Woolgoolga to Ballina Pacific Highway upgrade

Operational Monitoring of In-situ Threatened Flora Species (non-rainforest)

Annual Report 2022

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Woolgoolga to Ballina Pacific Highway Upgrade

In-situ Threatened Flora (non-rainforest flora)

Annual Monitoring Report 2022

Final Report

5 May 2023

Transport for NSW

Woolgoolga to Ballina Pacific Highway Upgrade

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Contents

1. Introduction

1.1 Background and objectives

As part of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project, a Threatened Flora Management Plan (TFMP) was developed to meet approval of the NSW condition requirements of MCoA D8 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Condition of Approval (CoA) 12. The TFMP identified potential impacts to threatened flora species listed under the EPBC Act and formerly under the *Threatened Species Conservation Act 1995*, now *Biodiversity Conservation Act 2016* (BC Act). Threatened plant species are being managed in two ways, 1) by the protection, monitoring and management of plants that remain in-situ adjacent to the W2B upgrade, and 2) by the translocation, monitoring and management of plants that are located within the road construction footprint. This report describes the monitoring methods and results for in-situ threatened plant species during construction and three years operation.

The in-situ threatened plant monitoring program documented in the TFMP outlines the methods and timing for ongoing monitoring of threatened plant species that are located in proximity to the W2B project corridor. The program aims to identify potential direct and indirect impacts during construction and the early stages of operation of the project by monitoring the performance of mitigation measures against management goals and implementing required corrective actions for adaptive management of the program.

The program commenced during the pre-construction phase in which baseline data was collected for a series of impact and control sites for each threatened species identified in the TFMP. This occurred in 2014. Impact and control sites were monitored in the first year of construction in 2017 from two monitoring events for Sections 1 to 2 and four quarterly monitoring events (Q1-Q4) for Sections 3 to 10 of the W2B upgrade (Jacobs 2018). Operational monitoring in Section 1-2 (2018) was completed in two (biannual) events in autumn and spring and transitioned to annual spring monitoring in 2019. For Section 1 and 2 the third and final operational monitoring event was completed in spring 2020 and for Section 3-10, the first and second year of operational monitoring was completed in spring 2020 and spring 2021, respectively. The current report describes the results of the third year of operational monitoring for Sections 3-10 completed in 2022. Operational monitoring is conducted annually in spring. As stated in the TFMP three consecutive years of operational monitoring would be carried out and following this period a review of the results would be undertaken to identify if further monitoring is required.

The report provides discussion on avoiding and minimising impacts to threatened plant species with reference to the goals in the TFMP. Suggestions for adaptive management and corrective actions is also provided where deemed to be required.

The in-situ threatened flora monitoring program is specific to 20 threatened plant species, these are listed in **Table 1-1** along with their status and relevant project section.

Table 1-1 Threatened flora species targeted in the construction and operational monitoring phase

Species	Common Name	Status		W2B Project section (monitoring in 2022)
		EPBC Act	BC Act	
Angophora robur	Sandstone Rough-barked Apple	V	V	3
Arthraxon hispidus	Hairy Joint Grass	V	V	8, 9, 10
Cyperus aquatilis	Water Nutgrass	-	E	3, 6, 7
Eleocharis tetraquetra	Square-stemmed Spike-rush	-	E	3
Endiandra muelleri subsp. *bracteata*	Green-leaved Rose Walnut	-	E	4

Species	Common Name	Status		W2B Project section (monitoring in 2022)
		EPBC Act	BC Act	
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V	Not monitored in 2022 (distribution is Section 2)
Grevillea quadricauda	Four-tailed Grevillea	V	V	3
Lindernia alsinoides	-	-	E	3
Lindsaea incisa	Slender Screw Fern	-	E	3, 6
Macadamia tetraphylla	Rough-shelled Bush Nut	V	V	8
Maundia triglochinoides	-	-	V	3, 6, 7
Melaleuca irbyana	Weeping Paperbark	-	E	7
Oberonia titania	-	-	V	10
Persicaria elatior	Tall Knotweed	V	V	4, 5
Prostanthera cineolifera	Singleton Mint Bush	V	V	6
Quassia sp. Moonee Creek	Moonee Quassia	E	E	Not monitored in 2022 (distribution is Section 2)
Rotala tripartita	-	-	E	6
V=vulnerable, E=endangered				

1.2 Detailed design outcomes

A small number of the in-situ monitoring sites established during the pre-construction phase of the project were inadvertently placed in areas that were subject to approved clearing associated from the detailed design. This was the result of selecting baseline monitoring sites prior to physically marking the project construction boundary. These sites, which were removed during approved Year 1 construction activities, were documented in the 2017 annual report (Jacobs 2018) however have been excluded from subsequent annual reports and components of the program were reset to account for the minor change.

Details of the program reset are provided in **Appendix B**. Following review of the detailed design and comparison with concept design the total number of remaining in-situ populations being monitored were reset across the whole project. Monitoring plots partially impacted in 2017 were continually monitored to examine any change post impact or from future direct or indirect impacts. Where possible, additional plots were established to monitor remaining populations adjacent to pre-existing impacted sites.

2. Methods

2.1 Timing and conditions

2.1.1 Survey timing

The timing of the monitoring described in this report followed in accordance with the TFMP which outlines monitoring is to be conducted:

- Every three months (quarterly) during the first year of construction.
- Every six months (biannually) during the second year of construction, and
- Every 12 months (annually) thereafter for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods).

This report details the results from the final Year 3 operational monitoring for Sections 3-10 and was conducted in late spring, between October and November 2022. A summary of all monitoring conducted to date includes:

- Pre-construction phase (2014): targeted surveys and plot set-up to develop a baseline over the autumn and spring of 2014 (Jacobs 2014).
- Construction phase (2016): project sections 1 and 2 (Year 1). Quarterly monitoring conducted by Landmark Ecological Consultants.
- Construction phase (2017-2019): monitoring conducted biannually in 2017 (Year 2 construction in Section 1-2), and quarterly in 2017 (Year 1 construction in Section 3-10) (Jacobs 2018), biannually (autumn and spring) in 2018, and annually (spring) in 2019
- Operation phase (2020-2022): monitoring conducted annually (spring) in 2020, 2021 and 2022.

Table 2-1 Timing of monitoring data collection relevant to different project phases and W2B project sections

Year	Project phase	Monitoring period and project section	Report
2014	Pre-construction – baseline data collection and plot set up	All in-situ flora (non-rainforest), located over sections 1-10	Jacobs (2014)
2016	Construction	Year 1 (s.1 & 2)	Landmark (n.d)
2017	Construction	Year 2 (s.1 & 2) and Year 1 (s.3-10)	Jacobs (2018)
2018	Construction	Year 3 (s.1 & 2) and Year 2 (s.3-10)	Jacobs (2019)
2019	Construction	Year 3 (s.3-10)	Jacobs (2020)
	Operation	Year 1 (s.1 & 2)	
2020	Operation	Year 2 (s.1 & 2) and Year 1 (s.3-10)	Jacobs (2021)
2021	Operation	Year 3 (s.1 & 2) and Year 2 (s.3-10)	Jacobs (2022)
2022	Operation	Year 3 (s.3-10)	Jacobs (2023) – current report

2.1.2 Climatic conditions

Given the length of the project study area spanning over 160 km, localised climatic conditions and rainfall vary across this extent and it is important to identify these conditions in interpreting the data and trends in natural variation of plants and changes in their health, abundance and occurrence. This is particularly important for threatened flora that grow in wetland and riparian habitats and depend on rainfall.

Total annual rainfall for 2022 ranged from 1,618.4 mm at Grafton Research Station (Sections 3-5), and 2,579 mm at New Italy (Sections 6-10). These totals combined with those in 2020 and 2021 (also operational years) have been significantly higher than the proceeding drought years of late 2018 and 2019 (during construction of the project). Indeed 2022 has recorded the highest annual rainfall total since monitoring began in 2014 (baseline), including the early 2018 flood event which occurred in the northern portion of the project (Section 7-10) (refer **Figure 2-3** for annual comparison).

The local area around each in-situ site received varied amounts of rainfall in the months preceding the spring 2022 monitoring, particularly during February and March 2022 which coincided with major flooding in the NSW Far North Coast, with Grafton receiving 502.4 mm and 348.6 mm, respectively, and New Italy receiving 754.6 mm and 686.8 mm, respectively. The lowest amounts of rainfall in 2022 in comparison occurred during the months of January, June and August for Grafton, and June, August and November for New Italy. Monthly rainfall trends were variable across the whole region though generally above average rainfall preceding the 2022 monitoring event (refer **Figure 2-1** and **Figure 2-2** for monthly totals).

Monthly rainfall data and monthly historical average from Grafton is presented in **Figure 2-1**, monthly rainfall data and monthly historical average from New Italy is presented in **Figure 2-2**, and annual and historical rainfall data from Grafton and New Italy is presented in **Figure 2-3**. Moderately high monthly totals occurred in the three months preceding the monitoring event (Grafton 277.2 mm and New Italy 366.2 mm).

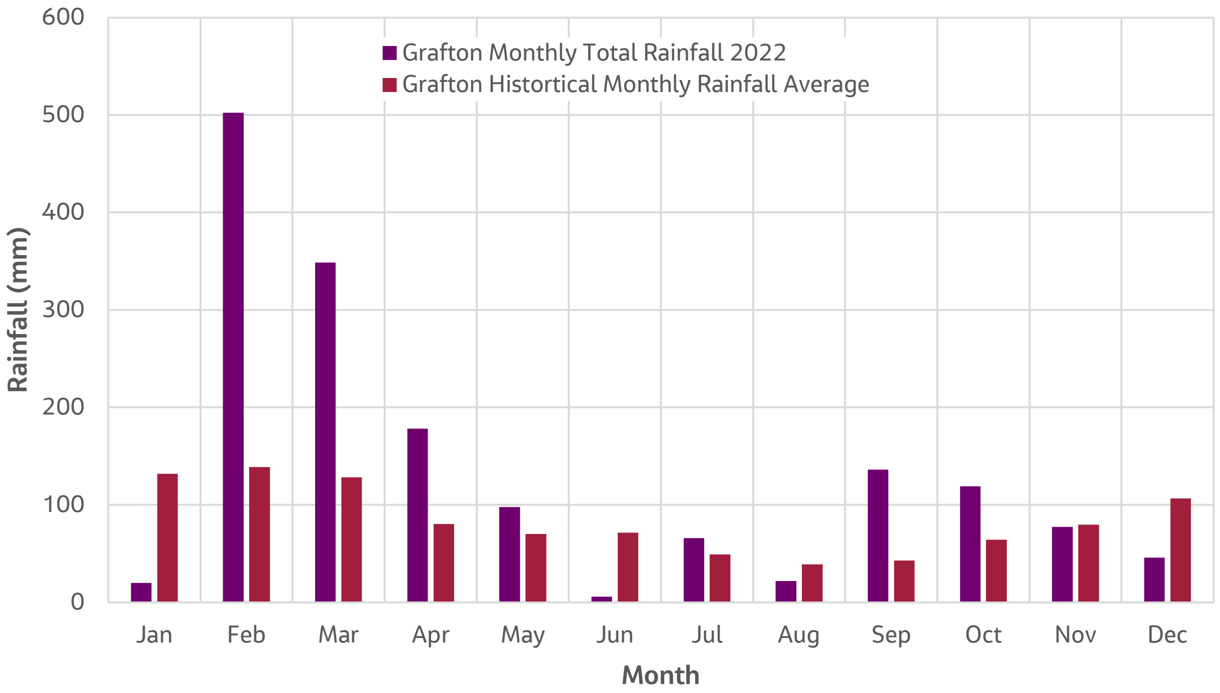


Figure 2-1 Monthly rainfall data and monthly historical average from Grafton Research Station (058077) for 2022

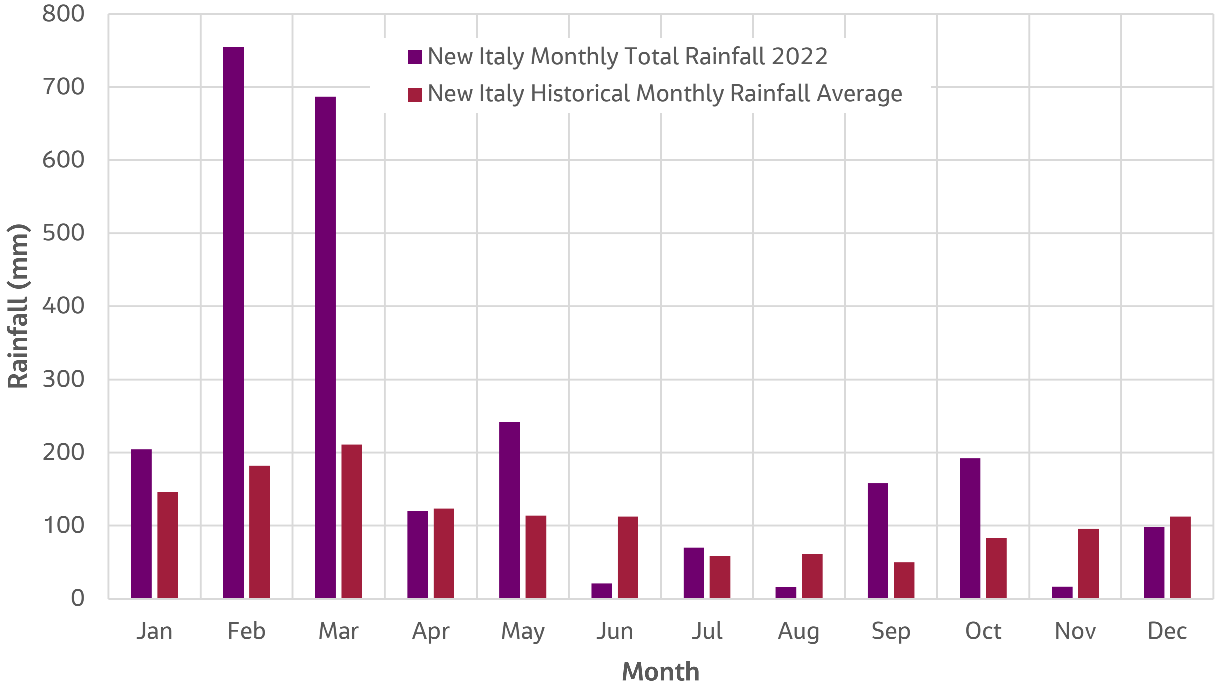


Figure 2-2 Monthly rainfall data and monthly historical average from New Italy (058097) for 2022

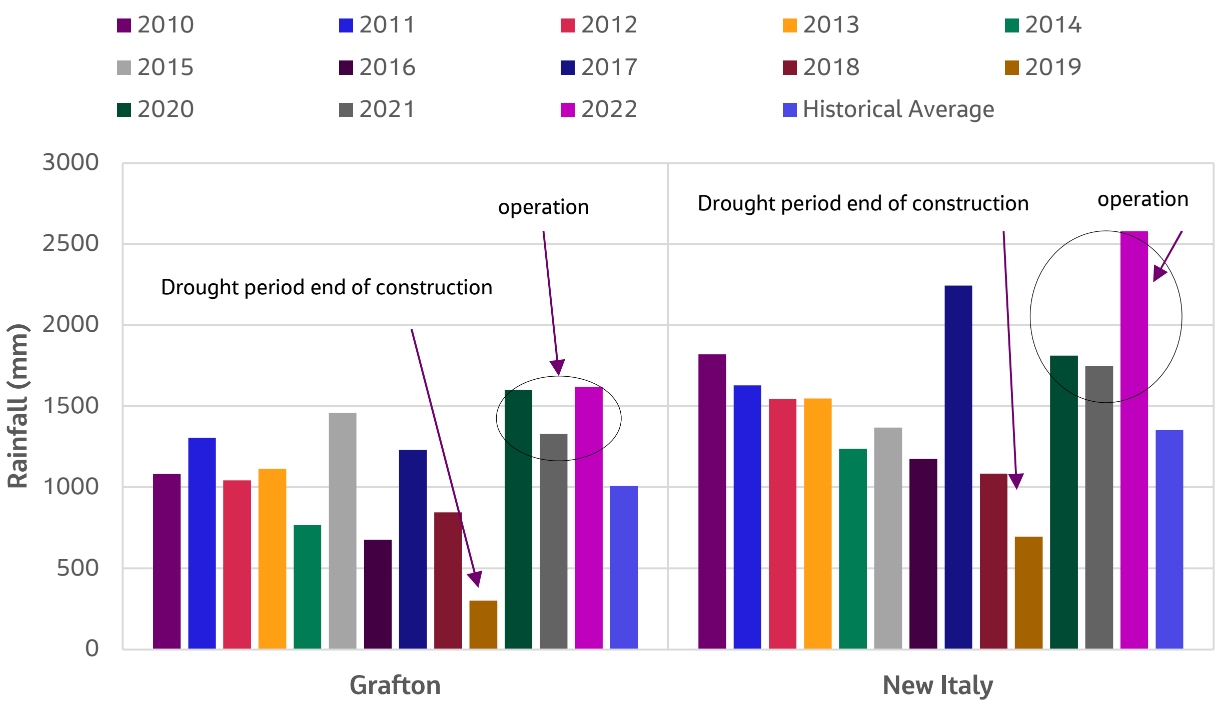


Figure 2-3 Annual and historical rainfall data from the Grafton (058077) and New Italy (058097) weather stations for the project monitoring period (2010-2022)

2.2 Monitoring sites

The pre-construction baseline surveys undertaken by Jacobs in 2014 identified and mapped 93 threatened flora species occurrences (sites) as the baseline of the in-situ monitoring program. This comprised 69 impact monitoring sites and 24 control sites (outside of the impact area). Two or three threatened flora species sites may occur in the same plot location. All sites monitored for pre-construction were established during the development of the project concept design. A total of 49 sites are monitored in Section 3-10 of the project (comprising 38 impact and 11 control sites). Site locations are illustrated in **Appendix A**. Refer to the Construction Monitoring of In-situ Threatened Flora (non-rainforest flora) Annual Report 2017 for a description of replaced, removed, or added sites from 2017 (also tabled in Appendix B).

2.2.1 Decommissioned monitoring sites

Of the total monitoring sites, 25 were removed from the monitoring program due to continued access restrictions at 10 sites, removal of 10 sites located within the detailed design construction footprint and other reasons for five other sites (refer **Table 2-2** for details). Additional sites were added or duplicated where possible and these are referenced in the initial W2B threatened flora monitoring annual report (Jacobs 2017).

Table 2-2 Details of in-situ monitoring sites removed from initial program (Impact: refers to site being removed as was found to be within the approved project area; No Access: refers to changed access arrangements with the property owner); Not Listed: refers to confirmation that the species was misidentified during the EIS, and thus later removed from the program)

Site	Chainage	Reason/status	Site	Chainage	Reason/status
Elt-1.1	5700	Impact	Ar-3.10	66500	Impact
Elt-1.2	6200	Impact	Ar-3.11	67700	Impact
Elt-C1.1	6400	No access	Pe-4.2	80600	Impact
Elt-C1.2	6400	No access	Pe-5.1	83400	Impact
Elt-1.4	6700	No access	Emb-4.2	80700	Impact
La-1.1	6200	Impact	Sp-4.1	80700	Not listed as threatened
La-C1.1	6400	No access	Sp-8.1	134900	Not listed as threatened
La-C1.2	6400	No access	Pc-6.2	101700	Impact
La-1.3	6700	No access	Pc-6.2a	101700	Monitored in W2B translocation program
La-C1.3	6400	No access	Pc-C6.1	101700	Replaced with additional in-situ site
Mt-C1.1	4900	No access	Oc-8.1	132200	Impact
Mt-1.2	5700	Impact	Pa-9.1	144400	*Calanthe triplicata* - not listed as threatened
Mt-3.3	64300	No access	Ah-10.5	157600	Impact

2.3 Sampling methods

2.3.1 Targeted surveys and species detection

The long-term monitoring program (pre, during and post construction) is designed to ensure that different plant life stages and climatic conditions are sampled over temporal monitoring events and years. Surveys focus on monitoring the health and condition of the in-situ individuals as well as identifying recruitment at the site. Detection of cryptic threatened flora was reliant on suitable climatic and seasonal conditions, particularly for *Cyperus aquatilis* and *Rotala tripartita*. Climate variability also has a marked effect on survivability and reproduction of *Lindernia alsinoides, Lindsaea incisa* and *Maundia triglochinoides,* whereby abundance changes in relation to rainfall and moisture. *Persicaria elatior* and *Arthraxon hispidus* and are also affected by rainfall, moisture conditions and competition, and due to their annual life cycle are only detectable at certain times of the year. *Persicaria elatior* would generally show signs of natural dieback in late autumn with few plants remaining in winter and seedlings would appear in late spring, depending on rainfall conditions and seed presence from the previous year. *Arthraxon hispidus* would dieback in winter and seedlings would appear in spring and begin to set seed in late autumn. *Cyperus aquatilis* and *Rotala tripartita* are also short-lived annuals and rely on wet summer periods.

2.3.2 Sampling technique

A 20 m x 20 m plot with a central 20 m transect was used at each site following the same techniques carried out in previous years and in line with the TFMP. Where possible, transects were aligned from north to south. At each monitoring event a photograph was taken at the northern end of the transect looking along the transect. Additional photographs were taken of the general habitat condition, individual plants and/or clusters of plants, and where insect attack and plant dieback were noted.

A tape measure was laid along the plot midline to record habitat condition (vegetation cover and structure) and used as a reference for plant locations. Vegetation condition was recorded along the transect with the canopy and midstorey (greater than one-metre high) cover recorded as percentage foliage cover every five metres (four points) along the transect and groundcover attributes were recorded at every metre (20 points) as either forb, grass, shrub (less than one-metre high), bare/water, litter or exotic. The central transect was also used to describe the distribution of threatened flora within the plot. Weed species and their cover abundance was recorded within the whole plot.

Habitat condition parameters and plant health indicators were recorded within the plot and the transect and associated with individuals in relation to threatened plants. This included but was not limited to:

- Genus, species, and subspecies.
- Identifier – unique plant number.
- Location – location; easting, northing & description.
- General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
- Leaf condition – healthy/unhealthy, colour, vigour.
- Flower/fruit – flower/fruit presence.
- Length of new shoots – average length of new shoots (estimate) and abundance of new shoots (counts or basic scale).
- Disease symptoms – evidence of disease (including presence / absence of Myrtle Rust, Cinnamon Fungus).
- Recruitment.
- Evidence of any other damage or disturbance.
- Plant community type.
- Canopy cover.

- Mid-storey cover.
- Ground-layer cover and composition.
- Weed cover of abundance and weed ground cover percentage.
- Recruitment of canopy and mid-storey species.
- Climatic events (e.g., drought, flood, unusually cold winter temperatures etc.).
- Maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring.
- Any other ecological impacts.

A quantitative measure of a subject plant's abundance and distribution within a plot was used for groundcover plants (and annuals) that are difficult to count and/or grow in large clusters. This method was adopted for *C. aquatilis* and *R. tripartita*. *L. alsinoides, L. incisa* and *M. triglochinoides.*

The technique involved the measurement of an area of occupancy (AoO) of subject plant's distribution within the plot and a series of 1x1 metre quadrats randomly placed within the AoO to either estimate percentage ground cover or count number of stems. Any plots with continual low abundances of individuals were directly counted. A measure of percentage cover was only used for *M. triglochinoides*. For *A. hispidus, C. aquatilis, R. tripartita*. *L. alsinoides and L. incisa,* stems (where present) and were directly counted within specified patches or mean number of stems determined in 1 x 1m quadrats for larger occurrences.

