TIWEST JV

Cooljarloo West
Cooljarloo North West
Cooljarloo South West
2012 Drill Program

Phytophthora cinnamomi occurrence assessment

Final

Report compiled by Evan Brown of Glevan Consulting

GLEVAN
CONSULTING

Disclaimer

This report has been prepared in accordance with the scope of work agreed between Tiwest JV and Glevan Consulting and may contain 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 by dieback assessors.

The entire evidence record dataset, which is a part of every assessment, is not presented as part of this report, but can be delivered on request.

Glevan Consulting applies buffer widths according to Department of Environment and Conservation Guidelines. Allowances in buffer widths are <u>not</u> made for extraordinary rates of spread caused by unpredictable significant spring, summer or autumn rain events. All buffers should be rechecked immediately prior to soil moving operations if a rain event of this nature has occurred within the assessment area.

Version Control

Document ID	Author	Date	Comments
A	EB	04/2012	
B	EB	04/2012	Included CW comments
Final	EB	07/2012	

Table of Contents

Background ***5***

Introduction ***7***

Phytophthora species present in the study area **8**

Previous assessments **11**

Occurrence and Risk assessment **12**

Method ***14***

Results ***17***

Discussion ***19***

Recommendations ***21***

Bibliography ***22***

Appendix 1 – Maps. ***24***

List of Figures

Figure 1 - Disease triangle....5

Figure 2 - Disease pyramid....6

Figure 3 - Location of CNW, CLW and CSW (relative to Cooljarloo)....7

Figure 4- CSW Occurrence Map....24

Figure 5 - CNW Occurrence Map....25

Figure 6 - CLW Occurrence Map....26

List of Tables

Table 1 - Phytophthora Dieback Occurrence Categories....12

Table 2 - Hygiene matrix....13

Table 3 - CNW Sample results....17

Table 4 - CNW Drill line summary 17
Table 5 – CLW Sample locations and results 18

BACKGROUND

Phytophthora Dieback is the name generally used in Western Australia to describe the disease symptoms of, and the causal agent, *Phytophthora cinnamomi*. This introduced soil-borne pathogen is a major threat to Australia's, and by implication, the vegetation and dependent biota within Tiwest's exploration areas. This disease is listed as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999, with a subsequent threat abatement plan introduced in 2001 (Environment Australia, 2001)

It is generally believed that *Phytophthora Dieback* was introduced to Australia during the early European settlement. From 1921 patches of healthy jarrah forest were observed to be dying, with Frank Podger and George Zentmyer establishing in 1964 that *Phytophthora Dieback* was the causal agent for the forest decline (DWG, 2011).

The impact of the disease on the vegetation is dependent on climatic conditions along with host plant species and suitable soils (Keane & Kerr, 1997). This relationship shown in Figure 1 describes all aspects required to create the disease.

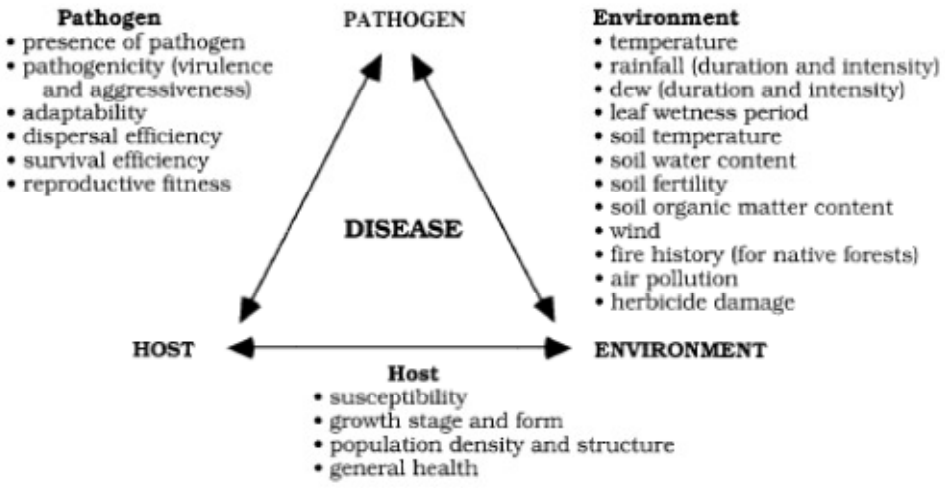

Figure 1 - Disease triangle

This relationship is also described in Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia Part 2 - National Best Practice Guidelines /

Appendix 3 as the disease pyramid (O'Gara, Howard, Wilson, & Hardy, 2005). This figure includes the additional element of time to demonstrate the progressive impact of the disease on susceptible vegetation.

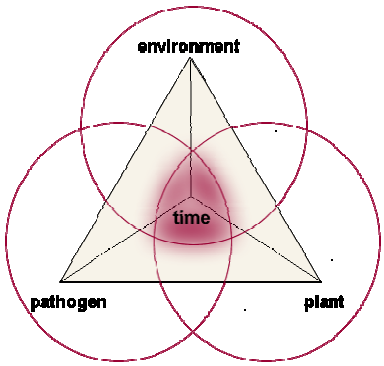

Figure 2 - Disease pyramid

It is recognised that *Phytophthora Dieback* has a greater and more widespread impact in areas of Western Australia where the average annual rainfall exceeds 600mm and the soil structure has a more acidic composition (Hardy, Colquhoun, Shearer, & Tommerup, 2001). The impact of the disease can be significant (but less widespread) in areas of lower rainfall if there are extra-ordinary rainfall events, or the pathogen is situated in a rainfall aggregating site, e.g. creek lines, water shedding from granite outcrops.

