NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

THREATENED FROG MANAGEMENT PLAN

Version 1.0

November 2013

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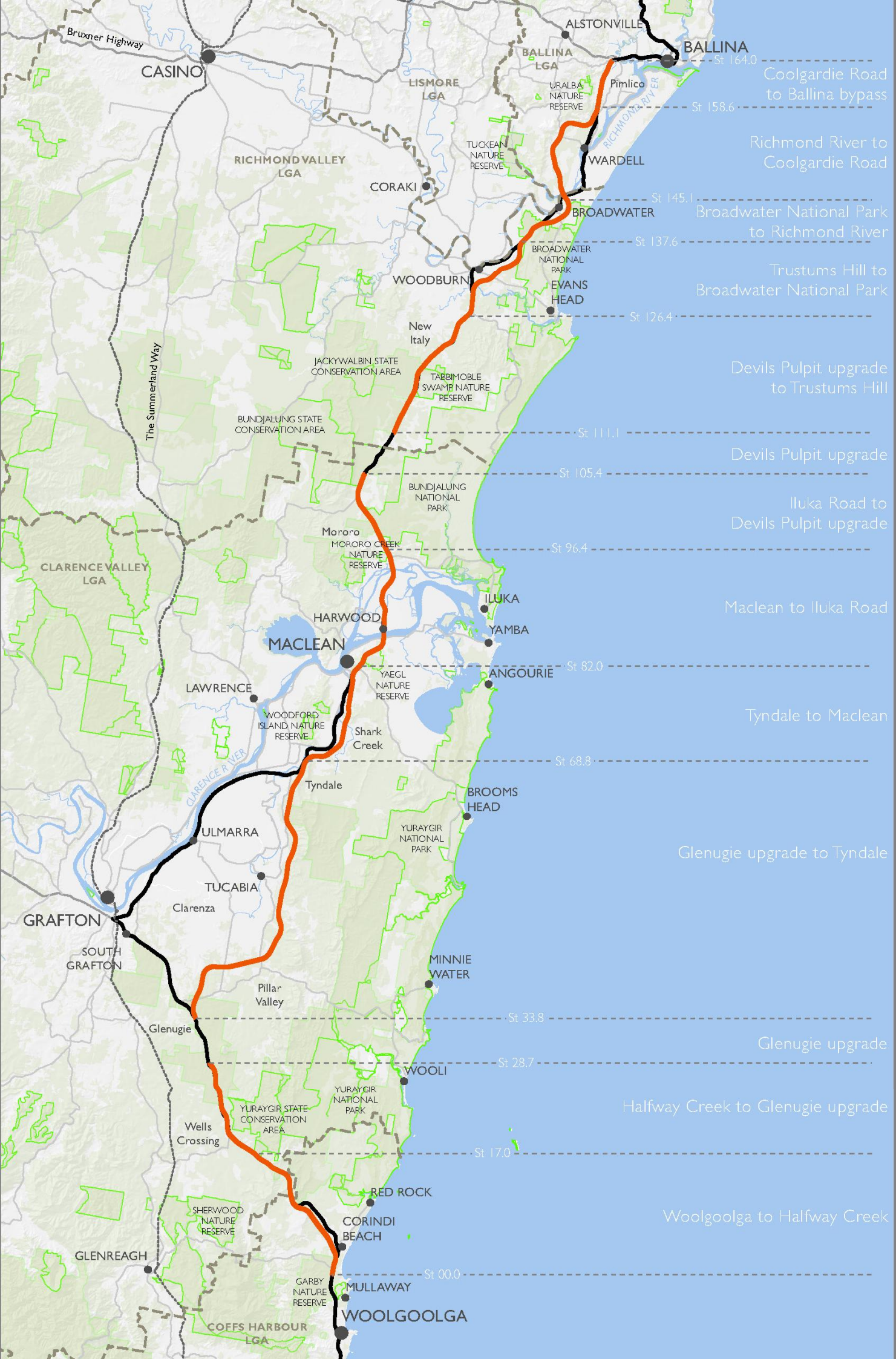
Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
RICHMOND RIVER
St 164.0
Coolgardie Road to Ballina bypass
11
St 158.6
Richmond River to Coolgardie Road
10
TUCKEAN NATURE RESERVE
WARDELL
RICHMOND VALLEY LGA
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
9
St 137.6
BROADWATER NATIONAL PARK
WOODBURN
EVANS HEAD
Trustums Hill to Broadwater National Park
8
St 126.4
New Italy
JACKYWALBIN STATE CONSERVATION AREA
TABBIMOBLE SWAMP NATURE RESERVE
Devils Pulpit upgrade to Trustums Hill
7
The Summerland Way
BUNDJALUNG STATE CONSERVATION AREA
St 111.1
Devils Pulpit upgrade
St 105.4
BUNDJALUNG NATIONAL PARK
Iluka Road to Devils Pulpit upgrade
6
Mororo
MORORO CREEK NATURE RESERVE
St 96.4
CLARENCE VALLEY LGA
ILUKA
HARWOOD
YAMBA
MACLEAN
Maclean to Iluka Road
5
ANGOURIE
St 82.0
YAEGL NATURE RESERVE
LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
Tyndale to Maclean
4
St 68.8
CLARENCE RIVER
Tyndale
BROOMS HEAD
YURAYGIR NATIONAL PARK
ULMARRA
Glenugie upgrade to Tyndale
3
TUCABIA
Clarenza
GRAFTON
SOUTH GRAFTON
MINNIE WATER
Pillar Valley
St 33.8
Glenugie
Glenugie upgrade
St 28.7
WOOLI
YURAYGIR NATIONAL PARK
YURAYGIR STATE CONSERVATION AREA
Halfway Creek to Glenugie upgrade
2
Wells Crossing
St 17.0
RED ROCK
SHERWOOD NATURE RESERVE
CORINDI BEACH
Woolgoolga to Halfway Creek
1
GLENREAGH
St 00.0
GARBY NATURE RESERVE
MULLAWAY
WOOLGOOLGA
COFFS HARBOUR LGA

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1. Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project (the project / the action), on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The location of the project is shown in the figure above.

Since 1996, both the Australian and NSW governments have contributed funds to the upgrade of the 664-kilometre section of the Pacific Highway between Hexham and the Queensland border, as part of the Pacific Highway Upgrade Program.

Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. However, the actual timing of construction, opening to traffic and completion is dependent on funding negotiations between the Australian and NSW governments. Assessments would be adjusted accordingly based on actual opening dates, for example noise and traffic predictions.

The project would upgrade around 155 kilometres of highway and represents the last priority (known as 'Priority 3' in the upgrade program) in achieving a four-lane divided road between Hexham and the NSW/Queensland Border. The project therefore forms a major part of the overall upgrade program and when constructed, would complete the four-lane divided road program.

The project would be jointly funded by the NSW and Australian governments.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina. These are separate projects, with Glenugie now complete and Devils Pulpit under construction. Altogether, these three projects would upgrade 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

A more detailed description of the Woolgoolga to Ballina Pacific Highway upgrade is found in the Pacific Highway upgrade: Woolgoolga to Ballina Environmental Impact Statement prepared by Roads and Maritime in December 2012.

1.2 Purpose and objectives

This threatened frog management plan addresses impacts of the upgrade and proposed mitigation on populations of threatened frogs and identifies the most appropriate management actions to be undertaken to ensure the long-term survival of these species in the area of the project. The plan focuses on species identified in the EIS as at greatest risk from the project which includes:

- Wallum Sedge Frog (*Litoria olongburensis*).
- Green-thighed frog (*Litoria brevipalmata*).
- Giant Barred frog (*Mixophyes iteratus*).

The plan identifies the proposed mitigation measures to be implemented for threatened frogs and a program for monitoring the effectiveness of these measures.

The objectives of the plan include providing:

- An effective threatened frog management plan with consideration to the concerns of main stakeholders.
- A summary of the locations where threatened frog populations may be impacted by the project.
- Management and mitigation measures that would be implemented during pre-construction, construction and operation of the project to minimise impacts on the threatened frog populations.

- A monitoring program to be implemented pre-construction and during construction and operation of the project the effectiveness of the mitigation measures proposed and inform an adaptive management approach.

1.3 Management structure and plan updates

Management structure

This plan provides a framework for any part of the proposed upgrade between Woolgoolga to Ballina where the threatened subject species would be impacted. This plan would be updated during detailed design or pre-construction stage of any proposal that may affect threatened species relevant to this plan. The final management plan would be specific to the project section, stage, program of works or singular element of infrastructure which makes-up the overall Woolgoolga to Ballina upgrade. The plan would operate in conjunction with the Construction Environmental Management Plan (CEMP) and project specific flora and fauna management plan (FFMP), or may be incorporated into a wider framework that includes such plans.

Roads and Maritime would finalise this plan in consultation with the NSW Department of Planning and Infrastructure (DP&I) and NSW Office of Environment and Heritage (OEH).

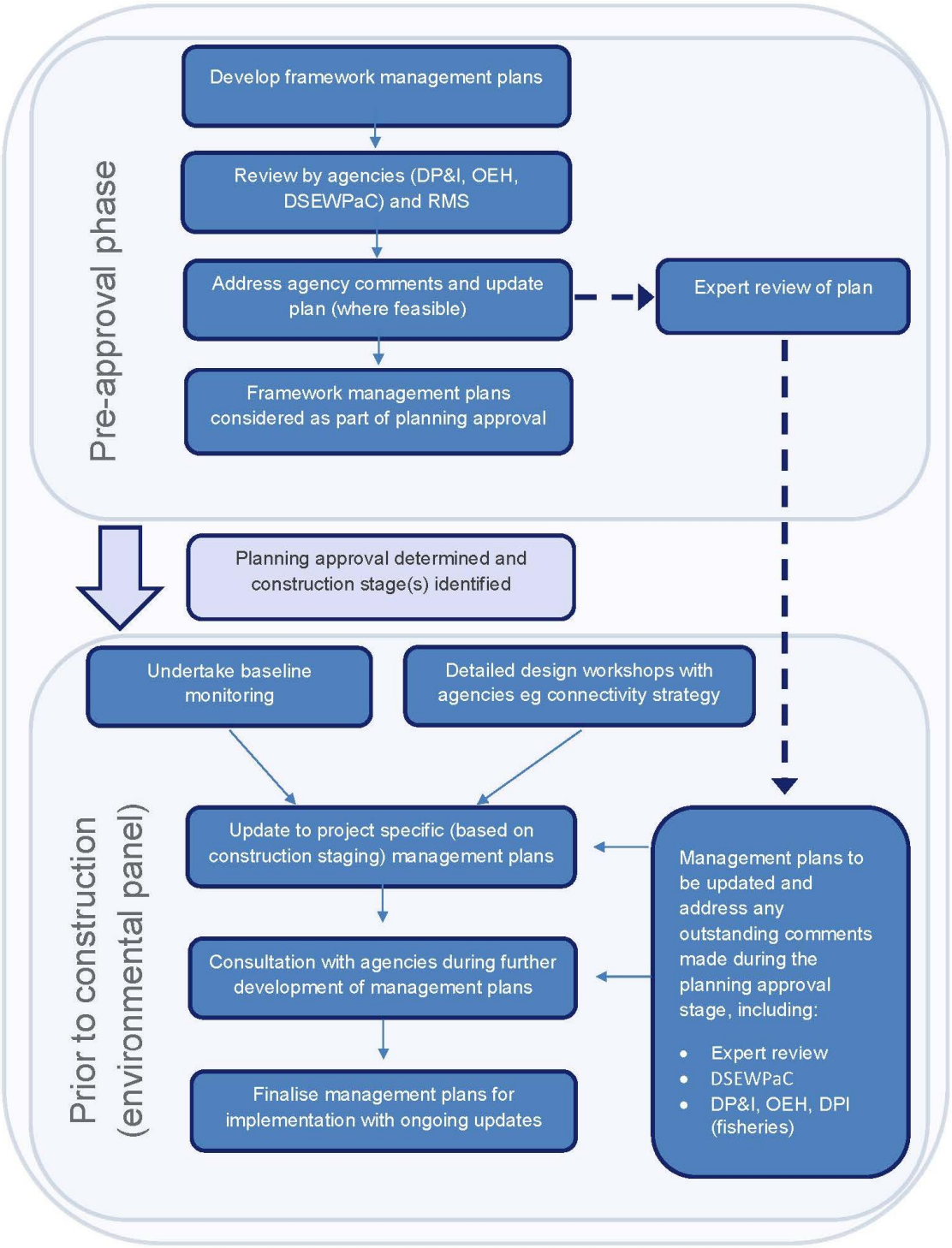
General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in **Chapter 8**. Following approval of the plan, the construction contractor and the contractors ecologist engaged for the relevant project sections would be responsible to oversee implementation of the plan

Plan updates

The plan is intended to be a dynamic document subject to continual improvement. The management plan would be updated as required to meet the mitigation and management measures committed to in the EIS and PIR reports and any Condition of Approval (CoA) for the project. Prior to implementation, the plan would be updated following independent expert review to incorporate any necessary changes that arise from that review. The process for the update of the plan is illustrated in Figure 1-1 below.

This plan identifies the general locations proposed for conducting monitoring and the methods, variables and timing of the proposed monitoring program. Details have been provided on the parameters for the selection of the final monitoring sites, both impact and control sites. It is not possible to pre-select the monitoring sites at this point in the planning and design process, as this requires consultation with affected landowners. The final selection of monitoring sites would be subject to further interrogation through the implementation of targeted surveys (refer to section 4.3) and confirmation of landowner access and would be presented in the first annual monitoring report with the intention of repeated sampling to be conducted at these locations.

Figure 1-1 Process to develop management plan



1.4 Plan authors and expert review

Authors

The management plan was prepared by Chris Thomson and Dr Josh Hale of Sinclair Knight Merz (SKM).

Chris is a group practice leader for ecology with a Bachelor of Applied Science and Graduate Certificate in Natural Resources and seventeen years professional experience managing biodiversity assessments and scientific reporting. He is a highly experienced field ecologist with extensive experience on major road projects with the Roads and Maritime, having worked widely throughout NSW as the technical lead on a range of environmental assessments including several Pacific Highway upgrades, the Hume Highway, Great Western Highway, Princes Highway and New England Highway along with numerous large and small arterial road projects including the M5, M4, Westlink M7 and Westconnex.

Chris has comprehensive knowledge of Commonwealth and NSW threatened species legislation, policies and guidelines and has extensive experience in the design of avoidance and mitigation measures for minimising impacts on threatened species. Chris also has a high level of experience on infrastructure projects including the development of compensatory habitat and offset strategies, biodiversity connectivity strategies, mitigation and monitoring strategies and threatened species management plans.

Josh Hale completed a PhD in 2011 on the conservation genetics of a range of south eastern Australian frogs, including the EPBC listed Growling Grass Frog (*Litoria raniformis*). In particular, Josh investigated the impacts of roads and other infrastructure on movement dynamics of frogs. Josh has experience developing and implementing frog monitoring programs in south-eastern Australia. These include a large scale program to assess the impacts of the Black Saturday bushfires on frogs in the Victoria and another investigating the impact of urban development on a range of species around Melbourne. Josh has also completed extensive frog monitoring on Lord Howe Island.

Expert review

An expert review of the plan was undertaken in August 2013 by Dr Frank Lemckert. Frank has been a professional scientist since 1992, specialising in the ecology and management of frogs and the management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland) establishing long-term research and monitoring programs into the management of forest fauna and developing strategies to mitigate the impacts of human disturbances on threatened fauna. He has worked extensively with the NSW state and Federal Governments on varying issues of fauna management and written reports and recovery plans. He is experienced in the application of state and federal legislation which relates to the conservation of threatened species and communities, having been directly involved in the assessment of major Environmental Impact Statements and Fauna Impact Assessment.

Frank also has a long and ongoing interest in education and wildlife training, heading the Forests NSW Wildlife School Training Program, which he continues at Niche. He coordinates all of the courses as well as providing large elements of the teaching program. He continues to have regular involvement in teaching senior biology students at several Universities.

Frank has been the author on over 100 scientific publications and reports including invited authorship for chapters in international book series. He has also undertaken more than 50 presentations at National and International conferences. A curriculum vitae which contains a list of published work on frogs for Dr Frank Lemckert is provided in Appendix A and a copy of his review of the management plan is attached as Appendix B. The recommendations provided in this review have been summarised in Table 1-1. The table also identifies how each of the recommendations has been addressed. Recommendations have been addressed in one of three ways:

- Adopted - plan updated.
- Adopted - plan to be updated prior to implementation.
- To be reviewed - recommendation to be reviewed further by Roads and Maritime prior to implementation. .

Table 1-1 Summary of recommendations from the expert review and how addressed in this plan

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP1	1.2	*Crinia tinnula* will not be adequately covered by many of the management actions for frogs documented in the plan. Recommendation: Remove all specific information on *Crinia tinnula* to be consistent.	Adopted- plan updated
TFrMP2	2.1.1	The information on habitats for Giant Barred Frogs is incorrect. Recommendation: This information is corrected to accurately reflect the consensus of available information.	Adopted- plan updated
TFrMP3	2.1.1	For the Green-thighed Frog, I would have thought quoting Lemckert et al (2006) would have been obvious in regards to habitat and general biology as it is a summary paper for this species. Recommendation: This information is corrected to accurately reflect the consensus of available information.	Adopted- plan updated
TFrMP4	3.1	Recommendation: The impacts of changes to pH leading to more neutral waters needs to be discussed in this MP.	Adopted- plan updated
TFrMP5	Table 3.1	Amphibians are the one group that have not been demonstrated to widely use over and underpass structures and this has support from a published study. There are instances of frog tunnels being of some use in some places overseas, but nothing in Australia. Similarly, the provision of compensatory ponds is widely used as a mitigation measure, yet there are almost no indications of any long-term success in using such a system. Recommendation: Change the rating to uncertain.	Adopted- plan updated
TFrMP6	4.3	I believe that the stated preferred window of frog surveys of late spring and summer is too narrow and restrictive, at least for the Green-thighed Frog, and suggesting a seasonal approach to monitoring is potentially quite misleading if setting survey and monitoring programs. Recommendation: That the information on the Giant Barred Frog and Green-thighed Frog is changed to reflect the published information that is based on a synthesis of all available data and not just a few points.	Adopted- plan updated
TFrMP7	4.3	Recommendation: Note that surveys for Giant Barred Frogs should not be undertaken immediately after heavy rains.	Adopted- plan updated
TFrMP8	4.3	In Paragraph 5 of Timing, Site-selection and Methods the distances advocated for the control and impact sites are not appropriately far enough apart. Recommendation: That the distances between Control and Impact sites be a minimum of 200m apart, unless physically not possible to do, in which case they need to be as far apart as it possible.	Adopted- plan updated
TFrMP9	Section 4.3 and 9	Should be Lemckert and Morse 1999. I note that this reference is not in the reference section at the back, along with a few others. Recommendation: Complete and make accurate the reference list.	Adopted- plan updated
TFrMP10	4.3	It is possible that some Wallum Sedge Frog breeding sites will be less than 50m in diameter/length (recent studies from Simpkins and Cat). Would be worth saying that transects for the Wallum Sedge Frog should be 50m in length unless the area is too small the achieve this. This would then need to be taken into account when analysing monitoring data. As per the Giant Barred Frog, this may mean a time-constrained search. Recommendation: That all transects be kept to the specified size unless otherwise impossible. This is not negotiable.	Adopted- plan updated
TFrMP11	4.3	Recommendation: Transects of Giant Barred Frogs be 20m wide and cover both sides of the stream. Transects for Green-thighed Frogs be 20m wide and cover the bank of the breeding site.	Adopted- plan updated
TFrMP12	All	I do not see that there is much use in assessing frogs for Chytrid through the use of visual surveys. Recommendation: That this form of Chytrid sampling be dropped from the MP.	Adopted- plan updated
TFrMP13	4.4.2	For the Wallum Sedge Frog, the extent of vegetation planted inside the pond is the key point, not that next to the pond. They live in emergent sedges not around the edges of ponds and so monitoring surrounding vegetation appears to have little relevance. Recommendation: The extent of emergent vegetation is measured as well as bank vegetation.	Adopted- plan updated

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP14	4.4.2	What happens if the ponds fail to provide compensatory habitat? What is the adaptive strategy that will be employed and how far will it go? This should be addressed somewhere in this document. It would be very important to say what has and has not worked amongst these examples and so what is the best approach to take. Recommendation: include a table that identifies the types of ponds that have been trialled before as compensatory habitat, what parameters were those attempted to be provided in the ponds and the information available indicating their success or failure if any.	Adopted- plan to be updated prior to implementation.
TFrMP15	4.4.2	The planting of densely packed emergent vegetation on pond fringes will minimise Cane Toad predation, not prevent it. They still use this habitat to some degree (See Semeniuk et al 2007).	Adopted- plan updated
TFrMP116	4.4.2	Green-thighed Frog compensatory ponds need to be ephemeral because otherwise they will not use them. Recommendation: That it is recorded that compensatory ponds for this species cannot be permanent ponds.	Adopted- plan updated
TFrMP17	4.4.2	Recommendation: That the design of Green-thighed Frog compensatory ponds be changed to state that they be created as large as is practically possible under the circumstances, be temporary pools and be placed, as far as is possible, within the most typically used habitats: wet sclerophyll or swamp forest with a dense understorey and deep leaf litter.	Adopted- plan updated
TFrMP18	4.4.2	I would note that the water quality parameters presented are fine for the Wallum Sedge Frog, but are not likely to be useful for the Green-thighed Frogs. They are not a Wallum species. I would strongly suggest that water quality requirements for Green-thighed Frogs be included as a well, with limits on what is and is not acceptable. I do not know specifically what they should be, but they should not be acid. Ledlin (1997) has some information on this. Recommendation: Include a table that notes the water quality parameters that should be achieved in compensatory ponds for each frog species, including minimum and maximum variation points that are acceptable.	Adopted- plan to be updated prior to implementation.
TFrMP19	5.3.3	I would just like to see it clarified that fall broadcast surveys should not be carried out during the day. Recommendation: Call surveys are noted as not to be undertaken during the day.	Adopted- plan updated
TFrMP20	5.3.3	The plan should provide a specific definition of a person experienced in frog exclusions. Recommendation: A specific level of experience is included for a qualified person to ensure consistency through the program. I would recommend a minimum 2 years or 1000 trap-nights as a starting point for consideration.	Adopted- plan updated
TFrMP21	5.3.9	The plan states that fences should installed for up to 200m either side of potential or known threatened frog habitat. This makes it okay to be only 20m as this falls into the criteria of up to 200m. I believe that a table would be most useful that specifically defines what are correct distances for different species and different habitats and why they should be that size. For example, Giant Barred Frog fencing need be no more than 50m wide based on the research of the movements of these frogs (Lemckert et al, Streatfield, Koch). Green-thighed Frogs probably need more, although there is little to base this on. I have done only a very limited study of this species that cannot say much as it was too short term to say anything about distances. Would be better applying a general approach as advocated by Semlitsch and Bodie (2003) or Lemckert (2004) which would fit in with the idea of a minimum 200m for smaller frogs, although a recent paper on the Wallum Sedge Frog (Meyer et al) indicates that they may move much further. Recommendation: A table is included that defines the correct distances of fencing for different species and different habitats and locations and why they should be that size.	Adopted- plan to be updated prior to implementation.
TFrMP22	5.3.6	Recommendation: Define what “where is reasonable and feasible” means.	Adopted- plan updated
TFrMP23	5.3.6	Recommendation: The TFMP should list rules on the maximum distances that frogs can be translocated.	Adopted- plan to be updated prior to implementation.

