JANDAKOT AIRPORT
DIEBACK MANAGEMENT PLAN

CONSERVATION MANAGEMENT PLAN
APPENDIX C

Jandakot Airport Holdings Pty Ltd
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1 Background

Jandakot Airport is managed by Jandakot Airport Holdings Pty Ltd (JAH) under a lease agreement with the Commonwealth Government. The airport site contains 119 ha of conservation precinct. JAH is regulated by the Commonwealth *Airports Act 1996* (Airports Act) and the associated *Airports (Environment Protection) Regulations 1997*.

The Airports Act requires JAH to prepare and implement a Master Plan every five years, which includes an Environment Strategy that outlines environmental management of the airport. Master Plan 2014 was approved in February 2015 and includes a commitment to implement this Dieback Management Plan.

Dieback is caused by an introduced soil and water borne pathogen known as *Phytophthora cinnamomi* which infects the roots of plants causing roots and foliage to die off. This often leads to the eventual death of the infected plant. Many local native plants are susceptible to dieback and its spread can have devastating effects on the ecology of remnant bushland areas. Death of susceptible species in large numbers can encourage weed infestation and impact on fauna habitat and feeding sources. Areas identified as containing dieback cannot be cured once infested, however appropriate management can minimise the spread of the disease (Dieback Working Group, 2005). Jandakot Airport is adjacent to two other conservation bushland areas, Ken Hurst Park and the Jandakot Regional Park. Whilst these neighbouring properties are also affected by dieback, it is important that the spread of dieback is minimised.

Five dieback infestations have been identified and mapped at Jandakot Airport, and these are mostly associated with dampland areas (see Figures 1 and 3). Jandakot Airport contains regionally significant bushland, which includes at least one declared rare flora species (*Caladenia huegelii*), and provides habitat for one rare fauna species (Carnaby's Black-Cockatoo) and other priority species (Western Brush Wallaby and Quenda). JAH is committed to protecting these areas by implementing the actions described in this Dieback Management Plan.

Armillaria luteobubalina (Honey Fungus) has also previously been identified at Jandakot Airport. Honey Fungus is a mushroom producing fungus which is probably native to Western Australia, but which also infects the roots of many native plants leading to plant death. Honey Fungus can be spread by soil, water and air which makes it more difficult to manage than *P. cinnamomi* (Glevan Consulting, 2000).

There are also a number of other *Phytophthora* species which can lead to dieback, however *P. cinnamomi* is the most common and virulent species in Western Australia (Dieback Working Group, 2005). These other *Phytophthora* species are detected through the same process (field interpretation and laboratory analysis of soil and plant tissue) used to confirm the presence of *P. cinnamomi*.

The impact of *Phytophthora* species other than *P. cinnamomi* can vary considerably from site to site, but is typically much lower than that of *P. cinnamomi*. Management of other *Phytophthora* species is normally considered on a case by case basis and is largely dependent on the impact/threat level present in each case. If they are to be managed, then in general, they are managed in the same way as *P. cinnamomi*.

P. nicotianae was identified within a section of highly disturbed remnant vegetation (maintained as an amenity landscaped garden bed) near the JAH Administration building during the 2011 assessment, however given the already degraded state of the vegetation, the threat posed by the pathogen is thought to be minimal.

2 Management

As previously stated, dieback infested areas cannot be cured and so the main management focus is to minimise its spread. The proposed management measures to be implemented at Jandakot Airport are detailed in the following sections.

Effective management of dieback spread is assisted by identifying areas of high conservation or those which are vulnerable to spread. JAH has identified the following as its priority areas for dieback management;

1. Conservation Precincts 1A and 1B - Areas containing the Endangered / Declared Rare Flora species *Caladenia huegelii*
2. Conservation precincts 2A and 2B
3. Dieback infested areas within bushland scheduled for clearing and development.

