MRC Graphite Pty Ltd

Munglinup

Phytophthora Dieback occurrence assessment – Version 2.0

GLEVAN CONSULTING

Disclaimer

This report has been prepared in accordance with the scope of work agreed between the Client and Glevan Consulting and contains results and recommendations specific to the agreement. Results and recommendations in this report should not be referenced for other projects without the written consent of Glevan Consulting.

Procedures and guidelines stipulated in various Department of Environment and Conservation and Dieback Working Group manuals are applied as the base methodology used by Glevan Consulting in the delivery of the services and products required by this scope of work. These guidelines, along with overarching peer review and quality standards ensure that all results are presented to the highest standard.

Glevan Consulting has assessed areas based on existing evidence presented at the time of assessment. The Phytophthora pathogen may exist in the soil as incipient disease. Methods have been devised and utilised that compensate for this phenomenon; however, very new centres of infestation, that do not present any visible evidence, may remain undetected during the assessment.

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Note on version numbering:

0.1 – 0.∞	*Internal documents*
1.0 – 1.∞	*First draft and iterations to Client.*
2.0	*Final document.*

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1 Summary

Glevan Consulting conducted an assessment of the vegetation associated with the Munglinup Graphite Project for the presence of Phytophthora Dieback. The study area covered 247.5 ha and was comprised of the drilling project area and the tracks used to access the drilling project area. Any historical drill lines that were still trafficable were also assessed. The study area was assessed primarily using the linear survey method, which involved assessing a 25m wide strip of vegetation on either side of the track / drill line.

The sections of Tenement M74/245 located outside of the actual field assessment area (areas inaccessible by vehicle) were assessed at a desktop level and have been determined to be uninterpretable. This classification was extrapolated using the visual evidence that could be observed from nearby tracks and vegetation mapping for the area.

The assessment was conducted from the 18-04-2018 to 19-04-2018 by Simon Robinson and no records or evidence of previous Phytophthora Dieback assessments were found for the area.

No Phytophthora Dieback infestations were observed within the project area. The majority (228 ha) of the study area, including the entire drill program area, was observed to be uninterpretable due to the presence of vegetation types containing an insufficient coverage of reliable indicator species.

A total of nine soil and tissue samples were taken during the assessment. All samples taken within the study area returned a negative result for the presence of *Phytophthora cinnamomi*. A control sample was taken at an obvious infestation outside the study area which produced a positive result.

While the study area has sufficient rainfall, suitable soil temperatures, and contains areas with susceptible vegetation, there is a distinct lack of sites where there are both susceptible vegetation types and high soil moisture (water-gaining sites) present. Without this combination of factors, there is a very low likelihood of disease occurrence within the study area.

The Phytophthora Dieback occurrence mapping provided in this report is valid for 12 months and will expire in April 2019.

2 Introduction

2.1 Background

Glevan Consulting was commissioned by MRC Graphite to conduct an assessment of the vegetation associated with the Munglinup Graphite Project for the presence of Phytophthora Dieback. The assessment is required to determine the dieback status of the drill lines and the access tracks that will be used during the program, which will assist in the development of any hygiene management that may be required.

2.2 Location of Study Area.

The study area is located within Tenement M74/245, approximately 2.5 km north of the town of Munglinup, and is comprised of the current drill program project footprint and any historical drill lines that are still trafficable. Mills Road and the project area access track were also assessed.