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP24	5.3.6	The TFMP information should be altered to reflect the general information available on the movements of this species.	Adopted- plan to be updated prior to implementation.
TFrMP25	5.3.8	f) How long should they be acclimatised for? 5 minutes? One hour? I am sure the former is not anywhere near long enough. Recommendation is that this needs to be specified: a minimum of 30 minutes.	Adopted- plan updated
TFrMP26	5.3.9	Does the frog fencing for the Woolgoolga to Glenugie project work? No point in including it in other works if it does not. Similarly, does the frog fencing in Figure 5-1 that was designed specifically for the Green-thighed Frog actually work to stop the Green-thighed Frog? Recommendation: The TFMP include a table that includes the type of fencing that is suitable for use for each species and what the evidence is that demonstrates it is suitable.	To be reviewed prior to implementation
TFrMP27	Table 5-2	The TFMP must define what a high rate of injury during clearing works is? Recommendation: The TFMP defines the type and extent of injuries which leads to a classification of a high injury rate.	Adopted- plan updated
TFrMP28	Table 5-2	What does Chytrid affected frogs found mean? As noted previously, it is not possible to guarantee that a frog carrying Chytrid can be identified as such by a visual inspection. Recommendations: That this form of Chytrid sampling be dropped from the MP.	Adopted- plan updated
TFrMP29	Table 5-2	How many is multiple tadpole deaths? I presume that two is enough. If that is 2 out of 10000, will that be a problem. This needs defining given the document has raised tadpole deaths as a significant problem that is a performance criteria. Recommendation: The TFMP defines the type and extent of injuries that are considered to be associated with de-watering and the number of tadpoles that should be considered too many. I would suggest 1%.	Adopted- plan updated
TFrMP30	6.3.4	Maintenance of compensatory ponds. What does “be maintained routinely” mean? Recommendation: Define accurately the term routinely.	Adopted- plan updated
TFrMP31	Table 6-1	Taking three days to clear a breach seems a rather long time. How few sightings of frogs are required to decide that connectivity structures are not being used successfully or appropriately by frogs? If one or two frogs use it in a year, would this be deemed sufficient to consider it successful? I would assume not, but the plan seems to say yes. It needs a proper definition. Recommendation: The TFMP defines the number of sightings necessary to conclude a structure is working. I would recommend 1% of the approximate population size of the frogs per year. This would maintain genetic diversity.	Adopted- plan updated
TFrMP32	Table 6-1	How much would constitute activity at a pond would be required before it is determined that a pond is being used successfully after 2 years? Recommendation: I would recommend a definition of a successful pond must include that a minimum 20% of the original number of frogs located at the previously used pond must use that pond for at least 3 years and that successful reproduction in the form of tadpoles from a minimum of three separate clutches reaching metamorphosis be included as the final performance criteria.	Adopted- plan updated
TFrMP33	Table 6-1	The TFMP needs to define specifically the levels of water quality variation that are not acceptable for the breeding sites. Recommendation: Covered previously.	Adopted- plan updated
TFrMP34	7.1	In the first full paragraph it is stated that at least two control sites should be selected per relevant project section. Recommendation: The number of control sites should be the same as the number of impact sites to get a balanced design, which makes analysis much simpler and more effective. Preferably there should also be a minimum of five independent samples within each category of sites. This would provide a minimum of statistical robustness under a normal Analysis of Variance analysis.	Adopted- plan updated

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP35	7	If the Roads and Maritime wants to ensure that it can demonstrate statistically that its mitigation is working effectively, any analysis undertaken must demonstrably indicate that a pre-determined level of change can be successfully detected by the monitoring program. Recommendation: That a flow-chart be included that identifies the method to develop an appropriate scientific monitoring program and that it include the requirement to be able to statistically detect a 25% decline in the population over a 5 year period.	Adopted- plan to be updated prior to implementation.
TFrMP36	7.2.1	Monitoring programs that do not undertake specific experimental manipulations are not likely to be able to determine the causes of any decline, just that there has been a decline. Specific tests will be required after that to assess what caused it. Similarly one of the critical failures of so many monitoring programs is the lack of definition of what is an acceptable change in populations and what is not. They usually say just that to monitor for a decline. Given the variability in frog numbers under natural circumstances and that there is likely a pattern of mostly declines with occasional increases under natural population processes (see Alford and Richards 1999), it is both very difficult to detect a decline statistically without a good program and it is not clear what it means even if a decline is detected where a drop in numbers in one year is all that is needed to trigger a response. I highly recommend that a standard monitoring strategy is provided in the TFMP to be used in subsequent MPs. It would be very useful to have a fully worked up and scientifically based template as to how monitoring should take place for each species – what methods, when, how long for and what are acceptable changes. This would ensure a uniform program is used across the remaining areas of Upgrade and significantly improve the quality of monitoring compared to what has been achieved previously. One of the other main values of providing such clear guidelines is that the same approach can be repeated accurately and consistently across all of the sections of road to be covered, which will provide valid comparisons between sections and data that can be pooled to provide a more sensitive meta-analysis of mitigation success across the range of Upgrades. That ultimately will give the Roads and Maritime a lot more power and confidence to say that mitigation is working or which mitigation works and which does not. This should be very useful in the long-term for overall frog management.	Adopted- plan updated
TFrMP37	7	It is stated that there is a preference for a BACI style monitoring program. However, using presence/absence as a means of defining change is not used in BACI studies because such an approach is not sensitive enough. Recommendation: A BACI program is used and it is based on population count data.	Adopted- plan updated
TFrMP38	7.2.2	I am not sure what "noticeable change in calling males or populations" means and it is not a useful measure of frog abundance. Frogs are notorious for their variation in calling activity between nights and so using this as fine-scale means of determining changes in population size is highly unadvisable under most circumstances, unless there are a lot of sampling points to account for this variation. Visual population counts or, much more preferably, mark-recapture studies generally are much more useful if carried out well. Recommendation: The Giant Barred Frogs and Wallum Sedge Frog should be monitored using a combination of counts of calling and visually identified animals. This is suitably based around the suggested transects.	Adopted- plan updated
TFrMP39	7.2.2	Green-thighed Frogs are an unusual exception to this rule as it seems that all males call at the same time over a very short period and individuals otherwise, are very difficult to locate. Recommendation: Total counts of adult males Green-thighed Frogs are used to monitor this species.	Adopted- plan updated
TFrMP40	7.2.2	The term "noticeable change in populations" needs to be defined appropriately if there is going to be any valid monitoring comparisons. As before, I did suggest a 25% decline in populations over 5 years, but there is dependence on how long the Roads and Maritime intends to monitor for. A best level of change may be determined through a detailed review of the literature. Recommendation: Already noted in regards to extent of change.	Adopted- plan updated

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP41	7.3.1	The TFMP needs to define what is a suitably qualified and experienced ecologist is to be used for frog monitoring? In regards to frogs, it is far better to say a suitable qualified and experienced herpetologist and define what is a suitable level of qualification and experience. For the Nowra Upgrade of the Princes Highway, a suitably qualified expert for the Green and Golden Bell Frog was defined as someone with at least 5 years' experience working with that frog. This is a good starting point. Recommendation: As noted before, define the minimum level of experience for each action. I would suggest an expert is someone who has had at least 5 years of experience working with the targeted frog. I would also suggest as an addition or an alternative including the requirement to have successfully detected the target species on at least 10 occasions. The latter will clearly demonstrate that the herpetologist is capable of finding these often hard to locate species.	To be reviewed prior to implementation
TFrMP42	7.1	As before, why would you choose 3 impact sites and 2 control sites? This is unbalanced and so statistically already a poor design. It should be at least 3 and 3 and preferably 5 and 5. The TFMP states that monitoring of control sites should try to follow the same approach in using transects. Recommendation: the control sites MUST be sampled in the same way as the impact sites. Otherwise they are not control sites and the monitoring program and analysis is invalid.	Adopted- plan updated
TFrMP43	7.3	Why should the evidence of the effectiveness of exclusion fencing be clear? I have already noted that hylid frogs climb fences of any type very well when they want to. I would not expect to see no frogs vs. lots of frogs. However, if the monitoring program is carried out effectively and the data collected adequately, the evidence for the effectiveness of the exclusion fencing should be statistically clear. Recommendation: The TFMP notes that there should be no detectable change in the numbers of frogs associated with areas controlled by frog fencing.	Adopted- plan updated
TFrMP44		When will the surveys of frogs occur for road kills? Surveying frogs for road kills is very hard to do and dangerous. Dead bodies are rapidly crushed and scavenging birds remove them usually relatively quickly. This monitoring needs to be carefully planned and managed. Is there a guide as to how this will be done? The TFMP should include a standard protocol for carrying out road kill surveys such that it will be safe for those carrying out the work. Recommendation: Remove the monitoring of Road kills as a requirement in the MP.	Adopted- plan updated
TFrMP45	7.3.2	Recommendation: Corrective actions must be undertaken if the performance criteria or are not met or set thresholds are breached. This is essential to demonstrate compliance.	Adopted- plan updated
TFrMP46	7.4.1	Recommendation: Do not use pitfall traps or motion sensitive cameras as a means of monitoring connectivity.	Adopted- plan updated
TFrMP47	7.4.1	Recommendation: State that time-lapse cameras be used as a minimum monitoring method for connectivity structures.	Adopted- plan updated
TFrMP48	7.4.2	Again define what would be considered to be effective use of the underpasses. One frog? Ten frogs? 5% of the known population number. A 50% drop in road mortality? I am not sure the best method without doing a detailed literature review and consideration of each species. The ultimate aim would be to maintain sufficient connectivity between both sides of a road to ensure long-term genetic integration of the overall population. This is not well known for Australian frogs but a level may be justifiable with a detailed review of the available scientific literature. Recommendation: As previously advised, the use of the structure by a minimum 1% of the estimated population size.	Adopted- plan updated
TFrMP49	7.4.2	How will increasing the monitoring program actually be a corrective measure for use of connectivity structures or, more critically, road kill? It is not a corrective measure. It is just a means to determine if the connectivity structures appear to be working. The corrective measure would be to add additional structures or change the structure or stop frogs using the road in some other way. Recommendation: Change the table to read to change/add to the structures and monitor.	To be reviewed prior to implementation

ID No	Section	Recommendation	How recommendation is to be addressed
TFrMP50	7.5.2	What will happen if frogs are present at compensatory breeding sites, but are not breeding at them? There is no corrective measure identified. I would assume it would mean that a review be undertaken of the created habitat to see if it was not created properly and measures taken to either alter the current pond or create new ones that will provide better habitat and that are again monitored to determine if they are more and suitably effective. That is adaptive monitoring and management and represents an actual corrective action. This should be changed. Recommendation: That if compensatory breeding habitat does not produce metamorphs within 3 years, that an investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (ie 3 more years of monitoring).	Adopted- plan updated
TFrMP51	7.6.1	Why up to four 0.5 m^2 quadrats. Should not the sampling be standardised for all sites to allow proper comparisons? Recommendation: The TFMP should simply state that four 0.5 m^2 quadrats will be undertaken at each site to provide replicate data sets.	Adopted- plan updated
TFrMP52	7.6.2	Define what good quality habitat restoration requires. At what point is it restored? We know that 30% loss of revegetation is bad, but at what time does restoration become adequate. Recommendation: Define what good quality habitat is so that it can be measured against.	Adopted- plan to be updated prior to implementation.
TFrMP53	7.6.2	What is "evidence of threatening processes being controlled or eradicated"? This suggests that one person maintaining a fence or removing a weed means that the threshold has been reached and all is good. I doubt this is what is meant. Again, state what is the minimum allowable level of maintenance to be undertaken each year? Recommendation: Define what appropriate evidence is.	Adopted- plan updated
TFrMP54	7.7	Recommendation: Annual reporting include an analysis of the data to determine if change has taken place and/or demonstrate if there is enough power to detect the specified levels of unacceptable change.	Adopted- plan updated
TFrMP55	7.7	Recommendation: Defining suitable levels of experience has already been covered.	To be reviewed prior to implementation
TFrMP56	Appendices	Profiles. Make sure that the same types of information are included in each of the profiles, providing a consistent approach to their management. As an example, some of the profiles contain specific information on the breeding season of the target species and some don't. Recommendation: The categories in each of the profiles are standardised.	Adopted- plan updated
TFrMP57	Appendices	The Giant Barred Frog has not been found south of the Hawkesbury River despite Cogger (2000) saying so. The Giant Barred Frog is not known to disperse hundreds of metres from breeding sites on any regular basis. Recommendation: Include in the information presented the above information.	Adopted- plan updated
TFrMP58	Appendices	The Green-thighed Frog is only found north of the Hawkesbury. Records south of this are erroneous. I do not know where this information comes from as it is not in the typical field guides. Recommendation: Change range to north of the Hawkesbury.	Adopted- plan updated

2. Threatened frog populations

2.1 Existing knowledge

2.1.1 Conservation status and preferred habitats

The threatened frog species relevant to and referred in this plan are described below, in addition to the status under NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The table provides a brief outline of the habitat requirements with further detail provided in the species profiles in Appendix B.

Species	Status		Preferred habitats
	EPBC Act	TSC Act	
Wallum Sedge Frog (*Litoria olongburensis*)	Vulnerable	Vulnerable	They are found in a wide range of habitats, but usually in acidic swamps on coastal sand plains. Found in wallum, woodlands and sedgelands on coastal swamps dominated by *Melaleuca quinquenervia* with an understorey of the sedge *Lepironia articulata* are typical habitat (OEH 2012). Suitable wallum swamps are characterised by low nutrients, highly acidic, tannin-stained waters occurring on Pleistocene coastal sand deposits (OEH 2012).
Giant Barred frog (*Mixophyes iteratus*)	Endangered	Endangered	They occur in uplands and lowlands in rainforest and wet sclerophyll forest as well as farmland and are strongly associated with permanent, usually slow flowing streams with good quality riparian vegetation (Ingram and McDonald 1993, Cogger 2000, Anstis 2002). They are usually found within 20 m of the edge of a stream (Lemckert and Brassil 2000). They can also be found associated with permanent streams in farmland, provided that suitable riparian vegetation is present (Hines *et al.* 2004).
Green-thighed frog (*Litoria brevipalmata*)		Vulnerable	Found in wet sclerophyll forest along the northern coast of NSW to Ourimbah (Anstis 2002). Also in a variety of habitats including dry to wet sclerophyll forest, rainforests and shrubland with a healthy understorey (reviewed in Lemckert *et al.* 2006). Breeding aggregations occur in still, ephemeral water habitats, and calling behaviour is strongly associated with rainfall (Lemckert *et al.* 2006)

2.1.2 Known and expected occurrence within the project

The following provides details of the known and expected distributions of each of the threatened frog species within the project. Figure 2-4 to 2-14 at the end of this chapter show the location of the frogs within the project.

Species	Identified records and project section	Potential habitat
Wallum Sedge Frog	Tentative identification in section 11 and the species could also occur in Section 6 to 11	Section 6-11
Giant Barred frog	This species was recorded at Corindi River, and Dirty Creek (Section 1). Suitable habitat for the Giant Barred frog occurs at other major freshwater creeks in Section 1-2, particularly Boneys Creek. In most cases the remainder of the study area provides limited habitat for the Giant Barred frog largely because it requires permanent creeks with adequate riparian vegetation often comprising moist sclerophyll or lowland riparian rainforest species (Lemckert and Morse 1999; Lewis and Rohweder 2005) (refer to Figure 2-1 to Figure 2-3 at the end of this chapter).	Section 1, 2 and 7
Green-thighed Frog	Green-thighed Frogs were reported in Sections 1-2 and 6 to 8. The species could occur in all sections.	Section 1-11

2.1.3 Threatening processes

Threats to the persistence of the Wallum Sedge Frog include:

- The destruction and degradation of coastal wetlands due to sandmining, coastal developments and road works.
- The reduction of water quality and acidification and de-acidification of coastal wetlands. De-acidification may open habitats to species that complete with Wallum Sedge Frogs.
- Impacts due to grazing and associated frequent burning of coastal wetlands.
- Impacts from pest vertebrate species (including Cane Toads, Foxes, Pigs, Mosquito Fish).

Threats to the persistence of the Giant Barred frog include:

- Sedimentation and pollution leading to a reduction in water quality.
- Changes in flow patterns (either decreased or increased flow).
- Burning leading to reduction in leaf litter and fallen logs which provide cover.
- Timber harvesting.
- Vegetation clearance.
- Predation by introduced fish on eggs and tadpoles.
- Chytrid fungus.
- Weed spraying close to streams.
- Impacts from pest vertebrate species (including Cane Toads, Foxes, Pigs, Mosquito Fish).

Threats to the persistence of the Green-thighed frog include:

- Reductions in local flooding due to changes to drainage.
- Degradation of semi-permanent and ephemeral ponds and damage to flood-prone vegetation.
- Habitat clearing for agriculture and development.
- Timber harvesting leading to habitat disturbance.
- Grazing and pasture fertilisation leading to a reduction in water quality.
- Grazing and associated burning leading to reduction in leaf litter.
- Impacts from pest vertebrate species (including Cane Toads, Foxes, Pigs, Mosquito Fish).

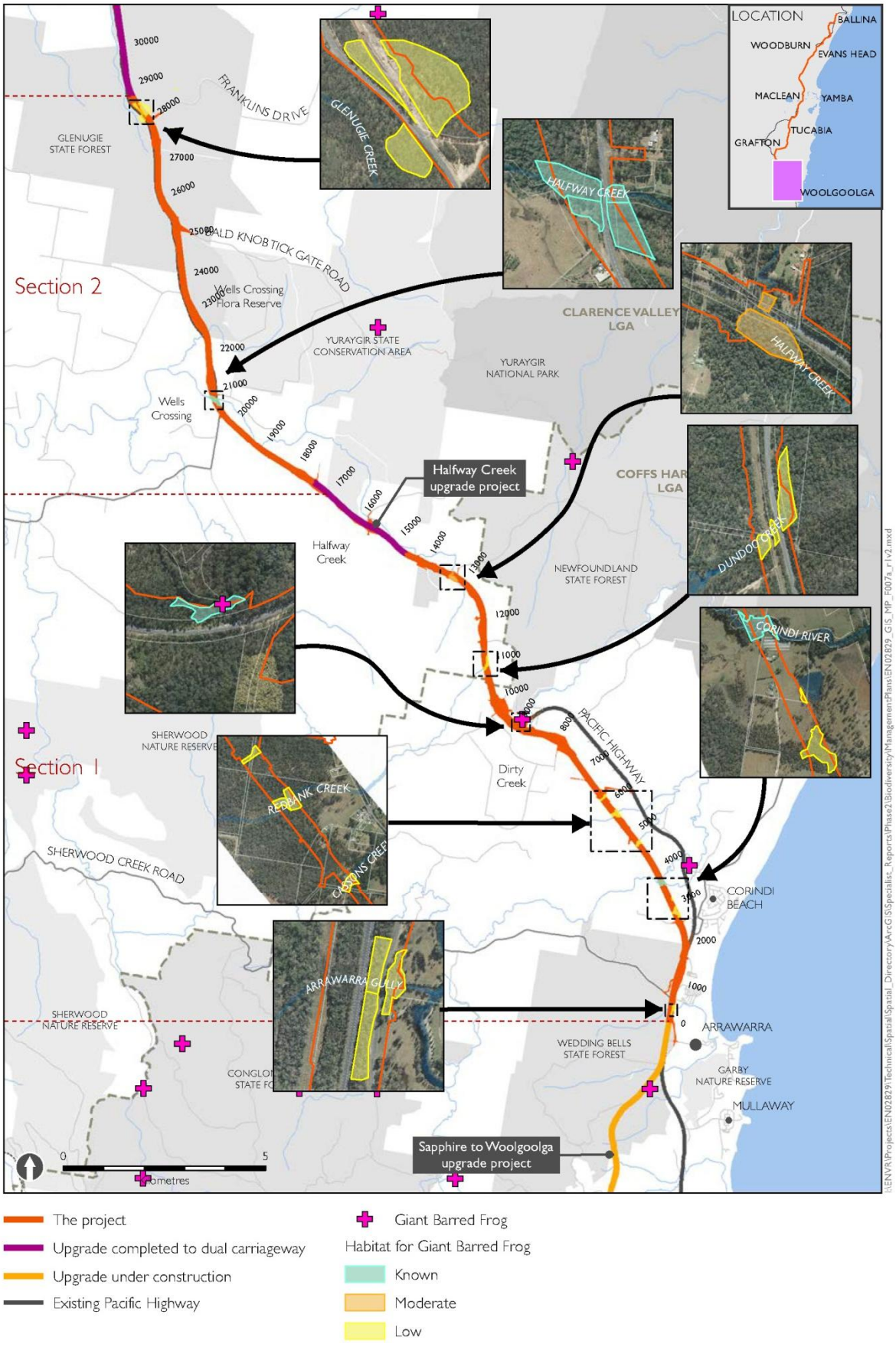


Figure 2-1 Giant Barred Frog records and distribution of habitat

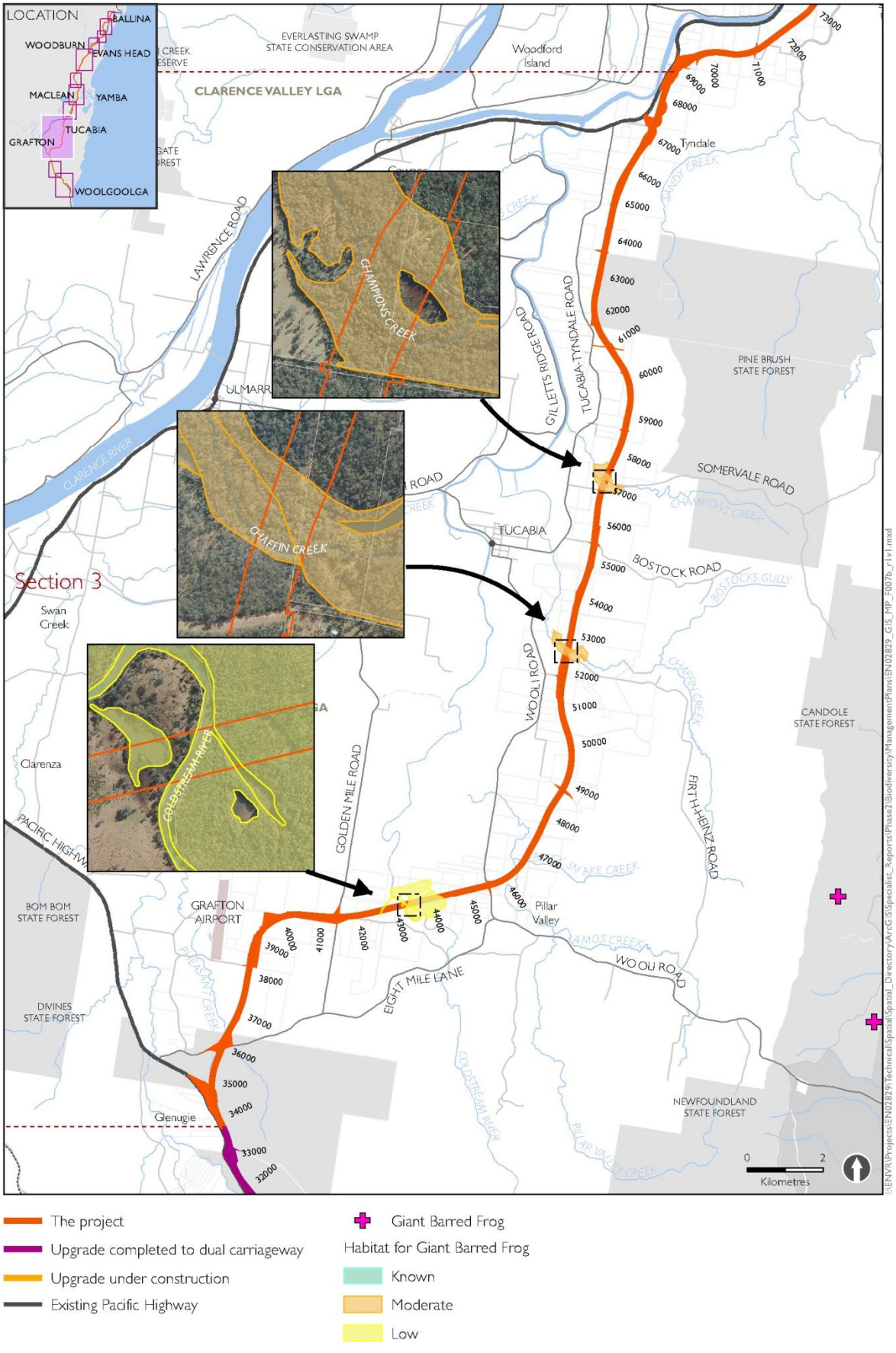


Figure 2-2 Giant Barred Frog records and distribution of habitat

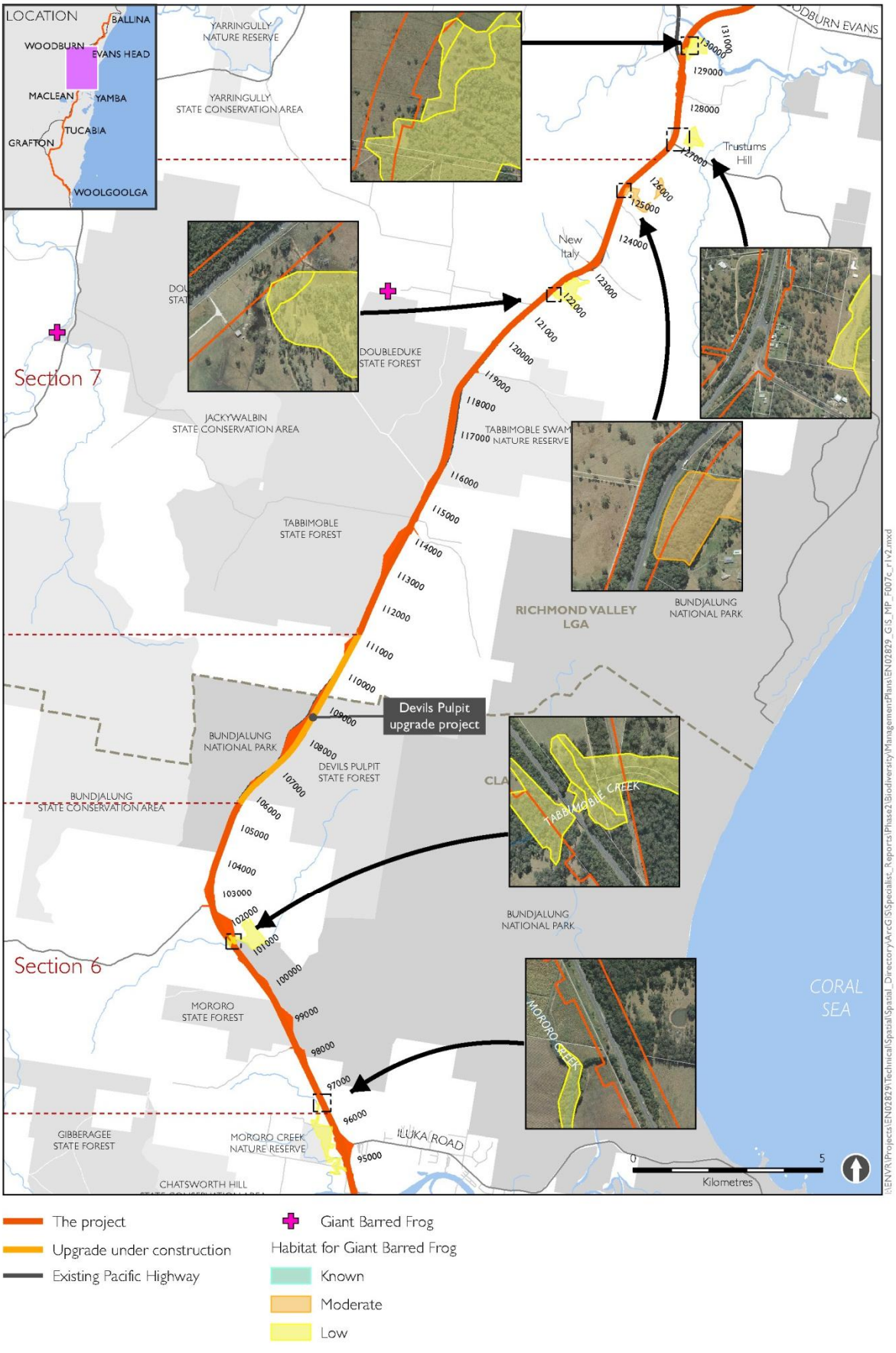


Figure 2-3 Giant Barred Frog records and distribution of habitat

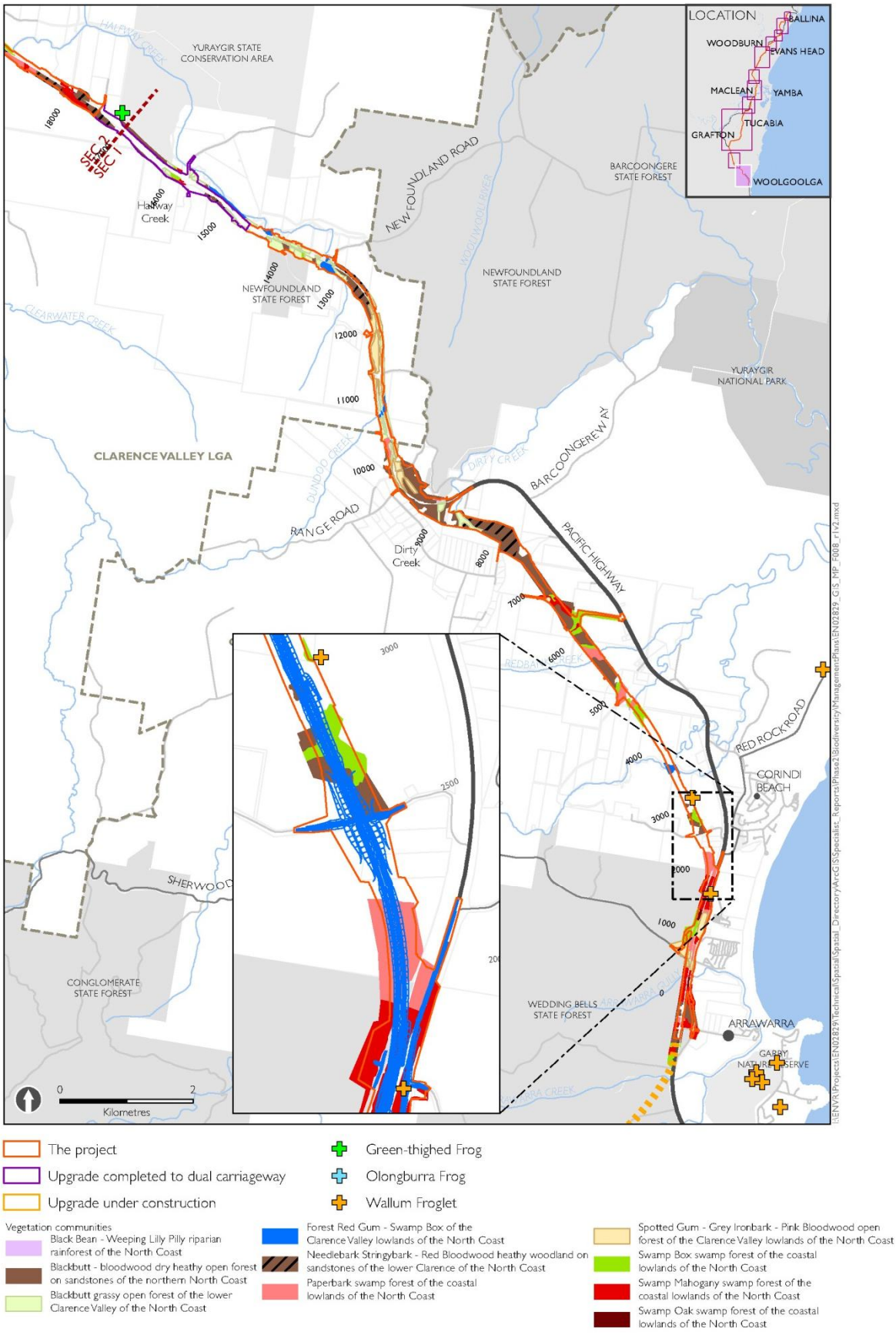


Figure 2-4 Wetland frogs and linked biometric habitat types (section 1)

