

Appendix P

Outcomes Strategy



Mount Emerald Wind Farm



Northern Quoll Outcomes Strategy

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1.0 Introduction

The Northern Quoll *Dasyurus hallucatus* is the smallest species of the quolls, a group of predominantly carnivorous marsupials found only in Australia and New Guinea (Van Dyck and Strahan, 2008).

The species is regarded as Endangered under the EPBC Act (1999), and is the subject of a recovery plan - National Recovery Plan for the Northern Quoll *Dasyurus hallucatus* (Hill and Ward 2010). The main aim of the recovery plan is to;

“minimise the rate of decline of the Northern Quoll in Australia, and ensure that viable populations remain in each of the major regions of distribution into the future. The recovery actions proposed here emphasise protecting key populations from colonization by cane toads and cats (especially through quarantine of offshore islands); fostering recovery of populations that have collapsed following cane toad arrival; managing secure populations (including captive and translocated); identifying and managing the threats to the Northern Quoll in the absence of cane toads; raising public awareness and native (sic) support of Northern Quoll in the absence of cane toads; raising public awareness and active support of northern quolls; and enhancement of cane toad management, including quarantine.”

Key listed threats include;

- cane toads,
- feral predators,
- inappropriate fire regimes,
- habitat degradation,
- habitat destruction,
- weeds,
- disease,
- hunting,
- population isolation

The disparity between historical records and the known contemporary distribution of *D. hallucatus* suggests that their populations underwent a catastrophic collapse during the 20th century, resulting in the disjointed range of the species in Australia and Queensland today (Braithwaite and Griffiths 1994, Oakwood 2008). Northern quolls in Queensland are known from only six disjunct populations;

- (1) Weipa,
- (2) eastern Einasleigh uplands/western and northern Wet Tropics boundary from Ravenshoe – Cooktown,
- (3) Townsville- Bowen,
- (4) Mackay/Whitsunday region and hinterland,
- (5) Rockhampton region and hinterland and,
- (6) Carnarvon Range (Burnett unpublished data),

It is possible that further survey effort in the southern and central Queensland regions will locate more populations.

The Mt Emerald quoll population forms part of the eastern Einasleigh upland/western wet tropics quoll population and like all remnant Queensland quoll populations, has survived there in sympatry with cane

toads, and during more than 100 years of European occupation with slight modification of their habitat (e.g. Woinarski *et al.* (2008), S. Burnett, University of the Sunshine Coast, unpublished data).

Studies by Burnett *et al.* (2013) suggest that the western and northern Atherton Tablelands, extending north to Cooktown, is a hot spot for Northern Quolls in Queensland and the area within a 55km radius of Mt Emerald contains 72% of the remaining Northern Quolls in the Einasleigh Uplands/Wet Tropics region. Conroy and Lamont (2013) further identify that the Mt Emerald quoll population experiences gene flow to and from adjacent populations in the upper Walsh River about 20km to the south-west, and the Lamb Range (Tinaroo and Davies Creeks) about 20km to the east and that Mt Emerald is likely a route through which gene flow from the Lamb Range through to the Herberton Range occurs.

An attempt was made to model the population viability (PVA) of the Mt Emerald quoll population using a suite of parameters derived by direct observation of this and nearby quoll populations, and parameters inferred from quoll populations across the species range (Shimizu and Conroy 2013). This PVA was hampered by a lack of detailed data on critical aspects of quoll population ecology and dispersal patterns, and the major recommendation of that report was to undertake studies to collect more of this data.

Further research has built on these studies and have been particularly focussed on establishing the best methods of detecting and enumerating quoll populations. Hemmings (2015) compared the efficiency of cage trapping versus camera trapping for detecting and enumerating the size of Northern Quoll populations at six sites between Townsville and Mareeba, revealing that camera trapping is at least as efficient as cage trapping. Given the much lower effort required to conduct a camera-trap versus a cage-trapping survey he recommends the use of trail cameras to locate and count quolls.

Current research (N. Foster, University of the Sunshine Coast, unpublished data) is exploring the most effective camera trap deployment for detection and population estimation of Northern Quolls. Foster (unpublished) has tested a variety of camera trap spacings on each of nine, 1-km-long transects between Mackay and Mareeba on the Atherton Tablelands. While these analyses are ongoing, the preliminary results suggest that even at 100-m-spacings, insufficient recaptures are had to permit strong mark-recapture derived population estimates to be obtained on these single transect-lines of camera traps.

The methods proposed below to effectively monitor Northern Quoll populations are derived from the above studies and suggest that for effective population estimation of Northern Quolls, a grid-based approach, at which cameras are spaced no more than 350-m-apart, and in which cameras are left in-situ for a minimum of 14 days are required to maximise the number of individuals detected, the number of recaptures, and hence to maximise the accuracy of spatially-explicit mark-recapture estimation of population size. **Figure 1** identifies the locations of the Mt Emerald Wind Farm and associated grid locations in the regional landscape.