2.1 Dieback Treatment

2.1.1 Phosphite Application

Phosphite (phosphonate) treatment has been identified as successful in boosting the defence mechanisms of dieback susceptible plants and minimising the spread of dieback (Dieback Working Group, 2005). Phosphite can be applied by injection directly into susceptible tree species, or by aerial or ground based spraying. Phosphite is taken up by the leaves or roots of the plant and accumulated in the plant's tissue (Dieback Working Group, 2005).

JAH has previously undertaken aerial phosphite spraying, and this treatment method was last performed in 2008. However, aerial spraying of large areas is no longer considered to be an appropriate method given the urbanisation of the Jandakot region (i.e. due to contamination/nuisance potential for neighbours). Given the low probability of new infestations appearing, the low rates of disease spread associated with the existing infestations, and the small size of the dieback infested areas, aerial spraying is not a cost effective method.

Instead, JAH will use a combination of ground-based spraying (for small understorey species) and trunk injection (for plants with a stem diameter of 10cm or greater). The exact methodology and concentrations used will be determined by the expert contractor engaged to undertake the treatment in-line with the most up-to-date advice issued by relevant dieback organisations, such as the Dieback Working Group or the Department of Parks and Wildlife (DPAW).

Treatment will take place during dry weather (preferably autumn) at three year intervals.

2.2 Dieback Prevention and Containment

2.2.1 Access

Restricting access to dieback areas, and particularly across dieback category boundaries, is the most effective method to minimise dieback spread. Much of Jandakot Airport is surrounded by a chain mesh security fence which minimises unauthorised access to bushland areas by trail bikes and the like. This fence is inspected daily and if required, repaired immediately to ensure security. Precinct 1A (boundaries as detailed within Master Plan 2009) is not within the secured 'Airside' area but the majority of the boundary is fenced (fencing will be completed following confirmation of the Eastern Link Road alignment). Precinct 1B (boundaries as detailed within Master Plan 2009) is fenced along all boundaries and isolated from operational airside areas. Precincts 2A, 2B and 6 are located within the secured 'Airside' area.

Limestone and other suitable track hardening materials have been laid over parts of the airport perimeter road to ensure tracks are traversable and provide a barrier across dieback category boundaries. This enables emergency response access and daily fence inspections to occur without fear of spreading dieback. Access to other sand tracks and firebreaks is restricted to JAH personnel and approved contractors (e.g. weed sprayers and wildlife consultants).

Should dieback monitoring indicate that the dieback front is advancing significantly greater than expected, JAH will consider hardening existing access tracks to act as a barrier across dieback category boundaries. However, as the 2014 dieback assessment concluded that the disease distribution was almost identical to the 2011 survey, it is unlikely that track hardening for dieback containment will be required in the near future.

Dieback infested areas are signposted as a reminder to vehicles and pedestrians to keep away, unless access into these areas is necessary and undertaken in an approved manner. All vehicle entry and exits points to dieback infested areas as well as tracks adjacent to infested areas are to be appropriately signposted. JAH will inspect signs annually. The 2014 assessment found no evidence of the pathogen being spread by vehicles.

Pedestrian access into Conservation Precincts and dieback infested areas is generally restricted to management activities such as fauna surveys, weed control, etc. This allows for controls to be specified, such as restricting access during wet weather, when there is the greatest risk of dieback spread from footwear.

JAH will continue to implement these access restriction measures.

Access across dieback category boundaries by wallabies and other animals is not currently restricted at Jandakot Airport. While macropods are believed to be responsible for spreading the disease in other locations, it is thought that macropods do not represent a significant risk in relation to disease spread within Jandakot Airport. The 2014 assessment found no evidence of the pathogen being spread by wildlife.

2.2.2 Construction/Earthmoving

If not managed correctly, construction or earthmoving activities which necessitate crossing dieback category boundaries can spread dieback through the movement of infested soil or plant material or via infested soil attached to vehicles and machinery.

