessment included the following LHI species:

- Criterion A: The LHI Wood-Feeding Cockroach (*Panesthia lata).* The TSSC concluded that predation by exotic rats could cause this species to become eligible for listing as threatened under the EPBC Act.
- Criterion B: Lord Howe Flax Snail (*Placostylus bivaricosus)*. The TSSC concluded that predation by rodents could cause the species to become eligible for listing in another category representing a higher degree of endangerment (critically endangered).
- Criterion C: Lord Howe Flax Snail (*Placostylus bivaricosus);* Lord Howe Island Gecko (*Christinus guentheri)* and Lord Howe Island Phasmid (*Dryococelus australis).* The TSSC concluded that rodents are currently or could adversely affect these species.

In NSW, *Predation by the Ship rat on Lord Howe Island* is listed as a key threatening process. Eligibility criteria include for listing as Key Threatening Process are:

- it adversely affects threatened species, populations or ecological communities
- it could cause species, populations or ecological communities that are not threatened to become threatened.

In their final determination in 2000 the NSW Scientific Committee was of the opinion that Predation by the Ship Rat, Rattus rattus on Lord Howe Island adversely affects two threatened species and could cause species or populations that are not threatened to become threatened.

The EPBC Act *Guidelines for Assessing the Conservation Status of Native Species* (TSSC, 2014) and NSW *Threatened Species Conservation Regulation 2010* provide guidance on eligibility criteria for listing of threatened species including probability of extinction. Both eligibility criteria are closely aligned to the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria (IUCN, 2012) which is used to maintain the Red List of Threatened Species (also known as the IUCN Red List), the world's most comprehensive inventory of the global conservation status of biological species.

Rodents are listed as a key threat to many of the TSC Act listed threatened species on LHI. Continued predation and competition from rodents as a result of not proceeding with the REP could lead to further population declines and increased risk of extinction. Current and potential threatened species listings under various TSC / IUCN categories below in Table 7, highlight the risk of further population declines and potential extinctions if the REP did not proceed. Many more species that could experience population declines are listed in Appendix 3 of the LHI BMP (DECC, 2007).

Table 7 Potential Population Declines of LHI Species

TSC Act / EPBC/ IUCN Category	**Definition and Probability of Extinction**	**Current and potential LHI species listings**
Critically Endangered	Is considered to be facing an extremely high risk of extinction in the wild. Probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 60 years).	Currently listed: • Whitelegge's land snail (*Pseudocharopa whiteleggei*) • Masters' charopid land snail (*Mystivagor mastersi)* • Mt Lidgbird charopid land snail (*Pseudocharopa ligdbirdi)* • Magnificent Helicarionid land snail (*Gudeoconcha sophiae magnifica)* • Little Mountain Palm (*Lepidorrhachis mooreana*) • Phillip Island Wheat Grass (*Elymus multiflorus var.*

		Kingianus) • *Calystegia affinis* Potential Listing: • Lord Howe Placostylus (*Placostylus bivaricosus*). Currently listed as Endangered • *Chionochloa howensis* (not listed) • *Passiflora herbertiana* ssp. *insulae-howe*i (not listed) • Gnarled mossy cloud forest (Threatened Ecological Community, not listed)
Endangered	Is considered to be facing a very high risk of extinction in the wild. Probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).	Currently listed: • Lord Howe Placostylus (*Placostylus bivaricosus*) • *Xylosma parvifolia* • *Geniostoma huttonii* • Rock Shield Fern (*Polystichum moorei)* Potential Listing: • LHI Gecko (*Christinus guentheri*) Currently listed as Vulnerable • LHI Skink (*Oligosoma lichenigera*) Currently listed as Vulnerable • *Cosprosma inopinata* (not listed) • Wood-Feeding Cockroach (*Panesthia lata)*
Vulnerable	Is considered to be facing a high risk of extinction in the wild. Probability of extinction in the wild is at least 10% within 100 years.	Currently listed: • Kermadec petrel (*Pterodroma neglecta*) • White-bellied storm petrel (*Fregetta grallaria*) • Lord Howe woodhen (*Hypotaenidia sylvestris*) • LHI Gecko (*Christinus guentheri*) • LHI Skink (*Oligosoma lichenigera*)

In addition to biodiversity losses, failure to proceed with the REP will negate the potential for the reintroduction of extirpated species confined to offshore islands (i.e. the Wood-Feeding Cockroach, Phasmid, Kermadec petrel, and White-bellied storm petrel), reintroduction of ecological equivalent extinct species and recovery of threatened species to enable restoration of ecological processes. None of these conservation actions would be possible with the ongoing presence of rodents on LHI. Failure to proceed with eradication will negate the restoration of these essential ecological functions.

Therefore it is highly likely that failure to proceed with the REP will allow continued negative impacts of rodents on biodiversity on LHI through:

- An increased risk that several species could experience population declines and become eligible for listing under any category under the TSC Act.
- An increased risk that several TSC Act listed threatened species could experience population declines and become eligible to be listed in another category representing a higher degree of endangerment
- An increased extinction probability for several species.

These impacts have a high probability of being avoided if the REP proceeds as evidenced on Macquarie Island. Since eradication of rabbits, rats and mice in 2011, eight species of birds have an improved conservation outlook (Birdlife Australia, 2016).

2.6.2 Failure to Mitigate Impacts of Ongoing use of Poison

Failure to proceed with the REP will mean continuation of the current (or an expanded) rodent control program (and the continuous presence of poison baits in the environment) essentially in perpetuity. The LHIB undertakes a rodent control program however many residents also carry out their own rodent baiting (sometimes in contravention to rodenticide label requirements). This control program only covers about 10% of the island. In order to mitigate biodiversity, world heritage and socio-economic impacts, it is likely that if the eradication did not proceed, an expanded control program would need to be implemented to protect ecological assets. Consequences of ongoing use of poison for rodent control on LHI include:

- Ongoing and continual exposure to poison for non-target species. For example in 2011, eight out of ten deceased woodhens examined for cause of death tested positive to Brodifacoum residue likely as a result of community rodent baiting. Numerous other woodhens have been observed exhibiting symptoms of Brodifacoum poisoning and many have recovered after being administered vitamin K antidote (Bower, H. *pers comms*, 2016). Ongoing exposure also increases the risk to non target species of bioaccumulation through consumption of poisoned invertebrates.
- Significant potential for rodents on LHI to develop bait shyness or resistance to poison. Mice have already developed a resistance to warfarin on Lord Howe Island (Billings, 2000). The suite of second-generation anticoagulants, which includes Brodifacoum, is the only tool currently available for effectively eradicating rodents from islands. Resistance to these poisons, if it develops, will make eradication impossible and will greatly restrict control, meaning impacts to biodiversity will be greatly magnified.
- Ongoing potential exposure to poison for humans particularly small children and pets.

A one off, planned eradication will eliminate these risks.

2.6.3 Failure to Mitigate Rodent Impacts to World Heritage Values

As a signatory to the “Convention Concerning the Protection of the World Cultural and Natural Heritage”, Australia has agreed to:

- “identify, protect, conserve, and present World Heritage properties”; and to
- “undertake 'appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage”

A 2014 World Heritage property outlook assessment undertaken by the IUCN considered the threat to the LHIG World Heritage values from rodents as a “High Threat” and recommended implementation of the rodent REP to address the threat (IUCN, 2016).

Failure to mitigate the threat of rodents on the LHIG could potentially result in the further degradation of World Heritage values (including endemic and threatened species) and the potential for the LHIG to be inscribed on the “World Heritage in Danger List”. The World Heritage Committee has previously inscribed other World Heritage properties to the “In Danger List” as a result of invasive species impacts (UNESCO, 2009). Examples include Djoudj National Bird Sanctuary (Senegal) listed in 2000, Galápagos Islands (Ecuador) in 2007 and Río Plátano National Park (Honduras) 1996.

Inscription to the “World Heritage in Danger List” would have severe reputational consequences for Australia. As the World Heritage values contribute immensely to the island’s economy and the wellbeing of its residents any degradation of the World Heritage values would also have a severe impact on the Island’s economy.

2.6.4 Failure to Mitigate Socio-Economic Impacts of Rodents

Rodents on LHI have the following socio-economic impacts:

- Impacts on community amenity though hygiene issues and spoiling of food stuffs including locally grown fruit and vegetables.
- Impacts to the tourism industry through negative interactions with rodents or rodent control program
- Impacts to the Kentia Palm industry through predation of seeds and seedlings
- Ongoing costs of rodent control. The LHIB currently spends $85,000 per annum on its rodent control program. Many residents also implement their own rodent control at their own cost (estimated to be $4,800 per annum).
- Ongoing potential for rodent borne diseases.

Failure to proceed with the REP will ensure the continuation of socio economic impacts from rodents on LHI and failure to reap the $141M in biodiversity and tourism benefits expected from the REP Gillespie Economics, 2016).

2.7 Potential Impacts of the Project

- The proposed REP has the potential for the following environmental impacts:
- Pollution of air, soil or water
- Bioaccumulation of poison in the environment
- Mortality of non-target species due to primary poisoning from consumption of bait pellets. This is considered on an individual species level in sections below.
- Mortality of non-target species due to secondary poisoning from consumption of poisoned rodents, fish or invertebrates. This is considered on an individual species level in sections below.
- Bird strikes and collisions from helicopter activity. This is considered on an individual species level in sections below.
- Disturbance from helicopter activity. This is considered on an individual species level in sections below.
- Potential impacts as a result of handling and captive management during the captive management program. This is considered for woodhen and currawong below.
- long term changes to ecological relationships affecting threatened species following the eradication of rats and mice
- Cumulative impacts with other projects or threats.

2.7.1 Fate of the Bait and Toxin in the Environment

The Pestoff 20R bait pellets are made from compressed finely ground cereal, and are designed to break down following absorption of moisture from soil or precipitation. Baits swell, crack and then crumble over time and the rate of pellet breakdown is influenced by temperature, rainfall and invertebrate activity.

The Pestoff 20R pellets will disintegrate very rapidly, when immersed in water, with the actual rate dependant on turbulence, flow, wave and current action.

Brodifacoum itself is highly insoluble in water (World Health Organisation 1995). It is slightly soluble in water at pH 9.2 or above but solubility reduces exponentially with decreasing pH. It has an estimated solubility of <10 parts per million in fresh water at pH 7 and 20^{O} C (U.S. EPA 1998). For comparison, table salt has a solubility of 1,200,000 mg/L under similar conditions.

Note: Solubility is the determining factor for the pesticide pathway beyond the bait in soil or water. For insoluble pesticides, fate in water (and therefore plants) is insignificant because negligible amounts of poison are dissolved.

During a laboratory study the stability of radio-labelled Brodifacoum in sterile buffered water showed that the half-life of Brodifacoum at pH 7 and 9 was much longer than 30 days. A precise calculation of the half-life was not possible because the degradation seen after one day did not continue (World Health Organisation 1995).

In laboratory studies using radioactive-labelled Brodifacoum, less than 2% of Brodifacoum added to any of four soil types tested, leached more than 2 cm (WHO, 1995) suggesting it is effectively immobile.

Brodifacoum in water will settle and bind to sediments and break down slowly. This is discussed in the soil and sediments sections below.

2.7.1.1 Fate in the Air

Brodifacoum is a solid and does not readily volatise or enter the atmosphere (Toxikos, 2010).

The baits are small, solid and specifically designed for aerial application and to minimise dust. Torr and Agnew (2007) found approximately 130 - 150 g fine material (<2mm size) in a 25 kg bag of Pestoff 20R bait as delivered. They also determined the amount of fines produced by mechanical abrasion during aerial dispersion from a number of different style hoppers to be approximately 50 – 330 g per bag. Therefore the maximum amount of fine particles (<2mm) from aerial application is assumed to be 150g as delivered in bags plus 330g produced during dispersion = 480 g (rounded up to 500 g). This equates to approximately 2% of the total bait content.

At the LHI REP proposed application rate of 12 kg/ha bait (first drop) and concentration of 20 mg/kg Brodifacoum (20 ppm) this equates to 240 mg/ha of Brodifacoum. If 2% of this 240 g/ha is fines (<2mm) this equates to 4.8 mg/ha (4.8 g/10000m^2) Brodifacoum dust. At a drop height of 50m this equates to 0.0000096 mg/m^3 or 0.0000096 ug/L Brodifacoum dust in the air column. Fine Particles in the air column are expected to settle on the ground reasonably quickly.

The occupational exposure limit applied to protect workers from the effects of Brodifacoum during manufacture of rodent bait is 0.002 ug/L or (2 µg/m^3) (Syngenta 2006 cited in Toxikos 2010). Thus the maximum estimate of Brodifacoum in inhalable particulates in air during aerial broadcasting is many orders of magnitudes lower than the concentration used to protect workers so is therefore considered to present negligible risk to the environment. No air pollution is expected.

A study of dust dispersion from aerial application by spreader buckets of similar bait pellets (albeit with a different toxin) over three separate application sites was undertaken by Wright *et al* in 2002. The study sampled for downwind dust deposition at 200m intervals up to 1km of the treatment areas and showed that whilst some dust drift could occur, concentrations outside the treatment area were significantly lower than with in the treatment area. Toxikos (2010), considered potential human exposure to dust during the LHI REP treatment area assuming no wind dispersion (a worst case scenario) and found that risks to humans were negligible.

2.7.1.2 Fate in Soil

The Pestoff 20R bait pellets are made from compressed cereal, and are designed to break down following absorption of moisture from soil or rain. Baits swell, crack and then crumble over time and the rate of pellet breakdown is influenced by temperature, rainfall and microbial and invertebrate activity. Mould and fungi can appear rapidly as breakdown proceeds; once this has happened baits are less likely to be eaten by non-target species.

Baits not exposed to weathering remain toxic for a long period and any bait not exposed to weathering (i.e. in bait stations or in dwellings) will be collected approximately 100 days after the second treatment.

A condition index for assessing bait breakdown has been developed (Craddock, 2004). The index uses a 1-6 scale, based on the following conditions and illustrated in Figure 26:

- Condition 1: Fresh Pellets/Pellets not discernible from fresh bait.
- Condition 2: Soft pellets. <50% of pellet matrix is or has been soft or moist. Bait is still recognisable as a distinct cylindrical pellet; however cylinder may have lost its smooth sides. <50% of bait may have mould. Bait has lost little or no volume.
- Condition 3: Mushy Pellet. >50% of bait matrix is or has been soft or moist. <50% of pellet has lost its distinct cylindrical shape. >50% of bait may have mould. Bait may have lost some volume.
- Condition 4: Pile of Mush. 100% of bait matrix is or has been soft or moist. Pellet has lost distinct cylindrical shape and resembles a pile of mush with some of the grain particles in the bait matrix showing distinct separation from the main pile. >50% of bait may have mould. Bait has lost some volume.
- Condition 5: Disintegrating Pile of Mush: 100% of bait matrix is or has been soft or moist. Pellet has completely lost distinct cylindrical shape and resembles a pile of mush with >50% of the grain particles in the bait matrix showing distinct separation from each other and the main pile. >50% of bait may have mould. Bait has definitely lost a significant amount of volume.
- Condition 6: Bait Gone: Bait is gone or is recognisable as only a few separated particles of grain or wax flakes.

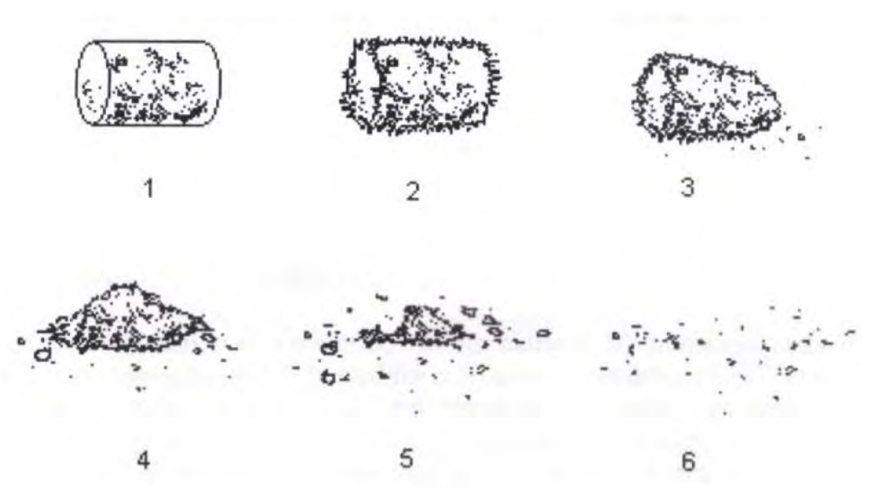


Figure 26 Illustration of typical bait condition (reproduced from Craddock, 2004)

Craddock (2004) monitored bait breakdown of 10mm pellets in a variety of habitats at Tawharanui Regional Park, north of Auckland in winter of 2003 as shown in Figure 27 below. All pellets had reached condition index score of 5.5 to 6 by 120 days.

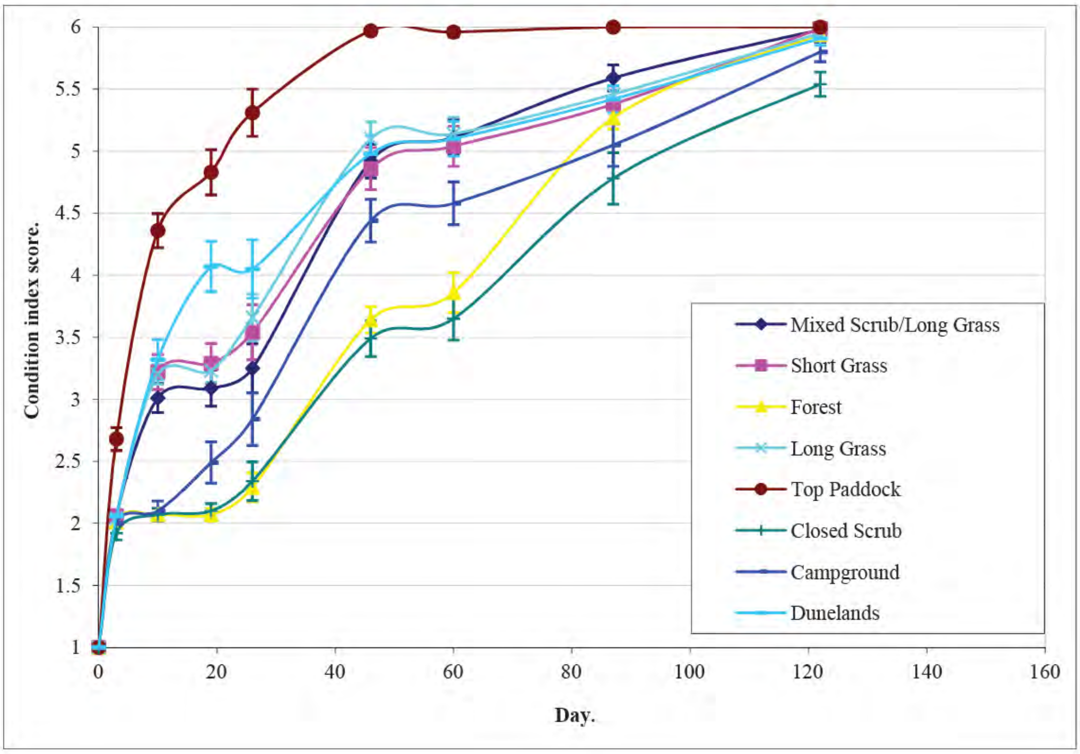


Figure 27 Bait Breakdown times of 10mm pellets (sourced from Craddock 2004)

A non-toxic bait trial using Pestoff 20R conducted on Lord Howe Island in August of 2007 examined bait breakdown and longevities in the environment (DECC, 2007a). Baits were covered with 6 mm wire mesh to prevent access by rodents or non-target species to trial baits. Cages containing 5.5 mm and 10 mm baits were placed at three locations: an open site with zero canopy cover, a medium cover site with a broken canopy and a full canopy cover site to monitor bait longevity. 100 baits were placed in each cage and samples removed at approximately weekly intervals and photographed to assess the status of the baits. Bait condition was assessed according to the Craddock (2004) condition scale described above. Results showed that both 5.5 mm and 10mm baits in all three habitats were in advanced stages of decomposition (at least Condition 4) after 55 days and 164.2 mm of rainfall. Further monitoring showed that all baits had completely disappeared after approximately 100 days.

Results of similar breakdown studies of Pestoff 20R in the environment on other temperate islands in New Zealand are shown below (Broome *et al.* 2016):

- Trials on Great Mercury island in New Zealand found that bait at 10 out of 12 bait sites monitored were completely broken down in five weeks. Baits monitored on sand dunes lasted 3 months;
- Bait monitored at Rangitoto and Motutapu Islands had disappeared completely from pasture in less than 1 month, from coastal broadleaf forest within two months and on bare lava field in ten months post baiting ;
- Baits on the Ipipiri Islands in the Bay of Islands were in the final stages of breakdown when monitored from pasture 28 days, from sand 91 days, from manuka scrub 147 days and from bare rock 203 days post baiting.

A New Zealand withholding period trial for sheep (Day, 2004), found Pestoff 20R baits degraded rapidly after placement in pasture and were severely degraded or completely gone by Day 60. Baits continued to contain some Brodifacoum for as long as they were present in the pasture, but all baits had completely disappeared by Day 90.

Although the cereal pellet disintegrates and disappears within 100 days or so, the poison takes longer to break down. Environmental factors such as temperature, rainfall, leaf litter, and presence or types of micro-organisms will determine breakdown times.

Manner of use of Brodifacoum baits and physical and chemical properties of Brodifacoum suggests little accumulation of Brodifacoum in soil, with concentrations of Brodifacoum in soil predicted to be negligible/low and occurring only sporadically according to bait treatment timings. Brodifacoum is strongly bound to soil particles, and radio-labelled Brodifacoum was found to be effectively immobile (i.e. not leached) in four soil types (World Health Organisation 1995). It is broken down by soil micro-organisms to its base components, carbon dioxide and water, the half-life being 12-25 weeks (Soil Degradation for 50% of the compound (DT_{50}) – typical 84 days: Field – 157 days; Shirer 1992).

Soil residue monitoring has been undertaken from various trials and eradication operations following the use of cereal-based Brodifacoum baits particularly in New Zealand. Soil residues have rarely been found in random sampling but have been detected from soil taken from near or under disintegrating baits. Operational monitoring reported to date suggests soil residues have fallen below detectable levels after two to six months. Results from field testing or monitoring of similar projects are shown below.

During the Little Barrier Island operation in 2004, soil samples were collected from directly under decaying Pestoff® 20R baits or where they had lain. Samples were taken 56 and 153 days after the aerial bait drop. Those in grassland areas had Brodifacoum residues of 0.2 μg/g (micrograms of poison per gram of soil) after 56 days, and 0.03 μg/g on day 153. In forested areas the figures were 0.9 μg/g on day 56 and 0.07 μg/g on day 153. These data indicate a rapid decline in Brodifacoum content in soil, with around a 90% reduction in poison levels between days 56 and 153 (Fisher *et al.* 2011).

Brodifacoum soil residues were also tested in a baiting trial conducted at Tawharanui Regional Park, Auckland. Soil samples were collected from directly beneath disintegrating baits at 56, 84, 112 and 153 days after first exposure to the elements. These samples produced residues of between 0.02 and 0.2 μg/g, with all positive samples occurring within the first 84 days; that is, no Brodifacoum was detectable in the soil immediately below baits after 84 days. The residues remained below the method detection limit (<MDL) from 110 days after the pellets were placed on the ground (Craddock, 2004).

Soil was sampled after aerial application of 10mm Pestoff 20R baits containing 20ppm Brodifacoum to the Ipipiri Islands in the Bay of Islands in June 2009. This project applied two applications of bait 20 days apart to give a combined total average application rate of 26 kg/ha. Samples were taken within 20cm of baits in three habitat types (pasture, bare rock, manuka forest). Soil samples taken 28 days following aerial application of baits contained Brodifacoum residues of 0.0016 mg/kg. Samples taken 58 days post baiting contained Brodifacoum residues of 0.002 mg/kg. Soil samples taken near baits laid in manuka scrub contained (very low) residues up to 147 days after baiting (Vestena and Walker 2010).

Analysis of bait and soil samples from Kapiti Island following an aerial application (14 kg/ha), showed only 10–30% of original levels of Brodifacoum in samples taken 3 months after the operation (Empson in Brown *et al.* 2006).

No residues of Brodifacoum were detected in soil samples taken from Lady Alice Island before, and then 2, 12, 34 and 210 days after an aerial poisoning operation using Talon □20P cereal pellets
1994 (Ogilvie *et al.* 1997).

Morgan and Wright (1996a) reported no Brodifacoum residues were detected in eight topsoil samples taken one month following the aerial application of Talon □ 20P cereal pelle
islands in October 1992.

An accidental release of 700kg of Pestoff 20R bait into a 30ha freshwater lake in Fiordland was monitored for a month. No residual Brodifacoum was detected in samples of sediment (*n*=16) (Fisher *et al.* 2012).

The manner of use of Brodifacoum baits and physical and chemical properties of Brodifacoum suggests little accumulation of Brodifacoum in soil. Concentrations of Brodifacoum in soil are predicted to be negligible/low and occurring only sporadically according to bait treatment timings. Brodifacoum would not be expected to leach in soil and no mobile degradation products are produced. Brodifacoum strongly binds to soil particles and is slowly broken down by microbial activity with a half-life of 12-25 weeks (Shirer 1992).

The low-moderate application rate of Brodifacoum for the LHI REP (0.4g / ha) and one off eradication means that any soil contamination and bioaccumulation would be of a sufficiently low magnitude as to not present a significant risk.

Breakdown of baits and Brodifacoum levels in soil will be monitored after the LHI REP.

Bait breakdown will be monitored at established monitoring and random sites using the Craddock Condition Index described above at approximately 30 day intervals until complete disintegration.

Post operational soil samples will be collected to monitor residues of Brodifacoum in the soil. Representative samples will be collected from directly below some toxic bait and at control sites away from bait pellets. Soil samples will be collected approximately 30 days after bait disintegration and approximately every two months (if required, dependant on results). All tests will be conducted at a NATA accredited analytical laboratory.

2.7.1.3 Fate in Fresh Water

The Pestoff 20R pellets will disintegrate very rapidly when immersed in water, dependant on turbulence, flow, wave and current action. The presence and type of sediment layers in a waterway will also affect the degradation of Brodifacoum in aquatic environments as will temperature, pH, volume, or presence or types of micro-organisms.

Brodifacoum is practically insoluble in water (WHO 1995), and leaching from soil into water is unlikely to occur. Erosion of soil might lead to Brodifacoum entering water bodies, where it is likely to be strongly bound to organic material and settle out in sediments (Eason and Wickstrom 2001). Brodifacoum degrades slowly in natural waterways. Where baits have been sown directly into waterways during other baiting operations worldwide, Brodifacoum residues have rarely been detected in water samples.

Due to the low solubility of Brodifacoum, detection of residues in fresh water after aerial and hand distribution of Pestoff 20R baits is extremely rare, despite at least 324 samples analysed over 11 operations (Broome *et al.* 2016).

The only residues of Brodifacoum which have been detected in water bodies following pest control operations in New Zealand come from a single sample of stream water collected 24 hours after bait application and within 20cm of baits in the stream bed. This sample measured 0.083ppm and was one of 12 samples taken within a week of aerial application of 10mm Pestoff 20R baits containing 20ppm Brodifacoum to the Ipipiri Islands in the Bay of Islands in June 2009. Three of the four stream water samples taken within 24 hours of bait application had no measurable residues (MDL 0.02ppb) (Vestena and Walker 2010). 25 Samples of drinking water taken from 13 tanks (covered or disconnected from roofs during the operation) and one bore over a two month period showed no Brodifacoum residues (MDL 0.02ppb) (Vestena and Walker 2010).

Pestoff 20R baits containing 20ppm Brodifacoum were applied in three aerial applications on Rangitoto and Motutapu Islands during the winter of 2009. In total about 38 kg/ha was applied to the islands over the three drops. Roof water collection systems were disconnected before baits were applied and roofs cleared of any baits afterwards. Four drinking water samples were taken about two months following the last bait application and tested for Brodifacoum residues. None were found (MDL 0.00002 mg/l) (Fisher *et al.* 2011).

During the 2004 Hauturu rat eradication, 8 water samples were taken directly downstream from Pestoff 20R baits lying in stream beds within 24 hours of the aerial drop. Brodifacoum was not detected in any of the samples taken (Griffiths, 2004). Samples tested from bore water on the island did not detect any Brodifacoum.

Two fenced ‘cells’ on Maungatautari (35 ha and 65 ha) each received two bait drops of Pestoff 20R Brodifacoum cereal bait in September and October 2004. 15 kg/ha was applied on the first drop and 8 kg/ha in the second. The area (c.8 ha) immediately around the inside of both cell fences was hand spread. A total 217 stream water samples were taken from 4 streams flowing out of the poison area. In each stream, samples were taken at the fence boundary and again 800 metres downstream. Time intervals post each drop for taking samples were 1hr, 2hrs, 3hrs, 6hrs, 9hrs, 12 hrs, 24hrs, 48hrs, 72hrs, 2 weeks, 3 months. No sample analysed detected Brodifacoum. The minimum detection level for these samples was 0.00002 mg/l (Fisher *et al.*2011.).

None of the seven water samples taken after bait application contained detectable residues of Brodifacoum (MDL 0.07ug/l) during the 2011 Macquarie island Eradication Project (Broome *et al.* 2016).

An accidental release of a box containing 700kg of Pestoff 20R bait by a helicopter flying over a 30ha freshwater lake in Fiordland was monitored for a month. No residual Brodifacoum was detected in samples of lake water (*n*=27) (Fisher *et al.* 2012).

In an isolated case, testing of liver and gut contents from two eels found dead in a Southland (NZ) waterway (Tomoporakau Creek, Branxholme) in May 2012, measured 0.095 ppm Brodifacoum in the gut contents of one eel (noting that other anticoagulants were not tested for). This suggests that the eel had recently ingested food containing Brodifacoum, probably through scavenging the carcass of a poisoned possum. There was a bait station approximately 100 metres from the location where a possum and eels (*n*=13) were found dead in the water (Fisher, 2013).

Laboratory studies using radioactive-labelled isotopes have shown that it is effectively immobile (i.e. not leached) in the soil (WHO 1995). It is strongly bound to soil particles; therefore contamination of ground water is not expected to occur.

Drinking water on LHI is primarily sourced from rain water tanks in the settlement area on LHI. Aerial application of baits will not occur in the settlement area and buffer zones from roofs and rainwater tanks will be established through individual Property Management Plans. There are a small number of bores on the island and covering of bores will also be discussed with individual owners. A small number of ephemeral streams are found on LHI. It is anticipated that a small amount of pellets may fall into these streams as part of the aerial distribution where they will sink and disintegrate rapidly. The Brodifacoum from these pellets will settle and bind strongly to sediments. The low-moderate application rate of Brodifacoum (0.4 g/ ha) for the LHI REP and one off eradication means that any environmental contamination would be of a sufficiently low magnitude as to not present a significant risk.

Random sampling will be conducted on water bodies on the island to monitor Brodifacoum levels after the bait drop. Water samples will be collected within 2 days of each bait drop and approximately weekly (if required, dependant on results). All tests will be conducted at a NATA accredited analytical laboratory. As a precaution tourists and residents will be advised not to drink from streams until laboratory testing confirms absence of detectable Brodifacoum. Supplementary water for people climbing Mount Gower will be provided during the eradication. Testing of resident’s water tanks and groundwater bores will be undertaken if requested on a case by case basis.

2.7.1.4 Fate in the Marine Environment

Bait will not be intentionally applied to the marine environment however when Brodifacoum pellets are applied aerially to islands in attempts to eradicate rodents, all terrestrial habitats which may harbour rodents must receive bait. In achieving this it is often the case that a small quantity of bait enters the marine environment near the shore. On LHI it will be impossible to collect these baits.

Howald *et al.* (2005) investigated how much bait entered the water when applied aerially to steep cliffs. The bait was applied with a spreader bucket and deflector arm at the rate of 15 kg/ha. SCUBA divers were used to count bait pellets on the sea floor and to observe the behaviour of marine organisms that encountered the baits. Boat- and island-based observers reported that no bait was directly spread into the ocean but a small amount of bait was seen to enter the water as a result of bouncing off the cliff faces (ibid). The divers counted a mean of 72 baits (range: 69-75) over 500 metres, at a 1-4 m depth on the ocean floor. No fish or other animals were observed feeding on the baits. This would equate to less than 0.5% of baits out of the approximate 15,000 baits applied over that area.

Empson and Miskelly (1999) investigated the fate of pellet baits, which fell into the sea as part of the Kapiti Island rat eradication. Non-toxic baits were dropped into the sea about 30 m offshore to a depth of 10 m and monitored by a diver. The bait disintegrated within 15 minutes. On the assumption that accidental discharges were likely to occur only in the coastal fringe, Empson and Miskelly (1999) concluded that it was unlikely that baits would withstand wave action and remain intact for more than a few minutes.

During the LHI REP it is expected that similar rapid disintegration of pellets will occur where pellets fall into the open ocean exposed parts of the coastline. With less wave action in the lagoon, pellet breakdown may take slightly longer in this environment. Bait entry into the lagoon will be minimised by hand baiting along the lagoon foreshore and through the use of the deflector arm on the spreader bucket. Trickle bucket option will also be used in areas where a thin line of bait application between 5-10m is required. This will be undertaken by removing the spinner from the bait bucket and allowing bait to be distributed via the selected aperture on the bucket.

Monitoring undertaken for similar projects has shown that of a total of 38 seawater samples analysed following three operations, none of the samples showed detectable Brodifacoum (Broome *et al.* 2016).

None of 12 seawater samples taken (within 20 cm of where baits had fallen) during the Ipipiri rodent eradication project in 2009 showed measurable residues of Brodifacoum (MDL 0.02ppb) (Vestena and Walker 2010).

None of 18 seawater samples taken from near Rat Island in Alaska following aerial application of baits showed measurable residues of Brodifacoum (MDL 0.02ppb) (Buckelew *et al.* 2009).

Sampling of the marine environment following application of Brodifacoum cereal baits at 15 kg/ha on Anacapa Island in California during 2001 and 2002 found no detectable residues in 8 seawater samples taken following baiting (Howald *et al.*2010). Four of these samples were taken within 24 hours of baiting and the remainder 1 month after.

In 2001 a truck crashed into the sea at Kaikoura spilling 18 tonne of Pestoff 20R (20 mg/kg Brodifacoum) cereal pellets into the water. Measurable concentrations of Brodifacoum were detected in seawater samples from the immediate location of the spill within 36 hours but after 9 days the concentrations were below the level of detection (0.02 µg/L). (Primus *et al.* (2005).

The low-moderate application rate of Brodifacoum (0.4 g/ ha) for the LHI REP, low solubility, high dilution factor in the marine environment and one off eradication mean that any sea water contamination would be of a sufficiently low magnitude as to not present a significant risk to marine life or humans through any activity (including swimming or snorkelling).

Additionally significant mitigation through the use of the deflector arm on the spreader buckets, hand baiting within the Lagoon foreshore area and only baiting above the high water mark will minimise bait entry into the water. No seawater samples will be analysed for Brodifacoum after the LHI REP.

It is reasonable to expect that breakdown in marine sediments, would occur similar to soil. Operational monitoring of marine sediment samples taken after application of baits in the 2009 Ipipiri eradication project found that one of 12 samples had detectable residues (MDL 0.001ppm). This sample was taken 24hours after bait application. All samples were taken from within 20 cm of baits.

The low-moderate application rate of Brodifacoum (0.4 g/ ha) for the LHI REP, high dilution factor in the marine environment, and one off eradication mean that any contamination of marine sediment would be of a sufficiently low magnitude as to not present a significant risk.

Additionally significant mitigation through the use of deflector buckets, hand baiting within the Lagoon foreshore area and baiting only above the high water mark will minimise bait entry into the water. No marine sediment will be analysed for Brodifacoum after the LHI REP.

2.7.1.5 Fate in Plants

Brodifacoum is strongly bound to soil particles and practically insoluble in water, therefore it is not likely to be transported through soils and into plant tissues. It is not herbicidal.

Sampling of grasses (Poaceae) collected 6 months following application of Brodifacoum cereal baits at 15 kg/ha on Anacapa Island in California during 2001 and 2002 found no detectable residues in the six samples tested (Howald *et al.* 2010).

A literature search failed to find published or verified unpublished data regarding plant uptake or persistence. However it should be noted to no impacts to vegetation have been recorded from over 380 eradication attempts globally.

Cereal forming the bait matrix has been crushed, screened and heat treated so there is no possibility of the cereal in the bait germinating on Lord Howe Island or spreading pathogens.

The proposed REP is unlikely to have a significant impact on vegetation on the island. Conversely the eradication of rodents is likely to have significant benefits to a range of individual plant species and many vegetation communities through increases in the abundance of plants, seeds and seedlings, thereby enhancing the process of forest regeneration.

2.7.2 Bioaccumulation

Brodifacoum has been shown to bio-accumulate in mammals, birds, invertebrates and fish following repeated sub-lethal exposures. The low-moderate application rate of Brodifacoum for the LHI REP (0.4g / ha) and one off eradication means that any bioaccumulation would be of a sufficiently low magnitude as to not present a significant risk. Bioaccumulation potential in invertebrates and fish / aquatic organisms is discussed below.

2.7.2.1 Bioaccumulation in Terrestrial Invertebrates

Brodifacoum is not expected to have significant effects on invertebrates as they have different blood clotting systems to mammals and birds. Trials and operational monitoring conducted during rodent eradications in NZ so far have shown few invertebrate species are at risk of primary poisoning, and deleterious effects on arthropod, annelid, and mollusc populations have been rarely detected (Booth *et al.* 2001; Booth *et al.* 2003; Craddock 2003; Brooke *et al.* 2011; Bowie and Ross 2006). Several studies have demonstrated significant increases in invertebrates numbers following rodent eradication (Booth *et al.*2001, Green 2002, and Green *et al.* 2011).

Observations of baits in the field during non-toxic bait trials conducted on LHI in 2007 showed invertebrate damage occurred within a day of the bait drop. Several species of invertebrates were scanned externally with UV light to determine if they had ingested bait. Slugs and one snail (not Placostylus) fluoresced brightly indicating bait uptake, whilst ants, cockroaches, termites and millipedes did not show any fluorescence even though ants and cockroaches were observed feeding directly on bait (DECC, 2007a).

Similarly bioaccumulation in terrestrial invertebrates has shown to be in low concentrations and short lived in similar eradication operations. Invertebrates appear to metabolise or excrete residues rapidly at first but may retain trace amounts for several weeks.

When large-headed tree weta (*Hemideina crassidens*) were dosed with 15 µg/g Brodifacoum (equivalent to consumption of a 6g Talon® 20P pellet), Brodifacoum persisted in the weta for a maximum of four days (Morgan *et al.* 1996). Booth *et al.* (2001) dosed tree weta at 10ug/g to evaluate the persistence of Brodifacoum over time. Four days after dosing, Brodifacoum residues had declined to below the limit of detection (0.02ug/g).

Brooke *et al.* (2013) studied the persistence of Brodifacoum in cockroaches and woodlice. In the first experiment cockroaches captured on Henderson Island were allowed to feed on Pestoff 20R pellets containing 20ppm for 4 days. Brodifacoum residues declined quickly in the first 24 hours followed by a gradual decline for the remaining 11 days of the experiment. By day 12 mean concentrations were 0.061ug/g. One cockroach collected in a control group before the treatment group were fed baits had a detectable Brodifacoum residue (below MLOQ) presumed to be from exposure to bait laid on the island 2 months previously. In a second experiment using cockroaches and woodlice, samples were tested for up to 42 days after access to Brodifacoum pellets (Pestoff 20R) was removed. Again depletion of Brodifacoum residues was rapid in the first two weeks followed by a long period of slow decline. Seven of 10 animals tested on day 35 contained measurable residues. By day 42 seven of 10 animals contained residues at a mean level of 0.02ug/g (Brooke *et al.*2013). This level is 1000 times less than the concentration of baits they fed on.

Craddock (2003a) fed captive locusts (*Locusta migratoria*) Pestoff possum baits containing 0.02 g/kg Brodifacoum and tested them for residue at 1,2,3,4,5,10 and 15 day intervals. The test group exposed for 72 hours were observed eating bait but only 2 of the 7 samples had detectable residues of Brodifacoum 3 to 4 days after dosing. Another test group exposed for 144 hours had no detectable residues. A bio-tracer experiment found the dye became undetectable 7 days after dosing. Craddock concluded that on average 48 hours of exposure gives a concentration of 0.41 ug/g which drops below the detection limit of 0.06 µg/g after 3 days.

Craddock (2003) sampled live invertebrates captured around bait stations using cereal pellets containing 20ppm Brodifacoum. He found weta, cockroaches and beetles up to 10m from a bait station contaminated with Brodifacoum residues. The highest residue levels (up to 7.47 ug/g) were closer to the bait stations and soon after they were filled with bait. After toxic bait had been removed from bait stations, residue levels in invertebrates took in excess of 4 weeks to return to background levels. Trace levels of Brodifacoum were still detectable up to 10 weeks after bait had been removed.

On Red Mercury Island, invertebrates were collected after the aerial application of Brodifacoum baits, and were analysed for Brodifacoum residue. No such residue was found in 99% of the sample (Morgan *et al.* 1996).

On Lady Alice Island, tree-weta and cockroaches were collected in the days and weeks after aerial baiting and tested for Brodifacoum; none was detected. A cave-weta and beetles found on the baits were also tested. No Brodifacoum was detected in the beetles, but was found in this weta (Ogilvie *et al.* 1997). Similar testing was done after the aerial application of Brodifacoum on Coppermine Island. In this instance no residues were found in the weta or beetles, or in the ants and weevils that were found on the baits, but residues were found in cockroaches (G.R.G. Wright cited in Booth *et al.* 2001). Non-target insects and millipedes in the Seychelles Islands consumed Brodifacoum bait with no apparent adverse effects.

Significant bioaccumulation in terrestrial invertebrates is not expected with the proposed LHI REP given the one off nature of the eradication, the relatively low dose and short timeframe in which bait will be available. Conversely the eradication will permanently remove the use of rodenticides including Brodifacoum on the island from the current control program.

2.7.2.2 Bioaccumulation in Terrestrial Vertebrates

Laboratory studies and field monitoring have shown that Brodifacoum can bio accumulate in terrestrial vertebrates and is very persistent in the livers of most sub-lethally exposed animals, (up to nine months in some cases). However short-term sub-lethal exposure is not expected to have any significant adverse effects. Brodifacoum residues have been detected in tissues of animals during the monitoring of field distribution, but not always associated with mortality or evidence of haemorrhage. Non-target deaths have been documented in eradication programmes. However, most incidences have involved low numbers and the affected species have recovered quickly to pre-eradication population levels, or higher, once invasive rodent species has been removed (Broome *et al.* 2016).