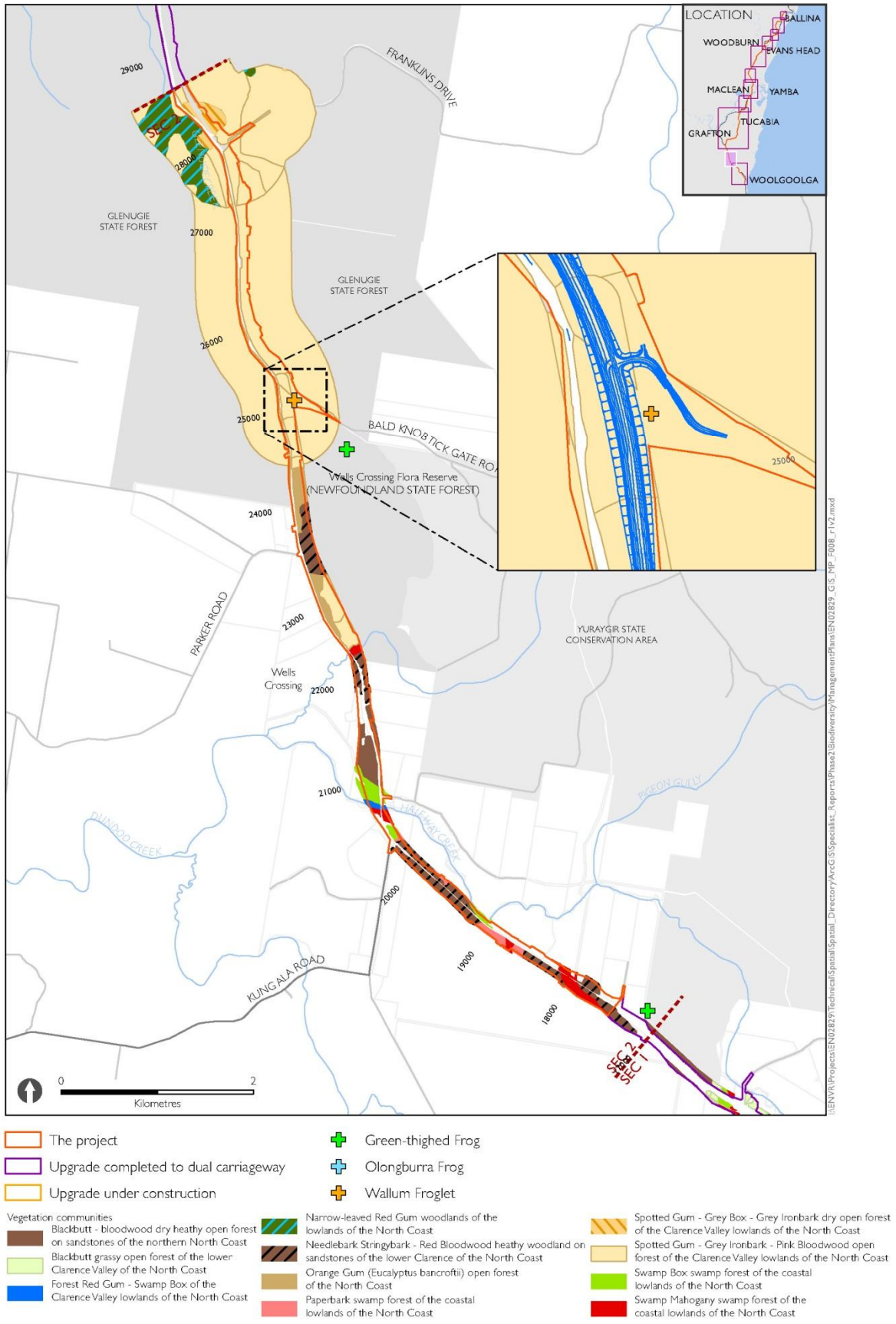


Figure 2-5 Wetland frogs and linked biometric habitat types (section 2)

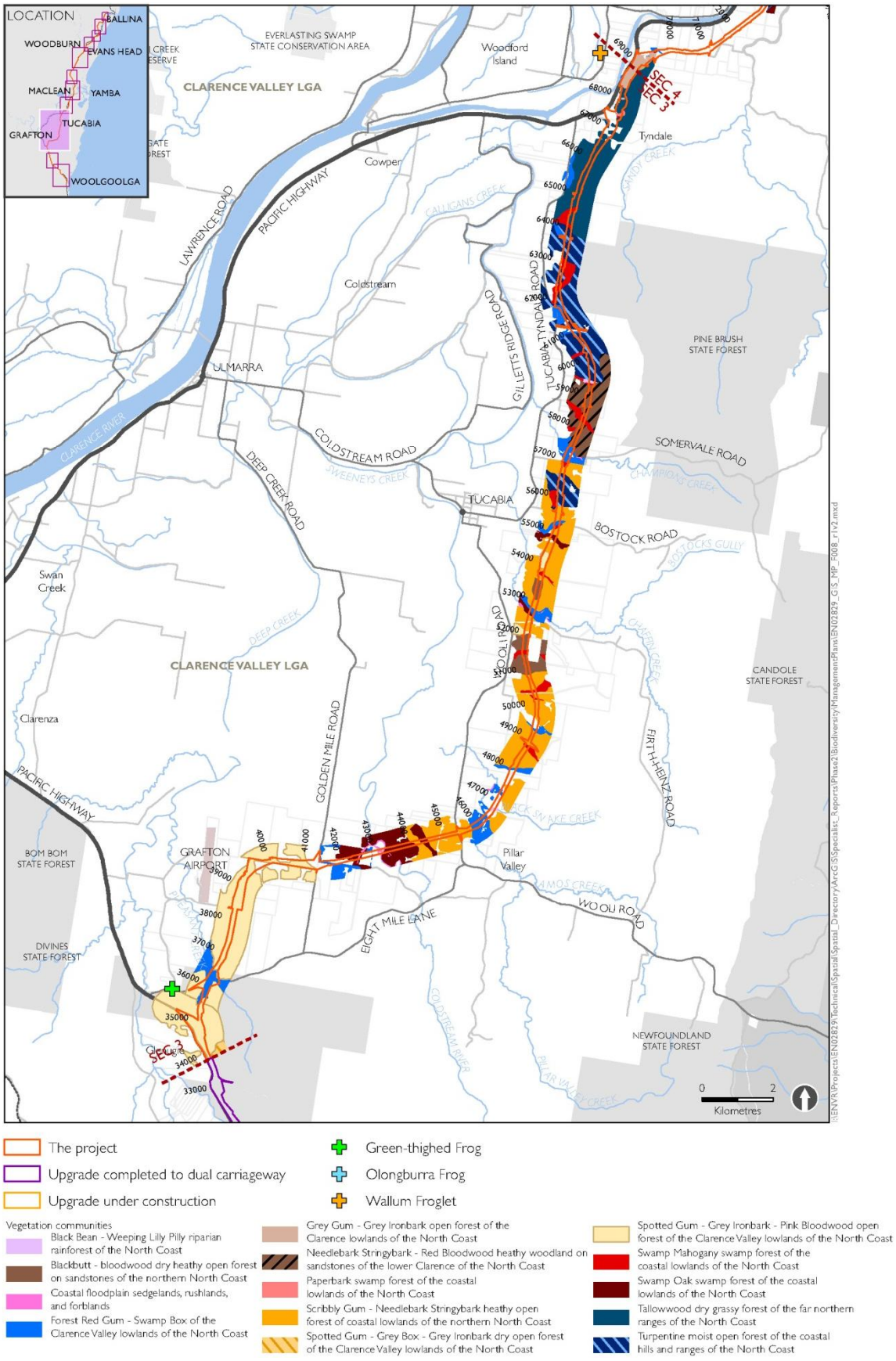


Figure 2-6 Wetland frogs and linked biometric habitat types (section 3)

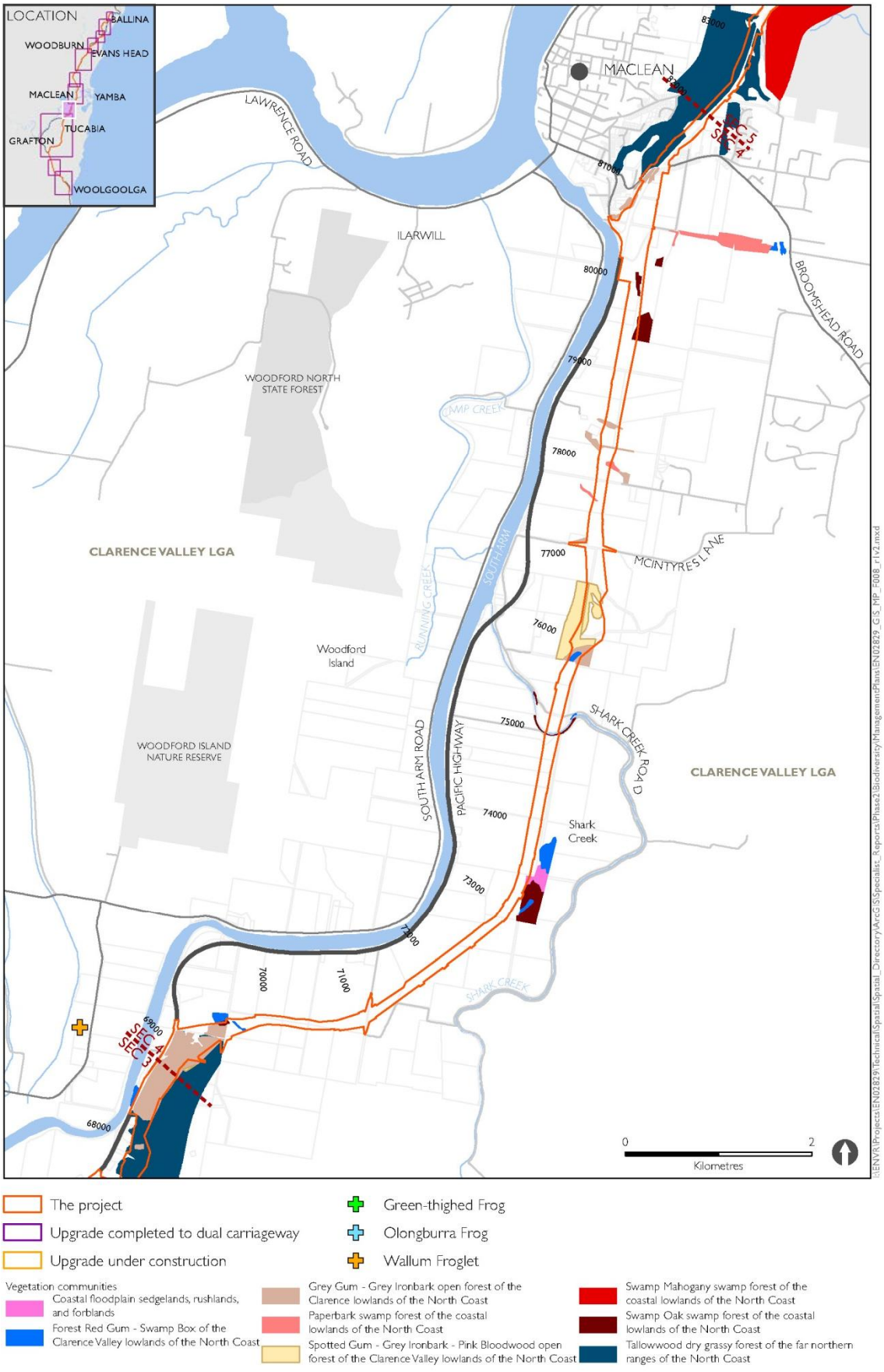


Figure 2-7 Wetland frogs and linked biometric habitat types (section 4)

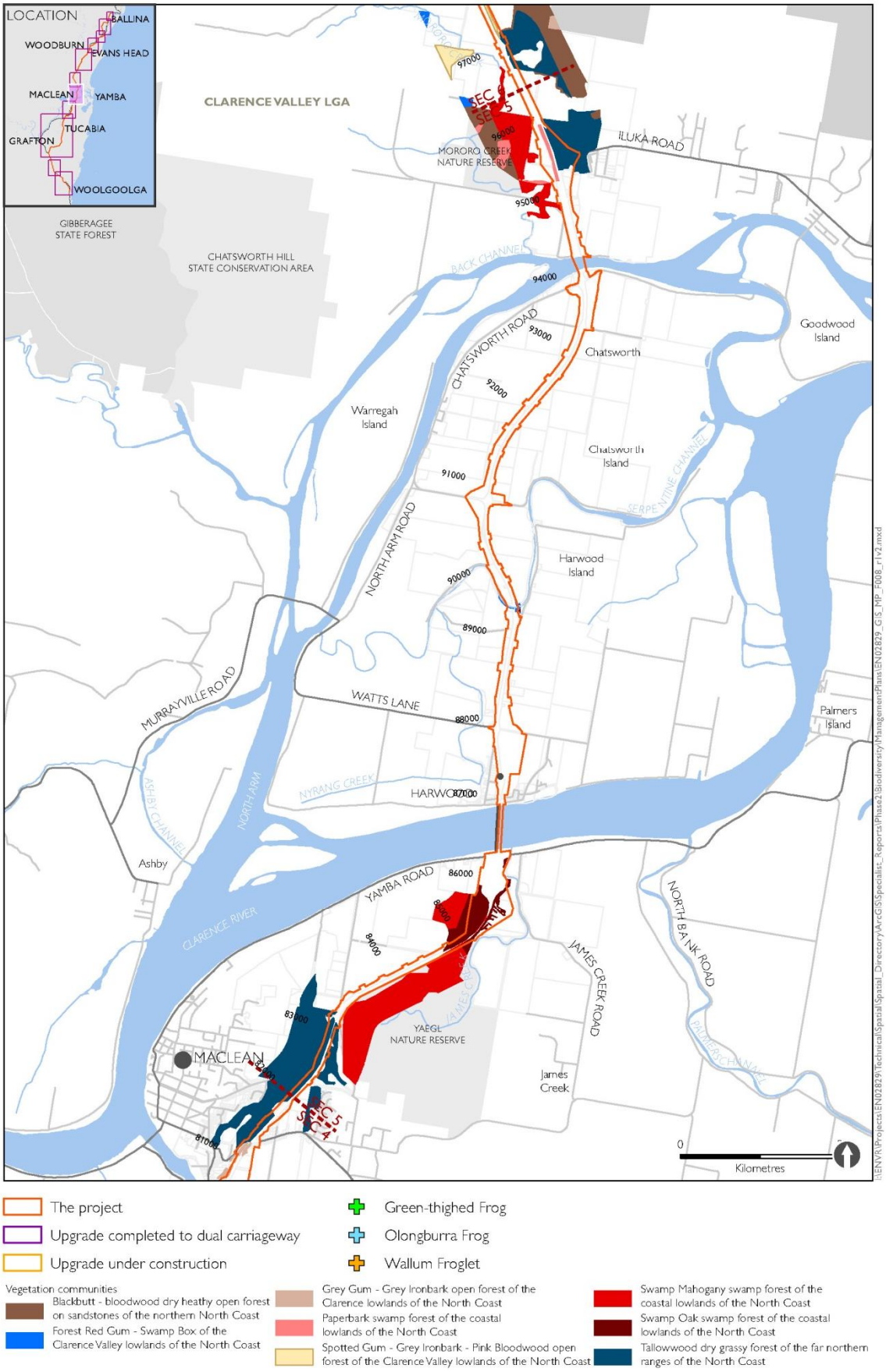


Figure 2-8 Wetland frogs and linked biometric habitat types (section 5)

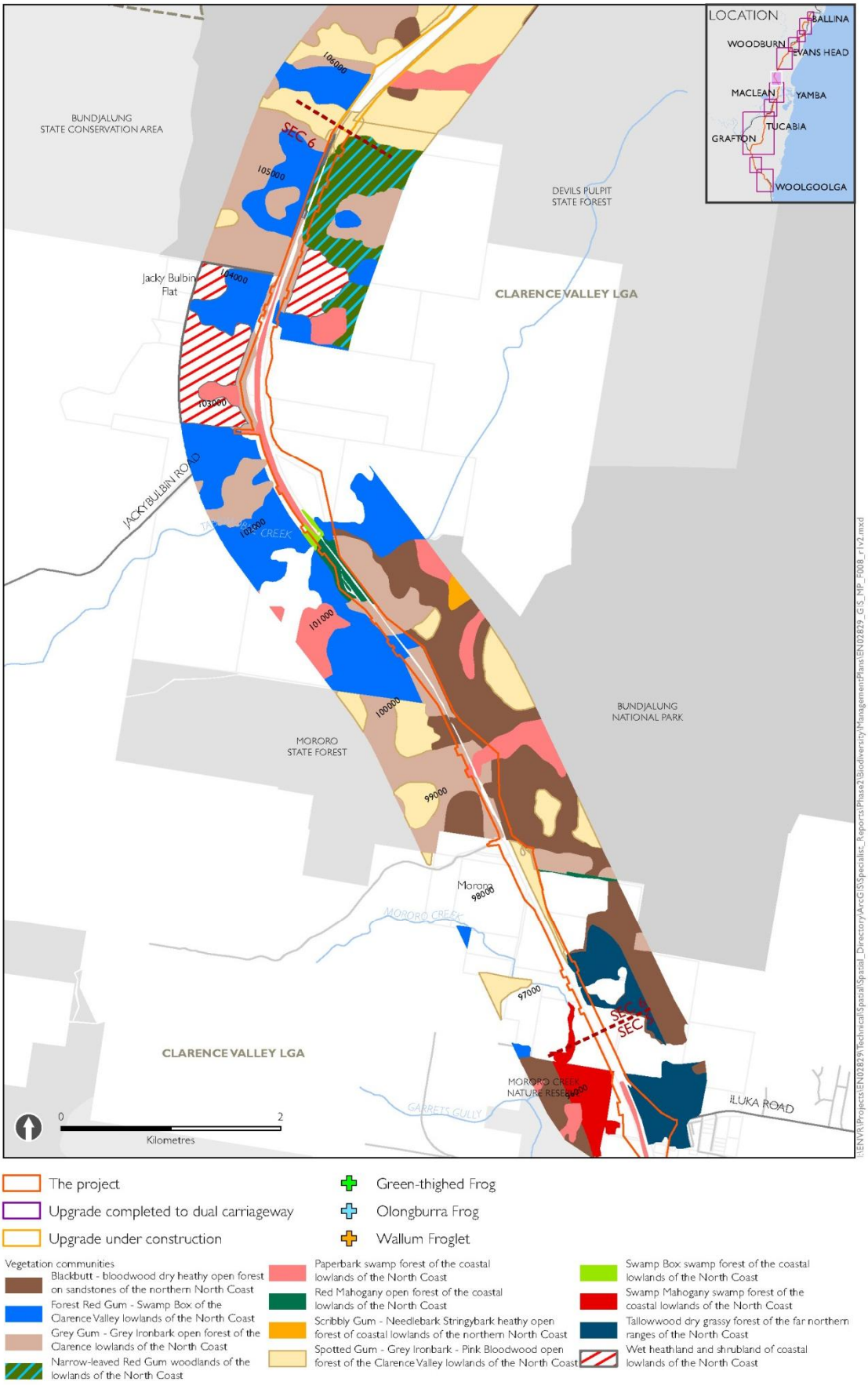


Figure 2-9 Wetland frogs and linked biometric habitat types (section 6)

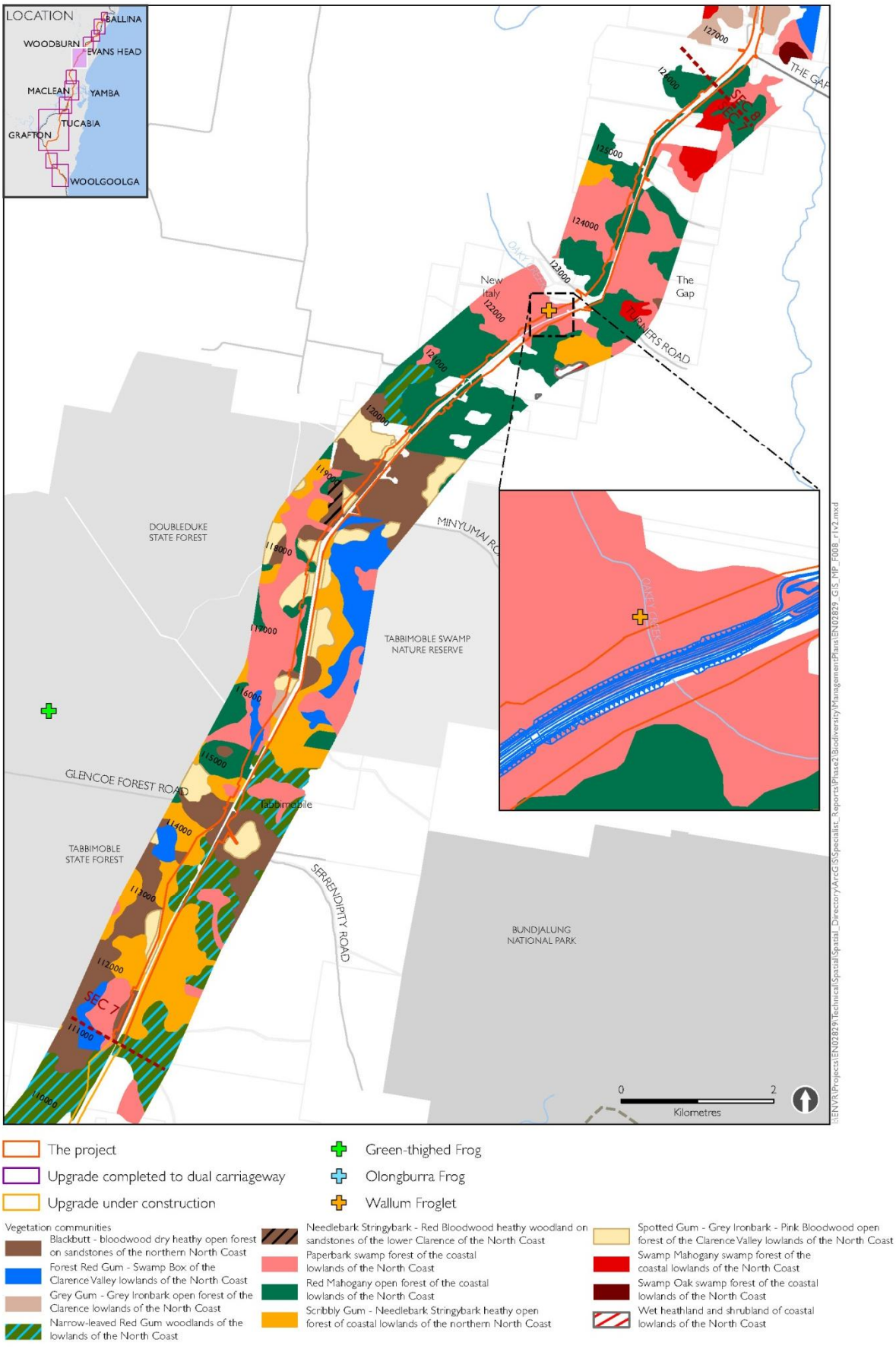


Figure 2-10 Wetland frogs and linked biometric habitat types (section 7)