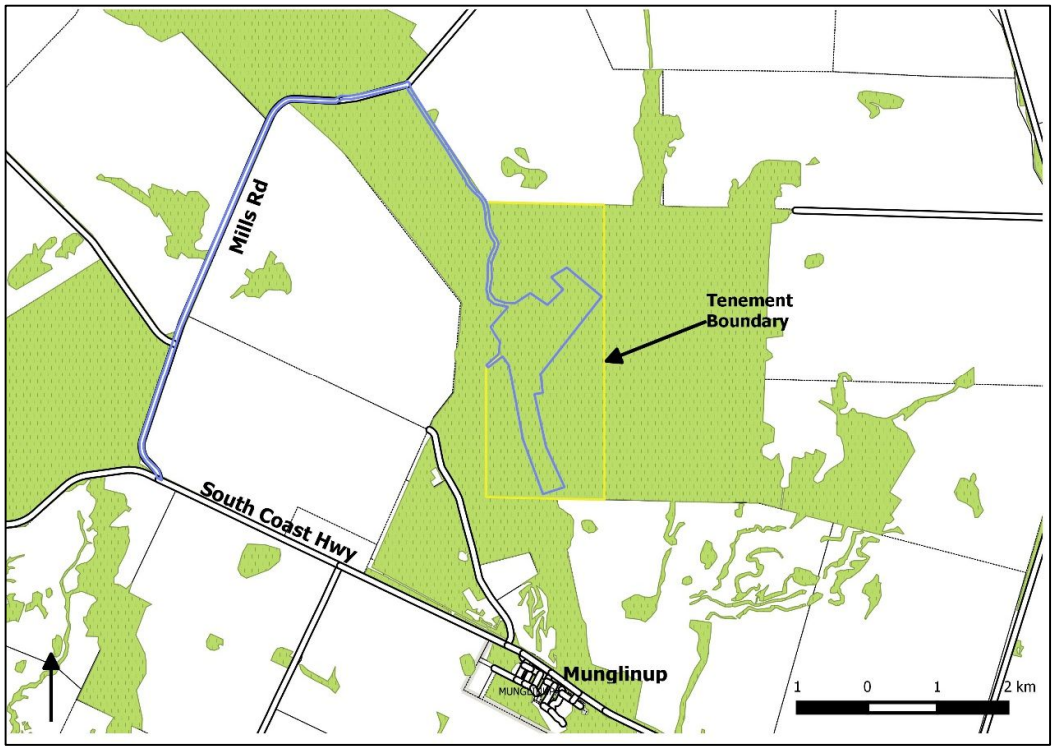


Figure 1 - Study Area (Blue boundary)

2.3 Study team

The assessment was conducted by Simon Robinson of Glevan Consulting on April 18th and 19th 2018. Mr Robinson (Interpreter Registration No: DPW-PDI-016) is accredited by the Department of Biodiversity, Conservation and Attractions (DBCA) in the detection, diagnosis and mapping of the Dieback disease. This accreditation recognises the skills and experience of Mr Robinson.

3 Phytophthora Dieback

The pathogen *Phytophthora cinnamomi* is an agent of environmental disease found in vulnerable areas of Western Australia. Phytophthora Dieback is the common name for the observable disease result of interaction between the pathogen (*P. cinnamomi*) and the vegetation hosts (susceptible plant species within vulnerable areas).

The environmental conditions of the site significantly affect the pathogens ability to survive or flourish and spread over time. All land with an annual average rainfall of more than 400 millimetres and suitable soil composition is considered vulnerable to Phytophthora Dieback. This large area stretches approximately from Perth, Bunbury and Augusta in the west to Narrogin, Ravensthorpe and Esperance in the east, and as far north as Kalbarri.

This vulnerable area has many different bioregions, having specific characteristics formed by climate and geology. These two factors are highly significant in determining the pathogen's effectiveness and resulting disease impact levels.

Other *Phytophthora* species responsible for vegetation decline are also regularly encountered during Phytophthora Dieback assessments. Two species frequently recovered in soil and tissue samples taken in south west W.A are *P. multivora* and *P. arenaria*.

It is not known whether *P. multivora* is indigenous or introduced. It is however widespread on the coastal plain sands and has been associated with the deaths of several different native plant species. This pathogen is also typically much less virulent and destructive than *P. cinnamomi* in the natural environment. The study area is not considered to be a favourable environment for *P. multivora* and its presence is highly unlikely. The nearest recorded recovery of *P. multivora* to the study area was on Hammersley Drive, west of Hopetoun, approximately 85 km away.

Phytophthora arenaria has not been reported outside of Western Australia and has only been recovered in native vegetation, suggesting it may be an indigenous species. Where the pathogen is active, symptomatic plants are scattered in the landscape. The overall impact within the natural environment is low due to the relatively low rainfall in the region and the sporadic nature of the disease. Phytophthora arenaria has not been recovered in close proximity to the study area.