Nine months after 15kg/ha Talon® 20P pellets were aerial sown on Red Mercury Island in 1992 six blackbirds were sampled. The livers of all six birds contained low levels of Brodifacoum (0.004 to 0.2 mg/kg) (Morgan *et al.* 1996)

After rat eradication on Langara Island (British Columbia) bald eagles (*Haliaeetus leucophalus*) were sampled for Brodifacoum residues and prothrombin time evaluation. Three out of the 20 eagles examined had been recently exposed to Brodifacoum, but none were suffering from clinical anticoagulation (Howald *et al.* 1999).

Native birds have been sampled on two occasions following the use of Brodifacoum during pest control operations in New Zealand. In 1995, four months after Brodifacoum was used in bait stations at Mapara Wildlife Management Reserve, King Country, 14 native birds (five tomtits, five whiteheads, one bellbird, one fantail, one Australasian harrier and one morepork) were sampled for Brodifacoum residues. Only the morepork contained residue. Four robins were sampled for Brodifacoum residues in Waipapa, Pureora Forest Park, two months after Brodifacoum was used in bait stations in 1997. None of the birds had Brodifacoum residues (Murphy *et al.* 1998).

One month after being exposed to Pestoff rodent blocks containing 0.02 g/kg Brodifacoum two plague (rainbow) skinks had liver residues of 0.005 and 0.01 µg/g (Wedding 2007).

Two Duvaucel's geckos (*Hoplodactylus duvauceli*) found in traps were tested for Brodifacoum residues. One of the geckos had 0.007 mg/kg residue in its liver. Brodifacoum had been used in the area in bait stations up until two years prior to the gecko being caught (Vertebrate Pest Record Database 11938 cited in Broome *et al.* 2016).

Mourning gecko (*Lepidodactylus lugubris*) and common house gecko (*Hemidactylus frenatus*) samples were collected live following aerial application of Bell Labs 25w bait on Palmyra Atoll. Although showing no clinical signs of poisoning, 14 of the 24 samples were found to contain Brodifacoum residues, indicating that they were exposed (Pitt *et al.* 2012).

Significant bioaccumulation in terrestrial vertebrates is not expected with the proposed LHI REP given the one off nature of the eradication, the relatively low dose and short timeframe in which bait will be available. Conversely the eradication will permanently remove the use of rodenticides including Brodifacoum on the island from the current control program.

2.7.2.3 Bio-accumulation in fish/aquatic organisms

Whilst Brodifacoum can bio-accumulate in fish and aquatic organisms from repeated exposure and may cause long term effects in the aquatic environment (Tomlin, 2009), there is limited evidence of marine vertebrates or invertebrates being adversely affected by Brodifacoum poisoning during rodent eradication projects.

Fish potentially killed by Brodifacoum poisoning have been observed on only a very few occasions and a few studies have found residues in live fish shortly after bait application. Where tissue samples have been separated, this contamination has been confined to livers. Further sampling of these sites indicate residues are not long lasting (Broome *et al.* 2016). Results from operational monitoring of similar projects are detailed below.

Following aerial application of baits on Ulva Island near Stewart Island (NZ) in 2011, fish were sampled 10 days after a final bait application (i.e. 43 days after first bait application). No residues were detected in the flesh of blue cod (*Parapercis colias*) (30 individuals combined into 6 samples), trumpeter (*Latris lineata*) (10 individuals combined into 2 samples), spotties (*Notolabrus celidotus*) (18 individuals combined into 4 samples), girdled wrasse (*Notolabrus cinctus*) (1 individual, 1 sample) (MDL 0.001ppm) (Masuda *et al.*2015). However 2 of 6 blue cod liver samples (30 individuals) taken at the same time were found to contain 0.026 and 0.092ppm. A further 20 blue cod (4 samples) were tested 1 month after final bait application (77 days after first bait application) and no residues were found in either flesh or liver (MDL 0.001ppm) (Masuda *et al.*2015). Four months after bait application 20 blue cod (4 samples) were again tested and none showed detectable residues in liver or flesh (Masuda *et al.*2015). In the same operation marine invertebrates were sampled 10 days after final bait application. 85 mussels (*Mytilus edulis*) were collected from 3 sites. These were batched to form 9 mussel samples. Three samples had residues ranging from 0.003ppm to 0.022ppm. Two of 8 limpet *(Cellana ornata*) samples (50 individuals) had detectable residues (0.002 and 0.016ppm). Both pipi samples (20 individuals), all 3 paua (*Haliotis iris*) (15 individuals), all 3 kina (*Evechinus chloroticus*) (15 individuals) samples and one cockle sample (7 individuals) had no detectable residues (MDL 0.001ppm). Five further mussel samples (50 individuals) were tested one month after final bait application and none were found to have detectable residues. However two of the 6 limpet samples (50 individuals) tested at this time had residues very close to the MDL of 0.001 ppm. Further testing of limpets and mussels was done 4 months after final bait application (i.e. 176 days after first bait application) resulting in one of 6 mussel samples (50 individuals) with detectable residue (0.018ppm). All 6 limpet samples (50 individuals) had no detectable residues. Further testing of limpets and mussels was undertaken 8 months after the bait application. Four limpet and 4 mussel samples taken from 2 sites had no detectable residues (MDL 0.001ppm) (Masuda *et al.*2015).

Following aerial application of baits on Shakespeare Open Sanctuary north of Auckland a large marine monitoring programme was undertaken, collecting 206 samples of 33 marine taxa from 4 sites before and after baiting. Among these samples were 2 blue cod, 1 parore (*Girella tricuspidata*), 1 spotty, 1 triple fin (*Forsterygion varium*), 1 moki (*Latridopsis ciliaris*), and 1 snapper (*Chrysophrys auratus*) taken 1 or 8 days after bait application. No detectable residues were found in any of the fish samples (MDL 0.001ppm). Samples were also collected for Pacific oysters (*n*=7), crayfish (*Jasus edwardsii*) (*n*=2), cushion star (*Asterina spp.*) (*n*=2), shrimps (*n*=1), kina (*n*=2), cockles (*Austrovenus stutchburyi*) (n=2), whelks, crab and sea cucumber (*Stichopus spp*). One of the post bait application samples catseye (*Turbo smaragdus*) had detectable residues (0.006ppm).

Interestingly one sample of catseye and one oyster sample taken before any bait was laid had low levels of Brodifacoum (0.009ppm and 0.002ppm respectively). However on re-testing the catseye sample remained below and the oyster sample equal to - the limit of detection (0.001ppm) (Maitland 2012).

Following the aerial application of baits (18 kg/ha over 2 applications) on Taranga (Hen) Island in Northland (NZ) in 2011, 4 samples each containing 3 crayfish were taken from near shore rocks. The selected sample collection sites were also adjacent to where two streams, draining the largest island catchments, entered the marine area. Two samples were collected 25 hours and two samples nine days after bait application. No residues were detected (MDL 0.0005ppm). During the same project 4 samples each containing 3 kina were similarly collected with no detectable residues (Broome *et al.* 2016).

Baits containing 20ppm Brodifacoum were applied in three aerial applications on Rangitoto and Motutapu Islands (NZ) during the winter of 2009. In total about 38 kg/ha was applied to the islands over the three drops. Five dolphins (*Delphinus spp*), a number of pilchards (*Sarditlops neopilchardus*) (tested as one sample) and nine little blue penguins found dead around the Hauraki Gulf at the time of the operation were also tested for residues. Only 3 of the penguins contained detectable residues of Brodifacoum but all of the birds necropsied showed no evidence of anticoagulant poisoning and starvation was considered the most likely cause of death (Fisher *et al.* 2011). Ten pipi and ten mussels collected three weeks following the final drop were tested for Brodifacoum residues. None were found (MDL 0.001 ppm) (Fisher *et al.* 2011).

A field trial was also conducted to examine the fate of Talon® 20P cereal pellets dropped into the sea at Kapiti Island (NZ) and any consumption by fish. Non-toxic baits disintegrated within 15 minutes and spotties, banded wrasse (*Notolabrus fucicola*) and triple fins were observed eating the bait. In subsequent aquarium trials blue cod, spotty and variable triple fin were fasted for 24 hours before being exposed to Brodifacoum cereal pellets for 1 hour. The fish were moved to a clean tank and held for 23-31 days, then killed and analysed. Six of 24 triple fins exposed to bait died although none were observed eating bait and no residue was detected in their livers. Of 30 spotties, six ate toxic bait and one died of Brodifacoum poisoning. Two other spotties which died were not observed eating bait but showed clinical signs of poisoning. It is thought the poison was absorbed through gills or skin. This is unlikely to happen in the sea given wave action and dilution (Empson and Miskelly 1999). There was no evidence of a population decline in spotties as a result of the aerial application of Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha on Kapiti Island, based on surveys conducted before and after the poison drops (Empson and Miskelly 1999).

In 2001 a truck crashed into the sea at Kaikoura (NZ) spilling 18 tonne of Pestoff 20R (20 mg/kg Brodifacoum) cereal pellets into the water. A butterfish (*Odax pullu*) sampled 9 days after the spill had Brodifacoum residues of 0.040 ppm in the liver, and 0.020 in the gut, although muscle tissue was below the MLD (0.020ppm). Residues in a scorpion fish (*Scopaena sp*.), two herring (*Sprattus* spp.) and an unknown species of fish collected between day 14 and 16 were all <0.020 ppm. Samples taken from two seals (*Arctocephalus forsteri*), two black backed gulls (*Larus dominicanus*) and a shag (*Phalacorcorax* spp.) found dead in the area following the spill contained no detectable Brodifacoum levels, and necropsies found no signs of anti-coagulant poisoning (Primus *et al.* 2005). Samples of mussels and paua taken from the immediate location retained measurable residues for up to 31 months. This result was probably confounded by the animals being re- exposed to Brodifacoum bait particles through wave action. Effects of the spill were only measurable within a $100m^2$ area surrounding the crash site (Primus *et al.* 2005)

Two of 5 pipi (*Paphies australis*) samples taken within 72 hours of aerial application of baits containing 20 ppm Brodifacoum to the Ipipiri Islands in the Bay of Islands (NZ) in 2009 were found to have low levels of Brodifacoum. Four mussel (*Perna canaliculus*) samples taken from the site at the same time were clear and nothing was detected in a further 4 pipi and 3 mussel samples taken at 1 and 2 months post bait application (MDL 0.001ppm). Samples in this study were deliberately taken from within 20cm of baits (Vestena and Walker 2010).

On tropical Palmyra Atoll non-toxic baits were dropped into four marine environments to observe the reactions of the marine species present. Baits placed on exposed tidal flats had no interest shown in them by the species present (fiddler crabs, bristle-thighed curlews and Pacific golden plover). In shallow (1m depth) water fish showed no interest in the first pellets entering the water. However on following occasions 3 species did eat baits. In moderate depth (3m) trials, 2 species took baits falling through the water and in deep (10m) water trials, 1 species was seen to mouth baits but consumption could not be confirmed. In total six of 20 species observed showed interest in the baits (Alifano and Wegmann 2010). In the same study crabs were held in captivity and fed Bell Labs 25W pellet baits containing Brodifacoum for 7 days followed by a natural diet. Crab excrement was collected daily and analysed for Brodifacoum content. Results indicated that Brodifacoum levels climbed over the first couple of days but then levelled out and fell to low levels within 3 days of the crabs moving off their bait diet to natural food. However traces (0.25ppm) could still be found 16 days after the pellet diet ended. Crabs did not appear to be affected by the toxin (Alifano and Wegmann 2010).

Nine of ten black spot sergeant fish (*Abudefduf sordidus*) collected live following aerial bait application of Bell Labs 25w bait on Palmyra Atoll were found to contain residues ranging from 0.05 to 0.315 ppm (whole fish). Two applications of bait (80 kg/ha and 75 kg/ha) were applied about 10 days apart. Fish samples were collected shortly after the second application. A number of mullet (*Liza vaigiensis* and *Moolgarda engeli*) and a single puffer fish were found dead after this application and were found to contain residues ranging from 0.058 to 1.16

ppm. Interestingly, over half the residue results from the dead mullet samples were within the range of residues found in the live sergeant fish (Pitt *et al.* 2012). All hermit crab samples collected soon after baiting contained residues with levels ranging from 0.134 to 1.58 ppm less than 5 days after baiting. By the 3rd sampling period (22-25 days post first bait application) one of 5 samples had no detectable residues, and by the 4th sampling period (6 weeks after the last baiting) only one sample had detectable residues (MLD<0.018). Aquatic fiddler crabs were also collected during this study and showed similar results (Pitt *et al.* 2015)

A range of fish species were tested for Brodifacoum contamination following the aerial application of baits (Bell Labs 25W) to Wake Atoll in the mid Pacific in 2012. Forty-two samples from six species collected from 7 sites around the island were tested. Five samples returned results above the MDL of 0.001 ug/g, ranging from 0.002 to 0.005 ppm. Because the fish (papio trevally and blacktail snapper) were tested whole, it is likely that the contamination measured was in the gut of the fish (R. Griffiths pers com. in Broome *et al.* 2016).

Sampling of the marine environment following application of Brodifacoum cereal baits at 15 kg/ha on Anacapa Island in California during 2001 and 2002 found no detectable residues in 26 tide pool sculpins (*Oligocottus maculosus*) which are small fish found in the intertidal zone (Howald *et al.* 2010). Sampling found no detectable residues in marine invertebrate fauna collected 15, 30 and 90 days following bait application (Howald *et al.* 2010). Included in these samples were 6 hermit crabs, 1 limpet, 22 mussels, 42 shore crab (*Pachygrapsus spp*) and 10 sea urchins.

Following aerial application of baits on Kaikoura Island near Great Barrier Island (NZ) in 2008 two samples were taken from a nearby mussel farm and tested for residues. None were found (MDL 0.001ppm) (VPRD 11421, 11422 cited in Broome *et al. 2016*).

Following aerial application of baits on Hauturu (Little Barrier) Island in the Hauraki Gulf (NZ) in 2004, two paua and two scallop (*Pecten novaezelandiae*) samples (each consisting of about 4 animals) were taken from near the island and tested for residues. None were found (MDL 0.001ppm) (Fisher *et al.* 2011).

Following the aerial application of baits on Motuihe Island in the Hauraki Gulf in 1997 two Pacific oyster (*Crassostrea gigas*) and 4 mussel samples were tested for residues. The oysters and 3 of 4 mussels had no residues detected (MDL 0.01ppm). One mussel sample had 0.02 ppm Brodifacoum, perhaps because a toxic bait was deliberately dropped into the rock pool it was living in (Fisher *et al.* 2011).

The low-moderate application rate of Brodifacoum (0.4 g/ ha) for the LHI REP, high dilution factor in the marine environment, and one off eradication means that the risk of bioaccumulation in local marine species would be of a sufficiently low magnitude as to not present a significant risk. The amount of Brodifacoum assimilated into the marine environment will be an extremely small fraction of (many orders of magnitude lower) the concentrations known to be toxic to fish (Empson, 1996).

Additionally significant mitigation through the use of deflector buckets, handing baiting within the Lagoon foreshore area and baiting above the high water mark will minimise bait entry into the water.

2.8 Alternatives Considered

Three alternative scenarios that have been considered are discussed below. These include:

- doing nothing
- continuing the current rodent control program
- eradication of rodents.

2.8.1 Do Nothing Scenario

The devastating impacts of introduced rodents on offshore islands around the world are well documented. The presence of exotic rodents on islands is one of the greatest causes of species extinction in the world (Groombridge 1992). Ship rats alone are responsible for the severe decline or extinction of at least 60 vertebrate species (Towns *et al.* 2006), and currently endanger more than 70 species of seabird worldwide (Jones *et al.* 2008). They suppress plants and are associated with the declines or extinctions of flightless invertebrates, ground-dwelling reptiles, land birds and burrowing seabirds (Towns *et al.* 2006). Mice have also been shown to impact on plants, invertebrates and birds (Angel *et al.* 2009).

Rats and mice prey heavily on birds, bats, reptiles, snails, insects and other invertebrates. The ship rat is known to eat seeds and other plant material, fungi, invertebrates, small vertebrates and eggs (NSW Scientific Committee 2000 in DECC 2007). Rats prey on the eggs and chicks of land birds and seabirds, and can cause major declines in these species (Merton *et al.* 2002). Mice eat the eggs and chicks of small bird species such as storm-petrels, but are also capable of killing chicks of birds as large as albatrosses.

Rats and mice consume vast quantities of seeds, flowers, fruits, foliage, bark and seedlings. This severely reduces seedling recruitment which changes the characteristics of native vegetation communities (Rance 2001; Shaw *et al.* 2005; Brown *et al.* 2006; Athens 2009; Meyer and Butaud 2009; Traveset *et al.* 2009). The impact that rats have on the regeneration of plants on islands is often not fully appreciated. After rats were removed from the Chetwode Islands, New Zealand, there was a twenty-fold increase in seedling numbers and a seven-fold increase in the diversity of plant species (Brown 1997a).

One of the indirect impacts of rats on islands is the loss of nutrients. Rats kill seabirds and this leads to a reduction in the amount of nutrients available from guano, regurgitations and failed eggs. These losses can profoundly affect the health and condition of forest ecosystems (Holdaway *et al.* 2007), as has happened on Norfolk Island after the loss of the Providence petrel (*Pterodroma solandri*).

Mice probably arrived on LHI by the 1860s. Rats arrived in 1918. Rats are implicated in the extinction of five endemic bird taxa (species or subspecies), at least 13 species of endemic invertebrates on LHI including two endemic land snails (Ponder, 1997) – *Epiglypta howinsulae* and a sub-species of *Placostylus bivaricosus* and 11 beetles. While many of these extinctions occurred within only a few years of rats arriving, the detrimental effect of rodents on the island's plants and animals is ongoing. They are also a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities, and three species of threatened invertebrates on LHI that are currently threatened because of the presence of exotic rats (DECC, 2007). Another four species of land snails have subsequently been added to this list.

Two seabirds – white-bellied storm-petrel (*Fregetta grallaria*) and Kermadec petrel (*Pterodroma neglecta*) – that once bred on the main island are now restricted to breeding on smaller, rat-free islands within the LHI Group. They were last recorded breeding on the main island by Roy Bell in 1913-1915, just prior to the introduction of rats. The Kermadec petrel nests above ground, where it is highly vulnerable to rat predation. The small size of storm-petrel adults, nestlings and eggs make them especially vulnerable to predation by rats.

The consumption of seeds and invertebrates by rats reduces the amount of food available to the island's seed-eating and insectivorous birds. This competition for food resources is likely to be reducing the abundance of remaining bird populations.

Rats prey heavily on reptiles and have severely reduced the abundance and distribution of the LHI skink (*Oligosoma lichenigera*) and LHI gecko (*Christinus guentheri*) on the main island (Cogger 1971). It is no coincidence that these species are more abundant on the rat-free outer islets (DECC 2007).

Rats are voracious predators of invertebrates. The loss of invertebrates on LHI is particularly significant because invertebrates play an important role in maintaining natural ecological functions, such as nutrient cycling, pollination, pest control and decomposition. Documented impacts to invertebrates include the loss of two endemic land snails (Ponder 1997) – *Epiglypta howinsulae* and a sub-species of *Placostylus bivaricosus* and 11 beetles. These beetles, that were present on LHI prior to the introduction of rats, have not been recorded since. This is despite significant effort including a systematic invertebrate survey by the Australian Museum between 2002 and 2004 (C. Reid unpublished data). Rats are also responsible for the local extirpation of Wood-feeding Cockroach *Panesthia lata* which now only occurs on offshore islands including the Admiralty Group. Rats are also widely believed to be responsible for the elimination of the endangered LHI Phasmid from the main island. The only remaining wild population of phasmid occurs on rat-free Balls Pyramid (Priddel *et al.* 2003).

Rats are believed to have caused the extinction of the bridal flower (*Solanum bauerianum*) and native cucumber (*Sicyos australis*) from LHI (DECC 2007). Rat predation on seeds and seedlings also severely reduces or stops recruitment of the little mountain palm *Lepidorrhachis mooreana*) and big mountain palm (*Hedyscepe canterburyana*) (Moore Jr 1966; Auld *et al.* 2010). It is thought that seed and seedling predation by rats is hindering the regeneration of the palm stand on Little Slope (Pickard 1982), and rodent eradication is considered critical for the long term conservation of both little and big mountain palms (Auld *et al.* 2010).

Rats consume the seeds of many other plant species including: blue plum (*Chionanthus quadristamineus*), green plum (*Atractocarpus stipularis*), pandanus (*Pandanus forsteri*) and tamana (*Elaeodendron curtipendulum*) (Harden personal observations). Rats damage the vegetative parts of a number of plant species, including all four species of palms on the island. Rats commonly chew through the rachis, completely detaching the frond from the tree (Pickard 1983; Harden personal observations). Rats damage the bark on the trunk and limbs of a number of tree species, including Sally wood (*Lagunaria patersonia*), tamana and island apple (*Dysoxylum pachyphyllum*). In severe cases this can result in the death of the tree (Harden personal observations). The impact on vegetation also indirectly affects invertebrates through habitat loss and birds through the removal of food sources.

A monitoring program has been established on LHI to assess and document the biodiversity benefits of removing rats and mice from the LHIG. The program provides a measure of the return on investment and allows an evaluation of current status of species so any impacts of the eradication of rodents on key non-target species can be tracked during their recovery. The most recent results (Carlile, 2015) show:

- seed and fruit losses to rats of all 16 plant species examined, comprising a mixture of plant families, life forms (trees, shrubs, vines) and habitats, with some experiencing very high losses
- recruitment failure as a result of rat predation on seeds and seedlings of the Critically Endangered Small Mountain Palm and associated loss of biotic process and interactions in the Critically Endangered Gnarled Mossy Cloud Forest (ibid)

- Low numbers of reptiles and birds and observed predation by rodents on eggs and suspected removal of nestlings in some species.

While the impacts of house mice on the LHI Group are difficult to positively confirm in the presence of rats and may not be as significant or as well understood as those of ship rats, they are likely to be similar to those demonstrated on other islands (see Newman 1994; Jones *et al.* 2003). For example, evidence on subantarctic Gough Island has identified mice as being responsible for increased mortality of several species of seabird nestlings (Cuthbert and Hilton 2004), including the Tristan albatross (*Diomedea dabbenena*). This albatross is a similar size to the masked booby (*Sula dactylatra*) which is the largest seabird breeding in the LHI Group. New Zealand studies have found that mice prey on reptiles and their eggs and can severely deplete populations (Towns and Broome 2003). Whilst the impacts of mice may be suppressed in the presence of rats (Angel *et al.* 2009), the potential negative impacts of house mice include:

- predation on seeds, competing with native seed-eating fauna for food resources
- severely reducing seedling recruitment which in turn changes vegetation communities
- predation of the eggs and chicks of small bird species, such as storm-petrels and the potential to attack large seabirds
- adverse effects on affected populations of the LHI skink and LHI gecko
- predation on invertebrate fauna which can cause the extinction of some species, as has occurred on Antipodes Island in New Zealand (Marris 2000)
- a detrimental effect on island nutrient recycling systems by reducing the abundance and diversity of soil invertebrates (Smith and Steenkamp 1990).

In summary, continued impacts to matters of NES; 10 bird species, two reptile species, six invertebrate species and two plants species (Table 6) are unacceptable in a do nothing scenario. Consequences of failing to proceed with the REP are detailed in section 2.6.

From the perspective of the human population, rats and mice are major domestic pests. They infest residences, destroy foodstuffs, vegetable gardens and contaminate homes with excrement. They are also a known health risk to humans as they harbour and transmit diseases and parasites.

From an economic perspective, rats cause considerable economic loss to the island's Kentia Palm *Howea forsteriana* industry with predation of seed as high as 30% (Parkes *et al.* 2004) severely reducing seed production (Pickard 1983; Billing 1999).

Tourism, the LHI Group's main industry, is based on the islands' unique biodiversity and World Heritage values. Evidence from LHI and other islands around the world (Towns *et al.* 2006) shows that the ongoing impacts of rodents on native fauna and flora erodes the biodiversity and World Heritage values, and therefore reduces the visitor experience offered by the island – the basis of its tourism industry.

In other locations the impact of invasive rodents on tourism has been acknowledged and is a primary consideration in decisions to eradicate rodents. In the Seychelles, which is a global biodiversity hotspot, the importance of rat eradication to tourism has been recognised (Nevill 2004). Tourism operators on privately owned islands funded eradications with the primary goal of facilitating the reintroduction of endangered bird species thus enhancing their existing tourism operations. Private tourist operators in the Seychelles have continued to embrace the eradication concept. This enthusiasm reflects the realisation that ecotourism is the fastest growing niche market in the tourism industry. Providing near pristine tropical island getaways allows the Seychelles to target the exclusive top-end tourist market.

A survey of island managers where rat eradications have been undertaken showed that ecotourism was the (or one of the) primary motivation(s) behind the activity. Resort owners noted that 'exclusive 5 star tourism and rats don’t mix' (Nevill, 2004). Tourism operators in the Seychelles promote the efforts made to rid their islands of rodents, and the benefits of doing so—the subsequent proliferation of fauna and flora and the opportunity to re-introduce species previously lost to predation. North, Frégate, Denis, and Bird Islands all promote the conservation initiatives conducted on their islands, including reporting on eradications. Island restoration facilitated by rodent eradication has resulted in North Island winning numerous travel awards including nomination as the best travel location on earth.

On Ulva Island in New Zealand, an eradication of rodents was undertaken in 1996. The success of the eradication, and subsequent reintroduction of species lost from the island as a consequence of rat predation, has resulted in the island becoming a premier tourist location. Tourist numbers increased from around 10 000 to 30 000 per year in the decade after rat eradication. This boost in tourism resulting from ecosystem recovery sustains 17 new businesses (A. Roberts, Department of Conservation pers. comm.).

2.8.2 Continuing the Rodent Control Scenario

Since ship rats and house mice arrived on LHI, the Lord Howe community has invested considerable resources in trying to keep the populations of both species under control.

Control is quite distinct from eradication. It aims to keep the negative effects within acceptable limits, but its ongoing nature brings with it a constant financial burden. It also brings an increased potential for negative impacts caused by the ongoing presence of poison in the environment.

Since the 1920s numerous methods of control have been tried on LHI including a bounty on rat tails, hunting with dogs, introduction of owls and the use of various poisons including barium chloride, diphacinone, warfarin, and now Brodifacoum and coumatetralyl. The prolonged use of warfarin has led to house mice becoming resistant to this poison.

Over time, the bait that the LHIB has used for rodent control has changed from warfarin to coumatetralyl, largely due to the LHIB being unable to source commercial quantities of warfarin as a consequence of rodents being largely resistant to it on the mainland. The coumatetralyl based bait currently used (in the product Ratex at a concentration of 0.38g/kg) is a first generation anticoagulant that has similar mode of action as warfarin. The LHIB has an Australian Pesticides and Veterinary Medicines Authority (APVMA) Minor Use Permit to apply the bait in stations with 200 gm of bait which is replenished five times per annum (approximately every 10 weeks) in order to reduce resistance build up in rodent populations. The LHIB rodent control baiting contract covers the servicing of 1,400 stations over 30 baiting areas throughout the Island's Settlement Area and in some sections of the Permanent Park Preserve for conservation purposes (approximately 10% of the island).

In addition to the LHIB rodent control contract, coumatetralyl is also supplied by the LHIB to residents who wish to use it on their properties. The main reasons for choosing this rodenticide for control measures is its low impact on non-target species on the Island; and to reduce the likelihood of rats and mice developing a resistance to Brodifacoum in the lead up to the eradication through unregulated resident use of Brodifacoum based products.

In 2015, the LHIB purchased 192 x 15 kg buckets (total of 2880kg) of Ratex grain bait containing coumatetralyl for use in its rodent control program to be used by both LHIB and leaseholders on the Island for rodent control. In the 6 months from January to the beginning of July 2016, the LHIB has used and provided to residents approximately 700 kg of Ratex grain bait for rodent control on Lord Howe Island.

In addition, many Island residents also purchase Brodifacoum based rodenticides such as Talon™ and Tomcat™ (generally at concentrations of 50 mg/kg) to control rats and mice around their properties and inside dwellings. As residents can purchase this locally or directly from the mainland, exact quantities used are unknown but it is estimated to be around 400kg per year over the 54 ha residential area. This equates to approximately 7.4 kg/ha per year of Brodifacoum alone. The LHIB has no control over this.

Anecdotal evidence gained via the Property Management Plan process has shown that a large percentage of residents in the settlement areas use commercially available Brodifacoum based rodenticides in off label situations (i.e. not in accordance with product label conditions) for their individual rodent control programs. This includes the use of Brodifacoum products in the open, away from buildings, in gardens or in combination with other products. Project Staff assisting with baiting through the settlement areas during the LHIB's scheduled baiting program have shown that as many as 1 in 3 residents are using Brodifacoum products such as Talon™ and Tomcat™ (50 ppm Brodifacoum) exclusively or in conjunction with LHIB provided bait, Ratex- coumatetralyl. The main reason given by residents for this supplementary baiting is the perceived view that the bait provided by the LHIB is not as effective at controlling rodents, particularly mice, as the Brodifacoum based commercially available products. This practice of using off label rodenticide has been demonstrated to indiscriminately poison birdlife on the Island as a secondary poison occurrence.

The present control baiting program does not adequately protect the island group's native flora and fauna. Even with the current level of control estimates of rodent numbers on the island range from 63,000 to 150,000 rats and 140, 000- 210,000 mice (30 -74 rats per hectare and 67-100 mice per hectare (DECC, 2007a and 2008)).

Rodents cannot be considered to be in equilibrium with native species on LHI. Based on the following:

- the number of extinctions attributed to rodents on LHI in a relatively short evolutionary timeframe
- the recent listings of new threatened species as a result of population declines attributed to rodent predation (i.e. land snails) and;
- the ongoing impacts to least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities, and seven species of threatened invertebrates on LHI

Continued impacts to listed TSC Act threatened species; 9 bird species, two reptile species, six invertebrate species and two plants species (Table 6) are unacceptable in the current scenario. Consequences of failing to proceed with the REP are detailed in section 2.6.

Widespread control is simply not practical given the large area and rugged terrain. There is also a significant risk that through ongoing control (and the continuous presence of poison baits) the island group's rodent populations will develop bait shyness or a resistance to current rodenticides. Mice have already developed a resistance to warfarin. The suite of second-generation anticoagulants, which includes Brodifacoum, is the only tool currently available for effectively eradicating rodents from islands. Resistance to these poisons, if it develops, will make eradication impossible and will greatly restrict control. 2013 studies show that within benign laboratory conditions, rats succumb to the bait as expected while mice currently take approximately three weeks (Wheeler and Carlile 2103). Ongoing use of poison in the environment also presents a major risk to non-target species including humans, pets and livestock through continued exposure. Ongoing exposure also increases the risk to non target species of bioaccumulation through consumption of poisoned invertebrates. As such, the effectiveness and long-term sustainability of the existing localised control programme, or an expanded programme, is highly questionable.

If the eradication proceeds and is successful, rodents will be completely eliminated from LHI. There will be no need to further implement the current rodent control program run by the LHIB, or for residents to bait within their own properties.

2.8.3 Preferred Scenario - Eradication

The ‘do nothing’ scenario and continuation of the current control situation on LHI are both considered unacceptable in the short term, medium term and long term, primarily because they fail to mitigate threats from rodents to threatened species and World Heritage values and will result in further species loss and degradation of values on the LHIG.

Eradication has become a powerful tool to prevent species extinctions and to restore damaged or degraded ecosystems (Towns and Broome 2003). The biodiversity benefits of removing rodents from islands are well recognised.

The eradication techniques proposed for LHI are neither novel nor experimental. They are the culmination of more than 30 years of development and implementation involving more than 380 successful eradications worldwide (Howald *et al.* 2007 and DIISE, 2016). Systematic techniques for eradicating rodents from islands were first developed in New Zealand in the 1980s (Moors 1985; Taylor and Thomas 1989; Taylor and Thomas 1993). Since then techniques have improved significantly, and eradications are now being attempted and achieved on increasingly larger and more complex islands, including those with human populations.

Aerial broadcasting of bait using helicopters has become the standard method used in eradications, particularly those on large islands (Towns and Broome 2003). This method has proven to be a more reliable and more cost-effective option than the previous ground based techniques. Depending on the nature of the area to be treated, aerial baiting has been combined with hand broadcasting of bait and the use of bait stations, particularly around areas of human habitation. The use of new tracking and mapping technologies such as global positioning systems and geographic information (computer mapping) systems has increased the efficacy of aerial-based eradication programmes (Lavoie *et al.* 2007).

The largest island successfully treated this way to date is 12,700 ha Macquarie Island in 2011 which saw the successful eradication of ship rats, house mice and rabbits (*Oryctolagus cuniculus).* The island housed 41 people at the time.

Similar operations to that proposed for the LHI Group that have been completed include:

- Campbell Island (11 300 ha) in the New Zealand subantarctic, where Norway rats (*Rattus norvegicus*) were eradicated.
- seven species including ship rats and house mice from Rangitoto and Motutapu Islands, New Zealand (~4 000 ha) in 2009
- four species of rodents, including house mice and ship rats, from several islands in the Bay of Islands, New Zealand (605 ha) in 2009.

These operations offer opportunities to share information on techniques and planning. Not only are the target species similar, the eradication on Rangitoto and Motutapu Islands had a small number of residents and livestock and thousands of daily visitors. The Bay of Islands includes several permanent residents, a full-time tourism operation and numerous day visitors. Macquarie Island, about nine times the size of LHI, is to date the largest island from which house mice and ship rats have been eradicated, either individually or in combination.

After completing a Feasibility Study in 2001, the LHIB has carefully considered and evaluated the eradication of rats and mice on the LHIG. Due to developments in eradication techniques during the past 20 years, particularly the refinement of aerial baiting methods, the eradication of both rats and mice on the LHI Group in a single operation is now feasible and achievable.

The many successful rodent eradication programmes undertaken on islands around the world have shown that the benefits to humans and native plants and animals are both significant and immediate. Benefits include (see review in Towns *et al.* 2006):

- significant increases of seeds and seedlings of numerous plant species on islands after the eradication of various rodent species
- rapid increases in the number of ground lizards (e.g. geckos, skinks) following removal of rats – including a 30-fold increase in one case
- dramatic increases in the numbers of breeding seabirds and fledging success
- rapid increases in forest birds and invertebrates.

Apart from the benefits to biodiversity, the proposed eradication operation is considered the most appropriate course of action for a range of social, health and financial reasons.

The anticipated benefits specifically relating to a rodent eradication programme on the LHIG include:

- recovery of a range of species an ecological communities directly at risk of extinction due to rodents such as the LHI Placostylus, Little Mountain Palm, Phillip Island Wheat Grass and Gnarled Mossy Cloud Forest
- a marked increase in birds, reptiles and insect density, diversity and distribution – this boost in diversity will increase food resources for predatory terrestrial vertebrates and potentially lead to population increases which will enrich the experience of both island residents and tourists
- increases in the abundance of plants, seeds and seedlings, thereby enhancing the process of forest regeneration
- removal of the economic and environmental burden of the ongoing control currently in place, eliminating the need for the ongoing use of rodent poisons in the environment and their associated long-term risks to native species, pets, livestock and people
- an increase in productivity in the island's kentia palm industry and returns to the local community
- the ability to return species (or closely related surrogates/ecological equivalents) that have long been absent due to the predation of rats and mice, such as the Island gerygone, grey fantail, Boobook Owl, LHI Wood-feeding Cockroach and LHI phasmid
- elimination of significant health risks caused by rodents, including a range of viruses, bacteria, internal parasites (such as intestinal worms) and external parasites (such as fleas, mites and lice), many of which can spread disease to humans
- elimination of the inconvenience currently experienced by residents caused by spoiled foodstuffs and rodent excrement – currently, keeping rodents out of dwellings is an ongoing task for the island's residents.
- increased agricultural productivity
- increased tourism by marketing a rodent free World Heritage Area.

Recent advances in rodent eradication techniques and the size and complexity of islands now treated, mean that eradication is now technically feasible on LHI. LHI will be the first island with a significant resident community for which both mice and rats have been targeted for eradication although other similar projects are in the planning phase elsewhere in the world, including 17000 ha Floreana Island in the Galapagos. The presence of a significant human population, associated livestock and two endemic species/subspecies at risk from poisoning, add to the complexity of the task. Notwithstanding, the eradication techniques to be used on LHI are neither novel nor experimental; they are the culmination of more than 30 years of development and implementation involving more than 380 successful eradications worldwide.

It is believed that the known ongoing and likely cumulative increasing impacts of rodents on LHI are unacceptable for the reasons stated. Any ongoing control operation requires the ongoing use of toxicants with the subsequent risks and the benefits of a control programme stop shortly after the programme stops for any reason e.g. lack of funds or toxicant resistance in rodents. This means that eradication is the only option to reduce these effects to an acceptable level in the short, medium and long term.

2.9 Selection of Eradication Technique

Systematic techniques for eradicating rodents from islands were first developed in New Zealand in the 1980s (Moors 1985; Taylor and Thomas 1989; Taylor and Thomas 1993). Since then techniques have improved, and rodents can now be eradicated from large, geographically and physically challenging and biologically complex islands. Eradication has become a powerful tool to prevent species extinctions and to restore damaged or degraded ecosystems (Towns and Broome 2003).

Early attempts at eradicating rodents from islands mainly used traps and bait stations, but as the technology has improved, aerial broadcasting of bait using helicopters has become the method of choice (Towns and Broome 2003). The use of new tracking and mapping technology such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) has increased the efficacy of aerial-based eradication programmes (Lavoie *et al.* 2007). The majority of successful eradications on large islands have used this methodology in combination with the rodenticide Brodifacoum in cereal pellets. The largest island successfully treated this way is subantarctic Macquarie Island (12700 ha), where rabbits, ship rats and mice were successfully eradicated (Springer, 2016).

A review of all rodent eradications using all methods in the Database of Island Invasive Species Eradications (DIISE, 2016) showed that

- For mice there have been 111 eradication attempts. 71 of these attempts have been declared successful, 26 have failed, and 14 are as yet unconfirmed. This gives a success rate of 73%.
- For Ships Rat there have been 428 eradication attempts. 316 of these attempts have been declared successful, 43 have failed and 69 are as yet unconfirmed. This gives a success rate of 88%.

However, as eradication techniques and understanding of the causes of failures improved over time, so has the success rate. For example:

- The success rate for mouse eradications from 1997-2014 on NZ islands using Pestoff 20R with 20 ppm Brodifacoum aerially applied is 100% or 11 from 11 attempts (Broome and Fairweather, 2016,).
- Rat eradications on islands over the period 1997- 2014 using this bait and method have been 98% successful (37 of 39 attempts) (DIISE 2016).

Failures most often occurred with mice, and the speculated causes of failure included technical issues (e.g., inadequate or insufficient bait deployment), failure to follow established protocols, observed or suspected non-target poisoning issues that halted the campaign, lack of funding and public support, and bait competition by terrestrial crabs on tropical islands. One of the problems with assessing failure rates for mice eradication attempts is that many operations were undertaken with the primary aim being to eradicate rats, without mice being specifically targeted. Examples include eradication operations on Patiti, Haulashore and Quail Islands in New Zealand, where bait stations were used at spacing suitable for rats but larger than desirable for mice. Consequently, mice were not eradicated. These operations are often recorded as failures for mice, although the methodology used was not designed for mice. On the other hand an aerial baiting operation designed to target rabbits on Enderby Island had the unexpected benefit of also eradicating mice (Torr, 2002). On LHI, both rats and mice will be specifically targeted for eradication and the operational methodology planned accordingly.

The reasons for the higher failure rate of mice eradications are unclear, but in the two major reviews of global eradication attempts (Howald *et al.* 2007; MacKay *et al.* 2007) the authors speculate that inadequate bait density on the ground could be a significant factor. Mice typically have smaller home ranges than rats, and therefore they have a lower probability of being exposed to bait that is in bait stations at standard densities for a rat eradication density i.e. 25 -50 m spacing, or is broadcast relatively sparsely. The solution for bait station operations is to use smaller spacing between stations, no larger than 10 m which is logistically challenging or often unfeasible for all but the smallest and topographically mundane islands. Possible solutions for aerial operations are to increase the bait rate (kg/ha) or to use a smaller bait that, when broadcast at the same application rate (kg per ha), provides a greater number of pellets per unit area. However, mice were eradicated from Montague Island in NSW, where small (5.5 mm diameter) and large (10 mm diameter) baits were used on different parts of the island. This operation, undertaken to compare the efficacy of the two bait sizes, demonstrated that both sizes are capable of eradicating mice, provided that there are no gaps in the distribution of bait. On LHI, adequate bait dispersal will be achieved primarily by using aerial broadcasting of large bait pellets at a nominal density of at least one bait every two square metres. In the settlement area, where mice are likely to not range as far, small bait pellets will be hand broadcast at a nominal density of at least one bait every half square metre. Where bait stations are used, these will be set at approximately 10 m spacing.

To minimise the risk of failure of the eradication it is vital to use tried-and-tested techniques that have proven repeatedly to be successful elsewhere. Use of published information, previous experience on other islands, on-site research, close collaboration with international experts, and peer-review will ensure that planning for the eradication of rodents on LHI is based on current best-practice techniques taking in to account the local situation.

2.9.1 Alternative Eradication Techniques Assessed as Unsuitable

A number of techniques were evaluated for undertaking the eradication and subsequently dismissed from detailed consideration as considered unfeasible or unproven.

2.9.1.1 Disease

While there is ongoing research focused on the development of taxon-specific diseases that can control populations of non-native species (such as by the Commonwealth Scientific and Industrial Research

Organization (CSIRO), www.cse.csiro.au/research/rodents/publications.htm), there are no pathogens with proven efficacy at eradicating rodents (Howald *et al.* 2007). Even a highly lethal rat-specific pathogen which may be suitable for ongoing control would be ineffective at eradicating rats from LHI because if the rat population rapidly declined, transmission rates of the introduced pathogen would also decline so as to be ineffective in eradicating the few remaining individuals. Furthermore, the introduction of novel pathogens into the environment carries tremendous potential risks to non-target species. Therefore, the use of pathogens is disqualified from detailed consideration.