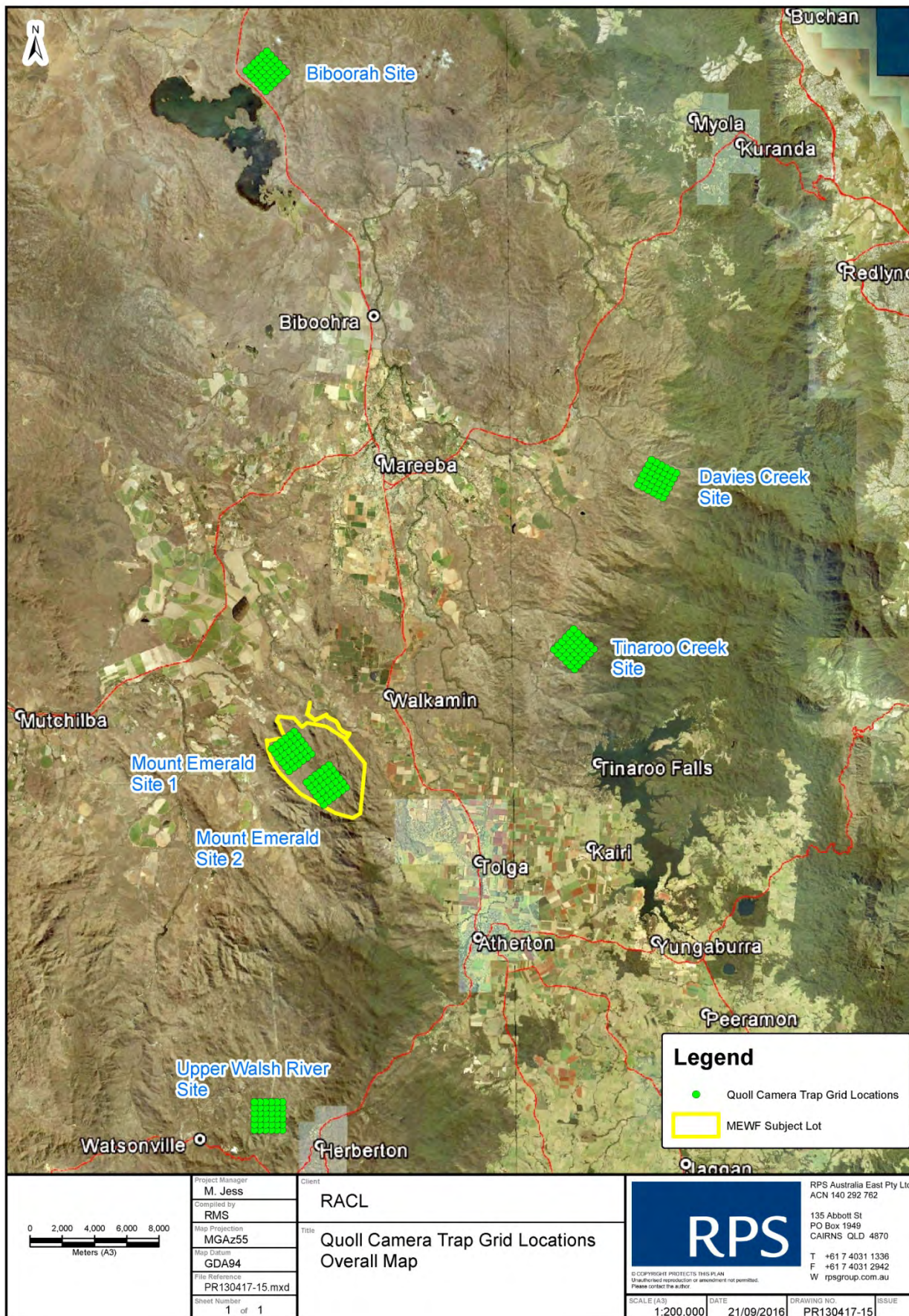


Figure 1 Quoll Camera Trap Grid Locations

2.0 Statement of Outcomes

The Condition 7 of the approval issued by the Department of the Environment under the EPBC Act for the Mount Emerald wind farm states “for the protection of the Northern Quoll, the approval holder must maintain a viable population of Northern Quoll on the wind farm site.”

The nature of the approval condition is in-line with the broader objectives of the National Recovery Plan for the Northern Quoll (Hill and Ward, 2010), particularly;

- Specific Objective 2 - Foster the recovery of Northern Quoll sub-populations in areas with cane toad;
- Specific Objective 5 - Maintain secure populations and source animals for future reintroductions / introductions, if they become appropriate

It is unknown what population size reflects a viable population, however the viability of the population can be inferred if changes in the size and distribution of the windfarm population remains within the range of values recorded at reference sites outside of the project area. Therefore, the key outcomes for the work outlined in this strategy are to identify any statistically significant changes in;

- (1) quoll population size between windfarm and reference sites between each monitoring occasion, and
- (2) site occupancy by quolls on the windfarm site compared to the reference sites.

Such changes will be determined by statistical comparison of the proportional change in population size and/or site occupancy between the windfarm and reference sites during each triannual monitoring occasion during construction, during each biannual monitoring event in each of three years following the construction phase, and at a single monitoring event in each of 5 and 10 years following completion of construction.

Numerical size of each quoll population will be defined through mark-recapture modelling (White and Burnham 1999), or where insufficient captures and recaptures are reasonably achievable, through the minimum number known to be alive method (Krebs 1966). Site occupancy will be estimated using occupancy modelling (McKenzie et al 2003).

3.0 Milestones

- (a) In the 12 months prior to construction, baseline data on quoll population size, site occupancy, population vital statistics and habitat condition is collected from two sampling sites on Mt Emerald and in four regional reference sites within a 50km radius of Mt Emerald.
- (b) In the first 12 months of the project, two funded PhD studies commence; Study 1: The distribution and population ecology of the Northern Quoll; Study 2: Spatial ecology and habitat selection by the Northern Quoll.
- (c) In each year of construction, triannual monitoring of quoll populations and their habitat at the project site and at least four reference sites will be monitored using the methods established at Milestone A.
- (d) In each year for three years post construction, triannual monitoring of quoll populations and their habitat at the project site and at all reference sites (identified above) will be undertaken using the methods of Milestone A.
- (e) In the fifth year post-construction, annual monitoring of quoll populations and their habitat will be undertaken at the project site and at the four regional sites using the methods of Milestone A.
- (f) In the tenth year post construction, annual quoll population and habitat monitoring will be undertaken at the project site and the four regional sites using the methods of Milestone A.

4.0 Performance Criteria

The following Performance Criteria are proposed for assessing the relevant performance of the Northern Quoll Management and associated environmental management in regards to the Mount Emerald wind farm.

- PC 1** During the preconstruction stage a monitoring program is established and baseline quoll population size, occupancy and population vital statistics and habitat data are collected for at least four regional reference sites and two Mt Emerald monitoring sites.
- PC 2** During and for three years after the construction phase, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.
- PC 3** In the 5th year after completion of construction, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.
- PC 4** In the 10th year after completion of construction, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.

5.0 Monitoring

Monitoring of Northern Quolls and their habitats will occur on six permanent study grids (Error! Reference source not found.). Each study grid will consist of 36 equidistant quoll and habitat monitoring points arranged on a 6 x 6 grid, with points 350m-apart (total grid dimensions 1750m x 1750m = 306.25ha). This approach to quoll monitoring is based on the findings of Hemmings (2015) and Foster (in prep).

