Targeted fauna survey for Leeuwin Road upgrade works – Cape Leeuwin Freshwater Snail *Austroassiminea letha.*

Report to Shire of Augusta-Margaret River

Ottelia Ecology

January 2021

Ottelia Ecology
Environmental Services | Aquatic Ecosystem Specialists

0417 997 388
info@otteliaecology.com.au
www.otteliaecology.com.au

/

Prepared for:

[redacted]
Senior Environment Landcare Officer
Shire of Augusta-Margaret River

Prepared by:

[redacted]
Ottelia Ecology
www.otteliaecology.com.au

Document Control:

Document Status	Prepared By	Submitted to	Date
Final Report	[redacted]		27/01/2021
Comments received			18/12/2020
Draft Report 3			27/10/2020
Comments received			22/10/2020
Draft Report 2			18/09/2020
Comments received			11/09/2020
Draft Report 1			08/09/2020

Disclaimer:

This document and the investigations undertaken represent work conducted by Ottelia Ecology on behalf of the Shire of Augusta-Margaret River for the purposes outlined in the project scope. Ottelia Ecology accepts no liability for its use for any other purpose.

Ottelia Ecology acknowledges the Noongar Wadandi people as the Custodians of the land on which this work was done.

Cover: Leeuwin Swamp in Augusta, August 2020 (R. Paice)

Contents

Introduction 1
Background 1
Project scope 1
Risks associated with the proposed road upgrade 1
Considerations for sampling 2
About the Cape Leeuwin Freshwater Snail 4
Species information 4
Known *A. letha* populations 5
Methods 6
Habitat assessment (stage 1) 6
Targeted search for LFS (stage 2) 6
Results 8
Habitat assessment 10
Targeted Survey 12
Discussion 16
References 16
Appendix 1. Site photos 19

Introduction

Background

The Augusta-Margaret River Shire contracted Ottelia Ecology to undertake a targeted search for the Cape Leeuwin Freshwater Snail (LFS) *Austroassiminea letha* along a 2 km section of Leeuwin Road that is planned to be upgraded near the Cape Leeuwin lighthouse. These works include some vegetation clearing and modification to existing culverts.

While there are no currently known occurrences of LFS in the specific areas proposed to be cleared or disturbed, populations have been recorded in close proximity. Previous records include locations in the Leeuwin Swamp wetland areas and east of Ringbolt Bay, approximately 180m south of Leeuwin Road.

A targeted search for the species was requested of the shire by the Department of Biodiversity, Conservation and Attractions (DBCA) as part of the process of applying for permission to clear vegetation via the Department of Water and Environmental Regulation (DWER).

Project scope

The proposed road works are located along a 2km section of Leeuwin Road between the Cape Leeuwin lighthouse carpark and Mathew Flinders Lookout (Figure 1). DBCA Blackwood district conservation officers have previously advised the impact zone of road works (east of Skippy Rock Road) was unlikely to contain *A. letha* but only an on-ground targeted search in freshwater seeps along the road would determine this with any assuredness. The Shire of Augusta-Margaret River requested that the targeted survey include a general search for suitable habitat within the entire 2km section of Leeuwin Road; and a targeted search for *A. letha* individuals within suitable habitat and proposed clearing areas. This wider scope was considered appropriate to enable the Shire to plan for future road upgrades in a way that minimizes risks to potential locations of *A. letha* populations.

The *A. letha* survey undertaken by Ottelia Ecology was conducted in two stages (both outlined in detail within the methods section):

1. A preliminary risk assessment including desktop review and mapping of potentially suitable habitat for *A. letha* along the length of Leeuwin Road between the Cape Leeuwin lighthouse and Mathew Flinders lookout.
2. Targeted field surveys to search for *A. letha* in identified risk areas using timed hand-foraging.

Risks associated with the proposed road upgrade

Key threats to *A. letha* from the proposed road upgrade are: habitat loss; physical disturbance from clearing activities and construction of culverts; and alterations to drainage. The only known population considered potentially at risk is the Leeuwin Swamp population. The status of this population since a fire occurred in the wetland during April 2019 fire is unknown, though it is likely to have been severely impacted given the large area burnt. Given the proximity to Leeuwin Swamp, it is possible that *A. letha* occurs in the project area, which could be impacted by road works. The coastal population at Ringbolt Bay

is not considered to be at risk from the proposal because it is 180m from the road, preventing physical disturbance, and hydrological connectivity to surface road drainage is unlikely.