2.9.1.2 Trapping

This alternative would involve the use of live traps and/or lethal ("snap") traps to eradicate rats and mice. This action would be extremely unlikely to succeed at LHI. In addition to the size and topography making this technique impractical and risky both for effectiveness i.e. being able to locate a trap in every rodent's territory and because of the extensive effort and considerable personnel risk required to set and monitor traps i.e. trapping cliffs. To access the traps for the 3-4 months required an extensive track network would be required which would have significant ecological impacts on vegetation including increasing the risk of erosion. Also to maximise the likelihood of success different traps would be required to target rats and mice effectively doubling the effort and impact. Also the use of live traps and/or lethal traps to remove rats and mice from an area is a strong selection agent in favour of rats that are "trap-shy". Thus, after extensive trapping the only rodents that would remain would be those that are behaviourally less likely to enter a trap, and these rodents would be very difficult to remove without the introduction of alternate methods such as toxicants. The use of live traps requires daily checking for humaneness to both target and non-target species which would be impractical given the number of traps involved. The use of kill traps presents an unquantified risk to non-target species, particularly inquisitive species such as Currawong and Woodhen, which would mean that these species would probably have to be taken into captivity for the duration of the operation, but also ground frequenting birds such a banded rail and emerald ground dove. Therefore, this alternative was excluded from detailed consideration.

2.9.1.3 Biological

The introduction of predators on rats and mice, such as snakes and cats, was dismissed because biological control most often only reduces, rather than fully eliminates the target species and thus fails to achieve the desired ecological benefit gained through complete rat removal. There is no known effective biological control agent for rats or mice on islands, and some forms of biological control would result in unacceptable damage to the environment. The introduction of cats to islands in order to control introduced rodents has been attempted numerous times since European explorers began crossing the Atlantic and Pacific Oceans. The introduction of a rodent predator, such as cats, generally results in a greater combined effect on birds than if one or the other were present alone.

When seabirds are present, cats have been shown to prey heavily on seabirds (Atkinson 1985), consuming fewer rodents during these times. When seabirds leave the islands following the end of the breeding season, cats switch prey to rodents, which allow the islands cat population to remain stable at a higher level than if no rodents were present on the island (Atkinson 1985, Courchamp *et al.* 1999, 2000). Thus, birds are affected not only by rodents but also the larger number of cats that are sustained by rodent presence on the island. Introduction of another species onto an island can have severe and permanent consequences to the ecosystem (Quammen 1996). Also introduction of any additional species, especially a predatory one such as snakes or cats would be contrary to the LHI biosecurity rules and counter to the ethos of restoring the island. Cats have already been removed from the island and there are no snakes on LHI. Therefore, this alternative was disqualified from detailed consideration.

2.9.1.4 Fertility Control

Fertility control has been used with limited success as a method of pest management in a few species, primarily larger mammals where individuals can be targeted for treatment (Fagerstone K.A, *et al.*2002). Experimental sterilization methods have included chemicals and proteins delivered by vaccine, and genetically-modified viral pathogens. However, the effectiveness of these experimental techniques in the wild, and their impacts to non-target animals are unknown.

The possibility of using a new rodent sterilisation technology called "Contrapest", developed by SenesTech Ltd was considered with the following issues identified:

- The product is not currently registered in any country. While SenesTech hope to have it registered in the USA next year it is likely to be some time before it is registered in Australia.
- The product, Contrapest, aims to *reduce* rat populations through sterilisation, by reducing fecundity but leaving some animals to defend territories i.e. **ongoing control not eradication**.
- It requires every female to be dosed with the product i.e. it needs to be regularly dispensed as there is no inherited or contagious transmission of the reduced fertility.

- The fertility control compounds (VCD and Triptolide) are not species-specific and could affect other mammals including humans.
- Currently the product is designed for rats although the developers state that it has the potential to be modified to target mice, along with other species, although dispensing the appropriate dosage is problematic at this stage.

The product is not suitable for the rodent eradication program on LHI as:

- The product is aimed at *reducing rat* numbers not eradicating them.
- The product needs to be ingested over a prolonged period (approx. 75 days) and all female rats would need to be exposed to the product. This would effectively mean that the product would need to be put out continually for the foreseeable future.
- While reducing rat numbers would have some benefits, only total eradication of rats and mice will give the anticipated ecological, social, economic and human health benefits.
- The product is currently dispensed by adding it to water. This is problematic for LHI as dispensers would need to be put over the whole island at approximately the same spacing as bait stations. The product needs to be consumed over many feeds as it affects the reproductive system slowly meaning that the bait would need to be made available in every territory for a prolonged period to affect even one generation of rats.
- Even if the product was used on the accessible areas and was able to reduce numbers, this would only be short term while the product was being dispensed. Also, rodents from the untreated areas would soon move in as resources, food and territory were freed up.
- The current product Contrapest is only for rats which would leave mice untreated.

Contrapest has been investigated for both the LHI program and by other rodent eradication organisations internationally and its use would be experimental hence it is not currently considered a feasible option for rodent eradication in the foreseeable future.

Repeated baiting of uncertain oral contraceptives on an inhabited and rugged island across seasons or capturing, vaccinating, and releasing every member of a single gender of the LHI rodent population is unfeasible. This lack of data and tools disqualifies the use of fertility control from detailed consideration (Tobin and Fall, 2005).

2.9.1.5 Fencing

We are aware that rodent proof fencing has been used with some success to create predator free enclosures in “mainland island” situations particularly in New Zealand (i.e. Zealandia and Maungatutari). These have stemmed from the success of island eradications using the techniques we propose. A significant review of fencing for conservation was undertaken by Burns et al in 2012. The inside of these enclosures are then baited with poison (most often aerially) to locally eradicate pests (Burns et al, 2012). We are not aware of fences being used as part of true island rodent eradications to date, although Stewart Island in New Zealand has considered fencing the settlement area and trialing eradication of rats, possums and cats within the settlement area first, as part of a staged eradication for the entire island (Bell, 2014). The Stewart Island eradication project has not yet been implemented. There is significant debate within the scientific community as to the value of fences for conservation and long term effectiveness is still being evaluated (Burns et al 2012).

Given the natural ocean barrier around LHI, proven effectiveness of the proposed REP bait and delivery methods, the presence of rats, mice and threatened species across the entire island and the ability of rats and mice to swim up to 500m, we see no justification or feasibility for a fence on Lord Howe Island. A fence(s) is considered unsuitable because:

- A fence would not eliminate risks to EPBC listed species currently threatened by rodent predation and competition or to EPBC species potentially impacted by implementation of the REP
- Intensive baiting is still required to eradicate rodents on whichever side of the fence was chosen to be rodent free. Control baiting in perpetuity would be required on the other side
- Fences will not eliminate all rodent invasions from the other side. Despite efficacy demonstrated in trials, ongoing reinvasions have occurred (Burns et al, 2012). Fences will slow the reinvasion rate but do not stop it (Bell, 2014). They have been demonstrated to be particularly ineffective against mice (Burns et al, 2012)
- Fence failures (i.e. tree damage, storm damage and human error such as not closing gates) are identified as major causes of reinvasion (Burns et al, 2012).

- Coastal ends of fences have proven particularly challenging (Burns et al, 2012). The fence would need to extend into the sea to prevent rodents walking around and even then rats and mice are known to swim up to 500m and could easily swim around the fence. Coastal fence ends protruding into the sea have not been used before (Bell, 2014) and would very susceptible to wave damage.
- Water ways are considered weak points for fences (Burns et al, 2012). Fences generally follow ridge lines to avoid waterways. This would be impossible on LHI
- Fences are not considered “walk away” solutions and require intensive vigilance and an ongoing inspection and maintenance regimes. They also have a finite life (about 25 years)
- Fences have high installation costs and ongoing maintenance costs relative to island eradication techniques. Average installation costs on Mainland New Zealand are approximately $225 / linear metre (Bell, 2014). Inspection and maintenance costs are around 5% of the capital every year
- Fences designed to prevent rodents will also act as barriers to threatened species movement, dispersal and breeding (Burns et al, 2012). The fence would require a curved hood, an underground skirt and mesh as small as 6mm in one dimension preventing movement of species such as woodhen and snails on LHI
- Vegetation clearing would need to occur in at least a 10m corridor around the fence. On LHI this could lead to potential disturbance to threatened species and habitat
- Movement of people and vehicles on LHI would limit effectiveness of the fence.
- Rodent proof fencing is likely to have very little community support on LHI

Fencing is therefore not considered a feasible alternative on LHI.

2.9.2 Preferred Technique – Use of Toxicant

As all other techniques above have been assessed as unsuitable and therefore eliminated from further consideration, it leaves the wide scale application of a suitable toxicant in highly palatable bait as the only feasible option for eradicating rats and mice from LHI. While this technique does entail some risks, primarily non-target species deaths, with detailed planning and implementation these risks can be minimised and mitigated to an acceptable level. The appropriate use of toxicants can meet all the criteria of a successful eradication (Cromarty 2002); this is since all individual animals at all parts of the island can be exposed to the technique within a narrow timeframe i.e. before they can reproduce. The use of toxicants is the most common and most successful method for eradicating *rodents from islands with over 300 islands worldwide having rodents eradicated using this technique. (*DIISE, 2015).

Discussion of suitability of a range of toxicants is described in the sections below.

2.10 Selection of Toxicant

2.10.1 Mortality Agents Assessed as Unsuitable

A critical component in any eradication is the choice of toxicant. A number of rodenticides have been used for rodent eradications in the past. While effective at control measures, many are unsuitable for the eradication program planned for LHI due to a range of issues including safety concerns, rodent avoidance or incomplete product development.

The use of many rodenticides was dismissed from further consideration for one or more of the following reasons: 1) greater toxicity to non-target wildlife; 2) lack of proven effectiveness in island rat eradications; 3) potential for development of bait shyness in the rat population; and 4) the lack of an effective antidote in case of human exposure. Each of these issues and the associated rodenticides are discussed below.

Most documented island-wide rodent eradication programs (226, 68 %) have used second generation anticoagulants, primarily Brodifacoum (Howald *et al.* 2007). Twenty-nine have used first-generation anticoagulants such as diphacinone. Nine additional eradications have used non anticoagulant toxicants including zinc phosphide, strychnine, and cholecalciferol. Acute rodenticides, such as zinc phosphide and strychnine, have the ability to kill rats quickly after a single feeding. However, because poisoning symptoms appear rapidly, the acute rodenticides can induce learned bait avoidance if animals consume a sub-lethal dose. Studies with zinc phosphide have demonstrated that rodents associate toxicity symptoms with bait they had consumed earlier if the onset of symptoms occurs as long as 6 to 7 hours after consumption (Lund, 1988). Thus, any individual that consumes a sub-lethal dose is likely to avoid the bait in the future (Record and Marsh, 1988). Also, acute rodenticides are often extremely toxic to humans and effective antidotes are not always available. The combination of these factors disqualifies the acute rodenticides from detailed consideration.

2.10.1.1 Cholecalciferol

A form of vitamin D that is an acute poison that to date has been used in at least three eradications, but all involved small islands and, in each case, baiting was supplemented with anticoagulants. Cholecalciferol, which is classified as a "sub-acute" rodenticide, has the ability to kill rats more quickly than the anticoagulant rodenticides, but most often more slowly than the acute rodenticides. Cholecalciferol has been used successfully to eradicate rats from very small islands (Donlan *et al.* 2003) it is less toxic to birds than Brodifacoum, but it is highly toxic to mammals, and treatment of poisoning is difficult. More importantly, there is evidence that mice can detect the poison in baits and will avoid it. This bait avoidance, while not critical in a control operation, would place an eradication programme at risk of failure. Thus, its use at LHI would be largely experimental in nature. The presence of unique taxa at LHI, and the need for a high probability of conducting a successful eradication on the first attempt, disqualifies cholecalciferol from detailed consideration.

2.10.1.2 Sodium monofluoroacetate

Commonly known as 1080, is an acute poison which can be detected by some rodents especially mice and is prone to promoting bait shyness making it unsuitable for eradication. There is also no known antidote.

2.10.1.3 Zinc phosphide

Is an acute poison that is used to control plague mice in cereal crops. Although there is little risk of secondary poisoning, this compound is a broad spectrum poison that is more toxic to birds than it is to rodents. The high risk of direct poisoning of non-target species and the risk of bait avoidance precludes its use on LHI.

2.10.1.4 Other agents

Some research has been conducted into developing toxicants that are specific to rats and mice, but these have proven not to be technically feasible at this time. Even if a new rodent specific toxicant is developed it will take many years to test and trial it to ensure it is suitable for eradications and is suitable to be used on an island the size of Lord Howe.

Similarly, long-term research to develop a mouse-specific mortality agent has been largely abandoned both in Australia and overseas. Work over the past two decades focussed on the development of a virally-vectored immuno-contraceptive agent which would be transmitted between mice, rendering females sterile. To be effective, this type of mortality agent requires ready transmission between individuals, but researchers were unable to resolve the problem of attenuation of the virus when spreading among wild mice. This attenuation ultimately halts the spread of the virus among the population. While developing an eradication tool capable of killing 100% of individuals was never a goal of the research programme, even broad-scale control is now considered unlikely. This conclusion led to the programme being abandoned.

Another rodenticide (named ***Eradibait***®) works by physically blocking water absorption in the gut of rats and mice. It is a type of cellulose that coats the fine hairs (villi) in the lower gut, disrupting messages to the rodent's brain causing it to stop drinking. This leads to dehydration, blood thickening, kidney dysfunction, coma and eventual death. The bait contains no toxicant; consequently there are no secondary-poisoning issues. Unfortunately, while the product has been used for control on farms it has never been used in eradication. Recent research conducted in New Zealand indicates that the bait has low palatability to rodents, and they will only consume it when no other food source is available. This makes it unsuitable for use in eradication, where every animal must consume a lethal dose.

2.10.1.5 Para-aminopropiophenone

(PAPP) is currently being developed for the control of feral cats, foxes and wild dogs. The need to encapsulate the poison has added considerably to the task. Trials show that PAPP does not kill rodents. It is possible that an analogue of PAPP could be developed as a rodenticide sometime in the future (Eason *et al.* 2009), but its potential effects on non-targets and its suitability for eradication are all unknown.

2.10.1.6 Anticoagulants

Anticoagulants act by effectively blocking the vitamin-K cycle, resulting in an inability to produce essential blood-clotting factors. A range of anticoagulant rodenticides are available which could potentially be utilised in an eradication operation on the LHIG. Anticoagulants are classified as either first-generation or second-generation. First-generation anticoagulants such as warfarin, diphacinone, pindone and coumatetralyl are generally of low toxicity but require a high concentration and multiple feeds over several of days to be effective (Hone and Mulligan 1982). The need for rodents to ingest large quantities of the bait to obtain a lethal dose of the poison increases the risk of failure in eradication. Second-generation anticoagulants including Brodifacoum, bromadiolone and difethiolone are more toxic, require lower concentrations and only a single feed to kill rodents and are thus preferred for use in eradications. However they do present a greater non-target risk.

Anticoagulants are defined as chronic (death occurs one to two weeks after ingestion of the lethal dose, rarely sooner), single-dose (second generation) or multiple-dose (first generation) rodenticides, acting by effective blocking of the vitamin K cycle, resulting in inability to produce essential blood-clotting factors — mainly coagulation factors II (prothrombin) and VII (proconvertin).

In addition to this specific metabolic disruption, massive toxic doses of 4-hydroxycoumarin, 4-thiochromenone and indandione anticoagulants cause damage to tiny blood vessels (capillaries), increasing their permeability, causing diffuse internal bleeding. These effects are gradual, developing over several days. In the final phase of the intoxication, the exhausted rodent collapses due to hemorrhagic shock or severe anaemia and dies calmly. The question of whether the use of these rodenticides can be considered humane has been raised. The main benefit of anticoagulants over other poisons is that the time taken for the poison to induce death means that the rats do not associate the damage with their feeding habits.

- First generation rodenticidal anticoagulants generally have shorter elimination half-lives, require higher concentrations (usually between 0.005% and 0.1%) and consecutive intake over days in order to accumulate the lethal dose, and are less toxic than second generation agents.
- Second generation agents are far more toxic than first generation. They are generally applied in lower concentrations in baits — usually on the order of 0.001% to 0.005% — are lethal after a single ingestion of bait and are also effective against strains of rodents that became resistant to first generation anticoagulants; thus, the second generation anticoagulants are sometimes referred to as "superwarfarins".

On Lord Howe Island mice are already totally resistant to warfarin and trials indicate they may also have a tolerance to Brodifacoum (Wheeler and Carlile, 2013; O'Dwyer *et al.* 2015). The suite of second-generation anticoagulants is the only tool currently available for effectively eradicating rodents from all but the smallest islands. Resistance to these poisons, if it develops, will make eradication impossible for the foreseeable future. Moreover, this could potentially result in a situation where there was no effective way to control rodents on the island, with catastrophic results for biodiversity, tourism and residents.

Diphacinone

Diphacinone is the most widely used first generation anticoagulant (FGA) for rodent eradications. And given the limited knowledge and experience on other FGA for eradications, it is the only one which would reasonably be considered for rodent eradication on LHI. Although effective at rat control in suitable conditions it has not been proven to be an effective and reliable tool for broadcast-based rodent eradications in general, largely due to the significantly greater application rates, relative to Brodifacoum, necessary for ensuring availability of bait, for a long enough period, to all rodents;

A total of 12 successful island rodent eradications have been reported using diphacinone as the primary toxicant and fifteen eradications using diphacinone are reported to have been unsuccessful (Howald *et al.* 2007, Island Conservation unpubl. data):

Toxicological Properties of diphacinone

The physiological action of diphacinone on target organisms is the same as for Brodifacoum: However, diphacinone and other first-generation anticoagulants have a reduced affinity for the enzyme that produces vitamin K-dependent clotting agents (in comparison to Brodifacoum and other second-generation anticoagulants,) resulting in a slower depletion time of these clotting agents in the bloodstream (Eason and Ogilvie 2009). Also, diphacinone is more actively metabolized and excreted by rats than Brodifacoum.

As a result of these properties, diphacinone requires multiple exposures to ensure a lethal dose is obtained. Although diphacinone can be lethally toxic to some rodents when administered in a single, large dose, it is relatively more potent in small doses administered over several days (Buckle and Smith 1994, Timm 1994). After considering these studies, we concluded that, to ensure 100 percent mortality to the rat population on LHI (eradication rather than control), if diphacinone was used, it would need to be consistently available and consumed by some rats for up to 12 days.

The primary advantage of diphacinone as a rodenticide for conservation purposes is the low risk it poses to non-target organisms in comparison to second generation anticoagulants. Diphacinone has comparatively low persistence in animal tissues, which makes toxicity to non-target birds through primary and secondary exposure less likely than for Brodifacoum (but does not eliminate the risk) (Fisher 2009). Furthermore, laboratory trials have indicated that diphacinone has low toxicity to birds when compared with Brodifacoum (Erickson and Urban 2004, Eisemann and Swift 2006). However, recent research suggests that the toxicity of diphacinone to some birds may be considerably higher than previously thought (Rattner *et al.* 2010), although the overall toxicity of diphacinone still remains low compared with Brodifacoum. From the perspective of non-target risk, particularly for birds, diphacinone is the optimum choice. However, the choice would be risky when gauged with overall baiting efficacy on LHI. The long exposure to diphacinone necessary to achieve rat and mouse mortality ultimately decreases the probability that all rodents would consume enough bait, given the conditions on the island. For example, the availability of other, natural food items and competition with other consumers both could decrease the probability of all rodents consuming enough bait. Competition with other consumers also would potentially leave some rat territories with inadequate access to bait. All of these factors increase the risk of eradication failure.

While diphacinone has been tested or used with favourable results in a number of landscape-scale rodent control efforts (Dunlevy *et al.* 2000, Spurr *et al.* 2003a, Spurr *et al.* 2003b), the success of these control efforts does not provide assurance that Diphacinone-50 would be successful as a tool for rodent eradication when competition for bait between the target species and non-target consumers is high (such as may occur on LHI).The goal of a rodent control operation is to reduce a rodent population to an acceptably small size and maintain low density populations, whereas the goal of an eradication operation is to permanently remove every rodent. This is a critical fundamental difference when assessing the relative merits of different bait products; a bait product that is available for use, attractive to rodents, but has an uncertain efficacy may be an excellent tool for a control operation but not for a broadcast eradication operation at this time.

2.10.2 Preferred Toxicant – Brodifacoum

The toxicant selected for the eradication of rats and mice from the LHIG is Brodifacoum, a second-generation anticoagulant. Mice on LHI are known to be resistant to warfarin, so there is a risk that other first generation anticoagulants such as diphacinone may also be ineffective on mice. Second-generation anticoagulants were developed specifically for use in situations where rodents had developed resistance to first- generation anticoagulants.

The second-generation anticoagulants floucoumafen and bromadiolone have both been used in eradications, but (i) the relative lack of information on the environmental effects of these poisons, (ii) uncertainty about their efficacy in such operations, as they have only had limited use (iii) the fact that they offer no appreciable advantages over Brodifacoum and (iv) there has been limited trials and field work done on these toxicants mean that they are not suitable for this project.

Like all anticoagulants, Brodifacoum disrupts the formation of blood-clotting factors. Death through internal haemorrhaging typically takes 3–10 days (Torr 2002), with mice sometimes taking longer to die than rats (Fisher 2005) and recently on LHI, to be up to two weeks longer than rats (Wheeler and Carlile, 2013 and O'Dwyer *et al.* 2016).

Characteristics supporting the use of Brodifacoum in the operation on LHI include:

- Brodifacoum has proven to be successful in over 226 eradications including all 14 eradications on islands greater than 500 ha in size.
- Brodifacoum has proven to be successful in a variety of climatic conditions including those similar to LHI.
- Brodifacoum is highly toxic to both rats and mice in minute quantities, allowing a lethal dose to be consumed in a single feed, thus avoiding the consumption of sub-lethal doses and the associated risk of bait shyness/avoidance.
- Brodifacoum is a chronic toxicant i.e. its action is delayed meaning the rodent does not associate any illness with the bait it has consumed, thus avoiding the consumption of sub-lethal doses and the associated risk of bait shyness/avoidance.
- Both target species are highly susceptible to Brodifacoum, simplifying logistics and maximising cost-effectiveness.
- When contained in Pestoff® 20R bait formulation, Brodifacoum is highly palatable to both species, as confirmed by field trials on LHI.
- Brodifacoum is highly insoluble in water, and its propensity to bind to soil particles prevents its leaching into the substrate on which it is spread. Consequently, contamination of waterways and runoff into the marine environment are negligible, and it is less likely than other poisons to accumulate in either aquatic systems or plant material (Toxikos 2010); Ogilvie *et al.* 1997)
- The half-life of Brodifacoum in the soil is reasonably short: 12–25 weeks depending on soil type and conditions.
- The non-target effects of Brodifacoum are well understood enabling planning to mitigate or minimise any non-target impacts.
- Although toxic to livestock, pets and humans if consumed, an antidote is readily available.

All second-generation anticoagulants are more toxic than the first-generation anticoagulants; consequently they have a greater potential to kill non-target species that consume bait. Also, second-generation anticoagulants persist longer in the tissues of those vertebrate animals that ingest bait; the estimated half-life of Brodifacoum in rat tissue is estimated to be 150 to 200 days (Erickson and Urban 2004), therefore, there is a greater risk of secondary poisoning. Although generally not toxic to invertebrates, anticoagulants can be ingested by some invertebrates (Spurr and Drew 1999) which may then be eaten by non-target species. Thus, the use of second-generation anticoagulants poses more of a risk than does the use of first-generation anticoagulants, but actions, as discussed elsewhere in this application can be taken to effectively mitigate or limit these risks. Acute toxicity of Brodifacoum to rats and mice is shown in Table 8. Assessment of suitability of other toxicants is considered in Table 9.

Table 8 Acute Oral Toxicity (LD50 Mg/Kg) of Brodifacoum to the Target Pests (from Broome et al.2016)

Species	**LD50 Value (mg kg -1)**	**References**
House mouse	0.4 (95%CL 0.30 – 0.63)	Redfern *et al.*(1976)
House mouse (caught from wild)	0.52	O'Connor and Booth (2001)
House mouse (wild caught from Gough Island)	0.44	Cuthbert *et al.* (2011)
Ship rat *Male*	0.73	Dubock and Kaukeinen (1978)
Female	0.65	Dubock and Kaukeinen (1978)
Ship rat (caught from wild)	0.46	O'Connor and Booth (2001))

Table 9 Suitability of Potential Toxicants for the Eradication of Rats and Mice

FGAC, first generation anticoagulant; SGAC, second generation anticoagulant; na, not applicable.

Mortality agent	Type	Palatability	Probability of killing all targeted individuals	Availability of manufactured formulations	Target specificity	Environmental persistence	Likelihood to induce aversion	Antidote available	Number of successful eradications
Cholecalciferol	Acute toxin	High	Low	High	High	Low	High	Yes	Low
Sodium monofluoroacetate	Acute toxin	High	Low	High	Low	Low	High	No	Low
Zinc phosphide	Acute toxin	High	Low	High	Low	Low	High	No	None
Rat-specific toxin	Acute toxin	Na	Low	Not available	High	Low	Low	na	None
Cellulose compound	Acute toxin	Low	Low	High	High	Low	High	na	None
PAPP	Acute toxin	Low	Low	Not available	?	?	?	Yes	None
Mouse-specific virus	Immuno-contraceptive	Na	Low	Not available	High	Low	Low	na	None
Diphacinone	FGAC	High	Low	High	Low	Low	Low	Yes	Low
Pindone	FGAC	High	Low	Low	Low	Low	Low	Yes	Low
Coumatetralyl	FGAC	High	Low	Low	Low	Low	Low	Yes	Low
Floucoumafen	SGAC	High	High	Low	Low	High	Low	Yes	Low
Bromadiolone	SGAC	High	High	Low	Low	High	Low	Yes	Low
Brodifacoum	SGAC	High	High	High	Low	High	Low	Yes	High

2.10.3 Detailed Brodifacoum Information

2.10.3.1 Overview

Brodifacoum is a second generation anticoagulant of the coumarin class. Its rodenticidal properties were first described in the early 1970s and it was first marketed in 1978. It is used globally for pest management. In Australia it is registered in all states and territories for the control of introduced rats and mice especially warfarin-resistant strains and is listed as a Schedule 6 poison (Macleod and Saunders, 2014).

2.10.3.2 Chemical name

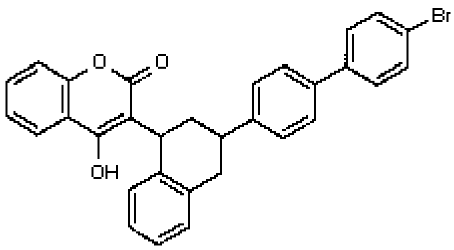
3-[3-(4'-bromo-[1,1'-biphenyl]-4-yl)-1,2,3,4-tetrahydro-1-naphthalenyl]-4-

hydroxy-2H-1-benzopyran-2-one.

2.10.3.3 Chemical and physical properties

The empirical formula for Brodifacoum is $C_{31}H_{23}BrO_3$ (see below) and its molecular weight is 523.4. Brodifacoum is an off-white to fawn-coloured odourless powder with a melting point of 228 –232ºC. It has a very low solubility in water (less than 10 mg/L at 20 ºC and pH 7). Brodifacoum is slightly soluble in alcohols and benzene, and soluble in acetone. It is stable at room temperature.

This section is from Eason and Wickstrom (2001)



2.10.3.4 Synonyms

3-(3-(4'-Bromo-(1,1'-biphenyl)-4-yl)-1,2,3,4-tetrahydro-1-napthalenyl)-4-hydroxycoumarin; Talon; Talon® Rat Bait, Talon® possum bait, Pestoff® possum bait

2.10.3.5 Mode of Action

Brodifacoum, like other anticoagulant toxicants, acts by interfering with the normal synthesis of vitamin K-dependent clotting factors in the liver of vertebrates (Hadler and Shadbolt 1975). In the liver cells the biologically inactive vitamin K1-2,3 epoxide is reduced by a microsomal enzyme into biologically active vitamin K, which is essential for the synthesis of prothrombin and other clotting factors (VII, IX, and X). Brodifacoum antagonism of the enzyme vitamin K1-epoxide reductase in the liver causes a gradual depletion of the active form of the vitamin, and consequently of vitamin K-dependent clotting factors. This results in an increase in blood-clotting time until the point where no clotting occurs i.e. blood is thinned to the point of haemorrhage which leads to death.

There is usually a lag period of 3-5 days between exposure and the onset of clinical signs. Initial clinical signs of Brodifacoum poisoning are usually characterised by depression/lethargy and anorexia. This is followed by anaemia with pale mucous membranes, dyspnoea, exercise intolerance, and haemorrhaging from numerous sites. Periarticular or intraarticular haemorrhage causing swollen joints and lameness is especially common in pigs (*Sus scrofa*), and abortion induced by placental haemorrhaging has been reported in cattle (*Bos Taurus*). Convulsions indicate bleeding into the central nervous system. Animals experiencing prolonged toxicosis may be icteric. Similar clinical signs occur in humans and include haematuria, bleeding gums, and easy or spontaneous bruising (Park *et al.* 1986).

As blood loss continues, cardiac murmurs, irregular heartbeat, weak peripheral pulses, ataxia, recumbency, and coma will be observed. Death due to hypoxia and hypovolemic shock may occur from 48 hours to several weeks after exposure. Animals may occasionally be found dead with no premonitory signs, especially if severe haemorrhage occurs in the cerebral vasculature, pericardial sac, abdominal cavity, mediastinum, or thorax (Murphy and Gerken 1989; Felice and Murphy 1995).

The greater potency of second-generation anticoagulants such as Brodifacoum compared to first-generation anticoagulants such as warfarin and pindone is likely to be related to their greater binding affinity for vitamin K-epoxide reductase (Parmar *et al.* 1987) and subsequent accumulation and persistence in the liver and kidneys after absorption (Huckle *et al.* 1988). All tissues that contain vitamin K-epoxide reductase (e.g. liver, kidney, and pancreas) are target organs for accumulating these toxicants.

This section is from Eason and Wickstrom (2001)

2.10.3.6 Pathology

Generalised haemorrhage is frequently evident at post-mortem. Areas commonly affected are the thoracic cavity, subcutaneous tissue, stomach, and intestine. The heart is sometimes rounded and flaccid with subepicardial and subendocardial haemorrhages. Histomorphological analysis of the liver may reveal centrilobular necrosis (death of liver cells at the centre of the liver lobes) as a result of anaemia and hypoxia. In brush tail possums, post-mortem findings range from mild to moderate haemorrhage in some limbs and in the gastrointestinal tract, to extensive haemorrhage throughout the body and major organs.

This section is from Eason and Wickstrom (2001)

2.10.3.7 Absorption, metabolism, and excretion

Brodifacoum is absorbed through the gastrointestinal tract. It can also be absorbed through the skin. After absorption, high concentrations in the liver are rapidly established and remain relatively constant. Disappearance from serum is slow with a half-life in rats of 156 hours or longer. The slow disappearance from the plasma and liver and the large liver: serum ratio probably contribute to the higher toxicity of Brodifacoum when compared with warfarin or pindone (Bachmann and Sullivan 1983). A proportion of any ingested dose of Brodifacoum bound in the liver, kidney, or pancreas remains in a stable form for some time and is only very slowly excreted.

Brodifacoum is not readily metabolised and the major route of excretion of unbound compound is through the faeces. Enterohepatic recirculation, the process that allows drugs and pesticides that have been absorbed to return to the gastrointestinal tract from the liver via the biliary tract, also plays an important role.

This section is from Eason and Wickstrom (2001)

2.10.3.8 Antidote

Effective antidote is Vitamin K1. As this toxin can affect the body for many months, the antidote must be administered regularly for an extended period.

2.10.3.9 Treatment

Treatment aims to stabilise (maintain airway, control shock), decontaminate (gastric lavage / emesis followed by administration of activated charcoal), reverse anticoagulant effect (Vitamin K1 antidote), and if necessary compensate for blood loss by transfusion of blood or plasma. Appropriate supportive care may include intravenous fluids and oxygen supplementation.

2.11 Selection of the Preferred Bait

2.11.1 Bait Description

The selected bait to deliver Brodifacoum is Pestoff® 20R manufactured by Animal Control Products, Wanganui, New Zealand. In New Zealand, Pestoff® 20R is registered in New Zealand for aerial and hand broadcasting in operations to eradicate rodents from non-stocked off-shore islands as well as fenced enclosures (mainland islands). In Australia the APVMA has previously approved the aerial dispersal of Pestoff® 20R on several islands in New South Wales (i.e. Montague Is), Western Australia (Hermite Is) and Tasmania (Macquarie Is). The Brodifacoum that the manufacturer of Pestoff 20R uses is currently registered for use in Australia under **Product No.: 56139**

A summary of islands that have had rodent eradication using Pestoff 20R is found in Appendix I – Island Eradications Using Pestoff.

Pestoff® 20R is a cereal-based pellet dyed emerald green to reduce its attractiveness to birds (Brown *et al.* 2006). Pestoff® 20R is produced to rigorous specifications so as to be hard enough to withstand being applied through a mechanical spreader with minimal fragmentation, and to have minimal dust residue. A trial using non-toxic bait pellets was undertaken on LHI during August 2007, and this confirmed that the baits were highly palatable to both rats and mice, and readily eaten by both species (DECC, 2007a) (in Appendix D – LHI Trials Package). Trials on LHI found that baits disintegrated completely after approximately 100 days although this is highly dependent upon precipitation and humidity.

Appreciating that it is written for the situation in New Zealand, the baiting operation will comply with the relevant conditions of the Code of Practice for Aerial and Hand Broadcast Application of Pestoff® Rodent Bait 20R for the

Intended Eradication of Rodents from Specified Areas of New Zealand. (Animal Control Products, 2006). This document is designed to achieve

- The safe utilisation of Pestoff® Rodent Bait 20R to enhance the long term survival of threatened biota or for other ecological or commercial reasons that may develop in the future.
- The containment of Brodifacoum following aerial and / or hand broadcast application of PestOff® Rodent Bait 20R within the operational boundaries of any Specified Area.
- Brodifacoum residues in meat or food products sourced from livestock farmed on land either inside the operational area or adjoining any Specified Area as a result of the aerial and / or hand broadcast application of Pestoff® Rodent Bait 20R comply with the regulatory thresholds (see NZFSA website for these prescribed limits).
- The potential for any health risk to humans, arising as a result of the aerial or hand broadcast of Pestoff® Rodent Bait 20R, is eliminated.

The cereal seed used as the base in the bait manufacture is ground to flour, screened to 1.5 mm (smaller than cereal seed) and heated, thereby denaturing the proteins required for germination. There is, therefore, no risk posed by weed invasion by using this particular bait. The amount of poison (Brodifacoum) in each bait is 20 parts per million (0.002%), much less than that present in commercial Talon® (50 parts per million), a bait readily available to purchase and currently used by the residents on Lord Howe Island. Pestoff® Rodent Bait 20R pellet product breaks down more quickly than most commercial rodenticides which tend to contain waxes and other compounds aimed at extending bait life in the field. This would extend unacceptably, the period of non-target risk. The more rapid physical bait breakdown rate for Pestoff® Rodent Bait 20R and its lower toxicity provide an effective compromise between maintaining target animal efficacy and reducing non-target risk

Typically, 10-mm diameter bait is used for eradications targeting rats. The most appropriate size bait to target mice is less certain. In light of suggestions that some failed attempts at mouse eradication may have resulted from inadequate density of bait (pellets per unit area), both 10 mm and 5 mm diameter bait was tested for eradicating mice by applying each size to different sections of Montague Island for efficacy. On average, each 5.5 mm pellet weighs approximately 0.6 g, whereas each 10 mm pellet weighs approximately 2 g. Thus, for the same application rate (kg per ha), use of the smaller bait resulted in four times the number of pellets on the ground. This increased the encounter rate for mice, improving the chances that all individuals had access to bait. Brodifacoum is highly toxic to mice (LD_{50} is approximately 0.4 mg/kg), so each individual mouse need consume only a single 5.5-mm bait to ingest a lethal dose of poison. Results from the eradication of mice from Montague Island demonstrated that mice could be successfully eradicated using bait of either 10-mm or 5.5-mm diameter.

Given that the most difficult component of the eradication will be removing mice from the settlement where alternative foods may be more readily available, a high-encounter rate is preferable. On the other hand, the practical advantages of 10 mm baits over 5.5 mm baits are:

- They have been used through aerial sowing buckets in large quantities without problems.
- The pilot can see baits being spread which can be an advantage sowing up to exclusion zones or sensitive boundaries.
- It is much more feasible to retrieve the larger baits that may be accidentally over-sown into exclusion zones.
- In contrast 5.5 baits breakdown faster in the environment and are less easily seen than the 10mm bait which means that they are likely to pose a lower risk to children and pets i.e. it is harder for children and pets to locate them so this bait size will be used around the settlement.

As a precaution against ingestion by humans, most commercial rodenticides contain a compound known as Bitrex® which is extremely bitter and highly distasteful to humans. There are indications that this additive may cause bait aversion in some rodents and this may have contributed to the failure of several operations targeting mice and rats (Cleghorn and Griffiths, 2002 and Kaukeinen and Buckle, 1992). As eradication must deliver a lethal bait to 100% of rodents Bitrex® along with any other related additive will not be incorporated into baits used in the eradication on LHI including those used in the settlement area.

The amount of Pestoff 20R bait rats and mice need to consume to result in death is shown below in Table 10.

Table 10 Amount of Bait a Target Pest Needs to Ingest to Result in Death Based on Highest LD50 mg/kg

Species	LD50 (Mg/Kg)	Average Weight Female (G)	Amount (Grams) Of 0.02 G/Kg Brodifacoum Bait for LD50
House Mouse	0.52	20	0.5
Ship Rat	0.73	160	5.8

2.11.2 On Island Trials

2.11.2.1 Efficacy Trials

An efficacy trial using Pestoff 20R undertaken on Lord Howe Island in 2013 indicated that the susceptibility of rats to Brodifacoum was in line with that for the species as a whole (Wheeler and Carlile, 2013) (see Appendix D – LHI Trials Package). That is, judging by the results of this trial, all the rats on LHI are susceptible to low levels of Brodifacoum and could consume a lethal dose in one day, but may require four or five meals to do so. The typical mouse on Lord Howe Island could consume a lethal dose in one day, requiring up to nine meals to do so. A second mouse toxicity trial undertaken in 2016 (O'Dwyer *et al.* 2016) showed that, while there is a wide range in the time until death following ingestion of Pestoff 20R, the poison will kill Lord Howe Island mice when the bait is provided in a manner that is consistent with field conditions. Efficacy is further considered by the Australian APVMA in their assessment of a Minor Use Permit application that has been lodged for the LHI REP.

2.11.2.2 Palatability and Uptake Trials

In 2007, a non-toxic bait uptake trial (DECC, 2007a) was undertaken on LHI that examined rodent and non-targets species uptake of the bait pellets, bait breakdown in the environment and spread of the bait using helicopter. The study concluded that bait was highly palatable to both rats and mice and that sufficient bait would be available for both species to receive a lethal dose under eradication conditions. It found bait breakdown in the environment was approximately 100 days. It also found that four bird species (the LH woodhen, buff banded rail and two introduced species) consumed bait along with some invertebrates (see Appendix D – LHI Trials Package).

A further study in 2008 (DECC, 2008) (see Appendix D – LHI Trials Package) examined bait sizes. Both small (5.5 mm) and large (10 mm) baits were shown to be palatable to rats and mice. Consequently, either baits would be appropriate for use in an eradication operation on LHI, however large baits are recommended for aerial operations, and small baits for hand broadcasting where it is critical to increase bait encounter rates for mice. It is believed that the benefits of using two bait sizes justify the added complexity of the operation.

2.11.3 Options for distribution

The overarching goal of successfully eradicating rodents is dependent upon ensuring the delivery of a lethal dose of toxicant to every rodent on the island in a manner that minimizes harm to the ecosystem while still maintaining a high probability of success.

There are three methods which have been considered for use either separately of in combination.

Bait stations.

Bait stations have been used successfully for rodent eradications including 5000 ha Langara Island (Taylor *et al*. 2000) however this was an exception due to the flat and open nature of the island and it was targeting Norway rats (Rattus norvegicus which have much larger territories allowing stations to be at 50 m spacing. Bait stations have several advantages over broadcast options: reduces the total amount of toxicant used; allows ongoing monitoring of bait take; restricts access to the toxicant by non-target species including humans; is more socially acceptable. However, there are also major disadvantages, namely: – inter species and intra species competition i.e. the risk that dominant individuals may exclude subdominant ones; logistics – a bait station needs to be placed in very rodent territory, this is as little as every 10 m^2 for mice (Mackay *et al.*2011). This is impractical for LHI given its size and topography which would give an unacceptable safety risk to personnel i.e. treating cliff areas.; there is a risk of neophobia i.e. that some individuals may not be willing to enter an enclosed bait station especially one that is designed to exclude other species including humans i.e. has baffles. Trials have shown that wooden tunnels have a higher acceptance rate than plastic tunnels (Spurr *et al.*2007) but are even more problematic for wide spread use due to their size and weight.

Due to both legal constraints and social demands is likely that bait stations will need to be used at specified areas around the island i.e. in and possibly around dwellings however due to the increased risk of failure identified above this will be kept to the minimum possible.

Hand Broadcast

This involves applying bait at the designated rate using teams of personnel in working in lines across a prescribed area. The technique has been used successfully on smaller islands with easy topography e.g. during trials for Palmyra Atoll (Wegman *et al.* 2012), and Rat Island in the Aleutians (Ebbert and Byrd 2000) (both only targeting rats i.e. baiting gaps are not such an issue due to larger individual territories., but is problematic on larger or steeper islands where there are problems accessing all areas by foot in a short period of time. This is important as bait needs to be available to all animals at one time otherwise there is a risk of animals moving from baited areas in to unbaited zones.

Advantages of hand broadcast: bait available to all individuals at once, if done to standard, hence no inter or intraspecific competition; no need for the animal to enter an artificial structure i.e. bait station; greater encounter rate i.e. a bait approx. every $2m^2$; better public perception due to not having helicopters flying. However the risk is that due to topography, vegetation or human error there can easily be a gap in the baiting leading to individuals not being exposed- in the case of mice this could be as small as $10m^2$.

LHI's dense vegetation would limit the distance between hand baiting transects to approx. 10m. Based on the effort required to broadcast bait by hand (19.5 person-hours/ha) (Buckelew *et al.* 2005), it would take a 30-person team over 100 days to complete each of the two bait applications. While some efficiencies could be expected with a larger operation (the 2005 trial islands were baited by teams of 4-5 people), the effort required for hand broadcast eradication at LHI would be monumental and would pose unacceptable safety risks in attempting to access all areas.

The risk to non-target species during a hand broadcast operation would not be decreased from that incurred during an aerial broadcast operation.

Due to both legal constraints and social demands is likely that hand broadcast will need to be used at specified areas around the island i.e. in and possibly around dwellings however due to the increased risk of failure and risk to staff safety identified above this will be kept to the minimum possible.

2.11.3.1 Aerial Broadcast

Using purpose designed equipment i.e. spreader buckets and technology i.e. GPS guidance systems, the ability to accurately and consistency apply bait via aerial distribution has led to major increases in both the size and difficulty of island e.g. 13000ha Macquarie Island (Springer 2015) and 50,000 ha South Georgia Island (Russell and Broome 2016).