Quoll monitoring will utilise a single incandescent flash, Reconyx™ 550 Hyperfire trail camera (or equivalent) simultaneously at each of the 36 points of each monitoring grid. Deployment, timing and programming of cameras must be consistent between each monitoring grid and each time, to ensure comparability of monitoring data. Trail cameras will be mounted 1.5m above ground level on a 90° bracket fixed to a vertical tree trunk with hex-head timber screws resulting in a vertical orientation (i.e. pointing directly down onto the target area). The target area will consist of an approximately 75-cm-square area cleared of grass and other obstructions, in the centre of which (i.e. immediately below the camera) is a 10-cm-length of 50mm PVC pipe with a cap at one end and a mesh cowling at the other, containing as many chicken necks as will fit (usually between 3 and 5). The container is preferably spray-painted black to minimise the risk of over-exposed photos caused by the camera's flash on a white object, and pegged to the ground so it can't be removed by scavengers.

Each camera will be programmed to take three images per trigger event, at medium/high sensitivity with no delay between trigger, and deployed for a minimum 14 days, without refreshing/replacing the bait.

Monitoring of quoll habitat will utilise the method outlined in the Queensland BioCondition Reference Site and Assessment Guideline (Eyre *et al.* 2011; Eyre *et al.* 2015) and will occur at half of the camera trap points on each grid, each time that quoll monitoring is undertaken.

The grids will be located on Mt Emerald (2 monitoring grids within the impact area), and at four reference grids within known Northern Quoll populations within 45km of Mt Emerald and within the same general climatic zone and broad vegetation community (**Table 1**).

Table 1 Indicative location of each 1750 x 1750m monitoring grid used to monitor quoll populations, quoll occupancy, feral carnivore occupancy and habitat attributes

Site	Type	Indicative grid centre point
Mt Emerald 1	Impact site	-17.181362, 145.38741
Mt Emerald 2	Impact site	-17.157438, 145.366421
Davies Creek	Reference site	-17.009332, 145.583918
Tinaroo Creek	Reference site	-17.101861, 145.534146
Upper Walsh River	Reference site	-17.366243, 145.354304
Biboorah	Reference site	-16.778739, 145.357973

6.0 Adaptive Management

This section outlines the adaptive management strategies that will be implemented to ensure that outcomes based conditions can be met more effectively. The following approach will be followed:

- General mitigation measures including management actions, significant species management plans and threatened species inductions developed for clearing, construction and operation of the MEWF;
- Northern Quoll Management Plan and Habitat Clearing and Management Plan for protection of fauna species during MEWF Activities;
- Pest Management Plan and Weed Management Plan;
- A Bushfire Management Plan promoting a regime of mosaic burns;
- Collection of Northern Quoll monitoring data which will be systematically evaluated and compared to baseline and reference site data on a regular basis (triannually up to 5 years) in a process of adaptive management to verify whether there are any responses to the immediate and long-term impact of construction;
- A regular review of external factors.

Table 2 below provides Adaptive Management Actions that will be implemented when key performance targets are not being met.

Table 2 Adaptive Management Actions

Number	KPI	Monitoring	Trigger for Adaptive Management	Management Actions	Reporting
1	During the preconstruction stage a monitoring program is established and baseline quoll population size, occupancy and population vital statistics and habitat data are collected for at least four regional reference sites and two Mt Emerald monitoring sites.	Monitor quoll populations (using trail cameras and using mark recapture modelling methods) and site occupancy (using occupancy modelling), and quoll habitat condition (using Bio-condition Index) at two sites at Mt Emerald, and at least four regional reference sites (Tinaroo Creek, Davies Creek, upper Walsh River, and Biboorah).	One round of monitoring not completed prior to construction.	Prioritise monitoring so that all monitoring on Mt Emerald is completed prior to any construction (roads, wind turbines or other infrastructure). Monitoring at regional reference sites can happen immediately after Mt Emerald monitoring is completed.	<ul style="list-style-type: none"> Monitoring Report; Database of Northern Quoll detections created; Quoll locations resulting from monitoring recorded in GIS database.
2	During and for three years after the construction phase, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.	Triannually monitor quoll populations (using trail cameras and using mark recapture modelling methods) and site occupancy (using occupancy modelling), and quoll habitat condition (using Biocondition Index), at two sites at Mt Emerald, and at least four regional reference sites (Tinaroo Creek, Davies Creek, upper Walsh River, and Biboorah).	<p>At any of the Mt Emerald monitoring sites, monitoring indicates that the quoll population has undergone a proportionally greater decrease in population size than the mean proportional population decrease on the four regional reference sites, over the same time interval.</p> <p>At any of the Mt Emerald monitoring sites, monitoring indicates that the quoll population has undergone a greater decrease in site occupancy than on the four regional reference sites, over the same time interval.</p> <p>Northern Quoll not detected on the Mt Emerald sites.</p>	<p>Repeat monitoring at all sites immediately, to rule out sampling errors.</p> <p>If after repeating the monitoring (above) adaptive management is still triggered, review the habitat monitoring data to attempt to identify a possible cause.</p> <p>Modify predator control and establish additional effective controls in consultation with DotE</p> <p>Where impacts to breeding are suspected or observed, implement management strategies including revised night time construction hours, directional lighting and use of low noise machinery in affected areas to minimise further disturbance.</p> <p>Review fauna corridor areas – set up trapping lines to determine impacts, observe edge effects and determine factors for decline.</p> <p>Review Bushfire management strategies to improve habitat condition where required to prevent premature</p>	<ul style="list-style-type: none"> Monitoring Report Identify relevant corrective actions with 28 days of monitoring event and notify DotE. Database of Northern Quoll detections created Quoll locations resulting from monitoring recorded in GIS database Input into Annual Environmental reports each year. Update website each year

Number	KPI	Monitoring	Trigger for Adaptive Management	Management Actions	Reporting
				<p>burn for example. Where insufficient habitat considers decreasing fire intervals to increase areas of variable fuel load to prevent wild fire and maintain a mosaic distribution. Refer to MEWF Bushfire Management Plan for further advice.</p> <p>Reduce and enforce speed limits in the vicinity of Quoll habitat through the implementation of signage, traffic calming devices and penalties.</p> <p>Consult with DotE and DEHP and update Outcomes Strategy where required.</p> <p>Assess the potential cause of reduction in habitat and Implement quarantine protocols, as detailed in the Northern Quoll Recovery Plan (2007) to prevent the spread of weed species into the MEWF project area (refer to MEWF Weed Management Plan. Notify DotE.</p> <p>Review revegetation works around culverts, dry access areas and revegetation areas (for fauna underpass areas), and identify cause for slow regeneration. Reinstate replace landscaping plants if suitable, or substitute with recommended species. Refer MEWF Revegetation Plan.</p>	