The impact of the pathogen in losses to the Australian economy is estimated to be between $160 million (Carter, 2004) and $200 million annually (EPA, 2011).

The impact of the disease on animals is less understood, however the greatest impact is likely to be to those species that require relatively dense species-rich shrub lands or have restricted diets. There is a growing body of evidence that the dramatic impact of *Phytophthora Dieback* infestations on plant communities can result in major declines in some animal species due to the loss of shelter or food sources.

INTRODUCTION

Glevan Consulting was commissioned by Tiwest JV to conduct an assessment along drill lines and access tracks associated with the 2012 exploration drilling program. The project area is defined by the Cooljarloo North West (CNW), Cooljarloo West (CLW) and Cooljarloo South West (CSW) exploration areas and shown in the following Figure 3 as the three exploration leases areas in close proximity to the Cooljarloo mine.

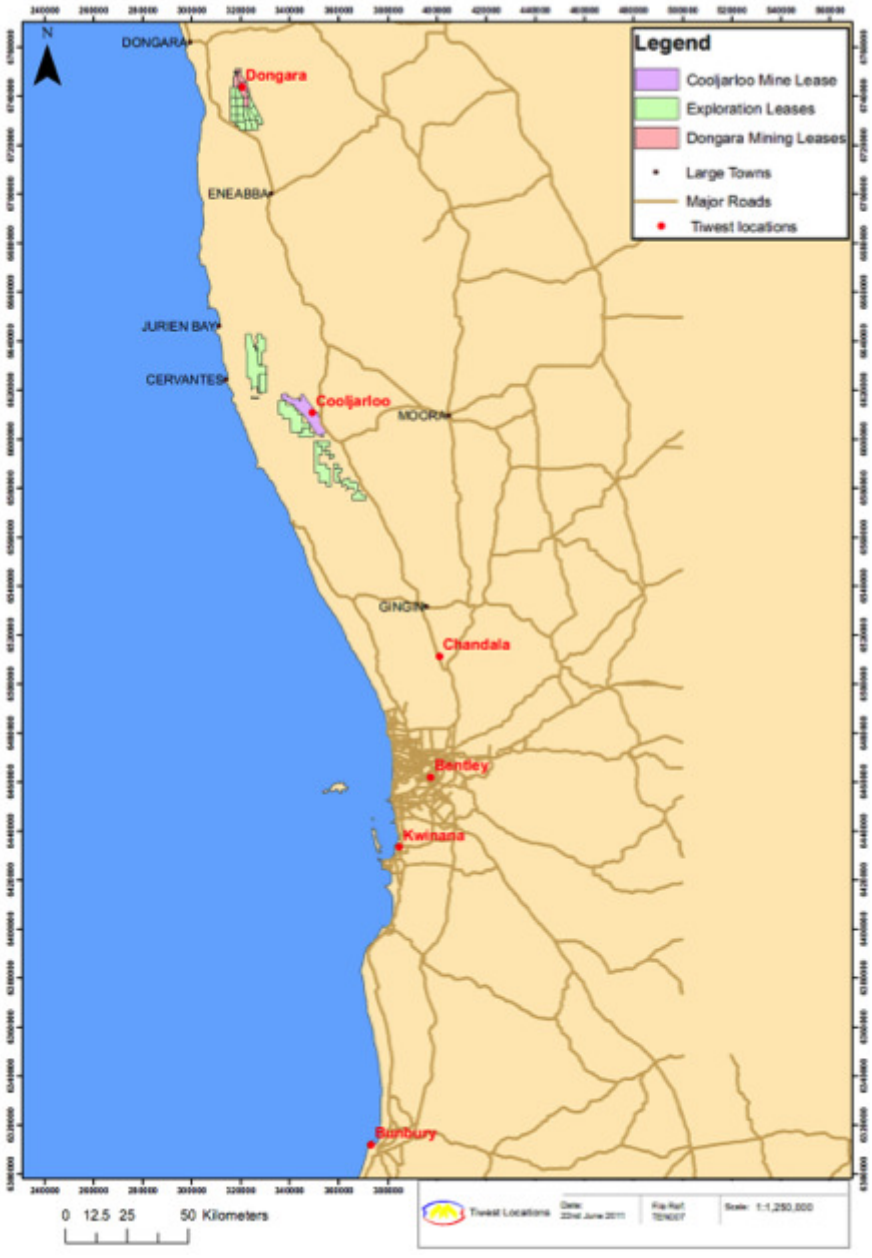

Figure 3 - Location of CNW, CLW and CSW (relative to Cooljarloo)

The current DEC policy statement on the "Management of *Phytophthora* and Disease Caused By It Policy Statement No.3 (1998)" states that "At least 8 (currently approximately 15, VHS (2010) Unpublished Report) distinct species of *Phytophthora* occur at various places in native plant communities of Western Australia. Whilst the potential importance of several of them still require some further elucidation, *Phytophthora cinnamomi* alone represents by far the greatest ongoing threat to conservation and other benefits to society which native plant communities provide." In light of this, the aforementioned policy therefore concentrates on *Phytophthora cinnamomi* and does not provide management guidelines on other *Phytophthora* species.

Phytophthora species present in the study area

Soil and tissue sampling has proven the existence of many species of *Phytophthora* throughout the southwest of Western Australia. The impact of the infestation on the vegetation can range from extremely severe (*P. cinnamomi*) to minor impact (probably endemic *Phytophthora* species).