Considerations for sampling

Austroassiminea letha occur in small areas in isolated, fragmented habitats, and are thus extremely vulnerable to habitat disturbance. It was essential that the act of survey did not pose a threat to remaining populations. The survey methods used were designed for minimal disturbance of habitat and any individuals that may have been encountered. As the snails are distinct in morphology from other species, there was no need for preserved live specimens to be vouchered. Photographic vouchering and submission of dead shells only was undertaken.

An initial habitat assessment was required to provide a review of the potential for *A. letha* to occur, and guide further targeted field surveys. There is an expectation for targeted field surveys of SRE to be completed when uncertainty is high (EPA 2016). The approach proposed in this case was to undertake further sampling in areas where the presence of *A. letha* was likely or possible and in areas of high disturbance associated with drainage lines regardless of likelihood of occurrence.

Consistent with EPA guidance, sampling was undertaken in winter, when *A. letha* were most likely to be active and avoiding disturbance during the summer aestivation period.

Figure 1. Study area for habitat assessment and targeted survey showing known locations of *Austroassiminea letha*.

About the Cape Leeuwin Freshwater Snail

Species information

The Cape Leeuwin Freshwater Snail *Austroassiminea letha* was first described in 1982 by Solem et al., who considered it a phylogenic relic, dating back to the Pleistocene and, potentially, Gondwana. It is a small reddish-brown snail up to 6mm in shell height with a dextral, conical spire with height:width ratio around 1.5 (Solem et al. 1982, Fukuda and Ponder 2003; Figure 1). Although commonly named as a freshwater snail, *A. letha* is considered amphibious. It is found in wet and humid environments, seepage films and splash zones near small freshwater streams and springs (Solem et al. 1982, Onton 2009). In order to sustain populations throughout the drier months the species requires conditions that are perennially moist or highly humid. Within these locations, *A. letha* may inhabit rocks, leaves, soil and litter but generally is found in very small areas at each site (Solem et al. 1982).

Specific habitat requirements have resulted in an extremely small distribution range of *A. letha*, fitting the definition of a Short Range Endemic (SRE) species (EPA 2016). SRE are characterized by low dispersal capacity, isolated populations, seasonal activity and low fecundity (Haver 2002). It is the only SRE gastropod in the South-west. It is a Threatened (Vulnerable) species under the Biodiversity Conservation Act WA 2016, and is also listed as Specially Protected fauna (Schedule 3).

Assimineid snails in Australia are quite unique. Although common in many other countries, where they are mainly found in marine and terrestrial habitats, there are only two species on the Australian mainland and these are freshwater species (Fukada and Ponder 2003, Lydeard and Cummings 2019). These two species, *A. letha* in the south-West and *Aviassiminea palitans* in northern Australia, are considered completely unrelated, suggesting they are either recent colonisations or Gondwanan relicts.

Figure 2. Austroassiminea letha (Onton 2009).

Known *A. letha* populations

Distribution of *A. letha* is restricted to seven (known) isolated populations from Cape Naturaliste to Cape Leeuwin (Onton 2009, Litoria Ecoservices 2019). All known occurrences are associated with freshwater seeps and springs draining from limestone formations near the coast and are generally located beyond the influence of tides or salt spray (Solem et al. 1982, Onton 2009). Previous database searches of the study area by Litoria Ecoservices (2019) identified *A. letha* within 10km of the project site and two known populations occur in the vicinity of the site (Figure 1):

1. Leeuwin Swamp, to the north of Leeuwin Road and west of Skippy Rock Road. Fourteen monitoring sites established by Slack-Smith (2006) have all previously been found to host live individuals. A fire at this site in April 2019 is likely to have seriously impacted this population. A survey following the fire has been undertaken by DBCA and the outcomes of this have been requested.
2. East of Ringbolt Bay and 180m south of Leeuwin Road. This is a new population discovered by DBCA associated with an assessment for Cape Leeuwin Trail (Litoria Ecoservices 2019).

Monitoring of *A. letha* was undertaken by DBCA in 2008-2009 to determine abundance, extent, threats and microhabitat preferences of three of six known populations and investigate genetic characteristics (Onton 2009). Abundance monitoring included three sites to the north of the current project area, but excluded Leeuwin Swamp, as this was sampled by Slack-Smith (2006).

Key outcomes from 2008-09 monitoring by Onton (2009) included:

- All live occurrences had dead shells present, usually at a much greater abundance than live shells.
- Microhabitat preferences: Abundance was associated with distance to surface water, with individuals most abundant <1m from freshwater streams and springs. This is considered an indicator of potential presence of the species.
- Sites have varied vegetation communities, including both native vegetation and areas with dense growth of exotic grasses and other introduced species.
- Additional occurrences were identified at Canal rocks and Boodjidup Creek.
- Genetic analysis concluded relatively high genetic linkage between populations, suggesting they are not genetically distinct.
- For the Leeuwin Swamp site, high threat ratings were given for declining surface water and increasing terrestrial vegetation, fire and climate change.