Number	KPI	Monitoring	Trigger for Adaptive Management	Management Actions	Reporting
3	In the 5 th year after completion of construction, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.	Biannually monitor quoll populations (using trail cameras and using mark recapture modelling methods) and site occupancy (using occupancy modelling), and quoll habitat condition (using Biocondition Index) at two sites at Mt Emerald, and at least four regional reference sites (Tinaroo Creek, Davies Creek, upper Walsh River, and Biboorah).	<p>At any of the Mt Emerald monitoring sites, monitoring indicates that the quoll population has undergone a proportionally greater decrease in population size than the mean proportional population decrease on the four regional reference sites, over the same time interval.</p> <p>At any of the Mt Emerald monitoring sites, monitoring indicates that the quoll population has undergone a greater decrease in site occupancy than on the four regional reference sites, over the same time interval.</p> <p>Northern Quoll not detected on the Mt Emerald sites.</p>	<p>Repeat monitoring at all sites immediately, to rule out sampling errors.</p> <p>If after repeating the monitoring (above) adaptive management is still triggered, review the habitat monitoring data to attempt to identify a possible cause.</p> <p>Review fauna corridor areas – set up trapping lines to determine impacts, observe edge effects and determine factors for decline.</p> <p>Review Bushfire management strategies to improve habitat condition where required to prevent premature burn for example. Where insufficient habitat considers decreasing fire intervals to increase areas of variable fuel load to prevent wild fire and maintain a mosaic distribution. Refer to MEWF Bushfire Management Plan for further advice.</p> <p>Reduce and enforce speed limits in the vicinity of Quoll habitat through the implementation of signage and penalties.</p> <p>Consult with DotE and DEHP and update Outcomes Strategy where required.</p> <p>Assess the potential cause of reduction in habitat and identify relevant corrective actions with 28 days of monitoring event. Implement quarantine protocols, as detailed in the Northern Quoll Recovery Plan (2007) to prevent the spread of weed species into the MEWF project area (refer to MEWF Weed Management Plan. Notify DotE.</p>	<p>Identify relevant corrective actions with 28 days of monitoring event and notify DotE. Data base of Northern Quoll Encounters Locations and habitat recorded in GIS data base</p> <p>Biannual Monitoring report</p> <p>Website Update</p>

Number	KPI	Monitoring	Trigger for Adaptive Management	Management Actions	Reporting
4	In the 10 th year after completion of construction, any detected proportional decreases in the size of the quoll population, decreases in site occupancy, or changes in population vital statistics on the two Mt Emerald monitoring sites are not statistically significantly greater than at the four regional sites over the same period.	Biannually monitor quoll populations (using trail cameras and using mark recapture modelling methods) and site occupancy (using occupancy modelling), and quoll habitat condition (using Biocondition Index) at two sites at Mt Emerald, and at least four regional reference sites (Tinaroo Creek, Davies Creek, upper Walsh River, and Biboorah).	<p>Trap success (i.e. capture rate) and estimated population X % of baseline data collected on Burnett et al (2013).</p> <p>Northern Quoll only recorded in regional sites.</p> <p>No signs of breeding (pouch young or sub adult).</p> <p>No evidence of individuals moving between sub populations.</p> <p>Northern Quoll struck by road vehicle.</p> <p>Evidence of increase in predation from exotic predators</p>	<p>Repeat monitoring at all sites immediately, to rule out sampling errors.</p> <p>If after repeating the monitoring (above) adaptive management is still triggered, review the habitat monitoring data to attempt to identify a possible cause.</p> <p>Review fauna corridor areas – set up trapping lines to determine impacts, observe edge effects and determine factors for decline.</p> <p>Review Bushfire Management Strategies to improve habitat condition if required.</p> <p>Reduce and enforce speed limits in the vicinity of Quoll habitat through the implementation of further signage and penalties.</p> <p>Consult with DotE and DEHP and update Outcomes Strategy where required.</p>	<p>Identify relevant corrective actions with 28 days of monitoring event and notify DotE.</p> <p>Monitoring Reports</p> <p>Data base of Northern Quoll Encounters</p> <p>Locations and habitat recorded in GIS data base</p> <p>Biannual Environmental report</p> <p>Website update</p>

7.0 Record keeping

The approval holder will provide a summary of findings arising from the monitoring data, and any corrective actions implemented annually to DotE.

The approval holder will establish a dedicated webpage that is publicly available for the lifetime of the project. The webpage must include a copy of the raw monitoring data and a descriptive of any corrective action undertaken.

All wildlife spatial data collected during monitoring will be provided to the Queensland Government Wildlife Online database and to the Commonwealth Atlas of Living Australia.