Aerial broadcast has all of the operational advantages of hand broadcast i.e. bait available to all individuals at once, plus it is more accurate i.e. less opportunity for human error and it is feasible for an island the size of LHI with its challenging topography.

As such the aerial application of highly palatable bait containing a suitable toxicant is the preferred technique for treating the bulk of LHI i.e. everything that is legally and socially acceptable including all the PPP.

2.12 Summary Comparison of Alternatives

The earliest eradications using toxicants utilised a network of bait stations, but this technique is very costly, time consuming and generally impractical for anything other than small islands (<100 ha) especially for mice. The exclusive use of Bait Stations on LHI is not possible given size and the rugged terrain. A far more cost-effective option is to spread bait aerially using a helicopter. Consequently, this approach has become the standard technique for most rodent eradications. Depending on the nature of the area to be baited, aerial baiting may need to be combined with hand broadcasting of bait or bait stations, particularly around areas of human habitation.

Hand broadcasting of bait and the use of bait stations are extremely resource intensive and hand broadcasting has a greater risk of gaps in coverage. Bait stations are problematic due to the density of stations required, especially for mice, and issues with interspecific and intraspecific competition, i.e. both mice and rats can be prevented from entering bait stations by dominant individuals of the same or other species, as well as quality of implementation. On LHI, rats may exclude mice from entering bait stations. This type of behaviour can put eradication operations at risk by violating a fundamental pre-requisite that all target animals are exposed to the poison. This means that in order to maximise cost-efficiency and minimise the risk of failure these methods tend to be used over the minimum area possible. The exclusive use of Bait Stations or traps on LHI is not possible given the size and rugged terrain.

A range of possible methods and mortality agents were considered for use in eradicating both rats and mice on LHI (Table 9 and Table 11). The only method capable of removing every rat and mouse on LHI is aerial distribution, in conjunction with minimal hand broadcast and bait stations where required, of highly palatable bait containing an effective toxicant. An evaluation of potential rodenticides for aerial control of rodents (Eason and Ogilvie 2009) concluded that Brodifacoum was the best rodenticide for island eradications. The use of any other mortality agent would be largely experimental and pose unacceptable risks of failure. The *Island Eradication Advisory Group* for the Department of Conservation in New Zealand who are recognised as leaders in this field, is of the opinion that "*there is no other alternative rodenticide on the market anywhere in the world with which we would have the same level of confidence in using to eradicate Ship Rats and mice from an island such as Lord Howe*".

Table 11 Assessment of Eradication Options

Eradication Technique	Suitable for eradication	Feasible for Eradication on LHI	Justification
Disease	No	No	No suitable pathogen yet developed that could eliminate all individuals.
Trapping	Yes	No	May be feasible for eradication on small islands, however may cause individuals to become trap shy. Size and inaccessible terrain of LHI makes this option unfeasible
Biological	No	No	Likely to fail to completely eradicate the target species. High likelihood of unacceptable non-target species impacts.
Fertility Control	No	No	No suitable fertility control yet developed that could eliminate all individuals.
Toxicant - Bait station / hand broadcast only	Yes	No	May be feasible for eradication on small islands. Size and inaccessible terrain of LHI makes this option unfeasible.
Toxicant – Aerial Broadcast only	Yes	No	Highly successful on uninhabited islands. Socially unacceptable on LHI.
Toxicant – Combination of Aerial and Hand Broadcast / Bait Stations	Yes	Yes	Brodifacoum in the form of Pest off 20R has been selected as the preferred toxicant on LHI considering proven success, efficacy and non-target impacts

2.13 Likelihood of Success

Whilst it is difficult to predict a likelihood of success, the selected eradication techniques, toxin and bait give the LHI REP the best chance of being successful given the constraints on LHI and based on global experience developed over 30 years and more than 380 successful eradications worldwide. The success rate for mouse eradications from 1997-2014 on NZ islands using the same bait and technique is 100% or 11 from 11 attempts (Broome and Fairweather, 2016,) whilst rat eradications on islands over the same period have been 98% successful (37 of 39 attempts) (DIISE 2016).

Constraints that increase the risk of failure and how they have been considered for the LHI REP are detailed below.

Constraint	Solution
Island size and topography (including cliffs, crevices, caves	The aerial distribution of baits is the only realistic method of baiting a large topographically challenging island such LHI. Aerial application using a spreader bucket has been shown to be effective in delivering a toxic dose of bait to every rodent on similar large and rugged islands (i.e. Macquarie and Campbell Islands). GPS technology will be used to ensure total bait coverage.
Permanent human population	To minimise potential risks to human health, a combination of hand broadcasting and bait stations will be used in the settlement area. This will allow coverage to be maintained including in roofs and under buildings. A clean up of island hard waste is currently underway and has successfully removed over 150 tonnes of hard waste that was providing potential rodent habitat. Access to individual properties is still under negotiation through the Property Management Plan process. To date negotiations have occurred over 90% of all properties with no property owners refusing baiting in some form.
Access to baits and inter species competition	The LHI REP has been specifically designed to target both rats and mice. Bait will be applied at a density that will allow all rats and mice access to a lethal

	dose.
Alternative food sources	Whilst LHI has alternate foods sources available, unlike tropical islands, the sub tropical LHI has reduced alternate food availability over winter when the REP is planned. The Pestoff 20R bait proposed to be used is specially designed to be highly palatable to rodents and this has been shown on LHI even with alternate food available in the laboratory and in field conditions. The Pestoff 20R bait is much more palatable than commercial rodenticides containing Brodifacoum as these contain waxes to preserve life and taste deterrents to prevent human ingestion.
Unexpected challenges	The LHIB will continue to work with global leaders in island eradications particularly the New Zealand Island Eradication Advisory Group (IEAG) to ensure best practice and lessons learnt from other eradications are considered.

The final decision by the LHIB to proceed with the eradication or not will be informed by assessment of the technical, social and financial feasibility. This will include:

- The technical feasibility. The IEAG will undertake a critical review of the operational plan and provide advice on likelihood of success for LHIB consideration.
- Social acceptability. The LHIB will consider the level of community support once all property Management Plans are complete and all approvals are received.

The LHIB will not proceed unless the REP is considered to have high likelihood of success.

2.14 Alternative Locations and Timeframes

Alternative locations were not considered.

The baiting is planned to occur in winter (June - August) of 2018 but may extend into September if there are problems such as unfavourable weather conditions. June- August is preferred because this is the time of the year when the rodents are at their most vulnerable due to the relatively low abundance of natural food. Many of the seabird species are also absent from the island at this time of years. This is also the low season for tourists on LHI. The operation will take place in a single year sometime between 2018 and 2019. Uncertainty remains concerning the year because there are a number of approvals that have not yet been obtained.

2.15 Compliance with the Principles of ESD

The proposed LHI REP is in compliance with the Principles of Ecologically Sustainable Development (ESD)

Principles of ESD	Demonstrated Compliance
(a) Decision-making processes must effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	The proposed REP considers both positive and negative short and long term environmental and socio-economic impacts of proceeding with the eradication compared to not proceeding. The REP will provide a range of environmental and socio-economic benefits that significantly outweigh potential negative impacts or risks. The final decision to proceed or not will be made considering whether environmental and human health risks have been appropriately mitigated and considering the technical, financial and social feasibility and acceptability of the project. Stakeholders including the local community have been extensively consulted and their concerns have been considered and addressed to the extent possible.
(b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty must not be used as a reason for postponing measures to prevent environmental degradation.	The proposed REP meets this principle. Rodents have previously been responsible or implicated in a number of extinctions on the LHIG (and around the world) and are a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates on the island.

	Failure to address the threat from rodents may lead to further serious or irreversible environmental damage. Significant effort has been made to ascertain potential impacts posed by the eradication based on global scientific evidence and local studies. However, full lack of scientific certainty on some aspects should not be used as a reason to postpone the eradication.
(c) The principle of inter-generational equity – that the present generation must ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The LHIB is directly responsible to the NSW Minister for the Environment and comprises four Islanders elected by the local community and three members appointed by the Minister. It is charged with the care, control and management of the Island's natural values and the affairs and trade of the Island. It is also responsible for the care, improvement and welfare of the Island and residents. Inter- generational equity has been a major consideration for the LHIB in its progression of the proposed REP. The LHIB recognises that long term protection of biodiversity and World Heritage values is intrinsic to the long term environmental and economic welfare of current and future generations of islanders. The implementation of the proposed REP will help to ensure the health, diversity and productivity of the LHI environment is enhanced for future generations through removal of rodent impacts on those values.
(d) The conservation of biological diversity and ecological integrity must be a fundamental consideration in decision-making.	The proposed REP will provide for conservation of biodiversity through the eradication of introduced rodents (rats and mice) from the LHIG. The eradication will permanently remove impacts from rodents to biodiversity and matters of NES including threatened and migratory species and World Heritage values.
(e) Improved valuation, pricing and incentive mechanisms must be promoted.	The REP will have significant economic benefits to LHI.

3 Initial Assessment

A general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110(3)(a) of the TSC Act)

3.1 Identifying Subject Species

3.1.1 Assessment of Available Information

The ecology and biodiversity of LHI has been extensively studied and documented over a long period of time providing an excellent baseline. The island has fascinated scientists since discovery in 1788 (Hutton, 1990) and a broad range of anecdotal accounts of sightings, collections and research projects relevant to the REP have been undertaken including rare plant surveys, breeding ecology of seabirds and invertebrate surveys (DECC, 2007).

Distribution and abundance, particularly of threatened and endemic species is comparatively well understood. Surveys have helped contribute to flora and fauna records for the island and the listing of many threatened species under both the EPBC Act and the TSC Act. Several surveys for rare plants have been undertaken by OEH (formerly DECC) to determine the distribution, population size and threats to a number of plant species (Hutton 2005 and Hutton 2001b). Outcomes of these surveys have resulted in the listing of several plant species on the TSC Act. The Australian Museum has been collecting systematic terrestrial invertebrate data since 1977 with results collated over time Cassis *et al.* (2003).

The bird life in particular has been extensively studied by scientists, locals and visitors. Records are kept on bird sightings and several ecological studies of the threatened seabirds on Lord Howe Island have been completed. These studies have focussed on breeding productivity and foraging ecology as a means of evaluating conservation status and threats.

Individual species such as the Lord Howe Woodhen, the LHI Currawong, and phasmid have all been well studied as part of recovery actions.

A summary of relevant studies undertaken included in Section 4.

References and studies cited include a broad range of:

- peer reviewed and published scientific literature
- Commonwealth and State government reports and website references
- unpublished reports prepared specifically for the proposed LHI REP undertaken by appropriately qualified and experienced LHIB, NSW OEH staff or consultants
- unpublished reports from a range of similar eradication projects undertaken around the world.

Of 196 references cited, 160 (81%) are from peer reviewed scientific journals, government documents and PhD thesis (92, 64 and 4 respectively). An additional nine are published books. The majority of these studies are considered to be very recent (within the last 5 years) or recent (within the last 15 years). Older studies are used where the information was considered still relevant. Studies from the scientific literature and Australian and State government reports and references were considered to be extremely reliable and credible. Studies undertaken for the LHIB by qualified and experienced staff or consultants and other global eradication projects (mostly undertaken by reputable foreign governments) were also considered reliable and credible. Uncertainties in any of the sources were noted and where relevant considered in this proposal.

Species lists, distribution and abundance of species on LHI is well summarised in resources such as the LHI Biodiversity Management Plan (DECC, 2007) and the Atlas of NSW Wildlife (www.bionet.nsw.gov.au/) which have been examined to determine what *threatened species* (as listed in the *Threatened Species Conservation Act 1995* (TSC Act) and *significant species* are present on the LHIG. These species are listed in section 3.1.2 below. Species listed in the Atlas of NSW Wildlife and/or named in the Lord Howe Island Biodiversity Management Plan (DECC 2007) are accepted as occurring on the Lord Howe Island Group and were automatically included as part of the Species Impact Statement because all of the LHIG will be subject to the rodent eradication. Data from the NSW Scientific Committee was examined for relevant Threatened Populations and Threatened Ecological Communities.

Not all species listed below, although present on LHI during certain periods of the year, are regarded as *subject species*. The reasons for their exclusion are set out in Table 12.

3.1.2 Identifying Threatened Species, Populations and Ecological Communities

3.1.2.1 Threatened Species

Species listed as threatened under the TSC Act, occurring or with the potential to occur in the project area are described in Table 12 below.

Not all species occurring or with the potential to occur will be impacted by the LHI REP. Risks to non-target species during an eradication programme are a function of the species present on the island group and their behaviour, susceptibility of those species present to the poison, composition and delivery method of the bait and the probability of exposure to the poison either directly or indirectly.

Species have been categorised based on their likelihood of occurrence and abundance on LHI at the time of the proposed REP and potential impacts. Table 12 makes assessment on whether the species are considered *subject species* and *affected species* and the associated threat category. Further validation for species not assessed as *subject species* is provided in Section 3.1.3. and validation for species considered as *subject species* but not *affected species* is provided in Section 5.2.1. Assessment of potential impacts to species identified as *affected species* is detailed in Section 5.2.2.

The threat categories used in Table 12 are:

- (A): will not be in the area during baiting or only a very small proportion of the population may be present, and although individuals may be potentially affected by the baiting programme, the species is not significantly threatened;
- (B): a vagrant or irregular visitor, therefore not a *subject* species because they are "not likely to be present in the area that is subject to the action……" (Section 110 (3) (a) TSC Act).
- (C): a marine species (fish, invertebrate, mammal or reptile) and therefore not threatened by the baiting programme (see Appendix J – Marine Hypothetical Scenario which offer arguments that discount the danger to marine life of the rodent eradication);
- (D): present on the LHIG but whose biological traits (e.g., diet, physiology) exclude them from being at risk;
- (E): a marine or migratory bird that may be present on the island group during the baiting period but whose ecology (e.g., diet, nesting habits and/or foraging area) exclude them from being at risk;
- (F): species potentially affected by the baiting programme;

Table 12 TSC Act Listed Threatened Species Occurring or with the Potential to Occur on the LHIG

Data primarily from DECC (2007), Hutton (1991), McAllan *et al.* (2004) and DoE (2016).

CE = *Critically Endangered*; E = *Endangered*; V= Vulnerable

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
Birds						
Australasian Bittern *Botaurus poiciloptilus*	Recorded Vagrant	Only one verified record for LHI (and that is from 1888) (McAllan *et al.* 2004) and not recorded as breeding. Recorded elsewhere feeding on freshwater crayfish, fish as well as frogs and tadpoles. It is therefore highly unlikely that the species will be present during the proposed baiting operations in winter and any population on LHI would be insignificant at a state, national and international scale. The impact of the proposed rodent eradication programme is assessed to be non-existent for this species.	No	No (B)	No	V
Black-browed Albatross *Diomedea melanophris*	Recorded Vagrant/irregular visitor; seabird	Only three records of occurrence in the LHIG, and all were at sea (McAllan *et al.* 2004). This species feeds on fish and squid. It is highly unlikely the species will be present during the proposed baiting operations in winter 2017. If any are present, they are highly unlikely to occur in shallower water within 2km from LHI, the Admiralty Islands and surrounding islets. The impact of the proposed rodent eradication programme is therefore assessed to be non-existent or negligible for this species.	No	No (B, E)	No	V
Black-tailed Godwit *Limosa limosa*	Irregular visitor	The five records of this species seen on LHI are confined to the spring and summer months (McAllan *et al.* 2004). The eradication programme is not a threat to this species as it would not be on the island during baiting.	No	No (B)	No	V

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
Black-winged Petrel *Pterodroma nigripennis*	Regular visitor; seabird	It is absent from the LHIG from May to October (McAllan *et al.* 2004), therefore the eradication programme is not a threat to it.	No	No (A)	No	V
Flesh-footed Shearwater *Puffinus carneipes*	Regular visitor; breeds LHIG	This deep-sea fish-eater arrives at LHI in August and departs in May (McAllan *et al.* 2004). It breeds underground (egg laying commences in December), arriving at and departing from these burrows only at night.	No	No (A, E)	No	V
Gould's Petrel *Pterodroma leucoptera*	Vagrant; seabird	Only two at-sea records and one beach-wash record for this species (McAllan *et al.* 2004). Diet of the species includes squid and fish. It is highly unlikely the species will be present during the proposed baiting operations in winter 2017. If any are present, they are highly unlikely to occur in shallower water within 2km from LHI, the Admiralty Islands and surrounding islets. The impact of the proposed rodent eradication programme is therefore assessed to be non-existent or negligible for this species.	No	No (B)	No	V
Great Knot *Calidris tenuirostris*	Vagrant; wader	Only one bird recorded on the LHIG, and that was in November 2002.The proposed baiting is not a threat to a significant population of the Great Knot.	No	No (B)	No	V
Greater Sand Plover *Charadrius leschenaultii*	Vagrant; wader	The three records for this species, spanning 1914 to 2002, are confined to spring and summer (McAllan *et al.* 2004). It is very unlikely that any Greater Sand Plovers will be on LHI during the period when baiting is proposed, therefore the species is not threatened by the rodent eradication.	No	No (B)	No	V
Grey Ternlet *Procelsterna cerulea*	Resident	These ternlets are present on the LHIG all year round (Hutton 1991). Nesting takes place from late August, eggs are laid in September and October (McAllan *et al.* 2004) and chicks fledge in December/ January (Hutton 1991). Their food consists of small fish and crustaceans collected from the sea surface. Poisoning is not a significant risk to the species but individuals	Yes	Yes (F)	Yes; but from helicopter-strike, not from poisoning	V

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		risk colliding with low-flying helicopters.				
Kermadec Petrel *Pterodroma neglecta*	Regular visitor; seabird	Breeds on Ball's Pyramid (which will not be baited) from November to May (Hutton 1991), and may been seen flying around Mt. Gower during summer. They are very rarely observed in the relatively shallow waters within two kilometres of LHI, the Admiralty Islands and surrounding islets (J. Shick pers. comm.). This species forages in deep water on squid, fish, crustaceans and, during the breeding season, insects. As it is not in the area when the baiting is planned it is unlikely to come into contact with bait or helicopter and therefore the eradication programme is not a threat to it.	No	No (A)	No	V
Lesser Sand Plover *Charadrius mongolus*	Irregular visitor	Approximately 23 Lesser Sand Plovers have been recorded on LHI between 1977 and 2003 (McAllan *et al.* 2004). Of the 13 records, dates on which the birds were seen are given for 11, all of which are confined to October to April. The small number of individuals involved, and the timing of their visits, indicate that the rodent eradication is not a threat to this species.	No	No (B)	No	V
Little Shearwater *Puffinus assimilis*	Regular visitor; seabird	Present on the LHIG February to October. Nests are in burrows. Most eggs are laid in July with the bulk of hatchings occurring in late August (Hutton 1991). The birds feed at sea, returning after sunset to feed their young. They depart before sunrise. Because the birds feed at sea, the population is not at risk of primary or secondary poisoning. As the adults are away from the island during daylight hours, it is very unlikely that any will be hit by the baiting aircraft.	Yes	No (E)	No	V
Little Tern *Sterna albifrons*	Vagrant	The five individuals recorded on LHI from 1967 to 2003 were seen in the period October to March (McAllan *et al.* 2004). Their diet consists of mainly fish (but also crustaceans, insects and molluscs) collected by diving into the sea or gleaning from its surface. Unlikely that this species will be affected by the baiting	No	No (B, E)	No.	E

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
Lord Howe Island Currawong *Strepera graculina crissalis*	Endemic sub-species; land bird	This bird is a sub-species of the mainland Pied Currawong, and is endemic to the LHIG. The entire population of the Lord Howe Island Currawong is restricted to LHI and the nearby islets (Mayr and Greenway 1962; Schodde and Mason 1999). The current population is 215 ± 11 birds (Carlile and Priddell, 2007) and appears to be stable as there is no empirical evidence of an historical decline (DEWHA 2009a). The Lord Howe Island Currawong is widespread on LHI, occurring in lowland, hill and mountain regions. It mainly inhabits tall rainforests and palm forests, especially besides creeks or in gullies, but it also occurs around human habitation, and forages amongst colonies of seabirds on offshore islets (DEWHA 2009a). It breeds in the forested hills of LHI, particularly in the south (Hutton 1991, McFarland 1994). Highest densities of nests are on the slopes of Mt Gower and in Erskine Valley (Garnett and Crowley 2000). Its breeding sites are located close to water in gullies (Garnett and Crowley 2000; Hindwood 1940; Hutton 1991). The currawong occurs singly, in pairs and family groups and, in the non-breeding season, in small flocks of up to 15 birds (DEWHA 2009a). It has been recorded breeding from October to December although breeding may commence in September (McAllan *et al.* 2004). During the breeding season breeding pairs and offspring probably occupy strongly-defended territories (Knight 1987). Data from a recent mark-recapture programme undertaken by the OEH suggests that not all currawongs are able to establish a breeding territory due to the lack of appropriate habitat (Carlile and Priddel 2007). In autumn and winter the species forms flocks and can be found in the settlement area	Yes	Yes (F)	Yes	V

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		(DEWHA 2009a). No information is available on the ages of sexual maturity or life expectancy, but it is probably capable of surviving to more than 20 years of age (Higgins *et al.* 2006). Breeding success appears to be relatively low; the only available, though limited, data suggests that less than 42% of nests produce fledglings (DEWHA 2009a). The Lord Howe Island Currawong is omnivorous; its diet consisting of fruits, seeds, snails, insects, the chicks of other bird species, and rodents (Garnett and Crowley 2000; Hull 1910; Hutton 1991; McFarland 1994).				
Lord Howe Island Golden Whistler *Pachycephala pectoralis contempta*	Endemic sub-species; land bird	The diet of the whistler is comprised of invertebrates. It will not eat pellets so it is not at risk of primary poisoning. It may be exposed to Brodifacoum by eating insects that have fed on pellets but few, if any, whistlers will receive a lethal dose this way.	Yes	Yes (F)	No	V
Lord Howe Island Silvereye *Zosterops lateralis tephropleura*	Endemic sub-species; land bird	The silvereye is considered to be at low risk given that it eats mainly fruit, seeds and insects. Local studies found no evidence that this sub-species consumed baits. Evidence from rodent eradications in New Zealand suggests that a few silvereyes may succumb to the effects of Brodifacoum, but at the population level the species was not harmed by rodent baiting. Any losses on LHI are likely to be small and short term. Any initial decline will be followed by a marked increase in populations due to the removal of rodents and subsequent increase in invertebrate food resources.	Yes	Yes (F)	Yes	V
Lord Howe Woodhen *Hypotaenidia sylvestris*	Endemic species; land bird	The Lord Howe Woodhen is a flightless bird endemic to LHI. Annual surveys of bird number are conducted in November- December since the 1980s. The population estimate in 1997 was 220-230 individuals and 71-74 breeding pairs (NPWS 2002).	Yes	Yes (F)	Yes	End.

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
		The population of woodhen has been increasing steadily over the last ten years (LHI Board unpubl. data. 209 birds were recorded as part of the annual population survey conducted in 2015. The 2015 survey data is still being analysed to produce a total population estimate using the methodology in Harden (1999). It is expected that the population estimate will be approximately 240-300 individuals (unpublished data). Woodhens usually lay eggs from August until January (NPWS 2002) or February (Gillespie 1993) and continue raising young until April (NPWS 2002). However, the start and finish dates of breeding can vary between years and there are breeding records for much of the year (Miller and Mullette 1985). Pairs have multiple broods during the breeding season (Gillespie 1993). Juveniles can breed at nine months of age (Marchant and Higgins 1993) but juveniles that do not establish a territory by the breeding season immediately following their own hatching generally do not survive (Harden and Robertshaw 1988, 1989). About 60% of juveniles die in their first year (Harden and Robertshaw 1989) possibly due to limited high-quality habitat (NPWS 2002). Breeding success is greater in the settlement area than in the southern mountains (Marchant and Higgins 1993, Harden and Robertshaw 1988, 1989). The species is currently impacted by rodents on LHI. The woodhen occurs predominately in three vegetation types: 1) Megaphyllous Broad Sclerophyll Forest (mainly palms), which covers 19% of the island; 2) Gnarled Mossy-Forest, which covers 2% of the island; and 3) Gardens around houses. About 40 % of the population lives in the settlement area of the island				

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
		(NPWS 2002). Over 80% of the woodhen's diet is comprised of earthworms (Miller and Mullette 1985). The bulk of the remaining 20% is made up of grubs, typically found in rotting logs. Snails, arthropods, seabird chicks, rodents, plant shoots, lichen and fungi are also eaten (NPWS 2002). Woodhen were observed eating non-toxic pellet baits during a trial conducted on LHI to gauge what species may eat the Pestoff 20R baits. Blue-coloured faeces have also been seen when handling some birds, indicating they had been consuming Brodifacoum wax blocks (Harden 2001). These blocks are widely dispersed around the settlement by residents. Further evidence of woodhens consuming Brodifacoum baits has come from its detection in the internal organs of several woodhens found dead along roadsides and recovery of ill birds that have been captured and treated with Vitamin K.				
Masked Booby *Sula dactylatra tasmani*	Resident; seabird	On LHI year round. Breeds from June to February with most egg-laying occurring in December. LHI is the most southerly breeding colony of boobies in the world (McAllan *et al.* 2004). This sub-species breed only on the Lord Howe, Norfolk and Kermadec island groups (McAllan *et al.* 2004). The birds feed at sea so are not, therefore, threatened by poisoning. However, boobies nest above ground so the breeding colony will be subject to disturbance from the baiting aircraft.	Yes	Yes (F)	Yes; risk of helicopter strike and disturbance at the colony.	V
Masked Owl *Tyto novaehollandiae*	Resident; land bird	Although classified as *Vulnerable* under the TSC Act, the Masked Owl was introduced to LHI (along with 5 other Australian and North American owl species) to controls rats in the 1920s and 1930s. The Masked Owl on LHI were until recently believed to be the Tasmanian race *(Tyto novaehollandiae castanops),* however genetic testing has found significant divergence of the LHI population with *T. n. castanops,* suggesting hybridisation with the Mainland race *(Tyto*	No	No Introduced	No	V

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		*novaehollandiae novaehollandiae) (*Hogan *et al.* 2013). This hybridisation and loss of genetic integrity would exclude translocation of the LHI Masked Owl to Tasmania or NSW. A recent study (Milledge, 2010) has shown that rodents currently provide the Masked Owl's main prey base on the Island, supplemented by occasional predation on other native birds but this may change if rats, the owls' staple diet, are eliminated from LHI. During the rodent eradication it is expected that most owls are likely to succumb to secondary Brodifacoum poisoning by ingestion of poisoned rodents. To avoid any remaining owls switching to a diet of solely native species in the absence of rodents, it is proposed to eradicate remaining owls via hunting or trapping before, during and after the baiting proposal.				
Painted Snipe *Rostratula benghalensis*	Vagrant; wader	There has only been one record on LHI, and that was in February 1990. Not recorded as breeding on the LHIG. Feeds on vegetation, seeds, insects, worms and molluscs, crustaceans and other invertebrates. It is therefore highly unlikely that the species will be present during the proposed baiting operations in winter and any population on LHI would be insignificant at a state, national and international scale. The impact of the proposed rodent eradication programme is assessed to be non-existent for this species.	No	No (B)	No	V
Pied Oystercatcher *Haematopus longirostris*	Vagrant	The species seen may in fact be the New Zealand South Island Pied Oystercatcher (McAllan *et al.* 2004). Five records for LHI, each of a single bird, cover the period 1950 to 1998. Pied Oystercatchers forage on rocky headlands, exposed reefs with rock pools, beaches and muddy estuaries for small fish and invertebrates such as limpets, worms, crabs and mussels but the risk of secondary poisoning is low. Unlikely to be present in significant numbers therefore	No	No (B)	Yes	E

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		the proposed baiting is not a threat to this species.				
Providence Petrel *Pterodroma solandri*	Regular visitor; seabird	Found on LHI year-round (McAllan *et al.* 2004). The Providence Petrel feeds at sea. It is present in its breeding grounds (the two southern mountains) from March to November. In August, Providence Petrels will be tending young in the nest underground so breeding birds will not be in the area until late afternoon/evening. However, non-breeders will be present during the days until mid-August (Hutton 1991), therefore there is the possibility of collision with low-flying helicopters dropping bait.	Yes	Yes (F)	Yes; but from helicopter-strike, not from poisoning	V
Red-tailed Tropicbird *Phaethon rubricauda*	Regular visitor; seabird	Summer-breeder; with about 500 to 1,000 pairs being active. Only a few birds are present during the winter months (McAllan *et al.* 2004). As the greater majority of birds will not be on the island group during the proposed baiting, the rodent eradication does not pose a threat to this fish-eating species.	No	No (A, E)	No	V
Sanderling *Calidris alba*	Vagrant	A regular summer migrant from Siberia and other Arctic breeding grounds to most of the Australian coastline, arriving from September and leaving by May. Unlikely to be present during the REP.	No	No (B)	No	V
Sooty Oystercatcher *Haematopus fuliginosus*	Vagrant	Only one bird has been recorded on LHI (in March 1987). The Sooty Oystercatcher forages on intertidal flats, beaches and sandbanks for small fish and invertebrates such as molluscs, crustaceans, worms and echinoderms. Individual Sooty Oystercatcher foraging on the beaches on LHI in August may be at risk of secondary poisoning however it is highly unlikely that any significant numbers would be present. Therefore no impact is expected from the REP	No	No (B)	Yes	V
Sooty Tern *Sterna fuscata*	Regular visitor /resident	Up to 35,000 pairs breed on the LHIG. This species has been recorded on the LHIG in all months but it is most common from August to February (Hutton 1991). Eggs are laid from late August until early December	Yes	Yes (F)	Yes; but from helicopter-strike and disturbance of nesting birds	V

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		although the main laying period is from September to November (McAllan *et al.* 2004). The Sooty Tern mainly feeds on fish, squid and crustaceans caught at sea; cicadas are also taken from the forests in summer (Hutton 1991). It is not susceptible to poisoning by the rodent eradication. However, there is a risk of birds colliding with the helicopters and spreader buckets dispersing the bait if the baiting extends into late August or September which is considered unlikely.			if aerial baiting occurs in late Aug, not from poisoning	
Swift Parrot *Lathamus discolor*	Vagrant; land bird	One record only from LHI and that is of a dead bird found in 1968. Not recorded as breeding on the LHIG. Feeds on nectar, mainly from eucalypts, but also eats psyllid insects and lerps, seeds and fruit. It is therefore highly unlikely that the species will be present during the proposed baiting operations in winter and any population on LHI would be insignificant at a state, national and international scale. The impact of the proposed rodent eradication programme is assessed to be non-existent for this species.	No	No (B)	No	E
Terek Sandpiper *Xenus cinerus*	Vagrant/irregular visitor; wader	Only five Terek Sandpipers seen on LHI from 1959 to 1991 (McAllan *et al.* 2004). The four records that have dates are for spring (one for September, two in November) and summer. Baiting LHI will not threaten this species.	No	No (B)	No	V
Wandering Albatross *Diomedea exulans) (potentially five sub-species: amsterdamensis, antipodensis, dabbenena, exulans and gibsoni)*	Vagrant/irregular visitor; seabird	Only five records of occurrence in the LHIG. Three were at sea, several kilometres from LHI, one was seen from LHI and one was found washed up on Blinky Beach (McAllan *et al.* 2004). This species feeds on fish and squid. It is highly unlikely the species will be present during the proposed baiting operations in winter 2017. If any are present, they are highly unlikely to occur in shallower water within 2km from LHI, the Admiralty Islands and surrounding islets. The impact of the proposed rodent eradication programme is therefore assessed to be non-existent or negligible for	No	No (B, E)	No	E

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
		this species.				
White-bellied Storm-petrel *Fregetta grallaria*	Regular visitor; seabird	It is present on the LHIG from September to May but only on outer islands. They are very rarely observed in the relatively shallow waters within two kilometres of LHI, the Admiralty Islands and surrounding islets (J. Shick pers. comm.). White-bellied storm-petrels forage in deep water and only come on land at night from September to May. This species is unlikely to be present during the baiting operation and thus is unlikely to come into contact with bait or helicopters. No impact on this species is expected.	Yes	No (A)	No	V
White Tern *Gygis alba*	Regular visitor; seabird	On LHI the White Tern is generally present from October to May; 60-100 pairs nest annually on LHI (Hutton 1991). Although recorded in all months, it is usually absent from the island group from June to September (McAllan *et al.* 2004). Its diet of small fish and squid, and the absence of most, if not all, terns in winter, indicate that this species is not at significant risk from the rodent eradication.	No	No (A, E)	No	V
Invertebrates						
Lord Howe Placostylus *Placostylus bivaricosus*	Endemic species	The Lord Howe Placostylus is a large land snail; the shell of a mature specimen can be up to 8 cm long. It is endemic to LHI with three sub-species recognised. *Placostylus bivaricosus* is the only sub-species of this snail known to be extant; other sub-species are either listed as extinct (*P.b. cuniculinsulae*) or have not been recorded in over 30 years (*P.b. etheridgei*). It has close relatives in New Zealand (*P. ambagiosus, P. bollonsi and P. hongii*). Other members of the genus occur in the Solomon Islands, Fiji and New Caledonia. Once rather common throughout much of the lowland, the decline of the species was first noted in the 1940s. Recently live individuals of this species have been recorded in targeted surveys at 14 out of selected 20	Yes	Yes (D;)	No	E

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		sites in 2006/2007 and in seven out of 21 selected sites in 2010. During the 2016 survey this species was only found at one site from which it had previously been reported (near Old Settlement Beach). Live animals could not be found in Stephen’s Reserve in 2007, 2010 or 2016. Altogether these negative records indicate that the species is probably extinct in Steven’s Reserve, where it once was very common (Kohler *et al.,* 2016). Hutton & Hiscox (in Kohler *et al.,* 2016) concluded that the greatest density of live *Placostylus* snails appear to be where the practice of a good rat baiting program is exercised and where dense, heavy leaf litter exists that precludes the snails from predation by introduced birds, which have been identified as a second probable threat. The 2016 survey at Old Settlement Beach indicates that the species is still relatively abundant at this site, but overall the species is considered to be in decline. Animals are rather long-lived (5 to 10 years). Adults are ground dwelling and aestivate, inhabiting the leaf litter of rainforest areas, burying into the sand during drier periods. They are nocturnal and crawl on the ground during humid or wet nights in the leaf litter in moist forests. Juveniles are arboreal (Kohler *et al.,* 2016). The Ship Rat identified as a major predator of the species and posing a significant threat to the Placostylus, (NPWS 2001). Continuing decline is expected in the absence of rodent eradication as current rodent control practices are not preventing decline (Kohler *et al.,* 2016). The removal of predators from all its current and previous occurrences is necessary to ensure its long-term survival.				
Gudeoconcha sophiae magnifica (a helicarionid land	Endemic species	A large shelled endemic snail, previously recorded from upper slopes and summits of both Mt Lidgbird and Mt Gower (a total of 18 specimen records from between	Yes	Yes (?)	Unknown	CE

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
snail)		1914 and 2002). No live animals were found despite extensive surveys conducted by the Australian Museum in 2001 and 2002 and was not recorded during a targeted 2016 Australian Museum survey on Mt Gower despite considerable efforts (Kohler *et al.,* 2016). This lack of positive records suggest that the species is absent from or rare in the surveyed area of the summit of Mt Gower. Very little is known about the biology and ecology of this endemic snail. The nominate form of G. sophiae has been reported to be crawling on the ground during wet nights (I. Hutton pers. comm.) and the subspecies magnifica is postulated to have the same behaviour. Rats are regarded as a significant threat to this snail (Beeton, 2008a and, Kohler *et al.,* 2016) and are possibly driving this species towards extinction, if they have not done so already. Largely unprotected from rodent predation due to inaccessibility of its range. Continuing decline expected in the absence of rodent eradication, as rodent control is not practicable throughout most of its extant range (Kohler *et al.,* 2016).				
Masters' Charopid Land Snail *Mystivagor mastersi*	Endemic species	This minute snail, endemic to LHI, is only known from a few sites, including the summit of Mount Lidgbird, Mount Gower, and lowlands sites; Blinky Beach and Boat Harbour (Beeton 2008b), (a total of 10 specimen records from between 1887 and 2002). Specimens from Mt Lidgbird and Mt Gower differ in shell morphology from lowland forms and may represent a distinct, undescribed species. The lowland form has last been recorded in 1971 near Old Settlement Beach and has not been recorded during the comprehensive surveys between 1999 and 2002, or during the 2016 survey. Therefore, the lowland form may be very rare or possibly extinct.	Yes	Yes (?)	Unknown	CE

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
		By contrast, there are several more recent records of *Mystivagor* from the summit of Mt Gower, including one specimen found during the 2016 survey. The population has probably declined, due initially to pigs and goats, then later to predation by the introduced rat (Beeton 2008b). The size of the current population is unknown. Largely unprotected from rodent predation due to inaccessibility of its range. Continuing decline expected in the absence of rodent eradication, as rodent control is not practicable throughout most of its extant range (Kohler *et al.,* 2016). Charopid species generally favour moist forests where they live in leaf litter and feed on decaying plant matter or biofilm. They have a very small range of activity as they attach themselves to the underside of leaves, bark etc. Because of their small size and lifestyle, charopids have a limited dispersal capacity (Kohler *et al.,* 2016).				
Mount Lidgbird Charopid Snail *Pseudocharopa lidgbirdi*	Endemic species	This snail, endemic to LHI, is now thought to be confined to Mount Gower although its distribution, prior to 1945, also included Mount Lidgbird and Erskine's Valley (Beeton 2008c). From 1887 until 2002, 239 specimens have been collected for museums. However, the number of snails found has declined markedly since 1981, with only six specimens being recorded for the period 1981 to 2002 (none alive). Because the effort to find snails has increased since 1925, the decline in finds has been interpreted as reflecting a severe drop in the snail's population (Beeton 2008c). Recorded during the recent survey in 2016 (1 specimen on Mt Gower). The decline in the snail's population is likely to be due to damage done to its environment by pigs and goats, then subsequently to predation by the introduced rat (Beeton 2008c). The size of the current population is	Yes	Yes (?)	Unknown	CE

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		unknown. Largely unprotected from rodent predation due to inaccessibility of its range. Continuing decline expected in the absence of rodent eradication, as rodent control is not practicable throughout most of its extant range (Kohler *et al.,* 2016). Charopid species generally favour moist forests where they live in leaf litter and feed on decaying plant matter or biofilm. They have a very small range of activity as they attach themselves to the underside of leaves, bark etc. Because of their small size and lifestyle, charopids have a limited dispersal capacity (Kohler *et al.,* 2016).				
Whitelegge's Land Snail *Pseudocharopa whiteleggei*	Endemic species	Previously recorded from upper slopes and summits of both Mt Lidgbird and Mt Gower (a total of 14 specimen records from between 1887 and 2002). Two specimens recorded during a 2016 survey on Mt Gower. This species is probably uncommon and has a restricted distribution at high altitudes of Mt Gower and Mt Lidgbird (Kohler *et al.,* 2016). The key threat to this snail is predation by introduced rats (Beeton 2008d). Largely unprotected from rodent predation due to inaccessibility of its range. Continuing decline expected in the absence of rodent eradication, as rodent control is not practicable throughout most of its extant range (Kohler *et al.,* 2016). Charopid species generally favour moist forests where they live in leaf litter and feed on decaying plant matter or biofilm. They have a very small range of activity as they attach themselves to the underside of leaves, bark etc. Because of their small size and lifestyle, charopids have a limited dispersal capacity (Kohler *et al.,* 2016).	Yes	Yes (?)	Unknown	CE
Lord Howe Island Wood-feeding Cockroach *Panesthia*	Endemic species	This cockroach was once found on the main island and several satellite islands but there are no records of it being found on the main island after the 1960s. It is	Yes	No (D)	No	E

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
lata		currently thought to be restricted to rat-free Blackburn and Roach islands. The key threat to this cockroach is predation by introduced rats. Unlikely to be susceptible to poisoning.				
Lord Howe Island Earthworm *Pericryptodrilus nanus*	Endemic species	It has only been located on the ridge of Mt. Gower. Unlikely to be susceptible to poisoning.	Yes	No (D)	No	E
Marine Mammals						
Australian Fur-seal *Arctocephalus pusillus*	Irregular visitor	Principal food items are cephalopods and fish. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V
New Zealand Fur-seal *Arctocephalus forsteri*	Irregular visitor	Principal food items are cephalopods and fish. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V
Blue Whale *Balaenoptera musculus*	Rare visitor	Occasionally recorded in waters around the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	E
Humpback Whale *Megaptera novaeangliae*	Recorded Vagrant/irregular visitor; Marine Mammal	Occasionally recorded in waters around the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V
Southern Right Whale *Eubalaena australis*	Rare visitor	Occasionally recorded in waters around the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	E
Sperm Whale *Physeter macrocephalus*	Recorded Vagrant/irregular visitor; Marine	Occasionally recorded in waters around the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
	Mammal					
Marine Reptiles						
Green Turtle *Chelonia mydas*	Recorded Vagrant/irregular visitor; Marine Reptile	In the LHIG, Green turtles regularly occur from the sheltered habitats of the lagoon through to the offshore fringing reefs and deeper shelf waters of the park. Feeds predominantly on seagrass and algae. No nesting recorded on the LHIG. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V
Leatherback Turtle *Dermochelys coriacea*	Recorded Vagrant/irregular visitor; Marine Reptile	Has been sighted very occasionally in waters around the LHIG and is likely to migrate periodically through the park's waters; it has a carnivorous diet consisting of jellyfish and other soft-bodied invertebrates. No nesting recorded on the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	V
Loggerhead Turtle *Caretta caretta*	Recorded Vagrant/irregular visitor; Marine Reptile	Occasionally recorded in waters around the LHIG as a visitor in the park during trans-Pacific migrations. Loggerheads are carnivorous, eating shellfish, crabs, sea urchins and jellyfish. No nesting recorded on the LHIG. Species unlikely to be present or present in small numbers. Unlikely to have sufficient exposure to bait.	Yes	No (C)	No	E
Terrestrial reptiles						
Lord Howe Island Southern Gecko *Christinus guentheri*	Recorded land reptile	Endemic to LHI and Norfolk Island. Once abundant on the main island until the mid-1930s, after which it declined dramatically, most likely due to predation by rats. Now rare on Lord Howe Island, more common on Blackburn and Roach Islands. Possibly present on other large offshore islets. This species feeds on beetles, spiders, moths, ants and other insects amongst the leaf litter.	Yes	Yes (F)	Yes	V

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
Lord Howe Island Skink *Cyclodina (Oligosoma) lichenigera*	Resident	Rich metallic bronze or olive above with numerous small brown longitudinal flecks or streaks, to about 80mm in length. Endemic to the Lord Howe Island Group and Norfolk Island. Rare on Lord Howe Island, more common on offshore islets – Blackburn Island, Roach Island and Ball's Pyramid, possibly other large offshore Islets. They feed on beetles, spiders, moths, ants and other insects amongst the leaf litter.	Yes	Yes (F)	Yes	V
Plants						
Knicker Nut *Caesalpinia bundoc*	Recorded	A woody scrambling shrub with bipinnate leaves and bright yellow flowers. The undersides of the leaf stems have sharp recurved hooks. The seed pod is also covered in recurved hooks, and contains two hard seeds. Rare and restricted occurrence on Lord Howe Island It is only found behind Ned's Beach and adjacent to Old Settlement Beach on Lord Howe Island. It is also found widely in the tropics and subtropics.	No	No (D)	No	E
LHI Morning Glory *Calystegia affinis*	Recorded	A delicate thin-stemmed twiner with white to pale pinky-purple flowers. Rare and very localised and restricted in its range. This species is endemic to Lord Howe Island and Norfolk Island. On Lord Howe Island it is known from eight locations; one on a slope at Old Settlement, the others at various locations in the southern mountains. Seed and seedlings potentially browsed by rodents.	No	No (D)	No	E
LHI Broom *Carmichaelia exsul*	Recorded	Broom-like leafless shrub with small white and purple pea flowers. Restricted to the southern mountains mainly around the 450-600m level, below the main cliffs of the mountains. Largest population at west end of Mount Gower north face, north edge of Big Pocket and near bottom of the	No	No (D)	No	E

Species	**Type of presence**	**Distribution, Abundance and Diet relevant to the LHI REP**	***Subject* species**	**Affected species (and threat category)**	**Individuals at risk (in the absence of mitigation)**	**TSC Act Listing**
		Razorback.				
Chamaesyce psammogeton	Recorded	Perennial herb, glabrous. The reddish-purple stems are prostrate, to 35 cm or more. Rare on Lord Howe Island, found only on Coastal dune at Blinkie Beach but also found in coastal NSW north to Queensland	No	No (D)	No	E
Coprosma inopinata	Recorded	A compact, prostrate shrub to 0.5m with light green lanceolate, opposite leaves. Only found on two remote ridges off the southern mountains.	No	No (D)	No	E
Phillip Island Wheat Grass *Elymus multiflorus subsp. kingianus*	Recorded	A tufted perennial grass, 30–100 cm tall, with a low, spreading habit, known from the Norfolk Island group and LHI. On LHI the subspecies (about 50 individuals) is record from only 2 locations (in close proximity) occurring between exposed basalt-derived cliffs near the water's edge, with littoral rainforest upslope (Auld *et al.* 2011). Seeds presumed to be predated by rodents.	No	No (D)	No	CE
Geniostoma huttonii	Recorded	A rare scrambling shrub to 1m high. Mainly found on the remote ridges and sheltered habitats in the southern mountains. On Mt Lidgbird it occurs on the south east corner at about 500m altitude. On Mount Gower it occurs on the cliff which leads into Little Pocket and above the Get Up Place.	No	No (D)	No	E
Little Mountain Palm *Lepidorrhachis mooreana*	Recorded	A stout, dwarf palm with a trunk to 2m high endemic to LHI. Confined to higher elevations in the southern mountains, mainly above 750m altitude. Rats are known to predate heavily on the developing seeds, and also chew the stems of leaf fronds.	No	No (D)	No	CE
Rock Shield Fern *Polystichum moorei*	Recorded	A fern with distribution limited to the southern mountains, favouring sheltered cliff faces and overhangs. Also known from low elevation near Kings Beach and mouth of Erskine Creek.	No	No (D)	No	E
Xylosma parvifolia	Recorded	Shrub to 2 m high. Restricted to the remote ridges in the southern mountains. Seed and seedlings potentially	No	No	No	E

Species	Type of presence	Distribution, Abundance and Diet relevant to the LHI REP	*Subject* species	Affected species (and threat category)	Individuals at risk (in the absence of mitigation)	TSC Act Listing
		browsed by rodents.		(D)		

3.1.2.2 Threatened Ecological Communities

The following Threatened Ecological Communities are found on LHI.