Leeuwin Swamp was sampled by the Western Australian Museum for the Water Corporation 2005 (Slack-Smith 2006; sample sites are shown on Figure 1). The *A. letha* population associated with Leeuwin Swamp is considered the largest remaining. It has declined over the years by a contraction in moist habitats due to drying of the swamp, although in 2005 was still considered to support reasonable numbers at most sampled sites (Slack-Smith 2006). A fire in April 2019 is likely to have had a substantial impact on the population, however the extent of this is not known (data from survey work since then has been requested).

Methods

Habitat assessment (stage 1)

A habitat assessment of the roadside and the coastal strip was undertaken on 29th-30th July 2020 to determine the likelihood of Leeuwin Freshwater Snail (*A. letha*) occurrence in the vicinity of roadworks and to guide targeted survey work.

Roadside vegetation areas were categorized as likely, possible, unlikely and extremely unlikely to provide habitat for *A. letha* based on an understanding of species requirements and known locations, based on the desktop review. Examples of these habitat types are provided in Figure 1. The assessment was undertaken by qualified environmental scientists Dr Robyn Paice and Ms Kirrily Hastings from Ottelia Ecology, both with considerable experience in assessment of aquatic ecosystems. Factors considered included:

- Soil moisture: Potential for moist conditions during dry periods, presence of seepage areas and drainage lines considered more likely to support *A. letha*. Well-drained upland areas considered unsuitable.
- Soil type: Granular soils more likely to support *A. letha* than gravel and fibrous soils with high content of coarse detritus.
- Vegetation type: Flora and vegetation present indicate soil moisture conditions. Rushes, grasses and soft shrubs considered more suitable than vegetation with dense branches at ground level and high levels of coarse detritus.
- Location in landscape: lower lying areas draining away from Leeuwin road considered more likely to support *A. letha* than higher areas sloping upwards from the roadside.
- Known populations: *A. letha* has been known to occur in the Leeuwin Swamp to the north of Leeuwin Road and in one location near Ringbolt Bay.

Targeted search for LFS (stage 2)

The habitat assessment identified risk areas for *A. letha* as locations classified as either being likely or possible habitat for the species in the vicinity of proposed clearing. In addition, all culvert areas were considered risk areas within unlikely habitat as these represent higher moisture areas and there is uncertainty of *A. letha* distribution. These risk areas guided selection of sites for further investigation in the targeted survey to confirm the presence or absence of *A. letha*. Surveying was done on 7th August 2020 (eastern section) and 27th August 202 (western section).

In consultation with DBCA, it was determined that the presence of dead *A. Letha* shells was considered indicative of the potential presence of this species and therefore in need of habitat protection. Although soil sieving and microscope inspection is normally necessary to locate live specimens, the population was considered to be too fragile for this method, given the potential for destruction of live specimens. In order to minimise the impacts of survey techniques *A. letha*, targeted searching was undertaken by gentle hand foraging among soil, leaf litter and vegetation. Searches were completed in August 2020 by qualified environmental scientists Dr Robyn Paice and Ms Kirrily Hastings from Ottelia Ecology, both with considerable experience in assessment of aquatic ecosystems (DBCA Authorisation to Take or Disturb Threatened Species TFA 2020-0096).

Searches were completed at 16 sites in risk areas shown in Figure 3 and 4, including the following locations:

- Proposed clearing areas on the north side of Leeuwin Road between the Water Wheel car park and Skippy Rock Road within likely and possible habitat types.
- In an area west of the proposed clearing area, north of the lighthouse carpark, considered as possible habitat.
- Within vegetation on both sides of the intersection of Leeuwin Road and Skippy Rock Road, within possible habitat not proposed for clearing.
- All culvert areas.

Timed searches, each with two people searching for 10 minutes, were used to provide a consistent sampling effort, and this was considered adequate for the small search areas involved. Searching included polygons for proposed clearing areas and transect searches. Transects were oriented perpendicular to the road and extending from the edge of the roadside bitumen for a distance of 20m. Transects were also searched for 10 minutes by two people, working from opposite ends, and searching within an area 1-2m wide depending on accessibility.

For proposed clearing areas, polygons were provided by the Shire, and searching extended beyond polygons where deemed appropriate to determine occurrence of *A. letha* in proximity to potential clearing disturbance.

Where *A. letha* shells were present within or in proximity to proposed clearing, a transect search was undertaken to determine the extent of occurrence.