The soil and tissue sample database of the Vegetation Health Services (Department of Environment and Conservation) was searched to determine previous recoveries of *Phytophthora* within and adjacent to the project area. An assessment was also made of likely *Phytophthora* species that may exist in the region of the project area. These likely species, based on current known range, are described in the following section.

Phytophthora cinnamomi has been recorded from several places adjacent to Cooljarloo near CLW and within the creek system on Munbinea Road at CNW. Sites of *P. cinnamomi* infestation occur along the Brand Highway roadside vegetation near CSW. The infestations near CSW and CLW do not affect the management of activities at these sites. Recoveries of *P. multivora* have also been made in the vegetation adjacent to the Brand Highway.

Phytophthora cinnamomi

Phytophthora cinnamomi is the *Phytophthora* species most frequently isolated from areas of dead vegetation in the South West (DEC, 2010). The pathogen grows as microscopic sized filaments (mycelium) on the surface of plant roots and invades the cells of susceptible host plants. Their food source is the root and basal stem tissue of living plants. The pathogen consumes the host plant causing lesions (areas that appear rotten). This weakens or kills the plants by reducing or stopping the movement of water and nutrients within the plant. Once attacked susceptible hosts rarely recover, most succumbing to a "sudden death" syndrome, rather than a "dying back or Dieback" syndrome.

Phytophthora cinnamomi has a very wide host range. A study conducted in 2004 compared the variation in estimates of susceptibility of native flora to *Phytophthora cinnamomi* among four databases and proposed an estimate of the proportion of the flora of the South-West Botanical Province of Western Australia that is susceptible to the pathogen. The estimates of the proportion of species susceptible to *P. cinnamomi* among the databases from the wide range of environments suggested that a realistic estimate of species susceptibility to *P. cinnamomi* infection in the south-western region was obtained. The mean of 40% susceptible and 14% highly susceptible equates to 2284 and 800 species of the 5710 described plant species in the South-West Botanical Province susceptible and highly susceptible to *P. cinnamomi*, respectively (Shearer, Crane, & Cochrane, 2004). Not all genera within a family or all species within a genus are necessarily susceptible. For example, some species of Eucalyptus are highly resistant (including Karri, Marri, Wandoo and Tuart) while some, such as Jarrah, are affected but have the ability to resist the invasion of the pathogen under certain conditions.

Phytophthora multivora

Phytophthora multivora was previously identified as *P. citricola* in WA based solely on the form and structure of the organism's characteristics. An analysis of the evolutionary history of the organisms however shows that *P. multivora* is unique and

comprises a discrete cluster, with the closest relative being *P. citricola*. This analysis also showed genetic variation which strongly supports the hypothesis that *P. multivora* in WA is not a recent clonal introduction, but rather was introduced long ago, or is endemic.

Over the last 30 years, in the absence of modern diagnostic techniques, *P. multivora* has been routinely identified in the south-west of WA as *P. citricola* using morphological characteristics. *P. multivora* has therefore been isolated in WA from natural forest and heath-land stands from beneath dead and dying plants of 16 species from seven families.

P. multivora is very widespread in south-west WA with a distribution similar to that known for *P. cinnamomi.* When analysing submitted soil and tissue samples, the Vegetation Health Service (Department of Environment and Conservation) uses detection methods developed specifically for *P. cinnamomi.* Under these conditions, *P. multivora* is the next most commonly isolated taxon after *P. cinnamomi*. There is now evidence that in some sites it may be *P. multivora* and not *P. cinnamomi* that is responsible for tree mortality, while the latter is driving the collapse of whole ecosystems known as *Phytophthora* Dieback (Scott, et al., 2009).

Phytophthora arenaria and P. constricta

These *Phytophthora* isolates were recently described, (Rea, Burgess, Hardy, Stukely, & Jung, 2011) having been known as *P. sp.1* and *P. sp.9*.

Phytophthora constricta and *P. arenaria* are homothallic species associated with the Kwongan vegetation on the sandplains of south-west WA. The species were predominantly isolated from dead and dying Banksia species and the soil associated with such plants. The variability in some genetic data for *P. constricta* and *P. arenaria* implies that these species are either:

- endemic,

- have been introduced on multiple occasions from a comparable ecosystem imposing selective pressures favouring adaptations suitable for survival in their current ecosystem, or
- were introduced long ago and have evolved in situ.

Whereas *P. cinnamomi* forms a visible and indiscriminate path of destruction through entire plant communities, *P. constricta* and *P. arenaria* have a more limited impact, selectively killing species belonging predominantly to the family Proteaceae. Furthermore, the incidence of *P. constricta* or *P. arenaria* is usually episodic following extreme rainfall events.

Phytophthora arenaria appears well adapted to the ecosystem from which it has been isolated. It has a high optimum temperature for growth of 30°C and, coupled with a thick oospore wall are life strategies favourable for growth and survival in the Kwongan on the warmer and drier northern sandplains from which *P. arenaria* has predominantly been isolated. In contrast, P. constricta has markedly lower optimum and minimum temperatures for growth than P. arenaria and is therefore suited to the Kwongan of the southern sandplains along the cooler south coast of WA, from where it has predominantly been isolated. It has been isolated though from samples taken at Badgingarra and Eneabba.

Previous assessments

A number of assessments of sections within the exploration area were conducted by Glevan Consulting from 2005 to 2010. Previous surveys have demarcated Dieback sites at CNW in the area of the current survey. These sites are associated with Munbinea Creek, that flows north to south on the eastern side of Munbinea Road. The creek crosses Munbinea Road to the south of the assessed area. An historic recovery of *P. cinnamomi* was made at this intersection in the 1980's. Some areas at CLW have been demarcated in previous surveys, but not within the area of the current survey.