To account for consistent temporal changes in site abundance and occupancy (i.e., increase/decline), a standard method of recording cover/abundance was applied across the entire plot for each monitoring event. This was calculated by multiplying the mean percentage ground cover, or mean number of stems, by the division of the AoO over the plot size, i.e. ((AoO / 400m^2) x mean cover or stem count).

The remaining species of shrubs, trees and orchids were directly counted as per the TFMP. A summary of plant health and habitat condition factors was recorded based on observing leaf condition, any notable dieback or insect attack, plant height, width, diameter at breast height (DBH) for tree species, number of trunks and habitat conditions.

Weed cover was measured using a modified Braun-Blanquet cover abundance score (Braun Blanquet, 1928; Poore 1955), refer

Table 2-3.

Table 2-3 Cover abundance score used for measuring weeds

Score	Description
1	Rare, few individuals present (three or less) and Cover <5%;
2	Common and cover <5%;
3	Very Abundant and Cover nearing 5% OR Cover from 5% to <25%;
4	Cover from 25% to less than 50%;
5	Cover from 50% to less than 75%;
6	Cover 75% or more

Other general information recorded at each plot included observations of the dominant flora species in each structural layer, prevailing site conditions (i.e., soil moisture, surface water levels and observed flow velocity for macrophyte species) and landscape parameters (i.e., landform, drainage, slope, and aspect).

2.4 Performance thresholds and corrective actions

The TFMP details an adaptive management approach to achieve management goals and mitigate impacts to in-situ threatened flora. The 2022 data is relevant to the operational phase of the project and has been compared with baseline and construction data to evaluate any impacts and determine effectiveness of the management measures used. This is assessed in the context of the performance measures identified in the plan (refer to **Table 4-1** and **Table 4-2**). The TFMP outlines the performance criteria relevant to the in-situ threatened plant species during the operational phase of the project as follows:

1. Zero mortality of retained in situ threatened plant populations has occurred during construction and for three consecutive monitoring periods post-construction and 8 per cent survival of tree, shrub and herbaceous perennials after five years.

2. At least 90 per cent of the plants planted as part of the revegetated areas have survived after the first year and 80 per cent after three consecutive monitoring events, and

3. Less than five per cent weed cover at retained in situ threatened flora sites (end of monitoring program) and less than 30 per cent weed cover at other revegetation areas.

These objectives are described in **Table 2-4** as 'performance goals' and have been identified along with the corresponding mitigation measure, and the associated monitoring approach which has been designed to identify if performance triggers have been met and corrective actions where they have not. This report outlines the results from the third consecutive year of post-construction monitoring and so is particularly relevant the first and third performance goals. The second performance goal is not address by the threatened in-situ plant monitoring program. As stated in the TFMP, three consecutive monitoring periods post construction would be carried out and following this period a review of the results would be undertaken to identify if further monitoring is required. If the data indicate that the mitigation measures have proven successful for three consecutive monitoring periods, then no further monitoring would be required.

Table 2-4 Mitigation measures and corrective actions for threatened flora during highway operation phase

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Zero mortality of retained in-situ threatened plant populations during construction and for three consecutive monitoring periods post-construction. Post the above period 80 per cent survival of tree, shrub, and herbaceous perennials after three years.	Clearly identify in-situ populations and exclusion zones. Implementation of weed management measures throughout operational period.	Threatened plant health monitoring and weed monitoring to occur as per Sections 8. Monitoring to occur annually of in-situ monitoring sites and control sites. Monitoring will occur for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods as per MCoA D8 (k).	Any mortality of in-situ threatened plants for the first three consecutive monitoring periods post construction. Post the above timeframe more than a 20 per cent decline for an in-situ threatened plant population over one monitoring event from the baseline (depending on species specific seasonal fluctuations).	Commence assessment of potential reasons for mortality, including natural events such as drought and fire within one month of trigger being identified. Review weed maintenance schedule within one month of trigger being identified. Identify potential threats, implement corrective actions, and modify monitoring as necessary. Offset any additional threatened plant impacts that have occurred as a result of the Project.

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
At least 90 per cent of the plants planted as part of the revegetated areas have survived after the first year and 80 per cent after three consecutive monitoring events.	Regular maintenance activities such as watering, mulching, weed control and supplementary plantings as required as per the landscape design.	For the first twelve months monitoring will be monthly. It will then go to every 6 months for two years. Monitoring will occur in Spring/Summer to evaluate the success of revegetation against performance objectives.	Monitoring and maintenance activities not being undertaken. More than 10 per cent of plants have died after year one, and more than 20% have died after three consecutive monitoring events.	Within one month of the trigger review and update maintenance methods as required. Identify any other potential threats and implement corrective actions as required. Any failed areas to be reseeded within 6 weeks of trigger. Ongoing monitoring and maintenance undertaken until plant health and/or ecological condition of habitat has been maintained at 80% survival after three consecutive monitoring events.
Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program).	Implementation of weed management measures throughout operational period.	Threatened plant health monitoring and weed monitoring to occur as per Sections 8. Weeds will be monitored in proximity to in-situ flora populations annually. Monitoring will occur for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods as per MCoA D8 (k)).	Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations. More than 30% weed coverage in revegetation areas.	Review weed maintenance program within one month of trigger being identified and update as required.

3. Results and discussion

3.1 Operational Year 3 monitoring (Sections 3-10)

3.1.1 Sandstone Rough-barked Apple (*Angophora robur*)

All thirteen *Angophora robur* sites (in-situ and control) (chainage:44600-67700) were visited between 31 October to 3 November 2022. In general, the results from the third year of operational monitoring identifies no mortality of in-situ trees and minimal changes in recruitment, with some new plants reported for some sites and others having experienced a small reduction in previously counted juveniles. Trees were assessed generally to be in very good to excellent condition (score 4-5). Some bare branches or branches with minimal foliage were observed but this appears to be characteristic of the growth habit of this species as observed from both impact and control sites.

From the 2022 data, the largest increase in seedling abundance occurred at ArC3.1 and Ar-3.2 (refer to **Figure 3-1**). The control site ArC3.1 that had previously been impacted by under scrubbing by the property owner was observed to be recovering in the ground layer, with 21 new *A. robur* juveniles counted and a large increase in mid-storey cover of all plant species. One mature tree was in poor health, which may have responded negatively to the disturbance. This impact is not project related and affects the control plot.

Conversely, the largest decline in seedlings occurred at Ar-3.3, from 21 seedlings in 2021 to 13 seedlings in 2022, and at Ar-3.9, from 6 seedlings in 2021 to 3 seedlings in 2022. At Ar-3.9, the shrub layer weed Lantana (*Lantana camara*) had increased to 15% foliage cover in the plot, associated with increased rainfall, which may have had a negative effect on survival of juveniles. The health of mature trees at these sites, however, was in very good-excellent (score 4-5) health in 2022.

Weed cover, mostly Lantana, has increased at some in-situ sites since 2021 but has also increased at some control sites, suggesting edge effects may not have been the cause, and this is likely associated with the higher rainfall in the last two years since commencement of operation. For example, Lantana increased to 30% foliage cover at in-situ Ar-3.10 during 2021-2022, but also increased to 25% at control Ar-C3.2.

General plant dieback was evident at sites Ar-3.4 and Ar-3.7 in 2021 and has been observed since Year 1 construction monitoring. As suggested previously, it may be associated with drought and heat stress and/or caused by the epidemic infection of the root-rot fungus Cinnamon Fungus (*Phytophthora cinnamomi*), but this would need to be confirmed. This dieback pre-dates the highway construction. Around 50% of the trees in these two plots had new shoots and showed slow recovery in 2021 and 2022. Trees at Ar-3.4 had recovered further in 2022 with 80% of the trees exhibiting with new shoots. There has been no decline in health of the trees at Ar-3.7.

Evidence of controlled groundcover fire was noted in the previous 2021 monitoring report at impact sites Ar-3.3 and Ar-3.4, which occurred two months prior to the monitoring event. This was associated with landholders and is not project related. These fires caused minor impacts to 3 small trees at Ar-3.3 and 1 small tree at Ar-3.4, and these were resprouting during the 2021 monitoring event. Monitoring in spring 2022 identified that the affected trees were in very good-healthy condition and showing further signs of post-fire recovery.

In 2021, a number of trees at sites Ar-3.1 and Ar-3.8 appeared to have had been impacted by storm damage. In 2022 all trees at Ar-3.1 were in very good-excellent condition. At Ar-3.8, one of the nine trees was still recovering and was assigned a score of 2, the rest were in very good-excellent condition.

No baseline data exists for sites Ar-3.10a and Ar-3.11a that were established in 2017. These sites were surveyed in 2022 and *A. robur* were found to be in excellent condition, as in previous years, and abundance of seedlings had remained the same since 2021.

A summary of all in-situ and control *A. robur* sites is presented in **Figure 3-1**.

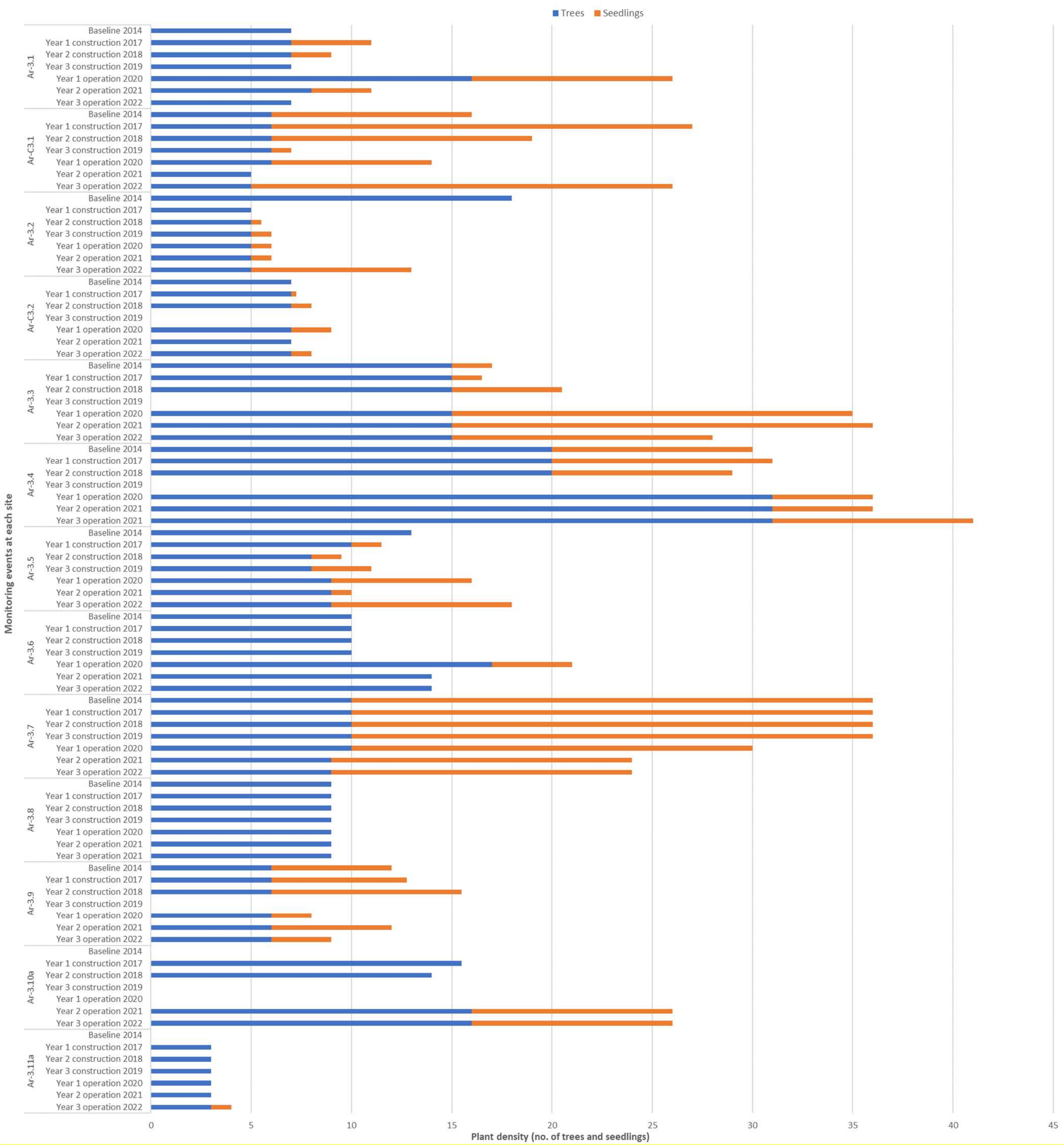


Figure 3-1 Number of *A. robur* trees and seedlings observed over eleven monitoring events (2014 [n=1], mean results for 2017 [n=4], mean results for 2018 [n=2], 2019 [n=1], 2020 [n=1], 2021 [n=1], 2022 [n=1] at eleven in-situ sites and two control sites)

3.1.2 Hairy-joint Grass (*Arthraxon hispidus*)

All six *Arthraxon hispidus* in-situ sites (chainage:129300-157900) and two control sites (chainage:157200-157500) were sampled in November 2022. *A. hispidus* was recorded as present at 50 % of the sites (Ah-8.1, Ah-10.1, Ah-10.2 and Ah-C10.2) and absent from the remaining 50 % (Ah-10.3, Ah-10.4, Ah-10.6 and Ah-C10.1) including both impact and control sites. Where *A. hispidus* was observed it was in very-healthy to excellent condition (score 4-5) and ranged in height from 5-15cm. *A. hispidus* is an annual species that naturally dies back each year and the abundance of plants observed at the sites surveyed as part of this monitoring program have fluctuated considerably since baseline surveys (refer **Figure 3-2**).

At Ah-10.2, mean number of stems per metre square was 8.25 in 2022, which is a slight increase since 2021 and the highest abundance among the sites. This was despite exotic cover remaining high and several aggressive weeds present, e.g., *Paspalum mandiocanum, Setaria sphacelata, Ageratina Adenophora*. This site had recently been grazed and most *A. hispidus* was observed growing in cattle pugs. Typical of annual species, *A. hispidus* prefers bare, disturbed ground for germination and growth, and previous studies have demonstrated that *A. hispidus* responds positively to grazing and slashing as it maintains an open structure in the ground layer (White, 2019).

There was also a small increase in mean number of stems at Ah-10.1, from 0.02 in 2021 to 0.08 in 2022. Conversely, both Ah-8.1 saw slight decreases in *A. hispidus* abundance, which was also observed at the control Ah-C10.2. The in-situ site Ah-8.1 had a moderate abundance of weeds (about 12% exotic cover in the plot), but the ground layer had an open structure and appeared suitable for *A. hispidus* growth. The control site Ah-C10.2 also had an open ground layer with patches of bare ground and no canopy cover.

Sites Ah-10.3, Ah-10.4 and Ah-C10.1 are a small distance apart and all in a Swamp Rice Grass (*Leersia hexandra*) dominated wetland with shallow standing water and a high abundance of the exotic forb Hairy Commelina (*Commelina benghalensis*). *A. hispidus* is not known to grow in water, although it often occurs near swamps and creeks. In spring 2022, *A. hispidus* was absent from these plots most likely because the species is not adapted to growing in water. *A. hispidus* was observed close to these plots, growing on a mound of earth above the water, which supports this explanation. *A. hispidus* has not been recorded in these plots for the last three years which coincides with above average rainfall during 2020-2022 following the 2019 drought year. In subsequent drier years the shallow wetland may dry out and *A. hispidus* may re-emerge in these plots.

At the in-situ site Ah-10.6 no *A. hispidus* has been recorded since 2019. The absence of *A. hispidus* in 2020 and subsequent years corresponds with an increase in ground layer weeds such as *Paspalum mandiocanum* and *Ageratina adenophora*, most likely from exclusion of grazing. The plot has had a dense cover of exotics since 2020 (close to 100% exotic cover) and the ground layer has lacked the open structure which *A. hispidus* requires for germination and growth.

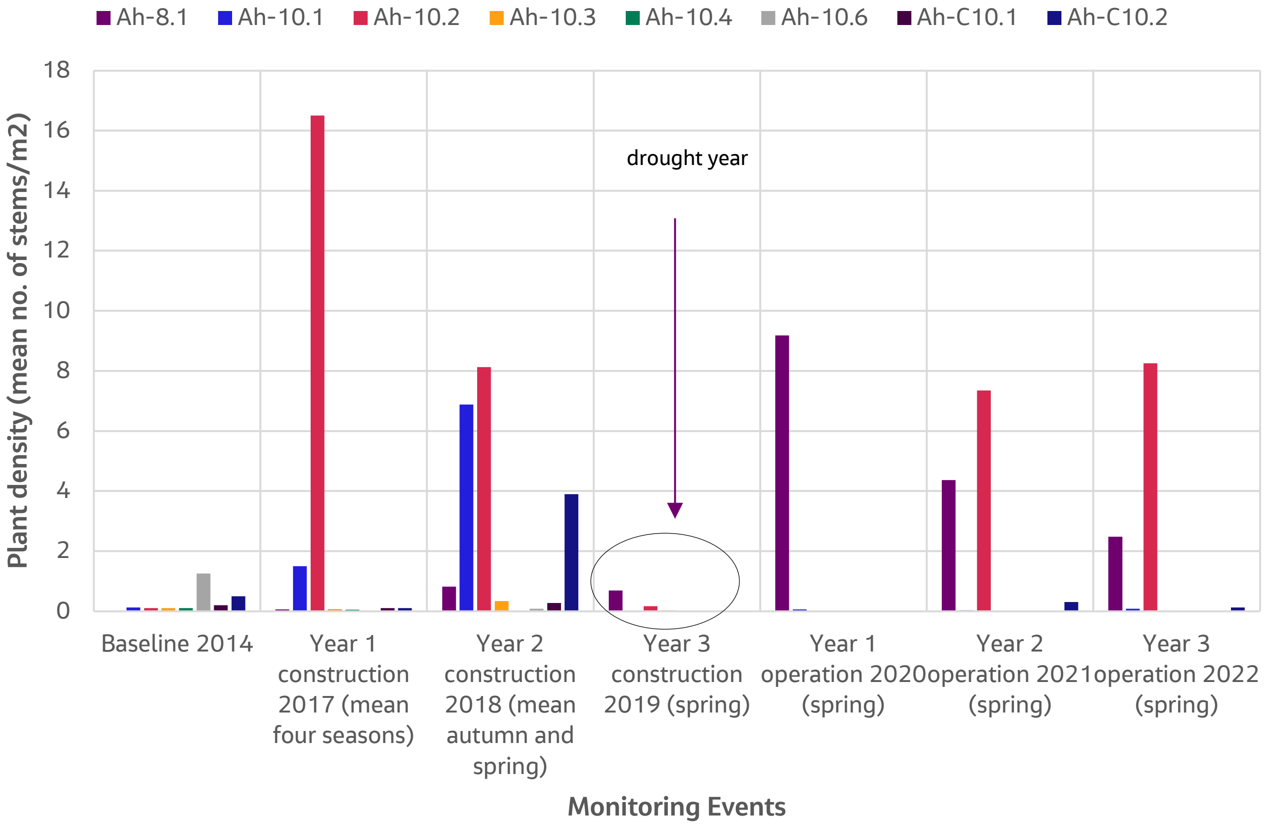


Figure 3-2 Density (mean no. of stems / m^2) of *Arthraxon hispidus* in each plot observed over eleven monitoring events at six in-situ sites and two control sites

Competition from weeds and the loss of an open structure in the ground layer continue to be threats to *A. hispidus* survival at the monitoring sites. This is primarily by exotic species such as *Paspalum dialatatum*, *Paspalum mandiocanum, Commelina benghalensis, Setaria sphacelata* and *Ageratina adenophora* forming dense groundcover (refer **Photograph 3.1 and 3.2**). This problem has been exacerbated by above average rainfall during 2020-2022 (post 2019 drought conditions) and the removal of cattle from some of the properties. These properties were previously managed through grazing and cattle removal occurred during the construction period of the project.

Table 3-1 shows the change in weed cover and number of weed species for all sites over all monitoring periods. This impact is not project related.

Table 3-1 Comparison of weed abundance ground cover and species richness) at *Arthraxon hispidus* monitoring plots (pre-construction, construction, and operational periods)

Site	Mean weed ground cover (%) / weed richness (No. spp.)						Change (%) in mean weed ground cover (baseline vs construction) / baseline vs operation (+/-)	Difference in no. of weed species (cons / oper (+/-)	Detailed design impact
	Pre-construction	Construction means	Operation Year 1	Operation Year 2	Operation Year 3	Operation means			
Ah-8.1	100/1	83.3	80/5	100/6	13/8	64	-16.7 / -36.0	+7 / +5	**No**
Ah-10.1	100/2	99.7	100/10	80/4	100/6	93.3	-0.3 / -6.7	+4 / +5	**No**
Ah-C10.1	20/1	15.5	19/3	0/0	30/1	16.3	-4.5 / -3.7	+3 / 0	**No**
Ah-10.2	85/3	70.8	100/3	90/6	97/10	95	-14.2 / +10.0	+7 / +3	**No**
Ah-C10.2	20/3	56.7	100/8	60/4	29.2/8	63	+36.7 / +43	+5 / +4	**No**
Ah-10.3	65/3	80	75/5	5/1	30/1	36.6	+15 / -28.4	+8 / -1	**No**
Ah-10.4	75/6	64.7	65/5	50/1	30/1	48.3	-10.3 / -26.7	+3 / -4	**No**
Ah-10.6	65/2	98.7	100/5	100/3	100/7	100	+33.7 / +35.0	+7 / +3	**No**

Photograph 3.1: Plot Ah10.4 Exotic species (*Paspalum)* and native Rice Grass *(Leersia hexandra).* Arthraxon hispidus has not been recorded her during operation, whichis result of competition.

Photograph 3.2: *Arthraxon hispidus* continuing to grow in spaces amongst exotic and native ground covers (Ah-8.1).

3.1.3 Water Nutgrass (*Cyperus aquatilis*)

No *Cyperus aquatilis* individuals were recorded from the monitoring plot during the spring 2022 survey, and this is consistent with previous years during construction and operation. This species is best detected during summer and autumn where climatic conditions are most suitable. It is likely the drought conditions in 2018/19 had resulted in loss of plants at this site, and despite good rainfall during 2020-2022, and localised flooding, the species has not re-appeared at this location.

Although individuals have not been detected since the baseline surveys, its absence from the site is not considered to be related to the project, but rather a change in conditions associated with climatic conditions, surface hydrology and weed abundance, which occurred prior to and during construction following flooding in year 1 and 2 of operation.

3.1.4 Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *bracteata*)

Site Emb-4.2 consisted of one mature *Endiandra muelleri* subsp. *bracteata* shrub, which was inadvertently removed by a construction contractor in January 2019. The contractor was required to implement a Remediation Plan to address corrective actions. Site Emb-4.2 has now been removed from the monitoring program.

Emb-4.1 (chainage: 81700) was inspected on 3 November 2022. The native vine *Smilax australis* and the weedy vine Dutchmen's Pipe (*Aristolochia elegans*) were growing on the single *E. muelleri* subsp. *bracteata* and a number of small eucalyptus branches had fallen on top of the plant. Despite this, it remained in good health and had increased in height in the last 12 months (refer **Photographs 3-3 and 3-4**). Insect activity and browsing on leaves in 2022 was minimal and consisted of only 5% of the leaves present. Leaf insect damage has been noted since the start of the program but hasn't caused detrimental harm to the plant and remains minimal in 2022. New shoots were observed at the top of the plant in 2022.