Three additional transects searches were completed in likely habitats to determine the proximity of proposed road works to potential populations. Seven transect searches were completed in total.

Where *A. letha* shells were observed, notes were made on the context of occurrence such as relative abundance and habitat type.

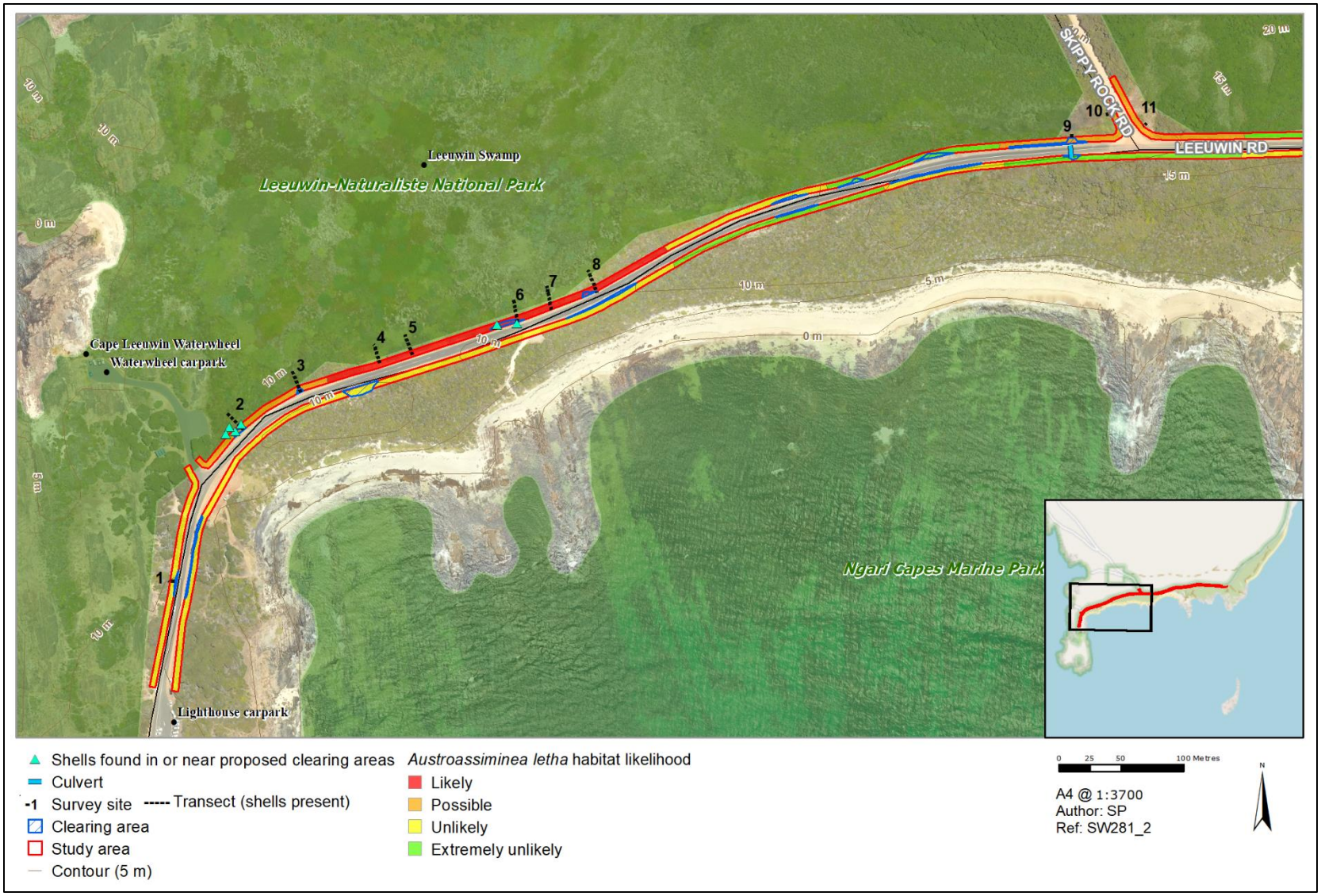

Figure 3. Survey area showing habitat types, targeted survey sites and presence of *A. letha*, western section.