Occurrence and Risk assessment

A *Phytophthora Dieback* occurrence assessment is the first step in developing an effective management plan for the pathogen. The assessment can assign four possible categories to the project area. These categories are; Unmappable, Infested, Uninfested and Uninterpretable (Table 1).

Once *Phytophthora Dieback* occurrence information has been assessed, protectable and unprotectable management categories can be overlayed on occurrence information to simplify the management of the area. All infested area is unprotectable. Unmappable, Uninterpretable and Uninfested will be given protectable or unprotectable status depending on local variations and influences, and will also be influenced by criteria specified in Exploration Drilling Risk Assessment Cooljarloo West, Woodman 2009.

The following table describes *Phytophthora Dieback* occurrence categories as defined by the Department of Environment and Conservation in the manual "*Phytophthora cinnamomi*. and disease caused by it, volume 1, Management Guidelines, 2003". The superior categories "Mappable" and "Unmappable" definitions are not yet published by the department, but are in general use at this time.

Table 1 - Phytophthora Dieback Occurrence Categories

<table>
<tr><td>Unmappable
Areas that are sufficiently disturbed so that Phytophthora Dieback occurrence mapping is not possible at the time of inspection</td><td colspan="2">Further categorisation may be possible after variable regeneration periods for different types of disturbance</td></tr>
<tr><td>Mappable
Natural undisturbed vegetation. Phytophthora Dieback occurrence mapping is possible. Three categories may result.</td><td>Infested</td><td>Areas that a qualified person has determined to have plant disease symptoms consistent with the presence of the pathogen Phytophthora Dieback.</td></tr>
</table>

	Uninfested	Areas that a qualified person has determined to be free of plant disease symptoms that indicate the presence of the pathogen *Phytophthora Dieback*
	Uninterpretable	Areas where indicator plants are absent or too few to determine the presence or absence of disease caused by *Phytophthora Dieback*

A risk assessment for *Phytophthora* Dieback relevant to vegetation type was developed by Woodman Environmental Consulting Pty Ltd (Woodman Environmental Consulting Pty Ltd, 2009) with input from Glevan Consulting. The outcome of any assessment therefore is to provide disease occurrence information that can be overlayed with the hygiene risk categories of the risk protocol. The vegetation communities and risk methodology (as applied to Cooljarloo West tenements) described in the risk protocol are described in Table 2. This risk assessment protocol can be used for areas that haven't been assessed, as in extensions to drill lines.

Table 2 - Hygiene matrix

Disease Occurrence or hygiene management category	**Hygiene criteria**	**Hygiene category**
	WEC protocol	
Infested	All sites interpreted by Glevan Consulting as Infested	Infested
Uninfested	All unsealed public access roads. Vegetation communities F1, W1, W2, W4, T1-T5, H1, H2, H4, S1, 4/W1, T4, H4, OW,FCT1-FCT8	High Risk
Uninfested	Vegetation communities FCT9-FCT11, H3, H5-H7, W3, W5-W8	Low Risk
Unmappable	Weed infested	High Risk
Unmappable (Burnt)	Dependent on vegetation community	
Unprotectable	All areas downstream of identified Infested areas and areas at a reasonable distance down slope of existing infestations.	High Risk

METHOD

Evan Brown, assisted by David Moon, Matthew Stewart and Clinton Wilkinson of Glevan Consulting assessed the drill lines and access tracks of the project area identifying areas at risk of disease introduction. In addition, considered high risk areas were also assessed, including firebreaks, and public roads.

The assessment was conducted in alignment with the relevant methodology prescribed by the Department of Environment and Conservation manual "*Phytophthora cinnamomi* and disease caused by it, Volume II Interpreter Guidelines for detection, diagnosis and mapping, 2001".

The results of previous assessments within the study area were also considered during the assessment, and the results of previous samples.

For the assessment, the interpreter specifically looked for those areas that are:

- Possibly infested with *Phytophthora cinnamomi*;
- possibly infested by other *Phytophthora* species;
- uninfested – free of plant disease caused by *Phytophthora cinnamomi*, and;
- uninterpretable or unmappable – those areas where presence or absence of *Phytophthora cinnamomi* cannot be determined, for example, no disease indicating species present, area has been burnt, cleared to pasture.

The detection of the presence of the plant pathogen *Phytophthora cinnamomi* involved 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. The presence of the *P. cinnamomi* pathogen can be confirmed through the laboratory analysis of soil and root tissue from dead and dying plants taken from the field. Conversely, an negative sample result should not be taken as proof that the pathogen is absent from the sampled location, but should be utilised

in the context of the field assessment. Refer to Table 3 and Table 5 for locations where soil and root tissue samples were taken.

A combination of the following factors was recorded in the field as potential indicators of the presence of disease caused by *Phytophthora cinnamomi* or other *Phytophthora* species:

Deaths of disease indicating species:

An indicator species is a plant species, which is reliably susceptible to *Phytophthora cinnamomi* (i.e. will die). Common indicator species include *Banksia grandis, Patersonia* spp., *Persoonia longifolia*, and *Xanthorrhoea* spp. 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.

Environmental factors:

Sites will vary in the way that disease is expressed both spatially and temporally. Environmental conditions can either favour or disfavour the growth and spread of the pathogen. Sites that are moist but not saturated are most favourable, sites that are well drained and mostly dry are least favourable.