Table 13 TSC Act Listed Threatened Ecological Communities Occurring or with the Potential to Occur on the LHIG

Name	Comment	TSC Act Listing
Lagunaria Swamp Forest on Lord Howe Island	Sallywood Swamp Forest is found in very limited areas of Lord Howe Island, in low sites that are occasionally inundated. Originally restricted to five small patches in the mid island lowlands of Lord Howe Island. Some of these patches have since been destroyed. It is a plant community dominated by the Sallywood tree. Other species found in this community include Mangroves, Kentia Palm, Cottonwood Hibiscus and Blackbutt (OEH, 2017). http://www.environment.nsw.gov.au/threatenedspeciesapp/	CE
Gnarled Mossy Cloud Forest on Lord Howe Island	Gnarled Mossy Cloud Forest on Lord Howe Island is confined to LHI. On the island it is restricted to the summit plateau of Mt Gower and in a greatly reduced form and extent on the narrow summit ridge of Mt Lidgbird. The Little Mountain Palm, which is listed under the TSC Act as critically endangered is confined to the Gnarled Mossy Cloud Forest as are four TSC Act listed critically endangered snails (*Gudeoconcha sophiae magnifica ms, Pseudocharopa lidgbirdi, Mystivagor mastersi and Pseudocharopa whiteleggei*) and the Lord Howe Island Earthworm, which is TSC Act listed as endangered. Rodents are listed as a key threat to the Gnarled Mossy Cloud Forest Ecological Community (OEH, 2017).	CE

3.1.2.3 Threatened Populations and Critical Habitat

No listed Threatened Populations or Critical Habitat was identified as occurring on the LHIG.

3.1.3 Threatened or migratory species not regarded as subject species

Additional detail for threatened species not regarded as *subject species* in Table 12 is provided below.

3.1.3.1 Vagrants, rare regular or irregular visitors

Records for the LHIG refer to species that rarely visit the island group, and such visits typically involve only a small number of individuals. Even if the proposed baiting constituted a real threat to these individuals, no "viable local population of the species is likely to be placed at risk of extinction…. by the proposed action" (Section 5A.2.a TSC Act). Accordingly, vagrants, rare regular visitors or irregular visitors to the LHIG are not regarded as *subject species* as they are "not likely to be present in the area that is subject to the action……" (Section 110 (3) (a) TSC Act).

3.1.3.2 Most Migratory Birds

Most of the *threatened* birds that breed on or regularly visit the LHIG will not be present, or present in very low numbers, when the baiting is proposed (July-August). As the baiting will not damage nesting habitat nor contaminate the prey species, namely fish, of these birds, they are not regarded as *subject species,* and are not noted as such in Table 12.

3.1.3.3 Plants

REP activities with the potential to impact on threatened plants are: works associated with building the captive management facility and bait distribution (through potential uptake of Brodifacoum by plants).

The captive management facility construction will occur through modification of existing greenhouses structures at the nursery site. If needed, previously cleared land at the nursery within the lowland settlement area will be used. No clearing of land is proposed.

Brodifacoum is not herbicidal, is highly insoluble (WHO, 1995) and binds strongly to soil particles, therefore it is not likely to be transported through soils and taken up by the roots of plants into plant tissues. There is no identified chemical process that would allow Brodifacoum to impact on plants. This is in contrast to 1080, which has been known to be taken up by plants, although concentrations of that toxin decline rapidly in plants (Ogilvie *et al.* 2006).

A literature search failed to find published or verified unpublished data regarding plant uptake or persistence. Sampling of grasses (Poaceae) collected 6 months following application of Brodifacoum cereal baits at 15 kg/ha on Anacapa Island in California during 2001 and 2002 found no detectable residues in the six samples tested (Howald *et al.* 2010). The fact that hundreds of Islands have been treated for rodent eradication around the globe and not a single case of terrestrial vegetation has been reported to have been affected detrimentally by Brodifacoum exposure is a clear indication that no impacts are expected on LHI.

Therefore no impact to TSC listed plants is expected. Conversely removal of rodents is expected to significantly benefit individual species (such as the Little Mountain Palm and Phillip Island Wheat Grass) and many vegetation communities through reduced predation on developing seeds, seedlings and stems of leaf fronds. Auld *et.al* (2010) found rats on LHI have increased the risk of extinction for the two endemic mountain palms for on Mt Gower. This is a consequence of rat predation of fruits which has the potential to limit recruitment in both palm species. Past observations highlight the lack of ripe fruits on *Lepidorrhachis* plants unless mesh caging was applied to exclude rats from the developing fruits. The impact of rats is greatest in *Lepidorrhachis*, where fruit losses reached 100% and small juvenile plants (<50 cm) were extremely rare in the presence of rats.

Direct and indirect impacts of poison baiting should be considered at an ecosystem level to allow anticipation of complex or interactive effects (Innes and Barker 1999; Zavaleta *et al.* 2001; Caut *et al.* 2009). Current threats to endangered plant species on LHI primarily relate to impacts of rodents and climate change. Elimination of rodents may result in increased impacts from other threats that are not currently recognised. For example, rodents consume invertebrates and compete with them for food. Hence the elimination of rodents may lead to increased population size and food consumption by invertebrates. Rodents are known to consume seeds, fruits and vegetative plant material. Consumption of seeds and seedlings is likely to have the greatest impact on demographic processes, reducing recruitment success and causing population structures to become dominated by older plants (e.g. Auld *et al.* 2010). There is no indication that invertebrates contribute to losses of similar magnitudes to those currently attributed to rodents. Hence it seems unlikely that invertebrates will maintain similar levels of seed or seedling predation after rodent elimination. There is also potential for secondary impacts resulting from increased competition from other plant species that may currently be suppressed by rodents. Of the listed species, only *Calystegia affinis* (NSW Scientific Committee 2012; Hutton *et al.* 2008) and *Elymus multiflorus* subsp. *kingianus* (Auld *et al.* 2011) are currently impacted by competition from weeds. The main competitors for *Calystegia affinis* (*Pennisetum clandestinum* and *Stenotaphrum secundatum*) rarely propagate by seed, so it is unlikely that elimination of rodents will lead to an increase in population size or vigour of these invasive grasses. In contrast, if rodents consume seeds of the main competitors of *E. multiflorus* (*Sporobolus* *africanus*, *Bromus cartharticus, B. diandrus* and *Paspalum* spp. - Auld *et al.* 2011) there is potential for increased competition. This may be offset by an increase in seed production of *E. multiflorus*. Appropriate monitoring strategies and capacity for further intervention, if required, is an important component of the eradication plan. On balance, eradication of rodents is unlikely to have significant negative impacts on threatened plant species. Their eradication is very likely to have positive impacts on several species, especially *Lepidorrhachis mooreana* which at present is known to be affected by rat seed predation (Auld *et al.* 2010).

Elsewhere it has been demonstrated that population reduction or the elimination of rodents leads to plant recruitment and recovery of vegetation on oceanic islands (e.g. Allen *et al.* 1994; Olivera *et al.* 2010; Le Corre *et al.* 2015). However, the structure and composition of vegetation is likely to be different from the pre-invasion condition, and impacts of invasive species may prevent or delay the return to the uninvaded state (e.g. due to a loss of plant species or the lack of appropriate disturbance regime – Grant-Hoffman *et al.* 2010).

It is also possible that rodent eradication coincides with impacts from other threatening processes, leading to concerns that the eradication or other management actions cause additional impacts. On Macquarie Island, declines in *Azorella macquariensis* roughly coincided with the eradication of rabbits on the island. However,

Bergstrom *et al.* (2015) (among others) concluded that this decline was coincidental rather than causally linked to the eradication program. They advise that baseline data is necessary to determine if change is 'permanent' or decadal scale cycle. Furthermore, since disease was a contributing factor, plant biosecurity efforts should be employed to minimise likelihood of introduction or spread of disease. On Lord Howe Island, introduction of myrtle rust or further spread or re-introduction of phytophthora are of concern. Protocols already exist to minimise risk of disease introduction or spread by staff involved in weed management or by bushwalkers and these protocols should also be applied to people involved in the rodent eradication program. As discussed above, understanding ecological processes, pre- and post-eradication monitoring, flexibility during the implementation phase and capacity for further interventions are all necessary to prevent manifestation of 'surprise effects' of rodent eradication on islands (Caut *et al.* 2009).

Any possible increase in weeds due to reduced seed predation, would be detected under the existing weed eradication strategy on LHI.

4 Survey

As mentioned in Section 3.1.1 above, the ecology and biodiversity of LHI particularly threatened species are well understood and documented. Habitat preferences and distribution, particularly of threatened species is well described in documents such as the Biodiversity Management Plan (DECC, 2007). Individual species such as the Lord Howe Woodhen, the LHI Currawong, and threatened land snails all been well studied as part of species recovery actions or as part of the REP. Population surveys for woodhens are undertaken annually by the LHIB, and currawong have been studied as part of the REP (Carlile and Priddel 2006). A range of biodiversity benefits monitoring studies have been undertaken for the REP (described in Section. 2.2.1.8). Key studies relevant to the REP are detailed below in Table 14.

More importantly however, the REP will take place over the entire LHIG with the exclusion of Ball's Pyramid. This means that all populations present on LHI at the time of the REP, and all listed habitats and vegetation communities on LHI will be subject to the REP. There are no alternative locations. Therefore all species documented in the NSW Wildlife Atlas and/or in the Lord Howe Island Biodiversity Management Plan (2007) as occurring in the LHIG, were automatically part of the Species Impact Statement. No additional specific surveys for threatened species and vegetation were therefore considered warranted.

Table 14 LHI Ecological Study Summary

Species / Group	Overview of Studies	Key References
LHI Biodiversity Management Plan	Collated summary of species records, distribution and abundance and key threats, particularly of threatened species. Forms a holistic management document for protection of the island's biodiversity. It also constitutes the formal recovery plan for many threatened species.	DECC, 2007. Included as Appendix H – LHI Biodiversity Management Plan
The General Zoology of Lord Howe Island	Anecdotal accounts of fauna sightings and collections made by the Australian Museum collecting party in 1887	Etheridge 1889
Environmental Survey of Lord Howe Island	Results and recommendations of a scientific survey undertaken in the early 1970s. The aim of the survey was to determine the current status of the flora and fauna and to recommend ways in which the long-term survival of the indigenous species could be assured.	Recher & Clark 1974
Vegetation of Lord Howe Island	A description and map of the vegetation of the LHIG	Pickard 1983
Mosses of Lord Howe Island	A checklist of the mosses of Lord Howe Island based on literature and collections in Australian herbaria together with a summary of their distribution patterns on the island	Ramsay 1984
Flora of Australia Volume 49 Oceanic Islands 1 - Flora of Lord Howe Island	Lists the vascular plants of the LHIG, both exotic and native, that have been recorded on the LHIG	ABRS 1994
Vegetation and Habitat of Significance Within the Settlement Area of Lord Howe Island	An update of vegetation mapping within the settlement area. Mapping of the distribution of high conservation value vegetation within the settlement area and information on the distribution of habitat for threatened flora and fauna species .	Hunter 2002
Birds of Lord Howe Is land - Past and Present	Descriptions of sea birds and land birds, both extant and extinct A recent inventory of all known bird	Hutton 1991

The Birds of the Lord Howe Island Group: A Review of Records	records from the LHIG. Management issues are discussed where relevant	McAllen et al. 2004
The Birds of Lord Howe Island	Check list of birds known from and known to have occurred on LHI	The Emu Vol XLJ July 1940 Part 1. Hindwood, K.A.
LHI Woodhen	Recovery Plan Survey Methods Census results	NSW National Parks and Wildlife Service, 2002 Harden, 1999
LHI Currawong	Population size and distribution of the Lord Howe Currawong	Carlile and Priddel 2006. Included as part of Appendix C – Captive Management Package.
Masked Owl (and	Distribution, diet and abundance on LHI Genetics	Milledge, 2010 Hogan *et al.* 2013 Both included a part of Appendix F – Masked Owl Package.
Lord Howe Island: Terrestrial Invertebrate Biodiversity and Conservation Report	A synopsis of collated existing information on the terrestrial invertebrates of Lord Howe Island. It includes a statistical analysis of invertebrate biodiversity patterns across the LHIG, focussing on endemism and species richness, an assessment of the conservation status of selected terrestrial invertebrate taxa, and identifies threatening processes and conservation recommendations. This report was commissioned by DECC and the LHIB in 2003.	Australian Museum, 2003
LHI *Placostylus*	Assessing the risk of Pestoff® 20R Brodifacoum baits to the Lord Howe Island flax snail (*Placostylus bivaricosus*	Wilkinson and Hutton, 2013. Included as part of Appendix D – LHI Trials Package
Critically endangered Land snails	Australian Museum survey for critically endangered land snails (70 person hours across different parts of the island) and assessment of potential impacts from the REP.	Köhler, Hyman, and Moussalli, 2016. Report is included in Appendix K – Land Snail Survey 2016.
LHI Wood-feeding Cockroach	Abundance and occurrence study	Carlile , N., Priddel, D, 2013
Biodiversity Benefits	Distribution and abundance of key indicator species pre and post REP Land Bird Surveys	Carlile 2015 Fullagar, P., Davey, C., Nicholls, A. O., and Hutton, I, 2014 and 2015. Included as Appendix G – Biodiversity Benefits Monitoring Package
Reptiles	The reptiles of Lord Howe Island.	Cogger, H. G, 1971
Marine	Management plan for the LHI Marine Park (Commonwealth) Natural Values of Lord Howe Island Marine Park	Environment Australia, 2002. Marine Parks Authority (2010

5 Assessment of Likely Impacts on Threatened Species and Populations

An assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action (Section 110(2)(b))

In the following sections, species identified in Table 12 as *subject species* are further assessed by:

- *Subject species* assessed as not being *affected species*
- *Subject species* assessed as being *affected species (*those species likely to be *affected* by the proposal, and to identify the nature, extent and degree of the effect).
    - Potential impacts likely to arise from the REP are well understood based on impacts (or lack of impacts) that have been documented in the global literature on similar eradications. Therefore it is considered unlikely that unknown, unexpected or irreversible impacts will occur.

The potential likelihood, consequences, duration and extent of these impacts are described in detail in the section below.

5.1 Subject species assessed as not being affected species

Table 10 also includes the *subject species* for the LHI Group. *Subject species* has been taken to refer to those *threatened, migratory* and *significant* species that will be present on the LHIG at the time of baiting, excluding those species noted in Section 5.1.1. Although a *subject species* may be present, it is not necessarily at risk of being harmed by the proposed baiting (see Section 5.2 for the assessment of *affected species*).

Validation for species assessed as not being *affected species* is presented below.

5.1.1 Terrestrial invertebrates

The only REP associated activity with the potential to impact on TSC Act listed terrestrial invertebrates is through direct consumption of bait (primary poisoning). Conversely, predation by rodents is regarded as a significant threat to many of the invertebrates on Lord Howe Island (DECC 2007), and was listed as a Key Threatening Process by the NSW Scientific Committee in 2000.

Consumption of Brodifacoum is not expected to have significant effects on invertebrates as they have different blood clotting systems to mammals and birds.

Potential impacts to individual species is detailed below.

Lord Howe Island Earthworm *Pericryptodrilus nanus*

Conservation status

Listed as E*ndangered* under the TSC Act.

This earthworm is endemic to LHI. It has only been located on the ridge of Mt. Gower were it was found in deep leaf litter in moist environments close to streams (NSW Scientific Committee 2008b).

Threats

- Potential competition with introduced earthworms (DEC 2005);
- Loss, destruction or disturbance of habitat caused by other non-native invertebrates (e.g., exotic ants) (DEC 2005);
- Habitat disturbance through trampling by people (DEC 2005);
- Predation by the Lord Howe Woodhen;
- Predation by rodents (DEC 2005);
- Potential predation by the Song Thrush *Turdus philomelos* and Common Blackbird *T. merula* (DEC 2005).

Risk Posed by the Rodent-Baiting Proposal

During a trial in 2007 (DECC, 2007a a number of non-toxic Pestoff® 20R pellets) were distributed on LHI, and observed that, typically, it took about 100 days for the pellets to breakdown in response to weathering. Although the cereal pellet disintegrates and disappears in 100 days or so, the poison may take longer to break down. Manner of use of Brodifacoum baits and physical and chemical properties of Brodifacoum suggests little accumulation of Brodifacoum in soil, with concentrations of Brodifacoum in soil predicted to be negligible/low.

Brodifacoum binds strongly to soil particles, where it is broken down by soil micro-organisms to its base components, carbon dioxide and water, the half-life being 12-25 weeks (Soil Degradation for 50% of the compound (DT_{50})– typical 84 days: Field – 157 days; Shirer 1992). In laboratory studies using radioactive-labelled Brodifacoum, less than 2% of Brodifacoum added to any of four soil types tested, leached more than 2 cm (WHO 1995).

There are a number of operations in New Zealand where soil has been tested extensively following the use of cereal-based Brodifacoum baits. During the Little Barrier Island operation in 2004, soil samples were collected from directly under decaying Pestoff® 20R baits or where they had lain. Samples were taken 56 and 153 days after the aerial bait drop. Those in grassland areas had residues of 0.2 μg/g (micrograms of poison per gram of soil) after 56 days, and 0.03 μg/g on day 153. In forested areas the figures were 0.9 μg/g on day 56 and 0.07 μg/g on day 153. Brodifacoum soil residues were also tested in a baiting trial conducted at Tawharanui Regional Park, Auckland. Soil samples were collected from directly beneath disintegrating baits at 56, 84, 122 and 153 days after first exposure to the elements. These samples produced residues of between 0.02 and 0.2 μg/g, with all positive samples occurring within the first 84 days; that is, no Brodifacoum was detectable in the soil immediately below baits after just 84 days (Craddock 2004). Analysis of soil samples from Red Mercury and Coppermine islands following rat eradication using Brodifacoum showed no residue in any samples, including samples taken only one month after the operation (Morgan 1993; Morgan and Wright 1996).

There is no specific data available about the interaction of the local earthworms with Brodifacoum. However, studies of the effect of Brodifacoum on the pasture worm (*Aporrectodea calignosa*) indicate that extremely high concentrations of Brodifacoum are required to kill worms (Booth *et al.* 2003). The concentration of Brodifacoum in soil required to cause mortality in pasture earthworms (500 to 1000 micrograms of poison per gram of soil) is more than 1000 times higher than the likely levels of Brodifacoum that would be found in soil directly below a bait pellet at the application rate proposed for LHIG. To put it another way, all the Brodifacoum present in 25 to 50 kg of bait would need to be distributed through 1 kg of soil for that soil to be toxic to earthworms (Broome *et al.* 2016). "Worms have shown no evidence of vulnerability to Brodifacoum poisoning" Broome *et al.* (2016).

No impact is therefore expected to the LHI earthworm.

Mitigation of the Proposed Rodent Eradication

In view of the high tolerance of earthworms to Brodifacoum, the extremely low concentration of Brodifacoum likely to enter the soil from Pestoff® 20R pellets, and the very limited movement of Brodifacoum away from decomposing pellets, the baiting proposal is not regarded as a threat to the Lord Howe Island Earthworm so no mitigation measures are proposed.

Lord Howe Island Wood-feeding Cockroach *Panesthia lata*

Conservation Status

Listed as *endangered* under the TSC Act.

This cockroach is endemic to the LHIG. It was once found on LHI but there are no records of it being found on the main island after the 1960s (NSW Scientific Committee 2008a). It is currently thought to be restricted to rat-free Blackburn and Roach islands (DECC 2007). Cockroach distribution on Blackburn Island appears to be limited by the exotic Rhodes Grass *Chloris gayana,* a dense mat grass impenetrable to the cockroach.

Ecology

Panesthia lata prefers damp and shaded locations where it burrows in soil under logs and rocks. They feed on leaf litter and rotting wood.

Threats

- The key threat to this cockroach is predation by introduced rats (DECC 2007);
- Mice may also prey on juveniles of this species (DECC 2007);
- The loss, destruction or disturbance of habitat caused by people, wildfire, or the invasion of weeds such as Rhodes Grass.

Risk Posed by the Proposed Rodent-Baiting

Unpublished data from Landcare Research (and cited in Booth *et al.*2001) shows the Tree Weta *Hemideina crassidens*, a member of the grasshopper group of insects, to have both high tolerance to Brodifacoum and a short retention time. Weta orally dosed up to 62.5 ug/g with Brodifacoum survived. This is a relatively large amount of Brodifacoum considering one 10 mm Pestoff bait pellet contains about 40 ug/g of Brodifacoum. Weta were also dosed with 10 ug/g of Brodifacoum to determine retention time; no Brodifacoum was detected after four days. Cockroaches on Henderson Island were fed Pestoff 20R pellets (the type proposed for the eradication on Lord Howe Island) for four days; 12 days later the concentration of Brodifacoum in these insects was 0.061 ug/g which is less than 1/300 of the concentration of the Brodifacoum in the baits they ate (Brooke *et al.* 2013).

Crabs on Ascension Island survived being fed 7 to 20 pellets containing Brodifacoum at 20 parts per million; no residues were detected in these crabs more than a month after they ate the pellets (Pain *et al.*2000).

The extent of residual Brodifacoum in arthropods examined in the days after the local application of Brodifacoum baits varies. On Stewart Island, less than 5% of beetles collected at bait stations contained residues (Wright and Eason 1991, and the highest residue was only 3.3 ug/g which is less than 9% of that found in a single 10 mm Pestoff pellet. No arthropods collected from Copper and Red Mercury islands had traces of Brodifacoum in them after baiting took place Morgan *et al.*1996). On Lady Alice Island, cockroaches were collected in the days and weeks after aerial baiting and tested for Brodifacoum; none was detected. However, 51% of invertebrates (including beetles, cockroaches and Weta) from another study contained traces of Brodifacoum (range 0.02 – 7.47 ug/g) after baiting (Both *et al.* 2001). Notwithstanding the presence of Brodifacoum residue in arthropods, the populations of arthropods either increases (Brown 1997) or remains the same as in adjoining non-baited areas (Spurr 1996), indicating that arthropod populations are not significantly harmed by Brodifacoum baiting programmes.

Although research on the effects of Brodifacoum on arthropods is limited, three general trends are apparent; 1) high doses of Brodifacoum are not lethal to the arthropod taxa; 2) baiting with Brodifacoum does not harm arthropod populations (Broome *et al.* 2016) and 3) the retention time of Brodifacoum within arthropods is short, and can be measured in days, not the months typical for vertebrate species. These three factors suggest that Lord Howe Island's arthropods will not be harmed by the rodent baiting.

Mitigation of the Proposed Rodent Eradication

As it is unlikely that the proposed rodent eradication will harm *Panesthia lata*, no mitigation actions are warranted.

5.1.2 Birds

Flesh-footed Shearwater *Puffinus carneipes*

Conservation status

Listed as *vulnerable* under the TSC Act.

This shearwater has a trans-equatorial distribution over the Pacific and Indian oceans, excluding the seas north of Australia (Hutton 1991). LHI is the only eastern Australian site where the bird breeds. Here the breeding colonies are from Ned's Beach to Clear Place, below Transit Hill and at Old Settlement Beach. The population estimate for LHI is 17,500 breeding pairs.

Flesh-footed Shearwaters are present on the LHIG from September (DECC 2007) to May. Egg laying commences in December. Nests are in burrows. The birds feed at sea on fish, squid and crustaceans, returning after sunset to LHI. They depart before sunrise.

Threats

- Ingestion of plastics;
- By-catch in long-line fishing;
- Loss of nesting habitat due to the expansion of human settlement;
- Motor vehicle traffic;
- Killing by residents of those birds building under houses;
- Predation of nestlings and adults by domestic dogs.

Risk Posed by the Rodent-Baiting Proposal

Unless baiting takes place in September, this shearwater will not be on LHI during the rodent eradication. If the birds are present during the rodent eradication they will not be harmed by the baiting as the birds feed at sea, more than two kilometres from the island therefore the population is not at risk of primary or secondary poisoning. Flesh-footed shearwaters begin to fly close to the island in the late afternoon; some individuals will land at this time but most individuals land during or following dusk (N. Carlile and D. Portelli pers. obs.) therefore it is very unlikely that any could be hit by the baiting aircraft.

Mitigation of the Proposed Rodent Eradication

No mitigation is required.

Red-tailed Tropicbird *Phaethon rubricauda*

Listed as *vulnerable* under the TSC Act.

The distribution of this species covers the tropical and sub-tropical waters of the Pacific and Indian oceans (DEC 2005). Breeding for this species is confined to oceanic islands, with the largest breeding concentration believed to be on the LHIG (ibid). During the summer months, between 500 to 1000 pairs of tropicbirds can be found on the LHIG nesting along the cliffs from North Head to Malabar and around the cliffs of the southern mountains as well as on the Admiralty Islands and Balls Pyramid (McAllan *et al*. 2004). Only a few birds are present during the winter months (McAllan *et al*. 2004).

Threats (DEC 2005)

- Invasion of breeding grounds by weeds, particularly Bitou Bush;
- Juveniles are susceptible to a common fatal disease.

Risk Posed by the Proposed Rodent Baiting

As the greater majority of birds will not be on the island group during the proposed baiting, and because this species solely feeds on fish, the rodent eradication does not pose a threat to the tropic bird.

Mitigation of the Proposed Rodent Eradication

None required.

White Tern *Gygis alba*

Listed as *vulnerable* under the TSC Act.

This species is widely distributed in the Pacific and Indian oceans, as well as, to a lesser extent, the Atlantic (Higgins and Davies 1996). It breeds on islands throughout its distribution. Eggs are laid directly onto horizontal branches, typically into a depression or damaged section of the branch (Hutton 1991). The sub-species *G. a. candida* breeds in the tropical Pacific Ocean, including on LHI, Norfolk Island, and the Kermadecs, as well as in the tropical Indian Ocean (Higgins and Davies 1996). A minimum of 334 pairs of White Terns nested on LHI in 2006 (Carlile and Priddel 2015) compared to the 2,000 – 2,500 pairs found on Norfolk Island (Higgins and Davies 1996). On LHI the White Tern is generally present from October to May. Although recorded in all months, it is usually absent from the island group from June to September (McAllan *et al*. 2004). Its diet is made up of small fish and squid.

Threats

- Predation of nestlings by currawongs;
- Predation of nestlings and adults by Masked Owls.

Risk Posed by the Proposed Rodent Baiting

Its diet, and the absence of most, if not all, terns in winter indicate that this species is not at significant risk from the rodent eradication.

Mitigation of the Proposed Rodent Eradication

None proposed.

White-bellied Storm-petrel *Fregetta grallaria*

Conservation status

Listed as *vulnerable* under the TSC Act.

The White-bellied Storm-petrel is widely distributed in the Southern Hemisphere over most of the Pacific and Atlantic oceans as well as extending into the Indian Ocean (Hutton 1991). Although it breeds on a number of island groups throughout its range (e.g., Kermadec, Austral, Juan Fernandez, Rapa, Tristan da Cunha and Gough (Hutton 1991)), the LHIG is the only breeding site in Australian waters. Here it breeds on Roach Island, Mutton Bird Island, Balls Pyramid and possibly Blackburn Island. It has not been recorded breeding on the main island since the arrival of rats. The small size of storm-petrel adults, nestlings and eggs make them especially vulnerable to predation by rats.

The population of this storm-petrel on the LHIG is estimated to be somewhere between 100 and 1,000 pairs (Hutton 1991). It is probably present on the island group all year but the highest concentration is from November until May. Egg laying commences in January, and chicks fledge in May. Nests are usually located amongst large rocks. The birds feed at sea in deep water on crustaceans and squid collected from the ocean surface, returning after sunset to change-over egg-sitting duties or to feed young. They depart before sunrise.

Threats

- Possible establishment of rats on islands containing storm-petrel nesting grounds (DECCW 2009);
- Local extinction due to small population size (DECCW 2009).

Risk Posed by the Rodent-Baiting Proposal

Because the birds feed at sea, the population is not at risk of primary or secondary poisoning. Few birds will be in the area during the proposed baiting, and these will only be present at night so there is no risk of collisions with low-flying aircraft. No impact on this species is expected.

Mitigation of the Proposed Rodent Eradication

No mitigation is required.

5.1.3 Marine Species

Potential impacts to TSC Listed threatened marine species are limited to accidental bait entry into the water (either through aerial distribution or a spill) leading to pollution of water, primary or secondary poisoning.

Pollution of marine water resulting in impacts to threatened marine species is considered extremely unlikely considering the minimal amount of bait likely to enter the water, the insolubility of Brodifacoum and the huge dilution factor which was discussed in 2.7.1.4.

Appendix J – Marine Hypothetical Scenario contains a number of hypothetical examples where the contamination levels resulting from that bait spill have been assumed to exist off the Lord Howe Island Group, and involve representatives of some of the fauna that may be found in the area. This analysis demonstrates that the risks to marine species around the Lord Howe Island Group are negligible, and, accordingly, marine species are not *affected species*.

5.1.3.1 Marine Mammals

There is no realistic pathway by which threatened marine mammals can be significantly exposed to rodenticide at the LHIG as a result of the proposed aerial baiting with Pestoff® 20R. The combination of Brodifacoum being practically insoluble in water, the infinitesimal amount of Brodifacoum that may land in the sea and the huge dilution factor preclude any significant effect upon marine mammals. Marine mammal species are also rare visitors to LHI waters, passing through on the annual migration and are therefore unlikely to encounter the bait.

The movement of aircraft involved in the baiting does have the potential to disturb marine mammals. Further detail provide in Appendix J – Marine Hypothetical Scenario.

5.1.3.2 Turtles

It is very unlikely that Green Turtles *Chelonia mydas* could be exposed to rodenticides by consuming baits directly or prey items that have ingested rodenticides. Adult Green Turtles feed exclusively on various species of seagrass and seaweed. Plants have not been documented to take up and store anticoagulants; therefore no effect on adult Green Turtles is expected to occur from ingestion of rodenticide in their food.

Juvenile Green Turtles and the other four species of turtle (Flatback Turtle *Natator depressus*, Hawksbill Turtle *Eretmochelys imbricata*, Leatherback Turtle *Dermochelys coriacea* and Loggerhead Turtle *Caretta caretta*) that may be encountered in the marine park are carnivorous, and will eat soft corals, shellfish, crabs, sea urchins and jellyfish. However, it is unlikely that these turtles will encounter marine invertebrates that may have been contaminated with Brodifacoum as a result of aerial baiting the LHIG with Pestoff® 20R. Evidence against the existence of a significant dietary exposure pathway for invertebrates is outlined in section 2.7.2. No turtle nesting occurs on the LHIG.

In summary, the proposed baiting of LHI does not pose a threat to threatened marine life because:

- The use of specialised equipment on the bait hopper will ensure minimal bait entry to the water. The amount of bait that may bounce off the cliffs to fall into the sea will be minimal (Howald *et al.* 2005; Samaniego-Herrera *et al.* 2009);
- The breakdown of baits that do land in the sea will be rapid (Empson and Miskelly 1999), therefore the opportunity for fish to take baits will be limited;
- Fish have shown a lack of interest in baits (Samaniego-Herrera *et al.* 2009, U.S. Fish and Wildlife Service and Hawai'i Department of Land and Natural Resources 2008), so it is unlikely that many fish will take baits;
- The possible death of those few fish that find and eat enough baits to prove fatal does not pose a threat at the population level;
- Baiting other islands using similar methods, although sometimes using significantly more bait, has not resulted in adverse effects on the marine environment as a whole. (Cole and Singleton 1996; Empson and Miskelly 1999; Howald et al. 2005; Samaniego-Herrera et al. 2009).

- Potential impacts are likely to be very localised and temporary in nature.

5.2 Subject species assessed as being affected species

For each *affected species*, the TSC Act requires information relating to conservation status (local, regional and State-wide), habitat requirements, relevant key threatening processes, and recovery and threat-abatement plans. Pertinent sections of that Act are as follows:

1) An estimate of the local and regional abundance of those species or populations {Section 110(2)(d)};
2) An assessment of whether those species or populations are adequately represented in conservation reserves (or other similar protected areas) in the region {Section 110(2)(e)};
3) An assessment of whether any of those species or populations is at the limit of its known distribution {Section 110(2)(e1)};
4) A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region {Section 110(2)(f)};

As discussed in Section 4, the entire LHIG excluding Ball's Pyramid will be subject to the REP. Therefore discussions regarding habitat are considered irrelevant. Similarly as LHI is separated from the mainland by more than 600km, regional representation is only discussed where it is considered valid, for example migratory birds.

In addition, Section 112D of the Environment Planning & Assessment Act states that, in determining whether or not concurrence should be granted, the Chief Executive of the Office of Environment and Heritage must take certain matters into consideration. These matters include:

- s.112D(e) "*whether the activity is likely to reduce the long-term viability of the species, population or ecological community in the region*"
- s.112D(f) "*whether the activity is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction".*

Assessment of potential impacts to affected species is discussed below.

5.2.1 Terrestrial invertebrates

The only REP associated activity with the potential to impact on TSC Act listed terrestrial invertebrates is through direct consumption of bait (primary poisoning).

Consumption of Brodifacoum is not expected to have significant effects on invertebrates as they have different blood clotting systems to mammals and birds.

Introduced slugs and snails used as analogues for native snail species in experiments suggest NZ terrestrial molluscs are not susceptible to Brodifacoum poisoning (Broome *et al.*2016). Whilst most studies of molluscs indicate a lack of impact of Brodifacoum (Booth *et al.* 2003; Bowie and Ross 2006), a study conducted in Mauritius reported mortality in two snail species after reports of snails consuming toxic baits (Gerlach and Florens 2000). Trials done in NZ so far have failed to show any effect on invertebrates feeding on Brodifacoum baits (Booth *et al.* 2001; Booth *et al.* 2003; Craddock 2003; Bowie and Ross 2006).

Booth *et al.* (2003) carried out a laboratory evaluation of the toxicity of Brodifacoum to native snails, using introduced common garden snails as a model. In one experiment, common garden snails were exposed to soil contaminated with Brodifacoum at 0.02 to 2 mg ai/kg. In a second experiment, snails were exposed to contaminated soil (100 to 1000 mg ai/kg) and Talon® 20P pellets. No snail mortality was observed in either experiment. The authors concluded that primary poisoning of native *Powelliphanta* snails from cereal pellets containing Brodifacoum was unlikely.

Bowie and Ross (2006) allowed introduced slugs (*Deroceras* spp.) held in captivity, to feed freely for 40 days on Talon 50WB® wax baits containing 0.05 mg/kg Brodifacoum. No mortality was observed.

Gerlach and Florens (2000) reported 100% mortality of two Seychelles Islands snails (*Pachnodus silhouettanus* and *Achatina fulica*) after they consumed Brodifacoum baits. Lethal doses varied with snail size, with 15-20mm *P. silhouettanus* being killed by a dose of 0.01 to 0.2 mg/snail within 72 hours. This is equivalent to a *P. silhouettanus* eating between 0.5 and 10 g of 0.02 g/kg Brodifacoum bait. *A. fulica* were killed by a dose of 0.04 mg/kg in 72 hours (Booth *et al.* 2003). This is equivalent to an *A. fulica* eating approximately 0.2 g of 0.02 g/kg Brodifacoum bait. Both species are ground-dwellers and ecologically similar to the larger, ground-dwelling species on LHI, such as *P. bivaricosus*, *G. sophiae* and *G. s. magnifica*.

Gerlach and Florens (2000) also reported observing *Pachystyla bicolor* eating baits and finding significant numbers of recently dead snails following a Brodifacoum operation to control rats in Mauritius.

In another experiment by Brooke *et al.* (2011) native snails were collected from the litter layer on Henderson Island in the Pitcairn group and held on the island in plastic boxes to which broken pieces of Pestoff 20R cereal pellets containing 20mg/kg Brodifacoum were added. A control group of snails in boxes were kept in similar conditions with no exposure to Brodifacoum. Each of seven species (Orobophana spp and Achatinellids spp) was tested this way for 10 days. After 10 days exposure a total of 3 snails from the treatment groups were found dead from a total of 57. In the control boxes a total of 4 snails were found dead from a total of 53 held. None of the dead snails were found to contain Brodifacoum residues.

During 2007, a study using non-toxic baits (similar to those cereal pellets to be used in the proposed eradication operation) was conducted on LHI to examine bait uptake by non-target species (DECC, 2007a) (in Appendix D – LHI Trials Package). These baits contained a fluorescent dye that glowed under ultraviolet light. During the trial conducted on LHI, some ants, slugs, cockroaches and snails (not Placostylus) were observed feeding on baits (DECC, 2007a). For each of these groups only a small proportion of individuals had consumed bait.

Research was conducted in 2009 to assess the vulnerability of the endangered LH Placostylus to Brodifacoum baits (Wilkinson and Hutton, 2013) (in Appendix D – LHI Trials Package). When given a choice between their natural diet and bait pellets, Placostylus will feed preferentially on their natural diet, ignoring bait. When all other feed was denied to them, they fed exclusively on Brodifacoum baits, but no mortality occurred. These findings demonstrate that there is negligible risk posed to *Placostylus bivaricosus* by the proposed eradication operation as the probability of a significant proportion of the *Placostylus bivaricosus* population consuming and dying from toxic baits in the wild is extremely unlikely. This is supported by an Australian Museum assessment in 2016 (Kohler *et al.*, 2016). Full report attached in Appendix N – Land Snail Survey 2016.

The assessment also considered the probability of the other four listed land snails coming contact with the broadcasted baits (at a density of 1 per 2 m^2) based on their ecology and behaviour.

Three of the critically endangered land snails, minute to small leaf litter-dwellers with small activity ranges (*Mystivagor mastersi*, *Peudocharopa ledgbirdi*, *P. whiteleggei*) were considered at moderate risk of exposure to bait placed (i.e. some but not all individuals may get in contact with baits). Susceptibility to Brodifacoum was unknown.

The fourth species *Gudeconcha sophiae magnifica*, a large ground-dwelling species with large activity ranges was considered to be at high risk of exposure to bait. This taxon belongs to the same family and is ecologically similar to *Pachystyla bicolor* from Mauritius, a species shown to be susceptible to Brodifacoum.

The study recommended experimental testing be conducted to examine the susceptibility of the common subspecies *G. sophiae sophiae* to Brodifacoum as surrogates for the critically endangered subspecies *magnifica*. It also recommended that, where possible, insurance populations of listed or Brodifacoum-susceptible species are kept in captivity over the duration of the baiting program but noted this is probably not a realistic option for the very rare and hard to find species *M. mastersi*, *P. ledgbirdi*, and *P. whiteleggei* and may also prove challenging for the rare taxon *G. sophiae magnifica* (Kohler *et al.*, 2016). Therefore it is considered that the extreme rarity of these species precludes any testing of their susceptibility to Brodifacoum, or capturing the species to safeguard them in captivity.