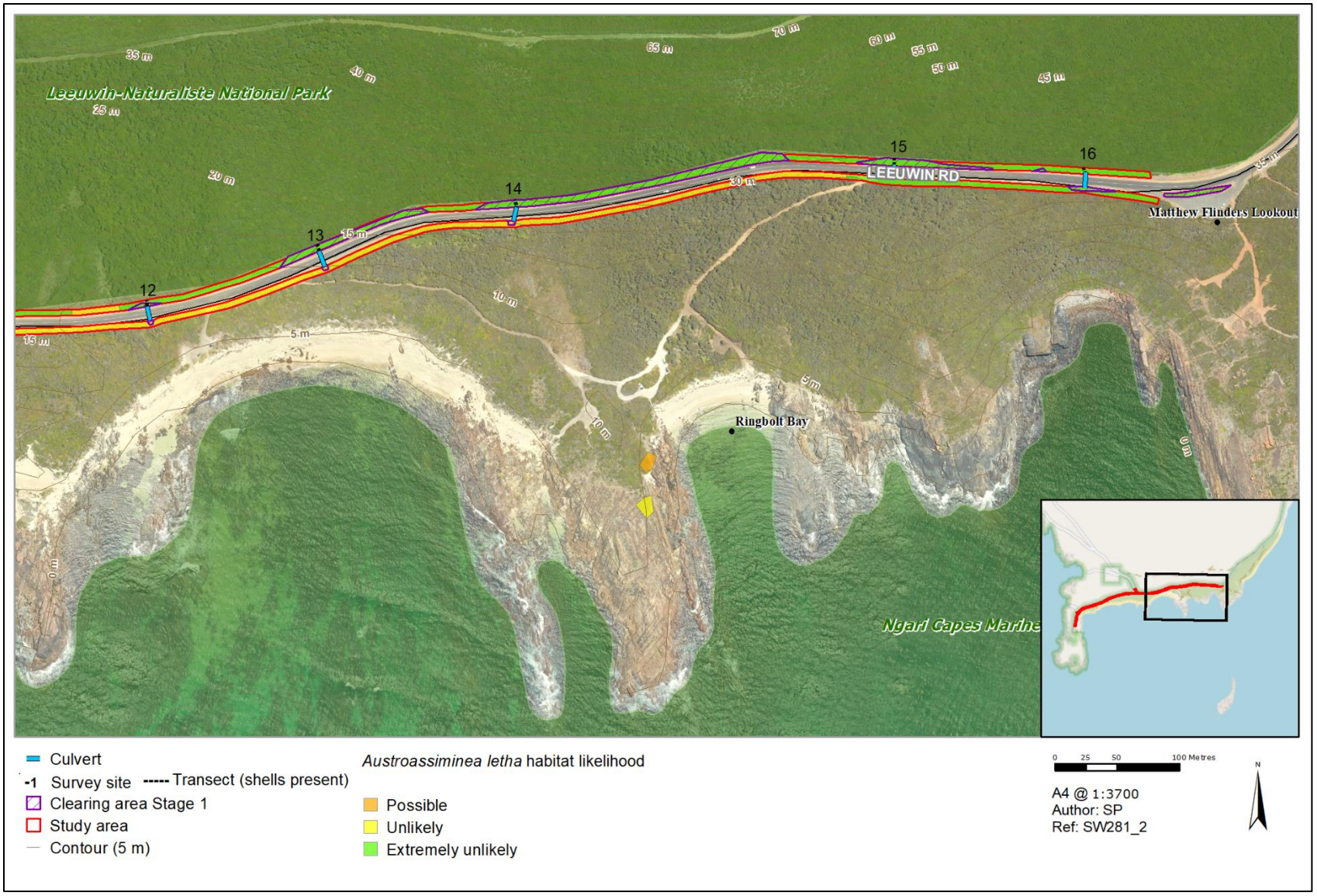

Figure 4. Survey area showing habitat types, targeted survey sites and presence of *A. letha*, eastern section.

Results

Habitat assessment

Habitat assessment results are presented in Figure 3 and Figure 4 and some examples are shown in Figure 5. General descriptions of the habitat types are as follows:

- Likely habitats were those within or close to lowland seasonally damp habitats with known occurrences nearby (Sites 4, 5, 6, 7, 9 north).
- Possible habitats were variable, including areas of higher ground or terrestrial vegetation close to known occurrences; rocky outcrops with seasonally wet areas but no known occurrences; areas with some wetland vegetation but not close to known occurrences (Sites 1, 2, 3, 8, 9 south, 10, 11).
- Unlikely habitats were those with dry soils and terrestrial vegetation, not close to known occurrences, but which sloped downwards away from road into damper habitat types (south side of Sites 12, 13, 14).
- Extremely unlikely habitat were dry habitats with terrestrial vegetation habitats on high ground sloping upwards from road (north side of Sites 12, 13, 14; Sites 15, 16).