3.1 The Pathogen

Phytophthora cinnamomi is a microscopic water mould. It belongs to the class Oomycetes and belongs in the Kingdom Stramenopila. It is more closely related to brown algae than to true fungi. Oomycetes organisms occupy both saprophytic and pathogenic lifestyles however *P. cinnamomi* is considered parasitic. It behaves largely as a necrotrophic pathogen causing damage to the host plant's root tissues because of infection and invasion.

The life cycle of *Phytophthora cinnamomi* is a continuous circle of infection, sporulation and further infection and is readily vectored by animals and human activity allowing for rapid invasion into new areas.

3.2 Host

A population of hosts is made up of susceptible, infected and immune or resistant individuals. The infection of host plants is an unseen activity happening constantly beneath the soil at an infested site.

The environmental conditions favouring or disfavouring the pathogen may change at a critical point during disease development, temporarily changing the rates of infection and invasion. This can be observed symptomatically after soil temperature change through winter months.

The plant host is a highly variable component of the disease development. Sites may range from having no susceptible host, to containing vegetation that is almost entirely susceptible. Within vulnerable areas, three main family groups are regarded as highly susceptible to Phytophthora Dieback disease, being:

- Proteaceae
- Ericaceae
- Xanthorrhoeaceae.

3.3 Environment

Two fundamental environmental characteristics influencing Phytophthora Dieback disease are rainfall and soil. Areas vulnerable to Phytophthora Dieback are defined as native

vegetation occurring west of the 400 millimetre rainfall isohyet. The correlation of increased Phytophthora Dieback impact with increased annual rainfall is generally applicable.

Certain soil properties influence Phytophthora Dieback disease development within the vulnerable areas:

1. Moisture is critical for *Phytophthora cinnamomi* to survive in the soil and for sporangia production.
2. Soil pH affects the growth and reproduction of the pathogen. The calcareous sands closest to the coast are alkaline and hostile to *Phytophthora cinnamomi,* but are favourable to *P. multivora.*
3. Fertile soils are less favourable to Phytophthora Dieback because the richness of nutrients aids strong host resistance, good soil structure allows water movement and drainage, and high organic matter provides antagonistic microflora.
4. Coarse-textured soils have larger pore spaces which favour dispersal of spores.
5. The optimum temperature for *Phytophthora cinnamomi* sporulation is 21 to 30°C, peaking at 25°C., but some sporangia can still be produced at temperatures as low as 12°C. The optimum growth range is 15 to 30°C and temperatures lower than 5°C or greater than 35°C are unfavourable for the persistence of survival of spores and the vegetative mycelia of *P. cinnamomi.*

4 Methods

4.1 Pre survey desktop study

Known databases of *Phytophthora* (all species) locations retained by Glevan Consulting and Vegetation Health Services (DBCA) were searched to determine previous recoveries of *Phytophthora* within the project area.

4.2 Interpretation

All interpretation work was undertaken in accordance with FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the department (DPaW, 2015). The personnel involved in the field work determined the presence of Phytophthora Dieback based on symptoms and disease signatures displayed in susceptible vegetation. These symptoms are supported through the strategic sampling and subsequent recovery of Phytophthora from soil and tissue samples taken during the assessment.

The detection of the plant pathogen Phytophthora Dieback involves the observation and interpretation of plant deaths (or reduction of biomass or perceived temporal change in vegetation structure) using a logical assessment of factors that imply pathogen presence above other possible causes of plant deaths or vegetation change. A combination of the following factors may indicate the presence of disease caused by *Phytophthora* Dieback or other *Phytophthora* species.

Deaths of disease indicating species:

An indicator species is a plant species, which is reliably susceptible to Phytophthora Dieback (i.e. will die). Common indicators include several species of *Banksia, Patersonia*, *Persoonia* and *Xanthorrhoea*. The distribution and composition of indicator species will vary from place to place according to vegetation types.

Chronology of deaths:

As the pathogen spreads through an area, some or all susceptible plants become infected and die. Consequently, there will be an age range from more recent deaths with yellowing or brown leaves through to older leafless stags to remnant stumps in the ground.