Weed cover at Emb-4.1 was relatively high in 2022, as in previous years. The amount of sunlight entering this site has increased from vegetation clearing during construction to the south (inside the project boundary) and dieback of Flooded Gum (*Eucalyptus grandis*) tree canopy, suspected to be caused by irregular roosting of Flying Foxes. The increased sunlight to the groundcover has been the cause of increases in weed cover which has increased to about 35% in 2022 and an increase of 25% since the baseline. The cover of weeds, however, is not currently having a detrimental impact on the health of the plant at this location.

Poisoning of weeds at Emb-4.1 has be undertaken in the past, and vines growing on the *E. muelleri* subsp. *bracteata* were pruned to free up the plant during monitoring in 2022. Star pickets, barrier fencing, and signage was removed in November 2022 as these structures were found to trap branches and facilitate climbing by vines. Without regular weed maintenance vines will grow back on the *E. muelleri* subsp. *bracteata* and may eventually smoother the plant, causing a decline in health and eventual death, particularly as Dutchmen's Pipe is an aggressive weed. This is a plausible scenario but is not certain as rainforest saplings smothered by vines are often observed to continue to grow, and restoration practitioners have argued that this is a natural process that "lifts" vines into the canopy.

Weed control should be carried out at Emb-4.1 until the site is self-sustaining to ensure the long-term survival of the single *E. muelleri* subsp. *bracteata*.

Photograph 3-3: E. muelleri subsp. bracteata at in-situ site Emb-4.1 showing star pickets that were removed

Photograph 3-4: New growth on E. muelleri subsp bracteata.

3.1.5 Four-tailed Grevillea (*Grevillea quadricauda*)

In-situ site Gq-3.1 sits on the edge of the forest and the cleared project corridor and much of the plot remains subject to increased sunlight from clearing for the project, although in 2022 there had been an increase in canopy cover resulting in more shade. Site Gq-3.1 had 18 adult *G. quadricauda* plants ranging from 20-180 cm high and 4 juvenile plants <20cm high in 2022, which is an improvement in contrast to the results from 2021. Observations of plant recruitment, seed dispersal and seedling mortality have varied over the years of monitoring. There were 24 seedlings counted in autumn 2018, 21 seedlings in November 2018, 20 in October 2019, 7 in November 2020, 8 in October 2021, and 4 in November 2022. These results reflect that some recruits from this period have now been counted as adult plants and there are now 18 adult plants recorded at site Gq-3.1 in 2022 compared with 6 at the start of construction in 2017. Regeneration is continuing along the road edge with a mixture of natives and exotics. Weeds include Broad-leaved Paspalum (*Paspalum mandiocanum*), Monterey Pine (*Pinus radiata*), Lantana (*Lantana camara*) and their cover has steadily increased. Despite the increase in weed cover, overall, the *G. quadricauda* plants were in excellent condition at site Gq-3.1 in 2022, with flowers/buds observed on 5 plants and new shoots on 50% of plants.

Shrub abundance at the control Gq-C3.1 remained at 15 individuals in 2022, and *G. quadricauda* was abundant immediately surrounding the plot. Plant height ranged from 40-200 cm with occurrence of new shoots and flowers/buds. Overall plants were assessed as being in excellent condition with new shoots and flowers observed on a number of plants.

A summary of *G. quadricauda* plant numbers at monitoring sites is presented in **Figure 3-3**.

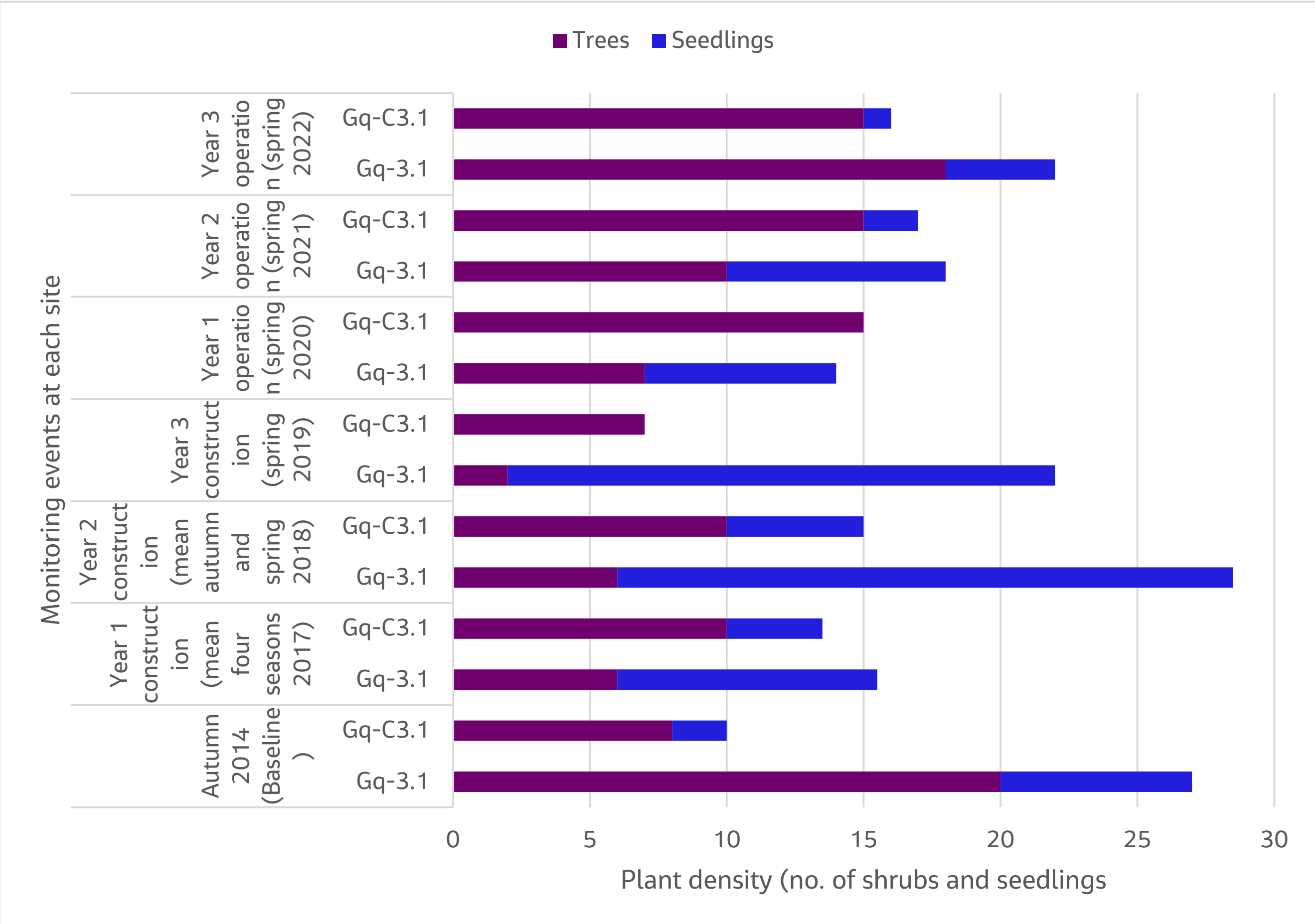


Figure 3-3 Number of *G. quadricauda* shrubs and seedlings observed over eleven monitoring events (2014 [n=1], mean results for 2017 [n=4], mean results for 2018 [n=2], 2019 [n=1], 2020 [n=1], 2021 [n=1] and 2022 [n=1] at in-situ and control site).

3.1.6 Slender Screw Fern (*Lindsaea incisa*)

In-situ site Li-3.1 had an area of occupancy of 43 m^2 in spring 2022, which is a slight increase since spring 2021. Area of occupancy was just 0.5 m^2 in 2019 (drought year) but steadily increased to 19.3 m^2 in 2020, then 33 m^2 in 2021 and now 43 m^2 in 2022. This site was directly impacted by the approved detailed design work prior to autumn 2018 survey with the construction of a man-made drainage line in the middle of the site, which resulted in some loss of ferns. The decrease in areas of occupancy to just 0.5 m^2 observed during 2019 surveys is possibly a result of a combination of this impact plus the drought conditions. Since this impact, there has been strong recovery of plants observed in the last three spring monitoring events in 2020, 2021 and 2022, and there are no further construction-related impacts occurring at the site. The plants in Li-3.1 were in good health and a range of ages and sizes of plants suggested reproduction and stages of maturity.

In-situ site Li-3.2 also increased in area of occupancy from 10 m^2 in 2019 (drought year), to 113 m^2 in 2020 and 190 m^2 in 2021. In 2022, the area of occupancy was 180 m^2 and *L. incisa* ferns were in excellent health, indicating that the population is stable.

Mororo State Forest had experienced a very hot fire in November 2019 which was also a drought year, subsequently no plants were observed at monitoring locations Li-6.1 and Li-6.2 within the State Forest in Section 6 during the 2020 survey and again in 2021 despite good post-fire recovery of other native species. Prior to this no plants were recorded in 2019 prior to the fire, during a drought phase and the environmental conditions at these sites are thought to have led to the decline rather than clearing for the project. Indeed, these observations are expected to be a result of lower-than-average rainfall and infrequent rainfall events in the region across 2018-2019, including the hot fire in late 2019. This species is likely to be sensitive to the very low rainfall trends and these observations are unlikely to be a project-related impact. In 2022, a small *L. incisa* patch was observed at the southern end of Li-6.1 (area of occupancy 1 m^2), a sign that the population may be slowly recovering. No plants were recorded at Li-6.2 in 2022. Post-fire regeneration of groundcover and midstorey species remained very dense in 2022 for both Li-6.1 and Li-6.2, offering little opportunity for *L. incisa* plants to establish.

In contrast however, plants at the control plot to the south (Li-C6.1) had recovered following the fire. No plants were recorded at the plot in 2018 and 2019, although an area of 30 m^2 of the plot contained young plants that were recorded in November 2020, 12 months after fire. It is unclear why plants re-appeared at the control plot but did not at the two nearby impact plots immediately after the fire. Evidently site characteristics of Li-C6.1 immediately following the fire favoured *L. incisa*, possibly more bare ground and less competition of groundcover species. In 2021, Li-C6.1 saw a decline in mean cover/m^2 (0.01% from 1.08% in 2020), and in 2022 cover remained low at 0.18%. Like the two impact plots, the control plot had dense post-fire regrowth of understorey species in 2022, and it is likely L. incisa is being outcompeted in the plot area.

Summary of mean percent cover for all *L. incisa* sites is presented in **Figure 3-4**.

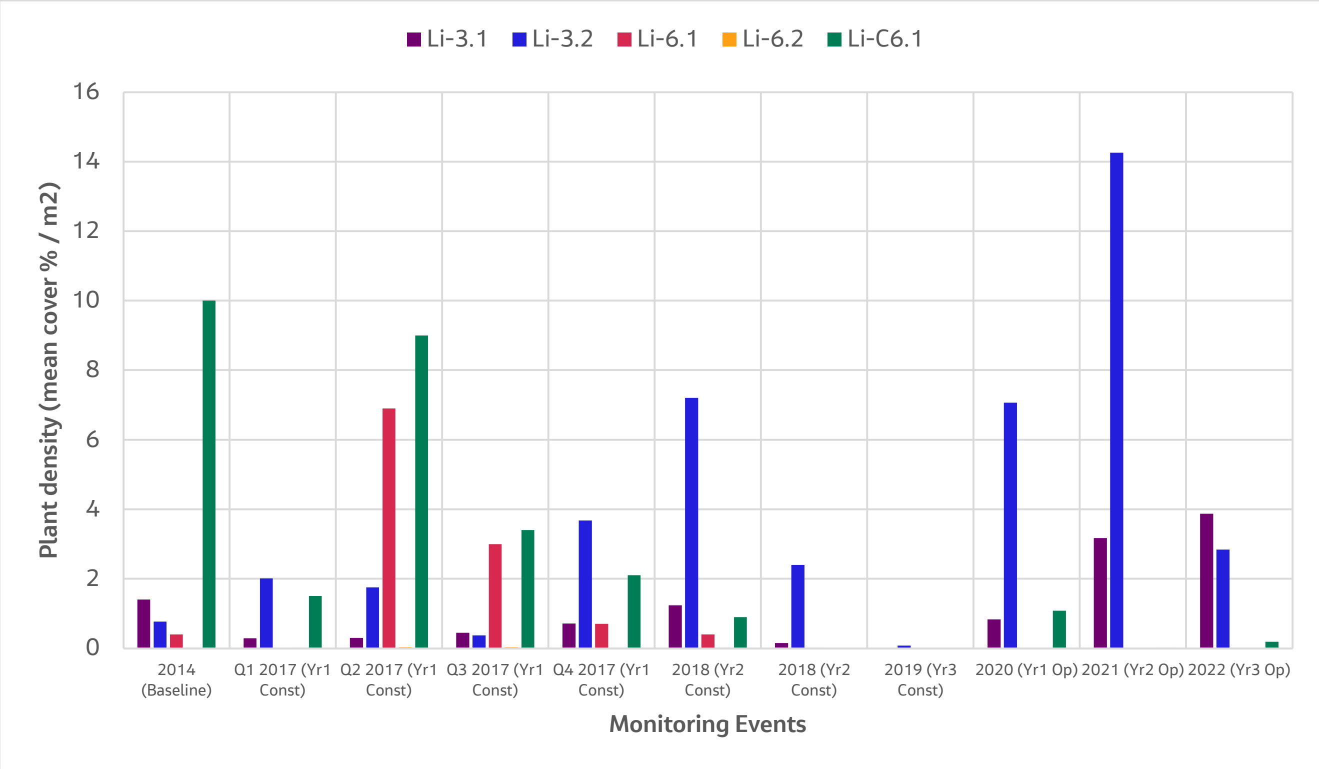


Figure 3-4 Density (mean no. of stems / m^2) of *Lindsaea incisa* observed over eleven monitoring events at four in-situ sites and one control site.

3.1.7 Rough-shelled Bush Nut (*Macadamia tetraphylla*)

There has been no notable change in health of the single *Macadamia tetraphylla* tree or change in weed cover over the three years of operational monitoring (2020-2022) at Site Mac-8.1 (chainage: 134700). The tree was likely temporarily inundated during the flood event in Woodburn in February 2022. In the November 2022 monitoring the health of the tree was excellent event, with healthy new growth and evidence of recent flowering in the last 12 months, although very little fruit, most likely due to lack of cross-pollination with other *M. tetraphylla*. Grazing has been excluded from the site and weed cover remains high at close to 100%. The most abundant weeds include *Senecio madagascariensis*, *Bromus catharticus* and *Bidens pilosa*.

Photo 3.5. Macadamia tetraphylla - new shoots in lower branches following flooding and heavy rainfall periods in early 2022

Photo 3.6. Macadamia tetraphylla - old woody fruits

3.1.8 *Maundia triglochinoides*

Changes in mean cover and area of occupancy of *M. triglochinoides* occurred at all impact and control sites compared with the data from the previous monitoring event (2021). No water pollution or other project-related impacts were observed at the sites and these annual fluctuations are expected to be naturally occurring and associated with changing hydroperiods of ponds and creeks where the species is found. Additionally, above average annual rainfall conditions were experienced in 2022, particularly during February and March when there was major flooding on the NSW North Coast. For species such as Maundia, these rapid high rainfall events may dislodge the shallow-rooted plants from stream bed habitat and account for temporal changes in areas of occupancy from annual monitoring events. The depth of water will change the micro-habitat conditions for the species, which prefers shallow ponded environments and edges of pools and dams.

For example, no plants were found at the control site Mt-C3.1 during 2020 surveys. Control site Mt-C3.1 had a large decrease in cover of *M. triglochinoides* from 150 m^2 area of occupancy in 2018 to 0.5 m^2 in 2019 (drought year) and plants appeared absent in 2020. The species was observed around 50 metres downstream from the plot persisting in a ponded section of the creek where it was previously not recorded. As above-ground plant parts of this species have dieback, presumably *M. triglochinoides* continue to exist only as tubers in the steam bed soil until sufficient water returns to fill the ponded sections. Plants were again present at site Mt-C3.1 in the 2021 survey with three new individuals identified in the plot and a mean percentage cover of 0.22 m^2. In spring 2022 mean percentage cover in the plot had slightly increased further to 0.625 m^2 and flowers were observed on some stems. However, immediately upstream and downstream of the monitoring plot there were large Maundia patches. It appeared that the depth of water within the plot was too deep and Maundia had re-established after the 2019 drought just outside the plot in shallower sections of the creek.

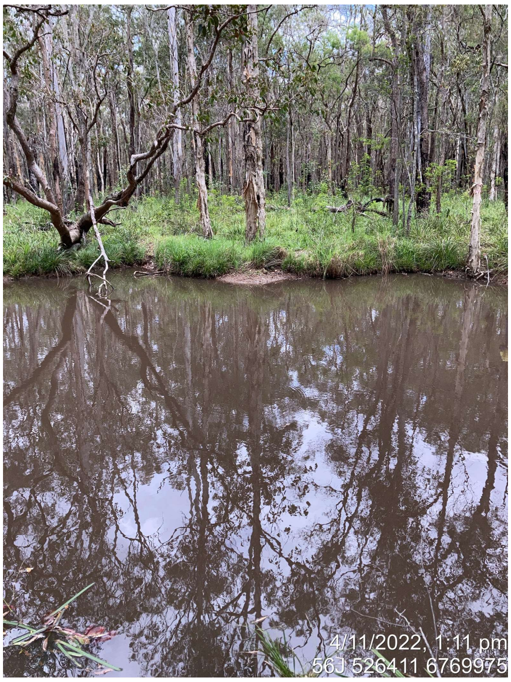
Similarly, at in-situ site Mt-3.1 only a few plants were observed in 2022, as in previous years, but approximately 40 m east of the monitoring plot there was a large Maundia population. The Coldstream River was full and there were Maundia stems floating on the surface within the plot at the time of monitoring. It is likely that water depth has been too deep during 2020-2022 but in subsequent drier years and resultant shallower water the population would be reasonably expected to expand.

Conversely in-situ site Mt-3.2 exhibited a large increase in mean percent cover during the recent year, from 0.40% in 2021 to 6.5% in 2022. Mean percent cover has remained low at Mt-3.2 throughout the monitoring program (generally <1%). The sudden increase in 2022 is most likely due to suitable water depth at the site during 2021-2022 and confirms that the project has not negatively impacted on the habitat of the species.

The cover of *M. triglochinoides* at the in-situ site Mt-7.1 decreased from 12% to 4.5% (mean percent cover) from 2019 to 2020 (associated with drought and fire period), however, there was a large increase to 38% in 2021 due to pond filling resulting in expansion of available habitat and good post-fire recovery. This is related to a large hot fire which passed through the habitat in November 2019 and plant abundance declined for the following 12 months. There was evidence of plants at the edge of the pond being burnt. During 2021-2022 the *M. triglochinoides* population remained large and healthy. In spring 2022 mean cover was 21%, plants were in excellent health, and flowers were observed on some stems. No weeds were present in the pond, and *M. triglochinoides* continued to dominate the plot along with the presence of *Philydrum lanuginosum*.

At in-situ site Mt-7.2 the natural changes in abundance and area of occupancy associated with changing hydroperiods and the remobilisation of shallow sediments is evident. The area of occupancy decreased to just 3 m^2 in spring 2017 but began recovering subsequently to 13 m^2 in 2018, 29 m^2 in 2019 and 2020, and 104 m^2 in 2021, most likely as a result of increased rainfall and flushing of the stream. In spring 2022, however, the area of occupancy decreased markedly to 15 m^2. The decrease in the area of occupancy is associated with major flooding (that occurred during February-March 2022), and the dislodgment of plants as described, as well as the shifting of shallow sediments creating a deeper pool not suited to recruitment of the plant. **Photo 3.7** is taken from the south side of the monitoring plot and shows the extent of the population prior to construction (2014). **Photo 3.8** is approximately the same location in 2022 and shows plants have disappeared after heavy flooding, the shallow bank has re-mobilised downstream, and the pond is likely now too deep for new plants to establish.

Photograph 3-7 Pre-construction phase at in-situ site Mt-7.2 showing healthy population of M. triglochinoides (May 2014)



Photograph 3-8. Year 3 operational phase (2022) at in-situ site Mt-7.2 showing absence of plants over previous distribution. The depth of water on the northern bank is evident

The population size of *M. triglochinoides* at in-situ site Mt-7.3 has fluctuated throughout the monitoring program. This site is directly within the corridor below and adjacent to the twin bridges. The area of occupancy was 80 m^2 during the baseline survey and remained similar at 86 m^2 during year 1 construction and 100 m^2 in year 2. In year 3, works associated with bridge construction reduced the cover to 56 m^2 in 2019 and to 22 m^2 in 2020 with significant shading over the plot continue to reduce the area of suitable habitat. In spring 2021 the site was showing evidence of good recovery with area of occupancy at 50 m^2 (**Photo 3.9**). Plants had spread to the east and west of the bridge in areas not previously occupied, although absent below the bridge, which is expected. In spring 2022, however, area of occupancy had decreased again to only 16 m^2 (**Photo 3.10**). As with in-situ site Mt-7.2, this is related to the February-March 2022 flooding event and dislodgment of plants, as is not expected to be related to project impacts.

Photograph 3-9: Year 2 operational phase at in-situ site Mt-7.3 showing population recover on west side of the north bound carriage way

Photograph 3-10: Year 3 operational phase at in-situ site Mt-7.3 following the February major flood event showing decreased area of occupation

Summary of mean percent cover for all *M. triglochinoides* sites is presented in **Figure 3-5**.

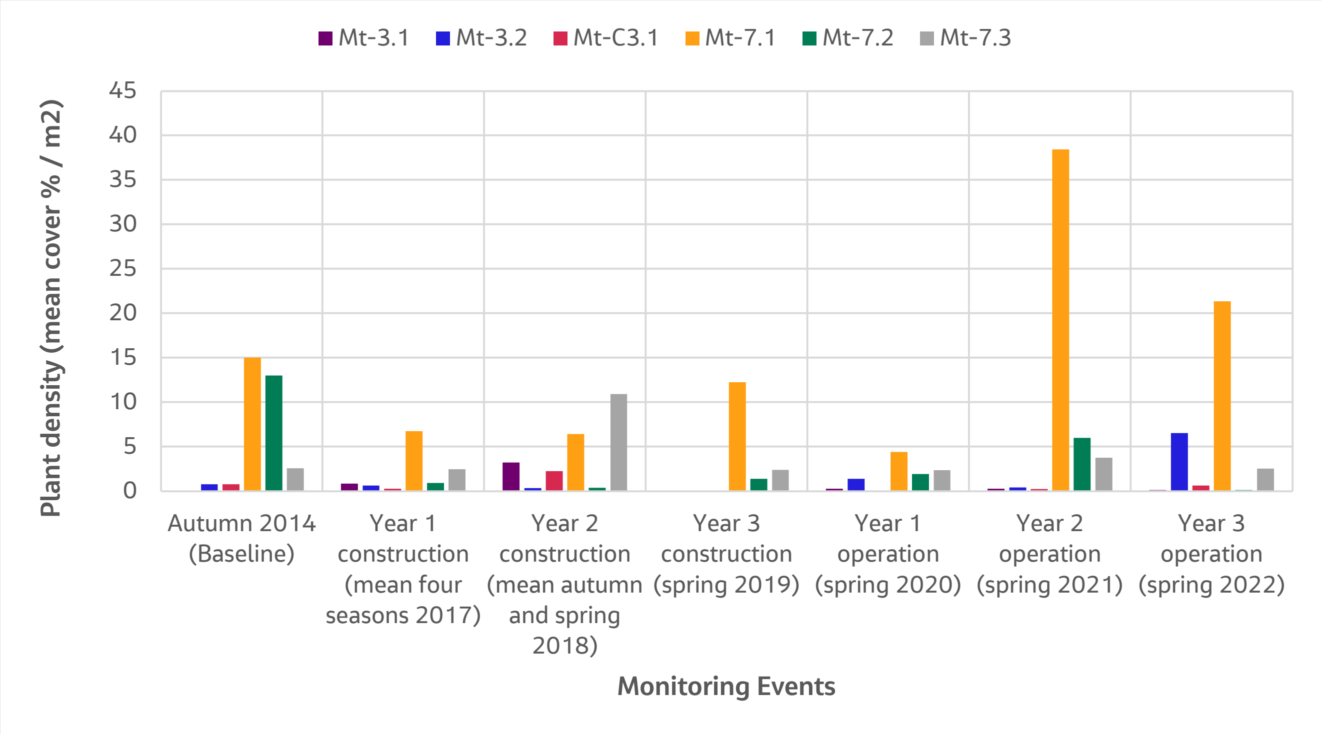


Figure 3-5 Density (mean cover % / m^2) of *Maundia triglochinoides* observed over eleven monitoring events at five in-situ sites and one control site

3.1.9 Swamp Tea-tree (*Melaleuca irbyana*)

As reported in 2020 all *M. irbyana* impact and control monitoring plots had been severely burned from a large wildfire which occurred in the last year of construction (November 2019). Very few trees were actually killed from the fire and the species has shown good post-fire recovery in 2020-22 as evidenced by basal resprouting, coppice shoots and new germination of plants that had spread seed post-fire, demonstrating the species response to fire.