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).

Sampling

The assessment process can also be assisted by strategic soil and tissue sampling, where a positive result confirms the presence of *Phytophthora*. A negative result needs to be analysed by the interpreter to determine if it is consistent with other factors at the site. A possibility that the current environmental conditions will not provide accurate results can also be explored.

RESULTS

CSW

Only one drill line (CSW_15) in the CSW project area was assessed. This line west of private property had been recently burnt and was defined as Unmappable. All other drill lines in CSW are completely contained on cleared farmland and was also Unmappable.

CNW

The drill lines for the CNW project are shown in the following image (Figure 5), generally west of Munbinea Road within the E70/2345 lease area. Lines CNW_82 to CNW_87 were assessed, the results of which are summarised in Table 4 below.

Table 3 - CNW Sample results

Sample	Easting	Northing	Plant sampled	Result
CNW01	327683	6621540	*Banksia attenuata*	Negative
CNW02	328813	6621544	*Xanthorrhoea preissii*	Negative

Table 4 - CNW Drill line summary

CNW_82	Section east of Munbinea Road is Uninfested until the eastern end, where the line appears to be infested, close to the drain at Munbinea Creek. The vegetation appears to have suffered some decline with deaths noted in the change of vegetation structure at the drain. The drill line has been demarcated with day-glow orange flagging tape at an appropriate buffer distance from the affected vegetation. This demarcation is placed at E330397 N6620513 GDA94 Zone 50, and the demarcation flagging may be removed and replaced with other visual markings if the existing flagging could be confusing to operators.
CNW_83	Predominantly Uninfested, the small section at the eastern end on private property is Unmappable.
CNW_84	Predominantly Uninfested, the small section at the eastern end on private property is Unmappable.
CNW_85	Uninfested
CNW_86	Western half of line is Uninfested, whilst the eastern portion is within private property and is Unmappable.
CNW_87	Western half of line is Uninfested, whilst the eastern portion is within private property and is Unmappable.

CLW

Twenty three samples were taken during the assessment to assist in the interpretation of disease symptoms noted in the vegetation. These sites are listed below (Table 5):

All samples taken to assist in the interpretation of the drill lines returned a result negative to the presence of *Phytophthora* at the sampled site. A sample analysed in the laboratory can only provide a positive or negative result to the presence of a *Phytophthora* within the soil and plant material taken from the sampled site. A positive result obviously shows that the sample site is infested by the *Phytophthora* pathogen. All samples taken from the Cooljarloo West area returned a negative recovery of *Phytophthora Dieback.*

The entire assessed CLW site is considered Uninfested.

Table 5 – CLW Sample locations and results

Sample	Easting	Northing	Plant sampled	Result
CLW01	347557	6605758	*X. preissii*	Negative
CLW02	346370	6605542	*Conospermum sp.*	Negative
CLW03	345284	6605340	*Adenanthos sp.*	Negative
CLW04	348480	6605934	*Conospermum sp.*	Negative
CLW05	348286	6606254	*Conospermum sp.*	Negative
CLW06	348788	6605904	*Banksia prionotes*	Negative
CLW07	348828	6605898	*Banksia prionotes*	Negative
CLW08	353002	6605025	*Banksia prionotes*	Negative
CLW09	353302	6605032	*Conospermum sp.*	Negative
CLW10	349112	6602094	*Multiple Banksia sp.*	Negative
CLW11	349175	6601965	*Multiple Banksia sp*	Negative
CLW12	349515	6602114	*Banksia sp.*	Negative
CLW13	348798	6602152	*X. preissii*	Negative
CLW14	348657	6601032	*Banksia sp.*	Negative
CLW15	345164	6603357	*Banksia sp.*	Negative
CLW16	345487	6604419	*X. preissii*	Negative
CLW17	346266	6604914	*Multiple X. preissii*	Negative
CLW18	346194	6603887	*X. preissii*	Negative
CLW19	347304	6603989	*X. preissii, Banksia sp.*	Negative
CLW20	348051	6605284	*X. preissii, Banksia sp.*	Negative
CLW21	348184	6604951	*X. preissii, Banksia sp.*	Negative
CLW22	352935	6610616	*Banksia sp.*	Negative
CLW23	352990	6610501	*Banksia sp.*	Negative

DISCUSSION

CSW

The majority of the drill holes with the current CSW drilling program are situated on cleared private property. The entire farming area is classified as Unmappable and a single hygiene unit.

One drill line traverses remnant vegetation (CSW_15) however the vegetation has been recently burnt rendering the line Unmappable.

Despite the drill line and the greater farming area being the same Dieback occurrence category, hygiene measures will be required for any machinery operating within the remnant vegetation.

CNW

The assessment of CNW was limited to the lines CNW_82 to CNW_87. All sections of the drill lines on private property are considered Unmappable.

The eastern end of CNW_82 (approximately 180m) traverses a wetland /drain system that appears connected to Munbinea Creek. The vegetation within this area was showing signs of deaths in disease indicating species, and a perceived structural change in the vegetation, therefore, this section of the drill line should be managed as infested.

An assessment of drill lines immediately north and south of CNW_82 in 2010 (Glevan Consulting, 2010) determined that sections of those lines were traversing areas of suspicious vegetation. Soil and tissue samples were taken during the 2010 survey that did not prove the presence of Dieback. A soil and tissue sample was not taken at the site during the current survey as it was considered that it would not assist the interpretation process. It was determined during the interpretation process that the site would be demarcated as Infested, regardless of whether the sampling of the site would lead to the positive identification of *P. cinnamomi* being present. Sampling

may be undertaken at the site under more favourable environmental conditions to prove the presence of the Dieback pathogen at the site, if required. These areas are upstream of a sample that was taken in the 1980's that proved the presence of the disease near the junction of Munbinea Creek and Munbinea Road.