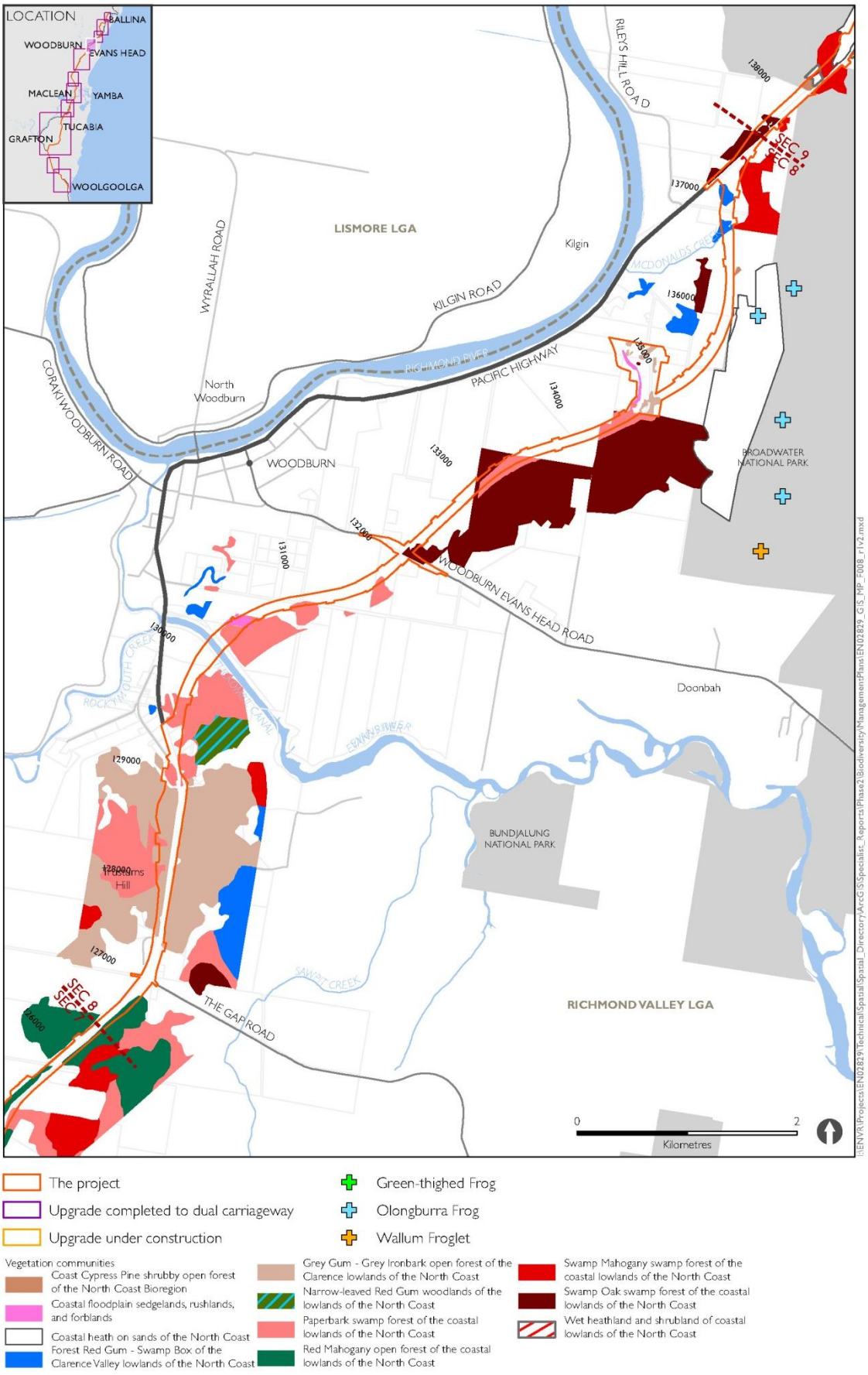


Figure 2-11 Wetland frogs and linked biometric habitat types (section 8)

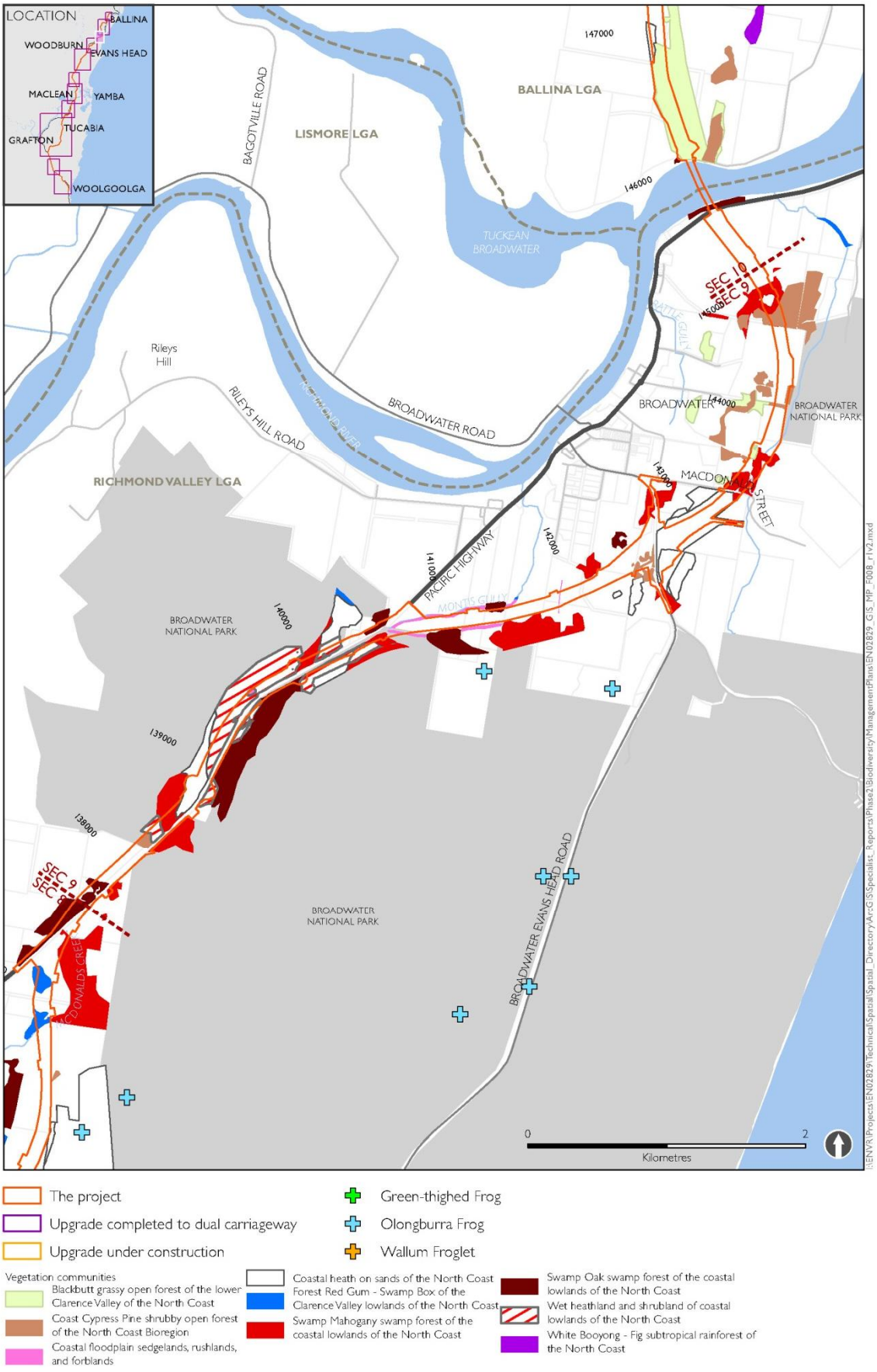


Figure 2-12 Wetland frogs and linked biometric habitat types (section 9)

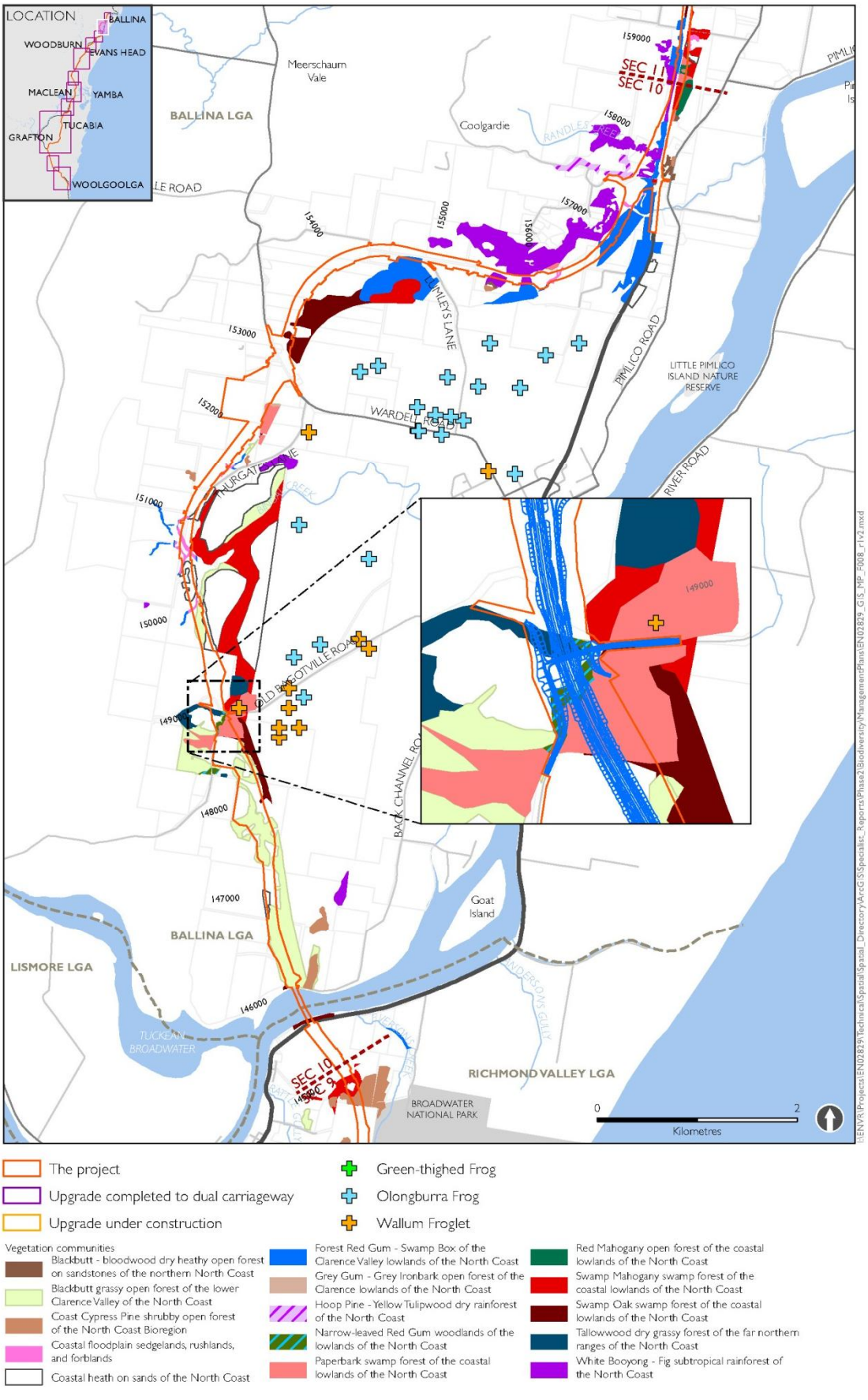


Figure 2-13 Wetland frogs and linked biometric habitat types (section 10)

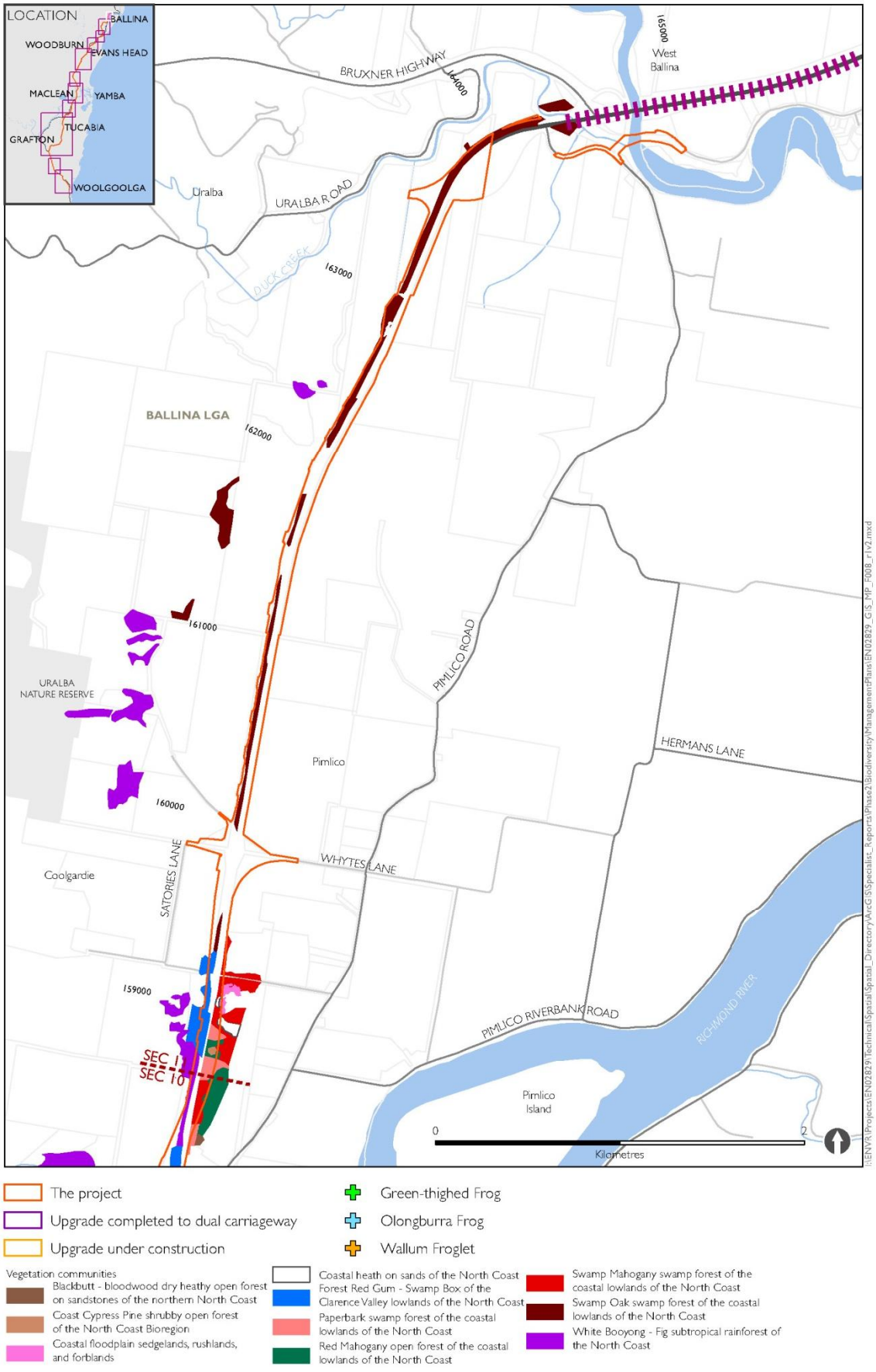


Figure 2-14 Wetland frogs and linked biometric habitat types (section 11)

3. Potential impacts and management approach

The following chapter provides a brief overview of the potential impacts to the threatened frog populations with reference to the more detailed impact assessment presented in the biodiversity working paper. It describes the potential impacts to the species at specific locations along the upgrade and during the pre-construction, construction and post-construction (operational) stages of the project. The mitigation approach presented in the EIS and documented in Chapters 4 to 6 of the management plan target the predicted impacts.

3.1 Potential impacts associated with the project

Impacts on the Giant Barred frog and Green-thighed frog are discussed in Section 4.3.2 (pp 368-369) of the Biodiversity Working Paper (Roads and Maritime 2012). Details of impacts on the Wallum Sedge Frog are reviewed in Table 4-16 (p 375) of the Biodiversity Working Paper (Roads and Maritime 2012).

There are a number of impacts potentially associated with the project including:

- Direct loss of habitat over small discrete areas through crossing freshwater aquatic habitats (drainage and creek habitats).
- Indirect edge effects on habitat remaining adjacent to the road (primarily the encroachment of weeds).
- The reduction of water quality and acidification and de-acidification of coastal wetlands.
- Detrimental changes to drainage patterns in known or potential habitats.
- Altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas.
- Sediment runoff during construction into known and potential habitat.
- Impacts from increasing the barrier effects of the existing highway including fragmentation of habitats and potential disruption to movements.
- Creation of habitat for the Mosquito Fish (*Gambusia holbrooki*), a known predator of tadpoles.
- Creation of breeding habitat for the Cane Toad (road side depressions) and increased dispersal opportunities within the road corridor.
- Transference of chytrid fungus.

3.2 Detailed design considerations

A number of factors would be addressed in the detailed design phase including the final location of frog exclusion fencing, detention basins and compensatory ponds. In-stream structures such as bridges and culverts would be designed and managed to minimise any potential impact on flow regimes and aquatic habitats.

3.3 Mitigation and monitoring approach

A number of measures to mitigate and monitor the impact of the project on threatened frogs during construction and operation of the project were identified in the EIS (biodiversity working paper) and Preferred Infrastructure Project and Submissions (PIR/SR) report. In general these measures related to:

- Provision of exclusion fencing, both temporary to exclude frogs from construction activities, but also permanent frog fencing to prevent frogs from accessing the roads during the operation of the road.
- Avoiding impacts to threatened frog populations and habitats outside the road footprint during construction through the effective use of sediment and erosion control measures.

- Water quality controls.
- Provision of crossing structures including bridges and culverts.
- Pest and pathogen management.
- Re-establishment of threatened frog habitat at approaches to crossing structures.
- Compensatory habitat (ponds) where habitat has been removed by construction activities.
- Develop a monitoring program to monitor impacts on the populations of threatened frogs and the effectiveness of mitigation measures and incorporate adaptive management actions where impacts are noted.

To minimise the impact of runoff during the operation, runoff from the project would be directed to detention basins before being discharged to drains and then local waterways. Basins would also be located adjacent to wetlands and watercourses to protect waterways from unexpected spills. Ensuring water quality is maintained during construction would help to prevent any increase in the numbers of the aquatic pest species Mosquito Fish (*Gambusia holbrooki*) which thrive in disturbed aquatic habitats and prey on tadpoles. Impacts would be expected to be minimal due to implementation of measures such as ensuring appropriate design of water storage areas and temporary drainage systems, controlling runoff from construction areas, and the implementation of routine water quality monitoring.

3.4 Effectiveness of mitigation measures

A summary of the proposed threatened frog specific mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in Table 3-1.

3.5 Adaptive management approach

The management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management and implementation of management actions followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan were based on the following SMART principles:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**esults-based.
- **T**ime-based.

Table 3-1. Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Direct loss of habitat over small discrete areas through crossing freshwater aquatic habitats (drainage and creek habitats).	Threatened frog fencing and compensatory pond strategy. Identification and clear marking of habitat exclusions zones via the use of temporary and permanent frog exclusion fencing. Installation and maintenance of fauna connectivity structures. Maintenance of constructed compensatory ponds	Roads and Maritime has developed and implemented frog fencing and compensatory ponds for a number of road projects. Specifically as part of these strategies monitoring the effectiveness of frog crossings through culverts, bridges and arches for the Bonville, Karuah to Bulahdelah, Bulahdelah to Coolongolook and Yelgun to Chinderah projects has been undertaken. Roads and Maritime has also constructed compensatory ponds for the Tugun Bypass and Kempsey Bypass projects. The long term success of compensatory ponds is uncertain. In addition, Roads and Maritime undertook a review of the use of fauna passage structures in 2009. This review found that a wide range of fauna was using underpass and overpass structures with the exception of amphibians. This is consistent with the results and conclusion of other research (Taylor and Goldingay 2003).	Uncertain, monitor effectiveness and implement contingencies where appropriate
Indirect edge effects on habitat remaining adjacent to the road (primarily the encroachment of weeds).	Management of edge effects particularly weed invasions, around known and likely threatened frog habitat. Weed management plan developed and implemented to control weeds.	Roads and Maritime has developed standard weed management procedures that are implemented during construction and are reported as part of the FFMP process. This includes pre-clearing surveys to identify weeds and noxious species and map their location for on-going monitoring and control during construction. Operational monitoring of weeds is conducted around *in situ* populations of threatened plants and control undertaken where required. Weed monitoring during construction is a routine procedure for road upgrades with a long history of success in NSW. Reporting for on-going weed impacts and controls around important habitats adjacent to the road have varied greatly in their success. The results suggest they are reliant on persistent effort, with on-going follow-up actions until such time as the population is proven to remain viable.	Moderate, monitor against performance and implement weed management actions
Detrimental changes to drainage patterns in known or potential habitats	Rainfall monitoring. Assessment of drainage performance, in particular flow rates through identified ponds and water bodies that are known to support frogs.	Typically drainage is dealt with on road upgrades using engineered solutions to slow surface flow and capture and treat run-off from roads. Standard designs have been developed and are affective for the purposes of reducing run-off impacts. However there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions

Altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas	Water quality managed in accordance with the Blue Book principles. Specifically, pH monitoring would be undertaken as part of the frog population monitoring.	Roads and Maritime has successfully used water quality controls across a number of Pacific Highway projects. Procedures for water quality management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP process. However as stated previously there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions
Sediment runoff during construction into know and potential habitat	Sediment and erosion control managed in accordance with the Blue Book principles.	Roads and Maritime has successfully used erosion and sediment controls across a number of Pacific Highway projects. Procedures for sediment and erosion management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP. However as stated previously there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions

4. Pre-construction management measures

4.1 Potential impacts during pre-construction phase

- Location of infrastructure within ancillary facility sites including heavy vehicle access may impact on frog habitat, movements, foraging and behaviour. However, this is probably unlikely due to the Roads and Maritime separation distance requirements for ancillary facilities from watercourses.

4.2 Goals for management

- Establish baseline information on habitat condition, location and status of threatened frog populations within the project.
- Protection of threatened frog habitat by accurately identifying important habitats for planning of appropriate exclusion zones,
- Installing temporary frog fencing prior to clearing works.
- Capture and relocation of frogs prior to clearing.

4.3 Targeted surveys

The objectives of the targeted frog surveys are to:

- To inform the design and management measures for threatened frogs on each stage of the upgrade including the locations of temporary and permanent frog exclusion fencing and compensatory habitat.
- To collect baseline population and habitat data to monitor impacts to populations and the effectiveness of mitigation measures as part of an adaptive management approach.

The targeted surveys would therefore aim to firstly identify the location of threatened frog populations for each upgrade section, and identify and map known and potential habitat for the target species. The confirmed locations will be used for ongoing population monitoring and use of connectivity structures by identifying impact and control sites. Details of the monitoring program are provided in Chapter 7, and the following information provides the proposed timing, methods and parameters for the targeted surveys which are intended to be repeated during construction and post-construction periods as per the monitoring program.

The targeted surveys and monitoring program are based on a whole of project approach as threatened frog populations are not applicable to all individual upgrade section. The data collected would be used as a meta-analysis to compare sites and effectiveness of mitigation measures applicable to known populations along the project.

Timing, site selection and methods

The targeted frog surveys should ideally be conducted over a minimum of two temporally separated surveys prior to construction to measure variation in the population and improve the statistical power of the monitoring program. Performing surveys at the correct time of year and under optimum conditions should ensure that individuals would be located if present. As a general rule these surveys would be conducted in the spring and summer periods, which coincide with the likely peak activity and calling periods for the target species (Lemckert and Mahony 2008).

It is important to note however, that monitoring needs to be conducted during the optimum conditions for each of the threatened frog species. For example, for monitoring of Wallum Sedge Frog populations Lewis and Goldingay (2005) found that rainfall in the week preceding surveys had a positive influence on frog abundance.

In contrast, following heavy rain Giant Barred Frogs are unlikely to attempt to breed and often move away from the stream's edge (Koch and Hero 2007). In these conditions it is unlikely that surveys will successfully locate individuals.

For Green-thighed Frog these conditions may be more restrictive. Green-thighed Frogs can call between September and April, but breeding behaviour is strongly dependent on rainfall sufficient to fill breeding ponds (Lemckert *et al.* 2006). For some sites, 20 millimetres of rain over a 24 hour period is likely to be sufficient, however different breeding sites may require 100 millimetres of rainfall over the same period. Green-thighed Frogs are also much more likely to call during the rainfall event (Lemckert *et al.* 2006). Given these specific requirements, Lemckert *et al.* (2006) found that breeding behaviour is often brief (consecutive nights of calling is rare) unpredictable and sporadic.

Successful monitoring of Green-thighed Frogs requires that each of these factors is considered. Lemckert *et al.* (2006) found that calling activity did not commence until ephemeral pools filled, which was usually following at least 50 millimetres of rainfall in a 24 hour period. Although the amount of rainfall required to fill ephemeral breeding habitats will vary between sites, 50 millimetres of rainfall over a 24 hour period is a reasonable starting point. Rainfall triggers to initiate monitoring at sites should be refined during the monitoring program.

The targeted and ongoing monitoring surveys should be done biannually in spring and summer (November to May) and within seven days of a notable rainfall. Ideally for the Green-thighed Frog this would be greater than 50 millimetres over 24 hours and during the rainfall event itself. It is noted that this may not be achievable so to control for this, the rainfall conditions in the week before and during the surveys are to be reported.

In order to select adequate survey sites prior to conducting the survey all drainage lines and wetland areas located within or close to the project would be inspected during daylight hours to assess their suitability for the target frog fauna. It would be necessary to select multiple impact and control sites. It should be noted that selection of suitable sites for Green-thighed Frogs may require inspections following rainfall to ensure that suitable breeding habitats have been inundated.

Impact sites would be within proximity to the upgrade (up to 100 metres), adjacent to mitigation measures and control sites upstream away from the project (>100 metres) or in proximity to the project where there is no mitigation. Control and impact sites should be located at least 200 metres and ideally 300 metres from each other. Further details on the site selection are discussed in Chapter 7. The location of control sites may be restricted by property access and therefore control sites may occur in other known reference locations such as nearby conservation reserves or state forests if suitable.

Nocturnal surveys would involve transect counts in breeding habitat as this technique has been found to be effective for Wallum Sedge Frog (Lewis and Goldingay 2005), and Giant Barred Frog (Lemckert and Morse 1999) and expected to be suitable for Green-thighed Frog. Transect lengths vary for the target species and are outlined below. Transect lengths should be kept to the specified length wherever possible.