The abundance of *M. irbyana* at in-situ site Mi-7.1 (chainage: 120800) during the 2021 surveys confirmed 39 trees of which 27 were mature and 12 were resprouting in the easement. This site was observed as still recovering from fire with signs of dead trunks on older trees and new shoots sprouting from the base and burnt trunks. In 2022 the dense clumps of coppicing stems made determining individual plants and estimating the population size difficult (refer **Photograph 3-9**). 64 adults and 51 juveniles were counted, the juveniles mostly confined to the easement, but this is probably an overestimate and stems of the same plant were probably counted as separate individuals. Regardless, the *M. irbyana* population in 2022 appeared healthy, with plants continuing to grow post-fire and strong recruitment, although probably of asexual means, i.e., root-suckering, basal resprouting.

Similarly, the abundance of *M. irbyana* at in-situ site Mi-7.2 (chainage: 120900) during the 2021 surveys confirmed 33 trees of which 10 were mature and still recovering from fire, and 23 were immature located on the gas easement where these were previously slashed and have resprouted. In 2022, these 10 mature trees were in good-very good condition (score 3-4) and 28 juveniles were counted on the gas easement. No signs of recruitment from seed were noted, however post-fire regeneration was commonly observed (refer **Photograph 3-10**).

At the control site Mi-C7.1, 20 mature *M. irbyana* were counted in 2022 and these individuals were in excellent condition with 100% of the trees with new shoots. The trunks of these adult *M. irbyana* did not die in the 2019 wildfire and so there has been no basal resprouting as observed at the in-situ sites. Approximately 200 juveniles were counted in 2022, mostly in the southeast corner and centre of the plot, and these appeared to be seedlings.

This species is known to have the ability to form root suckers and through root extension and interconnectivity form dense clumps of single clones. This is a common adaptive characteristic of wetland plants subject to very difficult conditions for survival, growth and sexual recruitment in which it was difficult to differentiate whether this species had seeded or sprouted from roots.

Photograph 3-9: Melaleuca irbyana in year 3 operation phase survey (November 2022) at in-situ site Mi-7.1. Dead trunk in centre of photograph new growth after fire.

Photograph 3-10: Juveniles plants were commonly counted in 2022 (3 years post-fire) demonstrating the species response to fire.

3.1.10 King of Fairies (*Oberonia titania*)

Both in-situ site Ot-10.1 and control site Ot-C10.1 (chainage:152300) were surveyed on 5 November 2022. As described in previous reports the in-situ site (Ot-10.1) occurs on the edge of the forest clearing adjacent to the highway. The plot is in an area close to the edge of the cleared project corridor (within 20 metres) and there has been increased light and solar exposure since clearing of the vegetation for the highway, and conditions are drier and hotter than the internal forest where the control plot is located (Ot- C10.1).

The 2022 survey recorded the following observations within the in-situ (impact) site Ot-10.1 (OT1-OT3 refer to separate plant locations within the monitoring plot):

- At Ot1 there were 2 clumps on the host tree (Bangalow Palm) in 2021 and in spring 2022 these same plants/clumps were present and in very good-excellent condition (score 4-5). One clump growing 5 m from the ground is facing north towards the forest edge and in 2021 appeared to be desiccating as a result of edge effects. This clump appears to have recovered, however, as it was in very good-excellent condition in 2022.
- Ot2 had 5 clumps on the Brown Kurrajong in 2021. In 2022, 4 plants/clumps were observed on the host tree. The top half of the host tree is leaning west at 45 degrees and the plants were growing on the underside of this section. All plants were in very good-excellent condition.
- At Ot3 there were 3 plants/clumps in 2022. One plant was located at the fork in the tree (Brown Kurrajong) 15 m from the ground, and the other two plants were growing on the outer bark facing west. All 3 plants are new as no plants were observed on the tree in 2021.

The 2022 survey recorded the following observations within the control site Ot-C10.1:

- At Ot1 there were 2 clumps/plants in 2022, compared to 4 clumps that were recorded in 2021. One plant was growing 12 m from the ground and was in the post-flowering stage and was browning. A score of 3 was assigned to this plant. The other plant was growing 4 m from the ground. This was a new plant (was not present in 2021) and was in excellent condition. A score of 5 was assigned to this plant.
- In 2022, Ot2 had 1 new plant in excellent condition growing about 1.5 m from the ground. This differs to the 2021 survey when two clumps were recorded. A recently dead plant was observed on a dropped limb from the host tree (*Trochocarpa laurina*).
- In 2022, Ot3 had 1 new plant in excellent condition growing about 9 m from the ground. This differs from the 2021 survey when two clumps were recorded.

Results from the 2021 survey suggested that edge effects as a result of forest clearing for the project had contributed to the decline of *Oberonia titania* at the impact site. This was because the in-situ site had around 7-10 less individuals than previous construction and operation surveys and some of the remaining plants were in poor condition due to desiccation. Furthermore, *O. titania* at the control site appeared healthy and the population size had remained stable.

The results from the 2022 survey (12 months later), however, indicate that the in-situ population has recovered and is no suffering from edge effects. The population size has increased during 2021-2022, with new plants replacing old plants that have died, and plants in very good-excellent condition and showing no obvious signs of desiccation This is despite *O. titania* continuing to be exposed to the forest edge. 2022 has been an exceptionally wet year for the NSW North Coast and it is possible that *O. titania* has responded positively to increased sunlight at the in-situ site as there has been sufficient moisture to prevent desiccation.

The control site had new *O. titania* plants that were not recorded in 2021 but overall, there were 4 less clumps/plants in 2022. It is unclear why there has been a decline in the control population but not at the in-situ site. In dry/drought years *O. titania* located in the forest centre (such as at Ot-C10.1) will likely fair better to ones situated close to the forest edge. The results of this monitoring study suggest the opposite may be true in wetter years. As the plants can sometimes grow on out branches of hosts trees, that are vulnerable to limbs falling in storms or naturally over time, and this is potentially what has happened at the control site.

Weed cover has increased at the in-situ site from the extensive amount of rain and in 2022 was around 25%. Dominant weeds included *Lantana camara, Ochna surrulata* and *Paspalum mandiocanum.* These weeds, however, are confined to the ground and shrub layer below where *O. titania* is growing and as such would are not expected to impact the species.

Photograph 3-11: Oberonia titania (in October 2021) on edge of forest clearing at in-situ site Ot-10.1 (facing west) showing desiccation

Photograph 3-12. The same individual from th left photograph in November 2022, there is no dessication and plant has doubled in size in Year 3 operation

Photograph 3-13: Oberonia titania at the control plot showing signs of senescence and natural dieback. The lifespan of the species is unknown

Photograph 3-14: Oberonia titania new plant at the control plot located adjacent to Photo 3-13

3.1.11 Tall Knotweed (*Persicaria elatior*)

Persicaria elatior was present at Pe-4.1, Pe-4.2a and Pe-C4.1 in 2022 but absent at Pe-5.1. The last time *P. elatior* was recorded at the monitoring sites was in 2018. The sudden disappearance of *P. elatior* in 2019 from impact and control sites was explained by the 2019 drought (refer **Figure 2-3)** rather than construction-related factors, and although 2020 and 2021 had above average rainfall, *P. elatior* was also absent in these years.

Throughout the monitoring program *P. elatior* has exhibited a negative trend, with number of individuals at both impact and control sites declining during 2014-2018 and then *P. elatior* absent from all sites during 2019-2021. However, in 2022 *P. elatior* was recorded at all sites again, except Pe-5.1, and population numbers were similar to what was recorded during baseline monitoring in 2014. No construction-related impacts have been observed at the monitoring sites, and given *P. elatior* is a riparian herb, yearly variation in rainfall is the most likely explanation for temporal fluctuations in population numbers over the monitoring period, with wetter years generally corresponding with higher population numbers.

P. elatior appears to have responded positively to high rainfall totals in 2022, which included the February-March floods on the NSW North Coast. Pe-4.2a is cleared land and in 2022 had mostly exotic grasses and no standing water, but despite site conditions seeming unfavourable for *P. elatior* growth, 12 *P. elatior* individuals were present, with some plants displaying vigorous growth up to 2m high. Pe-4.1 on the other hand is intact paperbark forest and in 2022, 80 *P. elatior* individuals were recorded with heights ranging from 0.2-1.3 m and plants generally in very good health. This site was inundated in places but *P. elatior* was generally growing where there was no standing water. Similarly, the control site Pe-C4.1 was entirely inundated albeit mounds of soil surrounding mature paperbark trees, and *P. elatior* was restricted to one of these island mounds in 2022. Unlike other *Persicaria* species, it appears *P. elatior* dislikes growing in standing water. Pe-5.1 is also intact paperbark forest and in 2022 site conditions were similar to Pe-4.1, however, no *P. elatior* was recorded. The *P. elatior* translocation site for the W2B project is located just south from Pe-5.1 and in 2022 there was good recruitment of the translocated populations and *P. elatior* was also observed outside the translocation plots (Benwell 2023). This suggests that *P. elatior* was likely present just outside the Pe-5.1 monitoring plot and in the same habitat patch.

The boom-and-bust lifecycle observed in this monitoring program is to be expected for an annual plant species such as *P. elatior*, whereby the species lies dormant in the soil seedbank until there is a disturbance event, for example inundation of water that kills the ground cover. It appears that *P. elatior* germination occurs soon after pooled water recedes and the ground is still bare. The species is short-lived and after it sets seed and dies will lie dormant until site conditions are again suitable for germination and growth, which based on this monitoring program, may not be a yearly occurrence.

In summary, there were healthy numbers of *P. elatior* at the monitoring sites in 2022, similar to baseline monitoring in 2014, and yearly fluctuations in population numbers appears to be independent of construction and operation of the highway, and instead related to variation in annual rainfall. Refer to **Figure 3-6** for a summary of results.

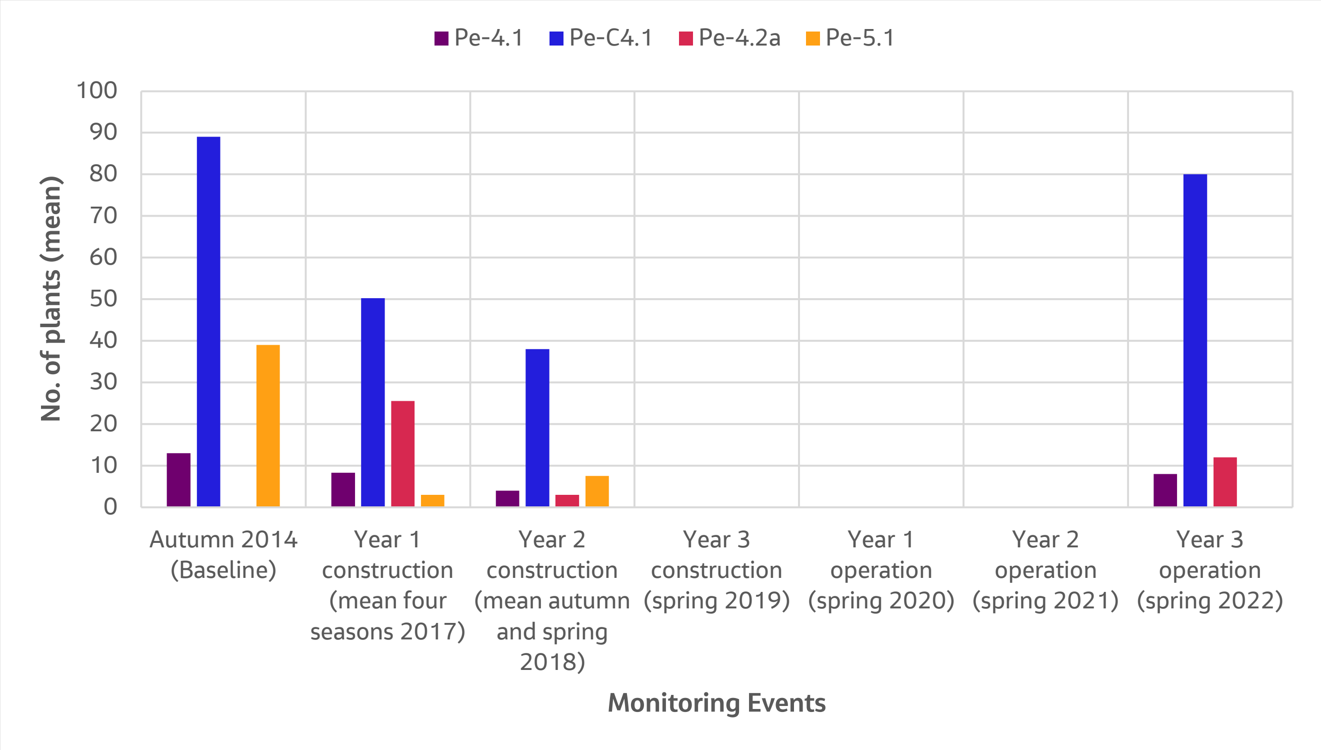


Figure 3-6 Mean number of *Persicaria elatior* plants over ten monitoring events (baseline and construction) at three in-situ sites and one control site. No baseline data exists for site Pe-4.2a as it was added in 2017.

Photograph 3.15. *Persicaria elatior* from impact plot Pe4.1, plants have returned here after 3 -year absence following drought

Photograph 3.16. Healthy *Persicaria elatior* growing on small soil mound in inundated swamp. This plant was around 2m tall

3.1.12 Singleton Mintbush (*Prostanthera cineolifera*)

Both the in-situ site (Pc-6.1) and control site (Pc-6.1a) were impacted by fire in November 2019 (in the third and final year of construction) and a decline in numbers was reported in the spring 2020 monitoring (Year 1 of operation). Subsequent monitoring in operation years 2 and 3 has reported strong recruitment and in spring 2022 (Year 3 operation) there was more *Prostanthera cineolifera* individuals than in 2014 and 2017 when monitoring began.

In spring 2022 Pc-6.1 had 135 *Prostanthera cineolifera* plants ranging from 30 cm to 2 m and 5 juveniles <30 cm. This is slightly less than the 141 plants and 29 juveniles recorded in 2021 but the height of plants has increased, and it is likely the population is thinning out as plants grow larger which is a natural process. Compared to the 2014 count of only 20 plants there has been a major increase in *P. cineolifera* numbers at the impact site. Lantana appears to have increased (estimated foliage cover in the plot was 5%) but the majority of post-fire regeneration in 2022 was native and *P. cineolifera* plants were in excellent condition.

Similarly, the control site Pc-C6.1a was impacted by fire in 2019 and there was an initial decline in *P. cineolifera* numbers in 2020 followed by strong recruitment in subsequent years. In spring 2022 the control site had 48 plants ranging from 30 cm to 2.8m and 3 juveniles <30cm. This is a marked increase compared to the count of 23 plants and 4 juveniles in 2021. There were minimal weeds at the control site in 2022 and *P. cineolifera* plants were in excellent condition with some in the fruiting stage.

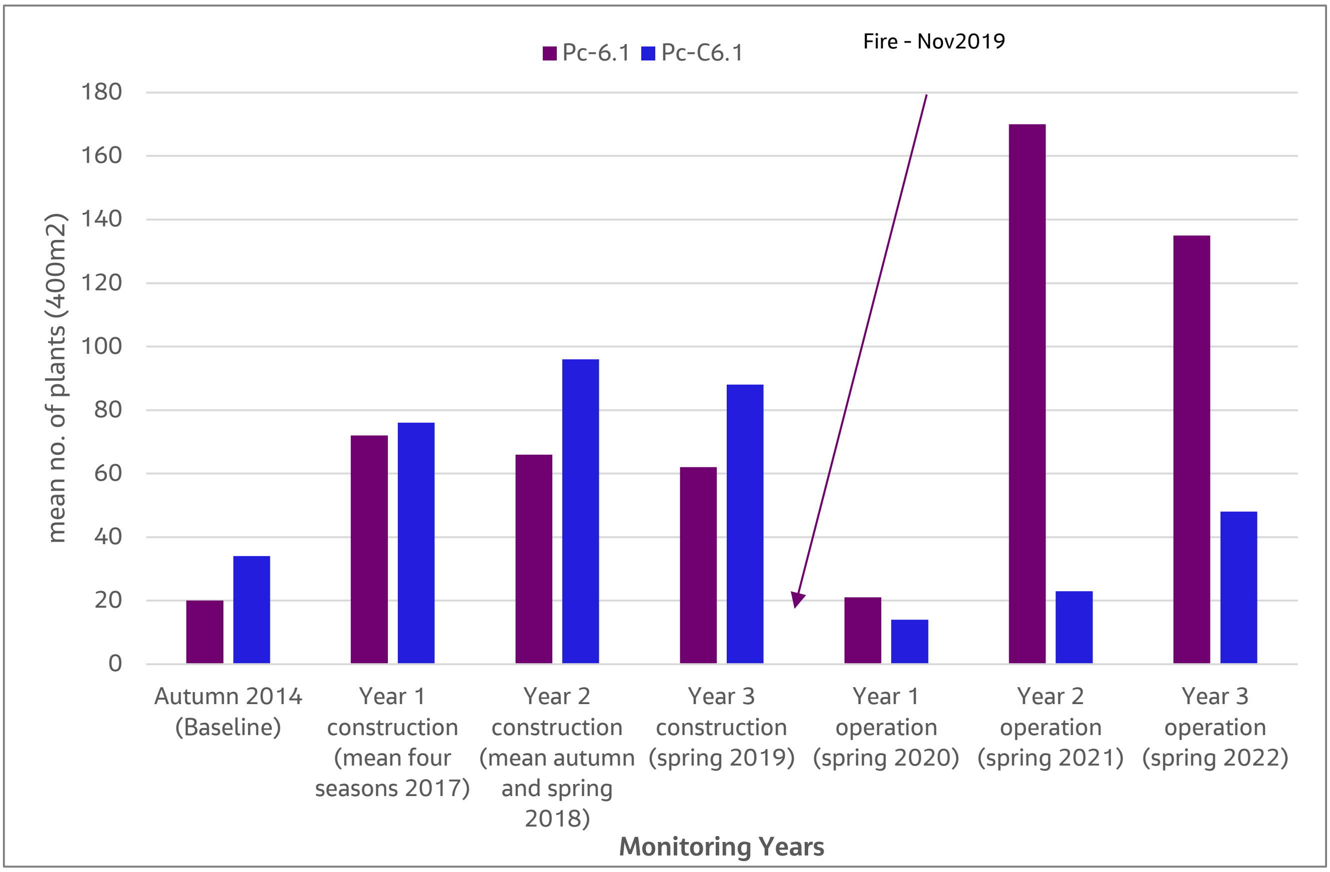


Figure 3-7 Mean number of *Prostanthera cineolifera* plants over ten monitoring events (baseline, construction and operation) at in-situ site (Pc-6.1) and control site (Pc-C6.1).

3.1.13 *Rotala tripartita*

Both *Rotala tripartita* in-situ sites Rt-6.1 and Rt-6.2 were surveyed on 4 November 2022. These sites are located adjacent to the highway (c.30m east), and no plants were recorded at either of these sites. The populations were small at around 70 plants when monitoring began in 2017 at the start of construction and conditions were more favourable. At this time 10 individuals were removed from the in-situ sites as part of the W2B project translocation program. These individuals were planted 0.5 km south at a TfNSW offset site. The latest results from the translocation monitoring show a 100 % increase in the ex-situ population, now at 20 individuals (Benwell 2021).

R. tripartita has not been recorded at the in-situ sites since April 2018 (Year 2 construction) when a few plants were observed at Rt-6.2. There have been no project-related impacts obvious at these sites and the absence of *R. tripartita* is considered likely a result of unsuitable hydrological habitat conditions as the drainage areas dried out during the drought and then when flooding returned these habitats were inundated with deeper water for prolonged periods, which is not suited to this species.

Conditions at Rt-6.2 appeared suitable for *R. tripartita* in spring 2022 with water receding and now shallow standing water in the drainage line and ground layer vegetation not too dense. This species is an annual or short-lived perennial and likely exists most of the time in the soil seedbank, only growing during periods of suitable rainfall. With above average rainfall for the last three years, *R. tripartita* may be expected to re-emerge at Rt-6.2; however, the species may require bare ground following a disturbance for germination and growth and at present competing ground layer vegetation at these plots may be too dense. The species may occur in more favourable micro-habitats away from the monitoring plots and further searches would be required to determine this.

Rt-6.1 on the other hand, appeared less suitable for *R. tripartita* in spring 2022, as water in the drainage line was deep and ground layer vegetation along the banks of the drain was mostly dense exotic grasses. There were, however, a few bare ground patches along the banks of the drain where *R. tripartita* may be expected to grow.

4. Evaluation of performance criteria, mitigation measures and impact thresholds

4.1 Amendments to the program and assessing impacts

As outlined in **Section 4.1** of the TFMP further pre-clearing flora surveys were undertaken by suitably qualified ecologists to reconfirm the distribution and abundance of threatened flora populations in proximity to the project prior to clearing for construction. Where additional populations of threatened flora were identified these were quantified and could be managed and translocated prior to clearing. This has resulted in a revised baseline threatened flora layer and shown in the **Appendix B** as "*Additional finds & GIS consolidation*".

Through the detailed design process, the project construction footprint was reduced. This resulted in a significant reduction to the overall impacts to threatened flora in-situ compared to quantities reported in the approved EIS/SPIR. Where there was an increase, this was contained within the project approval boundary and where feasible additional translocation efforts were undertaken.

The minor changes to the construction footprint affected the previous placement of some impact monitoring plots established in the early pre-construction phase. Replacement sites were established where there was opportunity to do this, which allowed for threatened species adjacent to the project boundary to be continually monitored and addressed the refinements of detailed design. Additionally, it was agreed with Transport for NSW to establish new control sites to allow for additional data to be collected where sites were on private land with access restrictions.

The updated clearing boundary as a result of the Detailed Design has changed the total number of threatened flora species and individuals expected to be impacted during construction and has reset the total remaining in-situ populations for following monitoring years.