Pattern of deaths:

The topography, soil type, vegetation type and drainage characteristics of an area together with the influence of climatic patterns and disturbances will influence the shape or pattern of an infested area over time. A typical recent infestation may show a small cluster of dead indicator species which, in time, will spread to become a small circular shape 'the ulcer effect' and then begin lengthening towards natural drainage channels. A fringe of recent deaths is often seen around the edge of the infested area. Patterns may be further highlighted by a paucity of ground cover within the infested area.

Other causes of indicator species death:

Phytophthora cinnamomi is not the only agent to cause death of native vegetation. Other agents include, but are not limited to:

- other *Phytophthora* spp, *Armillaria luteobubalina*, various cankers, insects;
- drought, wind scorch, frost, salinity, water logging, fire and lightning;
- senescence, competition, physical damage;
- herbicides, chemical spills (for example fuel).

Based on the field assessment, the Project Area can be distributed to the following occurrence categories.

Table 1 - Phytophthora Dieback occurrence categories

Vegetated area	Infested	Areas that have plant disease symptoms consistent with the presence of Phytophthora Dieback
	Uninfested	Areas free of plant disease symptoms that indicate the presence of Phytophthora Dieback.
	Uninterpretable	Areas where indicator plants are absent or too few to determine the presence or absence of Phytophthora Dieback.
	Temporarily uninterpretable	Areas that are sufficiently disturbed so that Phytophthora Dieback occurrence mapping is not possible at the time of inspection.
	Not yet resolved	Areas where the interpretation process has not confidently determined the status of the vegetation.
Non-vegetated area	Excluded	Areas devoid of vegetation are excluded from the assessment area.

4.3 Demarcation of hygiene boundaries

No demarcation was required during the assessment.

4.4 Soil and tissue sampling

Suspicious sites had a representative soil and tissue sample taken to assist with the interpretation process. The laboratory result can confirm the presence of the *P. cinnamomi* pathogen. A negative result does not necessarily prove that the pathogen isn't present at the site and should be supported by the field interpretation.

Sampling was conducted using the following procedure:

- All digging implements used were thoroughly sterilised prior to use with methylated spirits. The implements were then allowed to dry so that the integrity of the sample was not compromised.
- The area around the base of the plant/s to be sampled was cleared of vegetative matter to aid the digging process.
- The plant was dug to a satisfactory depth so that the tissue with the highest moisture content was obtained.
- Sections of the roots and stem base from all sides of the plant were taken and placed in a plastic bag. If any lesion was noticed on the tissue, it was also placed in the bag. A few handfuls of sand from various depths were also deposited in the plastic bag.
- The sample bags were irrigated with distilled water to try and simulate the optimum conditions for the *Phytophthora* to survive.
- Details, such as the date, sample number and interpreters were written on an aluminium tag, which was left at the site. The tag was demarcated with a strip of day-glow orange flagging tape.
- All digging implements used were again sterilised after each sample was taken to ensure that infected soil was not transported to the next sample site.

4.5 Soil and tissue sampling strategies

Soil and tissue samples were taken where there was decline featuring either multiple indicator species deaths (ISD's) or notable chronology present. Samples were also taken where there was a single, but very recent ISD present. This strategy assists in identifying any infestations that have been largely inactive but have recently begun expressing due to significant summer rainfall events. It also assists in identifying sites where the pathogen has been very recently introduced and where the other evidence used to confirm the presence of Phytophthora Dieback is absent.

4.6 Mapping

Subsequent to hygiene boundary demarcation, the boundaries were again walked and recorded utilising a handheld GPS. The recorded data was then transferred to a desktop computer and used to produce the relevant maps.

4.7 Limitations of disease mapping

The assessment for the disease caused by Phytophthora Dieback is based on interpreting the vegetation for symptoms which can be ascribed to the disease presence. These observable factors must be present during the assessment period. Management recommendations may be included if it is considered that the disease may be cryptic, or the project area displays evidence of activities that are considered a high risk of introducing the disease.

The validity of the occurrence mapping for this project is twelve months from the completion of this survey. All boundaries should be reassessed by 04/2019 if construction activities are still occurring beyond this time.