In wetland habitats (Wallum Sedge Frog) transect length would be a standardised 50 metres, where possible. Wallum Sedge Frog populations may be found in breeding habitats less than 50 m diameter. In this case a 30 minute timed search would be carried out.

For stream habitats (Giant Barred Frog) a 500 metre transect (250 m on either side of the stream) would be conducted where possible, and if not, a 60 minute timed search would be conducted. This recognises that property access may be constrained at survey sites such that it may not possible to search a 500 metre reach. In this instance a search time of 60 minutes should be adhered to, which may include both banks of the stream.

For the Green-thighed Frog, transects should follow the borders of the breeding sites. As with the Giant Barred Frog, 500 metre transects or a 60 minute search would be conducted. All transect start and finish points are to be recorded with a hand-held GPS (AGD94)

Monitoring will commence 30 minutes after dark and for each species will involve listening for the characteristic call of the male frogs. The transect searching method will be different for each species however.

For the Wallum Sedge Frog, spotlight searches focused one metre either side of the transect would be carried out (Meyer *et al.* 2006). For the Giant Barred Frog, the band within 20 metres of the edge of the stream would be spotlight searched (Lemckert and Brassil 2000). Green-thighed Frogs will be unlikely to be found through active searching and so detection relies on call identification. As the transect is walked, searching would still be carried out around the breeding habitat to capture any encountered individuals.

Time, temperature, identity and number of frogs are to be recorded divided into size classes (adults, juveniles and metamorphlings), and include the number of males calling, estimated from chorus size.

For Giant Barred Frog, all frogs detected are to be marked via a PIT tag (ie. micro-chipped). The objective of the PIT tagging is to individually mark each frog with a unique alphanumeric identifier which can be read via a bar code scanner. The marking of frogs would assist in the monitoring of underpass structures (referred to in Section 7.4).

4.4 Management measures

Details on the site specific mitigation measures for threatened frogs to be implemented during the pre-construction phase are detailed here and summarised in Table 3-2 along with performance thresholds and corrective actions.

4.4.1 Frog exclusion fencing

As noted in section 4.3, the data collected during the targeted surveys would be used to inform the location of temporary frog fencing to be erected prior to commencement of clearing.

Temporary frog fences are to be placed adjacent to known and potential habitats for the target species as identified from the targeted surveys.

The siting of ancillary areas including stockpiles and construction infrastructure would be planned to be located within cleared areas of the ancillary site and with consideration for appropriate distances to water bodies and potential frog habitats. This would occur across all ancillary sites for each stage of the project and would be documented in the CEMP.

4.4.2 Constructed ponds

In areas of known or potential habitat for Wallum Sedge Frog and Green-thighed Frog that would be degraded or impacted by the project, compensatory ponds would need to be constructed. The areas for these compensatory ponds would be informed by the targeted surveys.

Designs for compensatory ponds would be finalised as part of the detailed design in consultation with recognised authorities on threatened frogs. Important features to be considered include the hydrology and water quality requirements for both species and depth and vegetation planted both beside the ponds and within the ponds. Design criteria of the compensatory ponds would also be different for each species. These ponds would be completed prior to the degradation or destruction of the habitat they are compensating for.

Example compensatory pond design criteria provided below has been based on designs included in the following reports:

- *Tugun Bypass, Stewart Road to Kennedy Drive: Compensatory Habitat, September 2005* (DTMR 2005) for the Wallum Sedge Frog.
- *Pacific Highway Upgrade: Arrawarra Interchange to Chainage 16500 targeted frog survey, April 2013* for the Green-thighed Frog breeding ponds.
- *Woolgoolga to Half Creek targeted frog survey, Lewis Ecological Survey, July 2013.*
- *Half Creek to Glenugie targeted frog survey, Lewis Ecological Survey, July 2013*

As part of the Tugun Bypass Compensatory Habitat Package and as detailed in the Compensatory Habitat report (DTMR, 2005), a number of recommendations were provided based on observations made during field and laboratory work that focused on the compensatory frog ponds along the Tugun Bypass Project. These included:

- Ponds should generally be shallow and constructed in areas of high groundwater.
- Water quality should exhibit the following characteristics:
  - pH <5 (as influenced by humic acids) (for Wallum Sedge Frog only).
  - Hardness <100 ppm.
  - Salinity <350 µS/cm.
- Ponds should be ephemeral to prevent habitation by fish
- Pond fringes should be densely planted with emergent species to discourage use of the pond by Cane Toads (*Bufo marinus;* Semeniuk *et al.* 2007) and therefore reduce predation on native species.

Specific design criteria for ponds for Wallum Sedge Frogs and Green-thighed Frogs would be determined as part of the detailed design, but the following considerations should be made.

For Wallum Sedge Frogs, the following four performance criteria were developed as part of the Compensatory Habitat Report (DTMR 2005) to provide a means to determine success of the compensatory ponds based upon monitoring results:

- Ponds are to contain surface water for a period of >10 weeks per annum, for at least two of the three year monitoring periods.
- Waters within ponds are to have a pH <5 and an electrical conductivity (EC) <350 µS/cm.
- Ponds are to contain a margin of emergent macrophytes >200 millimetres thick and bank vegetation, and
- Ponds are not to contain fish.

The main element with designing a breeding site for Green-thighed Frog would be to ensure the water body periodically dries out. Green-thighed Frogs will not use permanent water bodies for breeding (Anstis 2002, Lemckert *et al.* 2006). Ephemeral ponds will also reduce the competitive interactions with pond dwelling frogs and predatory interactions associated with the exotic Mosquito Fish (Gambusia holbrooki). These ponds should be created as large as is practically possible and be placed, as far as is possible, within the most typically used habitats: wet sclerophyll or swamp forest with a dense understorey and deep leaf litter.

4.5 Performance thresholds and corrective actions

Table 4-2 summarises the pre-construction environmental planning measures for threatened frogs that would be completed prior to the commencement of construction.

Table 4-2 Mitigation measures, performance measures and corrective actions – pre-construction

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Establish baselines about the habitat condition, location and status of threatened frog populations within the project.	Targeted surveys including habitat condition and population locations.	Prior to construction as outlined in section 4.3.	Targeted surveys are completed during the appropriate season prior to construction	Delay construction of project sections if targeted surveys have not been undertaken in the appropriate season.
Protection of threatened frog habitat by accurately identifying exclusion zones, and installing frog fencing and compensatory ponds prior to clearing works.	Identify exclusion zones, frog fencing and compensatory pond locations. Install frog fencing and compensatory ponds.	Prior to clearing works.	Exclusion zones mapped and frog fencing and compensatory ponds installed prior to construction.	Delay construction of project sections if frog fencing and compensatory ponds have not been installed.

5. Construction management measures

5.1 Potential impacts during construction phase

- Impacts during clearing of vegetation and clearing adjacent to frog habitat.
- Frogs entering the construction corridor and becoming trapped in the corridor.
- Frogs being killed by construction traffic and activities.
- Disturbance and degradation to adjoining habitat including loss of aquatic plants and reduction in water quality.
- Contamination or changes to water quality of water bodies used by threatened frogs.
- Dewatering of wetlands to construct fill areas.
- Pathogen (chytrid) transported during construction.
- Change in pH of waterbodies due to discharge of freshwater from basins.
- Opening of habitats allowing entry of feral predators and competitors.

5.2 Goals for management

- Low rate of injuries to threatened frogs during clearing works.
- No injuries to threatened frogs during construction as a result of vehicle collisions.
- No injuries to frogs that need to be handled.
- No movement of chytrid fungus between sites.
- No injuries or mortality of threatened frogs as a result of dewatering activities.

5.3 Management measures

5.3.1 Work method statements

Environmental work method statements (EWMS's) would be prepared for specific activities that pose particular environmental risks, including risks to threatened frogs. EWMS's would ensure sound environmental practices are implemented to minimise the risk of environmental incidents or system failures, in accordance with the CEMP.

EWMS's covering activities with the potential to impact on threatened frogs would address all relevant management measures and be prepared in consultation with agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

5.3.2 Induction and training

Induction and training would be conducted with all contractors and other staff that would be working in the areas of known and potential threatened frog habitat. This training would identify threatened frog habitat, and crossing zones and key threats, with all personnel shown pictures of the species. The importance of following the clearing, and rehabilitation protocols would be made clear for any personnel that require access to the site.

5.3.3 Temporary frog exclusion fencing

As noted in section 4.3, the location of temporary frog fencing would be identified during the targeted surveys. Temporary frog exclusion fencing would be installed at the start of construction to protect identified threatened frog habitat, to prevent frogs entering works areas (including roads and lay down areas) and to minimise direct mortality as a result of the construction/disturbance activities.

The works area for the temporary fencing would be inspected/searched by an ecologist immediately prior to installing the temporary fencing. This search would use active techniques such as raking the leaf litter and inspections around tussocks and logs. A nocturnal survey may be required the night before including call broadcast, depending on the season and prevailing weather conditions.

Temporary frog fencing should be installed at least five (5) days prior to the construction activity/clearing works so that active searches for frogs can be performed within the clearing footprint during the pre-clearing process.

The temporary fencing installation should be inspected and signed off by a suitably qualified herpetologist/ecologist experienced in frog exclusion with a minimum of two years of experience conducting similar projects on the actual or closely related species.

Temporary frog fences should have the following design standards:

a) Installed for up to 200 metres either side of a potential or known threatened frog habitat including streams and breeding sites. Where the terrestrial habitat borders a stream that contains cleared land this could be reduced to 100 metres.
b) Fence height should extend to at least 900 millimetres above the ground (or > 500 millimetres if just for the Green-thighed Frog or the Wallum Froglet) and buried to a depth of between 50 and 100 millimetres.
c) A return of wing of three to five metres to minimise breaches.
d) Constructed using UV resistant shade cloth which is permeable to water.
e) Posts/pegs placed on the works side of the exclusion fence to prevent frogs using these structures to climb the fence.
f) Include relevant signage to identify the area and inform construction personnel.

5.3.4 Constructed ponds

As noted in section 4.3, the targeted surveys would inform the compensatory pond locations and design requirements. Examples of design criteria are provided in section 4.4.2. Compensatory ponds would be constructed during the road construction phase at select sites and routinely monitored to assess effectiveness as described in Chapter 7.

5.3.5 Frog hygiene protocol

The chytrid fungus (*Batrachochytrium dendrobatidis*) is a water borne pathogen that is capable of causing deaths in a range of frogs. It can be spread readily between wetlands and catchments on both personnel and equipment.

It is likely that chytrid fungus is widespread throughout the project area (Kriger 2007) and therefore it would be difficult to determine whether the road upgrade has facilitated pathogen transportation. Despite this, it is recommended that standard measures be implemented to prevent pathogen transportation throughout the project area.

Standard frog hygiene control measures would be implemented for all personnel and equipment that are required to enter threatened frog areas within project sections, as per *NSW Frog Hygiene Protocols* (DECC 2008 – Information Circular Number 6). It should be noted that it would be rare that personnel and equipment would be required to enter these areas given that they would be excluded from the construction areas.

The *NSW Frog Hygiene Protocols* (DECC 2008 – Information Circular Number 6) is provided in Appendix C. It includes the use of a disinfecting solution, containing benzalkonium chloride as the active ingredient, being sprayed on footwear and vehicle tyres. This should be undertaken at a set location and in such a manner so that no disinfectant enters any water bodies. Guidance has also been provided in the *RTA Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects.* The frog hygiene protocol includes:

a) Have water tested by a NATA accredited laboratory.
b) Minimising work during excessively wet or muddy conditions.
c) Programming of works should always move from uninfected areas to infected areas.

d) Set up of exclusions zones with fencing and signage to restrict access into contaminated areas.
e) Induction of all personnel (including visitors) on chytrid management measures for the site.
f) Providing vehicle washdown facilities.
g) Restricting vehicles to designated tracks and trails and parking areas.
h) Providing parking and turn around points on hard, well drained surfaces.
i) Providing boot wash facilities.
j) Disinfecting with cleaning products containing benzalkonium chloride or 70 per cent methylated spirits in 30 per cent water.
k) Disinfecting hands or change gloves between handling of individual frogs and between each site.
l) Only handling frogs when necessary, using the one bag one frog approach.
m) To avoid cross contamination, avoid transferring water between two or more separate water bodies.

These guidelines also outlined frog handling protocols that would be implemented during construction.

5.3.6 Pre-clearing and clearing surveys

Pre-clearing surveys for threatened frogs would occur where threatened frog habitat is to be cleared within the project and where clearing works would be undertaken adjacent to known and potential threatened frog habitat areas. The objective of the surveys would be to capture any frogs trapped in inside the temporary exclusion fencing and relocate to potential habitat outside the clearing limits, where the number of frogs reasonably allows. This may be particularly effective for Giant Barred Frog and Green-thighed Frog, however may not be possible for larger populations of Wallum Sedge Frog if present. This would be assessed on a site by site basis.

As noted in section 5.3.6, within five days of commencing clearing activities an ecologist/herpetologist would inspect/search the clearing footprint to relocate any frogs trapped within the temporary fencing. Searches should last a minimum of one (1) person hour per hectare of habitat that would be likely to be disturbed/cleared. Searches would active searches of the entire habitat such as raking the leaf litter and debris, inspections around tussocks and under logs, tadpole searches and spotlight. A nocturnal survey may be required the night before depending on the season and prevailing weather conditions.

All frogs and tadpoles encountered during the inspection/search would be relocated outside the exclusion fence to a suitable site within the same drainage and in general not more than 300 metres from the capture location. Information about the species, sex, breeding condition and snout-vent length should be recorded.

All frogs would be handled in accordance with the *NSW Frog Hygiene Protocols* (DECC 2008 – Information Circular Number 6) noted in section 5.3.5. Main points from this protocol include:

a) Wear disposable gloves when handling frogs.
b) Place only one frog in each plastic bags.
c) Do not re-use plastic bags.
d) Disinfect any handling equipment and boots when moving between waterbodies.
e) Wash hands thoroughly with disinfectant after handing frogs from one waterbody.
f) Frogs or tadpoles /spawn should not be moved between catchments.

In addition to the pre-clearing survey, immediately prior (within two hours) to the clearing/disturbance activities adjacent to identified populations, an ecologist would conduct active searches. At least 15 minutes of searching per hectare should be undertaken. Searching would be undertaken under rocks, logs, debris and in low vegetation around drainage lines and in depressions.

An ecologist/herpetologist for each relevant section of the project would supervise clearing activities until such as time that they are confident that no threatened frog species remain within the works area.

5.3.7 Unexpected finds procedure

The Roads and Maritime Biodiversity Guidelines unexpected finds process would be adopted as part of the environmental management during construction. This would be required as field surveys are not exhaustive and some frogs can move relatively large distances in short time periods. For example, although the Giant Barred Frog generally has a small home range (Streatfield 1999, Lemckert and Brassil 2000), in some circumstances, such as dispersal events, it has the capacity to move hundreds of metres over a one to two nights.

In general the unexpected finds procedure includes stopping construction activities, recording and removing the unexpected find from within the construction area.

5.3.8 De-watering protocols

In circumstances which require the dewatering of waterbodies that have been identified as threatened frog habitat, the following process would be adopted:

a) The dewatering process must be conducted in accordance with an Environmental Work Method Statement (EWMS) and with the Frog Hygiene Protocols (refer to Appendix C) for the control of disease in frogs.
b) The water body should be waded through by the project ecologist and intensive dip netting should be undertaken to remove as many aquatic fauna as possible. If the water body is too deep to effectively do this prior to pumping, then pumping should be ceased once the water body is shallow enough to allow effective wading and intensive dip netting conducted at this time.
c) The intake pipe must be placed in the deepest part of the water body if the water body is to be pumped dry.
d) A screen should be installed over the pump intake (at least 5 millimetre mesh size) to prevent tadpoles being sucked into the intake pipe.
e) All tadpoles would be identified where possible to species placed into separate holding containers.
f) All tadpoles should be released in nearby pools in adjacent habitat. Tadpoles should be acclimatised to the water temperature in the new location by immersing bags or holding containers for a minimum of 30 minutes.
g) In instances where there are numerous tadpoles from a wide range of species, preferential treatment would be given to threatened species.

5.3.9 Permanent frog exclusion fencing

Permanent frog fencing would be installed where there is a high chance of threatened frogs accessing the carriageway. Details on the location and extent of frog fencing would be informed by the targeted surveys and would generally follow the areas where temporary fencing would occur.

Fences have been designed as part of the detailed design phase for the Woolgoolga to Glenugie (W2G) project. Frog fencing on the W2B project would be the same as for W2G. Example of the types of frog exclusion fencing that could be installed are provided in Figure 5-1 and Figure 5-2 below. Note that the fence shown in Figure 5-1 was specifically designed for the Green-thighed Frog and would probably also be suitable for other small frog species. It was also identified for the W2G project that the standard fauna fence would be adequate for the Giant Barred frog.

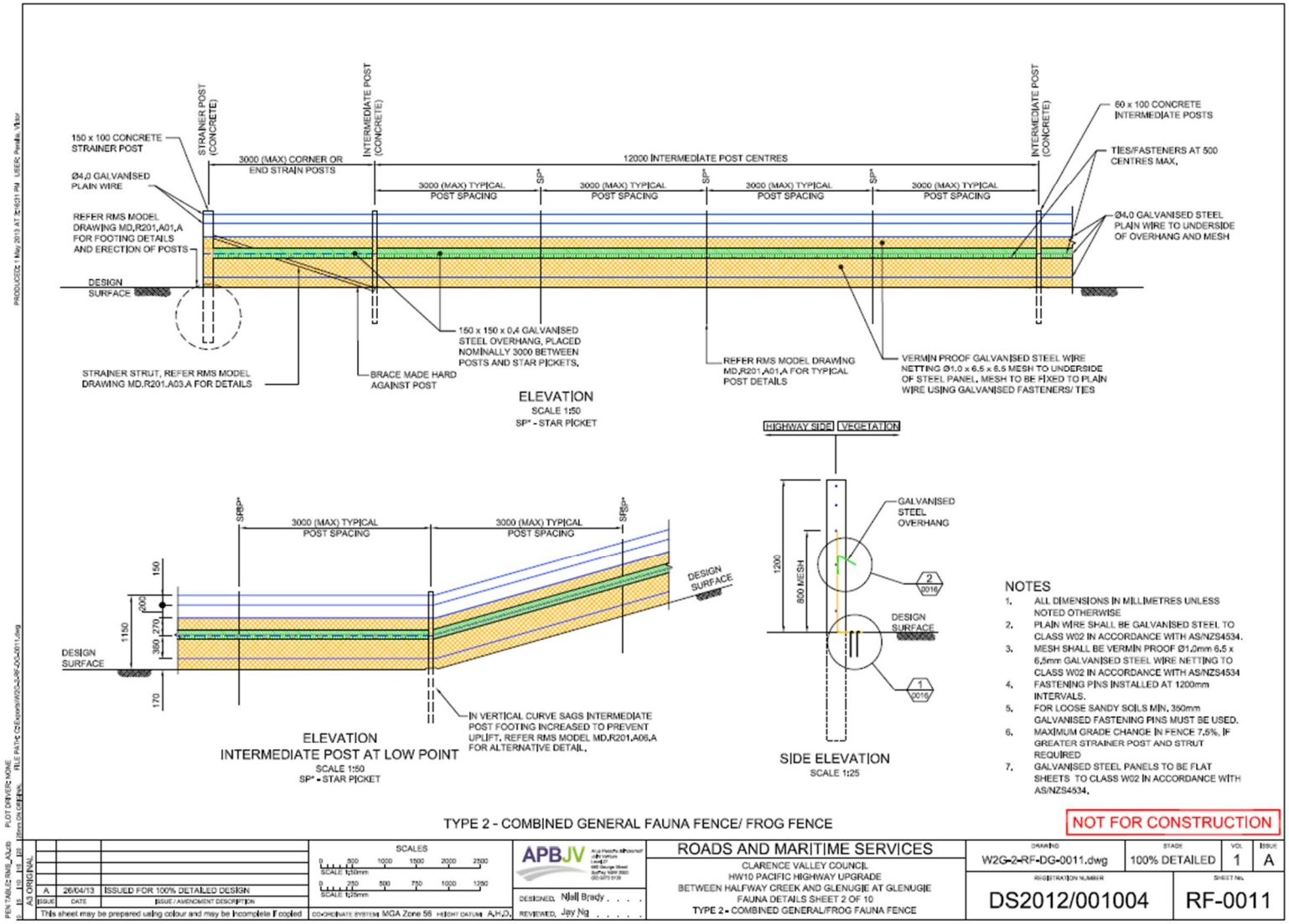


Figure 5-1 Example Type 2 general fauna/frog exclusion fence design (as per W2G detailed design)

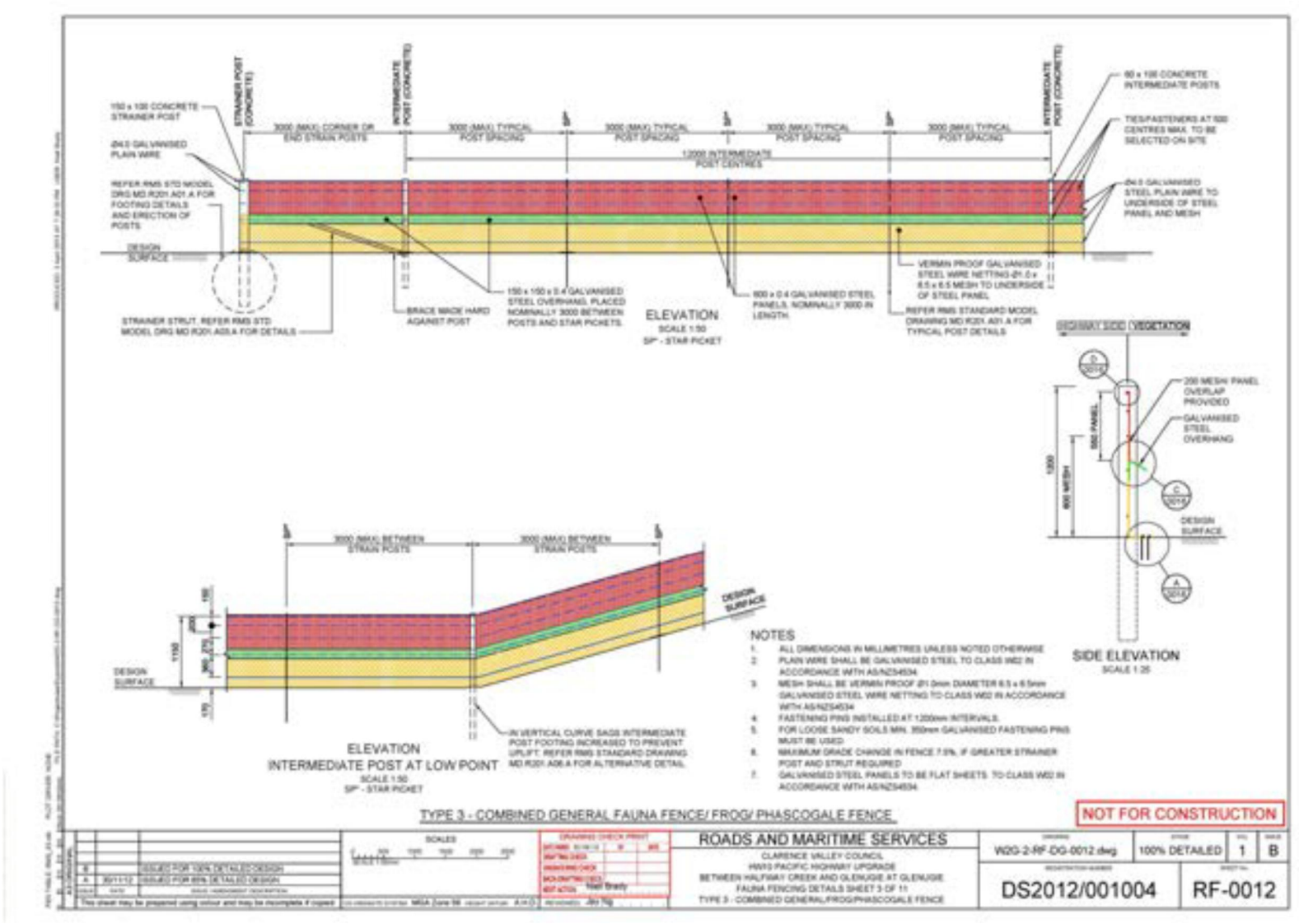


Figure 5-2 Example Type 3 general fauna/frog exclusion fence design (as per W2G detailed design)

5.3.10 Connectivity structures

Road crossing structures have been shown to reduce fauna mortality rates and to reduce the habitat fragmentation impacts of linear infrastructure. However the extent to which these are effective for frogs remains unclear.

Underpass crossing structures have been included in the design to target a range of fauna species which includes frog and many of these are combined drainage and fauna crossing structures in wetland and creek areas well suited to the target species. Structures targeting threatened frogs include:

- Dedicated fauna underpasses
- Combined drainage and fauna crossing structures.

Fauna connectivity structures and design principles, proposed locations and target species have been described in the Biodiversity Working Paper - Biodiversity Connectivity Strategy Appendix A (Tables A-3 and A-4) (Roads and Maritime 2012). Descriptions for structures targeting threatened frogs have been identified for the concept design and these are summarised in Table 5-1.

Table 5-1 Fauna crossing structures targeted at threatened frogs

Project section	Proposed fauna crossing structures
1-2	A combination of dedicated and combined fauna crossing structures were designed in key habitat and corridor locations, which included the following. • Five bridges with fauna passage beneath and retained along river banks • Twenty combined drainage / fauna passage culverts in wet areas • One dedicated underpass in swamp forest
3-5	A combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations which include the following. • Thirteen bridges with fauna passage beneath and retained along river banks • Eleven combined culverts in wet areas designed for combined drainage and fauna crossing capabilities
6-7	A combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations, which included the following: • Three bridges including two across identified major waterways and potential habitat for Oxleyan Pygmy Perch. • Three combined culverts in wet areas designed for combined drainage and fauna capabilities
8-11	• Two frog and small mammal underpasses (1.2 x 1.2 m) near to paperbark swamp and wetland vegetation within Broadwater National Park corridor • Four viaducts about 20 metres long between the Richmond River and Coolgardie Road • Three bridges with fauna passage beneath and retained along river banks • Twelve drainage culverts minimum 1.2 metres high between the Richmond River and Coolgardie Road (with a further six culverts minimum 0.9 metres high)

5.3.11 Weed management

A separate weed management plan would be developed for each staged section of the upgrade, as part of the CEMP to provide guidance for preventing or minimising the spread of noxious and environmental weed species during pre-construction, construction and operation. The plan would outline weed management measures to be implemented during construction.