Appendix B presents the final threatened flora impact for the project, outlining the following:

1) *EIS/SPIR boundary/impact* – Expected impact on threatened flora based off the concept design boundary/EIS and outlined in the Threatened Flora Management Plan.
2) *EIS/SPIR boundary/impact + Additional finds and GIS consolidation* - Expected impact on threatened flora based off the Concept Design/EIS boundary using the revised threatened flora layer.
3) *Current M-Class boundary/impact + Additional finds and GIS consolidation* - Expected impact on threatened flora based off the current Detailed Design boundary using the revised threatened flora layer.
4) *Net change* – Comparison between the Concept Design EIS/SPIR boundary and the Detailed Design Clearing boundary using the revised threatened flora layer.

As noted in **Section 2.3.2**, the baseline methods for determining the abundance of threatened groundcover species were coarse and a percentage of mean cover over an area of occupancy for each relevant species was subsequently introduced into the method during the construction monitoring surveys to improve the detection of change. This allowed for an effective measure of change to be monitored over each season and identified typical trends in plant dieback in response to rainfall and other climatic factors. A percentage mean cover for relevant species from baseline data was estimated to provide indicative comparisons for measuring performance criteria. Therefore, this information has been viewed with consideration of other site observations and evidence when scrutinising data after each sampling event prior to making and assessment of impact.

4.2 Discussion of observed impacts and threats to threatened flora

The third and final operational monitoring period in Section 1-2 was complete in spring 2020. Monitoring for the third year of highway operation in Sections 3-10 occurred in spring 2022 and comprised a total of 49 sites (38 impact and 11 control sites).

One positive finding from the 2022 operational monitoring in Sections 3-10 was that *Persicaria elatior* had re-emerged at three of the four monitoring sites for this species after not being present since 2018, three years covering the final stage of construction and early operation. As mentioned in Section 3.1.11 of this report, the disappearance of *P. elatior* in 2019 was explained by the 2019 drought (refer Figure 2-3) rather than construction-related factors, and although 2020 and 2021 had above average rainfall, *P. elatior* was also absent in these years. In contrast 2022 was an exceptionally wet year for the NSW North Coast with two major floods during February-March, and *P. elatior* appears to have responded favourably to this above average rainfall.

Another positive result was the recovery of *Oberonia titania* at in-situ site Ot-10.1, which in 2021 appeared to be suffering from edge effects. This was because the in-situ site had around 7-10 less individuals than previous construction and operation surveys and some of the remaining plants were in poor condition due to desiccation. The population size has since increased during 2021-2022, with new plants replacing old plants that have died, and plants in very good-excellent condition and showing no obvious signs of desiccation. One possible explanation for this is that after a period of adjustment *O. titania* has now responded positively to increased sunlight at the in-situ site during 2022, and this has been supported by the higher rainfall and moisture that has prevented further desiccation and decline.

Both the impact and control monitoring sites for Prostanthera cineolifera and Melaleuca irbyana occur on the western side of the highway and all were affected by fire in late 2019 at the end of the drought period. The long-term monitoring of these species has observed very good post-fire recovery, with increased numbers of plants and plant health and demonstrate the value in conducting long-term studies to compare the effects of highway construction.

Despite the above average rainfall in 2022, *Cyperus aquatilis* and *Rotala tripartita,* aquatic species reliant on persistent surface water, remained absent from their monitoring sites. These species have not been recorded since 2018. During the 2019 drought, water completely dried up at their sites and plants have not returned despite favourable wetter conditions in subsequent years. There has been no evidence of inadvertent construction-related impacts at these sites.

Most species experienced minor fluctuations and relatively stable results compared to previous years. For example, *Arthraxon hispidus* was present at the same sites and absent from the same sites as in 2021, and at some sites there was a minor increase in *A. hispidus* while at other sites there was a minor decrease in abundance. This was generally the case for *Prostanthera cineolifera*, *Melaleuca irbyana*, *Lindsaea incisa* and *Grevillea quadricauda* (see Section 3.1 of this report for further details). There is only one plant of *Macadamia tetraphylla* and *Endiandra muelleri* subsp. *bracteata* and both had remained in very good to excellent condition since 2021.

Long-term monitoring of the in-situ *Maundia triglochinoides* populations have identified some interesting findings with respect to the life cycle of the species. At in-situ site Mt-7.2, *Maundia triglochinoides* on the eastern side of the highway was impacted by a significant rainfall event during Year 1 of construction resulting in changed surface hydrology and the site and re-mobilising of sediments that were occupied by the population. The area of occupancy in the plot in 2017 had reduced to just 3 m^2 from a baseline of 100 m^2 in 2014 and 150m^2 in 2016. Since then, this population has recovered to 13 m^2 in 2018, 29 m^2 in 2019-20, and 104 m^2 in 2021, most likely a result of lower rainfall over this time resulting in decreased water levels and settling of sediment in the stream which have provided favourable opportunity for the species to colonise. In February and March 2022 (2.5 years after construction) another period of high rainfall and flooding changed the surface hydrology again and altered habitat suitability in the plot. By the spring 2022 monitoring period, the area of occupancy had decreased markedly to 15 m^2. Based on these data it is reasonable to expect this species life cycle (where it grows in dynamic stream environments) may involve shallow rooted plants being dislodged during flood events and re-locating further downstream where the opportunity exists. Indeed, at the other monitoring sites in isolated ponds and dams, *M. triglochinoides* has remained stable while at some stream sites large *M. triglochinoides* patches were observed upstream or downstream from the monitoring plot, where they were not present in the baseline survey, suggesting plants had re-established outside of the plot following flooding.

For *Angophora robur*, general plant dieback was evident at sites Ar-3.4 and Ar-3.7 in 2021 and has been observed since Year 1 construction monitoring. As suggested previously, it may be associated with drought and heat stress and/or caused by the epidemic infection of the root-rot fungus Cinnamon Fungus (Phytophthora cinnamomi), but this would need to be confirmed. This dieback pre-dates the highway construction. Around 50% of the trees in these two plots had new shoots and showed recovery in 2021. Trees at Ar-3.4 had recovered further in 2022 with 80% with new shoots and trees at Ar-3.7 have remained healthy. Evidence of controlled groundcover fire was noted at sites Ar-3.3 and Ar-3.4 during 2021, which occurred two months prior to the monitoring event. This was associated with landholders and is not project related. These fires caused minor impacts to 3 small trees at Ar-3.3 and 1 small tree at Ar-3.4, and these were resprouting during the 2021 monitoring event. These trees were continuing to recover in 2022 and were in very good-healthy condition. At the other *A. robur* sites, most trees were in very good to excellent condition and there had been minor changes in seedling numbers.

In summary, no major changes or notable impacts were observed from the 2022 operational monitoring in Sections 3-10 and most sites experienced minor fluctuations and relatively stable results compared to previous years.

4.3 Assessing operational impacts and mitigation performance

The TFMP lists potential impacts to in-situ threatened flora during the operational phase of the highway as:

- Degradation of retained threatened plant populations and habitat from edge effects
- Degradation of aquatic threatened plants associated with reduced water quality and/or changes to hydrological regimes

The current monitoring period represents the third year of highway operation and the third consecutive monitoring period post-construction. The relevant goals for mitigating impacts from operation of the project are addressed by the monitoring program as outlined in **Section 2.4**, include:

- Zero mortality of retained in-situ threatened plant populations has occurred during construction and for three consecutive monitoring periods post-construction and up to 80 per cent survival of tree, shrub, and herbaceous perennials after three years
- Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program).

The need for active management has been informed by the results of operational monitoring in year 1 and 2 and respective recommendations. Where required, the operational management measures, as outlined in the TFMP, include physical maintenance, such as watering, removal of damaging debris after storms, planting to replace mortalities, removal of bags and stakes (when used), maintenance of mulch cover and weed control as necessary.

For the current monitoring period, all stages of the project were in full operation and the data reports the third consecutive year of monitoring post-construction. As stated in the TFMP, three consecutive monitoring periods post construction would be carried out and following this period a review of the results would be undertaken to identify if further monitoring is required. Further to this, if the data indicate that the mitigation measures have proven successful for three consecutive monitoring periods, then no further monitoring would be required.

The mitigation goals described above represent the thresholds for measuring performance and in a case where these are not met then the need for action is triggered. The set of threshold triggers and corresponding corrective actions from the TFMP for the operational stage of the project are described in **Table 4-1** while **Table**

4-2 discusses the specific results of the Year 3 monitoring species and whether corrective actions have been triggered.

Table 4-1 Performance triggers and associated corrective actions for in-situ threatened flora during highway operation phase (from Table 7-3 TFMP)

Trigger for corrective action	Corrective actions
▪ Any mortality of in-situ threatened plants for the first three consecutive monitoring periods post-construction. ▪ Post the above timeframe more than 20 per cent decline for an in situ threatened plant population over one monitoring event from the baseline (depending on species specific seasonal fluctuations)	▪ Commence assessment of potential reasons for mortality, including seasonal fluctuations, natural events such as drought and fire within one month of trigger being identified. ▪ Review weed maintenance schedule within one month of tigger being implemented ▪ Identify potential threats, implement corrective actions, and modify monitoring as necessary ▪ Offset any additional threatened plant impacts that have occurred as a result of the project.
▪ Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations	▪ Review weed maintenance program within one month of trigger being identified and update as required.

Table 4-2 Assessment of mitigation performance against triggers for corrective actions during Year 3 operational monitoring

In-situ threatened flora species (Section 3-11)	Thresholds (triggers for corrective actions) and discussion of monitoring and corrective actions		Requires corrective action and further monitoring
	Any mortality of retained in-situ threatened plant populations for three consecutive monitoring periods post-construction	Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations	
Angophora robur	No tree mortalities recorded in the third year of operational monitoring. Recruitment and number of seedlings mostly remained stable or increased. Most trees in very good to excellent health (score 4-5)	There has been notably increases in Lantana at the in-situ sites associated with high rainfall in 2022 after lower-than-average rainfall I the proceeding operational years: ▪ Ar-3.9, which had 0% weed cover in the 2014 baseline and 1% Lantana cover at start of monitoring in 2017, has increased to 15% in 2022 ▪ Ar-3.10, which had 5% weed cover in the 2014 baseline and 3% Lantana cover in 2017 has now increased to 30% in 2022. It is unclear whether or not project-related edge effects were the cause of the increase in Lantana or simply related to increased rainfall totals n 2022. At the control site Ar-C3.2 there has also been a marked increase in Lantana, from 1% in 2017 to 25% in 2022, and so this weed is certainly capable of increasing away from the forest edge. If these in-situ sites were heavily disturbed in the past (before the project began) then it is likely that Lantana would still have increased even without vegetation removal for the project and the creation of new edges. Despite the increase in Lantana at these in-situ sites, tree health has remained in very good to excellent condition and recruitment of seedlings has been stable. Angophora robur has been mapped as a large population, mainly east of the project in Section 2-4. The monitoring plots where weed abundance has increased likely reflect the changed condition for many areas occupied by the species. It would not be possible to conduct weed works on this scale and removal of lantana at the plot scale would make little difference to the population. The trees in the plot are currently not showing any negative response to the increase in lantana, and further action is deemed not to be required.	No. Weed control is not recommended

In-situ threatened flora species (Section 3-11)	Thresholds (triggers for corrective actions) and discussion of monitoring and corrective actions		Requires corrective action and further monitoring
	Any mortality of retained in-situ threatened plant populations for three consecutive monitoring periods post-construction	Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations	
Arthraxon hispidus	No apparent loss of plants in third year of operational monitoring. All impact and control sites have been either stable or increased plant numbers. No decline in health or abundance noted.	Most of the *A. hispidus* sites are located in grazed paddocks and as such exotic plant cover has remained high and not increased above 10% from the baseline throughout the monitoring program. Cattle removal at some impact sites has led to an increase in exotic cover. This is consistent with the control sites.	No
Cyperus aquatilis	The individuals identified in the baseline were found to be absent from the site during the pre-construction period (prior to construction). Monitoring has continued for 3 years post-construction and the population has not returned within the monitoring plots.	Weed cover was low and consistent with baseline at this site.	No
Endiandra muelleri subsp. *bracteata*	An individual tree was accidentally removed on the west side of the Maclean Interchange in Year 2 of construction (and reported in Jacobs 2019) **Actions applied:** A rehabilitation / offset plan was prepared, with seed collected and propagated from the nearest population. 12 new plants were established and planted adjacent to the in-situ site 18 months later. The latest monitoring report dated September 2021 indicates 100% survival of these trees (Ecos Environmental 2021) The second tree (a sapling) to the north-east of the Maclean Interchange was alive and in good condition in November 2022 inspection. It remained in very good to excellent condition and had increased in height 0.5 m since the baseline in 2014. Insect browsing was minimal.	A dense infestation of the exotic vine Dutchman's Pipe (Aristolochia elegans) remans at the in-situ site. Weed abundance was high in spring 2022, at around 35% foliage cover and included aggressive competitors such as Dutchman's Pipe, Climbing Asparagus and Camphor Laurel. There has been a 25% increase since the 2014 (10% baseline). Weed control work was undertaken in 2019 and as a result weed cover was low in 2020 and 2021. It appears that follow up weed control work was not carried out because weed abundance increased markedly in 2022. The site is very degraded and competition from weeds is a threat to the long-term survival of the single *E. muelleri* subsp. *bracteata.*	**Yes,** further annual weed control is required (in late spring), for an additional 3 years to end of 2025 followed by re-evaluation. This should occur at the translocation receival site and the in-situ site
Grevillea quadricauda	No loss of plants in the third year of operational monitoring. Number of plants has remained the same at the control site and increased at the impact site through recruitment. Plants in very good to excellent condition.	Weed cover has remained around 10% but has decreased from 40% since initial construction phase, and this is not impacting plant health	No
Lindsaea incisa	No apparent loss of plants in third year of operational monitoring. The monitoring has demonstrated improved condition since drought years 2018/2019. Minor changes in area of occupancy at sites since 2021 however no mortalities, decline in health or abundance noted.	Weed cover was low at all impact and control sites in 2022 and consistent with baseline.	No
Macadamia tetraphylla	The single plant was alive in spring 2022. It remained in very good to excellent condition and insect browsing was minimal. The tree occurs on	Weed cover was consistent with baseline and reflects the grazed habitat the tree is located in.	No

In-situ threatened flora species (Section 3-11)	Thresholds (triggers for corrective actions) and discussion of monitoring and corrective actions		Requires corrective action and further monitoring
	Any mortality of retained in-situ threatened plant populations for three consecutive monitoring periods post-construction	Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations	
	the Richmond River floodplain and was likely flooded in February 2022, however, remains in good health		
Maundia triglochinoides	All impact and control sites appeared to have recovered from the drought years of 2018/2019 with increased rainfall and flushing of sediment. There have been fluctuations in plant numbers at control and impact sites where these occur in dynamic stream habitats (in particular Mt7.2 – see discussion in Section 3.1.8). This temporal change reflects the species habit of being dislodged in flooding events and temporary increases in water depth. These fluctuations in density reflect natural life cycle of the species and there has been no complete mortality or absence.	Weed cover was low at all impact and control sites in 2022 and consistent with baseline.	No
Melaleuca irbyana	The control and impact sites are continuing to regenerate after the November 2019 bushfire. Some trees suffered fire damage but have since regenerated through basal resprouting and in 2022 they were continuing to recover. No tree mortalities have occurred and in 2022 there were abundant seedlings as a result of fire-cued seed germination. No decline in health or abundance noted.	Weed cover was low in 2022, as in previous years.	No
Oberonia titania	Morality of plants was noted in the 2nd year of operational monitoring and associated with increased exposure and dry periods in 2018-20. No corrective actions were applied at that time, other than continue monitoring to identify and future declines. Following significant rainfall over 2022 the number of plants at the in-situ site has increased and were in very good to excellent condition (score 4-5) in 2022. The results suggest that in-situ plants are not suffering from project-related edge effects, despite a decline in the population in 2021.	Weed cover at the in-situ site was about 14% in 2014 and has increased to about 20% in 2022 (6% increase) this is below the threshold, although weed abundance is relatively high due to edge effects. Weeds present include aggressive competitors such as Lantana and *Ochna serrulate.* In contrast at the control site Lantana has remained around 5% since 2014 and not increased. The recorded weeds are confined to the ground and shrub layer below where O. titania is growing and as such are not expected to impact the species. However, they are a potential threat to the long-term survival of *O. titania*, as they may increase bushfire risk and impede the establishment of canopy trees.	No
Persicaria elatior	Has re-emerged at three of the four monitoring sites after not being present since 2018. The sudden disappearance of *P. elatior* in 2019 was explained by the 2019 drought rather than project-related factors. *P.*	The in-situ site Pe-4.2a had high weed cover in 2022 but this site is cleared land and the high weed cover is consistent with baseline. Weed cover was low at the other sites.	No

In-situ threatened flora species (Section 3-11)	Thresholds (triggers for corrective actions) and discussion of monitoring and corrective actions		Requires corrective action and further monitoring
	Any mortality of retained in-situ threatened plant populations for three consecutive monitoring periods post-construction	**Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations**	
	elatior appears to have responded favourably to the above average rainfall in 2022 and all recorded plants were in very good to excellent condition.		
Prostanthera cineolifera	Some losses of mature plants occurred due to a wildfire in November 2019, independent from the highway operation. There has been strong post-fire recruitment and growth and in 2022 populations were large and healthy.	Weed cover low, as in previous years.	No
Rotala tripartita	No further project related loss of plants in third phase of operational monitoring. All impact and control sites have showed decline or absence of plants related to changed hydrology and drought conditions. Plants have not returned to the monitoring plots; however, this is not project related.	Exotic grass cover relatively high because sites located on grazed land. Exotic cover in 2022 consistent with baseline.	No

5. Correction actions and recommendations

5.1 Assessing mitigation performance

The current monitoring report presents the data from the third consecutive year of operational monitoring for in-situ threatened plants. All in-situ populations monitored were in Sections 3-10 of the W2B project, with year 3 completed in 2021 for Section 1 and 2. Monitoring has been continuous for a 6-year period comprising 3 years construction and 3 years operation, with the baseline data for each monitoring plot first established 8.5 years prior in early 2014. Climatic conditions have varied considerably during this time, with low annual rainfall in 2014, and again 2018-19, and higher than average rainfall in 2020-22. Two major flood events occurred in 2017 (Year 1 of construction) and again in 2022 (Year 3 of operation).

Throughout the project biodiversity mitigation has been applied consistent with the construction environmental management plans (CEMP), and importantly in line with the Threatened Flora Management Plan (TFMP). The adaptive management approach adopted for the TFMP has been effective in triggering a response where required, for example the inadvertent loss of Endiandra muelleri subsp. bracteata in project Section 4 (Year 1 construction), triggered actions to source viable seed from local populations, and use these to offset the loss at a ratio of 12:1. This was effective, and the planted population has a 100% survival rate.

Other reported losses from in-situ populations over the monitoring program were noted and cautiously monitored. These losses were later confidently correlated with the temporal change in climatic conditions that were experienced rather than attributed to the project, and the control plots served to inform this decision. For example, the fluctuating abundance of aquatic annual species at some locations as a result of drought years and subsequent flooding. Similarly, some populations in Sections 6 and 7 were temporarily affected by the large - scale fire event which also occurred in late 2019. Temporal changes in the in-situ populations of Maundia triglochinoides, Persicaria elatior, Prostanthera cineolifera, Lindsaea incisa and Arthraxon hispidus were the most notable in this regard and all associated with changed climatic conditions. The monitoring in the third year of operation, followed significant rainfall and flooding in February and saw a positive return to baseline abundances for these species, including a return to in-situ and control monitoring plots that were absent in years 1 and 2 of operation.

The year 2 operational monitoring report described a loss of plants at the in-situ Oberonia titania population. It was suggested that this may be associated with edge effects, as plants had declined in health and some mortalities noted compared with the control. The corrective action adopted was to wait for another 12 months and monitoring again in 2022 to assess any adjustment at the site and need for further corrective action. Subsequently, monitoring in year 3 has observed a recovery of health in the population and recruitment of new plants, such that there has been no net loss. This change may be due to the individuals adapting to conditions on the edge and may have been assisted by the wetter seasonal conditions throughout the year. Nonetheless the population has returned to baseline and no further monitoring is required.

Overall, the mitigation measures applied during construction and operation have been found to be effective and the performance measures have been met, such that no further monitoring is required. A negative response to the higher-than-average rainfall in 2022 has been the observed increase in abundance of exotic plant species in general not only in the monitoring plots, but other locations in remnant forest further from the project. This was noted in three in-situ population locations above the threshold for triggering action documented in the TFMP. This included *Endiandra muelleri subsp. bracteata* (1 location – Emb-4.1) and *Angophora robur* (2 locations – Ar3.9 and Ar3.10). This impact has triggered a need to conduct weed control at the Endiandra muelleri subsp bracteata locations to ensure the population health post 3-year operation. Weed control associated with *Angophora robur* is not required.