5 Project area environmental data

5.1 Rainfall

Climate statistics retained by the Bureau of Meteorology (BOM, 2018) since 2002 for the nearby Munglinup West weather station, indicate an average annual rainfall of 473 mm. In terms of rainfall, the study area is in the vulnerable zone, but in the 400mm to 600mm range, where the disease is generally restricted to water-gaining parts of the landscape. Water-gaining areas are typically the lowest parts of the landscape and include creeks, rivers and wetlands. The study area does however experience occasional significant summer rainfall events, which would increase the likelihood of the disease establishing outside of water-gaining areas.

5.2 Soil types

The chief soils within the study area are hard alkaline and neutral yellow mottled soils which may contain ironstone gravel. The north eastern part of the study area contains ironstone gravels with shallow leached sands, below which layers of boulder laterite or large amounts of ironstone gravel occur. Average soil temperatures above 20 degrees Celsius are favourable for sporulation and such conditions would occur within the study area during several months of the year.

5.3 Vegetation structure

The study area is dominated by Mallee shrubland and *Eucalyptus* woodland, with occasional Proteaceous shrubland observed. The mallee shrubland typically features a low overstorey of mallees over a dense understorey of shrubs dominated by *Acacia* and *Melaleuca* species. The *Eucalyptus* woodland features an overstorey of *Eucalyptus* trees, with a relatively sparse understorey of *Acacia* and *Melaleuca* shrubs, with occasional thickets. The Proteaceous shrubland is characterised be scattered mallees over a relatively dense, proteaceous understorey.

While the study area has sufficient rainfall, suitable soil temperatures, and contains areas with susceptible vegetation, there is a distinct lack of sites where there are both susceptible vegetation types and high soil moisture (water-gaining sites) present. Without this combination of factors, there is a very low likelihood of disease occurrence within the study area.

6 Results

6.1 Phytophthora Dieback occurrence distribution

No Phytophthora Dieback infestations were identified within the study area. A total of 19.5 ha was observed to be uninfested, while the remaining 228 ha was mapped as uninterpretable due to an insufficient coverage of reliable indicator species (Table 2). The only uninfested sections observed occurred on the roads and tracks used to access the project area (see Occurrence Map).

Table 2 - Area Summary

Category	Area (ha)	% of total area
Infested (with *P. cinnamomi*)	0	0
Uninterpretable	228	92
Uninfested	19.5	8
TOTAL AREA	247.5	100

The sections of Tenement M74/245 located outside of the actual field assessment area (areas inaccessible by vehicle) were assessed at a desktop level and have been determined to be uninterpretable (Appendix 11). This classification was extrapolated using the visual evidence that could be observed from nearby tracks and vegetation mapping for the area. This area will be further assessed during the second field assessment, scheduled to occur in July, at which time the uninterpretable status will be verified.

A desktop review of Phytophthora Dieback occurrence in the Ravensthorpe / Esperance area indicates the pathogen has been identified at several sites throughout the area (see appendix 12). There are a significant number of known infestations associated with roadside vegetation throughout the area. The vegetation associated with the infestations appears to be Proteaceae and Ericaceae rich shrubland and Banksia woodland, generally south of the South Coast Hwy.

In terms of sites in the vicinity of Munglinup, there are several areas that are not currently mapped as infested that appear to be infested. Several sections of vegetation exhibiting decline consistent with the presence of Phytophthora Dieback were observed adjacent to the South Coast Hwy, particularly in lower parts of the landscape. The low-lying area adjacent to

Munglinup Golf Course on Reynolds Road is also heavily infested, as is the creekline further north on Reynolds Road. Springdale Road to the south of Munglinup is also heavily infested, with at least 25 km of the road mapped as infested.

6.2 Disease expression

No evidence of Phytophthora Dieback disease presence was observed within the study area.

6.3 Soil and tissue samples

A total of nine soil and tissue samples were taken during the assessment. All of the samples returned a negative result for the presence of *P. cinnamomi,* with the exception of sample 4, which was taken outside the study area as a control sample. No records of previous Phytophthora recoveries were found for the project area.