In general, weed management plans include descriptions and mapping of major weed infestations identified during pre-clearing surveys, with appropriate management actions outlined to be implemented for each infestation. The details in the weed management plans would most likely vary for each section of the project but would include:

- Taxa and potential sources of the weed species.
- Weed management priorities and objectives.
- Sensitive environmental areas within or adjacent to the site.

- Location of weed infested areas.
- Treatment and removal methods for all weed species of national significance.
- Mechanical weed control methods such as slashing or mowing, as well as where suitable a range of herbicides to avoid the development of herbicide resistance.
- The use of herbicides should be carefully considered near populations of threatened frogs, give that
- Measures to prevent the spread of weeds.
- A monitoring program to measure the success of weed management.
- Strategic management with adjacent landowners.
- Appropriate disposal of weed infested materials and soils to be identified in the CEMP.
- Communication strategies to improve contractor awareness of weeds and weed management.

Details on monitoring the performance of weed management as well as corrective actions to be implemented in instances of change from performance measures are provided in the weed management plan.

5.3.12 Sedimentation fencing

Detailed site specific erosion and sediment control plans would be prepared as part of the CEMP and FFMP for each section of the project. Appropriate sediment fences would be erected around any threatened frog habitat where works are adjacent to the project.

These details would be further designed on a site specific basis as part of the CEMP following the outcomes of the targeted surveys. These measures would be important in maintaining the current condition of threatened frog habitats, particularly near wetlands, swamps and creek lines.

Sedimentation fencing would be monitored regularly and repaired if damaged or filled with trapped sediment.

5.3.13 Managing water quality

Procedures would be implemented to maintain water quality during construction, which would be included in the CEMP. These measures would be important in maintaining the current condition of retained threatened frog habitat areas and include:

- Controlled access to watercourses by construction workers and vehicles.
- All refuelling and maintenance to be undertaken in designated bunded areas away from overland flow paths and low-lying areas.
- Specific measures for water detention basins including appropriate discharge where necessary.

5.4 Performance measures and corrective actions

Table 5-2 summarises the construction environmental planning measures for frogs and corrective actions if the measure deviates from the performance criteria.

Table 5-2 Mitigation measures, performance measures and corrective actions - construction

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Low rate of injuries to threatened frogs during clearing works.	• Installation of temporary fencing. • Active frog searches five days prior to clearing activities as detailed in section 5.3.5. • Ecologist present during clearing activities.	Prior to and during clearing works	High rate of threatened frog mortality during clearing works (a high rate of mortality would be defined as greater than three confirmed deaths as a result of the clearing works for each individual upgrade section)	• Stop clearing works and check temporary fencing for breeches. If breeches found repair. • Conducting additional active searches for frogs.
No injuries to or mortality of threatened frogs during construction as a result of vehicle collisions.	• Temporary frog exclusion fencing in place during construction. • Unexpected finds procedure.	Weekly inspection of exclusion fencing.	• Temporary exclusion fencing not installed prior to construction commencing. • Injured or dead frogs found during construction. • Unexpected find.	• Delay construction until temporary exclusion fencing has been installed. • Stop works, investigate and review the exclusion fencing requirements, repair breeches and update as appropriate. • Conducting additional active searches for frogs.
No injuries to frogs that need to be handled.	Fauna handling procedure.	Event based. During clearing works.	Frog mortalities noted during clearing works.	• Stop work and reinforce the fauna handling procedure. • Review fauna handling procedure and update as required. • Review need for further active surveys within the construction area.
Minimise movement of chytrid fungus between sites.	Frog hygiene protocol.	Measures to minimise the spread of chytrid fungus to be implemented during construction if chytrid fungus is found in a construction area.	Non-compliance with hygiene protocols by construction vehicle operators	• Implement chytrid fungus mitigation measures prior to construction. • Ensure all staff have been trained in frog hygiene protocol. • Stop, evaluate and change methods/protocols, consider testing water to identify source.
Low rate injuries or mortality of threatened frogs as a result of dewatering activities.	• De-watering protocol. • Frog hygiene protocol.	Event based.	• Fauna handling procedure not developed and implemented. • De-water protocol not developed and implemented. • Injured or dead frogs and tadpoles found during dewatering activities.	• Delay dewatering activities until a fauna handling procedure and de-watering protocol have been developed. • Ensure all relevant staff are trained in the de-watering protocol and fauna handling procedure. • Stop and evaluate dewatering protocol if effectiveness is low (greater than approximately 1% of frogs and tadpoles from the site dying during dewatering).

6. Operational management measures

6.1 Potential impacts during operational phase

- Direct mortality from vehicle strike.
- Degradation of habitat values due to edge effects, predominantly an increase in weeds, loss of riparian or aquatic plants.
- Changes in hydrology or water quality as a result of road construction leading to a degradation of habitat.
- Loss of connectivity and access to important habitats.
- Increased dispersal opportunities or habitats for feral species, in particular Cane Toads.

6.2 Main goals for management

- No ongoing degradation of known threatened frog habitat adjacent to the project.
- No mortality of threatened frogs from vehicle strike adjacent to known habitat areas.
- Maintenance of frog access to important habitats, demonstrated use of connectivity structures.
- Use of constructed compensatory ponds by threatened frogs.

6.3 Management measures

6.3.1 Habitat revegetation

Revegetation works would be incorporated into the landscape plans and would be undertaken following construction in any areas disturbed within the road corridor that are adjacent to identified important threatened frog habitats or beyond if the habitat is located within properties owned by Roads and Maritime. This may include ponds, ephemeral areas, creek riparian areas, culvert and bridge locations to restore connectivity, and wetlands within the road corridor to minimise edge effects. This may also include sediment and water treatment ponds and immediate surrounds where these occur adjacent to identified important threatened frog habitats. Finally it would also include any compensatory ponds constructed that were revegetated.

Consideration of the threatened frog species located adjacent to revegetation areas would be required to ensure suitable plant species are used to revegetate these areas suited to the threatened frog species.

6.3.2 Maintenance of frog exclusion fencing

Roads and Maritime would conduct periodic monitoring and maintenance of frog exclusion fencing including checking frog exclusion fences after floods to ensure integrity. The program would include ongoing inspections of the structures as part of the standard maintenance requirements for stability and damage and replacement where necessary. Monitoring would also be conducted in response to observations and reports of frog road kills in the vicinity of the important frog habitats and exclusion fencing. The need for further monitoring would be reviewed after the initial five years.

6.3.3 Maintenance of fauna connectivity structures

Roads and Maritime would conduct periodic monitoring and maintenance of dedicated and combined underpasses. The program would include ongoing inspections of the structures as part of the standard maintenance requirements for stability and damage and replacement where necessary. Refer to section 7.4 for details on how the periodic monitoring would be undertaken.

Monitoring would also be conducted in response to observations and reports of frog road kills in the vicinity of the important frog habitats, culverts and corridors.

6.3.4 Maintenance of compensatory ponds

Constructed compensatory ponds would be maintained routinely (e.g. once a quarter) if the monitoring program identifies that the ponds are not being used or do not meet the relevant design criteria. This may include ensuring that planted fringing vegetation has been maintained appropriately and to ensure water quality and soil condition is suitable for threatened frog presence. Refer to section 7.5 for details on how the periodic monitoring would be undertaken.

6.3.5 Weed management

The Ecological Monitoring Program outlines the weed management and monitoring measures to be implemented post-construction. The noxious weeds and environmental weed infestations monitored during construction would inform the operational weed monitoring locations. Refer to the Ecological Monitoring Program for details on operational weed management and monitoring.

6.4 Performance measures and corrective actions

Table 6-1 summarises the operational environmental planning measures for threatened frogs and corrective actions if the measure deviates from the performance criteria.

Table 6-1 Mitigation measures, performance measures and corrective actions - operation

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
No ongoing degradation of known threatened frog habitat adjacent to the project.	Habitat revegetation / landscaping design. Weed control.	As per section 6.3 maintenance measures.	Revegetation failing, (e.g. > 30% cover, plant dieback). Weed cover surrounding habitat more than 30%.	Review and increase maintenance time and frequency if required. Replace lost plants. Increase monitoring frequency.
No mortality of threatened frogs from vehicle strike adjacent to known habitat areas.	Maintenance of permanent frog exclusion fencing. Checking of fences after floods to ensure integrity.	Routine (i.e. quarterly) monitoring of permanent exclusion fencing. Monitoring would also be conducted in response to observations and reports of frog road kills in the vicinity of the important frog habitats, culverts and corridors.	Threatened frog road kill reported near frog exclusion fencing.	Check permanent frog exclusion fencing for breeches. Repair breeches within three days of inspection. Re-evaluate strategies if threatened frogs continue to avoid structures.
Maintenance of frog access to important habitats, demonstrated use of connectivity structures.	Maintenance of frog connectivity structures or corridors to allow connectivity between populations, including the removal of debris from culverts.	Routine (i.e. quarterly) monitoring of culverts and corridor structures. Monitoring would also be conducted in response to observations and reports of frog road kills in the vicinity of the important frog habitats, culverts and corridors.	Threatened frog road kill reported near important habitat areas. Connectivity structures not being used by threatened frogs. Number of sightings necessary to determine if structures are being successful Routine (i.e quarterly) monitoring/maintenance finds high sediment or debris build-up in culverts.	Remove any obstructions as soon as possible following inspection / reported threatened frog deaths. Re-evaluate connectivity structures if threatened frogs continue to avoid structures.
Use of constructed compensatory ponds by threatened frogs.	Provision of compensatory frog ponds.	Routine (i.e. quarterly) monitoring of compensatory ponds to ensure that fringing vegetation is in good condition, and water quality and hydroperiod are suitable, as per Chapter 7.	Revegetation failing, (e.g. > 30% cover died, plant dieback). Water quality or hydroperiod unsuitable for frog presence. A minimum of 20% of the original number of frogs at the impacted pond using the compensatory pond for at least 3 years and that successful reproduction in the form of tadpoles reaching metamorphosis be recorded.	Increase maintenance time and frequency if required. Replace lost vegetation. Complete site specific investigation to ensure that water quality and hydroperiod is suitable. Review monitoring program, consider conditions during surveys and re-evaluate. Check water quality and vegetation condition. Revegetate if required. Provisional measures such as additional ponds should be considered.

7. Monitoring program

7.1 Objectives

The objectives of the monitoring program are to:

- Evaluate the success of mitigation measures for threatened frogs (frog exclusion fencing, underpass structures, constructed ponds and habitat revegetation).
- Further understand the habitat requirements of the threatened frog species in the locality.
- Confirm the extent of secondary impacts on populations of threatened frog species including the presence of Mosquito Fish populations and habitat degradation and identify any additional mitigation measures that may minimise these impacts.

The monitoring program has been designed to continue until the mitigation measures are proven to be effective over three consecutive post-construction monitoring periods. This program and methods described in this chapter can be refined over time, subject to progress against the above matters. The location of impact and control sites would be determined by the targeted surveys and reported in the targeted survey report for each upgrade section. To provide a statistically robust design, a minimum of five independent sites in each experimental category (i.e. control, impact) should be used.

There would be potential for natural variation in populations of threatened frog species for a range of reasons. Further monitoring/assessment would be undertaken if a decline of population numbers of threatened frogs is identified as being attributable to the construction and operation of the road, hence the intentional use of control sites. This monitoring/assessment would identify the cause of the decline and/or remedial actions to be commenced as necessary, taking into account potential causes such as dry seasons, population fluctuations and other natural variation. The monitoring/assessment would be dependent upon the monitoring already conducted prior to the decline being noted. Any contingency measures to be implemented would be agreed to by the relevant regulatory authorities (OEH and DSEWPaC) prior to being commenced.

7.2 Population monitoring

This program is based on a BACI (Before-After-Control-Impact) design to confirm the effectiveness of the mitigation measures at maintaining *in situ* populations of threatened frogs. It follows a mitigation-construction BACI design, with populations compared at (1) five (if possible) control sites away from the road, (2) five (if possible) control sites along the highway (existing or new road) with no mitigation measures, and (3) five (if possible) impact sites (known habitat sites) with mitigation measures.

7.2.1 Methods and duration

The objective of the frog monitoring program would be to confirm the status and condition of the threatened frog populations adjacent to the project in known population sites identified by the targeted surveys.

The survey methodology for each species is described in section 4.3 and is based on transect counts and at optimum detection times for each of the three target threatened frog species. Construction and post-construction monitoring would be undertaken twice annually using the methods described in Chapter 4 and compared with pre-construction data at control and impact sites. The performance of the mitigation measures would be assessed against the thresholds described in section 7.2.2 and corrective measures implemented where population declines can be demonstrated as attributable to the project.

In order to demonstrate effectiveness the success of the mitigation measures would need to be shown over three consecutive post-construction monitoring periods. Conversely in the event that population declines are detected the monitoring program may need to extend greater than two to three years and up to five years to confirm this (Lewis & Goldingay 2005). At this point the need for future monitoring or other provisional measures would be evaluated in consultation with the relevant regulatory authorities.

The monitoring program should be sufficient to give a reasonable confidence of the condition of relevant frog populations (although it is important that the methodology outlined in Chapter 4 is followed, in particular in relation to the timing of surveys). Comparisons of presence/absence data between pre-construction monitoring and post-construction monitoring are critical indicators of the impacts of construction activities on threated frog populations. However it should be noted that population count data that comes out of the transect counts will be used in the BACI study to determine if there has been any declines in impacted populations.

7.2.2 Performance indicators and corrective actions

Should it become clear that sites that were occupied prior to road construction have become unoccupied, or abundance (estimated using the transect counts) has declined at impacted (but not unimpacted) sites, corrective actions must be implemented. Performance indicators and corrective actions are outlined in Table 7-1.

Table 7-1. Performance thresholds and corrective actions for population monitoring

Performance indicator	Corrective actions
The absence of threatened frogs at sites identified as occupied in the targeted surveys.	Review monitoring methods, considering further monitoring and assessment should there be a decline in population abundance.
A 25% decline in abundance of frog populations over 5 years . Frog abundance determined by transect call and visual observation counts (as outlined in Section 4.3).	To be confident that declines are due to the road itself (and not general declines), consideration of other factors (i.e. natural variability) in population changes is necessary. To do this, comparison against control sites would be required. Consider potential for natural variation to be responsible for decline in population numbers/density (compare against control sites). Investigate efficacy of frog exclusion fencing. Ensure that habitat conditions are suitable, in particular hydrology (hydroperiod) and water quality and vegetation.

7.3 Frog exclusion fencing

7.3.1 Methods, timing, intensity and duration

Monitoring would be conducted by a suitably qualified and experienced ecologist with at least two years of experience assessing the suitability of frog exclusion fencing with similar species to confirm the efficacy of the frog exclusion fences. Surveys of frog exclusion fencing would be conducted at suitable times of the year when frogs are likely to be active (i.e. likely when monitoring is occurring, refer to section 4.3).

A Control-Impact (CI) approach would be used. At each monitoring location, at least five (if possible) monitoring sites (within and either side of the exclusion fence) and at least five (if possible) control sites would be established. Control sites include locations along the road where there is no exclusion fencing. Monitoring of control sites would utilise broadly the population survey methods outlined in section 7.2. As frogs would be unlikely to be calling adjacent to exclusion fences, active searching would be required. Captured frogs would be handled as per the fauna handling procedure and frog hygiene protocol in Appendix C.

If suitable times are chosen for monitoring and provided populations are large enough, evidence of the effectiveness of exclusion fencing should be statisically clear. If populations are small, or movement behaviour is not evident, determining the effectiveness of exclusion fencing may be difficult. An indicative level of movement behaviour would be able to be confirmed from control sites, but factors such as population size should be considered (i.e. large populations would be likely to lead to higher number of frogs movements).

7.3.2 Performance indicators and corrective actions

Should high levels of road mortality be identified in close proximity to exclusion fencing corrective actions must be considered. Performance thresholds and corrective actions are identified in Table 7-2.

Table 7-2 Performance thresholds and corrective actions for exclusion fencing monitoring

Performance thresholds	Corrective actions
No detectable change in the numbers of frogs associated with areas controlled by frog fencing.	Review monitoring methods, considering increasing frequency, intensity and duration, to ensure individuals are identified. Review fencing and ensure any breeches are repaired. Review the location of the fencing to identify of additional fencing is required.

7.4 Underpass structures

7.4.1 Methods, timing, intensity and duration

Monitoring would be conducted by an experienced frog ecologist to confirm the efficacy of connectivity structures. Connectivity structures for the Giant Barred frog are planned for Section 1 to 3 and 6 to 7 of the project.

Surveying connectivity structures would be conducted at suitable times of the year when frogs are likely to be active (i.e. likely when breeding pond monitoring is occurring, refer to section 4.3).

A Control-Impact (CI) approach should be used. At each monitoring location, at least five (where possible) monitoring sites (within and either side of the crossing structure or exclusion fence) and at least five (where possible) control sites would be established. Control sites would be locations along the road where there are no crossing structures.

Monitoring of connectivity structures for Giant Barred frogs would be conducted in Sections 1 to 3 and 6 to 7 of the project. As discussed targeted surveys would be required at potential or pre-selected monitoring locations to confirm the presence and abundance of the target species and hence inform optimal monitoring locations where sufficient data can be collected for statistical analysis.

Monitoring of control sites would use broadly the population survey methods outlined in section 7.2. As frogs would be unlikely to be calling from connectivity structures, active searching of these structures would be required.

Time lapse cameras would also be installed where conditions are suitable (sufficient light etc.) to detect usage.

If suitable times are chosen for monitoring and provided populations are large enough, evidence of the effectiveness of connectivity structures should be clear. If populations are small, or movement behaviour is not evident, determining the effectiveness of crossing structures may be difficult. An indicative level of movement behaviour would be able to be confirmed from control sites, but factors such as population size should be considered (i.e. large populations are likely to lead to higher number of frogs moving).

7.4.2 Performance indicators and corrective actions

Should evidence of frogs not using crossing structures emerge or high levels of road mortality be reported, a number of corrective actions must be considered. Performance thresholds and corrective actions are identified in Table 7-3.

Table 7-3 Performance thresholds and corrective actions for underpass structures

Performance thresholds	Corrective actions
The use of the structure by a minimum 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts not clogged with debris or sedimentation).	Review monitoring methods, considering increasing frequency, intensity and duration, to ensure individuals are identified. Investigate habitat adjoining the connectivity structures and consider improving. Ensure crossing structures are adequately maintained, i.e. fencing is not damaged, and connectivity structure is operating correctly. Provide additional frog fencing if deemed to be required.

7.5 Constructed ponds

7.5.1 Methods, timing, intensity and duration

Compensatory ponds constructed for the project would be monitored as part of the ongoing monitoring program and are to refer to this program for timing. The monitoring would include undertaking a diurnal nocturnal survey including spotlighting, and active dedicated searches for adult frogs and tadpoles which would be undertaken at the optimum time and in optimum conditions (as described in section 4.3. Other data to be collected at each monitoring event would include:

- A photograph taken during daylight hours of the pond.
- A visual assessment of the condition of the aquatic vegetation growth (macrophytes).
- The presence of Mosquito Fish.
- Whether water is present or absent and a visual assessment of water quality, recording details of rainfall data over the preceding month.

7.5.2 Performance thresholds and corrective actions

Where compensatory ponds have been constructed monitoring would be undertaken to confirm if the ponds have been used by threatened frogs as breeding habitat. Performance thresholds and corrective actions are outlined in Table 7-4.

Table 7-4 Performance thresholds and corrective actions for constructed ponds

Performance thresholds	Corrective actions
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (ie 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving (if possible) and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.

Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation. No persistent water present in ponds despite recent rainfall	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality. Assess possible causes for water draining from the pond and apply physical corrective actions
Mosquito Fish present and threatened frogs / tadpoles absent	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.
Constructed habitat suitable for frogs (e.g. wetlands have a suitable hydroperiod, water quality and associated vegetation). Revegetated native habitat in good condition (e.g. <30% cover died, plant dieback). Frog presence confirmed during monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydroperiod.

7.6 Riparian habitat revegetation

7.6.1 Methods, timing, intensity and duration

Any stream or wetland areas or other critical habitats identified in the pre-construction surveys that are to be disturbed during construction (for example areas next to culverts or bridges) would need to be suitably revegetated. The objective of the monitoring program would be to ensure that those revegetation measures have been effective over time. It may be unsuitable to have a 'before' or 'control' comparison with rehabilitated or revegetated wetlands. In these cases, monitoring would be conducted to ensure that habitats become or remain suitable for frogs following their construction/rehabilitation.

Quantitative habitat surveys would be undertaken at each of the threatened frog monitoring sites identified during the targeted surveys. To complete the survey, transects would be established perpendicular to the channel or wetland at each site. The number and location of these transects would be identified on a site by site case and may include dividing the site into even segments and then randomly selecting a point in each segment. Wetted width and average water depth would be measured along each transect.

Four 0.5 m^2 quadrats would be randomly positioned along each transect. Fewer quadrats may be used in channels that have a wetted width of less than 2.5 metres or small wetlands adjacent to the project corridor. Substrate composition, woody debris cover and vegetation cover would be estimated within each quadrat and pooled for each transect. Aquatic plants in each quadrat would also be identified and recorded.

Transects would also be randomly positioned along each stream bank to estimate the amount of root masses, undercut bank, vegetation overhang and riparian vegetation cover at each site. The total length of the transect would equal approximately 20 per cent of the wetted perimeter at each site.

Photo points would be established at each site with a GPS and repeat photographs would be taken from the same location on each survey. Biannual surveys would be undertaken until such time as it can be established that the habitat has been restored effectively. Habitat surveys would be conducted at the same time as population surveys

7.6.2 Performance indicators and corrective actions

Any habitat changes that have been identified at construction sites or downstream of the construction area that was not also evident at sites immediately upstream of the project would be attributed to the construction or operation of the project. Such results would trigger immediate investigation into the specific cause so that appropriate remedial action can be taken such as replanting, replacing lost trees, weeding and physical modification.

The main performance thresholds and corrective actions have been outlined in Table 7-5.

Table 7-5 Performance thresholds and corrective actions for riparian habitat revegetation

Performance thresholds	Corrective actions
Good quality habitat restored in and surrounding the receiving site. Evidence that maintenance is carried out each year. At least 60% of the planted riparian vegetation is surviving after the first year.	Review steam / wetland revegetation areas maintenance procedures, assess the threats to the plants, and modify maintenance or other threats where necessary and possible. Conduct replanting to replace lost plants. Physical measures to halt bank erosion.

7.7 Evaluation, project review and reporting

Reports would include:

- The results of the population surveys for detailed design of each project including mapping the location and extent of habitats and populations and baseline data for inclusion in the project monitoring program.
- Annual reporting include an analysis of the data to determine if change has taken place and/or demonstrate if there is enough power to detect the specified levels of unacceptable change.
- Reporting annual results during the construction phase including the results of the monitoring program of a minimum of two night sampling per site for all species, except for the Giant Barred Frog, which requires a minimum of four nights sampling per site (DEWHA 2010).
- Reporting any change to performance indicators and how these were addressed in terms of actions implemented.

7.7.1 Responsibility

The ecologist/herpetologist employed to undertake the threatened frog species monitoring for each relevant project section would be responsible for the evaluation of the monitoring information collected. The ecologist/herpetologist would have at least two years of experience completing similar monitoring programs with closely related frog species.

7.7.2 Timing

A brief annual report would be prepared by the contractor for distribution to the Roads and Maritime and other relevant government agencies (DP&I, OEH and DSEWPaC) regarding the annual population counts. Separate reports would be prepared for each project built relevant to the target species.

A final report would be prepared at the conclusion of the monitoring period for each project built. This report would incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long-term survival of the Green-thighed frog, Wallum Sedge frog and Giant Barred frog populations in the locality.

8. Summary table and implementation schedule

Table 8.1 provides an overall example summary of the actions proposed in the above plan. It also identifies the person responsible for the actions and the estimated timing of the project.

The program schedule would be updating following a review of the approval and project timelines.

Table 8-1: Summary table and implementation schedule of management plan

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre-construction management									
1.1	Targeted surveys	Ecologist	X						
1.2	Identify frog exclusion fencing locations	Ecologist	X						
1.3	Identify frog compensatory pond locations	Ecologist	X						
1.4	Ancillary facilities	Contractor	X						
2. Construction management									
2.1	Work method statements	Contractor		X					
2.2	Inductions and training	Contractor		X					
2.3	Temporary frog fencing	Contractor		X					
2.4	Construction of compensatory ponds	Contractor		X					
2.5	Frog hygiene protocol	Contractor		X					
2.6	Pre-clearing and clearing surveys	Contractor		X					
2.7	Unexpected finds procedure	Contractor		X					
2.8	De-watering protocols	Contractor		X					
2.9	Permanent frog exclusion fencing	Contractor		X					
2.10	Connectivity structures								
2.11	Weed management	Contractor		X					
2.12	Sedimentation fencing	Contractor		X					
2.13	Water quality	Contractor		X					
3. Operational management									
3.1	Habitat revegetation	Roads and Maritime			X	X	X	X	X
3.2	Maintenance of frog exclusion fencing	Roads and Maritime			X	X	X	X	X
3.3	Maintenance of connectivity structures	Roads and Maritime			X	X	X	X	X
3.4	Maintenance of compensatory ponds	Roads and Maritime			X	X	X	X	X
3.5	Weed management	Roads and Maritime			X	X	X	X	X
4. Operational monitoring program									

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
4.1	Population monitoring	Ecologist	X	X	X	X	X	X	X
4.2	Exclusion fencing monitoring	Ecologist	X	X	X	X	X	X	X
4.3	Underpass monitoring	Roads and Maritime		X	X	X	X	X	X
4.4	Riparian habitat revegetation	Roads and Maritime		X	X	X	X	X	X
4.5	Evaluation and reporting	Ecologist	X	X	X	X	X	X	X

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10. Acronyms and abbreviations

Acronym / Abbreviation	Description
D&PI	Department of Planning and Infrastructure
OEH	The NSW Office of Environment
DSEWPaC	The Department of Sustainability, Environment, Water, Population and Community
Roads and Maritime	Roads and Maritime Service
DECC	Department of Environment and Climate Change (now called OEH)
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* – Commonwealth legislation
TSC	*Threatened Species Conservation Act 1995* – NSW legislation
Project area	The area that is to be impacted by the construction of the road

Appendix A – Dr F. Lemckert CV

FRANK LEMCKERT BSc, MSc, PhD

Team Leader - Ecology

Professional Memberships

- Australian Society of Herpetologists (President)
- NSW Declining Frogs Working Group (Secretary)
- Royal Zoological Society of NSW
- American Society of Icthyologists and Herpetologists

Qualifications

- Bachelor of Science – University of Sydney
- Masters of Science (Zoology) – University of the Sydney
- Doctor of Philosophy (Zoology) – University of Newcastle (NSW)

Employment History

2011-present	Team Leader - Ecology, Niche Environment and Heritage Pty Ltd
1995-2011	Research Scientist, State Forests of NSW
1993-95	Scientific Officer, NSW Forestry Commission
1992-93	Technical Officer, NSW Forestry Commission
1992	Technical Officer, NSW National Parks and Wildlife Service
1987-1991	Demonstrator, School of Biological Sciences University of Sydney

Career Overview

Frank has been a professional scientist since 1992, specialising in the ecology and management of frogs and the management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland) establishing long-term research and monitoring programs into the management of forest fauna and developing strategies to mitigate the impacts of human disturbances on threatened fauna. He has worked extensively with the NSW state and Federal Governments on varying issues of fauna management and written reports and recovery plans. He is experienced in the application of state and federal legislation which relates to the conservation of threatened species and communities, having been directly involved in the assessment of major Environmental Impact Statements and Fauna Impact Assessment.