CLW

The drill lines in Cooljarloo West are shown on Map 1.3. The vegetation throughout the area is generally in a healthy condition, however many Banksia deaths were noted, generally associated with the edges of low-lying areas. This pattern of deaths is reasonably consistent with infested damplands where the deaths appear on the dunal system surrounding the dampland, however the pattern is also consistent with drying conditions. It appears in drier seasons, the Banksia species occupying more marginal areas of existence will succumb to drought conditions. These conditions were also noted on the ridges of the dunes, with Banksia deaths also noted. A sampling strategy was developed such that representative samples of these Banksia deaths were conducted.

The results of the CLW area are not reported by drill line. The entire area has been extensively covered during this assessment and last year's assessment, and therefore the site can be treated as one contiguous area allowing consistent hygiene measures through the site.

RECOMMENDATIONS

Current Tiwest JV Dieback risk and management techniques should be adopted for activities conducted at the CNW, CSW and CLW sites. In particular, the following Hygiene management should apply.

- (CNW) - Clean on Entry (CoE) points should be developed for all machinery accessing the vegetation from Munbinea Road.

- (CSW) - Clean on Entry (CoE) points should be developed for all machinery accessing CSW_15 from the farmland.

- (CSW) - Access throughout the farmland need not be restricted due to Phytophthora considerations but may be restricted due to weed management.

- (CLW) – As the entire CLW site has been assessed as Uninfested, the Woodman risk protocols should not be needed (under normal conditions) with the area contained by the drill lines considered a single hygiene unit.

  (CLW) - In the event of significant rainfall, COE points should be installed as per the Woodman protocols to any wetland or dampland areas that are fed from areas outside of the assessed area.

- (CNW, CSW, CLW) - Any site where CoE points cannot be established should be accessed in dry-soil conditions only.

BIBLIOGRAPHY

CALM. (2004). *Best practice guidelines for the management of Phytophthora cinnamomi.* Unpublished.

Carter, R. (2004). *Arresting Phytophthora Dieback: The Biological Bulldozer.* (K. Vear, & B. Dell, Eds.) WWF Australia.

DEC. (2010). *Vegetation Health Service Annual Report 2009-2010 Phytophthora Detection.* Unpublished.

DWG. (2011). *What is Dieback?* Retrieved October 13, 2011, from dieback.org.au

Environment Australia. (2001). *Threat Abatement Plan for Dieback caused by the root-rot fungus Phytophthora cinnamomi.*

EPA. (2011). *Phytophthora Dieback*. Retrieved October 13, 2011, from State of the Environment Report 2007: www.soe.wa.gov.au/report/biodiversity/phytophthora-dieback.html

Glevan Consulting. (2010). *Tiwest 2011 Drill Program Dieback Occurrence Report.* Unpublished.

Hardy, G., Colquhoun, I., Shearer, B., & Tommerup, I. (2001). The impact and control of Phytophthora cinnamomi in native and rehabilitated forest ecosystems in Western Australia. *Forest Snow and Landscape Research, 76*(3), 337-343.

Keane, P., & Kerr, A. (1997). Factors affecting disease development. In APPS, J. Brown, & H. Ogle (Eds.), *Plant Pathogens and Plant Diseases* (pp. 287-298). Rockvale Publications.

O'Gara, E., Howard, K., Wilson, B., & Hardy, G. (2005). *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia: Part 2 - National Best Practice Guidelines.* CPSM. Department of Environment and Heritage.

Rea, A., Burgess, T., Hardy, G., Stukely, M., & Jung, T. (2011). Two novel and potentially endemic species of Phytophthora associated with episodic dieback of Kwongan vegetation in the south-west of Western Australia. *Plant Pathology*, 1-14.

Scott, P., Burgess, T., Barber, P., Shearer, B., Stukely, M., Hardy, G., & Jung, T. (2009). Phytophthora multivora sp. nov., a new species recovered from declining

Eucalyptus, Banksia, Agonis and other plant species in Western Australia. *Persoonia*(22), 1-13.

Shearer, B., Crane, C., & Cochrane, A. (2004). Quantification of the susceptibility of the native flora of the South-West Botanical Province, Western Australia, to Phytophthora cinnamomi. *Australian Journal of Botany*(52), 435-443.

Woodman Environmental Consulting Pty Ltd. (2009). *Exploration Drilling Risk Assessment Cooljarloo West Phytophthora cinnamomi and Weed Hygiene Risk.* Unpublished.

APPENDIX 1 – MAPS.