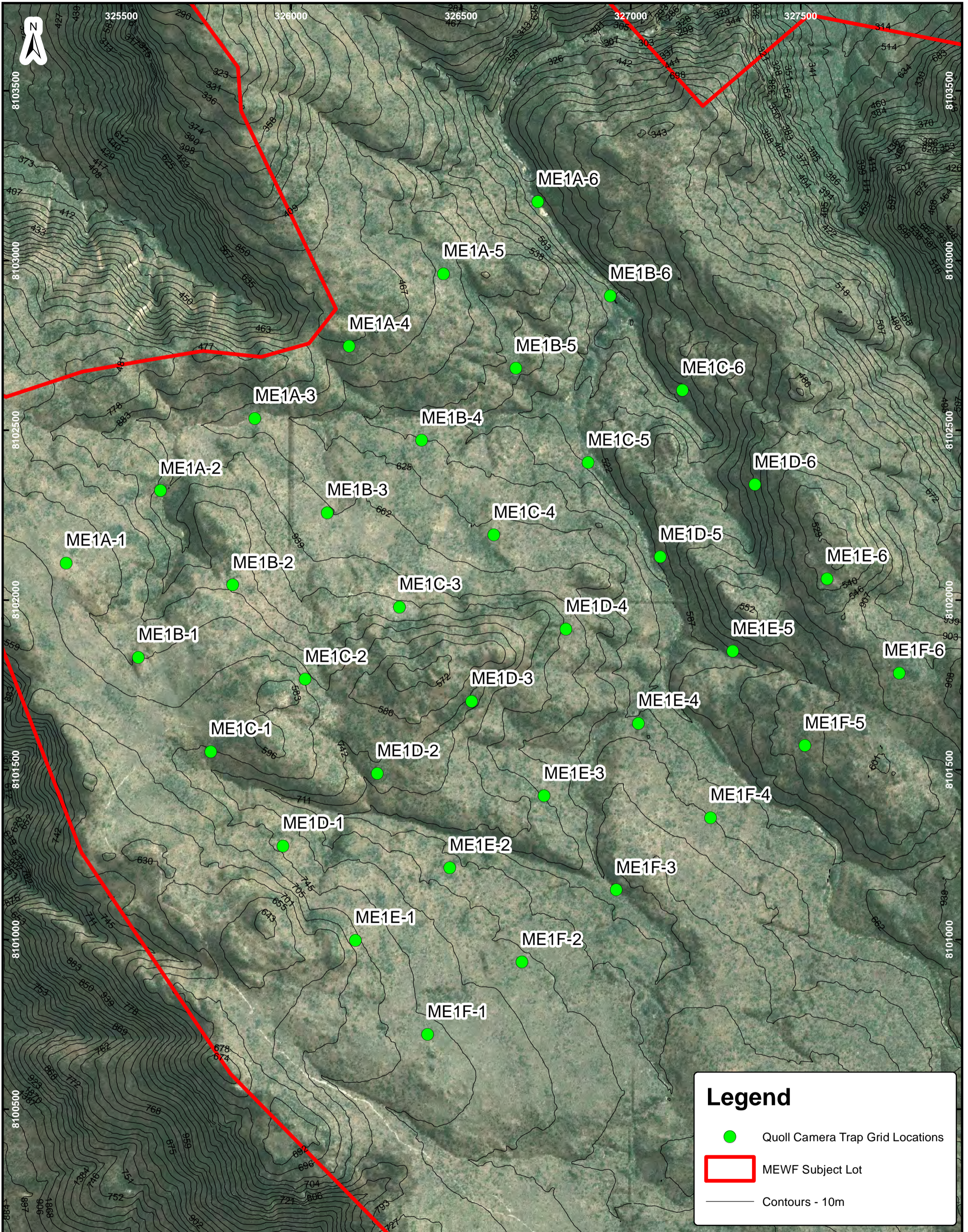
Data arising from research funded by the approval holder will be published in peer reviewed journals during the lifetime of the project.

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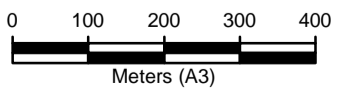
Appendix I

Quoll Camera Trap Grid Locations



Legend

- Quoll Camera Trap Grid Locations
- MEWF Subject Lot
- Contours - 10m



Project Manager M. Jess
Compiled by RMS
Map Projection MGAz55
Map Datum GDA94
File Reference PR130417-16.mxd
Sheet Number 1 of 1

Client Ratch Australia
Title Quoll Camera Trap Grid Locations Mount Emerald Site 1

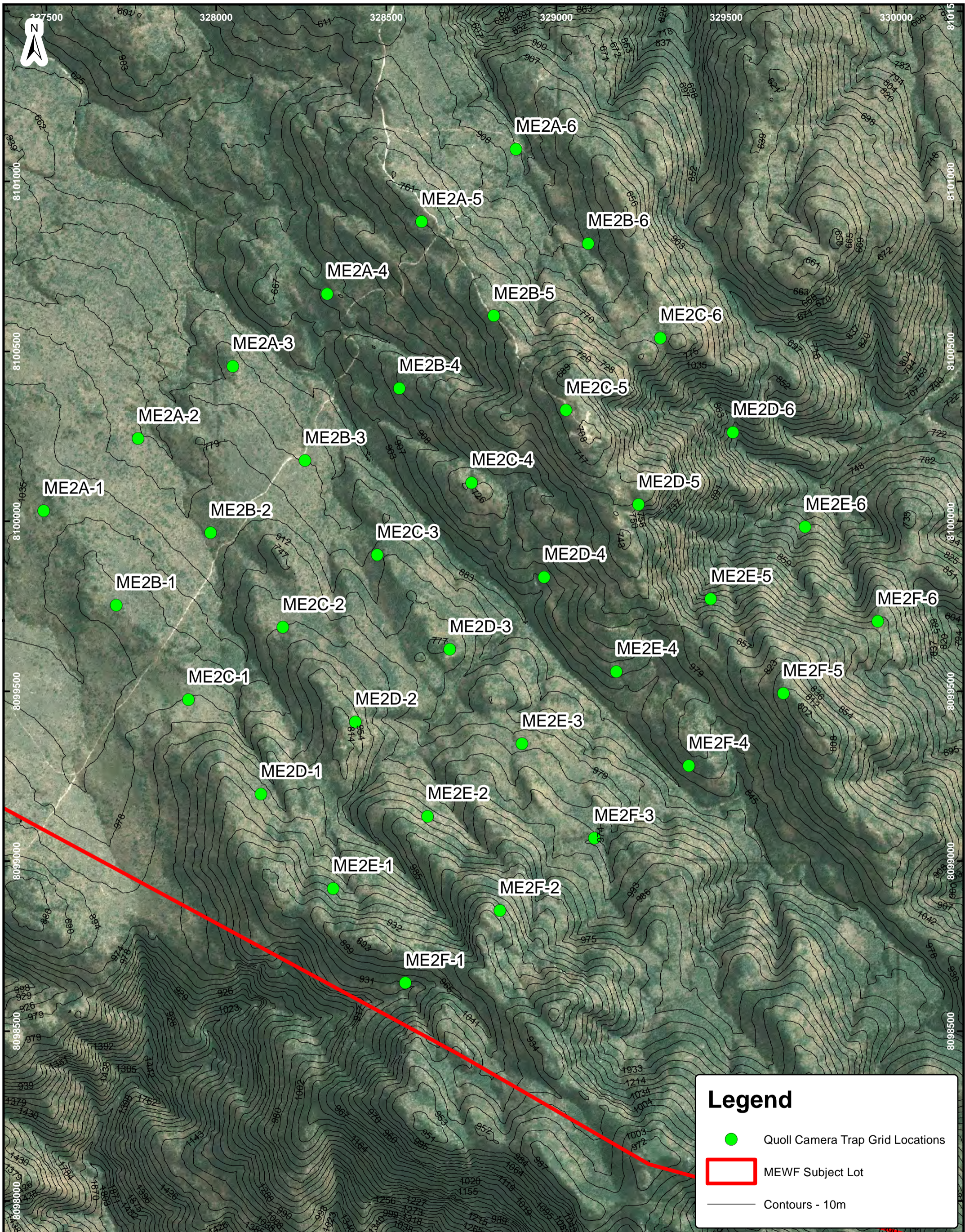
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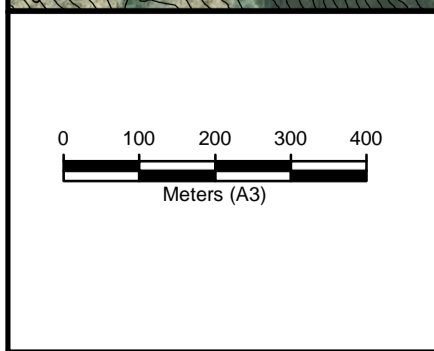
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Legend