Table 3 – Project Area Sample Summary

Sample	Plant sampled	Easting	Northing	Result
1	***Jacksonia furcellata***	**300942**	**6272854**	***Negative***
2	***Synaphea sp.***	**301630**	**6272966**	***Negative***
3	***Leucopogon sp.***	**301705**	**6271860**	***Negative***
4	***Xanthorrhoea platyphylla***	**301365**	**6269018**	***Positive***
5	***Banksia sp.***	**300530**	**3275916**	***Negative***
6	***Synaphea sp.***	**301198**	**6273826**	***Negative***
7	***Leucopogon sp.***	**301785**	**6271305**	***Negative***
8	***Banksia sp.***	**300915**	**6275360**	***Negative***
9	***Banksia sp.***	**297600**	**6275750**	***Negative***

7 Discussion

7.1 Phytophthora Dieback occurrence distribution

The absence of sufficient indicator species encountered throughout much of the assessment was due primarily to the presence of vegetation types that are naturally void of the species used to detect the presence of Phytophthora Dieback. The sections of mallee shrubland and *Eucalyptus* woodland were almost entirely void of reliable indicator species with only small, scattered areas containing indicator species.

While the majority of the study area is uninterpretable, the absence of susceptible vegetation types coinciding with water-gaining sites, means there is a low likelihood of the disease being present, and that the entire uninterpretable area is most likely uninfested. In fact, it is also highly probable that Tenement M74/245 is uninfested in its entirety.

The Munglinup River, which intersects the south west portion of the tenement is the most likely source of infestation, however, due to the vegetation types associated with the river, it is not possible to determine the disease status. Two samples were taken immediately adjacent to the river, both of which returned negative results.

The boundary between the uninfested and uninterpretable areas was not demarcated, as it is thought that no hygiene points are required. This is based on operations being conducted under dry soil conditions. Should there be a requirement for vehicle and machinery movement to occur during wet conditions, then it is recommended to implement clean-down points on the boundary between the uninfested and uninterpretable areas. This only applies to the current project area access track, not Mills Road, which is a public access road and does require hygiene management.

7.2 Disease expression

The Infestation associated with sample 4 (control sample) and another infested site to the north, exhibited evidence of significant levels of recent disease activity. This indicates that conditions are currently very favourable for the disease, and where the disease is present in susceptible vegetation, it should be readily detected.

There were a significant number of areas throughout the study area in which vegetation decline was observed. None of that decline however was consistent with the presence of Phytophthora Dieback. Deaths were scattered and random, lacked chronology and were generally confined to a single species.

3

8 Recommendations

- Ensure all vehicles and machinery are clean upon arrival to site. This is particularly important for vehicles/machinery that have been working in other areas where dieback management may not be in place.

- Soil movement from uninterpretable areas into uninfested areas is to be prevented. In wet conditions where soil adheres to vehicles and machinery, cleandown will be required when entering uninfested areas from an uninterpretable area.

- For operations undertaken during wet conditions, inspection/hygiene points, including washdown equipment will be required at the boundary between uninfested and uninterpretable areas. Vehicles should be inspected and washed down if necessary before entering uninfested areas from uninterpretable areas. Inspection/washdown is not required when entering uninterpretable areas from uninfested areas. A Hygiene Management Plan would assist in identifying and outlining the necessary hygiene requirements.

- Conduct operations under dry soil conditions. Where activities occur under dry soil conditions and soil does not adhere to vehicles and machinery, they may move from uninterpretable areas into uninfested areas without performing a cleandown.

- Operational areas that are located within uninfested areas are required to be assessed every 12 months. Phytophthora Dieback occurrence information expires 12 months after the assessment completion date in operational areas and is no longer valid after this period. No further assessments are required for uninterpretable areas, as the status of these areas will not change.