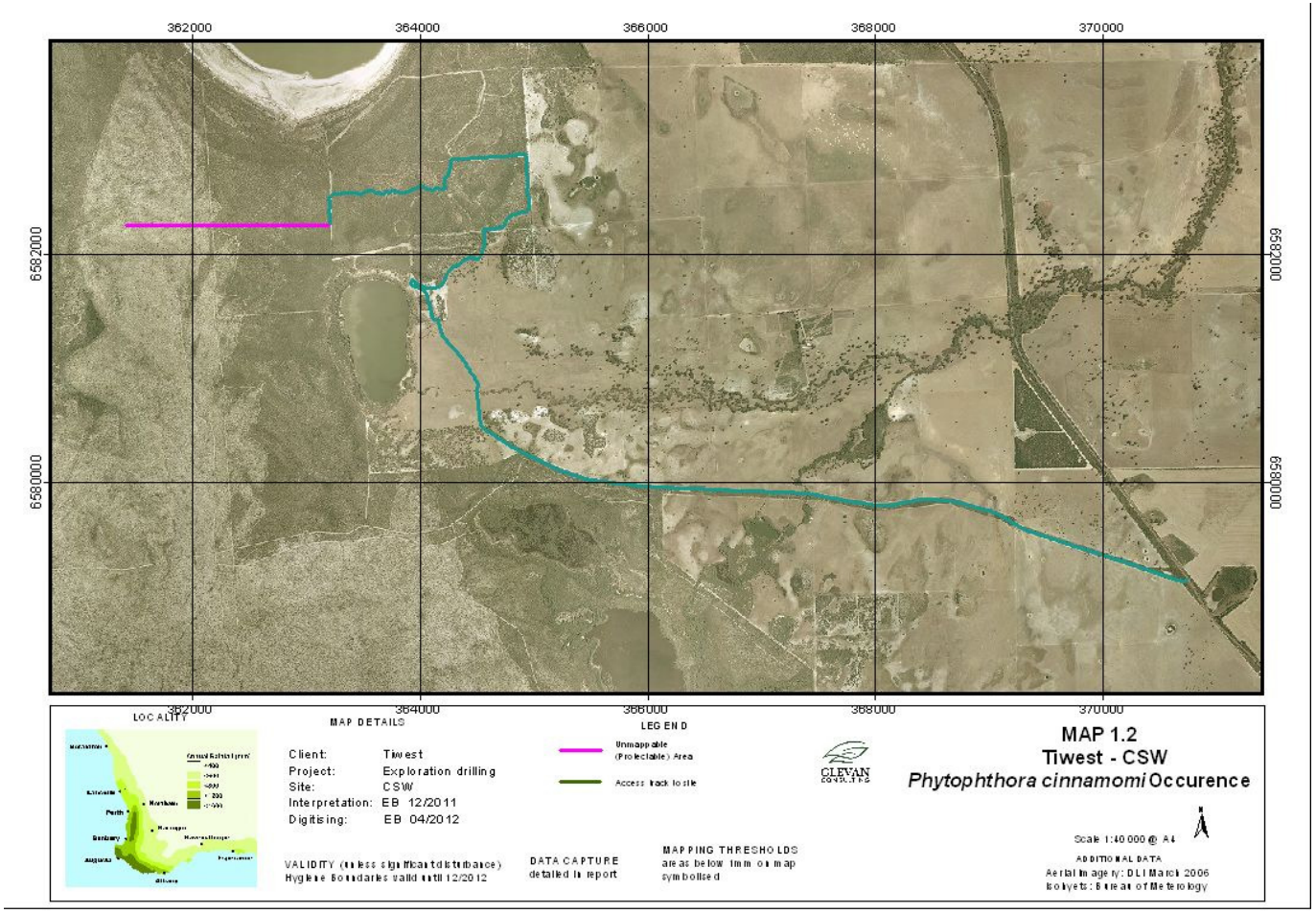

Figure 4- CSW Occurrence Map

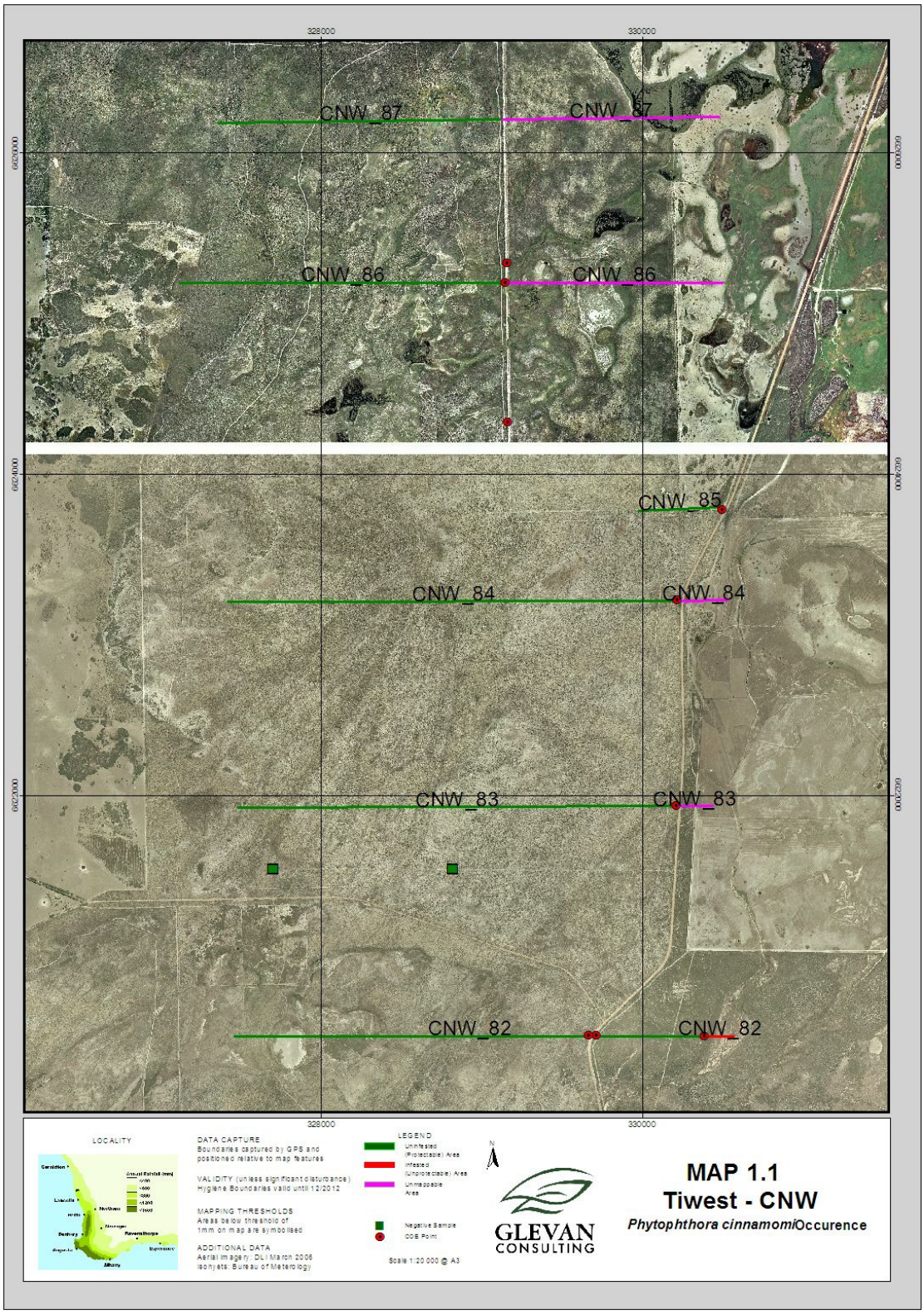