The one endangered: *Placostylus bivaricosus* and four critically endangered species of land snails on LHI: Masters' charopid land snail, Mount Lidgbird charopid land snail, Whitelegge's land snail and *Gudeoconcha sophiae magnifica* are highly threatened by rat predation and it is likely that if rats are not removed these species will become extinct; some may already be extinct. (Kohler *et al.*, 2016). Whilst it is possible that some individuals of these species may be at risk of poisoning, this possibility must be weighed up against the threats associated with not removing rodents including almost certainty that predation by rats will result in the extinction of these species, in particular the critically endangered species living at high altitudes, where they are currently largely unprotected from rodent predation due to the inaccessibility of the area. Therefore a significant impact to these species is not expected from the REP when compared to not proceeding with the eradication. Proceeding with eradication of rats is listed as a priority action in the Commonwealth Conservation Advices for these species.

Gudeoconcha sophiae magnifica

Conservation status

Listed as *critically endangered* under the TSC Act.

Very little is known about the biology and ecology of this endemic snail which is, or was, predominantly confined to Mount Gower and Mount Lidgbird (Beeton 2008a). This habitat is protected in the island's Permanent Park Preserve.

Threats

- The key threat to this snail is likely to be predation by introduced rats (Beeton 2008a; NSW Scientific Committee 2015a);
- The Song Thrush and Common Blackbird are known to prey on the Lord Howe Placostylus, so they probably prey on this species as well (Beeton 2008a);

- Loss or destruction of habitat caused by wildfire, the invasion of weeds or trampling by tourists and other people (Beeton 2008a).

<u>Population estimate</u>

It appears that this endemic species has never been relatively common on LHI, at least in historic times. Only 76 specimens have been collected by the Australian Museum between 1907 and 2002. This represents only 0.34% of the total snail collection from LHI (Beeton 2008a). Evidence also indicates that numbers may have declined over time (Beeton 2008a). A recent survey undertaken to specifically search for this snail (Kohler *et al*. 2016) failed to find any specimens, including shells.

<u>Risk Posed by the Rodent-Baiting Proposal</u>

Laboratory tests, involving the administering of Brodifacoum, conducted on two species of snails in the Seychelles resulted in the death of all test subjects (Gerlach and Florens 2000) although laboratory tests conducted in other parts of the world indicated that other snails are not susceptible to Brodifacoum baits (Booth *et al.* 2003). In Mauritius dead snails of the species *Pachystyla bicolour* were found near bait stations, suggesting that this species may be harmed by Brodifacoum baits. It may also suggest nothing more sinister than large numbers of snails congregating at bait stations, and that this concentration of snails makes it easier to find snails that have died from a variety of reasons.

Kohler *et al.* (2016) state that *P. bicolour* is ecologically similar to *Gudeoconcha s. magnifica*, and have suggested that, because of this similarity, the LHI snail may be placed at high risk by the REP. However, Kohler *et al*. do acknowledge that this assessment is made without knowing if the LHI snail is susceptible to Brodifacoum, and is based solely on the ecological attributes of the snail. These authors also say “The eradication of both rats and mice (both equally important) is the most cost efficient and only feasible way to ensure the survival of the critically endangered (snail) species in the long term” (page 17); and on page 2 “Overall, we consider the eradication of rodents which represent the greatest threat to the indigenous snails, to outweigh any potential short-term negative effect” of the REP. It appears that baiting could place *G.s. magnifica* at risk of extinction but the continued presence of rodents will send (or has already sent) this subspecies to extinction. The threat posed by rodents to this species is highly significant (Beeton 2008a; NSW Scientific Committee 2015a), and justifies the use of Brodifacoum during the REP to remove such a major threat.

<u>Mitigation of the Proposed Rodent Eradication</u>

Testing this species for vulnerability to Brodifacoum or collecting a representative sample of the population for safe keeping is not feasible. This species is so rare (only 29 specimens, most of which were dead, were collected from 1998 and 2002, and none was found during the last three years of survey on Mount Lidgbird {Beeton 2008a}) that it is very unlikely animals could be found to take into captivity. None were found in an intensive search undertaken in 2016 (Kohler *et al.* 2016). Rats are regarded as a significant threat to this snail (Beeton 2008a; Kohler *et al.* 2016) and are possibly driving this species towards extinction, if they have not done so already. Current data indicates that long-term viability of this species, under present circumstances, is unlikely (Beeton 2008a). The method proposed for the eradication of rodents from LHI may potentially place *Gudeoconcha s. magnifica* at risk of poisoning, but this possibility must be weighed up against the high probability that predation by rats will result (or has resulted) in the extinction of this snail.

Lord Howe Placostylus *Placostylus bivaricosus*

<u>Conservation Status</u>

Listed as *endangered* under the TSC Act.

The Lord Howe Placostylus is a large land snail, the shell of a mature specimen can be up to 8 cm long. It is endemic to LHI but has close relatives in New Zealand (*P. ambagiosus, P. bollonsi and P. hongii*). Other members of the genus occur in the Solomon Islands, Fiji and New Caledonia. The Lord Howe Placostylus was once abundant and widespread on the island, inhabiting the leaf litter of rainforest areas. The decline of the species was first noted in the 1940s (NSW NPWS 2001).

Three recent sub-species of the Lord Howe Placostylus are recognised:

1) *Placostylus bivaricosus bivaricosus* is *endangered*, having declined in extent and number. It was formerly common over the northern end of LHI from sea level to the top of Malabar Hill (approximately 200 m).The current stronghold for this sub-species is the Settlement but other sites where the snail has been recorded since the 1970s are North Bay, near Transit Hill and the vicinity of the airport (NSW NPWS 2001).
2) *Placostylus bivaricosus etheridgei* occurred in the mountains at the southern end of the Island up to an altitude of 350 m. It is probably extinct (Ponder 1997, Beesley *et al.* 1998) although it is still hoped that this sub-species exists as isolated local populations on Little Slope and Big Slope (NSW NPWS 2001).

3) *Placostylus bivaricosus cuniculinsulae* was restricted to Blackburn Island. It is now believed to be extinct due to the loss of the original forest cover from this island as a result of grazing/browsing by rabbits (NSW NPWS 2001).

Habitat

Observations of Placostylus in the 19th Century indicate that this snail prefers shady, damp situations, preferably on scrubby calcarenite hillsides (NSW NPWS 2001). Ponder and Chapman (1999) found Placostylus “sheltering under well-developed, moisture-retaining leaf litter in forests” often in the vicinity of Banyan trees *Ficus columnaris,* and mostly on calcarenite-derived soils and sandy soils. All recent records have been in made in evergreen closed forests dominated by either Kentia Palm or Greybark *Drypetes australasica/*Blackbutt *Cryptocarya triplinervis* association (or ecotones between the two) (NSW NPWS 2001).

Habitat Protection

Areas providing habitat for the Lord Howe Placostylus are protected in the Permanent Park Preserve and Environment Protection areas, the latter as delineated in the LHI Regional Environmental Plan 1986.

Ecology

Lifespan for the Lord Howe Placostylus is unknown but its close relatives in New Zealand may live for 20 years, with maturity reached after three to five years (NSW NPWS 2001). Eggs are laid in the soil under leaf litter. Fallen dead leaves from broadleaf trees are thought to be its food source (NSW NPWS 2001).

Threats (NSW NPWS 2001)

- Loss of habitat through clearing of lowland forest. Forty-four per cent of the prime habitat for this snail has been cleared since settlement. Presently only 128 ha remains.
- The Ship Rat is a significant threat to the Placostylus, being a major predator of the species; the eradication of rats from LHI is a key recommendation of the Recovery Plan for the Lord Howe Placostylus.
- Flesh-footed Shearwaters *Puffinus carneipes* nest in prime snail habitat in the coastal evergreen closed-forests growing on calcarenite in the northeast of the island. Large numbers of snail shells have been found in the nesting areas of this seabird but no live snails have been found suggesting that disturbance of snail habitat by expanding populations of this shearwater is a major threat to the Lord Howe Placostylus.
- The introduced Song Thrush and Common Blackbird prey on the Lord Howe Placostylus, and maybe a significant threat to it.
- The invasion of snail habitat by introduced plants is likely to diminish the quality of the habitat for the snail. The effect on the snail of the use of herbicides to control these weeds is unknown.
- The use of snail bait around gardens in the Settlement Area to control the introduced garden snail is likely to threaten the Lord Howe Placostylus.
- Free-ranging chooks *Gallus gallus domesticus* feed on snail eggs and hatchlings.

Risk Posed by the Rodent-Baiting Proposal

When laboratory-acclimated Lord Howe Placostylus were exposed to non-toxic baits (containing the biomarker pyranine that fluoresces under ultra violet light) along with natural food in a feed-choice trial, they fed exclusively on natural food as no fluorescing faecal samples were detected. This finding suggests that the likelihood of significant proportions of the species consuming toxic baits is extremely small. When snails were only offered toxic baits, they ate the baits but no mortalities resulted from the exposure indicating that Placostylus is not vulnerable to Brodifacoum (Wilkinson and Hutton, 2013).

Mitigation of the Proposed Rodent Eradication

None proposed.

Masters’ Charopid Land Snail *Mystivagor mastersi*

Conservation status

Listed as *critically endangered* under the TSC Act.

This snail, endemic to LHI, is only known from a few sites, including Mount Lidgbird, Mount Gower, Blinky Beach and Boat Harbour (Beeton 2008b). However, recent surveys suggest that the species is now confined to the summits of the two southern mountains (Beeton 2008b). Only 17 specimens have been collected by the Australian Museum in 140 years (Beeton 2008b). An eighteenth snail was found in 2016 (Kohler et al. 2016).

Ecology

Little is known about the biology of this species, including its habitat requirements but this snail is believed to be arboreal (Beeton 2008b). Masters’ Charopid Land Snail is a relatively uncommon snail and although there is insufficient quantitative data available to prove that the snail population has declined, it is probable that it has (Beeton 2008b). The size of the current population is unknown.

Threats

- The key threat to this snail is predation by introduced rats (Beeton 2008b; NSW Scientific Committee 2015b);
- The Song Thrush and Common Blackbird are known to prey on the Lord Howe Placostylus, so they may prey on this species as well (Beeton 2008b);
- Loss, destruction or disturbance of habitat caused by exotic ants, wildfire, the invasion of weeds or trampling by tourists and other people (Beeton 2008b).

Risk Posed by the Rodent-Baiting Proposal

As the ecology of this species is mostly unknown (Beeton 2008b), there is little data available to indicate that this snail is not at risk of either primary or secondary poisoning. Based solely on ecological data, Kohler *et al*. (2016)) place this species in the moderate risk category. However, if it is arboreal (Beeton 2008b) then baiting is unlikely to pose a threat to it as the greater majority of baits will be distributed onto the ground surface.

Mitigation of the Proposed Rodent Eradication

Testing this species for vulnerability to Brodifacoum or collecting a representative sample of the population for safe keeping is not feasible due to this snail's rarity. Only 18 Masters' Charopid Land Snails have been found since 1869 (Beeton 2008b; Kohler *et a*l. 2016). Only one of these 18 was alive when collected so, therefore, it is very unlikely any could be found to take into captivity. Rats are regarded as the major threat to this snail (Beeton 2008b) and are possibly driving this species towards extinction. The proposed eradication of rodents from LHI may place Masters' Charopid Land Snail at risk of poisoning, but this possibility must be weighed up against the high probability that predation by rats will result in the extinction of this snail.

Mount Lidgbird Charopid Snail *Pseudocharopa lidgbirdi*

Conservation status

Listed as *critically endangered* under the TSC Act.

This snail, endemic to LHI, is now thought to be confined to Mount Gower although its distribution, prior to 1945, also included Mount Lidgbird and Erskines Valley (Beeton 2008c).

Ecology

Little is known about the biology of this species, including its habitat requirements apart from its association with wet rock surfaces (Beeton 2008c).

From 1887 until 2002, 239 specimens have been collected for museums. However, the number of snails found has declined markedly since 1981, with only six specimens being recorded for the period 1981 to 2002. Because the effort to find snails has increased since 1925, the decline in finds has been interpreted as reflecting a severe drop in the snail's population (Beeton 2008c). Additionally, only one live specimen has been found since 1979 (Beeton 2008c; Kohler *et a*l. 2016). The decline in the snail's population is likely to be due to damage done to its environment by pigs and goats, and predation by the introduced rat (Beeton 2008c). The size of the current population is unknown.

Threats

- The key threat to this snail is predation by introduced rats (Beeton 2008c; NSW Scientific Committee 2015c);
- The Song Thrush and Common Blackbird are known to prey on the Lord Howe Placostylus, so they may prey on this species as well (Beeton 2008c);
- Loss, destruction or disturbance of habitat caused by exotic ants, wildfire, the invasion of weeds or trampling by tourists and other people (Beeton 2008c).

Risk Posed by the Rodent-Baiting Proposal

As the ecology of this species is mostly unknown (Beeton 2008c), there is little data available to indicate whether this snail is at risk of either primary or secondary poisoning.

Mitigation of the Proposed Rodent Eradication

Testing this species for vulnerability to Brodifacoum or collecting a representative sample of the population for safe keeping is not feasible due to this snail's rarity. Only seven Mount Lidgbird Charopid Snails have been found since 1981 (Beeton 2008c; Kohler *et a*l. 2016). Based on its ecological attributes, Kohler *et a*l. (2016) regard this species as at medium risk from the REP. It is very unlikely that a captive colony could be established. Rats pose a significant threat to this snail (Beeton 2008c) and, unless eradicated, they may drive this species towards extinction.

Whitelegge's Land Snail *Pseudocharopa whiteleggei*

Conservation status

Listed as *critically endangered* under the TSC Act.

Ecology

Little information on the natural history and biology of this species is known. It has been recorded living under and inside logs and in moss (Beeton 2008d). Once found on both of the southern mountains, it now appears to be limited to Mount Gower (Beeton 2008d).

Only 36 specimens have been lodged with the Australian Museum. This represents 0.15% of the Museum's total collection of LHI snails, and suggests that this species is uncommon. Furthermore, in spite of increased survey effort, only four specimens have been found since 1971 compared to 32 before 1920, indicating a significant decline in snail abundance (Beeton 2008d; Kohler *et a*l. 2016).

Threats

- The key threat to this snail is predation by introduced rats (Beeton 2008d; NSW Scientific Committee 2015d);
- The Song Thrush and Common Blackbird are known to prey on the Lord Howe Placostylus, so they may prey on this species as well (Beeton 2008d);
- Loss, destruction or disturbance of habitat caused by exotic ants, wildfire, the invasion of weeds or trampling by tourists and other people (Beeton 2008d).

Risk Posed by the Rodent-Baiting Proposal

As the ecology of this species is mostly unknown (Beeton 2008d), there is little data available to indicate whether this snail is at risk of either primary or secondary poisoning. Based on its ecological attributes, Kohler *et a*l. (2016) regard this species to be at medium risk from the REP.

Mitigation of the Proposed Rodent Eradication

Testing this species for vulnerability to Brodifacoum or collecting a representative sample of the population for safe keeping is not feasible. This species is so rare (just four specimens, only three of which were alive when found, have been collected since1971) that it is very unlikely animals could be found to safely take into captivity. Rats are regarded as a significant threat to this snail (Beeton 2008d). The eradication of rodents is the best course of action to ensure the protection of Whitelegge's Land Snail.

5.2.2 Terrestrial reptiles

REP activities with the potential to impact on TSC Act listed terrestrial reptiles include distribution of the bait through primary poisoning (direct consumption) and secondary poisoning (consumption of poisoned invertebrates).

There are two species of native terrestrial reptile on LHI, the LHI Skink *Oligosoma lichenigera* and the LHI Gecko *Christinus guentheri*. Both species occur on the offshore islets around LHI as well as on Norfolk Island, although each island group may have different sub-species. Although once widespread across the main island (DECC 2007), the skink now seems to be confined to sedge-grass habitat (Bray personal communication, Wheeler and Madani 2015), the dense structure of which may protect the skink from predators such as rodents. Predation by introduced rodents is regarded as the major threat to these species (DECC 2007).

Each species is considered to be at low risk of poisoning, and both are likely to substantially increase in abundance following the removal of rodents (Towns and Daugherty 1994, Hoare *et al.* 2006).

There is little published information on the interactions between reptiles and Brodifacoum worldwide (Hoare and Hare 2006). There has only been one reported incident of widespread death amongst reptiles following eradication operations that have used Brodifacoum baits (Merton 1987). In general, reptiles do not appear to be interested in cereal pellets (Merton 1987) but, after cereal-based pellets were dispersed onto Round Island, Mauritius, Telfair's Skinks *Leiolopisma telfairi* were seen eating rain-softened Talon pellets containing Brodifacoum at 20 parts per million (Merton 1987). A number of larger (80–100 g) skinks were later found dead (ibid). Ten skinks were autopsied but only one showed evidence of internal bleeding. The low proportion of deaths that could be attributable to haemorrhaging plus the observation that it was only larger skinks found dead, and for death to be associated with warm days, led Merton (1987) to conclude that Brodifacoum interfered with this reptile's ability to thermoregulate. Despite these deaths the number of reptiles, including Telfair's Skink, on Round Island has markedly increased since the baiting was undertaken (North *et al.* 1994).

Gunther's Gecko *Phelsuma guentheri,* although present during the same baiting programme as Telfair's Skink, showed a lack of interest in pellets (Merton 1987). Reluctance to eat bait was also shown by the skink *Oligosoma maccanni* (which is a close relative of the LHI Skink). When lizards in the laboratory were offered cereal-based pellets as their sole source of food, only a relatively small amount of bait was consumed (Freeman *et al.* 1996). However, two species of New Zealand geckos have been observed consuming Brodifacoum baits (Christmas 1995; Hoare and Hare 2006); therefore it is possible that the Lord Howe Gecko may eat Pestoff® 20R pellets. A number of skinks and geckos have been recorded eating Brodifacoum baits but without apparent harm. Wright's Skink (Mabuya wrightii) commonly took Brodifacoum baits from bait stations on Fregate Island but no mortality was observed (Thorsen *et al.* 1999). Fisher and Campbell (2012) noted that at least 25% of the population of Lava Lizards (Microlophus duncanensis) would sample bait on Pinzon Island but considered that there was no population level effect. Most (i.e., 60-80%) of bait stations at Tauwharanui showed regular visitation by Oligosoma smithii between February and April 2007 but no dead skinks were ever found, and out of 802 captures in pit traps, no live-trapped skinks showed signs of poisoning (Wedding 2010 Aerial application of Brodifacoum baits was undertaken on Palmyra Atoll and followed up with sampling 28 geckoes (Mourning Gecko Lepidodactylus lugubris and the Common House Gecko Hemidactylus frenatus) for Brodifacoum residues; it was found in 14 of them (Pitt *et al.* 2012).

The two LHI species are considered at risk of ingesting Brodifacoum if they feed on invertebrates that have themselves fed on Brodifacoum-laced baits. However the risk of secondary poisoning for these species is low because:

- Baiting will take place in winter when reptiles may be relatively inactive. Unpublished reports by Rebecca Bray (Monash University) to the LHIB indicate that both species of reptile are active in autumn, and that, for the skink, this level of activity is less than half that which occurs in summer; pitfall trapping in November/December 2010 and February 2011 caught 244 and 266 skinks respectively while the same trapping effort in April/May 2010 resulted in 117 captures. No comparable surveys were conducted in winter. However, in keeping with the precautionary principle, it is accepted that a number of reptiles will be active during the baiting period.

- the proportion of invertebrates that will have fed on Brodifacoum baits will be small so even if they are foraging at this time then most of the potential prey that they will encounter will not be poisoned (on Red Mercury Island for example, no Brodifacoum residue was found in 99% of the sample of invertebrates collected after the aerial application of Brodifacoum baits (Morgan *et al.* 1996);

Although there is potential for the two threatened reptiles to ingest Brodifacoum, the world-wide trend for reptiles on islands that have been baited with Brodifacoum to eradicate introduced mammals such as rodents, is to greatly increase in number (Towns 1991, 1994; North *et al.* 1994).

Two months after the application of Brodifacoum baits on Stanley Island, lizard pitfall capture rates were 29% higher than the previous best (Towns *et al.* 1993). The population of the Spotted Skink Oligosoma lineoocellatum on Nukuwaiata Island increased by 67% over the two years following aerial baiting with Brodifacoum (Brown 1997). There was no change in the abundance of the population of the gecko *Tarentola bischoffi* immediately after baiting with Pestoff 20 was undertaken on Selvagem Grande Island; but there was a significant population increase after three years (Olivera *et al.* 2010). The number of skinks on Korapuki Island in New Zealand increased 30 fold within 5 years of rats being removed (Towns 1994).

Another potential source of ingesting Brodifacoum for reptiles is through their consumption of invertebrates that have fed on baits (that is, through secondary poisoning). However, most invertebrates are unlikely to contain Brodifacoum; published values for the proportion of invertebrates containing Brodifacoum residue after baiting range from 1% (Morgan *et al.* 1996) through to 4% (aerial baiting) and 44% (baiting using bait stations) (Broome *et al.* 2016) on to 51% (Booth *et al.* 2001).

Because the available world-wide evidence indicates that skinks and geckos either do not eat baits, or if they do, with the exception of Telfair's Skink, they do so with impunity, then both species are not in danger of primary poisoning leading to haemorrhaging. The positive response of geckos and skinks after baiting referred to above also indicates that secondary poisoning is not a threat. This is evidenced on LHI, where the main population of the LHI skink occur at North Bay, which is currently extensively baited for rodents. If consuming Brodifacoum from any source risks compromising the ability of the two reptiles to thermoregulate as may have been the case with Telfair's Skink (Merton 1987) then such a possibility is mitigated by conducting the rodent eradication in winter.

The Lord Howe Island Gecko *Christinus guentheri*

Listed as *Vulnerable* under the TSC Act.

<u>Distribution and Ecology</u>

This gecko species is found only on the LHIG and on Norfolk Island. On the LHIG it is present on the main island, Balls Pyramid, Blackburn Island and Roach Island (DECC 2007). It may be present on other islets (ibid). The species was abundant on LHI until the mid-1930s when its numbers declined dramatically (ibid). The timing of the decline and the fact that it is still common on rat-free Blackburn and Roach islands suggest that predation by the rat was the cause for the population collapse.

A wide range of vegetation communities, ranging from lowland rainforest to montane rainforest as well as grasslands on the islets appear to be acceptable to the gecko provided there are abundant rocks to provide shelter for it.

It feeds on beetles, spiders, ants and other invertebrates amongst the leaf litter (DECC 2007).

Threats

- Predation by introduced rodents;
- Habitat disturbance due to weed invasion, clearing and trampling;
- Possible competition for food with the introduced skink *Lampropholis delicata*.

Risk Posed by the Proposed Rodent Baiting

There is little published information on the interactions between reptiles and Brodifacoum worldwide (Hoare and Hare 2006). Merton (1987) reported Telfair's Skink (*Leiolopisma telfairi*) as feeding on rain-softened pellet bait, and this apparently led to a number of deaths in this species. However, Gunther's Gecko *Phelsuma guentheri,* although present during the same baiting programme as Telfair's Skink*,* showed a lack of interest in pellets (Merton 1987). Reluctance to eat bait was also shown by the skink *Oligosoma maccanni* (which is a close relative of the LHI Skink). When lizards in the laboratory were offered cereal-based pellets as their sole source of food, only a relatively small amount of bait was consumed (Freeman *et al*.1996). However, two species of New Zealand geckos have been observed consuming Brodifacoum baits (Christmas 1995; Hoare and Hare 2006), therefore it is possible that the Lord Howe Gecko may eat Pestoff® 20R pellets.

Another potential source of ingesting Brodifacoum for reptiles is through their consumption of invertebrates that have fed on baits (that is, through secondary poisoning). That this secondary poisoning poses a significant risk to the Lord Howe Island Gecko is unlikely as the number of invertebrates that will have fed on Brodifacoum baits and retained the toxin before being consumed by the gecko is likely to be small (on Red Mercury Island for example, no Brodifacoum residue was found in 99% of the sample of invertebrates collected after the aerial application of Brodifacoum baits (Morgan *et al.* 1996)).

Although there is potential for this gecko to ingest Brodifacoum, the world-wide trend for reptiles on islands that have been baited with Brodifacoum to eradicate introduced mammals such as rodents, is to greatly increase in number (Towns 1991, 1994; North *et al*. 1994).

Mitigation of the Proposed Rodent Eradication

No mitigation is proposed as baiting is very unlikely to pose a significant threat to the Lord Howe Island Gecko.

The Lord Howe Island Skink *Oligosoma lichenigera*

Listed as *Vulnerable* under the TSC Act.

Distribution and Ecology

This skink is restricted to Norfolk Island and the LHIG (DECC 2007) although Cogger *et al*. (2006) suggest that the two island populations are genetically distinct, and should be placed into different taxa.

Rats prey upon this species and are probably the principal reason for its decline on the main island (DECC 2007). The introduced Delicate Skink *Lampropholis delicata,* which arrived in the early 1990's, has spread from the settlement to the Northern Hills and Intermediate Hill, and may compete for food with this species (DECC 2007). Possibly the effect of rodents on Delicate Skinks is less severe than it is on the LHI Skink because the Delicate Skink is much smaller, thereby better able to use small rock crevices and dense vegetation to evade rats.

On the LHIG the Lord Howe Island Skink is present on the main island, Balls Pyramid, Blackburn Island and Roach Island (DECC 2007). It may be present on other islets (ibid).

A wide range of vegetation communities, ranging from lowland rainforest to montane rainforest as well as grasslands on the islets appear to be acceptable to the skink provided there are abundant rocks to supply shelter for it (DECC 2007). However, on the main island, the skink now seems to be confined to sedge-grass habitat (Bray personal communication, Wheeler and Madani 2015), the dense structure of which may protect the skink from predators.

It feeds on beetles, spiders, ants and other invertebrates amongst the leaf litter (DECC 2007) and fruit (Bray personal communication).

Threats

- Predation by introduced rodents;

- Habitat disturbance due to weed invasion, clearing and trampling;
- Habitat loss due to storm surge (Wheeler and Madani 2015);
- Possible competition for food with the introduced skink *L. delicata*.

Risk Posed by the Proposed Rodent Baiting

In general, the risk of primary poisoning in reptiles is minimal as reptiles do not appear to be interested in cereal pellets (Merton 1987). However, after cereal-based pellets were dispersed onto Round Island, Mauritius, Telfair's Skinks were seen eating rain-softened Talon pellets containing Brodifacoum at 20 parts per million (Merton 1987). A relatively small number of larger (80–100 g) skinks were later found dead (ibid). Based on circumstantial evidence Merton (1987) concluded that Brodifacoum interfered with this reptile's ability to thermoregulate, and some of the larger individuals died from overheating. Despite these deaths the number of reptiles, including Telfair's Skink, on Round Island has markedly increased since the baiting (North *et al.* 1994). Therefore, it is possible that the Lord Howe Island Skink may eat Pestoff® 20R pellets, and this could lead to some deaths, but the overall effect on the species will not be detrimental. To the contrary, the removal of rodents will likely result in a substantial increase in reptile numbers (Towns 1991, 1994; North et al. 1994). It may be no co-incidence that the last remaining stronghold of the LHI Skink on the main island is the sedge-grass habitat of the beach dunes at North Bay in the immediate vicinity of bait stations set to protect the local population of the LH Placostylus (Wheeler and Madani 2015).

Merton postulated that the cause of death of Telfair's Skink was that Brodifacoum interfered with the inability of larger skinks, those over 80 grams, to thermoregulate, and so these larger skinks died from overheating. If so, then baiting LHI in winter should negate such a possibility especially as LHI skinks are relatively small, the heaviest caught in April 2015 was 9.7 g (Wheeler and Madani unpublished data).

Insectivores such as this skink risk ingesting Brodifacoum if they feed on invertebrates that have fed on Brodifacoum-laced baits. However the risk of secondary poisoning for this skink is low because:

- the proportion of invertebrates that may have fed on Brodifacoum baits will be small so even if skinks are foraging then most of the potential prey that they will encounter will not have been exposed to Brodifacoum (Morgan *et al.* 1996);
- the coagulation chemistry in reptilian blood is different to that found in mammals and birds, and as such, the risk posed to reptiles from baiting programmes using Brodifacoum is considered low (Merton 1987).

It is also unlikely that this species will feed on pellets considering that another *Oligosoma* species (*O. maccanni*) did not feed on poisoned cereal pellets (Freeman *et al*. 1996).

Mitigation of the Proposed Rodent Eradication

No mitigation is proposed as baiting is very unlikely to pose a significant threat to the Lord Howe Island Skink.

5.2.3 Birds

Potential impacts to TSC listed threatened birds from the proposed LHI REP include:

- Primary poisoning from consumption of bait pellets
- Secondary poisoning from consumption of poisoned rodents, fish or invertebrates
- Disturbance as a result of helicopter activities
- Collisions with the helicopter
- Impacts as a result of handling and captive management during the captive management program (LHIC and LHW only)

Emerald Dove *Chalcophaps indica*

Conservation status

-a regionally *significant* species

Although the species is common and relatively widespread, being found in India, China, south-east Asia, the Philippines, New Guinea, islands in the western Pacific including Norfolk and Lord Howe islands as well as northern and eastern Australia (Higgins and Davies 1996), the Lord Howe population may be significant. The local birds behave somewhat differently to other members of the species in that they are very tame. This may represent a trait typical of island species that have evolved in isolation, suggesting that the Emerald Dove has been established on LHI for some considerable time. However, Hindwood (1940) suggests that the dove may have been introduced about 150 years ago.

Their main habitat is the open lowland forest (Hutton 1991). Favoured food is fallen forest fruit fervently foraged from forest floors.

The breeding season occurs in spring and summer (Hutton 1991).

Risk Posed by the Rodent-Baiting Proposal

During 2007, a study using non-toxic pellet baits of various colours was conducted on LHI to examine bait uptake by birds (DECC 2007a). Emerald Doves consumed red baits and brown baits, but completely ignored green baits, which supports the view that colouring baits green deters many bird species from eating them. Therefore they are considered unlikely to be impacted by the REP.

Mitigation of the Proposed Rodent Eradication

Non-toxic bait trials indicated that the Emerald Dove will not consume bait if it is dyed green, which they will be for the eradication. No mitigation, other than the use of green baits, is proposed.

Grey Ternlet *Procelsterna cerulea*

Conservation status

Listed as *vulnerable* under the TSC Act.

The Grey Ternlet has a widespread distribution over the tropical and sub-tropical sections of the Pacific Ocean (Hutton 1991). Its only breeding sites in Australian waters are on Norfolk and Lord Howe islands (ibid). On the LHIG they nest along the cliff faces of North Head, the Admiralty Islands, Mutton Bird Island, Gower Island and Balls Pyramid. These ternlets are present on the LHIG all year round, and are estimated to number 100 to 1,000 pairs (Hutton 1991). Nesting takes place from late August, eggs are laid in September and October (McAllan *et al.* 2004) and chicks fledge in December/ January (Hutton 1991). Their food consists of small fish and crustaceans collected from the sea surface.

Threats

- Predation of eggs and young by rodents at nesting sites on LHI (rodents are absent from the other islands in the LHIG) (DECCW 2009);
- There is potential for loss of nest sites on the sea cliffs of the northern hills due to competition with introduced pigeons *Columba livia* (DECCW 2009).

Risk Posed by the Rodent-Baiting Proposal

Poisoning is not a significant risk to the species as it feeds on fish but individuals risk colliding with low-flying helicopters. Baiting will take place in winter and whilst it is possible that unseasonable wet or windy weather may delay the second baiting run until very early September, this is considered very unlikely. Birds may be disturbed from the nest sites by over-flying helicopters but, unless baiting takes place in September (the month when egg laying starts), this limited disturbance is unlikely to significantly affect breeding.

Mitigation of the Proposed Rodent Eradication

Aircraft altitude during the flying of transects will be set so as to cause minimal disturbance to roosting birds while still achieving baiting efficiency. If major disturbance eventuates then the transect altitude will be adjusted and set at a height which does not significantly unsettle roosting birds. Such an adjustment is also necessary to ensure the safety of the helicopter and its crew.

Kermadec Petrel

Conservation status

Listed as *vulnerable* under the TSC Act.

The Kermadec Petrel ranges over subtropical and tropical waters of the South Pacific. The only known breeding sites in Australian waters are Balls Pyramid (near Lord Howe Island) and Phillip Island (near Norfolk Island). This species breeds on Balls Pyramid from November to May (Hutton 1991), and may been seen flying around Mt. Gower during summer. The Kermadec Petrel (western) feeds on squid, fish, and crustaceans.

Threats

- Possible introduction of the Black Rat to offshore islands.
- Risk of local extinction due to small population size.

Risk Posed by the Rodent-Baiting Proposal

This species is unlikely to be present during the baiting operation and thus is unlikely to be exposed to bait.

Mitigation of the Proposed Rodent Eradication

No mitigation is required.

Little Shearwater *Puffinus assimilis*

Conservation status

Listed as *vulnerable* under the TSC Act.

In the Southern Hemisphere the distribution of the Little Shearwater is from the mid South Pacific Ocean, around the southern coastline of Australia, across the Indian and Southern Atlantic oceans and past the west coast of the tip of South America. In the Northern Hemisphere it is found in the Atlantic Ocean to the west of North Africa and south-western Europe (Hutton 1991). The breeding colony on the LHIG (estimated to contain between 1,000 and 10,000 pairs – Hutton 1991) is one of the larger breeding colonies in the Australasian region (Hutton 1991). The main breeding site on the LHIG is Roach Island. There are smaller breeding groups on Blackburn Island, Mutton Bird Island and Mutton Bird Point (ibid).

This shearwater is present on the LHIG from February to October. Nests are in burrows. Most eggs are laid in July with the bulk of hatchings occurring in late August (Hutton 1991). The birds feed at sea, returning after sunset to change-over egg-sitting duties or to feed young. They depart before sunrise.

Threats

- Predation by rodents at the nesting grounds (DECCW 2009);
- Encroachment of the nesting grounds by weeds (DECCW 2009).

Risk Posed by the Rodent-Baiting Proposal

Because the birds feed at sea, the population is not at risk of primary or secondary poisoning. Adults sitting on eggs in burrows are unlikely to be overly disturbed by over-flying aircraft. Adults moving to and from the nesting-sites to feed do so at night so it is very unlikely that any will be hit by the baiting aircraft.

Mitigation of the Proposed Rodent Eradication

No mitigation is required.

Lord Howe Island Currawong *Strepera graculina crissalis*

Conservation status

Listed as *vulnerable* under the TSC Act.

This bird is a sub-species of the mainland Pied Currawong, and is endemic to the LHI Group. The entire population of the Lord Howe Island Currawong is restricted to LHI and the nearby islets (Mayre and Greenway 1962; Schodde and Mason 1999). The current population is 215 ± 11 birds (DECC 2007) and appears to be stable as there is no empirical evidence of an historical decline (DEWHA 2009).

The Lord Howe Island Currawong is widespread on LHI, occurring in lowland, hill and mountain regions. It mainly inhabits tall rainforests and palm forests, especially those beside creeks or in gullies, but it also occurs around human habitation, and forages amongst colonies of seabirds on offshore islets (DEWHA 2009). Its breeding sites are located in gullies, close to water, in undisturbed forests on the slopes of hills and mountains (Garnett and Crowley 2000; Hindwood 1940; Hutton 1991; McFarland 1994). Highest densities of nests are on the slopes of Mt Gower and in Erskine Valley (Garnett and Crowley 2000).

The currawong occurs singly, in pairs and family groups and, in the non-breeding season, in small flocks of up to 15 birds (DEWHA 2009). It has been recorded breeding from October to December although breeding may commence in September (McAllan *et al.* 2004). During the breeding season it occurs in strongly defended territories that are probably occupied by a breeding pair and its offspring (Knight 1987). In autumn and winter it forms flocks and can be found in the settlement areas (DEWHA 2009).

No information is available on the ages of sexual maturity or life expectancy, but it is probably capable of surviving to more than 20 years of age (Higgins *et al.* 2006). Breeding success appears to be relatively low; the only available, though limited, data suggests that less than 42% of nests produce fledglings (DEWHA 2009).

The Lord Howe Island Currawong in omnivorous; it eats fruits and seeds, snails, insects, rodents and the chicks of other bird species (Garnett and Crowley 2000; Hull 1910; Hutton 1991; McFarland 1994).

Threats

- The small size of the population makes it highly vulnerable to threatening processes.

- Two potential threats have been formally identified: namely the introduction of an exotic predator, and persecution by humans attempting to protect other bird species and/or domestic fowls (Garnett and Crowley 2000; Hutton 1991).

Mitigation of the Proposed Rodent Eradication

The proposed rodent eradication poses a significant threat to Lord Howe Pied Currawong (LHPC). LHPC were not found to consume non-toxic baits during a trial conducted in 2007 (Appendix D – LHI Trials Package), thus they are highly unlikely to eat the baits deployed in the REP but there is a risk that some individuals will succumb to secondary Brodifacoum poisoning by eating poisoned rodents even though most poisoned rodents will die underground. Fenn *at el (*1987) found that during the rat poisoning on English farms that the "majority" of rats died underground, while Harrison *et al.* (1988) estimated that only 4% of rats died above ground during baiting programs. Although approximately 90% of those rodents poisoned are likely to die in dens underground or amongst dense vegetative cover (Taylor 1993, Howald 1999, Buckelew 2007), it is possible that a number of free-ranging LHPC will consume baited rodents during the eradication, thereby placing some of the current population at risk. To mitigate this impact, as many individuals of the population as possible (approximately 50-60%) from across the island (to maintain genetic diversity) will be captured immediately prior to the baiting, and will remain in captivity until baits and rodent carcasses have disintegrated, which is expected to take 100 days after final baiting. After this time the risk of secondary poisoning for currawongs is likely to be negligible (as by then poisoned rodents will no longer be a potential food source). Once breakdown of bait and carcasses has been confirmed, captured birds will be released regardless of whether the eradication was a success or not.

A mortality rate for free-ranging Currawongs cannot be predicted with any certainty but it is expected to be low and thus not have a significant impact on the population. Studies of the diet of LHC have shown that rodents make up only a small proportion of the food taken by LHPC: of 441 identified items of food provided to nestlings only 11 (2.5%) of those items were rodents (Carlile and Priddel 2006). Moreover, 50% of breeding pairs (2 of 4 nests that were closely observed) provided no rodents to their chicks. Further evidence that it is unlikely that a large number of LHPC will succumb to secondary poisoning is provided by the LHIB's practice of collecting dead or moribund birds that are suspected to be suffering from Brodifacoum poisoning as a result of eating rodents that have been poisoned from baits used in the current control programme. Subsequent testing of those birds for Brodifacoum residues have shown that since 2009, no LHPC have been observed or collected with suspected Brodifacoum poisoning, This is in contrast to the 14 individuals of other species processed, 11 (two Masked owls, eight LHW, and one Buff-banded rail) of which tested positive for Brodifacoum residues. Therefore, while 40-50% of LHPC will not be taken into captivity it is unlikely that a significant proportion of these birds will die from eating poisoned rodents.

The stability displayed in the present population size and the presence of non-breeding LHPC during the breeding season (a result of a lack of availability of unoccupied breeding territories), suggests that LHI is currently at carrying capacity for LHPC. If so, the potential death of a proportion of the free-ranging LHPC population from poisoning due to the proposed REP does not, in itself, threaten the long-term viability of the population. It is expected that losses due to poisoning will be compensated by increased breeding success of the survivors, including those released from captivity. The removal of rodents may also lead to an increase in the carrying capacity of LHI and/or a rise in breeding success as there will be substantially more food available for LHPC (e.g., forest fruits, seeds, invertebrates, reptiles and small birds).

In the unlikely event a large number of free-ranging individuals die from secondary poisoning, the genetic diversity in the LHPC population could be reduced. No genetic studies of LHPC have been undertaken, so current levels of genetic diversity or whether any genetic population structure exists, are not known. However, the remoteness of LHI from the mainland source populations suggest that the LHPC population is likely to have been founded by a small number of individuals and thus may already have low levels of genetic diversity (e. g. Bollmer *et al*. 2011). Thus it is difficult to predict the genetic consequences of losing some of the free-ranging individuals from the population. Nonetheless, to mitigate the potential impact of a loss in genetic variation a relatively large number of individuals will be taken into captivity (100 to 120 individuals or 50-60% of the population) and LHPC will be caught from across their island range. This strategy should ensure that a large proportion (>95%) of the current genetic variation is included in the captive population (Weeks *et al.* 2011). An integral component of the captive management of LHPC is the capture of free-ranging LHPC. Carlile and Priddel (2007) noted that LHPC can be caught in reasonable numbers in the period from June to October but are more difficult to catch outside this period. To ensure that LHPC can be caught outside of this optimal period, a number of feeding stations will be established across the island in winter-spring 2016. In 2013 a trial captive management and release of LHPC and LHW was managed by Taronga Zoo staff (Taronga Conservation Society Australia, 2014) with the assistance of OEH Science Manager. The LHPC for the trial were sourced from a single location where a local resident had been regularly feeding the birds. At this single location, not only were the 10 pairs caught and removed for three months of the trial, but a subsequent 55 individuals were caught at the site prior to their release. The feeding station provided an ideal location for capture and monitoring of individuals within a section of the island. The 2007 report by Carlile and Priddel had relied on broad-scale locations for trapping where a maximum of 10 birds could be caught at a single site over an eight–day period. Using the feed station in 2013, 50 birds were caught in a seven–day period (Australian Bird and Bat Banding Scheme data). The feeding table attracts good numbers of visiting birds outside the 'optimum period' determined by Carlile and Priddel (2007) and presents a far superior opportunity for capture of LHPC than previously available. The established stations will provide a reliable source of food for LHPC and will become focal points for captures. Already established stations indicate that LHPC readily use the stations and it is expected that this strategy will enable the necessary number of LHPC to be caught during the time available prior to commencement of rodent baiting.

Holding LHPC in captivity from approximately June until October may disrupt the birds' breeding season for one year. However, it is unlikely that all birds left in the wild will be poisoned by the operation and thus disruption would not impact the entire population, and given that currawongs can live for more than 20 years (David Drayman ABBBS pers com) such disruption is not expected to result in a significant long-term impact to the population.

The captive facility will be located on LHI and will be managed by a highly experienced team of aviculturists most likely from Taronga Zoo. The LHIB is unaware of any previous attempts to hold or breed LHI currawong away from LHI. To ensure all husbandry protocols are correct, a trial involving 10 LHPC was conducted in 2013 (Taronga Conservation Society Australia, 2014) with all birds successfully released. One critical lesson learnt from this trial was how currawongs reacted to being confined with or near other currawongs during the breeding season. Further detail on the proposed captive management is provided in Section 2.2.1.2. The trial report is included in Appendix C – Captive Management Package**.** Surveys will be performed post-eradication to monitor the outcomes of the mitigation strategy (for details see Section 7.5.1).

In summary, in the absence of mitigation, a significant impact to LHPC is likely to occur from the LHI REP. With the proposed mitigation in place, it is considered possible that the REP will still have a significant impact on LHPC through the temporary disruption of a breeding cycle, although it is unlikely that a long-term population decrease will occur. Any potential impacts will be temporary. This temporary potential impact, will be substantially offset by the improvement in biodiversity if impacts of rodents are removed as a result of the REP. No other offsets are proposed.