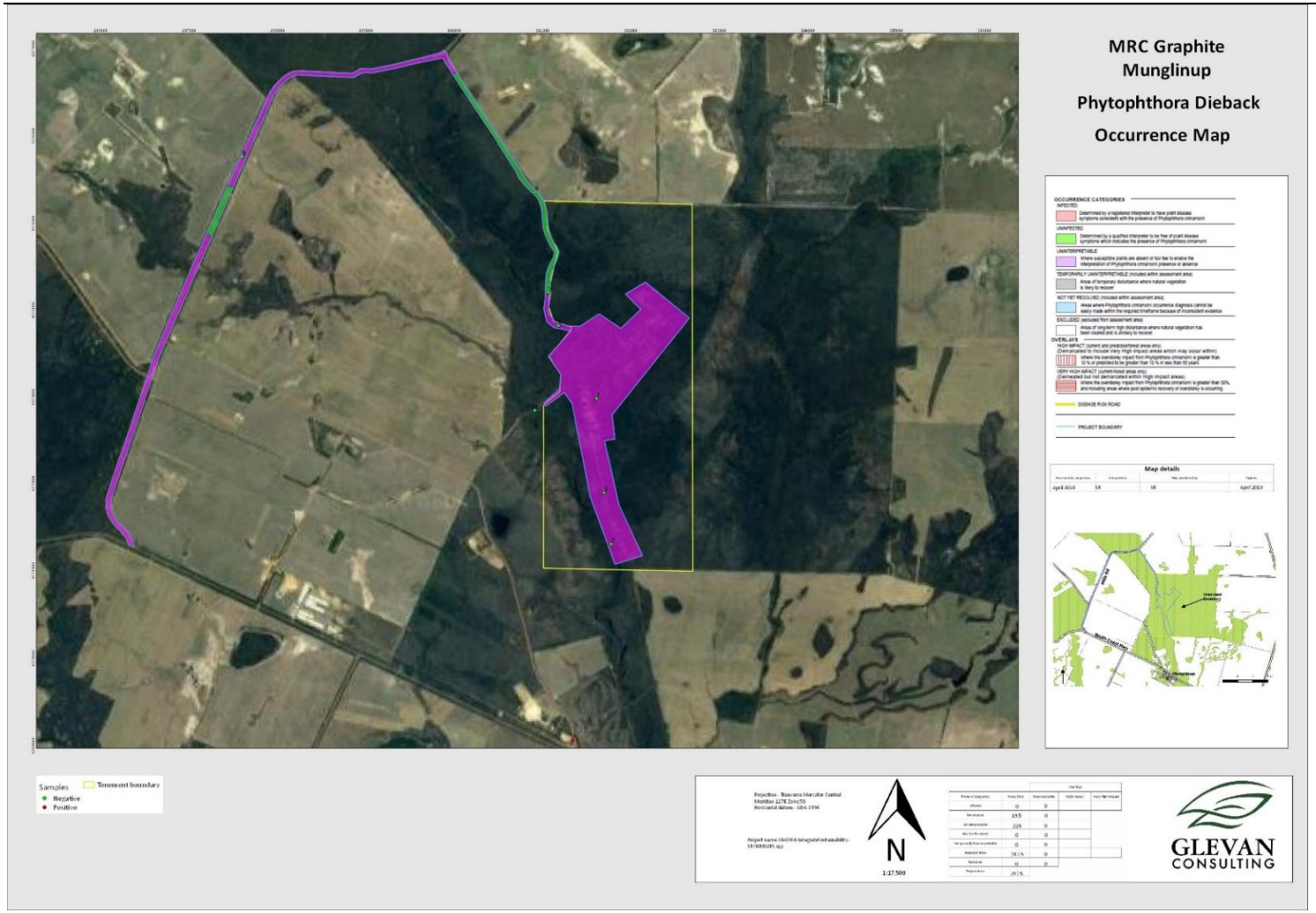
9 Bibliography

Bureau of Meteorology, Climate Statistics for Australian Locations. Available from: http://www.bom.gov.au/climate/averages/tables/cw_012044.shtml [15 May 2018].

Department of Parks and Wildlife. (2015). *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the department.* Unpublished.

Project Dieback, DIDMS. Available from: https://didms.gaiaresources.com.au/data/editor/viewdata/[30 May 2018].

10 Appendix – Phytophthora occurrence map



11 Appendix – Extrapolated Phytophthora Occurrence For Area Not Included in Field Assessment

12 Appendix – Known Phytophthora occurrence Ravensthorpe to Esperance

Please note: This map only contains the infested areas that have been mapped and submitted to the Dieback Information Delivery Management System (DIDMS) and does not depict the full extent of Phytophthora Dieback infestation within the area.