Figure 5 - CNW Occurrence Map

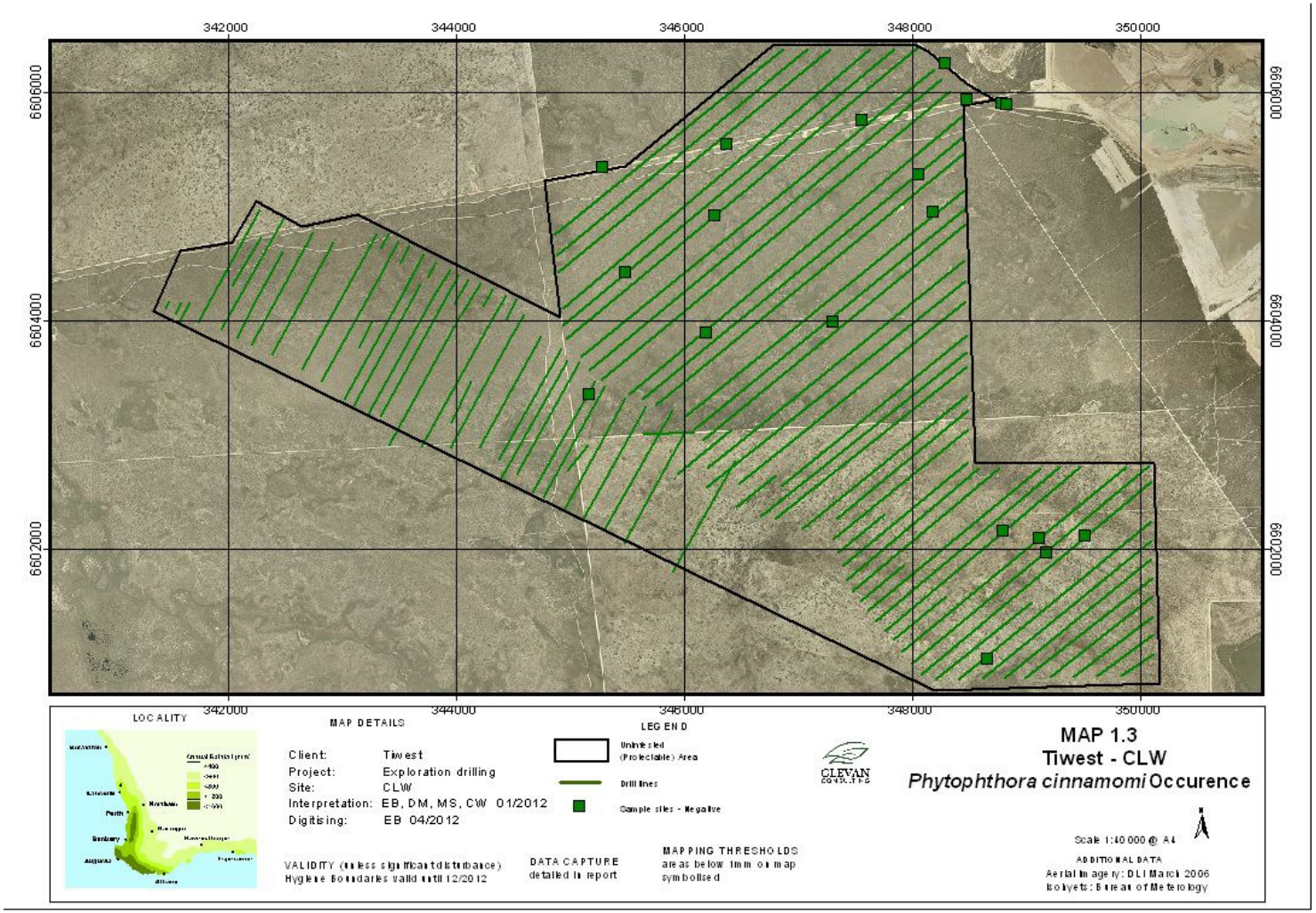

Figure 6 - CLW Occurrence Map