Areas identified as likely or possible *A. letha* habitat were restricted to the Leeuwin Swamp and nearby areas and several seepage areas close to the coast. There is a known occurrence of *A. letha* in Leeuwin Swamp, although a fire in the area in 2019 may have had a severe impact on this population. Proposed clearing areas adjacent to Leeuwin Swamp present the greatest risk of disturbance to *A. letha.* These areas were identified as requiring further inspection in the targeted survey.

The habitat of the known population at Ringbolt Bay and the possible habitat area west of this are located about 180m from the road. There is no risk of physical disturbance to these locations from proposed road works. Impacts through changes to drainage are also considered negligible due to low proximity and low likelihood of reliance of these habitats on surface road runoff characteristics. These areas did not require further assessment.

Culvert locations, although mostly located in unlikely habitat areas, present a greater risk due to the potential presence of damp habitat and the high level of disturbance. These areas were identified as requiring further inspection in the targeted survey.

No further survey was deemed necessary for roadside clearing areas identified as unlikely and extremely unlikely habitats west of Skippy Rock Road due to minimal chance of *A. letha* occurrence. The searches within this area around culverts are considered a sufficient subsample of this area.

Figure 5. Habitat type examples for likelihood of *Austroassiminea letha* occurrence.

Likely:

Possible:

Unlikley:

Extremely unlikely:

Targeted Survey

Dead *A. letha* shells were found at sites 2-8 between the Waterwheel carpark and Skippy Rock Road on the north side of Leeuwin Road (Figure 6). No *A. letha* shells were located at any other survey sites. Detailed results are presented in Table 1 and 2 and site photos provided in Appendix 1. No live shells were encountered in the survey, however this does not confirm that live individuals do not occur at these sites or in close proximity. Survey scientists are confident of the identification of these shells as *A. letha* from taxonomic descriptions by Solem et al. (1982) and Fukuda and Ponder (2003) and available imagery in literature and online. The image in Figure 6a has been identified as *A. letha* by the Western Australian Museum's Department of Aquatic Zoology, and additional voucher specimens (dead shells only) have been forwarded confirmation.

At sites where *A. letha* shells were found they mostly occurred at least 6m from the edge of the bitumen and were more abundant with increasing distance toward and within Leeuwin Swamp to the north. The exceptions were sites 6 and 7, where shells were found within 1m of the edge of the bitumen. At site 6, shells were common at the east end of the proposed clearing area. At site 7, although shells were found near the road, no clearing is proposed. At site 2, shells were found close to, but not within the proposed clearing area. No shells were found at any culvert sites.

Figure 6. Images of *Austroassiminea letha* from the targeted search, August 2020. Close-up image of dead *A. letha* shells in varying condition (a) and an area with abundant shells on site (b).

Table 1. Results of targeted searches for *Austroassiminea letha* in risk areas adjacent to Leeuwin Road, from Leeuwin Lighthouse carpark to Skippy Rock Road, Augusta, August 2020.

Site No.	Site description	*A. Letha* presence	Notes
Site 1	In and near proposed clearing identified as possible habitat, west roadside.	Absent	Roadside outcrop of granite, no seepages. Moss and low coastal shrubs including *Leucopogon*, *Pimelea, Acacia, Eutaxia*.
Site 2	Adjacent to waterwheel toilet carpark, possible habitat area, north roadside.	Present (dead shells) Timed hand search: Isolated dead shells (8) adjacent to proposed clearing area Closest shell 5.8m from bitumen. Transect search: No shells 0-6.5m from bitumen; isolated 6.5-16m; abundant 16-20m	Grasses, *Lepidosperm*a *gladiatum,* unidentified creeper, various weeds. Shells all found under leaf litter (burnt creeper) near *L. gladiatum*. This habitat extends 3.5 m from edge of bitumen towards swamp.
Site 3	Transect extending from proposed clearing area in possible habitat, north roadside.	Present (dead shells) Transect search: 4 dead shells 6.5-8.5m from road edge; 2 dead shells 18-20m.	Dense *Scaevola* with some *L. gladiatum* and mixed shrubs.
Site 4	Transect in likely habitat, no clearing proposed, north roadside.	Present (dead shells) Transect search: 1 dead shell 7m from road; 4 shells 13-20m.	Dense kikuyu grass slopes steeply from road to bare wetland area with *Olearia* and various grasses and weeds at edge. Shells found in kikuyu and on bare sediment.
Site 5	Transect in likely habitat, no clearing proposed, of roadside.	Present (dead shells) Transect search: Isolated (8) dead shells found along transect.	Dead *Melaleuca* trees (burnt) with Kikuyu, dense *Rhagodia baccata* and *Olearia axillaris*, various other weeds notably *Sonchus* sp. Shells found in diverse habitat: Bare sediment, beneath shrubs within leaf litter. Not found in grass or among dense branches on ground.
Site 6	In and near proposed clearing area in likely habitat	Present (dead shells) Timed hand search:	Road edge: dense kikuyu, *Sonchus* and other weeds