- Quoll Camera Trap Grid Locations
- MEWF Subject Lot
- Contours - 10m



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Map Projection MGAz55
Map Datum GDA94
File Reference PR130417-17.mxd
Sheet Number 1 of 1

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Title Quoll Camera Trap Grid Locations Mount Emerald Site 2

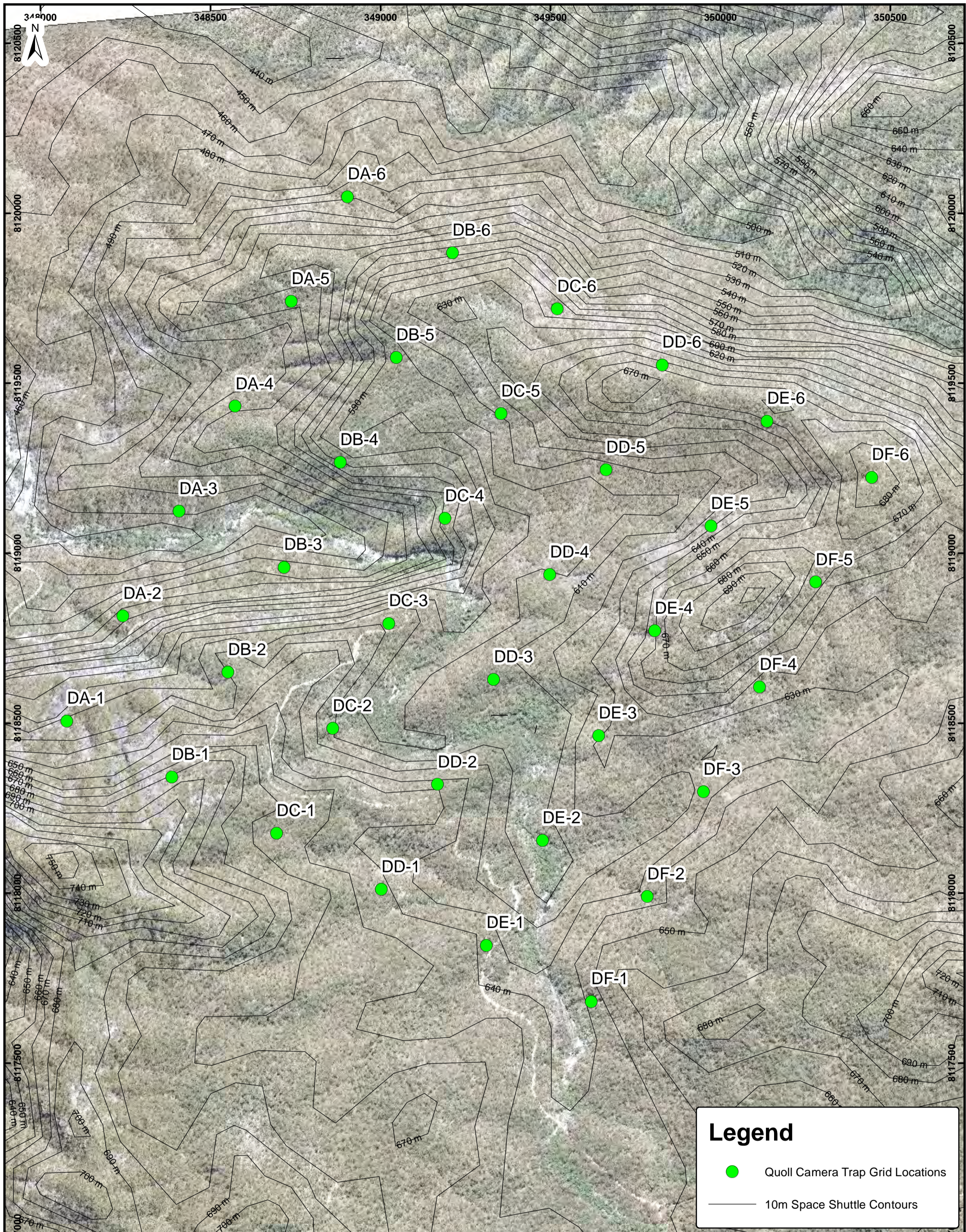
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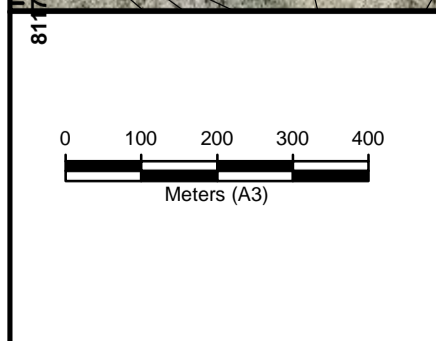
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Legend

- Quoll Camera Trap Grid Locations
- 10m Space Shuttle Contours



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Map Projection MGAz55
Map Datum GDA94
File Reference PR130417-18.mxd
Sheet Number 1 of 1