A Construction Environmental Management Plan (CEMP) is developed for all construction and earthmoving activities. Where dieback management activities are identified as a high risk and not adequately addressed within the CEMP, the JAH EM will require the contractor to develop a project-specific Dieback Management Plan as part of the Works Permit conditions.

CEMPs and/or project-specific DMPs will be consistent with the JAH Contractor Dieback Hygiene Policy and Guidelines (Attachment 1).

2.2.3 Drainage

Water can easily spread dieback via surface or groundwater flows. There is no standing water at Jandakot Airport, although there are a number of areas which have been identified as damplands (see Figure 3). Stormwater flows are minimal due to the highly free-draining and sandy soils present.

Drainage from developed areas is described in detail within Maser Plan 2014 and the Jandakot Airport Local Water Management Strategy (Essential Environmental 2015). The majority of stormwater drainage basins on the airport are located within cleared and developed areas well away from Conservation Precincts. There is one artificial infiltration basin in Conservation Precinct 1B which receives stormwater from areas within the older airside developments of the airport. Stormwater previously infiltrated across a wide area until the drainage was redesigned in 2005/06, resulting in stormwater being confined to the Precinct 1B Mustang Road verge. Despite the previous basin area being identified as “completely degraded” (as per the Bush Forever scale) in a 2005 vegetation survey (Cardno BSD, 2005), more recent surveys (Ecoscape, 2011) have defined this area as “good” to “very good”. This is due to a significant increase in vegetation biomass within the basin since 2005. The basin has been mapped as dieback uninfested (Glevan 2015), but it is at high risk of becoming infested in the future as it is directly adjacent to a dieback infested area.

Most of the dieback infested sites at Jandakot Airport are associated with damplands or low points across the airport. This means that stormwater runoff would tend to run towards these areas, thereby minimising dieback spread away from these areas. JAH will ensure that there is no managed stormwater discharge from dieback infested or uninterpretable areas into uninfested areas.

The groundwater at Jandakot Airport flows in an approximately north to north-westerly direction. This means that areas north to north-west of dieback infested areas are high risk areas which may be subject to natural dieback spread via the groundwater. These dieback ‘fronts’ are routinely targeted during triennial phosphite treatments.

2.2.4 Landscaping and Revegetation

JAH regularly undertakes landscaping in development areas and occasionally undertakes revegetation projects in Conservation Precincts. These need to be managed carefully to minimise dieback spread and ensure successful growth of plants.

The need to undertake rehabilitation or revegetation within the Conservation Precincts of Jandakot Airport can be triggered by:

- Bushfires;
- Impacts of weeds on vegetation condition not successfully managed by weed control;
- Impacts of dieback on vegetation condition not successfully managed by phosphite and other dieback management measures;
- The closure of surplus or non-essential firebreaks and access tracks;
- Verge impacts from the construction of new roads as detailed in Master Plan 2014.

No areas within the Jandakot Airport Conservation Precincts are currently identified as requiring rehabilitation or revegetation. However, in the event that revegetation is required to be undertaken at some future point, the Rehabilitation and Revegetation Guidelines (CMP Appendix D) have been developed to assist in planning.

Sourcing Seed and Plants

It is JAH policy that all revegetation in Conservation Area utilise only provenance seeds and plant species indigenous to the site.

All landscaping in developed areas should be consistent with the Jandakot Airport Landscape Design Guidelines. Landscaping works should consist primarily of species indigenous to the area, with other water efficient native species allowed to supplement.

JAH has limited capacity to propagate plants from seed or cuttings onsite, and the majority of the plants using in landscaping and revegetation will be propagated offsite. Plants grown offsite are to be purchased from NIASA (Nursery Industry Accreditation Scheme Australia) or other appropriately accredited nurseries, to ensure that appropriate dieback hygiene measures have been implemented and minimise the risk of introducing further dieback infections onto Jandakot Airport.

Transplants should not be collected from dieback infested areas as the risk of spreading dieback into uninfested areas is too great. Seed can be collected from dieback infested areas as long as appropriate dieback clean-down procedures are implemented for all shoes, vehicles and tools.