In the event that rodents are detected after the eradication attempt and contingency measures are considered, potential impacts to the captive managed population will be reassessed.

Lord Howe Island Golden Whistler *Pachycephala pectoralis contempta*

Conservation status

Listed as *vulnerable* in the TSC Act.

This sub-species, endemic to LHI, is widely distributed in the forests of the main island, ranging from sea level to mountain tops. It is often seen feeding, typically on spiders, insects and their larvae, around homes in the settlement area.

Breeding season: from September to January.

Population size: 100 – 1,000 pairs (Fullagar *et al.* 1974).

Threats:

- Predation by rodents
- Clearing of lowland forests;
- Possible competition for food resources from the introduced Common Blackbird and Song Thrush;
- Risk of extinction due to small population size and restricted distribution; and
- Invasion of habitat by introduced plants.

Risk Posed by the Rodent-Baiting Proposal

The diet of the whistler is comprised of invertebrates. It will not eat pellets so it is not at risk of primary poisoning. It may be exposed to Brodifacoum by eating insects that have fed on pellets but few, if any, whistlers will receive a lethal dose this way. There have been no reports of whistler deaths in the settlement area where this bird is quite common, and where far-more potent Brodifacoum baits than those proposed for the eradication, are presently widely used.

Mitigation of the Proposed Rodent Eradication

No mitigation is proposed; advice from Taronga Zoo suggests that catching and holding LHI Golden Whistlers in captivity, as an insurance population, will likely result in the death of those birds.

The eradication of rodents from the LHIG is expected to benefit the whistler by the elimination of a probable predator and the increase in food resources.

Lord Howe Island Silvereye *Zosterops lateralis tephropleura*

Conservation status

This sub-species, endemic to LHI, is listed as *vulnerable* under the TSC Act.

It is widely distributed on the main island, occurring in all habitats except open fields. Its diet consists of insects, fruit and nectar.

Breeding season: from spring to summer.

Population size: 100 – 1,000 pairs (Fullagar *et al.* 1974).

Threats

- Predation by introduced rodents;
- Predation by the Lord Howe Island Currawong, Australian Kestrel and Sacred Kingfisher; and
- Risk of extinction due to small population size and restricted distribution.

Risk Posed by the Rodent-Baiting Proposal

The silvereye is considered to be at low risk given that it eats mainly fruit, seeds and insects. Local studies found no evidence that this sub-species consumed baits although Eason and Spur (1995) suggest that the New Zealand silvereye would probably eat cereal-based baits if encountered. Results from rodent eradications in New Zealand suggests that a few silvereyes may succumb to the effects of Brodifacoum, but at the population level the species was not harmed by the rodent baiting. Any losses on LHI are likely to be small and short-term, as they were in New Zealand. Any initial decline will be followed by a marked increase in populations due to the removal of rodents and subsequent increase in invertebrate and fruit food resources.

Mitigation of the Proposed Rodent Eradication

No mitigation is proposed; advice from Taronga Zoo suggests that catching and holding LHI Silvereyes in captivity, as an insurance population, will likely result in the death of those birds.

Lord Howe Woodhen *Hypotaenidia sylvestris*

Conservation status

Listed on Schedule 1 of the TSC Act as an *endangered* species.

The Lord Howe Woodhen is a flightless bird endemic to LHI (NSW NPWS 2002). The population estimate for 2012 is at least 250 individuals (LHIB unpublished data). The population of woodhen has remained relatively static over much of LHI (DECC 2007) with the exception of those birds in the settlement where numbers have more than tripled (47 in 2002 (NSW NPWS 2002) to 153 in 2012 (LHIB unpublished data)), possibly in response to the provision of supplementary feed and water to settlement birds by the islanders.

Woodhens usually lay eggs from August until January or February and continue raising young until April (NSW NPWS 2002). However, the start and finish dates of breeding can vary between years and there are breeding records for much of the year (Miller and Mullette 1985). Pairs have multiple broods during the breeding season (Gillespie 1993). Juveniles can breed at nine months of age (Marchant and Higgins 1993) but juveniles that do not establish a territory by the breeding season immediately following their own hatching generally do not survive to reach adulthood (Harden and Robertshaw 1988, 1989). About 60% of juveniles die in their first year (Harden and Robertshaw 1989) possibly due to limited high-quality habitat (NSW NPWS 2002). Breeding success is greater in the settlement area than in the southern mountains (Marchant and Higgins 1993, Harden and Robertshaw 1988).

Habitat

The woodhen occurs predominately in three vegetation types:
1) Gnarled Mossy-Forest, which covers 2% of the island;
2) Megaphyllous Broad Sclerophyll Forest (mainly palms), which covers 19% of the island; and
3) Gardens around houses. About 40 % of the population lives in the settlement area of the island (NSW NPWS 2002).

Diet

Over 80% of the woodhen's diet is comprised of earthworms (Miller and Mullette 1985). The bulk of the remaining 20% is made up of grubs, typically found in rotting logs. Snails, arthropods, seabird chicks, rodents, plant shoots, lichen and fungi are also eaten (NSW NPWS 2002). Woodhen were observed eating non-toxic pellet baits during a trial conducted on LHI to gauge what species were likely to eat the Pestoff® 20R baits proposed for use in the rodent eradication. Blue-coloured faeces have also been seen when handling some birds, indicating they had been consuming dyed wax bait blocks containing rodenticide (Harden 2001). These blocks are widely dispersed around the settlement by residents. Evidence of Brodifacoum poisoning has been detected during post-mortems conducted on woodhens found dead along roadsides in the settlement.

Threats (NSW NPWS 2002)

- Loss of preferred habitat through clearing for agriculture or development, or the encroachment of weed species;
- Vulnerable to disease and natural disaster due to its limited distribution;
- Increased rat control may lead to increased owl predation on woodhen;
- Competition for food in the settlement area from Common Blackbirds, Song Thrushes, Buff-banded Rails and Purple Swamphens;
- Consumption of rat bait used in the on-going rodent control; and
- Domestic dogs.

Risk Posed by the Rodent-Baiting Proposal

This species is at risk of both primary and secondary poisoning. Woodhen have been recorded eating non-toxic bait pellets. They are also known to eat rodents that have been poisoned during the ground baiting that currently takes place around the Settlement.

Mitigation of the Proposed Rodent Eradication

This species is at risk of both primary and secondary poisoning. Woodhen have been recorded eating non-toxic Pestoff bait pellets (DECC, 2007a). They are also known to eat rodents that have been poisoned during the ground baiting that currently takes place around the Settlement and will also consume poisoned birds.

The protection of this species requires that it be taken into captivity during the eradication. Approximately 80 - 85% of the population will be captured prior to the baiting and will remain in captivity for the duration of the operation; that is, until the baits (and rodent carcasses) have disintegrated and pose no further risk approximately 100 days (Craddock, 2004). After this time the risk of secondary poisoning for woodhens is likely to be negligible (as by then poisoned rodents will no longer be a potential food source). Once breakdown of bait and carcasses has been confirmed, captured birds will be released regardless of whether the eradication was a success or not.

It is expected that individuals that are not captured may succumb to primary or secondary poisoning, however a mortality rate cannot be accurately predicted. Studies of similar species in New Zealand (Weka and Kiwi) have found a wide range in mortality rates to the species from similar eradications. Weka mortality rates as high as 80-90% was observed during a rodent eradiation on Ulva Island (Eason et al. 2002) whilst on Taukihepa Island a deliberate attempt to eradicate introduced weka following a rodent eradication was abandoned due to a higher than expected survival of weka post poisoning (P. McClelland pers comm.). Little Spotted kiwi were monitored through the Kapiti Island rat eradication using 50 banded birds, 10 of which also had radio-transmitters (Robertson and Colbourne 2001). Two of the 10 birds with radio-transmitters died (a mortality rate of 20%) within a month of the poison drops. Six months after the eradication, 46 of the banded birds were still alive. Robertson and Colbourne (2001) estimated that in the worst-case, poison induced mortality was 8%. Two brown kiwi were found dead following aerially applied Pestoff 20R on Motuarohia Island as part of Project Island Song in 2009. One was confirmed to have Brodifacoum residues and the other was too decomposed to test. Anecdotal reports of kiwi calls after the operation did not indicate a change in population (Vestena and Walker 2010). At Rarewarewa and Riponui, Northland, none of 55 radio collared brown kiwi died from Brodifacoum poisoning after eradication (Robertson et al. 1999).

The captive population will include both adults and juveniles, and will be collected from across LHI to ensure that the deepest practical gene pool is maintained. It should be noted however that the gene pool experienced a severe bottle neck with the reduction in numbers prior to the captive breeding program in the 1980s. Birds originating from the remotest parts of LHI (e.g., the summit of Mt Gower) will be transported to, and back from, the holding facility by helicopter to minimise transport time and its associated stress on the birds. The captive facility will be located on LHI and will be managed by a highly experienced team of aviculturists most likely from Taronga Zoo. Woodhen have previously been successfully held in captivity (Gillespie, 1993) so information is already at-hand for captive management. A trial involving 22 birds was conducted in 2013 to ensure all husbandry protocols are correct (Taronga Conservation Society Australia, 2014). No aggression was noted during the 2013 trial with many birds per aviary. The trial report is included in Appendix E – Captive Management Package. As part of the recovery program and captive breeding program on LHI in the late 1980s, there is anecdotal evidence that two woodhens (a male and a female) were removed to Taronga Zoo on the mainland in 1989. The birds were observed mating but were not bred. The female died in 1990 after 11 months in captivity, with post mortem revealing that she died as a result of being egg bound. The male died in 1994 after more than 4 years in captivity. Results of the post mortem examination indicated that the male died of trauma. There was no indication of what had caused the trauma (Fry, G, pers comms, 2013). A captive colony could be established on the Australian mainland, subject to finding a zoo that is interested. Discussions with Taronga Zoo have indicated that they do not have available space or interest in establishing a LHW population. Discussions are continuing with other zoos. These actions, namely the establishment of on-site and off-island captive facilities, are in accordance with recommendations made in the “Recovery Plan for the Lord Howe Woodhen Gallirallus sylvestris” (NPWS 2002) which calls for the development of a plan for the establishment of an on-island captive-breeding facility in the event of a substantial reduction in woodhen numbers; and the establishment of captive populations at sites other than LHI as insurance against a catastrophe affecting the wild population. Further detail on the proposed captive management is provided in Section 2.2.1.2.

Woodhens are to be held in captivity during most of the duration of one breeding season. Although the release of the birds is dependent on how long it takes the baits and carcasses to breakdown, it is likely that the woodhen will be released by December, a hundred or so days after the second aerial bait-drop. If so, then the birds will have up to two months of the current breeding season to lay eggs (Gillespie 1993). Body conditioning through diet manipulation, such as the provision of woodgrubs in the weeks leading up to release, may also be able to improve reproduction immediately post release (Gillespie, 1993). Woodhens have also been bred very successfully in captivity on LHI (in pair cages) and may therefore breed in captivity. The full or partial loss of one breeding season is unlikely to have a significant effect on the population particularly given the lifespan can be in excess of 15 years. Similarly, the death of many of those woodhen that are not taken into captivity is also unlikely to result in long-term harm to the overall population. Presently, about 60% of juveniles die in their first year (Harden and Robertshaw 1989) and this is more than likely a result of a lack of high-quality habitat (NPWS 2002) for them to occupy. The death of the adult birds that are not taken into captivity will provide vacant territories for many, otherwise doomed, juveniles that fledge in the years immediately following the rodent eradication.

Previous post-release monitoring of captive LHW shows that the captive breeding programme is likely to be successful. An integral component of the conservation recovery programme for the LHW was an in situ captive breeding program established in 1980 (Miller and Mullette 1985). Between 1981 and 1985, 82 captive-reared LHW were released, along with the wild LHW taken into captivity, across six sites in the lowlands and slopes of the southern mountains (Miller and Mullette 1985). Depending on the release site, between 0% and 75% of released LHW were subsequently re-sighted (Harden et al. unpubl. data). The site where no released LHW were resighted was Little Slope, which was difficult to access and therefore poorly monitored. However, the number of LHW on Little Slope, where no wild LHW occurred, almost doubled within six years of the release of captive-bred birds (Miller and Mullette 1985; Harden 1999).This indicates survival and/or breeding success of released captive-bred LHW at Little Slope was high. Of the 20 LHW held in captivity in 2013 as part of a trial to establish captive husbandry protocols for the LHI REP (Taronga Zoo Conservation Society 2014), 25% were observed post-release in 2014 and/or 2015.

In the absence of mitigation, a significant impact to woodhens is likely to occur from the LHI REP. However with the mitigation proposed in place, it is considered unlikely that either long term population decrease or major disruption to a breeding cycle will occur. Impacts are likely to be temporary. It is therefore considered unlikely that the REP will have a significant impact on woodhens. In the event that rodents are detected after the eradication attempt and contingency measures are considered, potential impacts to the captive managed population will be reassessed.

The eradication of rodents is likely to result in an increase in terrestrial invertebrates which will likely lead to population increases for woodhen. The density of LHI Wood-feeding Cockroach on Blackburn Island (Carlile and Priddel 2013) suggests that following reintroduction of this species to the main island will present a significant increase in food availability for woodhen.

Masked Booby *Sula dactylatra tasmani*

Conservation status

Listed as *vulnerable* in the TSC Act.

This sub-species breeds on Lord Howe and Norfolk islands as well as on the Kermadec Islands, the latter group being administered by New Zealand (DEHWA 2009). One set of estimated population sizes for this sub-species is, for LHIG 600-900 pairs, for Norfolk Island 300 pairs, and for the Kermadec Islands <100 pairs (ibid). However, Garnett and Crowley (2000) suggest the LHI population to be only 500 individuals while Priddel (1996) estimates that there are between 200 and 300 birds nesting on LHI. Regardless which estimate is correct, the LHI birds constitute a significant proportion of the breeding population of the sub-species. In the LHIG the breeding colonies are on Balls Pyramid, Mutton Bird Island, the Admiralty Islands, and LHI (at King and Mutton Bird points) (DECC 2007). All breeding occurs in the Permanent Park Preserve. The LHIG is the most southerly breeding location of this species (all sub-species considered) in the world (McAllan *et al.* 2004).

On the LHIG the booby is resident year round. It breeds from May/June to February, with the peak of the laying season being in December (DEWHA 2009). Nests are built on the surface in high open areas.

Threats

- Predation of eggs and young by rodents (DECCW 2009);
- Long-line fishing (DEHWA 2009);
- Possible loss of eggs and small chicks to Buff-banded Rails (DEWHA 2009).

Risk Posed by the Rodent-Baiting Proposal

The birds feed at sea, so, therefore, adults are not threatened by poisoning from the rodent eradication. However, these birds nest above ground so the breeding colony will be subject to disturbance from the baiting aircraft. Disturbance at the colony may lead to egg damage and chick mortality. Also adults flying between the colonies and feeding areas are at the slight risk of helicopter-strike. The impact of helicopters (Bell 206) on Blue-footed (*S. nebouxii*) and Brown (*S. leucogaster*) booby on Isabel Island in Mexico was quantified by Samaniego–Hererra *et al.* (2010). Helicopters most commonly flew within 30-100m of nesting boobies, but sometimes as close as 10m. Nest occupancy and breeding success in the sub-colony where bait was distributed using a helicopter did not differ from two sub-colonies baited by hand. Importantly, no nest abandonment was recorded for either species and no boobies were harmed during eradication operations. Further, the most common behavioural responses to helicopter disturbance was 'no reaction' (58%) and 'became alert' (39%). 'Startle' responses (4%) and 'escape' (2%) responses were rarely observed. Most of the time (92%) when birds reacted, they resumed normal behaviour within 10 seconds. Boobies remained alert but did not exhibit signs of stress (e.g. regurgitating, nest abandonment) even during the highest level of disturbance from a helicopter (measured by sound produced, 94 decibel, helicopter height, 10m, and terrain comprised of no vegetation cover). The use of a helicopter (Bell 47) to survey nests of the critically endangered Abbott's booby (*Papasula abbotti*) on Christmas Island found that the typical response of birds sitting in their nests was to look at the helicopter but remain sitting or not respond at all (Commonwealth of Australia 2001). The trial survey recommended using helicopters in future surveys because disturbance was assessed to be negligible or non-existent. Similarly, only minor and transitory impacts from helicopter disturbance were observed in colonies of King Penguins on Macquarie Island (Springer and Carmichael 2012). Collisions with helicopters during baiting operations have been reported for Red-footed Boobies (*S. sula*): four individuals out of ~100 present at the time of baiting operations on Palmyra Atoll (Pitt *et al.* 2015; W. Pitt pers. comm.) and one individual on Enderbury Island in the Phoenix Islands (Pierce and Brown 2011). However, it is noteworthy this species, unlike the considerably larger Masked Booby, perches in trees which may place them at greater risk of taking flight and colliding with a helicopter. The risk of collisions with a helicopter for Masked booby on the LHIG is assessed to be very low because Masked booby rarely fly >10m above the height of the colony, rest and build nests exclusively on the ground, and typically depart from the colony by losing altitude from a standing position at the edge of the islet or promontory (N. Carlile and D. Portelli pers. obs., see Machovsky-Capuska *et al.* 2016).

Mitigation of the Proposed Rodent Eradication

Mitigation measures will be in place to minimise disturbance and the risk of collision. Specifically, helicopter flight times over Masked booby colonies will be restricted to periods when birds are less likely to be leaving or arriving at the colony (movements are greatest shortly after dawn and in the late afternoon), helicopters will be restricted to flying at a height of >30 above colonies and only during light wind (<15 knots), and operational speed will not exceed 50 knots in the vicinity of colonies. In light of the above, the likelihood of a significant impact from helicopter disturbance to Masked booby on the LHIG is assessed to be low.

This species maintain a cleared area with a radius of 0.75-1m from the centre of its nest (Marchant and Higgins 1990). The aerial bait delivery system will disperse baits at a density of approximately two bait pellets per square metre; thus 1-2 baits will be expected to fall within reach of nesting Masked Boobies. However, as this species feeds exclusively on prey captured at sea (Marchant and Higgins 1999), it is expected that birds will either ignore bait pellets or remove them to outside the cleared area around their nest. Most chicks are expected to hatch after the baiting operation (hatching occurs from July to December; Hutton 1991) and are fed exclusively by regurgitation from adult birds; thus they too are not expected to ingest any bait pellets on the ground around nests. Due to the remoteness and rugged terrain of the location of almost all breeding colonies (>80% of the Masked booby breeding population; it is not feasible to have human observers present within colonies during aerial baiting operations (to monitor disturbance or collect baits from the vicinity of nests). Furthermore, disturbance was slightly higher in sub-colonies of Blue-footed and Brown boobies baited by hand than in the sub-colony baited using a helicopter on Isabel Island (A. Samaniego-Herrera pers. comm.). The prolonged presence of a human observer in close vicinity of Masked booby nests—to monitor disturbance during the baiting operation or to remove bait pellets as they fall—poses a risk of nest desertion and the death of newly hatched chicks left unattended (see Burger and Gochfeld 1993). In light of the above, removal of bait pellets from the vicinity of Masked booby nests is considered unnecessary. This assessment is supported by the observation that no Blue-footed, Brown, Red-footed or Masked booby were harmed during baiting operations on five islands in the Gulf of California and Caribbean, where bait pellets were not removed from within colonies (Samaniego-Herrera *et al.* 2009, 2010, in press; A. Samaniego-Herrera pers. comm.).

A significant impact of the proposed rodent eradication programme is assessed to be highly unlikely this species. In contrast, it is expected that the REP will have long-term positive impacts on the species for example, the number of Masked Boobies breeding on Tromelin Island increased by 22-23% each year following the eradication of *Rattus norvegicus* (Corre *et al.* 2015).

Masked Owl *Tyto novaehollandiae*

Conservation status

Listed as *vulnerable* in the TSC Act.

Masked Owls were introduced to LHI in the 1920s in an attempt to control the rats. It is estimated that there are between 10 and 100 pairs present on LHI (DECC 2007). Although the species is classified as *vulnerable* under the TSC Act, on LHI these owls are regarded as exotic and seen as pests, and as such, killed under licence issued by the Office of Environment and Heritage. Masked Owls have been recorded eating a number of bird species on LHI including woodhen, terns and two of the petrel species but they are unlikely to be a significant threat to any of these species at present. The population of the woodhen, for example, has remained constant for ten years (DECC 2007), while that of the White Tern *Gygis alba*, a recent colonist, is increasing. However, this situation may change if rats, the owls' staple diet (DECCW 2009), are eliminated from LHI.

Risk Posed by the Rodent-Baiting Proposal

A large proportion of the local owl population is likely to succumb to secondary poisoning as a result of the proposed rodent eradication. Those that remain are likely to substitute native birds in place of rats in their diet and hence eradication of remaining birds will be pursued as part of the REP (see section 2.2.1.5).

Mitigation of the Proposed Rodent Eradication

No mitigation is proposed. To the contrary, the survivors will be targeted for eradication to eliminate this species from LHI.

Providence Petrel *Pterodroma solandri*

Conservation status

Listed as *vulnerable* in the TSC Act.

Although widely distributed in the western Pacific Ocean, there are only two known breeding locations for this species (Hutton 1991). The main site is LHI, specifically Mt Gower and Mt Lidgbird, where between 10,000 and 100,000 birds can be found during the breeding season spanning March to November (ibid), although numbers of Providence Petrels can be found on LHI year-round (McAllan *et al.* 2004). The other, much smaller, breeding site is Philip Island, near Norfolk Island. Both sites are conservation reserves, the former under the jurisdiction of the NSW Government, the later administered by the Commonwealth Government.

Providence Petrels construct nests in burrows.

Threats

- Heavy downpours of rain which can lead to the flooding of burrows (Bester *et al*. 2007);
- Predation of eggs and young by rodents and woodhens (Bester *et al*. 2007);
- Disturbance of birds and habitat by people (DECCW 2009).

Risk Posed by the Rodent-Baiting Proposal

In August, Providence Petrels will be tending young in the nest. Breeding birds will be in the area from late afternoon onwards to display in the airspace above the breeding sites, find mates and visit burrows (Hutton 1991). Non-breeders will also be present in the area during the day until mid-August (ibid).Therefore, there is the possibility that those petrels flying above the breeding grounds could collide with low-flying helicopters dropping bait.

It is extremely unlikely that their diet of squid and fish caught offshore of LHI will lead to secondary poisoning of petrels.

Helicopters flying over the nesting grounds are very unlikely to disturb young petrels as they are in burrows.

Mitigation of the Proposed Rodent Eradication

Helicopter strike with those birds involved in courtship and incubation will be avoided by restricting helicopter flights around the southern mountains to midday on each day of baiting. The majority of returns from foraging to provision chicks occur after early July (Marchant and Higgins 1990) avoiding any overlap with proposed helicopter movements.

The species will have limited contact with bait pellets while nesting as it nests either underground or within deep cavities on the ground; further, as stated above, this species is highly unlikely to consume any bait pellets as adults feed exclusively at sea and chicks are fed exclusively by regurgitation from adults.

A significant impact of the proposed rodent eradication programme is assessed to be highly unlikely this species. In contrast, it is expected that the REP will have long-term positive impacts on the species. The density of burrows of seven seabird species, including the Flesh-footed shearwater, increased following rat eradication on New Zealand islands (Buxton *et al.* 2016), and the breeding success of Cory's shearwater (*Calonectris* *diomedea*)—which is a similar size to Providence petrel and Flesh-footed shearwaters—increased following control of black rats at the Chafarinas Islands (Igual *et al.* 2006).

Sooty Tern *Sterna fuscata*

Conservation status

Listed as *vulnerable* in the TSC Act.

The Sooty Tern has a world-wide distribution in the tropical and sub-tropical waters of the Pacific, Indian and Atlantic oceans (Pringle 1987). Lord Howe Island is one of the species' most southerly breeding sites. Up to 35,000 pairs breed on the LHIG (Hutton 1991) although Fullagar *et al.* 1974 (cited in Higgins and Davies 1996) estimated that the breeding population on the LHIG was up to one million pairs. The only other major breeding site for the Sooty Tern in Australia is at Norfolk Island, which has an estimated 40,000 to 70,000 pairs (Higgins and Davies 1996). This species has been recorded on the LHIG in all months but it is most common from August to February (Hutton 1991). Nests may be established on sand, grass or rock, either in the open or under bushes (Pringle 1987). Eggs are laid from late August until early December although the main laying period on the LHIG is from September to November (McAllan *et al.* 2004). In August, large flocks can be seen circling over their breeding sites at the Admiralty Islands, Mutton Bird Island, Balls Pyramid, Mt Eliza, Malabar, North Head, King Point and Mutton Bird Point (Hutton 1991).

The birds mainly forage at sea, in offshore or pelagic zones; rarely do they forage around islands (Higgins and Davies 1996).The Sooty Tern typically feeds on fish, squid and crustaceans caught at sea; cicadas are also taken from the air over the forests at night in summer (Hutton 1991).

Threats

- Human disturbance of breeding colonies;
- Predation of eggs and chicks by rats;
- Infestation of colonies by virus-infected ticks.

Risk Posed by the Rodent-Baiting Proposal

Sooty Terns are not susceptible to poisoning by the rodent eradication. However, there is a risk of birds colliding with the helicopters and spreader buckets dispersing the bait. Late August nesters may also be disturbed, and this could jeopardise eggs although it is considered unlikely that aerial baiting will extend into late August

Mitigation of the Proposed Rodent Eradication

Aircraft altitude during the flying of transects will be set at a height which does not substantially unsettle nesting birds nor compromise baiting efficiency.

5.2.4 Potential Long Term Ecological Changes.

While it is difficult to predict the long term ecological changes that are expected to occur on LHI following successful rodent eradication, evidence from rodent eradication projects elsewhere has shown that a wide range of taxa benefit from the eradications of invasive mammals. For example, a recent review by Jones *et al.* (2016) found that 236 native species have benefitted from the eradication of invasive mammals worldwide. Rodent eradications made up 57% of the studies reviewed and the benefits included population recoveries, re-colonisations and re-introductions, and increases to vegetation cover. Examples relevant to this include, a doubling of reproductive output (number of chicks produced) by Wedge-tailed Shearwaters on Moko'auia Island following eradication of Black Rats (Marie *et al.* 2014); a 23% increase in the number of breeding pairs of Masked Boobies, and re-colonisation by White Terns on Tromelin Island following eradication of Norway Rats (Le Corre *et al.* 2015); an increase in the density of burrows of seven seabird species, including the Flesh-footed Shearwater, following rat eradication on New Zealand Islands (Buxton *et al.*2016); increases in abundance of four species of land birds on Hawadax Island, Alaska, five years after rodents were eradicated (Croll *et al.* 2016); recovery of invertebrate (cricket) populations after rodent eradication in the Falkland Islands (St Clair *et al.* 2011); and dramatic increases in plant cover on Tromelin Island after rodent eradication (Le Corre 2015). It is expected that LHI populations of seabirds, land birds, invertebrates and vegetation would similarly benefit in the long-term from the eradication of rodents.

Unassisted re-colonisations by species that were formerly present on LHI are also difficult to predict but two of the most likely species to re-colonise are white-bellied storm-petrel and Kermadec petrel. Both of these species formerly bred on the main island (Hindwood, 1940) with their extirpation purportedly due to the impacts of invasive rodents. Re-colonisation by the white-bellied storm-petrel could be assisted through the use of a call-playback system to attract potential re-colonisers. Re-introductions are also possible for a number of species that have been extirpated from the main island but still exist on offshore islets in the LHIG; these include the Lord Howe Island Wood-feeding Cockroach *Panesthia lata* and the Lord Howe Island Phasmid *Dryococelus australis*.

Negative impacts on native populations have also been reported following rodent eradications. Most negative impacts are due to poisoning either from consumption of baits or through secondary poisoning following consumption of poisoned rodents. Such impacts are usually short term and populations recover once the baiting operations have ceased (Jones *et al.* 2016). Species at risk of being affected by bait consumption or secondary poisoning that occur in the LHIG include the Lord Howe Woodhen and the Lord Howe Pied Currawong (DECC, 2007a). Comprehensive mitigation plans are in place for both of these species (see section 6). Other documented impacts of island eradication programs on non-target species have involved species that consumed rodents as a primary food source. No species in the LHIG are expected to be impacted in this way other than the introduced Masked Owl, which is proposed to be eradicated concurrently with the REP.

If the eradication is not successful but rodent populations are substantially reduced, it is expected that any ecological changes, positive or negative, will be only temporary until rodents return to pre-REP levels. If rats are successfully removed, but mice remain it could be expected that the mouse population would initially increase exponentially, and then settle into some sort of equilibrium at a much higher density than current levels. It is likely that major benefits would still accrue to the palm industry and to many natural environments attributes (e.g. return of smaller seabirds, recovery of *Placostylus* populations, and possible establishment of 'analogue' species to replace extinct taxa). Other benefits may accrue, such as partial recovery of lizard populations, but not to a level which could be expected if all rodents were removed. Invertebrate populations, particularly larger and/or ground-dwelling species, may not show any recovery if mice remained. Re-introduction of the Phasmid may still be possible, given that they co-existed with mice prior to the rat invasion, but population establishment may be retarded or even prevented by the population imbalance of potential predators and their prey.

The 'nuisance value' of mice around residences would be likely to increase, necessitating on-going control. Some appreciable economic, social and conservation problems will remain if mice survive an eradication attempt, but significant gains will have been made in all aspects even if rats only are removed.

Because it is difficult to accurately predict long-term ecological impacts of the REP, a series of programmes to monitor potential benefits to biodiversity (population increases, expansions of breeding areas etc.) and the outcomes of mitigation measures for non-target species have either been established or are planned for future implementation. For example, in Part 2 of the REP Action Plan, pre-eradication monitoring is being undertaken to collect baseline data to enable determination of subsequent short-, medium- and long-term trends and changes in the distribution and abundance of key taxa following the removal of exotic rodents from LHI. Taxa included in these studies are: land birds; Black-winged petrel, Little shearwater; land snails; ground and tree dwelling invertebrates; Big Mountain Palm; Little Mountain Palm and fruiting plants.

Part 3 of the Action Plan is comprised of the capture and management of LHPC and LHW, monitoring of LHPC remaining in the wild during rodent eradication activities, and the staged release and monitoring of LHPC and LHW following the bait drop. Biodiversity benefits monitoring will also continue for the range of taxa monitored in Part 2 of the Action Plan. The monitoring project will be managed by the LHI Rodent Eradication Project Manager (LHI REPM) and coordinated by the Science Division of the OEH Heritage NSW (Science Manager). Fieldwork and analysis will be undertaken by OEH staff, collaborating scientists or contractors. Involvement of the Lord Howe Island community will be encouraged for all projects, subject to skills and licensing restrictions. For details of monitoring plans see Section 6.5.

5.2.5 Cumulative Impacts

Potential cumulative impacts from the REP were considered with:

- Other potential actions - the proposed wind turbines on LHI and ;
- Other key threatening processes on the island such as weeds, habitat clearing and degradation, other human related threats and anthropogenic climate change.

The wind turbine proposal forms part of the Hybrid Renewable Energy Project, which aims to reduce diesel consumption and the costs of electricity generation on the island. The current proposal is stage 2 of the HREP. Stage 1 has been approved by the Board, and comprises an access road to the solar farm, a photovoltaic solar farm, a battery bank and associated infrastructure.

A biodiversity assessment of the wind turbine project undertaken in 2016 (NGH Environmental, 2016) found the following:

- The turbines would be sited in a cleared paddock around 1.5 hectares in size. The site carries exotic pasture and is primarily used for dairy cattle grazing. No threatened flora species recorded were recorded at the site.
- The site has minimal habitat value for wildlife. It may be used for foraging by some insect and bird species, but is unlikely to provide limiting or essential habitat resources for local fauna. Birds including the LHI currawong use the airspace above the paddock).

- Seven-part tests of significance for NSW threatened species and Assessments of Significance for nationally threatened and listed migratory species conclude that the proposal would not result in significant impact to these species.

As the LHI currawong is the only species on which the REP will have a potential significant impact (temporary disruption to one breeding cycle) and the wind turbine is unlikely to have an impact on currawongs, no significant cumulative impacts are expected from the wind turbines and REP.

When potential impacts of the REP are considered with other threats including climate change, no significant cumulative impact is expected. This is due to the localised and short term nature of potential impacts from the REP and excepted long term benefits to species and ecosystem recovery in the absence of rodents.

When considered as one action out of many related conservation and recovery actions currently being implemented or planned by the LHIB, the REP will add significant contribution to net positive cumulative impacts for species and biodiversity for the LHIG.

In contrast, not proceeding with the REP would allow continued impacts from predation and completion by rodent on a range of species, increasing cumulative impacts with other threats (DECC, 2007).

6 Assessment of Likely Impacts on Ecological Communities

Section 110(3)(a) of the TSC Act states that the SIS must provide:

> *……. a general description of the endangered ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action.*

The TSC Act lists two threatened ecological communities on Lord Howe Island which are the *Lagunaria* Swamp Forest and the Gnarled Mossy Cloud Forest (both of which are *critically endangered).*

6.1 The Lagunaria Swamp Forest (i.e., the Sally Wood Swamp)

Conservation status

Listed as a *critically endangered ecological community* (NSW Scientific Committee 2003).

Lagunaria Swamp Forest is confined to Lord Howe Island where it is restricted to the lowland area, which has largely been cleared for settlement (NSW Scientific Committee 2003). Height of the forest is 10 -15 m tall. The major canopy dominant, *Lagunaria patersonia* subsp. *patersonia* is confined to Lord Howe Island and Norfolk Island. Other canopy trees include *Hibiscus tileaceus* (Kurrajong) and *Myoporum insulare* (Juniper) (Pickard 1983, Auld and Hutton 2002). Shrubs are generally sparse and may include *Aegiceras corniculatum* (Mangrove), *Cryptocarya triplinervis* (Blackbutt) and *Celtis conferta* subsp. *amblyphylla* (Cotton-Wood) (NSW Scientific Committee 2003). The groundcover may include *Cyperus lucidus* (Cutting grass), *Commelina cyanea* and *Hydrocotyle hirta,* and is generally sparse where the tree canopy is intact, but may be denser on edges and where the tree canopy has been disturbed.

The distribution of the community is restricted to low-lying swampy areas at altitudes below 20 m. This distribution was mapped by Pickard (1983), who estimated that its original distribution may have covered as little as six hectares, distributed across five restricted locations on the island. The community has undergone a very large reduction in geographical distribution with greater than 95% of the community estimated to have been lost (Pickard 1983, Auld and Hutton 2002). None of the locations are protected within the Lord Howe Island Permanent Park Preserve. *Lagunaria* Swamp Forest falls entirely within the jurisdiction of the Lord Howe Island Board. Individual plants of *Lagunaria patersonia* may be scattered through the forests from sea level to about 600 m elevation on Lord Howe Island, but such locations do not form a part of the *Lagunaria* Swamp Forest community (NSW Scientific Committee 2003).

Lagunaria Swamp Forest has been seriously depleted by land clearing at all sites of its occurrence. The remaining fragments are only a few square metres in area, and are degraded by edge effects, weed invasion, alteration to water regimes, and from cattle grazing. The remnants are likely to include only a sample of the original flora and at least some appear to be transitional assemblages with other vegetation communities. However there have been a number of restoration activities undertaken by the Lord Howe Island Board to begin to restore this community. Actions have involved habitat plantings and fencing of remnants, or in some cases previously occupied habitat, in order to exclude cattle (NSW Scientific Committee 2003).

Risk Posed by the Rodent-Baiting Proposal

The REP does not pose a risk to plant species (see Section 3.1.3.3) and is unlikely to have a significant impact on any resident fauna species within this threatened ecological community (discussed in section.5.2 above). Therefore no impact to this Community is expected.

Conversely removal of rodents is expected to significantly benefit individual species (i.e. sallywood) within this community through reduced predation on developing seeds, seedlings and stems of leaf fronds.

Mitigation of the Proposed Rodent Eradication

None proposed.

6.2 Gnarled Mossy Cloud Forest on Lord Howe Island

Conservation status

Listed as a *critically endangered ecological community* (NSW Scientific Committee 2011).

Gnarled Mossy Cloud Forest on Lord Howe Island is characterised by the following assemblage of species:

Asplenium pteridoides	*Asplenium surrogatum*

Atractocarpus stipularis	*Blechnum contiguum*
Blechnum fullagarii	*Blechnum howeanum*
Carex inversa	*Coprosma huttoniana*
Cryptocarya gregsonii	*Cyathea brevipinna*
Cyathea howeana	*Cyathea macarthurii*
Dendrobium moorei	*Diplazium melanochlamys*
Dracophyllum fitzgeraldii	*Dysoxylum pachyphyllum*
Elaeocarpus costatus	*Elatostema reticulatum*
Gahnia howeana	*Grammitis* spp.
Hedyscepe canterburyana	*Hymenophyllum* spp.
Lastreopsis nephrodioides	*Lepidorrhachis mooreana*
Leptospermum polygalifolium ssp. *howense*	*Lordhowea insularis*
Machaerina insularis	*Macropiper hooglandii*
Melicope contermina	*Metrosideros nervulosa*
Microlaena stipoides	*Microsorum* spp.
Negria rhabdothamnoides	*Olearia ballii*
Olearia mooneyi	*Phymatosorus scandens*
Pittosporum erioloma	*Polystichum whiteleggei*
Rapanea myrtillina	*Symplocus candelabrum*
Tmesipteris truncata	*Zygogynum howeanum*

However, the total species list of the community is considerably larger than that given above, with many species present in only one or two sites or in low abundance (NSW Scientific Committee 2011). At any one time, above-ground individuals of some species may be absent, but the species may be represented below ground in the soil seed banks or as dormant structures such as bulbs, corms, rhizomes, rootstocks or lignotubers. The list of species given above is of vascular plant species; the community also includes non-vascular plants, micro-organisms, fungi, cryptogamic plants and a diverse fauna, both vertebrate and invertebrate. These components of the community are less well documented (NSW Scientific Committee 2011).

Gnarled Mossy Cloud Forest on Lord Howe Island is confined to Lord Howe Island in New South Wales. On the island it is restricted to the summit plateau of Mt Gower (some 27 ha) and in a greatly reduced form and extent on the narrow summit ridge of Mt Lidgbird (NSW Scientific Committee 2011). Gnarled Mossy Cloud Forest on Lord Howe Island is currently recognised following the work on vegetation classification on Lord Howe Island by Pickard (1983) who describes the community as Gnarled Mossy Forest. Other studies describe the community as Moss Forest (Oliver 1916), Cloud Forest (Mueller-Dombois & Fosberg 1998) and Mossy Cloud Forest (Harris *et al*. 2005). Recent work (Harris *et al*. 2005) has detailed the species composition and internal variation within the community, along with its conservation significance. Small-scale patch dynamics such as tree death and fall, and storm and lightning damage, are likely to be key drivers of turnover in plant populations in Gnarled Mossy Cloud Forest (NSW Scientific Committee 2011). Extensive Providence Petrel (*Pterodroma solandri*) burrowing may also influence plant recruitment (NSW Scientific Committee 2011). Many non-vascular plants are dependent upon cloud cover and the structure provided by the trees and shrubs.

Gnarled Mossy Cloud Forest on Lord Howe Island is a forest of 2-8m tall, depending on aspect and whether it occurs on ridges or in drainage lines (NSW Scientific Committee 2011). On the summit plateau of Mt Gower, the dominant species are *Zygogynum howeanum* and *Dracophyllum fitzgeraldii* (Pickard 1983, Harris *et al*. 2005). Associated trees include *Cryptocarya gregsonii, Elaeocarpus costatus, Leptospermum polygalifolium* subsp. *howense, Negria rhabdothamnoides*, *Pittosporum erioloma, Symplocus candelabrum,* and the palms *Hedyscepe canterburyana* and *Lepidorrhachis mooreana* (NSW Scientific Committee 2011). Tree Ferns (*Cyathea* spp.), large tussock sedges (*Machaerina insularis* and *Gahnia howeana*), ferns *Blechnum fullagarii, B. contiguum, B. howeanum, Grammitis wattsi* and other ferns, mosses and lichens are abundant (ibid). Gnarled Mossy Cloud Forest on Lord Howe Island also occurs on the summit ridgetop of Mt Lidgbird above 750 m elevation, but is much more exposed and restricted in area (Pickard 1983). A vegetation plot on the summit of Mt Lidgbird in Gnarled Mossy Cloud Forest had a dominant canopy of *Hedyscepe canterburyana, Cryptocarya gregsonii, Dysoxylum pachyphyllum, Negria rabdothamnoides, Pittopsorum erioloma* and *Cyathea macarthurii*, along with *Grammitis diminuta, Carex* sp., *Olearia mooneyi, Rapanea myrtillina, Zygogynum howeanum, Lordhowea insularis, Gahnia howeana, Negria rabdothamnoides, Coprosma lanceolaris, Dendrobium moorei, Coprosma* *putida, Macropiper hooglandii*, *Microsorium scandens, Asplenium milnei, Asplenium surragatum, Elatostema grande, Hymenophyllum* sp. (Hutton and Auld unpublished data cited in NSW Scientific Committee 2011).

Some 86% of the vascular plant species in Gnarled Mossy Cloud Forest on Lord Howe Island are endemic to Lord Howe Island and approximately 17% are endemic to this community or only occur within it and on adjacent slopes below (Harris *et al*. 2005). There is extensive development of non-vascular epiphytes (Pickard 1983). Ramsay (1994) details the mosses of Lord Howe Island and lists 105 species, in 58 genera and 36 families. Twenty percent of these are endemic to the island and some 37 taxa are recorded from the Mt Gower area, with 15 species apparently confined to the southern mountains (Ramsay 1994).

Gnarled Mossy Cloud Forest on Lord Howe Island is a key component contributing to the southern mountains biodiversity hotspot on Lord Howe Island (DECC 2007), particularly for plants and invertebrates. Cassis *et al*. (2003) found that the assemblage of terrestrial invertebrates in the Gnarled Mossy Cloud Forest exhibits high species richness, high levels of endemism and many species are restricted to the Gnarled Mossy Cloud Forest.

Several threatened taxa occur within the Gnarled Mossy Cloud Forest on Lord Howe Island (NSW Scientific Committee 2011). These include:

Birds: Lord Howe Island Woodhen, Providence Petrel, Lord Howe Silver Eye and Lord Howe Island Currawong. These birds also occur at lower elevations but Gnarled Mossy Cloud Forest forms key core habitat for the petrel and woodhen in particular;

Invertebrates: Lord Howe Island earthworm, *Pericryptodrilus nanus* is confined to this community and dependent upon it. Four endemic snails (*Pseudocharopa whiteleggei, Pseudocharopa lidgbirdi, Mystivagor masteri* and *Gudeoconcha sophiae magnifica)* are listed under the EPBC Act as *Critically Endangered*; and all are restricted to the Gnarled Mossy Cloud Forest (NSW Scientific Committee 2011). In 2015, these four snail species were listed as *Critically Endangered* in the TSC Act. Cassis *et al*. (2003) identify a number of invertebrates (ants, beetles and spiders) that are found in the cloud forest that should be considered for listing as threatened;

Plants: The *critically endangered Lepidorrhachis mooreana* (Little Mountain Palm) is endemic to Lord Howe Island and is confined to the Gnarled Mossy Cloud Forest (NSW Scientific Committee 2011).