Client Ratch Australia
Title Quoll Camera Trap Grid Locations Davies Creek Site

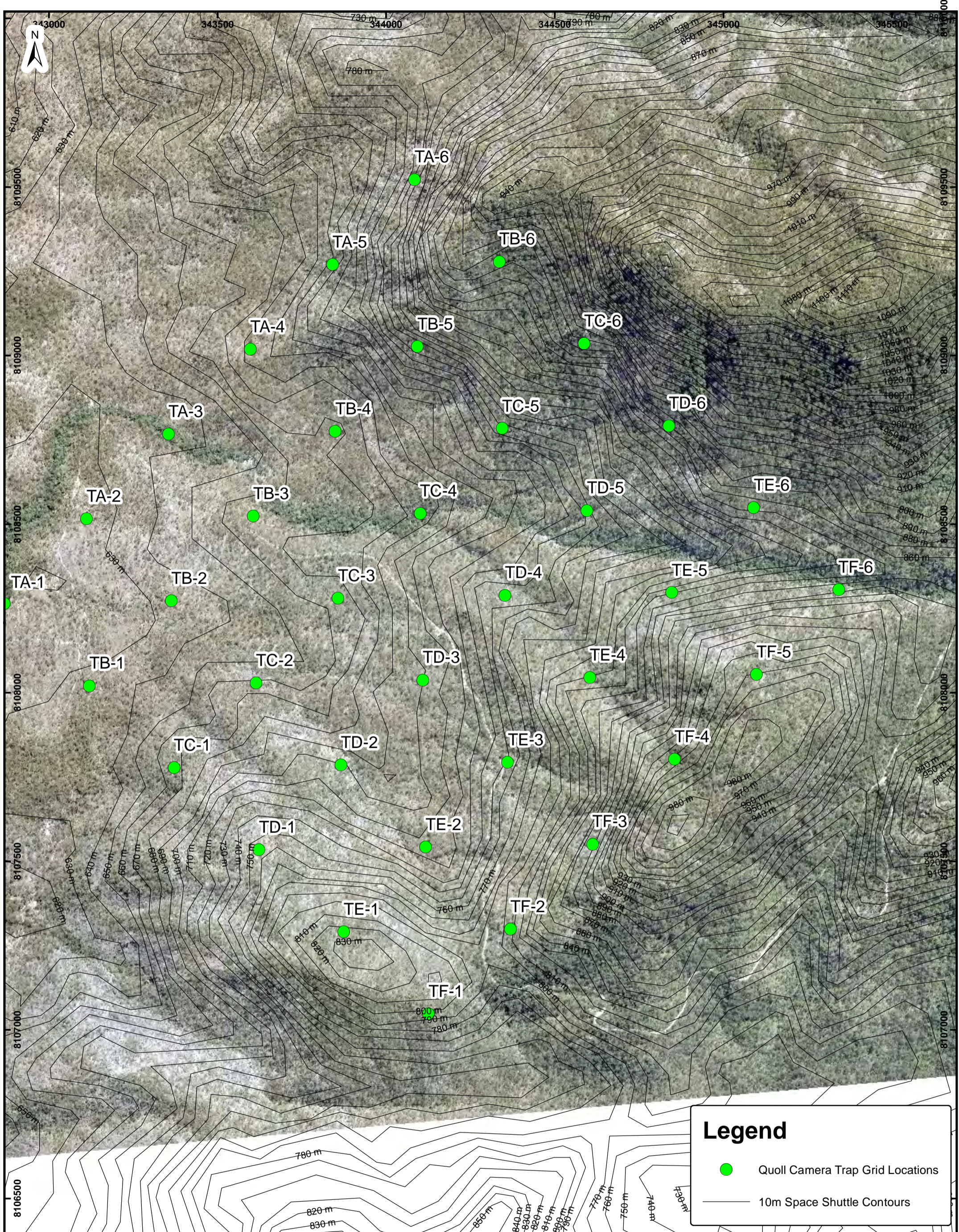
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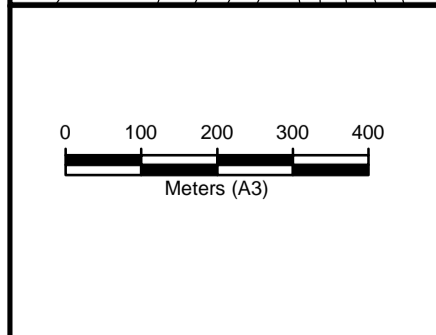
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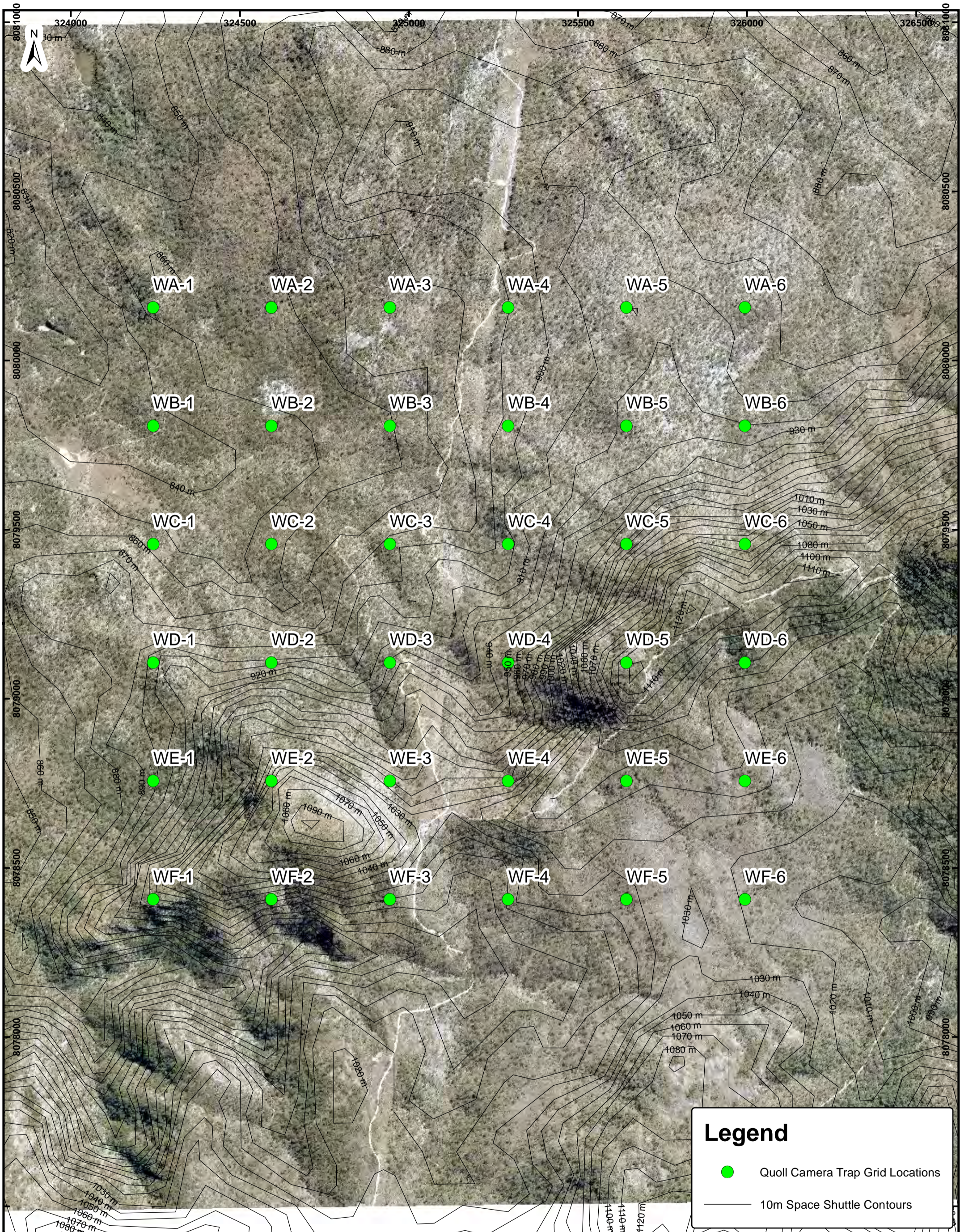
- Quoll Camera Trap Grid Locations
- 10m Space Shuttle Contours