Frank also has a long and ongoing interest in education and wildlife training, heading the Forests NSW Wildlife School Training Program, which he continues at Niche. He coordinates all of the courses as well as providing large elements of the teaching program. He continues to have regular involvement in teaching senior biology students at several Universities.

Frank has been the author on over 100 scientific publications and reports including invited authorship for chapters in international book series. He has also undertaken more than 50 presentations at National and International conferences.

As the project manager for both large and small projects, Frank has been required to develop methodology, co-ordinate multi disciplined field teams, prepare reports incorporating results from several disciplines and maintain effective communication with the client and various regulatory and/or public authorities.

Professional Vision

To significantly contribute to the sustainable management of Australia's natural resources and promote a greater awareness and understanding of the unique natural history of this country. To provide scientifically based and sound advice on the management of fauna to ensure the survival of our fauna and flora whilst allowing continued use of Australia's natural resources.

Skills

- Ecological surveys, assessment and monitoring
- Herpetology
- Project management
- Environmental approvals
- Expert witness and peer review
- Government agency consultation and advocacy
- Impact minimisation (mitigation)
- Leadership in education course development and management
- Post-graduate Student Supervision

Key achievements/ flagship projects

Pacific Highway Upgrades: Karuah to Coolongoolook, 1997-Current

Frank has been the scientist that has developed investigations into the management of the Green-thighed Frog along this section of the Pacific Highway. He coordinated a major study of the species in the region and provided advice on specific management strategies. He has maintained an ongoing monitoring program of the species leading to further refinements in their management and assessments of success of the mitigation works.

Princess Highway Upgrades: South Nowra 2011 - Current

Frank has been involved in the recent survey and assessments of the impact of this Upgrade on the Green and Golden Bell Frog that has been located along the Upgrade. Frank was directly involved in the writing of the EPBC and EP&A/TSC Act assessments, an EPBC Referral and is assisting in the development of suitable mitigation works and monitoring to manage the ongoing works.

Princess Highway Upgrades: Gerringong 2011 - Current

Frank has been involved in the recent survey and assessments of the impact of this Upgrade on the Green and Golden Bell Frog and the Fishing Bat and has written a management plan for the bat to assist in its translocation from a bridge that is to be removed. He is also part of the ongoing monitoring of this species.

Forests NSW Environmental Impact Statements, 1991-95

Frank oversaw the review of Environmental Impact Statements and associated Fauna Impact Statement prepared to cover all of the forestry areas of NSW. This required liaison with Government Departments and experts in the field of fauna management and to review all documentation to ensure that statutory and legal requirements were met and that the best available scientific information was used to complete the assessments.

Forests NSW Fauna Monitoring Strategy, 2008-2011

Frank assisted in the development of the broad-scale fauna monitoring program for Forests NSW for use across its estate. In particular, he developed alternative strategies to monitor frogs and undertook the pilot program for reptile monitoring in the Pilliga Forests of northwest NSW.

Relevant Papers

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Appendix B – Dr F. Lemckert Review

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19th September 2013

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Dear Tina

RE: REVIEW OF THE THREATENED FROG MANAGEMENT PLAN FOR THE WOOLGOOLGA TO BALLINA UPGRADE OF THE PACIFIC HIGHWAY

Please find following my completed review of this document. I have finalised the document by noting those changes that are recommendations and those that are suggestions. If you have any questions in regard to this review, please do not hesitate contacting me.

Yours Sincerely

Frank Lemckert
Niche Environment and Heritage

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Review of Woolgoolga to Ballina/Pacific Highway Upgrade Threatened Frog Management Plan

I would like to acknowledge a few points about this review of the Threatened Frog Management Plan (TFMP):

- I have been deliberately hard in my review, raising even small points for consideration. I consider that this is important as it will avoid challenges to aspects of the work as it is applied during the various stages of the Upgrade.
- I have raised a number of points that relate to the generic nature of advice provided that I feel make this MP too open in this advice. I accept that it is often and clearly stated that more detail will be provided in the final MPs for each Upgrade section, but clearer guidance in this plan will provide for less unneeded and confusing variability in actions carried out in the various final section MPs. This will look more professional for the RMS, at least in my opinion.
- Following on from this, I would much prefer to see specific measureable targets set in the TFMP rather than use general terms of success.
- I attempt to base and/or support all of my comments on published materials with referencing that inform those comments. Where this is not possible, I prefer to at least use unpublished, but still available works and attempt to minimise the use of unpublished data and personal opinion as these are not possible to test in terms of their accuracy. In short, I am trying as far as it is possible to be very transparent in my comments and provide information gathered scientifically or from other people beyond myself to support the views that I present so that anyone can understand why I have come to a particular conclusion or raised a specific point about the TFMP.
- 1.4 – As simply a technical aside, I found the third paragraph to be way too convoluted and complicated. It is just one long sentence that could be broken up into two or three.
- In regards to Josh Hale, he is indeed a good researcher, but I would like to see exactly what implementing frog monitoring programs throughout SE Australia actually means. He is into genetics and fragmentation in urban environments around Melbourne. I would like to see more of his credentials for work in northern NSW systems displayed. I am sure he is very capable and comes from a very well credentialed group of researchers, but the systems are very different.
- 2.1.1 and other points in the TFMP – make sure all scientific names are italicised. For example, *Lepronia articulata* is not italicised in 2.1.1.
- 2.1.1 – the information on Giant Barred Frog habitat requirements is incorrect, as least as far as I know or can see. I have never heard of them being present in heath and I would not ever classify them as occurring in areas where water accumulates – not unless that is the way anyone would refer to a stream.

As a general point, I suggest that if would be worth considering how the cane toad may be positively impacted by the provision of a large road and the many associated settling ponds. The cane toad is a recognised significant threat to the survival of these frogs (through competition, poisoning or predation) and the potential to positively influence its spread and growth in populations may be very of value in long term management planning.

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The comments on specific sections of the TFMP are listed by Section and are as follows:

1.2 Purpose and Objectives

I do not agree that *Crinia tinnula* will be adequately covered by many of the management actions for frogs documented in the plan. *Crinia tinnula* uses many of the same habitats as *Litoria olongburensis* (see Anstis 2002 and the EPBC Website), but it uses a greater range of habitats and so assessments for *Litoria olongburensis* will not cover some areas used by *Crinia tinnula*. Surveys undertaken to remove this species during pre-clearing will be ineffective. This frog is highly cryptic and almost impossible to locate visually, even when calling.

If this species is to be excluded from impact and mitigation consideration, it should be removed entirely from the document, except at the one point where it is explained why it is not being considered. This makes is clear that this species is not of concern in regards to this Project. If it is to remain in, the TFMP should detail exactly which management actions are going to be effective in mitigating impacts on *Crinia tinnula*. It is too easy to say that without actually demonstrating how it will be true.
Recommendation: Remove all specific information on *Crinia tinnula* to be consistent.

I also believe that surveys of road-killed individuals will provide poor results to determine presence or effectiveness of mitigation. *Crinia tinnula* are a very small frog (<20mm) and so vehicles crushed by cars are most likely impossible to identify as that species when other species or *Crinia* are likely to also be present in the same area.
Suggestion: Remove the requirement to monitor road kills of this species.

Dot point 7 should probably read "... construction and operation of the project to test the effectiveness.....

1.3 Management structure and plan updates
The second sentence is missing "the" between during and detailed.

2.1.1
The information on habitats for Giant Barred Frogs is incorrect and needs to be corrected. There are numerous references of value and importance provided in the EPBC website for this species, almost all of which have been ignored, with a result that there is a too narrow set of information provided for this species and important components and information are missed and this has management implications. I have never seen nor heard of them occurring in heath. The cited study of Lewis and Rohweder 2005 does not indicate heath. They are a forest frog and also occur only on permanent streams and rivers as indicated by Cogger 2000, Anstis 2002, Lemckert and Morse 1999 and any other reference I can find. It is incorrect to refer to them using areas where water accumulates and this should be changed. All of the references indicate it is a permanent stream breeding species and saying where water accumulates sounds like they use temporary streams as breeding sites, which would lead to surveys in inappropriate areas. I would not cite Lewis and Rohweder 1999 as the only authority on what constitutes Giant Barred Frog habitat. This was a study in just one catchment and does not reflect the much wider range of this species. Other references that should

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be included are all cited in the EPBC webpage on this species (see http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1944) as well as the general field guides (Cogger 2000, Anstis 2002). This may be the reason listing that this frog requires pool/riffle sequences as an important component of its habitat as this is the finding of the Lewis and Rohweder reference. They do use such areas, but I have seen and tracked them using larger streams (Lemckert and Brassil 2000) and rivers with no such sequences (Lemckert and Morse 1999). They are just big and slow flowing water bodies. They are also quite capable of using streams in cleared farmlands as long as there is retained riparian vegetation that leaves a suitable microhabitat, which is an important point to note (Lemckert and Morse 1999 and see the EPBC Webpage again). The current description looks too narrow and will likely lead to the missing of important riparian habitats when developing sectional MPs.

I have added a whole range of references on the Giant Barred Frog taken from the DSEWPC webpage that demonstrate the breadth of work on the species and so how limited the reference works use in this study are.

Lemckert et al (2006) should be consulted for the Green-thighed Frog in regards to habitat and general biology as it is a summary paper for this species. It has reviewed all of the available information and nothing new has come to light that I am aware of.

Recommendation: This information be corrected to accurately reflect the consensus of available information.

2.1.2. Known and expected occurrences within the project

For the Giant Barred Frog, I would note the same issues as listed above in identifying suitable habitats for this species when developing sectional MPs.

The order of the listing of species in the various tables should be consistent throughout the TFMP. Currently it swaps around.

Suggestion: Reorder information in tables to be consistent

2.1.3 Threatening processes

Impacts from vertebrate pest species applies to all three species of frogs – particularly in reference to the cane toad, but also foxes and possibly pigs. Cane toads can either poison tadpoles or adults when they consume eggs or smaller toads respectively. There is also likely to be competition for resources and breeding sites and the production of roads with wider open spaces is likely to favour the spread of cane toads through otherwise forested areas.

The same is true of and includes introduced fish.

Suggestion: Apply the impacts to all of the frog species.

Should that be acidification or de-acidification of coastal wetlands? I understand that acidification can be a problem where acid soils are exposed. Equally however, there is a lot of concern about the neutralising of wallum swamp waters that can allow competitor species to enter these environments and displace both the Wallum Sedge Frog and Wallum Froglet (see Meyer et al 2006). This needs to be included in the report as it is identified as a significant issue in the Recovery Plan.

Recommendation: The impacts of changes to pH leading to more neutral waters needs to be discussed in this MP.

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3.5 Adaptive management approach

I have quite a few comments on tightening this approach that will come later in the document. Good monitoring is the key to demonstrating good management outcomes or the requirement to make changes and is rarely effectively carried out.

Table 3.1 Mitigation measures and evaluation of their effectiveness

I do not understand how the first row of this table ends up determining that the mitigation measures of fencing, compensatory ponds and under/overpasses lead to a moderate effectiveness rating. As is noted, amphibians are the one group that have not been demonstrated to widely use over and underpass structures and this has support from a published study. There are instances of frog tunnels being of some use in some places overseas, but nothing has been scientifically tested through the published literature in Australia (at least that I know of). Similarly, the provision of compensatory ponds is widely used as a mitigation measure, yet I know of almost no indications of any long-term success in using such a system and nothing scientifically tested has been published that provides a clear demonstration of success. There are claims that it works for Green and Golden Bell Frogs, but even that is based on unpublished work and all of the published work has shown failure. It may be able to work and the RMS might very well still want to try, but I don't think it is realistic to say that we have any form of likelihood in achieving a positive outcome. Why give it a moderate rating when there is no evidence that it is effective? This is one area where the RMS really needs to develop much more effective monitoring to demonstrate success or start to look at changes to current practices to get some demonstrated success.

Recommendation: Change the rating of uncertain.

4.3 Targeted Surveys

The stated preferred window of frog surveys of late spring and summer is too narrow and restrictive for the Green-thighed Frog and suggesting a seasonal approach to monitoring is potentially quite misleading if setting survey and monitoring programs. Whilst the Green-thighed Frog does most usually call/breed in late spring and summer, the review of the published breeding biology by Lemckert et al 2006 makes it quite clear that season is not really important. The key and only really significant consideration is rainfall. If enough falls, this species can breed at any time between September and May and has been heard calling in August. Late spring and summer is the more likely to get this sort of weather, but it is not at all a defining period. If the rains fall only before or after this period, then monitoring will be a pointless exercise and this needs to be specifically recognised in the TFMP.

Instead the TFMP should recognise that the flooding of the breeding ponds is the critical point for the Green-thighed Frog and not the level of rainfall. I am quite sure that under most circumstances the figures of a minimum 75mm of rainfall over 24 hours or 150mm or rainfall over 72 hours will see Green-thighed Frogs call, but less than this can be quite adequate and I usually work on at least 50mm as per the Lemckert et al 2006 paper. However, it is also quite clear that the rainfall needs to fill the relevant water body. If 75mm of rain will not do this they will not call. If only 20mls of rain will do it, the frogs will breed. What is critical is monitoring the breeding ponds to see that they have filled, not the rainfall itself. The TFMP needs to state that monitoring needs to be specifically associated with flooding of the designated breeding site or compensatory ponds and not specifically rainfall.

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Note that two different levels of critical rainfall are used in this section – 75mm or 100mm of rain in 24 hours.
The timing of the survey relative to the rainfall event is critical and the TFMP should state that the Green-thighed Frog only calls when it is still raining. When it stops, they stop. So it might have rained 100mm in the last day, but if monitoring takes place the day after and it is no longer raining, the monitoring will be ineffective. You have to be there when it is raining and not after and this needs to be made clear.
Green-thighed frogs are not searched for effectively using call playbacks as they are either already calling or will not respond. It is not reasonable to rely on them as any sort of indication of absence of this species.
Recommendation: That the information on the Green-thighed Frog is changed to reflect the published information that is based on a synthesis of all available data and not just a few points.

In contrast, when heavy rains fall, monitoring the Giant Barred Frog is not likely to be effective. During times of heavy rains, these frogs do not attempt to breed and often move away from stream edges (Streatfield 1999) and do not call. At such times, they will be much harder to find if using the transect format advocated under the plan and will use different habitats at that time, leading to variation in monitoring results.
Recommendation: Note that surveys for Giant Barred Frogs should not be undertaken immediately after heavy rains.

In Paragraph 5 of Timing, Site-selection and Methods the distances advocated for the control and impact sites are not appropriately far enough apart. Under the listed system an impact site could be 99m from the mitigation point and the control site at 101m – just two metres away. I doubt that anyone would think that these would then represent separate sites for comparisons. For appropriate statistical analysis, the populations sampled at sites need to be independent of each other. Reviews of the movements of frogs suggest that they move an average of 200-300 from breeding sites. This would suggest that control and impact sites need to be a minimum 200m apart (in fact all sites need to be at least 200m apart) to achieve the requirement for independent sample sites. I do not know how easy it will be to achieve such a split, but it is essential to do this if any analysis is to be valid.
Recommendation: That the distances between Control and Impact sites be a minimum of 200m apart, unless physically not possible to do, in which case they need to be as far apart as it possible.

Transect counts are suitable for Green-thighed Frogs, as long as the transect is not a straight line, but follows the border of breeding sites. Then they are fine and should try to circumnavigate the breeding site as this is almost always easily done.

I am not sure whether the reference should be Lemckert and Morse 1999. I note that, either way, this reference is not in the reference section at the back, along with a few others. Please make the list complete.
Recommendation: Complete and make accurate the reference list.

It is possible that some Wallum Sedge Frog breeding sites will be less than 50m in diameter/length (recent studies research studies from Clay Simpkins and Katrin Lowe at Griffith University). This would then need to be taken into account when analysing

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monitoring data. It should be stated that habitats should be selected to allow a 50m transect to be traversed, if at all possible. The same statement needs to be made for the Giant Barred Frog so that whoever undertakes the surveys is aware that keeping to the standard transect length is of very high importance to allow proper monitoring to take place.
Recommendation: That all transects be kept to the specified size unless otherwise impossible. This is not negotiable.

The method of using a 1m wide visual transect is fine for the Wallum Sedge Frog and is standard for this species (Meyer et al 2006 and the EPBC Referral Guidelines for this species: http://www.environment.gov.au/epbc/publications/pubs/draft-referral-guidelines-for-comment-litoria-olongburensis.pdf). However, the use of a 1m wide transect is not appropriate for either the Green-thighed Frog or Giant Barred Frog. Surveys for the former are carried out through aural surveys for calling frogs during breeding events and they are otherwise very hard to locate. I would highly recommend a search of the breeding site or compensatory pond along with a 20m wide strip of the bank. Giant Barred Frogs range across a 20m wide strip of embankment from the stream edge (Streatfield 1999; Lemckert and Brassil 2000) and it almost certainly depends on the night as to how close to the stream they will be. A 1m wide visual strip will provide very poor count in return of actual numbers present that will be very hard to analyse. To get good counts use a 20m wide band from the water's edge on either side of the stream is a standard approach. A 500m transect is also quite standard.
Recommendation: Transects of Giant Barred Frogs be 20m wide and cover both sides of the stream. Transects for Green-thighed Frogs be 20m wide and cover the bank of the breeding site.

I do not see that there is much use in assessing frogs for Chytrid through the use of visual surveys. One of the interesting points about Chytrid is that seemingly healthy frogs can be found just dead with no evidence of ill health, but Chytrid has killed them. The only useful method of detecting the fungus is by swabbing. That is what is required if there is an interest in understanding this disease on the site. There needs to be a statement here of why Chytrid is being tested for. From there we can work out what is the required approach to sampling. I would recommend dropping this requirement as being irrelevant and of no value.
Recommendation: That this form of Chytrid sampling be dropped from the MP.

4.4.2 Constructed Ponds
For the Wallum Sedge Frog, the extent of vegetation planted inside the pond is the key point, not that next to the pond. They live in emergent sedges not around the edges of ponds and so monitoring surrounding vegetation appears to have little relevance.
Recommendation: The extent of emergent vegetation be measured as well as bank vegetation.

As a broad question, what happens if the ponds fail to provide compensatory habitat? I address this question later, but it is worth noting what will happen, as seems likely (indicated by the RMS themselves), if they fail to work? What is the adaptive strategy that will be employed and how far will it go? This should be addressed somewhere in this document.

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Lots of examples of compensatory habitat are provided. But nowhere is there any evidence as to their success in mitigating impacts or even their relative use by frogs. I think that is critical to be included here. If this is a simple case of reproducing failure without thought, then it is useless. The RMS review is supposed to have stated that such works rarely succeed. That is my experience too. It would be very important to say what has and has not worked amongst these examples and so what is the best approach to take. I assume some have been demonstrated to have worked. It is an important point to make. If a type of compensatory habitat has been demonstrated to work effectively (eg frogs breed successfully at a pond for three consecutive years), it should be the recommended procedure. If one has been used and it has been seen to fail, then it should be recommended against. If there is no evidence one way or another, then this should also be made clear as then it is up to the Project Manager to decide what approach to take. There would be no relevant guidance except to say to use the best apparent option and report on its effectiveness.
Recommendation: Include a table that identifies the types of ponds that have been trialled before as compensatory habitat, what parameters were those attempted to be provided in the ponds and the information available indicating their success or failure if any?

The planting of densely packed emergent vegetation on pond fringes will minimise cane toad predation, not prevent it. They still use this habitat to some degree (See Semeniuk et al 2007), although it may help to some degree and I am not trying to discourage its use.

Green-thighed Frog compensatory ponds need to be ephemeral because otherwise they will not use them. It does not matter whether they have *Gambusia* or if there are other frogs around. They may be adapted to these sites for that reason, but a permanent pond without fish or competitors will still not be used as they just don't use such sites (see Robinson 1995; Anstis 2002; Lemckert et al 2006 and any other reference work on this species).
Recommendation: That it is recorded that compensatory ponds for this species cannot be permanent ponds.

More detail needs to be provided as to why the compensatory Green-thighed frog ponds should be of the style that is recommended. Why make the Green-thighed Frog ponds 12m squared? This does not fit with the work of Ledlin 1997 who found that they typically use much larger ponds than this. I know that they more often than not use sites that are deeper than 400mm (I have waded through sites up to my chest) and this is confirmed by Ledlin (1997). The design approach should be changed (see following), unless some specific reasons can be given as to why a 12m x 12m pond of 400mm or less is the best design. A poor pond design is likely to result in failure.
Following on from this, the statement that that breeding ponds for the Green-thighed frog should not be over-designed to replicate features from other known breeding locations should be removed as completely misleading. Why would anyone not try to re-create known breeding habitats? Why produce something that they are not known or are rarely recorded to use? Is this not setting the process up to more likely fail than not? I understand from discussions with the RMS that this recognises that the Green-thighed Frog has sometimes been located using smaller breeding sites such as wheel ruts as breeding sites: different to larger temporary pools located in wetter forest types with

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denser understorey and thick leaf littler. However, these are relatively unusual sites compared to those typically used and are likely not preferred or the best breeding sites, based on the studies and reviews that have been done. It is akin to saying that we can manage koalas by planting pine trees because people have seen them occasionally in pine plantations. Would anyone accept such an approach to managing koalas? The best chance of success is to create the most commonly used type of habitat, which is presumably also the preferred and most successful breeding habitat.
Recommendation: That the design of Green-thighed Frog compensatory ponds be changed to state that they be created as large as is practically possible under the circumstances, be temporary pools and be placed, as far as is possible, within the most typically used habitats: wet sclerophyll or swamp forest with a dense understorey and deep leaf littler.

I would note that the water quality parameters presented are fine for the Wallum Sedge Frog, but are not likely to be useful for the Green-thighed Frogs. They are not a Wallum species. I would strongly suggest that water quality requirements for Green-thighed Frogs be included as a well, with limits on what is and is not acceptable. I do not know specifically what they should be, but they should not be acid. Ledlin (1997) has some information on this.
Recommendation: Include a table that notes the water quality parameters that should be achieved in compensatory ponds for each frog species, including minimum and maximum variation points that are acceptable.

Table 4.2
Again, be consistent in the approach to tables in general. The first listed performance threshold is where there is a failure to complete surveys, but the second is a success at completing mapping and fencing. It should take the same approach on both occasions. I recommend the first Threshold be changed to "Targeted surveys are completed during the appropriate season prior to construction". Should surveys not be completed as required, the action then should be that construction is unable to be carried out. All other Tables should be altered to follow the same format if they do not already do so.
Suggestion: Alter the tables to be consistent in their approach, starting as above.

5.1 Potential impacts during construction phase
I would suggest adding "Opening of habitats allowing entry of feral predators and competitors. Where these roads are emplaced or enlarged it provides greater opportunities for disturbance tolerant feral species to enter environments and creates more edge effects on surrounding sites that also make more open habitats for them. Construction sites are much more suitable for cane toads that native forest.

5.3.3 Temporary Frog Exclusion Fencing
It should be clearly stated that call broadcast surveys must be carried out at night and not during the day. These are currently included in a general category of actions for pre-clearing surveys along with raking litter and searches around logs and tussocks, which are day-time activities. It could be read as all being done at the same time, which would be inappropriate.
Recommendation: Call surveys be noted as not to be undertaken during the day.

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The TFMP should provide a specific definition of a person experienced in frog exclusions is. Is it someone who has read a book once or someone who has checked a fence once? I would not think either would qualify, but both have some form of experience? Be specific to avoid inconsistent results and the potential for failure to appoint a suitable person should any works be challenged legally. I would recommend a minimum 2 years or 1000 trap-nights as a starting point for consideration.
Recommendation: A specific level of experience be included for a qualified person to ensure consistency through the program. I would recommend a minimum 2 years or 1000 trap-nights as a starting point for consideration.

Again, it state that fences should installed for up to 200m either side of potential or known threatened frog habitat. This makes it okay to be only 20m as this falls into the criteria of up to 200m. The TFMP should include a table that specifies the arrangement for each of the target species and that these cannot be varied without prior consent from the RMS. I believe that such a table would be most useful as it will define the correct distances for different species and different habitats and why they should be that size. This will prevent unnecessary variation for developed section MPs when different companies chosen for each section look to vary the formula and get the cheap option. Giant Barred Frog fencing need be no more than 50m wide based on the research of the movements of these frogs (Lemckert and Morse 1999; Streatfield 1999, Lemckert and Brassil 2000), all of which indicate that movements outside of this distance are very rare. Green-thighed Frogs probably need more, although there is relatively little to base this on. I have done only a very limited study of this species that can not say much as it was too short term to say anything about distances. It would be better applying a general approach as advocated by Semlitsch and Bodie (2003) or Lemckert (2004) which would fit in with the idea of a minimum 200m for smaller frogs.
Recommendation: A table be included that defines the correct distances of fencing for different species and different habitats and why they should be that size.