Threats

The Gnarled Mossy Cloud Forest on Lord Howe Island is threatened by a number of factors. The exotic Ship Rat has been on Lord Howe Island for almost 100 years. Auld *et.al* (2010) found rats on LHI have increased the risk of extinction for the two endemic mountain palms on Mt Gower. This is a consequence of rat predation of fruits which has the potential to limit recruitment in both palm species. Past observations highlight the lack of ripe fruits on *Lepidorrhachis* plants unless mesh caging was applied to exclude rats from the developing fruits. The impact of rats is greatest in *Lepidorrhachis*, where fruit losses reached 100% and small juvenile plants (<50 cm) were extremely rare in the presence of rats.

The effect of rats on other plants is poorly known, but rats consume seeds and leaves of a number of other taxa (Auld and Hutton 2004), including *Dietes robinsoniana* which occurs in the Gnarled Mossy Cloud Forest. Rats are also a serious threat to a number of invertebrates, including the threatened snails listed above (Beeton 2008 a,b,c,d). Only 7% of the summit plateau of Mt Gower is baited to reduce the effects of rats on the palm species in this community.

Risk Posed by the Rodent-Baiting Proposal

The REP does not pose a risk to plant species (see Section 3.1.3.3) and is unlikely to have a significant impact on any resident fauna species within this threatened ecological community (discussed in section.5.2 above). Therefore no impact to this Community is expected.

As rats are a significant threat to several plants and animals that are integral to the Gnarled Mossy Cloud Forest (NSW Scientific Committee 2011) the eradication of rodents will benefit this community.

Mitigation of the Proposed Rodent Eradication

None proposed.

7 Ameliorative Measures

Measures used to mitigate potential environmental harm are summarised below. The LHIB are the responsible party for implementing the mitigation measures with assistance from OEH Science Division for some monitoring aspects. Mitigation will be undertaken with regard to relevant standards, statutory obligations and relevant approval conditions from the various approvals agencies (see section 9). Costs for all mitigation measures proposed are well understood and have been included in the funded project budget. Sufficient budget remains to implement the proposed measures.

7.1 Bait selection

Baits dyed green are often avoided by birds. This has been verified in trials conducted on LHI in 2007 with non-toxic Pestoff® pellets (DECC, 2007a). In that trial the Emerald Dove ate red pellets and brown pellets when offered to it, but ignored completely the green pellets. Baits to be used for the rodent eradication will be green.

The lower concentration of Brodifacoum in the bait, namely 20 parts per million, also reduces the possibility of non-target kills while still being highly lethal to rodents. Baiting on LHI currently involves the use of bait containing 50 parts per million of Brodifacoum which is 250% as toxic as that proposed for the eradication.

Pestoff® Rodent Bait 20R pellet product breaks down more quickly than most commercial rodenticides which tend to contain waxes and other compounds aimed at extending bait life in the field. This would extend unacceptably, the period of non-target risk. The more rapid physical bait breakdown rate for Pestoff® Rodent Bait 20R and its lower toxicity provide an effective compromise between maintaining target animal efficacy and reducing non-target risk.

An expected outcome of this mitigation is reduced non target species impacts.

7.2 Timing of baiting

The eradication is proposed to occur in June – August. It is at this time of year that most migratory seabirds are absent from the LHI Group. Even though seabirds are unlikely to eat baits and rodents, conducting the baiting when they are not present eliminates the already negligible risk to them.

The risk of collision with helicopter to the several seabird species that are present during the baiting will be reduced by taking advantage of the diurnal movements of seabirds. In this way sections of LHI will be baited when those birds are foraging at sea and away from their roosting grounds. To reduce disturbance to those species that are present throughout the day, baiting height for the helicopters will be set at an altitude that does not unduly disturb roosting or nesting birds.

An expected outcome of this mitigation is reduced non target species (seabird) impacts.

7.3 Minimising Bait Entry in the Water

Baiting around the coast line will occur above the mean high water mark to minimise bait entry into the marine environment. A deflector arm can be attached to the spreader bucket to restrict the arc of the swathe to 180º and will be used particularly when baiting the edge of buffer zones and to minimise bait entry into the marine environment when baiting coastal areas.

The Lagoon foreshore and some other beaches will be hand baited.

Expected outcomes of this mitigation are minimised bait entry into the water to reduce risks of pollution, marine non target species, impacts and bioaccumulation.

7.4 Captive Management

Woodhen and currawongs are highly susceptible to poisoning; the former from eating baits and poisoned rodents, the latter from preying on poisoned rodents. A large proportion of the population of the woodhen (80-85%) and currawongs (50-60%) will be taken into captivity to mitigate the risk of poisoning from the proposed baiting.

The period of captivity will start from approximately two months before baiting commences until baits and rodent carcasses have broken down (or for a total period of up to nine months). The time that baits are available is estimated to be 100 days although the rate of bait breakdown will be monitored (as described in Section 2.7.1.2) to ensure birds are not released at a time which may put them at risk.

Significant experience has been gained in managing woodhen populations in captivity on LHI. During a recovery program for the species (1981-1983), protocols for capturing and housing woodhens were established (Gillespie, 1993). The highly successful captive breeding and release program resulted in the release of 82 birds bred from just three breeding pairs originally captured (NPWS, 2002). Prior to the commencement of the program it was estimated that only 37 individuals remained in the wild.

In preparation for the LHI REP, a captive management pilot study was conducted in 2013 for woodhen and currawongs on LHI (Taronga Conservation Society Australia, 2014) has also added significant knowledge on the captive management of the two species. The pilot study showed that woodhens and currawongs could be held in large groups for prolonged periods with no observable impact. All 20 woodhens and 10 currawongs were successfully released at their individual capture sites. The trial report is included in Appendix C – Captive Management Package.

The expected outcome of this mitigation is protection of species at risk from the REP.

7.4.1 Bird capture

Only experienced staff will be involved in the capture of both species. These include rangers on LHI who are involved in the capture of woodhen for banding as part of the annual monitoring of the population and OEH scientific officers (with assistance from the LHIB rangers) that have been catching and banding currawongs since 2005 to determine their population status and movements. Hand-nets will be used to capture woodhen, and clap-traps will be used for currawongs. Upon capture, birds will be placed into cloth bags or ventilated cardboard boxes (one bird per bag or box) and taken to the holding facility where they will be checked by a veterinarian. A veterinarian with bird experience will be on site during all capture and release operations.

Birds will be collected from across the island including Mt Gower which will be accessed by helicopter to minimise stress to the birds. The Woodhen Survey Manual (Harden, 1999) provides details around how to capture woodhens.

7.4.2 Captive Housing Design and Location

The design plans for the holding pens used for each species during the 2013 trial were prepared by an experienced aviculturist from Taronga Zoo considering knowledge gained from previous facilities built to house these birds (both at Taronga Zoo and on LHI) as well as advice from New Zealand where the Weka, a species similar to the woodhen, had been kept in captivity during rodent-eradication operations undertaken in that country. These, together with recommendations from the pilot study will be used to inform the detailed design of the larger facility needed during the REP.

Indicative plans from the 2013 pilot study are attached as part of Appendix C – Captive Management Package.

The captive management facilities will be constructed by modifying existing facilities at the Nursery, where the facilities for the pilot study were built. If required, expansion may occur on previously cleared land at the nursery Site (Figure 9).

Woodhens will held in enclosed paddocks 14 m by 14 m (see Figure 7), holding approximately 20 birds each. No aggression was noted during the 2013 trial with similar bird numbers per aviary. For the currawongs, aviaries 1.5 m wide x 3 m high x 6 m long aviaries, will be constructed, holding approximately 2 birds.

Guiding principles used in designing and determining the location of aviaries have included

- Locating the aviaries away from areas frequented by people;
- Providing adequate shade and protection from inclement weather and avian predators;
- Ensuring the birds feel secure by the provision, if need be, of screens between pens containing antagonistic co-specifics;
- Providing cover within pens in which the birds can shelter;
- Ensuring the pens can be effectively cleaned;
- Ensuring drainage is adequate;
- Ensuring internal structures are without sharp surfaces and pointed edges.

A Construction Management Plan for construction of the aviaries was developed in 2013 and will be updated to consider the expansion required for the REP. The 2013 Construction Management Plan is attached to this referral as part of Appendix C – Captive Management Package.

7.4.3 Captive Husbandry and Disease Management

At the commencement of the captive period each bird will be banded (if not already) and examined by a veterinarian from Taronga Zoo who is experienced in avian medicine. The initial health status of individual birds will be determined by detailed physical examination together with body weight measurement and faecal examination for intestinal parasites. While in captivity on LHI, the birds will be under the care and authority of Taronga Zoo. A team of aviculturists will be employed to manage the holding facility for the period that the birds are held.

During the captive period the birds' behaviour and food intake will be monitored daily by experienced keepers and body weight will be monitored regularly. Parasite loads will be monitored by faecal examination.

At the end of the captive period each bird will undergo another physical examination by a veterinarian to ensure that it is fit for release.

Previous health assessments conducted on the Lord Howe Woodhen and other avian species on the island have not identified infectious diseases causing illness (Curran, 2007, included in Appendix C). The most likely disease or injury scenarios that may arise in the captive period include trauma due to con-specific aggression, parasitism especially coccidiosis, and outbreak of stress induced disease due to opportunistic environmental organisms such as salmonellosis and aspergillosis.

Facilities will be available for isolation of sick birds. Basic veterinary diagnostic investigation of any ill birds will be undertaken on the island while samples for more detailed diagnostic testing including histopathology and more complex haematology and serum biochemistry will be sent to Taronga Zoo for processing

A scientific licence issued by the NSW OEH under Section 132C of the National Parks and Wildlife Act 1974 is required to capture woodhen and currawongs on Lord Howe Island.

The capture or housing of birds can result in the injury or death to individuals. Measures taken to reduce the likelihood of injury or death to birds in the program are:

- Experienced staff will be involved in the capture of both species
- A bird-specialist veterinarian will be on site during capture and release operations
- Experienced aviculturists from Taronga Zoo have designed the holding facilities to be sited on LHI
- Experienced aviculturists from Taronga Zoo will manage and care for birds through their period in temporary captivity
- Advice on captive management has been sought from, and will continue to be refined with, specialist aviculturists. Central to this process has been the examination of the successful captive-breeding programme for woodhen undertaken on LHI in the 1980s, the 2013 pilot study, as well as captive trials undertaken in New Zealand with Weka (a species similar to the Woodhen)
- Exclusion of rodents from the facility
- If the holding facilities are found to be inadequate after birds have been taken, attempts will be made to rectify any problems.

Notwithstanding these precautions, a small number of birds (~ 15) are likely to die in captivity due to natural mortality (e.g., due to old age) because birds captured for the trial will reflect the age structure and general health of birds on LHI.

7.5 Impact Monitoring

An extensive monitoring program will be conducted during and after the REP. This includes

- Monitoring of weather in the lead up to and during the REP. This will ensure bait can be distributed safely and effectively and not during adverse weather conditions.
- Monitoring breakdown of baits after distribution. Bait breakdown will be monitored at random sites using the Craddock Condition Index described above at approximately 30 day intervals until complete disintegration. This will provide confidence in bait breakdown prior to release of captive managed species.
- Soil Monitoring after distribution. Post operational soil samples will be collected to monitor residues of Brodifacoum in the soil. Representative samples will be collected from directly below some toxic bait and at control sites away from bait pellets. Soil samples will be collected approximately 30 days after bait disintegration and approximately every two months (if required, dependant on results). All tests will be conducted at a NATA accredited analytical laboratory. This will provide evidence that pollution has not occurred.
- Random sampling will be conducted on water bodies on the island to monitor Brodifacoum levels after the bait drop. Water samples will be collected within 2 days of each bait drop and approximately weekly 30 (if required, dependant on results). All tests will be conducted at a NATA accredited analytical

laboratory. Rain water tanks will be sampled if requested by residents. This will provide evidence that pollution has not occurred and water is safe to drink.

- Analysis of milk samples post baiting. This will provide evidence that milk is safe to drink.
- Monitoring of captive LHW post release (see details below). This will provide evidence of recovery.
- Monitoring of free-ranging LHPC and captive LHPC post-release (see details below). This will provide evidence of recovery.

7.5.1 Monitoring programme for the Lord Howe Pied Currawong

With approval of the REP (baiting) it will be necessary to have a three-phase program involving captivity, monitoring and release of the Lord Howe Pied Currawong (LHPC).

In the first phase, 50–60% of the LHPC adult population will be captured using manually operated, baited butterfly-traps and brought into captivity. This process will target breeding pairs close to the settlement and from Mount Gower to cover the range of birds from the island. Trapping will involve an intensive 3-week program in May 2017 and will include transporting LHPC from Mt Gower by helicopter in conjunction with Woodhen activities (see below). This phase will require the construction of captive management facilities within the lowlands by Taronga Zoo and the LHIB.

The second phase will involve surveys, including trapping and banding free-ranging LHPC not captured in the first phase. Understanding the movements of the free-ranging birds will allow their fate to be broadly monitored. As these individuals are to be left in the wild during the period of risk (i.e. a 6-week period during and in the period immediately following the baiting operation until rodent carcases are deemed to be no longer available for scavenging- based on the recovery and monitoring of the breakdown of fresh rodent carcases) a five-day survey effort will be implemented every two weeks (proposed dates: May 29 – June 2, June 12 – 16; June 26 – 30 July 10 – 14). Any individuals found suffering from the suspected effects of poisoning will be captured and treated in captivity by a qualified aviculturist or vet until they recover.

The final phase will involve the gradual release of captive LHPC. Initially, five pairs of birds will be released at their capture locality. These birds will be monitored using two-staged VHF transmitters (fitted with mortality switch) for a period of two weeks. If all birds remain alive and well, the remainder of the captive currawongs will be released at their capture locality (potentially commencing 31 July 2017). The transmitted birds will be re-caught to remove devices if they have not already become detached due to their inherent 'weak-link'. Any birds recovered dead from these initial releases will be autopsied to determine cause of death and sampled for Brodifacoum contamination. If tests prove positive the re-release of the remaining birds will be delayed for a further two weeks whereupon the process will be repeated, commencing with initial monitoring of transmitter-fitted individuals.

Population size of the LHPC has been estimated previously using trapping, banding and mark-recapture analysis (Carlile and Priddel 2007). Full monitoring and population estimates will recommence in spring-summer of 2016 to obtain pre-eradication population estimates; the protocols are well-established. With Science Manager consultation, birds attracted to designated locations across the island with food, can be monitored and any unbanded birds caught, banded with an individually unique combination of colour-bands, and released. A second round of surveys will then take place to re-sight captured birds and capture unbanded birds. Population size can then be estimated using mark-recapture analysis, and the size of the population tracked over time. Similar surveys will be performed in spring-summer 2017 allowing comparisons of (i) the persistence of the population following rodent eradication with prior estimates, (ii) the survival of birds that were left in the wild during the period of risk compared to those held in captivity, and (iii) productivity of breeding birds in the first year of a rodent-free environment.

It is suggested that four ten-day survey periods (October to January) are carried out annually for three years following the eradication to monitor population changes of the species in a rodent-free environment. It is expected that if the species experiences negative impacts from a rodent-free environment (through reduced food availability, for example) these impacts will first become apparent during chick provisioning and post fledging survival. Specific attention will be paid to nesting attempts and provisioning behaviour of adults to determine any negative responses to a rodent-free environment. Post-fledging survival will be monitored through subsequent annual surveys.

7.5.2 Monitoring programme for the Lord Howe Woodhen

With approval of the REP (baiting) it will be necessary to have a three-phase program involving captivity, monitoring and release of Lord Howe Woodhen (LHW).

The first phase will be to capture LHW using standard capture techniques (Harden 1999) and bring into captivity the entire accessible LHW population (as part of annual monitoring, more than 70% of the population are captured or sighted for visual retrapping of banded birds). While the capture and transport of birds from the lowland areas will be relatively straightforward, the birds removed from Mount Gower and Erskine Valley will require considerable trapping effort and transport arrangements. Birds will be transported from predetermined ‘nodes’ within the landscape. OEH Science manager will manage birds at the point of capture prior to their helicopter removal from the southern mountains to captive management facilities in the settlement. Helicopters were previously used to transport LHW with no reported ill-effects (Miller and Mullette 1985).

If not already banded, all LHW held in captivity will be banded prior to release with one individually numbered stainless steel metal band supplied by the Australian Bird and Bat Banding Scheme (ABBBS) on the left tarsometatarsus and one plastic yellow band with a unique three-digit black number on the right tarsometatarsus. The yellow plastic band replaces the previous marking scheme for wild LHW that used three coloured metal bands in addition to the ABBBS band (Harden 1999). The new scheme was adopted in 2014 because the colour coating on metal bands wears off over time, precluding the individual identification of banded LHW by sight. All LHW captured for the captive management program that were banded prior to 2014 will have their three coloured metal bands removed and replaced with a single yellow plastic band as described above. The timing of banding will be at the discretion of the aviculturists and may occur at the time of capture, during health checks while in captivity, or immediately prior to release.

The second phase will involve limited release and monitoring of LHW following the disintegration of baits and rodent carcasses, expected to take 100 days after final baiting. The birds will be released in pairs at their point-of-capture and monitored using 2-stage VHF transmitters. Initially, 6 pairs will be released, three within the settlement and three within the Permanent Park Preserve in the lowlands and Erskine Valley. Following two weeks of movements the birds will be re-captured, transmitters removed and blood collected for analysis of Brodifacoum residue. Following confirmation of the absence of Brodifacoum residue, release of the remaining captive birds will commence. If tests prove positive the re-release of the remaining birds will be delayed for a further two weeks whereupon the process will be repeated, commencing with initial monitoring of a different cohort of transmitter-fitted individuals.

The final phase will involve the release of all remaining captive LHW. These birds will be released at their point-of-capture (potentially commencing 12 October 2017). Birds trapped from Mount Gower may require helicopter transport, however for birds transported by foot into Erskine Valley, the use of specifically designed transport cases may be used to transport birds to be released at sites remote from convenient transport routes. OEH Science Manager will assist LHI Board management with this final phase of the release.

Future surveys of LHW should follow the systematic approach of current annual surveys (Harden 1999) with additional surveys to monitor breeding success. These surveys will assess juvenile recruitment in the first three years following rodent eradication to determine breeding success and chick survival relative to earlier studies.

Annual surveys of LHW are carried out in November–December over two full working weeks following standardised survey protocols (Harden 1999). These surveys were instigated immediately after the 1980–1985 captive breeding and release program and will continue indefinitely. Where possible, all LHW encountered during surveys are individually identified by colour-bands or an ABBBS metal band (if recaptured), or if they are not banded are captured and banded. Surveys thus constitute a census of the population, whereby a concerted effort is made to identify all surviving LHW occupying readily accessible parts of the island (Mount Gower–Erskine Valley, Boat Harbour–Grey Face, Far Flats, Settlement, and Clear Place). Up until 2002, this intensive survey was repeated in April to record the number of surviving juveniles, and thus obtain an index of breeding success for the population. A monitoring program incorporating two surveys per year will be re-instated for three years encompassing one year before (2016–17), immediately after (2017–18), and one year after (2018–19) the captive management of LHW. Supplementary monitoring will also be undertaken in the first few months following the final releases of captive LHW (see below). The April 2017 survey will provide a contemporary estimate of the breeding success index prior to the captive management program. Within two weeks of the final release of captive, an intensive survey will be undertaken to determine the survival of released LHW and identify any surviving individuals not taken into captivity. Searches will be made in any areas normally outside the survey area where LHW are released. Following this intensive survey, fortnightly monitoring of released LHW will be undertaken in areas where high numbers of LHW currently reside. These include:

- Mount Gower (part) - surveyed by contractors experienced in trekking Mount Gower and surveying woodhens
- Golf Course and surrounds – surveyed by LHI Board staff
- Waste Management Facility – surveyed by LHI Board staff
- Residential gardens in the main Settlement – surveyed by LHI Board staff with assistance from members of the LHI community

Additionally, incidental sightings will be solicited from LHI Board staff and island residents using a pro forma and/or an online portal on the LHI Board website. Monitoring will continue until the end of March 2018, after which a second intensive survey will be undertaken in the first two weeks of April 2018. It is expected that the breeding success index will be lower than in 2017–18 because released LHW will have less time to successfully rear offspring over the optimal spring–summer breeding period. The November–December survey in 2018 will provide an estimate of the population size to compare with the estimate obtained prior to the captive management program in November–December 2016. The April 2019 survey will allow a determination of whether breeding success has returned to a level similar to that prior to the captive management program. If breeding success has not returned to a similarly high level, a survey will also be undertaken in April 2020.

7.6 Operational Non Target Species Mitigation

Non target species impacts will be mitigated during the operational phase of the REP. A Non Target Mitigation Plan has been developed to detail the mitigation measures to reduce the incidence of non-target mortalities as a result of the REP. The aim of the plan is to provide clear and effective guidance for the REP team and project stakeholders in the implementation of mitigation, monitoring and adaptive management actions to minimise impacts on non-target species. A summary is provided below and more is provided in Appendix E – Non-target Impact Management Plan.

7.6.1 Helicopter Impacts

Only experienced pilots with island eradication bait application experience will be used during the REP to aerially bait areas around Providence Petrel nest sites. Pilots will be briefed daily before flights to be well informed of the location and direction of departing foraging birds before baiting begins. Although it is very unlikely any birds will be present due to early departure from the island to foraging grounds at sea, pilot safety and bird impacts at anytime must be taken into consideration to eliminate bird strike occurrence.

Providence Petrel breeding grounds are located on the southern end of Lord Howe Island on the slopes of Mt Lidgbird and Mt Gower. Due to the inaccessible terrain, a mitigation team member will view all baiting over-flights from Capella Hill which provides a clear view of all mountainous nesting areas on the southern mountains. In order to view Providence Petrels flight paths behind the mountains a second mitigation team will be observing flight paths via a boat from the ocean behind Mt Gower. Should Providence Petrels display unusual behaviour or become overly agitated during baiting over-flights, the observer will contact the pilot by radio to instruct on an alternative action, which may include gaining further altitude to reduce the proximity to birds while maintaining the flight path, or abandoning the flight path and returning at a later time from a different altitude. Both observers will, in any case, provide a commentary on the birds' behaviour to the pilot during each flight, to supplement or confirm what the pilot will be seeing beneath the helicopter.

7.6.2 Treating and euthanasia of poisoned Non Target species

Daily monitoring for sick and dead non-target species will be undertaken throughout accessible areas of the island. Sick individuals displaying signs of poisoning will be treated with Vitamin K where possible. Where recovery is not observed, euthanasia of poisoned wildlife is considered appropriate for the welfare of affected animals, and to enable mitigation personnel to collect and dispose of what will become a toxic carcass once an animal dies. The removal of these animals may reduce the threat of non-target species poisoning. Euthanasia will only be a feasible option for those animals that are very easily caught and restrained e.g. completely or nearly immobile animals. If an animal is still mobile and not easily caught, it should not be chased. All woodhens and currawongs will all be bought in for treatment with antidote Vitamin K in all instances.

In order to euthanize moribund non target species in New South Wales, necessary training and the appropriate ethics approval to euthanize non-targets is required. Personnel will be trained in euthanasia by blunt trauma/ cervical dislocation as this method is practical for remote field use. Unless a vet is present, it is recommended that all sick animals that can be accessed to be euthanased or rendered unconscious with a strong blow to the head, sufficient for immediate loss of consciousness and for them not to recover.

- This method must be properly applied to be effective and humane; therefore training to ensure sufficient skill of the operator is essential. It is proposed that training be undertaken by a number of staff in order to meet these ethics requirements with visiting vets while on the island. These trained staff will then be assigned to search teams during the monitoring period. An appropriate mallet or similar instrument should be used and birds need to be restrained adequately with the head held against a solid surface and one blow with sufficiently force needs to be applied at an appropriate angle to the skull. If not performed correctly, various degrees of consciousness with accompanying pain can occur. All incidents of euthanasia must be documented and reported in weekly reports to SAC and the steering committee. Documentation must include details of the demeanour/condition of the bird prior to euthanasia, as well as details of the method and efficacy of euthanasia. This process will enable appropriately qualified and experienced personnel to make informed assessments and provide advice as required

7.6.3 Collection of Biological Samples

Samples from deceased wildlife may be collected for two different reasons during LHIREP; 1) to confirm species and determine sex of non-target species killed, or 2) to determine the levels of Brodifacoum in deceased individuals of the non-target populations.

The collection of samples to assess the amount of Brodifacoum within the non-target species is slightly more labour intensive than genetic samples, although very straightforward when abdomens are opened for assessment of haemorrhaging. Samples can be collected to confirm the cause of death on those carcasses where it is unclear, as well as providing information on toxic loads and potentially the longevity of the toxin within non target populations. It must be noted that sample information will have to be sent to Brisbane for testing at a NATA accredited analytical laboratory.

Livers provide the most appropriate tissue for Brodifacoum samples to be collected from. These must be frozen once collected. Ten samples to be collected from differing levels of carcass code condition as outlined in the Mitagation Plan Appendix 2. The sample collection process will be in accordance with the 'NZ vertebrate pest residue database guidelines', copies of which will be held on Lord Howe Island and used as a reference by field staff.

7.6.4 Carcass Removal and Disposal

Brodifacoum breaks down in the environment from the action of soil micro-organisms. As pellets and carcasses containing Brodifacoum decompose, the toxin also breaks down. The baits and poisoned carcasses can remain toxic for at least seven months after being broadcast. The aim of carcass removal is to remove and dispose of poisoned animal carcasses to ensure that they are unavailable to be scavenged by woodhens and currawongs when they are released. Burial and or incineration at the Waste Management Facility is a practical means of disposal available in remote field situations encountered on LHI.

All carcasses encountered during search and collection must be disposed of in an appropriate manner that ensures safe disposal and meets label requirements. A disposal protocol will be developed by the Mitigation Team Leader prior to the commencement of baiting that will ensure this objective is achieved. This will be based on 2 options for burial and incineration that exist on LHI – in preferred order these are;

- Use of the existing incinerator located at the Waste Management Facility (WMF) to incinerate carcasses (preferred option).
- purpose dug deep burial pits located at the WMF to appropriate depth to allow microbial breakdown of carcasses.

Opening of the skin and body cavity to check for haemorrhaging will also greatly assist decomposition of carcass by allowing better contact between soil and tissue rather than fur/feathers

7.6.5 Contingency planning and adaptive management measures for non target mitigation

Should unexpected impacts occur, an adaptive management framework is critical to ensure impacts are effectively managed over the duration of the operation.

The reality of logistics associated with undertaking works on Lord Howe Island means that large scale approaches for mitigating the effects of the REP baiting operation must be planned and organised and the scope for implementing new measures is limited. However, if the operation is not managed effectively it could lead to long-term and devastating impacts on populations of threatened species, in particular the LHI Woodhen and LHI Currawong. As such, all efforts must be made to ensure that impacts are minimised and this will require the investigation and implementation of appropriate mitigation measures. More detail is given in the Non Target Mitigation Plan in Appendix E.

8 Assessment of Significance of Likely Effect of Proposed Action

This SIS provides a demonstrated need for the REP based on documented evidence of significant impacts of rodents both globally and on LHI. It presents evidence of ongoing impacts at the species and ecosystem level on LHI even in the presence of ongoing rodent control. It demonstrates support for the REP through a range of legislative instruments, recovery plans and the like and outlines the unacceptable consequences of failing to proceed. It also provides evidence of expected benefits.

Detailed consideration of alternatives assessed is provided together with justification of why continuing with the current control program is unacceptable. It provides evidence of why other methods were considered unsuitable for an eradication on LHI and why the toxin, bait and delivery methods were selected based on over 30 years of lessons and experience globally.

It outlines the project details and mitigation and considers in detail, potential risks to threatened species and ecological communities based on results from numerous similar eradications around the world.

It concludes that significant impacts are highly unlikely for most threatened species and ecological communities. Species considered most at risk are the LH Woodhen and the LH Pied Currawong. In the absence of mitigation, a significant impact to woodhens is likely to occur from the LHI REP. However with the mitigation proposed in place, it is considered unlikely that either long term population decrease or major disruption to a breeding cycle will occur. Impacts are likely to be temporary. It is therefore considered unlikely that the REP will have a significant impact on woodhens

In the absence of mitigation, a significant impact to LHPC is likely to occur from the LHI REP. With the proposed mitigation in place, it is considered possible that the REP will still have a significant impact on LHPC through the temporary disruption of a breeding cycle, although it is unlikely that a long-term population decrease will occur. Any potential impacts will be temporary. This temporary potential impact will be substantially offset by the improvement in biodiversity if impacts of rodents are removed as a result of the REP. No other offsets are proposed.

With the mitigation described in Section 7 in place, the REP is not excepted to have a significant impact on any TSC Act listed threatened species or ecological community.

The REP is essential and beneficial. Risks have been addressed through proposed mitigation to the point where they are considered to be very low. Any potential impacts are localised and short term and far exceeded and offset by the benefits that will be provided by implementation of the REP. Potential impacts of the REP are also considerably less than the ongoing impact of failing to proceed.

A summary of assessment of potential impacts is presented in Table 15 below.

Table 15 Summary of Assessment of Impacts to Threatened Species and Ecological Communities

Threatened Species / Ecological Community	Potential Impacts Associated with the REP	Assessment of Impacts	Mitigation Measures	Consequences of not proceeding undertaking the REP
Threatened Birds	Direct and secondary poisoning through consumption of baits or deceased rodents	In the absence of mitigation, a significant impact to woodhens is likely to occur from the LHI REP. However with the mitigation proposed in place, it is considered unlikely that either long term population decrease or major disruption to a breeding cycle will occur. Impacts are likely to be temporary. It is therefore considered unlikely that the REP will have a significant impact on woodhens In the absence of mitigation, a significant impact to LHPC is likely to occur from the LHI REP. With the proposed mitigation in place, it is considered possible that the REP will still have a significant impact on LHPC through the temporary disruption of a breeding cycle, although it is unlikely that a long-term population decrease will occur. Any potential impacts will be temporary.	Captive management of significant portions of the population under the care of a team of specialist aviculturists from Taronga Zoo.	Continued competition with rodents for resources (woodhen). Continued exposure to direct and secondary poisoning through consumption of baits or poisoned rodents from the existing control program.
Threatened Reptiles	Primary poisoning (direct consumption) and secondary poisoning (consumption of poisoned invertebrates).	Each species is considered to be at low risk of poisoning, and both are likely to substantially increase in abundance following the removal of rodents.	No specific mitigation	Continued decline from rodent predation
Threatened Invertebrates	Direct poisoning through consumption of baits	Low risk to four species and higher risk to *Gudeoconcha sophiae magnifica*. Land snails, earth worm and wood feeding cockroach are highly threatened by rat predation and it is likely that if rats are not removed these species will become extinct.	Possible Brodifacoum testing on surrogates species	Continued decline and likely extinction from rodent predation

Threatened Marine Mammals and Reptiles	Localised and temporary pollution of water, primary or secondary poisoning.	Pollution of marine water resulting in impacts to threatened marine species is considered extremely unlikely considering the minimal amount of bait likely to enter the water, the insolubility of Brodifacoum and the huge dilution factor. Species unlikely to have sufficient exposure to the bait	Minimising bait entry into the water through the use of directional deflector arm on the bait bucket.	Unlikely impact
Threatened Plants	Works associated with building the captive management facility and bait distribution (through potential uptake of Brodifacoum by plants).	No impact is expected to listed plant species. Conversely removal of rodents is expected to significantly benefit individual species (such as the Little Mountain Palm and Phillip Island Wheat Grass) and many vegetation communities through reduced predation on seeds, seedlings and stems of palm-leaf fronds.	No clearing of vegetation	Continued seed and seedling predation from rodents causing population declines.
Threatened Ecological Communities	Potential impacts to component species	The REP does not pose a risk to plant species and is unlikely to have a significant impact on any resident fauna species within threatened ecological communities. Therefore no impact to this Threatened Ecological Communities is expected.		

9 Additional Information

9.1 Qualifications and Experience

Qualifications and experience of authors contributing to the SIS are described in Table 16.

Table 16 Qualifications and Experience of Authors

Name and Organisation	Qualifications	Input into PER
Andrew Walsh Project Manager Rodent Eradication Project Lord Howe Island Board	Bachelor of Applied Science (Ecology and Biodiversity) Diploma of Management Certificate II in Quarantine Inspection	Primary Author
Robert Wheeler Assistant Project Officer Conservation Science Team Office of Environment & Heritage	Bachelor of Science (Zoology, Botany); Associate Diploma Park Management	Primary Author
Anthony Wilson Assistant Project Manager – Community Lord Howe Island Board	Bachelor of Science (Zoology) Graduate Certificate River Health Diploma Human Resource Management	Secondary Author
Hank Bower Manager Environment and World Heritage Lord Howe Island Board	Bachelor of Applied Science (ecology) (Hons) Certificate 2 Bush Regeneration (Tafe)	LHI Biodiversity
Pete McClelland Member IEAG NZ Department of Conservation	Bachelor of Science (Zoology) Master in Applied Science	Secondary Author LHI REP Project Manager 2012-2015
Nicholas Carlile Principal Scientist Conservation Science Team Office of Environment & Heritage	Masters of Science (Botany) Bachelor of Arts (Botany) Assoc. Dip. Resource Management	Primary Author: land birds Full Critical review
Dr Terry O'Dwyer Senior Scientist Conservation Science Team Office of Environment & Heritage	Bachelor of Environmental Science (Hons) PhD (Physiological Ecology)	Fauna impact assessment Fauna monitoring plans
Dr Dean Portelli	Bachelor of Science (Honours) (Zoology) Doctor of Philosophy (Biological Science)	Lord Howe woodhen Migratory bird species
Dr David Priddel	Doctorate of Philosophy (Zoology)	Critical review

Principal Scientist (retired)	Bachelor of Science (Hons Zoology)	
Ian Wilkinson Department of Agriculture and Food Western Australia		Primary Author 2009 Rodent Eradication Plan and numerous related studies. LHI REP Project Manager 2006 - 2012
Dr Frank Koehler Senior Scientist Australian Museum	Doctorate of Philosophy (Zoology) Master of Science (Biology)	Primary Author: Land snails
Dr Isabel Hyman Scientific Officer Australian Museum	Doctorate of Philosophy (Zoology) Bachelor of Science (Zoology)	Secondary Author: Land Snails
Dr Adnan Moussalli Senior Curator Terrestrial Invertebrates Museum Victoria	Doctorate of Philosophy (Zoology) Bachelor of Science (Zoology)	Secondary Author: Land Snails
Gary Fry Taronga Conservation Society Australia Master of Wildlife Management (Habitat)	Master of Wildlife Management (Habitat)	Critical Review Captive Management
Keith Broome Technical Advisor - Threats NZ Department of Conservation	35 years' experience in invasive pest management. Chair - Island Eradication Advisory Group	Critical Review: Eradication
Cameron Miller National Practice Leader – Natural Resources AECOM Australia Pty ltd.	18 years experience Masters of Science (Ecology & Management) Bachelor of Science	External Third Party Review

We also acknowledge the previous work on the REP undertaken by Dr Ian Wilkinson concerning bait palatability to rodents, non-target reaction to baits, and to feeding trials involving PestOff 20 and the Lord Howe Island Placostylus. We have also relied heavily on a draft eradication plan written by Dr Wilkinson and Dr David Priddel in 2009. For this assistance we are grateful, however the current protocol does vary in some significant respects from the 2009 version, so this acknowledgement should not be construed as indicating Dr Wilkinson or Dr Priddel endorse wholly or in part the current eradication plan.

We also thank Keith Springer of the Tasmanian Parks and Wildlife Service for information concerning the environmental effects of Brodifacoum baits.

9.2 Other Approvals Required for the Development or Activity

The LHIB is the responsible party for obtaining all required approvals prior to commencement of the REP. The LHIB is also the party responsible for ensuring compliance with any conditions of approvals received and will comply with any monitoring, enforcement or review requirements arising from the approvals.

9.2.1 Australian Government

9.2.1.1 Approval under the EPBC Act

Approval has been sought from the Department of Environment and Energy for the REP under the EPBC Act for an action that could have a potential impact on Matters of National Environmental Significance.

The following provides an update on progress of this approval application:

- A referral was submitted on 11 May 2016. Referral # EPBC 2016/7703
- The Project was considered a " controlled action" to be assessed by Public Environment Report on the 30 June 2016
- A Draft Public Environment was accepted by the Department on 31 October and was put on public exhibition inviting submissions from 2 November 2016 to 2 December 2016
- A Final Public Environment Report addressing public submissions was submitted on 21 December 2016.
- Additional information was requested by the Department on 6 February 2017 and provided 10 February 2017.
- The assessment decision is expected in Mid to late April 2017

Contact officer is:

Mark Jenkins

EPBC Assessment Officer

Mark.Jenkins@environment.gov.au

02 6274 1558

9.2.1.2 Australian Pesticides and Veterinary Medicines Authority

Approval from the APVMA in the form of a "Minor Use Permit" for use of the bait product during the LHI REP is required under the *Agricultural and Veterinary Chemicals Code Act 1994.* As the active constituent (Brodifacoum) is currently registered for use in Australia by the APVMA and therefore has established regulatory standards, a Limited Level Environmental Assessment is applicable. The Limited Level Environmental Assessment considers fate in the environment (soil, air and water) environmental toxicology, bioaccumulation and potential impacts to all species present. The application also included a Work Health and Safety Module and a Safety and Efficacy Module that included impact to Human Health. The application for a Minor Use Permit was submitted on 19 April 2016 and assessment by the APVMA is expected to take approximately nine to ten months. Public Exhibition and Consultation is not required by the APVMA for a Minor Use Permit, however the LHIB has made the application package available to the LHI community post submission. Community feedback received over several years was addressed in the application package.

Primary contact is:

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9.2.1.3 Civil Aviation Safety Authority

Various approvals from the Civil Aviation Safety Authority will be required for the helicopter operations including flights and pilot licensing. These will be sought in conjunction with the selected helicopter provider.

9.2.2 NSW Government

Statutory environmental impact assessment will be undertaken as follows:

- The Board has received legal advice that the proposed baiting programme to be undertaken on the island does not constitute an activity for the purposes of Part 4 or 5 of the NSW *Environment Planning and Assessment Act 1979* and as such it does not require approval under the EP&A Act. In order to meet the definition of an "activity" for the purposes of the Act, the programme would need to be considered to be a "use of the land" or constitute "work on the land". The baiting of the rodents is not likely to be considered to be "work" or a "use of the land".

Advice received from the NSW OEH is that the NSW Assessment Bilateral Agreement would not apply to the Part 4 Assessment

However assessment under Part 4 of the NSW *Environment Planning and Assessment Act 1979* is required for construction of the Captive Management facility. This will be assessed via a Development Application with a statutory public notification and comment period. The LHIB is the consent authority.

In addition, given the broad public interest in the proposal, a non-statutory Public Environment Report as above will be made publicly available. That document will assist the community to understand the overall purpose of the proposal, the range of approvals required, and enable social and economic factors to be identified and considered.

- The Development Application (DA 2017-13) was submitted on the 19 January 2017 with public exhibition from 20 Jan 2017 to 3 February 2017.
- The Development Application will be decided at the May 2017 LHIB Board meeting in conjunction with the final Go / no go Decision for the entire REP.
- Primary Contact is:
    - Dave Kelly
    - Manager Environment and Community Development, LHIB
    - Dave.Kelly@lhib.nsw.gov.au
    - Telephone 02 6563 2066

- A Species Impact Statement (this document), which considers the REP including capture and holding of the birds, and a Threatened Species License under Section 91 of the *NSW Threatened Species Conservation Act 1995* are also required.
- NSW Dept. of Primary Industries (Marine Parks and Fisheries) - assessment under Division 2 of the NSW *Marine Estate Management Act 2014 and Fisheries Act 1994*. This assessment will consider potential impacts to NSW listed threatened marine species, habitats and the State LHI Marine Park values.
    - A section 220ZW License to Harm application was submitted to Fisheries on 3 Nov 2016
    - A NSW Marine Parks permit application was submitted to Marine Parks on 30 December 2016
- NSW Environmental Protection Agency - owners consent to aerially bait within 150 m of dwellings and public places required under the NSW *Pesticides Act 1999*.

9.2.3 Local Government

The LHIB has the status of a local government authority, and a consent authority under the Environmental Planning and Assessment Act 1979. The Development Application for the captive management facility will be assessed under the Lord Howe Island Local Environmental Plan 2010. These assessments will consider and address statutory requirements and will include a comprehensive assessment of the impacts, risks and proposed mitigation of the eradication program relevant to each agency's jurisdiction.

Relevant Contact is:

- Dave Kelly
- Manager Environment and Community Development, LHIB
- Dave.Kelly@lhib.nsw.gov.au
- Telephone 02 6563 2066

9.3 Licensing Matters

The following licenses are required for various aspects of the REP:

- License to Harm threatened species under Section 91 of the TSC Act. It is expected that this would be an outcome of this SIS.
- License to Harm threatened species under the *Fisheries Act*. It is expected that this would be an outcome of the Section 220ZW application submitted (described above)

- License to capture listed threatened species (Woodhens and Currawongs) under Section 91 of the TSC Act.

  LHIB Staff currently have a license # 100831 – which allows LHIB staff to harm, trap, hold (including dead specimens), release fauna and pick flora for identification purposes. This would need to be renewed prior to the REP with Taronga Zoo staff added.

  OEH staff involved in capture of currawongs are currently covered under Animal Ethics Committee license 050725/02. This may need to be extended to cover the REP

- Licensing of operators under the *Pesticides Act 1999.*
  - It is expected that helicopter pilots contracted will have a commercial distribution license and a Pesticide use license for prescribed pesticide works for aerial baiting components
  - LHIB staff will require a Pesticide use license for prescribed pesticide works for ground baiting components.

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Appendices

Appendix A – Director General's Requirements for a Species Impact Statement for the Lord Howe Island Rodent Eradication Project

Appendix B – DGRs Checklist

Appendix C – Captive Management Package

Appendix D – LHI Trials Package

Appendix E – Non-target Impact Management Plan

Appendix F – Masked Owl Package

Appendix G – Biodiversity Benefits Monitoring Package

Appendix H – LHI Biodiversity Management Plan

Appendix I – Island Eradications Using Pestoff

Appendix J – Marine Hypothetical Scenario

Appendix K – Land Snail Survey 2016