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Map Projection MGAz55
Map Datum GDA94
File Reference PR130417-19.mxd
Sheet Number 1 of 1

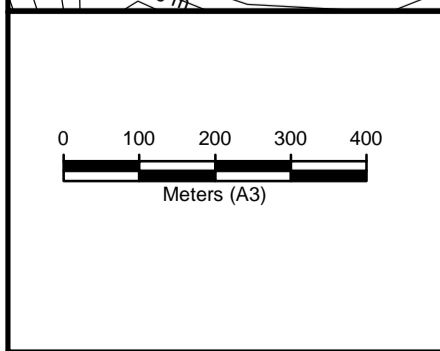
Client Ratch Australia
Title Quoll Camera Trap Grid Locations Tinaroo Creek Site

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Legend

- Quoll Camera Trap Grid Locations
- 10m Space Shuttle Contours



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Map Datum GDA94
File Reference PR130417-20.mxd
Sheet Number 1 of 1

Client Ratch Australia
Title Quoll Camera Trap Grid Locations Upper Walsh River Site

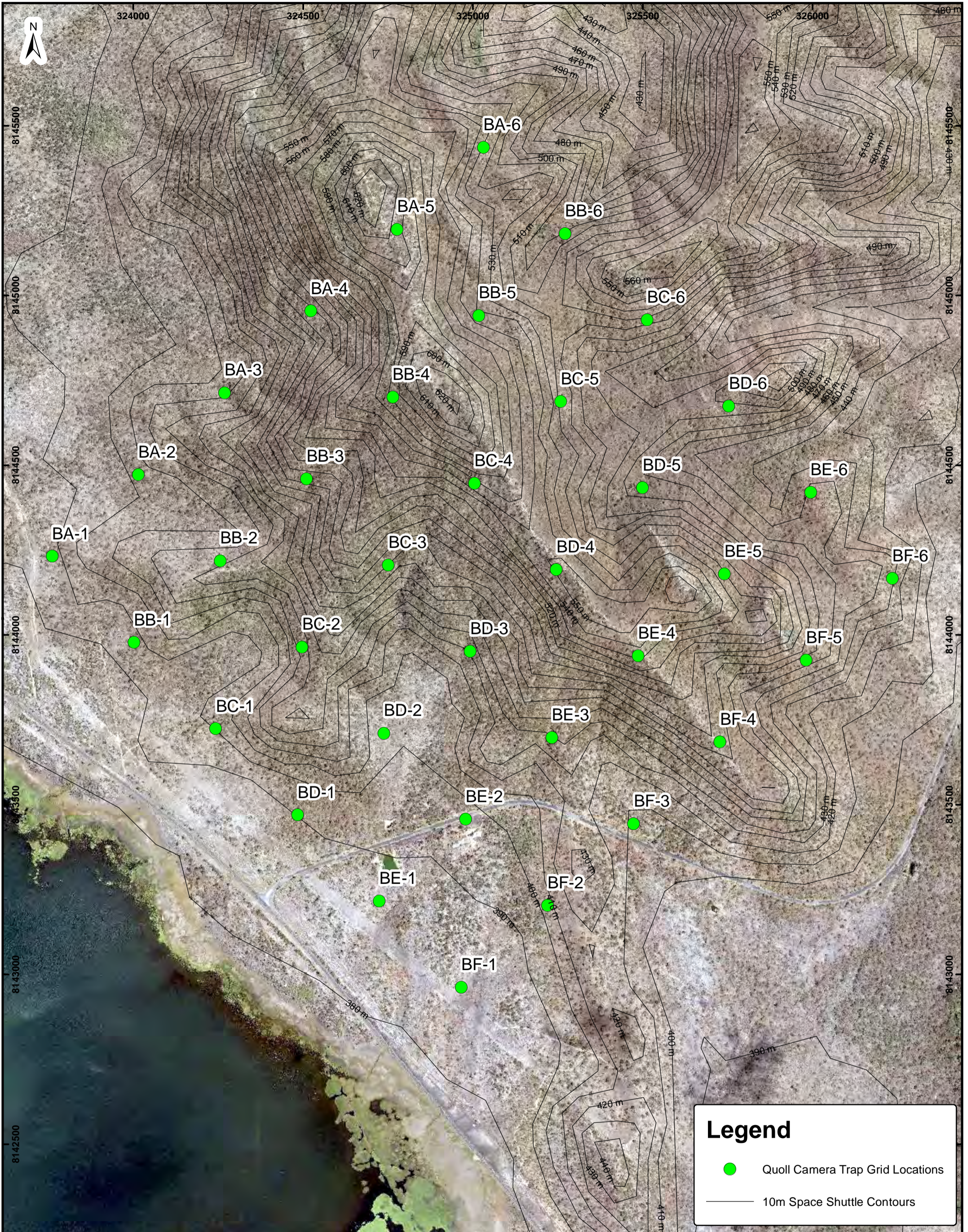
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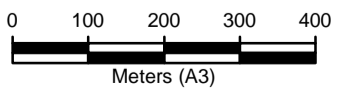
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Legend

- Quoll Camera Trap Grid Locations
- 10m Space Shuttle Contours



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Sheet Number 1 of 1

Client Ratch Australia
Title Quoll Camera Trap Grid Locations Biboorah Site



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