I would note that no great expectation should be placed upon the frog exclusion fencing actually stopping tree frogs from going accessing clearing or construction sites. Tree frogs can climb just about anything if they want to. It I just up to them.

5.3.5 Frog hygiene protocol
I would point out that the Chytrid fungus is almost certainly present right through every section of road works being proposed. The studies of (Kriger et al 2007) demonstrated that this fungus is in every population of *Litoria wilcoxii* that are present through this region and so the use of the protocols is problematic. The same was true of Green and Golden Bell Frogs at Nowra. It is worth noting this point in case Chytrid is located and there is the potential for someone to then suggest that it was the road Upgrade that is the reason for its turning up. I am not sure what the desire is from this document in regards to understanding Chtyrid in areas of roadworks. This should be explained. If it is to show that mitigation is working, then the RMS and the construction companies will need to undertake pre-work sampling followed by a suitably designed monitoring plan to be able to show this Chytrid prevalence has not increased in construction areas.
In my opinion, the ongoing use of Hygiene Protocols are highly unlikely to have any influence on the movement of Chytrid fungus through any of the individual Project sections. There is strong evidence to indicate it will already be present throughout the local frog populations and that this disease is being consistently spread around by

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species of frogs with some relative immunity to its effects. The use of the Hygiene Protocols serve no specific purpose in controlling Chytrid under these circumstances. The one significant exception to this case would be where an isolated population of Threatened frogs was present within the areas covered by the Upgrade, which then may allow for the potential introduction of the disease to a new area. This is highly unlikely, but the provision of adequate sampling pre-construction, would identify if this could possibly be the case.

Suggestion: That the MP includes provision for a proper pre and post-construction monitoring program for Chytrid fungus, using swab sampling to accurately identify and monitor Chytrid prevalence through the life of the Upgrade.

Point (m) states that "To avoid cross contamination, generally avoid transferring water between……". What does generally mean? When is it or is it not acceptable? The current statement means that anyone can transfer water any time and not be in breach of this protocol. Be specific so that it is clear when it can be done and when someone has breached the rules.

5.3.6 Pre-clearing and clearing surveys

Recommendation: Define what "where is reasonable and feasible" means. I assume this refers to populations being too large or extensive to warrant such movements, but make that clear. Otherwise again, there are no explicit criteria to demonstrate failure to act appropriately.

Recommendation: The TFMP should list rules on the maximum distances that frogs can be translocated.

It says to adjacent habitat outside of the clearing limits. But also notes that frogs should in general not be moved more than 300m from their location. This should be stated and, as noted before, will differ for the different species. A table detailing appropriate distances for each species should be provided and the distances should attempt to keep frogs within their likely home ranges/activity areas. This may not always be possible, but the herpetologist/ecologist undertaking any move should be well aware of what is the required outcome. Otherwise it is too easy to decide that a case can fit into the not general part category and move them where they want without fear of breaching any rules or guidelines. I would recommend that the distances be no more than 200m for the Green-thighed Frog and Wallum Sedge Frog and no more than 100m for the Giant Barred Frog.

Recommendation: The TFMP should include a table listing the maximum distances that frogs can be translocated.

5.3.7 Unexpected finds procedure

The statement that Giant Barred Frogs have the capacity to move hundreds of metres over one or two nights is misleading. The works of Streatfield 1999 and Lemckert and Brassil 2000 and communications with Dr Michael Mahony (University of Newcastle) all indicate that individuals of this species tend to hold very small home ranges (less than 2000 square metres). They may move hundreds of metres in one night, but this is very typically around a point and rarely in a long straight lines. So they do have the capacity to move hundreds of metres, but such movements are not dispersal events along streams and such movements can rarely be expected to occur.

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Recommendation: The TFMP information should be altered to reflect the general information available on the movements of this species.

Second paragraph should read the unexpected finds procedure and not fins procedure.
5.3.8 De-watering protocols

f) how long should they be acclimatised for? 5 minutes? One hour? I am sure the former is not anywhere near long enough. Recommendation is that this needs to be specified: a minimum of 30 minutes.
e) states that tadpoles should be identified to genus, but in doing so this means that they cannot be categorised into species to meet criteria g). That is, it is not possible to give preferential treatment to a tadpole of a threatened species when you don't know what species it is. Suggestion: that this point be clarified.

5.3.9 Permanent frog exclusion fencing
Does the frog fencing for the Woolgoolga to Glenugie project work? No point in including it in other works if it does not. Similarly, does the frog fencing in Figure 5-1 that was designed specifically for the Green-thighed Frog actually work to stop the Green-thighed Frog? The way it is written suggests that all of the fencing is the right fencing to use and should be used in all upcoming works with full expectation of success. But if there is no evidence that they do, then why specify that these designs are the ones that should be used? I would prefer the statement be made that it is unclear that these fences work or not and so consideration needs to be given to the type of fencing that can be used in each instance and there is no specific fencing recommended for any location or species. This puts the emphasis on finding out what does work and encourage research into understanding what are appropriate fence designs.
Recommendation: The TFMP include a table that includes the type of fencing that is suitable for use for each species and what the evidence is that demonstrates it is suitable.

5.3.11 Weed management
How does the use of herbicides fit in with the management of threatened frogs? Any guidelines as to how to do both in the same area? There should be given that herbicides have been previously demonstrated to have an impact on frogs.

Table 5-2
The TFMP must define what a high rate of injury during clearing works is? What is the threshold to decide that a high rate has occurred? What sort of injuries are those that are considered to constitute injuries that can be directly attributed to the construction of the road rather than a naturally occurring injury.
Similarly, what constitutes multiple injuries noted over one day. I guess it means two frogs. But what sort of injuries are appropriate for consideration?
Recommendation: The TFMP defines the type and extent of injuries which leads to a classification of a high injury rate.

What does Chytrid affected frogs found mean? As noted previously, it is not possible to guarantee that a frog carrying Chytrid can be identified as such by a visual inspection. Given this, how will this uncertain assessment work? Is there a plan to undertake other sampling that it much more specific and accurate? Otherwise, finding a sick frog will be a

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matter only of random chance, making it very difficult to determine if this means a change in rates of the disease. Counting sick found frogs is not going to provide a standardised sampling process that can allow statistical comparisons which are essential to demonstrate whether mitigation is working or not. If a statistically valid monitoring program is to be conducted for Chytrid it will need a lot better thought and planning and should be based on swabbing the skins of frogs and having these samples tested for the presence of this fungus.
Recommendations: Already provided.

Injured frogs found during dewatering – I assume that we are talking about injuries associated with dewatering and so must be fresh and relevant injuries. How will these be identified as being related to de-watering and not just natural processes? If they are found, what will happen in regards to de-watering? I presume that there will be a stopping of the de-watering and the RMS advised of the injuries and discussions made in regards to suitable changes that will have to be demonstrably followed.

How many is multiple tadpole deaths? I presume that two is enough. If that is 2 out of 10000, will that be a problem. This needs defining given the document has raised tadpole deaths as a significant problem that is a performance criteria.
Recommendation: The TFMP defines the type and extent of injuries that are considered to be associated with de-watering and the number of tadpoles that should be considered too many. I would suggest 1%.

6.1 Potential impacts during operational phase
Again, I would suggest that the document includes consideration of an increase in feral activity as a result of works.

6.3.4 Maintenance of compensatory ponds
What does "be maintained routinely" mean? Is there a program somewhere that mentions what is the level of routine maintenance that is considered to be acceptable or what water quality measures are required to be maintained to ensure a pond have been adequately maintained. It should be clear in the TFMP as to what is acceptable and so that it is clear is this action is being properly undertaken.
Recommendation: Define accurately the term routinely.

Table 6-1
Taking three days to clear a breach seems a rather long time.
How few sightings of frogs are required to decide that connectivity structures are not being used successfully or appropriately by frogs? If one or two frogs use it in a year, would this be deemed sufficient to consider it successful? I would assume not, but the plan seems to say yes. It needs a proper definition.
Recommendation: The TFMP defines the number of sightings necessary to conclude a structures is working. I would recommend 1% of the approximate population size of the frogs per year. This would maintain genetic diversity.

As before, monitoring of fringing vegetation for compensatory ponds will be of little value for the Wallum Sedge Frog. It is the emergent vegetation that is important.

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How much would constitute activity at a pond would be required before it is determined that a pond is being used successfully after 2 years? If one frog calls at a site does this make it a suitably used pond? Probably not if there were 1000 to start with. And if there is no successful breeding then I would still not see it as a successful pond. I think that this could and should be much better defined. I don't see that one frog using a pond can or should be viewed as success. I would recommend a definition of a successful pond must include that a minimum 20% of the original number of frogs located at the previously used pond must use that pond for at least 3 years and that successful reproduction in the form of tadpoles from a minimum of three separate clutches reaching metamorphosis be included as the final performance criteria.

The TFMP needs to define specifically the levels of water quality variation that are not acceptable for the breeding sites. How much can the water temperature or salinity or pH or conductivity change before it is no longer acceptable. This is a common practice in water quality assessments. This would most effectively be achieved through the provision of a table that, for each species, provides the preferred range of water quality measures as well as the acceptable upper and lower limits.
Recommendation: Covered previously.

7.1 Objectives
In the first full paragraph it is stated that at least two control sites should be selected per relevant project section.
Recommendation: The number of control sites should be the same as the number of impact sites to get a balanced design, which makes analysis much simpler and more effective. Preferably there should also be a minimum of five independent samples within each category of sites. This would provide a minimum of statistical robustness under a normal Analysis of Variance analysis.

This would be an appropriate place to provide the steps to develop an effective monitoring program, including adaptive monitoring, which should follow this process:

- Develop specific question about impacts
- Define what is acceptable level of change (decline or increase over defined time period)
- Devise statistically valid monitoring program to answer question
- Define actions to be taken should change occur
- Collect data to test if question can be answered
- Modify sampling to ensure that question can be answered
- Repeat and report
- Determine changes in management that will be undertaken if change is detected.

If the RMS wants to ensure that it can demonstrate statistically that its mitigation is working effectively, any analysis undertaken must demonstrably indicate that a pre-determined level of change can be successfully detected by the monitoring program. The majority of monitoring programs currently in place do not have enough power to detect even large changes in populations and so do not provide any test of the value of prescriptions. The TFMP can specifically stipulate the intention of any program to provide this level of information and that this is demonstrated through annual reviews and analysis of data. Defining what that level is would also usefully be incorporated into this TFMP. Deciding this for each species would take a significant review of the available

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literature, but I would suggest a decline of more than 25% over 5 years (or pro-rata) be a provisional target.
Recommendation: That a flow-chart be included that identifies the method to develop an appropriate scientific monitoring program and that it include the requirement to be able to statistically detect a 25% decline in the population over a 5 year period.

7.2.1 Methods and duration
Monitoring programs that do not undertake specific experimental manipulations are not likely to be able to determine the causes of any decline, just that there has been a decline. Specific tests will be required after that to assess what caused it. Similarly one of the critical failures of so many monitoring programs is the lack of definition of what is an acceptable change in populations and what is not. They usually say just that to monitor for a decline. Given the variability in frog numbers under natural circumstances and that there is likely a pattern of mostly declines with occasional increases under natural population processes (see Alford and Richards 1999), it is both very difficult to detect a decline statistically without a good program and it is not clear what it means even if a decline is detected where a drop in numbers in one year is all that is needed to trigger a response.
I highly recommend that a standard monitoring strategy is provided in the TFMP to be used in subsequent MPs. It would be very useful to have a fully worked up and scientifically based template as to how monitoring should take place for each species – what methods, when, how long for and what are acceptable changes. This would ensure a uniform program is used across the remaining areas of Upgrade and significantly improve the quality of monitoring compared to what has been achieved previously.
One of the other main values of providing such clear guidelines is that the same approach can be repeated accurately and consistently across all of the sections of road to be covered, which will provide valid comparisons between sections and data that can be pooled to provide a more sensitive meta-analysis of mitigation success across the range of Upgrades. That ultimately will give the RMS a lot more power and confidence to say that mitigation is working or which mitigation works and which does not. This should be very useful in the long-term for overall frog management.

It is stated that there I a preference for a BACI style monitoring program. However, using presence/absence as a means of defining change is not used in BACI studies because such an approach is not sensitive enough.
Recommendation: A BACI program is used and it is based on population count data.

7.2.2
The title of Corrective Actions in the table is misleading. These are not really corrective actions. They are really assessments as to why there might have been a change with some attempt to fix vegetation changes, but they should be monitored anyway. Corrective actions would be changes to current actions in light of a determined level of ineffectiveness.
Suggestion: Change the title of this Table.

I am not sure what "noticeable change in calling males or populations" means and it is not a useful measure of frog abundance. Frogs are notorious for their variation in calling activity between nights and so using this as fine-scale means of determining changes in

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population size is highly unadvisable under most circumstances, unless there are a lot of sampling points to account for this variation. Visual population counts or, much more preferably, mark-recapture studies generally are much more useful if carried out well.
Recommendation: The Giant Barred Frogs and Wallum Sedge Frog should be monitored using a combination of counts of calling and visually identified animals. This is suitably based around the suggested transects.
Green-thighed Frogs are an unusual exception to this rule as it seems that all males call at the same time over a very short period and individuals otherwise are very difficult to locate.
Recommendation: Total counts of adult males Green-thighed Frogs be used to monitor this species.
The term "noticeable change in populations" needs to be defined appropriately if there is going to be any valid monitoring comparisons. As before, I did suggest a 25% decline in populations over 5 years, but there is dependence on how long the RMS intends to monitor for. A best level of change may be determined through a detailed review of the literature.
Recommendation: Already noted in regards to extent of change.

7.3.1 Methods timing intensity and duration
The TFMP needs to define what is a suitably qualified and experienced ecologist is to be used for frog monitoring? In regards to frogs, it is far better to say a suitable qualified and experienced herpetologist and define what is a suitable level of qualification and experience. For the Nowra Upgrade of the Princes Highway, a suitably qualified expert for the Green and Golden Bell Frog was defined as someone with at least 5 years experience working with that frog. This is a good starting point.
Recommendation: As noted before, define the minimum level of experience for each action. I would suggest an expert is someone who has had at least 5 years of experience working with the targeted frog. I would also suggest as an addition or an alternative including the requirement to have successfully detected the target species on at least 10 occasions. The latter will clearly demonstrate that the herpetologist is capable of finding these often hard to locate species.

As before, why would you choose 3 impact sites and 2 control sites? This is unbalanced and so statistically already a poor design. It should be at least 3 and 3 and preferably 5 and 5.
The TFMP states that monitoring of control sites should try to follow the same approach in using transects.
Recommendation: the control sites MUST be sampled in the same way as the impact sites. Otherwise they are not control sites and the monitoring program and analysis is invalid.
Why should the evidence of the effectiveness of exclusion fencing be clear? I have already noted that hylid frogs climb fences of any type very well when they want to. I would not expect to see no frogs vs lots of frogs. However, if the monitoring program is carried out effectively and the data collected adequately, the evidence for the effectiveness of the exclusion fencing should be statistically clear.
Recommendation: The TFMP notes that there should be no detectable change in the numbers of frogs associated with areas controlled by frog fencing.

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When will the surveys of frogs occur for roadkills? Surveying frogs for roadkills is very hard to do and dangerous. Dead bodies are rapidly crushed and scavenging birds remove them usually relatively quickly. This monitoring needs to be carefully planned and managed. Is there a guide as to how this will be done? The TFMP should include a standard protocol for carrying out roadkill surveys such that it will be safe for those carrying out the work.
Recommendation: Remove the monitoring of Roadkills as a requirement in the MP.

7.3.2 Performance indicators and corrective actions
The TFMP should not state that "corrective actions should be considered"? This clearly means that they don't have to be carried out if people don't want to. Is that the intent?
Recommendation: Corrective actions must be undertaken if the performance criteria or are not met or set thresholds are breached. This is essential to demonstrate compliance.

7.4.1
Again the monitoring design should not be unbalanced.

Pitfall trapping is suggested as a means of monitoring underpasses or connective structures. Pitfall trapping is very labour intensive, may not work for tree frogs and has lots of ethical issues for their use.
Motion sensitive camera traps may be used, but these appear not to be very effective in detecting frog movements as frogs do not trigger them easily.
Recommendation: Do not use pitfall traps or motion sensitive cameras as a means of monitoring connectivity.

A better option is the use of time-lapse cameras as a more effective means of monitoring underpass use by frogs. These capture any animals moving through the structure as long as the quality of light and shot is adequate and has worked in overseas studies on frogs using underpasses. Another alternative worthy of consideration is to use pit-tagging as a means of identifying frog movements. There are various systems available that can be set up at the ends or middle of the tunnels/structures, in or out of water, that will detect frogs passing within close proximity of a sensor and identify the specific individual passing by the point. Such a method would provide significantly more detail than the use of cameras as it will identify if there are 100 frogs crossing a site once or 1 frog crossing 100 times. It will also indicate differences in movement patterns by juveniles and the two sexes.
Recommendation: State that time-lapse cameras be used as a minimum monitoring method for connectivity structures.

Again define what would be considered to be effective use of the underpasses. One frog? Ten frogs? 5% of the known population number. A 50% drop in road mortality? I am not sure the best method without doing a detailed literature review and consideration of each species. The ultimate aim would be to maintain sufficient connectivity between both sides of a road to ensure long-term genetic integration of the overall population. This is not well known for Australian frogs but a level may be justifiable with a detailed review of the available scientific literature.
Recommendation: As previously advised, the use of the structure by a minimum 1% of the estimated population size.

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7.4.2
How will increasing the monitoring program actually be a corrective measure for use of connectivity structures or, more critically, road kill? It is not a corrective measure. It is just a means to determine if the connectivity structures appear to be working. The corrective measure would be to add additional structures or change the structure or stop frogs using the road in some other way.
Recommendation: Change the table to read to change/add to the structures and monitor.

7.5.2
What will happen if frogs are present at compensatory breeding sites, but are not breeding at them? There is no corrective measure identified. I would assume it would mean that a review be undertaken of the created habitat to see if it was not created properly and measures taken to either alter the current pond or create new ones that will provide better habitat and that are again monitored to determine if they are more and suitably effective. That is adaptive monitoring and management and represents an actual corrective action. This should be changed.
Recommendation: That if compensatory breeding habitat does not produce metamorphs within 3 years, that an investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (ie 3 more years of monitoring).

7.6.1
Why up to 4 0.5m^2 quadrats. Should not the sampling be standardised for all sites to allow proper comparisons?
Recommendation: The TFMP should simply state that four 0.5m^2 quadrats will be undertaken at each site to provide replicate data sets.

7.6.2
Define what good quality habitat restoration requires. At what point is it restored? We know that 30% loss of revegetation is bad, but at what time does restoration become adequate.
Recommendation: Define what is good quality habitat so that it can be measured against.

What is "evidence of threatening processes being controlled or eradicated"? This suggests that one person maintaining a fence or removing a weed means that the threshold has been reached and all is good. I doubt this is what is meant. Again, state what is the minimum allowable level of maintenance to be undertaken each year?
Recommendation: Define what is appropriate evidence.

7.7 Evaluation, project review and reporting
Annual reporting should include an analysis of the data collected to determine if it can answer the questions being asked of it. Is there enough data and is the analysis sensitive enough to detect the changes that are considered to be sufficiently great to cause concern in a pre-determined timeframe? Try looking at Lemckert et al (2011) to understand the issues here. This is a critical step as the monitoring is meaningless unless it really can detect the changes that are required to be known and frogs are difficult to develop monitoring programs for. Mostly it seems that monitoring means a

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report each year saying that some frogs were seen or not seen and, at the end there might or might not have been a change and nothing was done even if there possibly was a change. Section 3.5 of the TFMP talks about the good process of measuring change, but if the data is not good enough to do it, then it means nothing.
Recommendation: Annual reporting include an analysis of the data to determine if change has taken place and/or demonstrate if there is enough power to detect the specified levels of unacceptable change.

As I noted before, I do not like the use of an ecologist to undertake targeted frog work. This implies that anyone can do it regardless of whether they have expertise with the frogs I question or not. I prefer the term Project Herpetologist or Appointed Herpetologist to recognise that this takes a lot more skill than just knowing something about frogs. Otherwise it means that you can have a botanist doing the targeted surveys or population monitoring for a frog they have not seen or even hear of before. They are still ecologists. And define clearly what the experience is that is needed to do this work. If this general TFMP is clear in the level of experience required, it will transfer across a much more consistently to the MPs developed for each section of the Upgrade.
Recommendation: Defining suitable levels of experience has already been covered.

Profiles
Make sure that the same types of information are included in each of the profiles, providing a consistent approach to their management. As an example, some of the profiles contain specific information on the breeding season of the target species and some don't.
Recommendation: The categories in each of the profiles be standardised.

The Giant Barred Frog has not been found south of the Hawkesbury River despite Cogger (2000) saying so. There are no museum records or any proof of any type to show this. This is an error.
The species also uses deep and slow flowing streams and rivers without rocks.
The Giant Barred Frog is not known to disperse hundreds of metres from breeding sites on any regular basis. This describes the movements of the Great Barred Frog and Stuttering Barred Frog. The Giant Barred Frog is very different in its habits. Home ranges are no more than 50m wide in almost all cases (see work by Streatfield 1999 or talk to Dr Michael Mahony, University of Newcastle). There is a lot of research work that clearly demonstrates that these frogs stay pretty much always within 20m of their breeding stream and I have not seen any information showing frogs more than 50m from a stream. This is all based on long-term radio-tracking work. I can only assume that the author/s have again confused the habits of this frog with that of the very different acting *Mixophyes balbus*.
Recommendation: Include in the information presented the above information.

The Green-thighed Frog is only found north of the Hawkesbury. Records south of this are erroneous. I do not know where this information comes from as it is not in the typical field guides.
Recommendation: Change range to north of the Hawkesbury.

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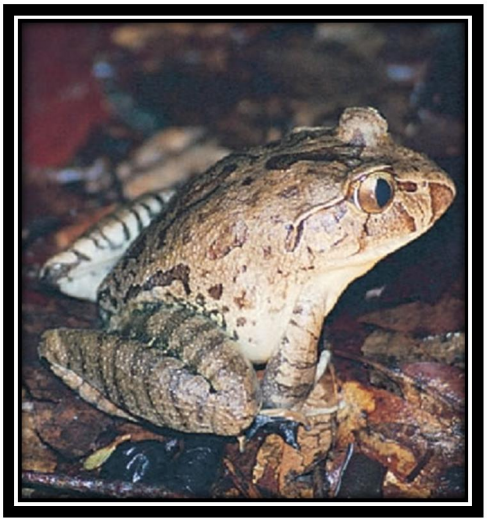
Appendix C – Species profiles



Giant Barred Frog
(*Mixophyes iteratus*)

Source:
http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Giant Barred Frogs are large frogs, up to 115 mm in length. They are olive to dark brown above with paler or darker blotches, and cream to pale yellow below. The skin is finely granular. The pupil of the eye is vertical and the iris is pale golden in the upper half and brown in the lower half. The call is a deep 'ork' breaking into a series of 'orks' and grunts. The Giant Barred Frog can be most easily distinguished from other barred frog species by the black thighs with smaller yellow spots, distinct barring on the limbs, dark blotches on the sides, absence of a creamy stripe on the upper lip and the distinctive eye colour.

LEGISLATIVE STATUS

TSC Act: ENDANGERED; EPBC Act: ENDANGERED.

DISTRIBUTION

Coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold. Considered to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains.

HABITAT

- Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m.
- They breed around shallow, flowing rocky streams and deep and slow flowing streams and rivers without rocks, from late spring to summer.
- Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched.
- Tadpoles grow to a length of 80 mm and take up to 14 months before changing into frogs. They feed primarily on large insects and spiders.
- Adult frogs usually remain within 20m of their breeding stream

THREATS

- Reduction in water quality, from sedimentation or pollution.
- Changes in water flow patterns either increased or decreased flows.
- Reduction of leaf-litter and fallen log cover through burning.
- Timber harvesting and other forestry practices.
- Vegetation clearance.
- Predation on eggs and tadpoles by introduced fish.
- Weed spraying close to streams.
- Chytrid fungal disease.

Green-thighed Frog (*Litoria brevipalmata*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Green-thighed frogs are named for the bright green or blue-green colour on the groin and back of the thighs. They are small frogs (to 40 mm in length), rich brown to chocolate brown on the back, sometimes with smaller black flecks. A broad black stripe runs from the snout to the flank, ending as a series of blotches. The call is a continuous series of ‘quack’ or ‘wok’ sounds.

LEGISLATIVE STATUS

TSC Act: VULNERABLE.

DISTRIBUTION

Occurs in isolated localities along the coast and ranges from north of the Hawkesbury River to south-east Queensland.

HABITAT

- Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. It prefers wetter forests in the south of its range, but extends into drier forests in northern NSW and southern Queensland.
- Breeding occurs following heavy rainfall from spring to autumn, with larger temporary pools and flooded areas preferred. Frogs may aggregate around breeding sites and eggs are laid in loose clumps among water plants, including water weeds. The larvae are free swimming.
- The frogs are thought to forage in leaf-litter.

THREATS

- Changes to drainage patterns which reduce periodic local flooding.
- Damage to semi-permanent and ephemeral ponds and flood-prone vegetation.
- Clearing of habitat for agriculture or development.
- Habitat disturbance through timber harvesting.
- Reduction in water quality through grazing and pasture fertilisation.
- Reduction of leaf-litter and cover of fallen logs through grazing and associated burning.

Wallum Sedge Frog
(*Litoria olongburensis*)

Source:
http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Wallum Sedge Frogs are small, slender frogs up to 25 mm long. They are light green to light brown above, with a dark brown streak running from the nostril to the eye and down the flank and another cream-coloured stripe from below the eye to the flank. They can be distinguished from the similar but more common and widespread Eastern Dwarf Tree Frog (Litoria fallax) by their longer body, more pointed snout and brown-flecked throat. The call is an insect-like buzzing.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Occurs in coastal areas from Fraser Island in south-east Queensland to Woolgoolga in northern NSW.

HABITAT

- Paperbark swamps and sedge swamps of the coastal “wallum” country. Wallum is a Banksia dominated lowland heath ecosystem characterised by acidic waterbodies.
- Wallum Sedge Frogs are usually found amongst sedges and rushes in coastal wetlands.

THREATS

- Destruction and degradation of coastal wallum and coastal wetlands for road works, coastal developments and sand mining.
- Reduction of water quality and changes to acidity in coastal wetlands.
- Grazing and associated frequent burning of coastal wetlands.
- Impact by vertebrate pest species.

Appendix D – Frog hygiene protocol