	close to swamp, north roadside. Transect adjacent to proposed clearing area in likely habitat.	Dead shells found within 1m of road edge common in patches, most common at east end of clearing area. Transect search: Dead shells common throughout transect length even at edge of road. Note: 5-minute search on south side of the road in case clearing area can be moved – no dead shells found.	and occasional *Olearia axillaris.* Transect vegetation: Kikuyu graduating down to *Lepidosperma*, *Olearia* and scattered *Scaevola* and *Ficinia nodosa*. Dead shells found in all types of vegetation.
Site 7	Transect in likely habitat, no clearing proposed, north roadside.	Present (dead shells) Transect search: Dead shells common throughout transect from close to road edge, abundant at north end of transect (18-20m).	Kikuyu graduating down to *Lepidosperma*, *Olearia* and scattered *Scaevola* and *Ficinia nodosa*. Dead shells found in all types of vegetation.
Site 8	Transect extending from proposed clearing area in likely habitat north roadside.	Present (dead shells) but absent in clearing area close to road. Transect search: No shells within 6m of road. Scattered dead shells 6-20m from road.	Kikuyu graduating down to *Lepidosperma*, *Olearia* and scattered *Scaevola* and *Ficinia nodosa*. Dead shells found in all types of vegetation.
Site 9 north	In and around proposed clearing area in possible habitat, including culvert area, north roadside.	Absent	
Site 9 south	Culvert area in extremely unlikely habitat, south roadside.	Absent	
Site 10	West side of Skippy Road in possible habitat.	Absent	No shells found within search to 5m of road edge.

Table 2. Results of targeted searches for *Austroassiminea letha* in risk areas adjacent to Leeuwin Road, from Skippy Rock Road to Mathew Flinders Lookout, Augusta, August 2020.

Site No.	Site description	*A. Letha* presence	Notes
Site 11	East side of Skippy Rock Road intersection.	Absent	No shells found throughout rock outcrop area.
Site 12 north	Culvert area in extremely unlikely habitat within proposed clearing area	Absent	
Site 12 south	Culvert area in unlikely habitat	Absent	
Site 13 north	Culvert area in extremely unlikely habitat within proposed clearing area	Absent	
Site 13 south	Culvert area in unlikely habitat	Absent	
Site 14 north	Culvert area in extremely unlikely habitat within proposed clearing area	Absent	
Site 14 south	Culvert area in unlikely habitat	Absent	
Site 15 north	Culvert area in extremely unlikely habitat within proposed clearing area	Absent	
Site 15 south	Culvert area in extremely unlikely habitat	Absent	
Site 16 north	Culvert area in extremely unlikely habitat	Absent	
Site 16 south	Culvert area in extremely unlikely habitat within proposed clearing area	Absent	

Discussion

The proposed clearing for the upgrade to Leeuwin Road is considered to present a minor risk to the *A. letha* population associated with Leeuwin Swamp. This risk is due to confirmed *A. letha* habitat on the north side of the road, indicated by the presence of dead shells in close proximity to the proposed clearing area at site 2; and the presence of dead shells within and adjacent to the proposed clearing area at site 6.

Although thorough hand searching was done, particularly in microhabitats where dead shells were common, no live *A. letha* were encountered during the survey. It is, however, possible that live individuals are present in this habitat but were not located during the survey. Sieving of soil and closer inspection may have yielded live individuals, however DBCA recommended that this method not be used due to the invasive and time-consuming nature of this sampling.

While the presence of dead shells does indicate *A. letha* habitat, the habitat of Leeuwin Swamp has changed considerably over time. Firstly, there has been a change in hydrology and a contraction in the wetland habitat that has led to a decline in the population of *A. letha* in Leeuwin Swamp (Slack-Smith 2006). Due to these changes in hydrology, it is possible that the population may no longer extend to habitat on higher ground such as those close to the roadside. Secondly, there is some uncertainty as to the impact of a fire in April 2019 between the Waterwheel car park and Skippy Rock Road, north of Leeuwin Road. This fire has clearly caused mortality of many individuals, evidenced by grey and burnt shells. However, not all shells and not habitats appeared scorched.