5.2 Recommendations

Operational corrective actions follow the same actions if thresholds are triggered for any loss of plants or increases in weeds. Overall, the mitigation measures applied during construction and operation have been found to be effective and the performance measures have been met, such that no further monitoring is required. While no further monitoring is required at in-situ plant populations, the small population size for Endiandra muelleri subsp bracteata in section 3 and absence of any other individuals in the locality suggests further monitoring of the 12 planted individuals in addition to annual weed removal at the in-situ site should continue for a further three years. Details are provided in Table

Table 5-1 Recommendations for monitoring and maintenance associated with Endiandra muelleri subsp bracteata (Green-leaved Rose Walnut)

Recommendation	TfNSW response
1. Conduct annual weed control around the single in-situ Endiandra muelleri subsp bracteata to the north-east of Maclean Interchange for a further three spring seasons (to 2025) to remove highly invasive exotic weeds, particularly vines, which are threatening survival of this individual. After three years assess the health and growth of the tree, and cover of exotic vines at the site to determine whether additional annual weed works is required	Adopted
2. Continue annual maintenance and monitoring of the 12 planted Endiandra muelleri subsp bracteata adjacent to the Maclean Interchange for a minimum 3 years to assess tree health and remove weeds. Make a further assessment at the end of two years	Adopted

6. References

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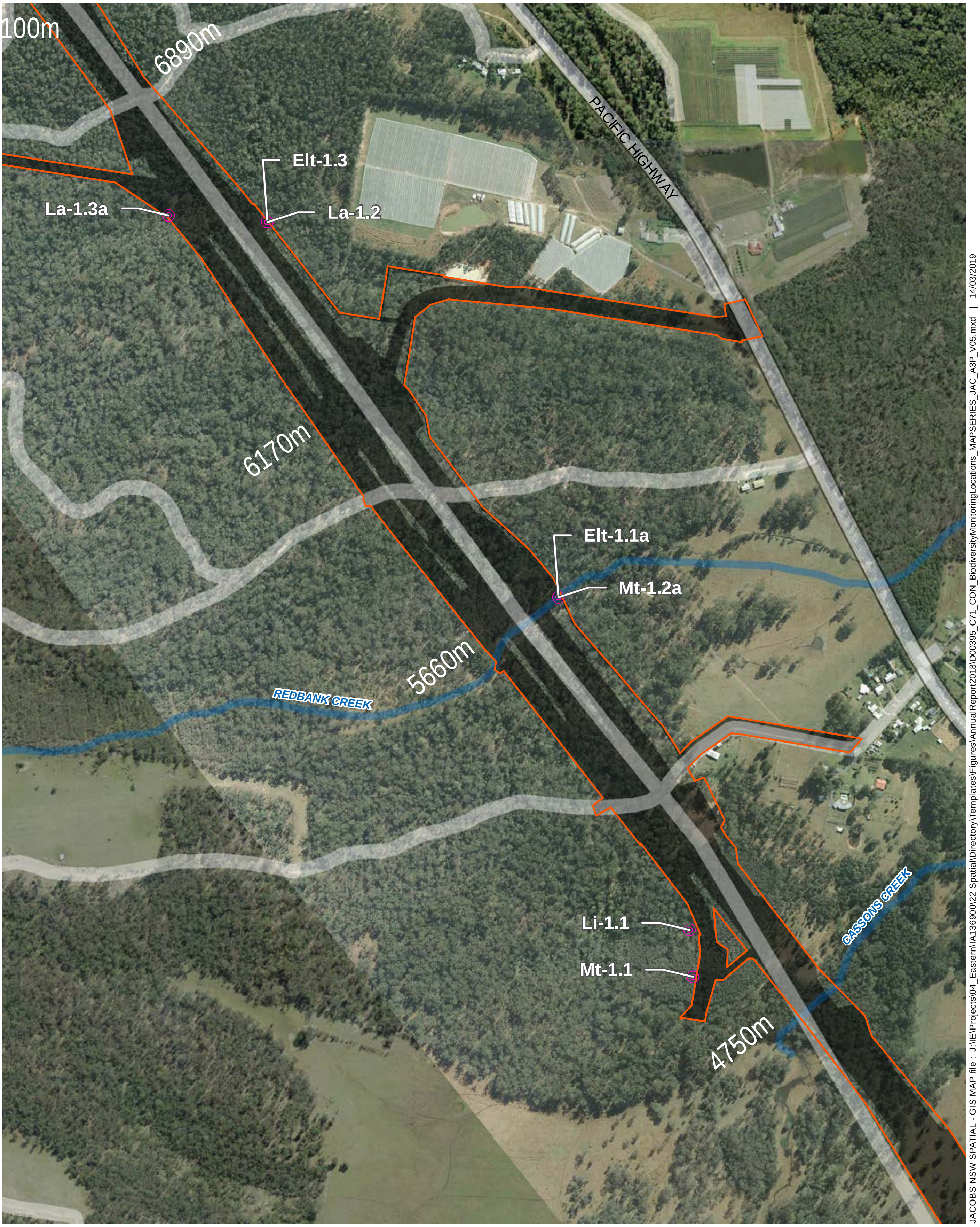
Appendix A. Threatened Flora Monitoring Sites (Figures)



Legend

- Monitoring location - Impact (Jacobs 2018)
- Waterway (DFSI Mar 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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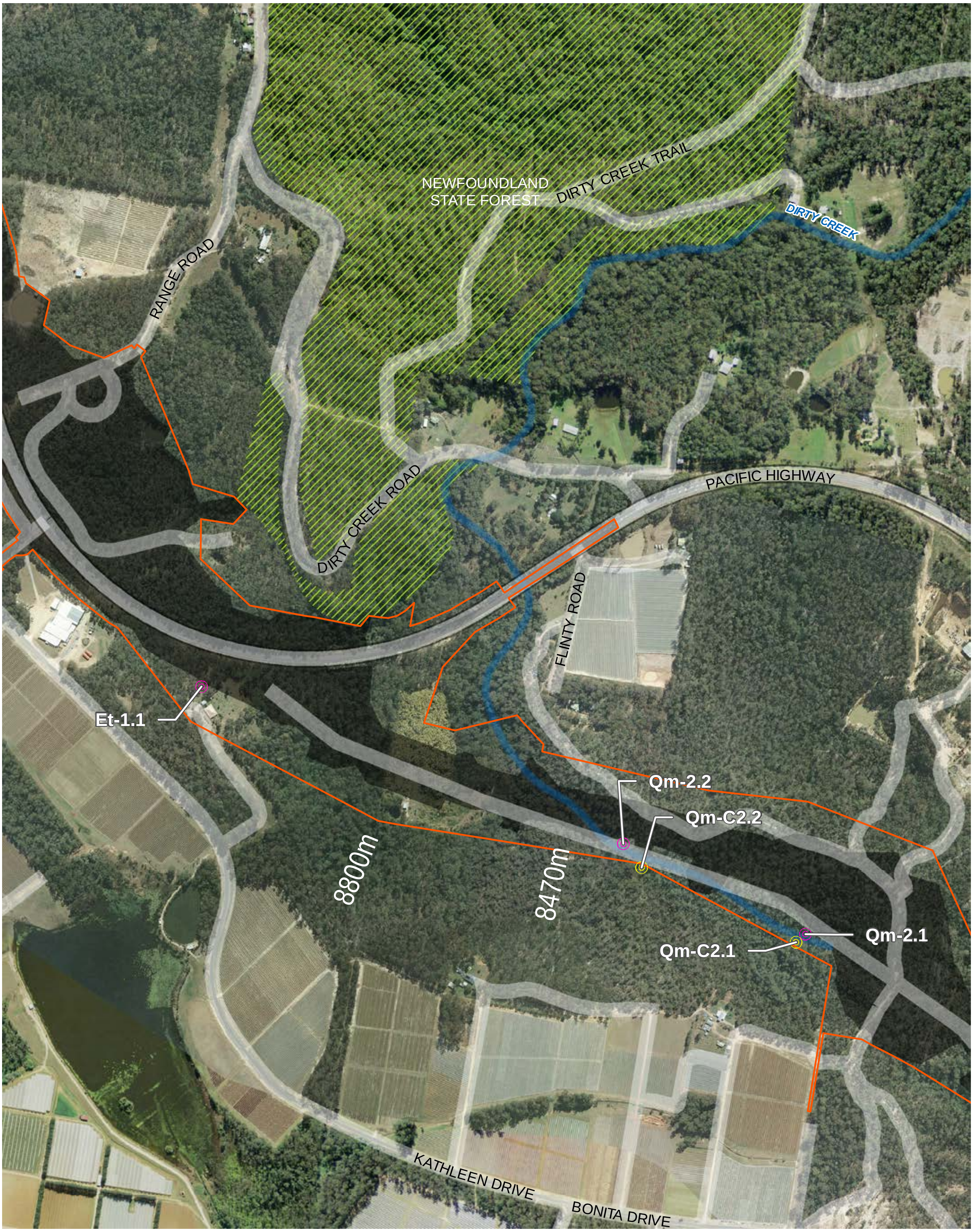
BALLINA
GRAFTON
WOOLGOOLGA

Figure A-1 | Threatened flora monitoring locations



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Legend

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- Clearing boundary (PC 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-2 | Threatened flora monitoring locations

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Legend

- Monitoring location - Control (Jacobs 2018)
- State Forest (DFSI Mar 2018)
- National Park (DFSI Oct 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-3 | Threatened flora monitoring locations

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- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Waterway (DFSI Mar 2018)
- State Forest (DFSI Mar 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-4 | Threatened flora monitoring locations

Legend

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- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- National Park (DFSI Oct 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-5 | Threatened flora monitoring locations

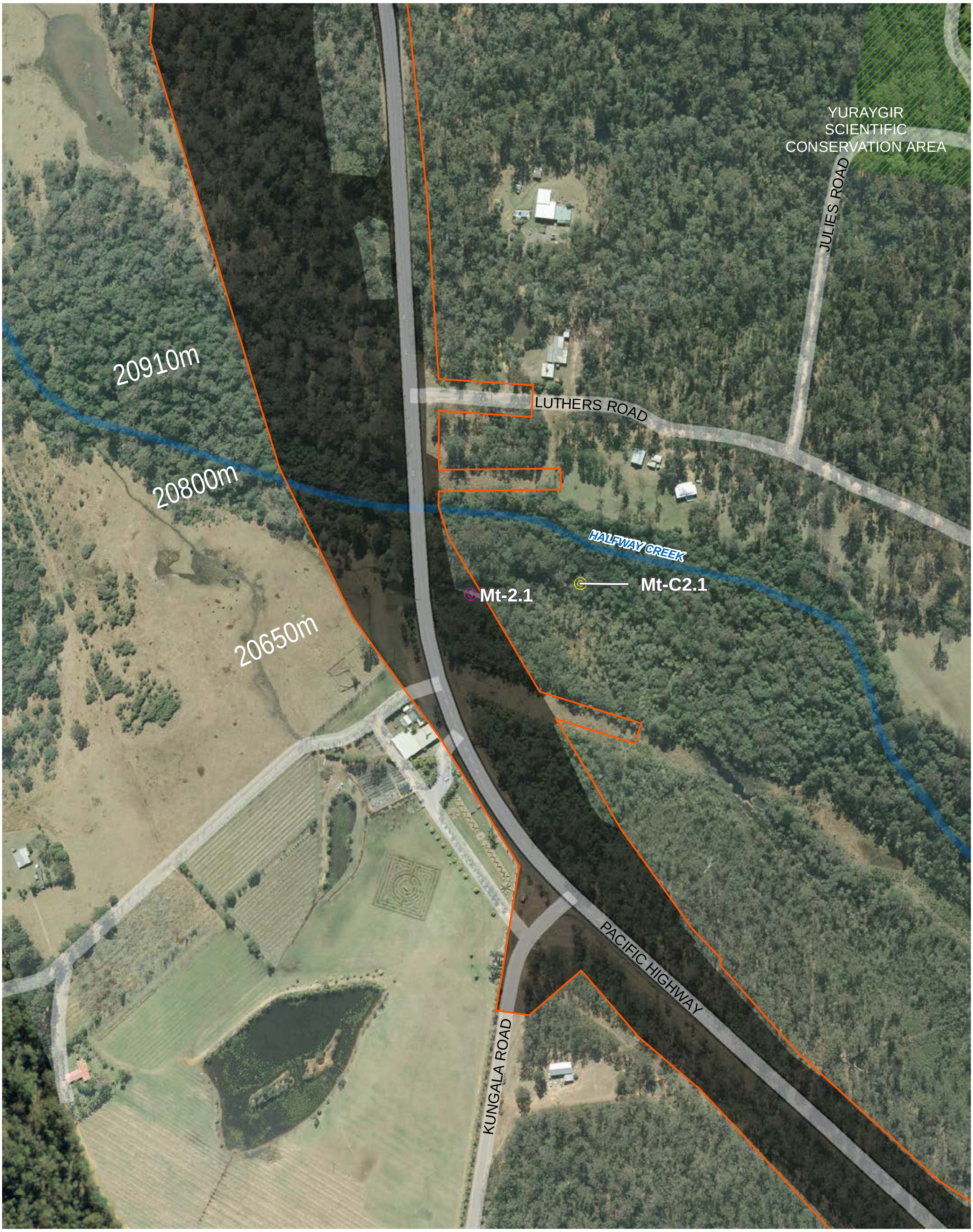

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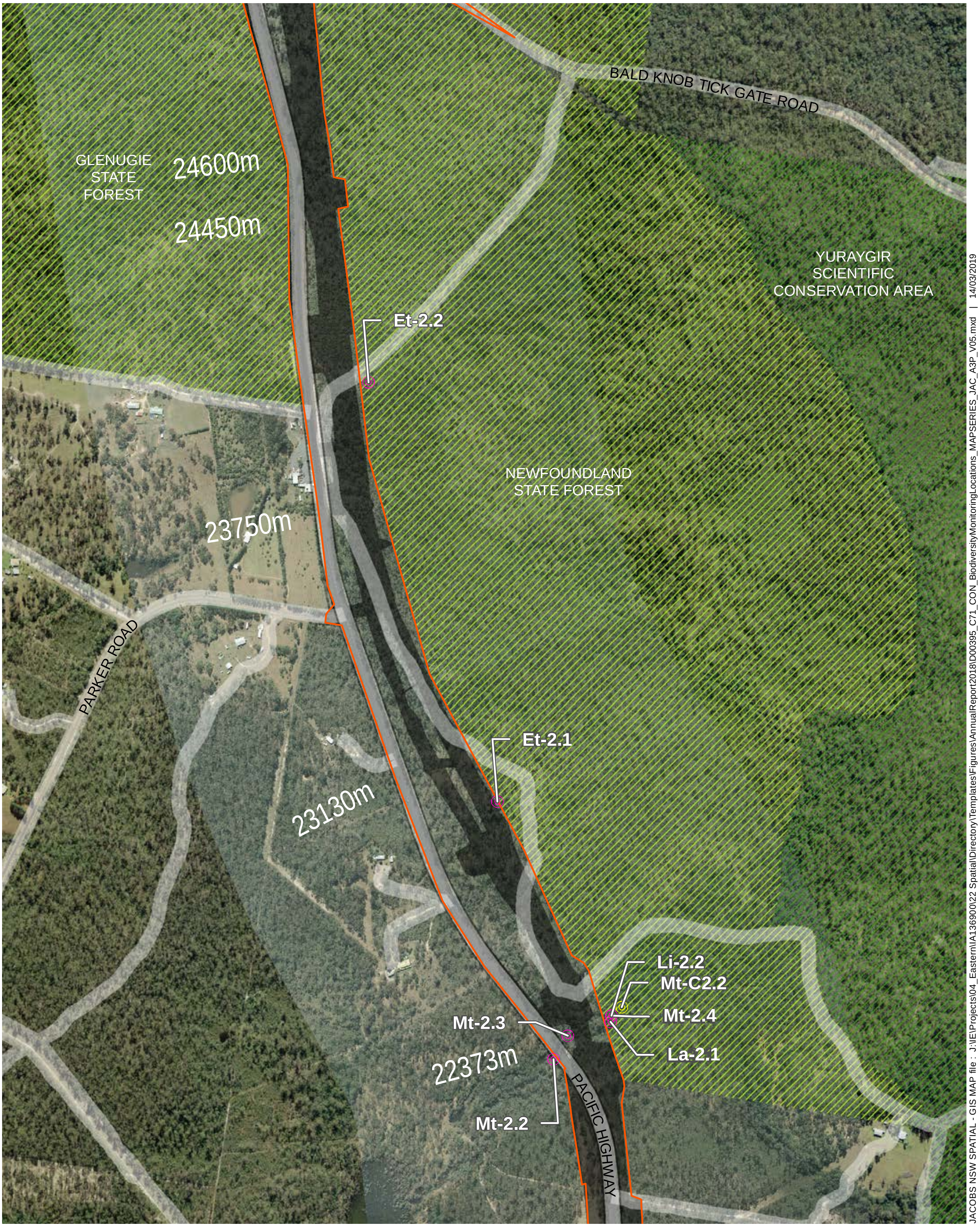
Figure A-6 | Threatened flora monitoring locations



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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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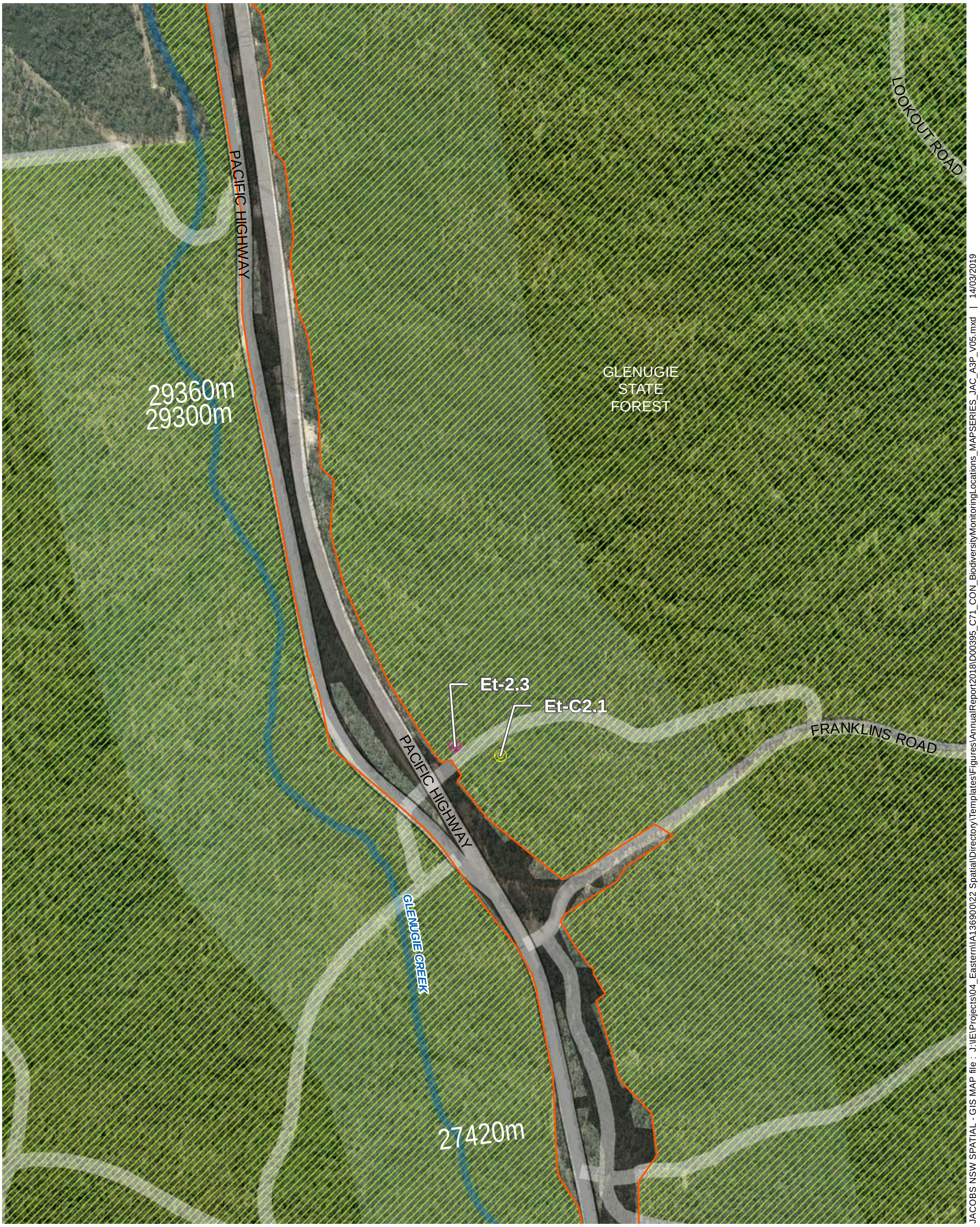
Figure A-7 | Threatened flora monitoring locations



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- Clearing boundary (PC 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

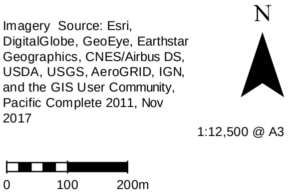

Figure A-8 | Threatened flora monitoring locations

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Figure A-9 | Threatened flora monitoring locations

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- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
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Figure A-10 | Threatened flora monitoring locations

Legend

- Monitoring location - Control (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-11 | Threatened flora monitoring locations

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Figure A-12 | Threatened flora monitoring locations

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Figure A-13 | Threatened flora monitoring locations

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-14 | Threatened flora monitoring locations

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Figure A-15 | Threatened flora monitoring locations

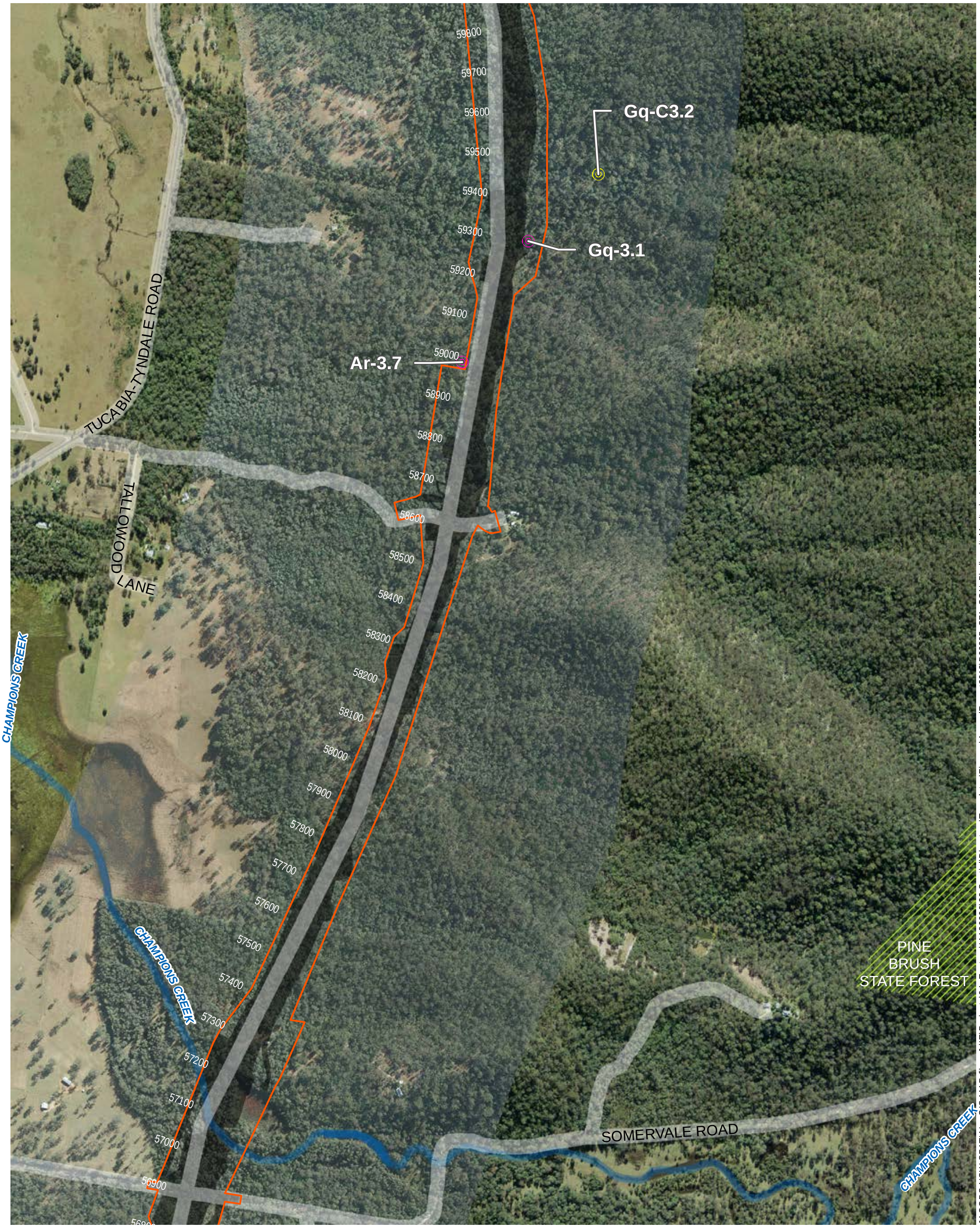

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Figure A-16 | Threatened flora monitoring locations

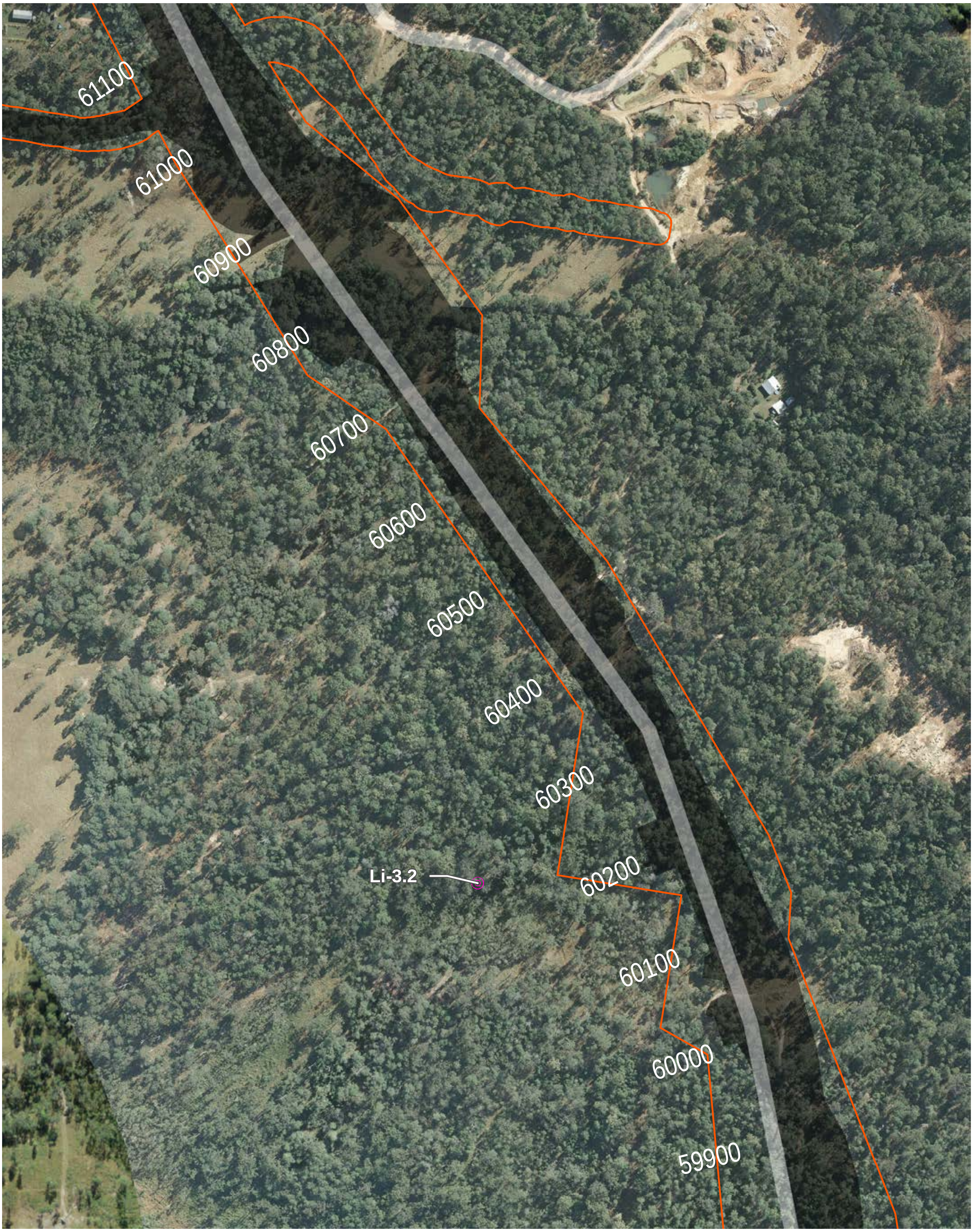

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Figure A-17 | Threatened flora monitoring locations

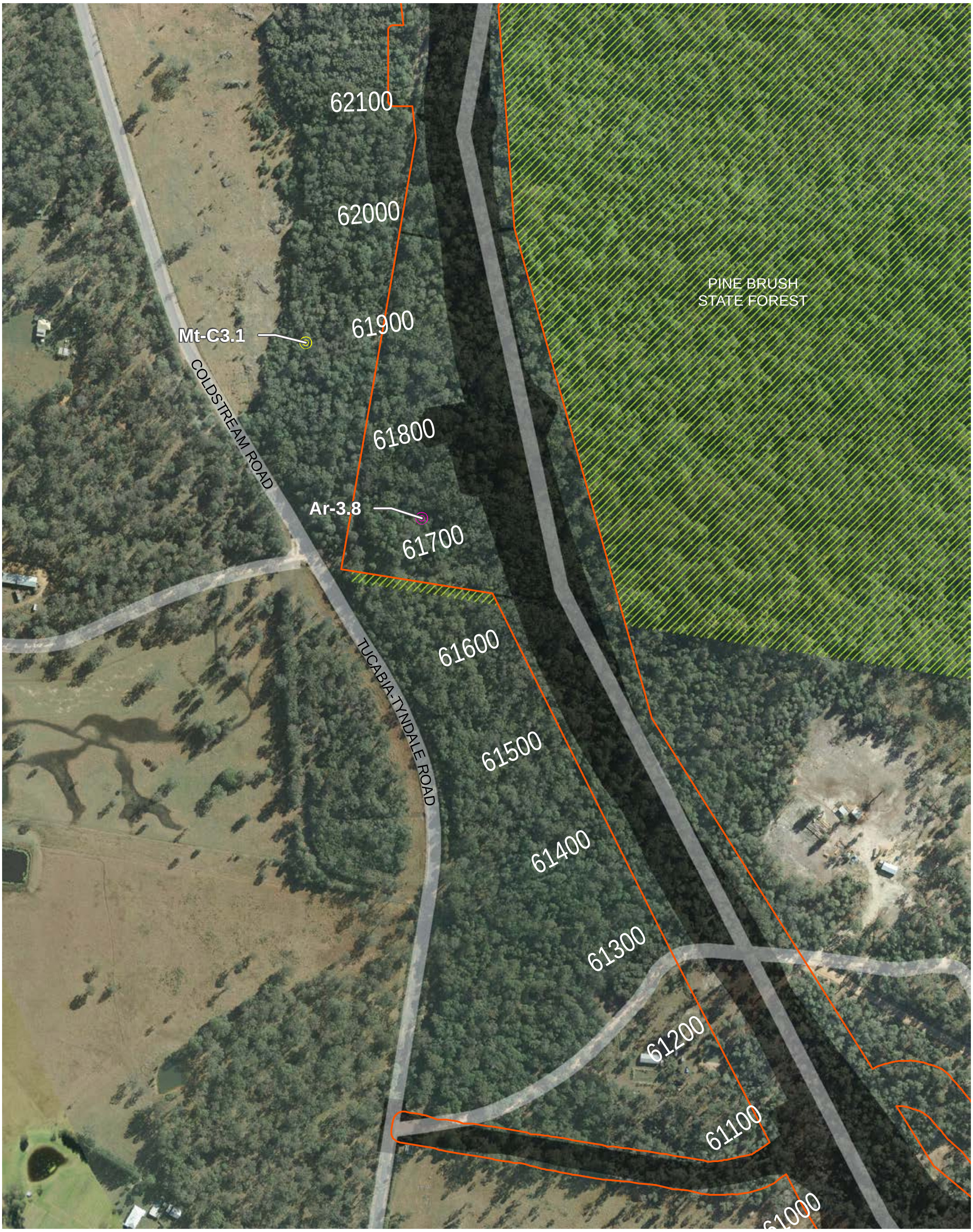

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Figure A-18 | Threatened flora monitoring locations

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Figure A-19 | Threatened flora monitoring locations

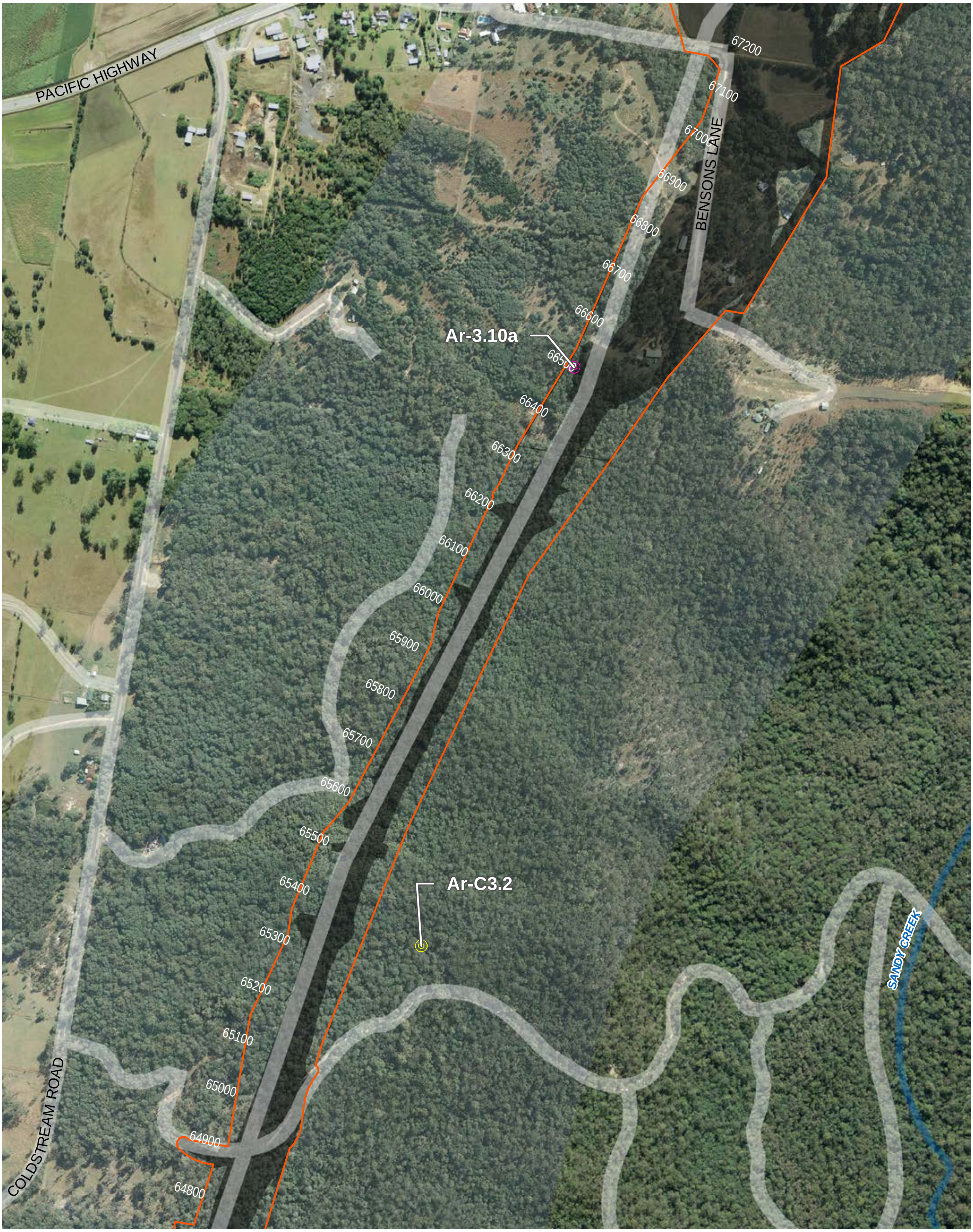

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Figure A-20 | Threatened flora monitoring locations

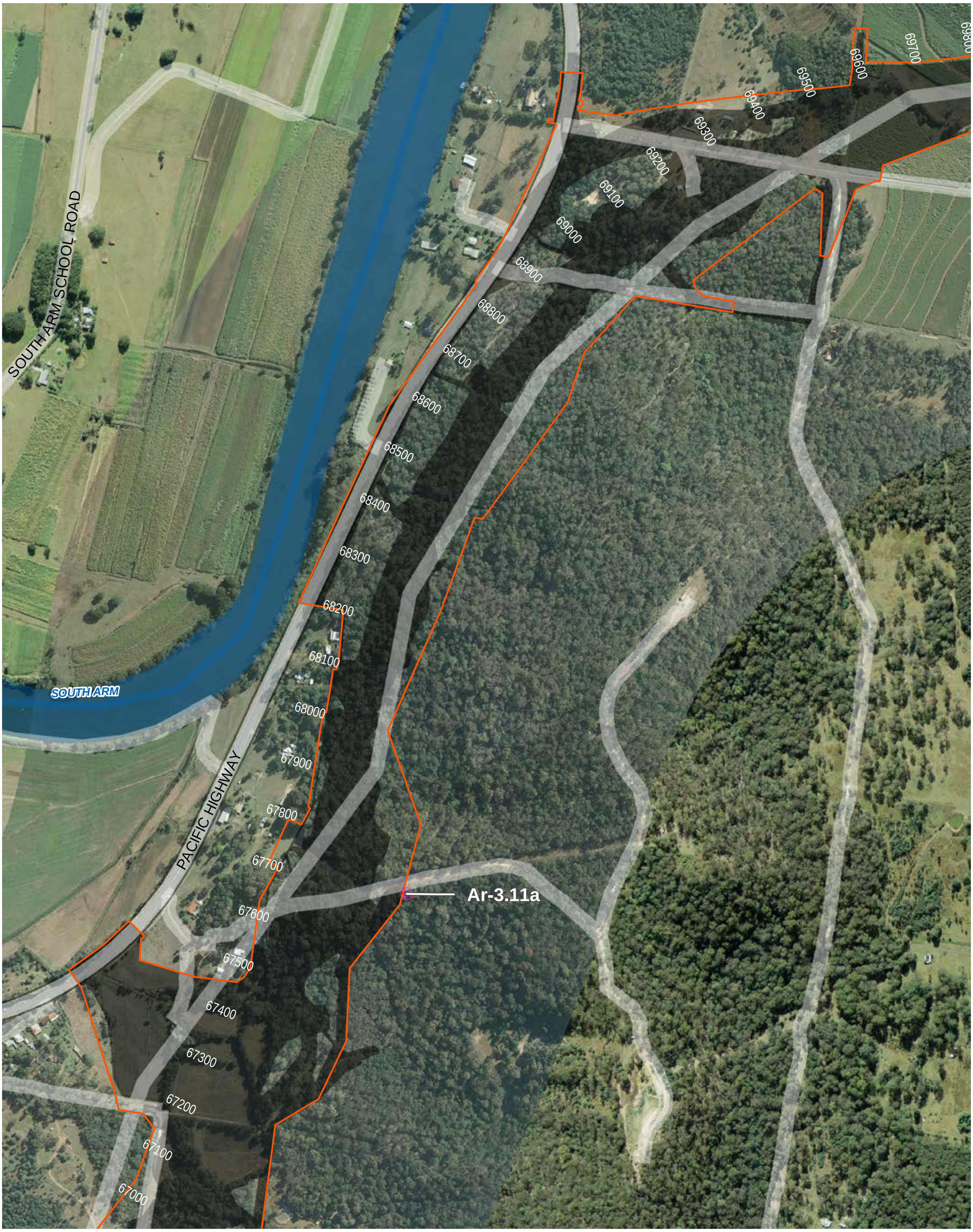

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Figure A-21 | Threatened flora monitoring locations

Legend

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-22 | Threatened flora monitoring locations

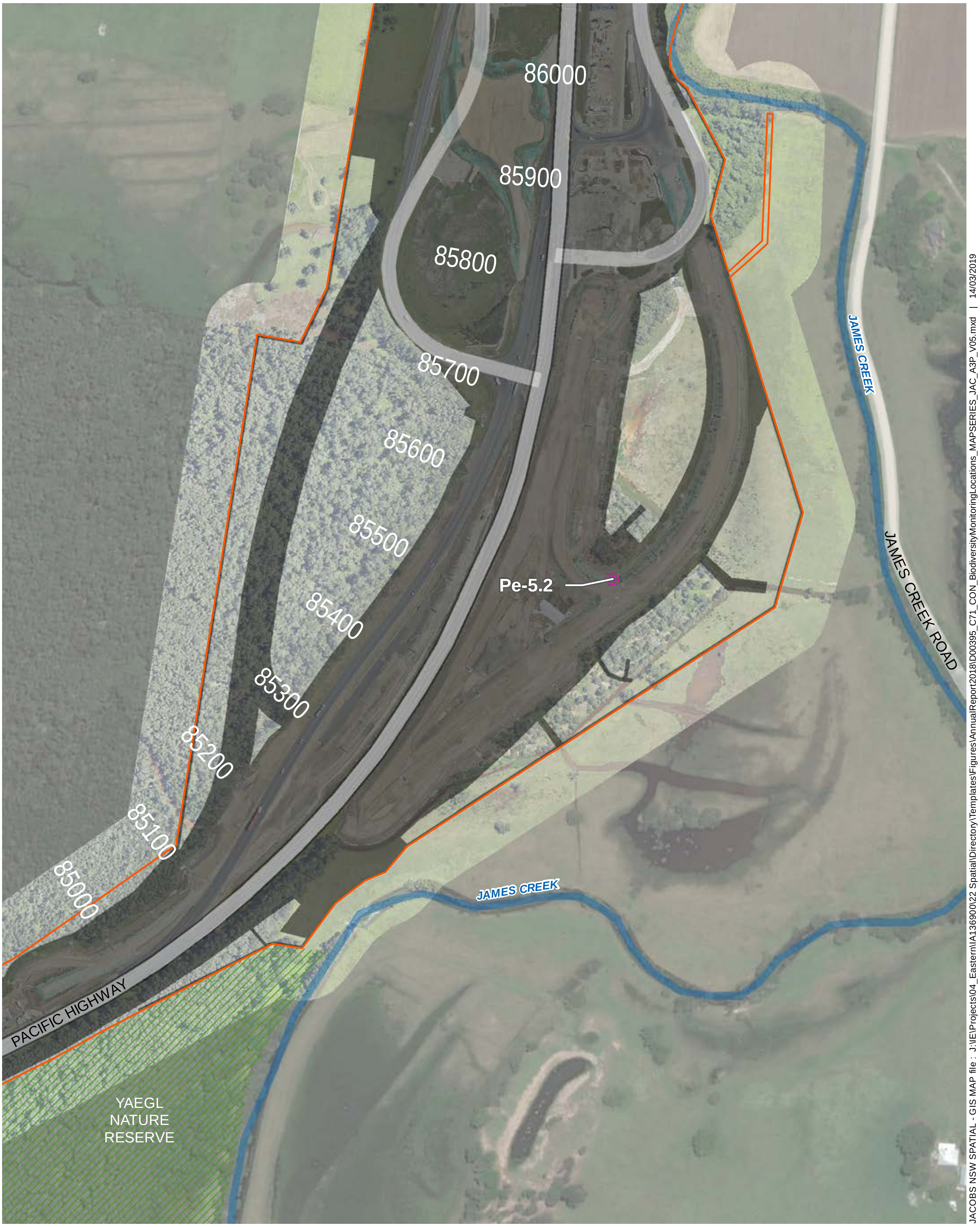

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Figure A-23 | Threatened flora monitoring locations

Legend

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- Monitoring location - Impact (Jacobs 2018)
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Figure A-24 | Threatened flora monitoring locations

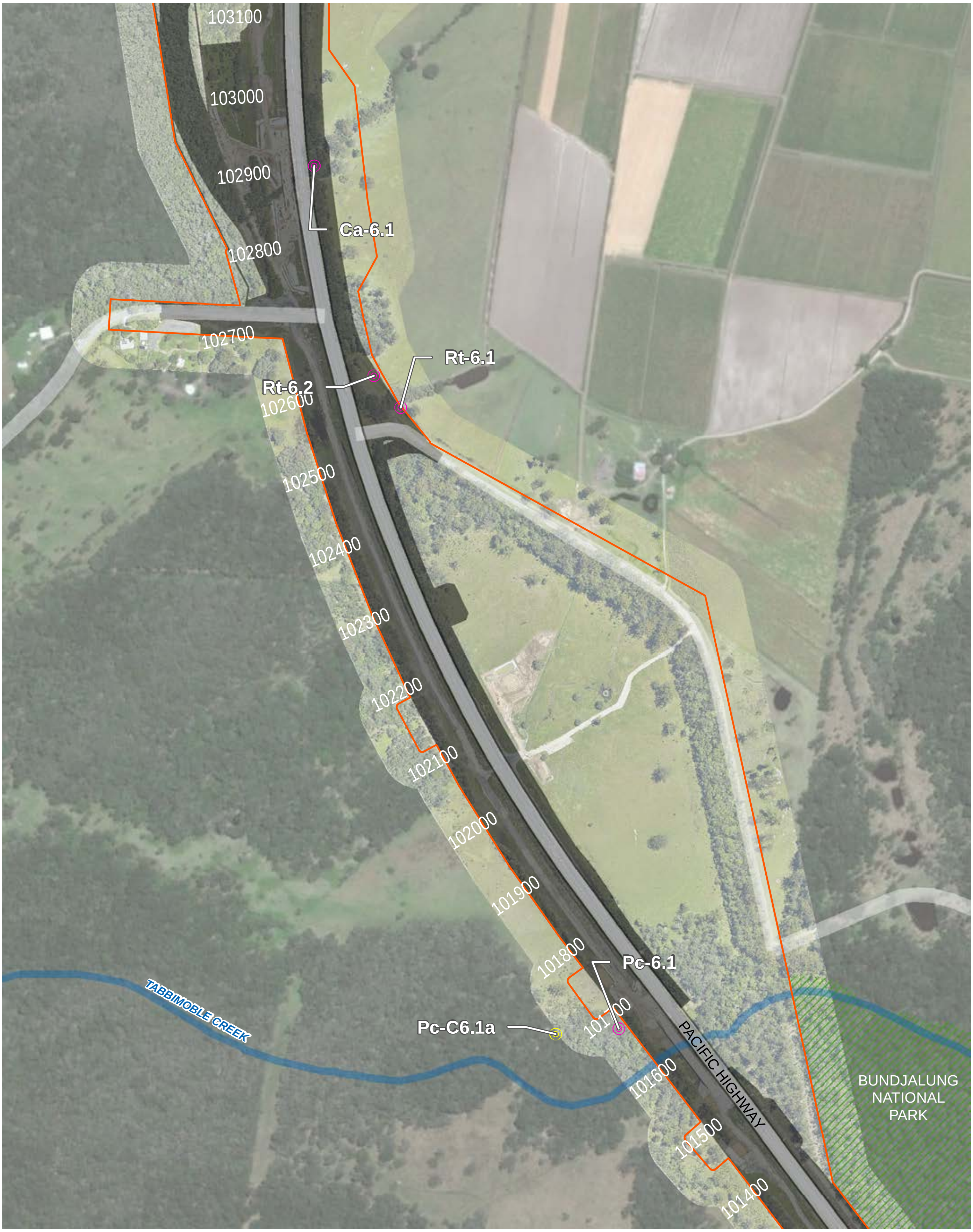

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Figure A-25 | Threatened flora monitoring locations

Legend

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- State Forest (DFSI Mar 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

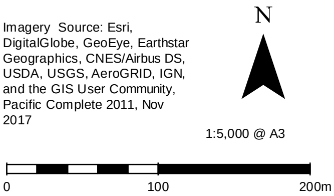


Figure A-26 | Threatened flora monitoring locations

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- State Forest (DFSI Mar 2018)
- National Park (DFSI Oct 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-27 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\AnnualReport2018\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V05.mxd | 14/03/2019