While no *A. letha shells* were found at sites 9 and 10, these sites are close to two sites where they have been previously found by Slack-Smith (2006) and more recently in 2019 by DBCA. This known habitat is within the Leeuwin Swamp and has not been affected by fire, so is likely to be important for conservation. The surveyed roadside habitat is different to that within the swamp, with dense terrestrial vegetation and gravelly soils. The small proposed clearing area at site 9 is not considered *A. letha habitat,* however the vegetation would provide a good buffer to the snail population and so clearing should be minimised. Skippy Rock Road is closer to the known habitat and this should be considered in any future road works.

At site 2, risk to *A. letha* during roadworks may be avoided through ensuring clearing is restricted to the proposed area and that any other disturbance associated with road works, such as unloading and storage of materials and movement of equipment, does not extend beyond the clearing polygon into any vegetated portion of the north side of Leeuwin Road.

At site 6, the proposed 1m wide clearing will overlap identified *A. letha* habitat, although no live individuals were encountered. However, it is possible that this habitat is no longer viable due to its position in the landscape and increasingly dry conditions of the swamp. It is also possible that no live individuals occur there due to this contraction in habitat and/or the 2019 fire.

Mitigation strategies

In considering the outcomes of this survey, the Shire of Augusta-Margaret River will adopt the following strategies to minimise impacts of road works on *A. letha* habitat:

- Recognise the potential for disturbance of *A. letha* habitat at associated with proposed clearing at site 6 and consider advice from DWER and DBCA as to managing impacts as provided;

- Minimise clearing as much as possible on the north side of Leeuwin Rd in areas of ‘potential’ or ‘likely’ habitat.
- Temporary marking, using tape or plastic mesh, around ‘potential’ and ‘likely’ snail habitat to avoid any accidental disturbance.
- Implement weed and dieback hygiene measures during clearing and construction (clean vehicles and machinery) prior to entering the site.
- Maintain existing drainage patterns and ensure there is no movement or runoff of water or sediment into ‘potential’ or ‘likely’ snail habitat.
- Undertake pH testing of road material and lime-dose the material used in road shoulders, if required.

References

EPA (2016) *Technical Guidance: Sampling of short range endemic invertebrate fauna.* Guidance No. 20. Environmental Protection Authority, Government of Western Australia.

Fukuda, H. and Ponder, W.F. (2003) Australian freshwater assimineids, with a synopsis of the recent genus-group taxa of the Assiminidae (Mollusca: Caenogastropoda: Rissooidea). *Journal of Natural History* 37:1977-2032.

Litoria Ecoservices (2019) Fauna and Habitat Assessment Cape Leeuwin Trail, Dead Finish to cape Leeuwin. Report to Shire of Augusta Margaret River.

Lydeard, C. and Cummings, K.S. (Eds.) (2019) *Freshwater Mollusks of the World: A Distribution Atlas.* John Hopkins University Press, Baltimore.

Onton, K. (2009) *Cape Leeuwin Freshwater Snail Monitoring Report 2008-2009,* South West Region, Department of Environment and Conservation, Bunbury, Western Australia.

Slack-Smith, S. (2006) Report on a survey of the molluscan fauna of the Cape Leeuwin Swamp, Western Australia, particularly the endangered species, Austroassiminea letha. Western Australian Museum, Perth.

Solem, A., Girardi, E., Slack-Smith, S. and Kendrick, G. (1982). *Austroassiminea letha*, gen. nov., sp. nov., a rare and endangered prosobranch snail from south-western Australia (Mollusca: Prosobranchia: Assimineidae). *Journal of the Royal Society of Western Australia* 65:119-129.

Appendix 1. Site photos

Site 1. Possible habitat close to proposed clearing area, west roadside. Shells absent.

Site 2. Proposed clearing area in possible habitat, north roadside. No shells within clearing area; shells present >5.8m from roadside.

Site 3. Transcect extending from proposed clearing area in possible habitat, north roadside. No shells within clearing area; shells present >6.5m from roadside.

Site 4 transect. Llikely habitat, no clearing proposed, north roadside; shells present >7m from roadside (Site 5 similar habitat).

Site 6. Proposed clearing area in likely habitat close to swamp, north roadside. Shells <1m from roadside. 	Site 6 transect. Shells throughout. 
Site 7. Likely habitat, no clearing proposed. Shells present. 	Site 8. Likely habitat, no clearing proposed. Shells present. 

Site 9. Proposed clearing area west of Skippy Rock Road. Shells absent. 	Site 11. Possible habitat area east of Skippy Rock Road. Shells absent. 
Site 13. Example extremely unlikely habitat in eastern section, culvert area, north roadside. Shells absent. 	Site 13. Example unlikely habitat in eastern section, culvert area, south roadside. Shells absent.