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:10,000 @ A3

0 100 200m

Figure A-28 | Threatened flora monitoring locations

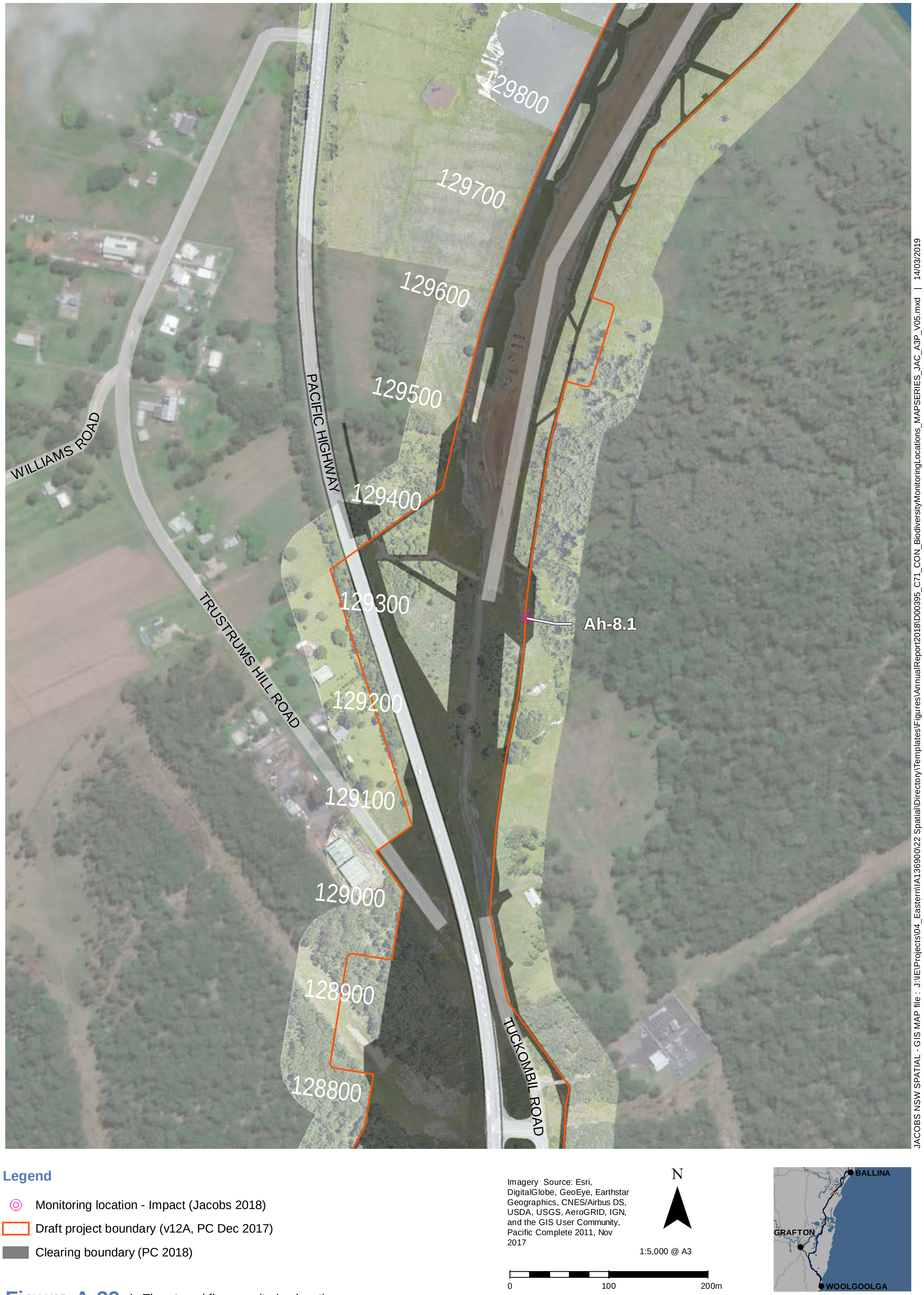
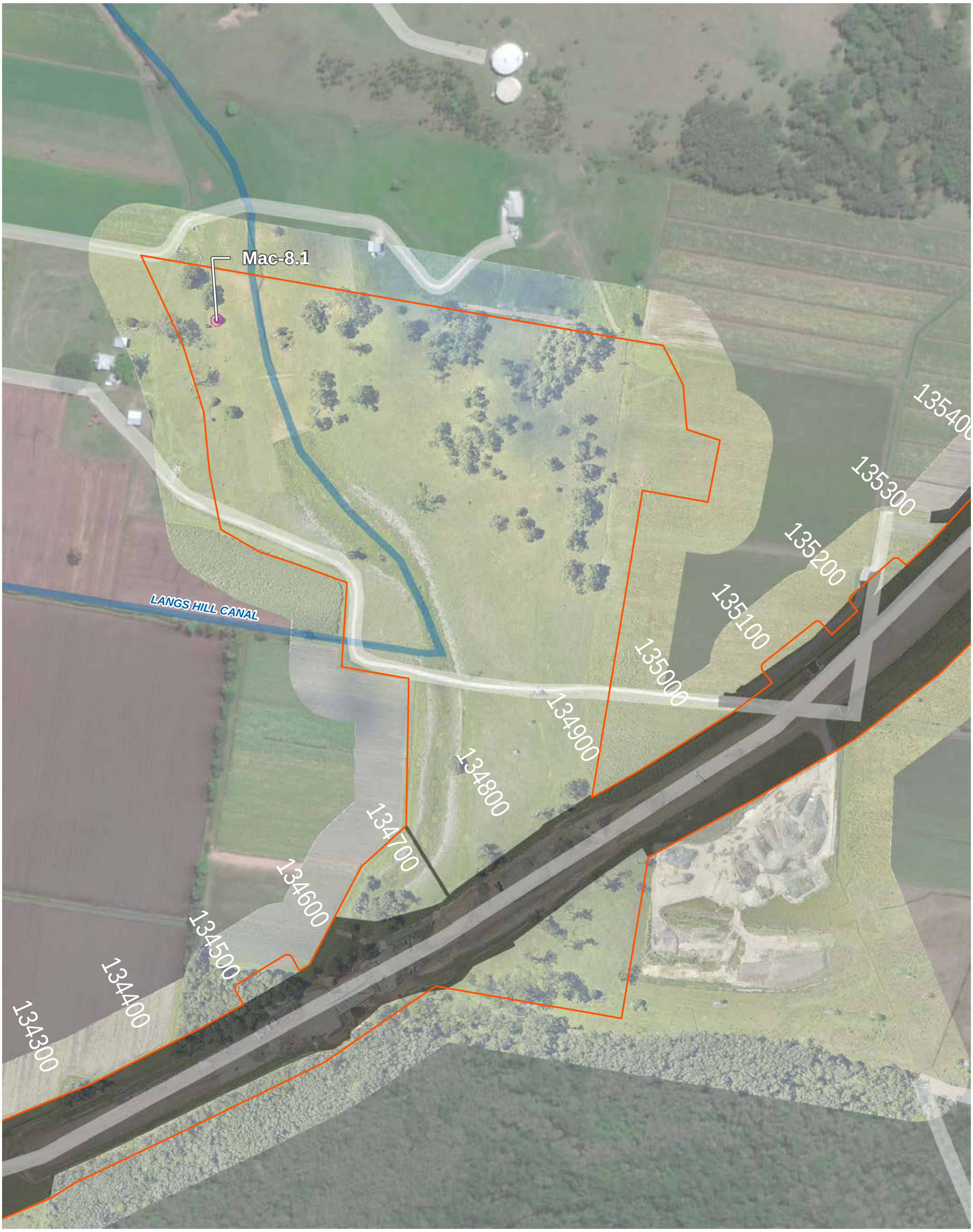


Figure A-29 | Threatened flora monitoring locations



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\AnnualReport2018\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V05.mxd | 14/03/2019

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Waterway (DFSI Mar 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-30 | Threatened flora monitoring locations

Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

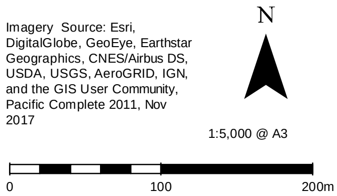
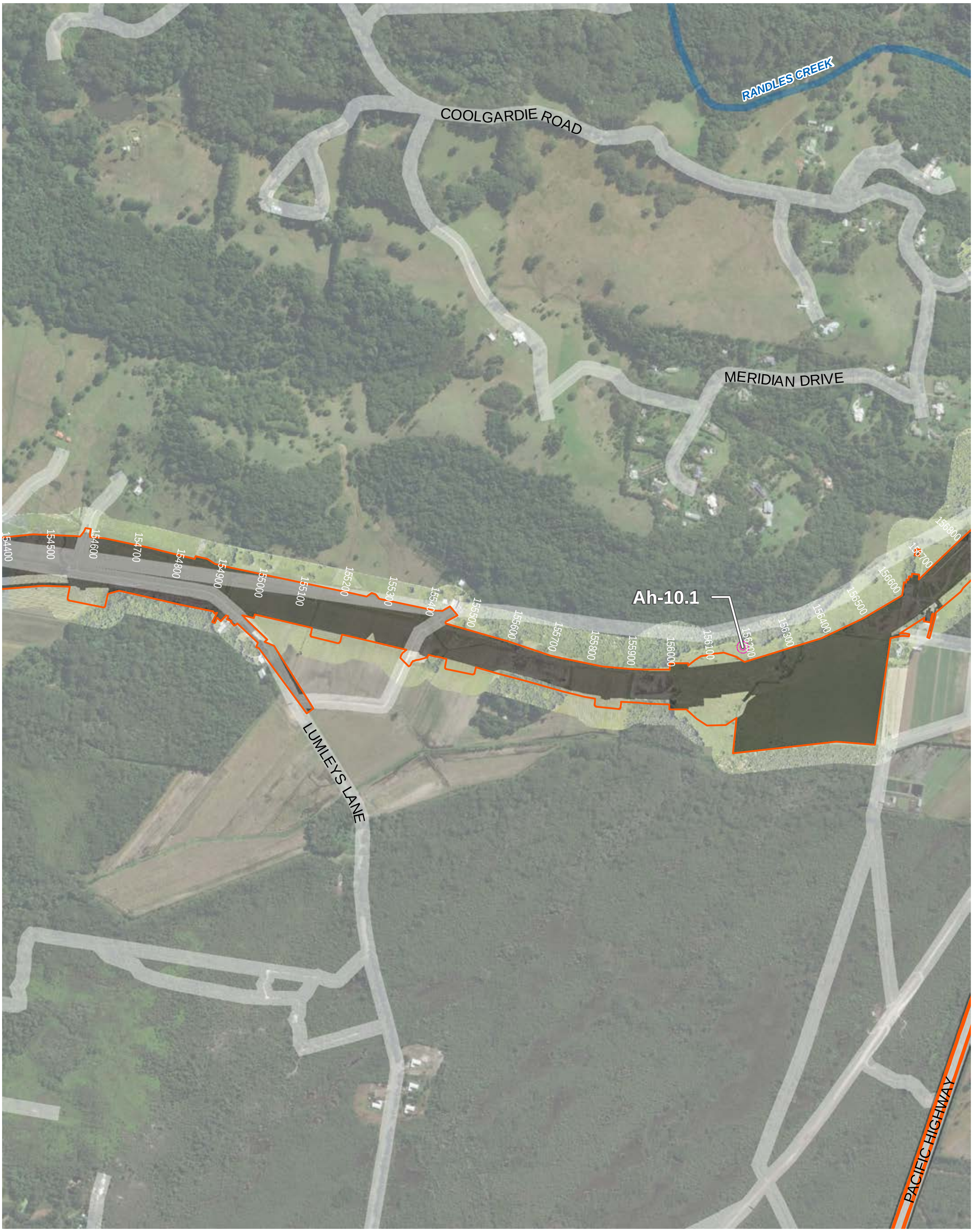


Figure A-31 | Threatened flora monitoring locations



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\AnnualReport2018\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V05.mxd | 14/03/2019

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Waterway (DFSI Mar 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:12,500 @ A3

0 100 200m

Figure A-32 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\AnnualReport2018\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V05.mxd | 14/03/2019

Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Waterway (DFSI Mar 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Pacific Complete 2011, Nov 2017

Figure A-33 | Threatened flora monitoring locations

Appendix B. Differences in EIS vs Current Clearing Boundary for Threatened Flora (Year 2 reset)

Common name	Scientific name	Location	Direct								Indirect within 10m								Indirect with 10 to 20m							
			EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current M-Class boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current M-Class boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**	EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current M-Class boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current M-Class boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**	EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current M-Class boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current M-Class boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**
Rough-barked Apple	Angophora robur	S3	6443	6443	5915	-528	87.895	89.115	78.568	-10.547	1146	1146	1512	366	20.691	21.137	25.886	4.748	1208	1208	1092	-116	19.572	21.056	23.565	2.509
		S4	108	108	18	-90	2.618	2.561	0.237	-2.324	3	3	35	32	0.462	0.550	1.147	0.597	8	8	34	26	0.425	0.480	0.986	0.506
		Total	6551	6551	5933	-618	90.513	91.676	78.805158	-12.871	1149	1149	1547	398	21.153	21.687	27.033	5.346	1216	1216	1126	-90	19.997	21.536	24.551	3.015
Broad-leaved Apple	Angophora subvelutina	S1				0		0.290	0.291	0.001			1	1		0.050	0.051	0.001				0		0.054	0.054	0.000
		Total	0	0	0	0	0	0.290	0.291	0.001	0	0	1	1	0	0.050	0.051	0.001	0	0	0	0	0	0.054	0.054	0.000
White laceflower	Archidendron hendersonii	S10	1	3	4	1				0.000	4	8	1	-7				0.000	18	18	17	-1				0.000
		Total	1	3	4	1	0	0.000	0.000	0.000	4	8	1	-7	0	0.000	0.000	0.000	18	18	17	-1	0	0.000	0.000	0.000
Veiny Lace Flower	Archidendron muellerianum	S10			2	2				0.000				0				0.000				0				0.000
		Total	0	0	2	2	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
	Artanema fimbriatum	S3		5	5	0				0.000				0				0.000				0				0.000
		Total	0	5	5	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Hairy-joint grass	Arthraxon hispidus	S1	2	2	2	0				0.000				0				0.000				0				0.000
		S3	1	1	1	0				0.000				0				0.000				0				0.000
		S8	38	38	16	-22	0.238	1.244	0.097	-1.147		2	17	15		0.020	0.115	0.095	8	8	20	12	0.038	0.038	0.101	0.062
		S10	347	347	376	29	1.232	0.256	1.575	1.320	47	47	52	5	0.697	0.697	0.861	0.164	53	53	35	-18	0.846	0.858	0.811	-0.046
		Total	388	388	395	7	1.47	1.500	1.672	0.172	47	49	69	20	0.697	0.717	0.976	0.259	61	61		-6	0.884	0.896	0.912	0.016
Stinking laurel	Cryptocarya foetida	S10	41	51	49	-2				0.000	1	1	7	20				0.000	6	7	3	-4				0.000
		Total	41	51	49	-2	0	0.000	0.000	0.000	1	1	7	20	0	0.000	0.000	0.000	6	7	3	-4	0	0.000	0.000	0.000
Water nutgrass	Cyperus aquatilis	S1	1	1	1	0	0.021	0.021	0.030	0.009				0		0.013	0.004	-0.009				0				0.000
		S2	6	6	6	0	0.003	0.003	0.003	0.000				0				0.000				0				0.000
		S6	113	121	111	-10				0.000				0				0.000			10	10				0.000
		S7	8	3	3	0				0.000	2	1		-1				0.000	1		1	1				0.000
		Total	128	131	121	-10	0.024	0.024	0.000	0.009	2	1	0	-1	0	0.013	0.004	-0.009	1	0	11	11	0	0.000	0.000	0.000
Davidson's Plum	Davidsonia jerseyana	S10				0				0.000			1	1				0.000				0				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	0	1	1	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Square-stemmed spike-rush	Eleocharis tetraquetra	S1	253	58	235	177	0.815	0.787	0.889	0.101	43	178	58	-120	0.118	0.135	0.144	0.009	48	44	11	-33	0.12	0.122	0.114	-0.007
		Total	253	58	235	177	0.815	0.787	0.889	0.101	43	178	58	-120	0.118	0.135	0.144	0.009	48	44	11	-33	0.12	0.122	0.114	-0.007
Green-leaved rose walnut	Endiandra muelleri ssp. bracteata	S4			2	2				0.000		1	1	0				0.000	2	1	1	0				0.000
		S10	3	4	4	0				0.000	10	11	2	-9				0.000	3	4	10	6				0.000
		Total	3	4	6	2	0	0.000	0.000	0.000	10	12	3	-9	0	0.000	0.000	0.000	5	5	11	6	0	0.000	0.000	0.000
Square-fruited Ironbark	Eucalyptus tetrapleura	S2	822	868	919	51	20.285	20.990	19.388	-1.602	193	188	181	-7	6.337	7.205	6.090	-1.114	115	102	92	-10	4.87	6.585	5.394	-1.191
		S3				0			0.573	0.573				0		0.743	0.170	-0.573				0		0.720	0.154	-0.566
		Total	822	868	919	51	20.285	20.990	19.960	-1.029	193	188	181	-7	6.337	7.948	6.260	-1.687	115	102	92	-10	4.87	7.305	5.548	-1.757
Four-tailed grevillea	Grevillea quadricauda	S3	3	3	5	2		0.020	0.020	0.000	35	35	34	-1	0.017	0.018	0.018	0.000	14	14	13	-1		0.003	0.003	0.000
		Total	3	3	5	2	0	0.020	19.980	0.000	35	35	34	-1	0.017	0.018	0.018	0.000	14	14	13	-1	0	0.003	0.003	0.000
Noah's false chickweed	Lindernia alsinoides	S1	1811	958	1035	77				0.000	18	72	17	-55				0.000	91	17	31	14				0.000
		S2				0				0.000				0				0.000	4	2		-2				0.000
		Total	1811	958	1035	77	0	0.000	0.000	0.000	18	72	17	-55	0	0.000	0.000	0.000	95	19	31	12	0	0.000	0.000	0.000
Slender screw fern	Lindsaea incisa	S1		1470	1470	0	0.013	0.013	0.013	0.000		250	250	0		0.001	0.001	0.000		330	330	0	0.003	0.003	0.003	0.000
		S2		409	409	0		0.024	0.024	0.000		1	1	0		0.003	0.003	0.000		2	2	0		0.004	0.003	0.000
		S3			1	1			0.005	0.005			2	2			0.007	0.007			1	1		0.001	0.003	0.002
		S6		11437	11927	490	0.37	0.370	0.281	-0.089		1501	3903	2402	0.058	0.058	0.137	0.078		3221	186	-3035	0.148	0.152	0.346	0.194
		Total	0	13316	13807	491	0.383	0.406	0.323	-0.084	0	1752	4156	2404	0.058	0.062	0.148	0.086	0	3553	519	-3034	0.151	0.159	0.356	0.196
Macadamia Nut	Macadamia integrifolia	S10				0				0.000			2	2				0.000			2	2				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	0	2	2	0	0.000	0.000	0.000	0	0	2	2	0	0.000	0.000	0.000
Rough-shelled Bush Nut	Macadamia tetraphylla	S5		3	2	-1				0.000			1	1				0.000				0				0.000
		S8			2	2				0.000	2	2		-2				0.000				0				0.000
		S10	10	10	10	0				0.000				0				0.000	3	3	11	8				0.000
		Total	10	13	14	1	0	0.000	0.000	0.000	2	2	1	-1	0	0.000	0.000	0.000	3	3	11	8	0	0.000	0.000	0.000
Maundia	Maundia triglochinoides	S1	5	4	6	2	0.075	0.103	0.117	0.014	5	1	1	0	0.038	0.044	0.042	-0.001		1	1	0		0.032	0.032	0.000
		S2	34	28	20	-8	0.075	0.069	0.052	-0.017	45	43	39	-4	0.072	0.082	0.054	-0.028	16	6	10	4	0.073	0.065	0.075	0.010
		S3	3	3	1	-2	0.016	0.050	0.020	-0.029			1	1		0.006	0.026	0.020	1	1	2	1		0.034	0.068	0.035
		S7	11	10	8	-2	0.023	0.023	0.018	-0.005	16	18	4	-14		0.008	0.003	-0.005	1	3	1	-2		0.018	0.002	-0.016
		Total	53	45	35	-10	0.189	0.245	0.207	-0.038	66	62	45	-17	0.11	0.140	0.126	-0.014	18	11	14	3	0.073	0.148	0.177	0.029
Weeping paperbark	Melaleuca irbyana	S7	1582	1582	1539	-43	2.761	2.761	2.714	-0.047	132	132	165	33	0.322	0.322	0.413	0.091	41	42	68	26	0.203	0.246	0.250	0.004
		Total	1582	1582	1539	-43	2.761	2.761	2.714	-0.047	132	132	165	33	0.322	0.322	0.413	0.091	41	42	68	26	0.203	0.246	0.250	0.004
Yellow-Flowered King of the Fairies	Oberonia complanata	S8	18	20	20	0	0.033	0.033	0.038	0.005	1	2	8	6	0.013	0.013	0.011	-0.002	6	7	1	-6		0.003	0.000	-0.003
		Total	18	20	20	0	0.033	0.033	0.038	0.005	1	2	8	6	0.013	0.013	0.011	-0.002	6	7	1	-6	0	0.003	0.000	-0.003
	Oberonia titania	S10				0				0.000				0				0.000		13		-13	13			0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	13	0	-13	13	0.000		0.000
	Olax angulata	S2		1	1	0				0.000				0				0.000				0				0.000
		Total	0	1	1	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Birdwing Butterfly Vine	Pararistolochia praevenosa	S10		40	50	10				0.000		10		-10				0.000		1	1	0				0.000
		Total	0	40	50	10	0	0.000	0.000	0.000	0	10	0	-10	0	0.000	0.000	0.000	0	1	1	0	0	0.000	0.000	0.000
Tall knotweed	Persicaria elatior	S4	53	53	98	45	0.153	0.153	0.137	-0.016	3	8	108	100		0.042	0.521	0.479	1	3	64	61	0.006	0.006	0.436	0.430
		S5	23	23	97	74	0.047	0.057	0.154	0.097	25	25	30	5	0.069	0.077	0.060	-0.017	68	68	29	-39	0.084	0.098	0.057	-0.041
		Total	76	76	195	119	0.2	0.210	0.291	0.081	28	33	138	105	0.069	0.120	0.581	0.462	69	71	93	22	0.09	0.104	0.493	0.389
Singleton mint bush	Prostanthera cineolifera	S6	609	616	653	37	0.424	0.424	0.438	0.015	260	258	228	-30	0.188	0.188	0.177	-0.011	106	106	99	-7	0.229	0.229	0.204	-0.026
		Total	609	616	653	37	0.424	0.424	0.438	0.015	260	258	228	-30	0.188	0.188	0.177	-0.011	106	106	99	-7	0.229	0.229	0.204	-0.026
Moonee Quassia	Quassia sp. Moonee Creek	S1	73	133	73	-60	0.08	0.152	0.080	-0.073	137	173	137	-36	0.105	0.091	0.107	0.016	250	185	243	58	0.126	0.106	0.120	0.014
		Total	73	133	73	-60	0.08	0.152	0.080	-0.073	137	173	137	-36	0.105	0.091	0.107	0.016	250	185	243	58	0.126	0.106	0.120	0.014
	Rotala tripartia	S6			2	2				0.000				0				0.000	2	6		-6				0.000
		Total	0	0	2	2	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	2	6	0	-6	0	0.000	0.000	0.000
	ROTAP Trichosanthes subvelutina	S10				0				0.000		1	1	0				0.000				0				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	1	1	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Siah's Backbone	Streblus pendulinus	S10	4	4	3	-1				0.000	1	1	4	3				0.000	2	2	1	-1				0.000
		S4											1	1				0.000	1	1		-1				0.000
		S8												0				0.000		2		-2				0.000
		Total	4	4	3	-1	0	0.000	0.000	0.000	1	1	5	4	0	0.000	0.000	0.000	3	5	1	-4	0	0.000	0.000	0.000
Smooth-bark Rose Apple, Red Lilly Pilly	Syzygium hodgkinsoniae	S10	6	6	2	-4				0.000	4	4		-4				0.000		6	8	2				0.000
		Total	6	6	2	-4	0	0.000	0.000	0.000	4	4	0	-4	0	0.000	0.000	0.000	0	6	8	2	0	0.000	0.000	0.000