Revegetation in Dieback and High Risk Areas

In dieback areas, only dieback resistant species (See Attachment 2) should be planted. In areas adjacent to dieback infestations or high risk areas for dieback spread (e.g. areas subject to significant earthmoving), dieback resistant species should be planted.

When the condition of dieback infested areas has declined to the point of requiring revegetation, it can be difficult to maintain the area's original vegetation type. Shearer and Hill (1989) observed that in *Banksia* woodlands of the Bassendean Dune system of the Swan Coastal Plain, most of the dominants and many understorey species are susceptible to *P. cinnamomi.* *Banksia attenuata*, *B. ilicifolia* and *B. menziesii* are commonly lost from communities, leaving scattered trees of *Eucalyptus todtiana* (Prickly bark) and *Nuytsia floribunda* (W.A Christmas tree), both of which are largely resistant to infection. These species, along with strains of dieback-resistant jarrah identified from areas in the state's south-west, will be considered where there has been significant overstorey decline.

Seedlings are known to be particularly susceptible to death from dieback, even if they are not of a dieback susceptible species. In dieback infested areas, it may be appropriate to revegetate using direct seeding instead of planting seedlings.

Topsoil and Mulch

Topsoil and mulch may be collected from cleared areas for reuse in landscaping as long as materials from dieback infested areas are kept within the infestation boundaries.

2.2.5 Bushfire Management

JAH has in place a Bushfire Management Plan which outlines the planning for and response to fire incidents at Jandakot Airport. Fire access is provided as described in Section 2.2.1. Current dieback mapping is included in the Bushfire Management Plan, along with the following guidelines to address dieback spread during fire response and recovery:

- Try to keep all machinery operations in one area, either in dieback infested or uninfested areas
- Minimise the entry of machinery or vehicles into bushland areas, or keep to marked access tracks
- During earthworks take care not to push dieback infested soil into uninfested areas
- Avoid areas where soil can be picked up e.g. muddy or wet areas, or clean soil off vehicles.

3 Research and Industry Consultation

JAH recognises that research is an important part in improving dieback identification and management measures. In previous years JAH has supported a number of dieback related projects undertaken by Murdoch University students and has been involved with the Dieback Working Group (DWG). JAH will, wherever practicably possible, support future dieback research proposals by facilitating access to dieback infested areas on Jandakot Airport.

There are a number of Phytophthora dieback organisations in Western Australia, including the DWG, the Dieback Consultative Council (DCC), Dieback Response Group (DRG) and the Centre for Phytophthora Science & Management (CPSM). Where necessary, JAH will consult with these organisations and dieback professionals to ensure that the most appropriate prevention and treatment methods are being applied at Jandakot Airport.

4 Identification & Monitoring

Dieback infestation is usually identified via two methods – interpretation and laboratory testing. During dieback surveys, all bushland areas are assigned one of the following categories:

- Dieback infested – dieback is present
- Dieback uninfested – dieback does not appear to be present at the time of the survey
- Dieback uninterpretable – the presence or absence of dieback cannot be determined as the bushland is too degraded or does not contain plant species which are susceptible to dieback.

These categories are used to determine appropriate management measures in each area.

4.1 Interpretation

Dieback interpretation is undertaken by an appropriately qualified dieback interpreter who is accredited by DPAW. Reassessment is recommended every three years.

Dieback interpretation involves a visual assessment of the plant species present in a given area. Deaths of susceptible species and their approximate age are noted as well as the general health of non-susceptible species. Deaths of a number of different aged susceptible species may indicate the presence of dieback. Deaths of non-susceptible species may indicate an alternative cause of death such as drought, fire or other disturbance (Glevan Consulting 2005, 2012, 2015).

A combination of interpretation and laboratory testing methods give the most reliable method of dieback identification.

The first dieback interpretation undertaken at Jandakot Airport was in completed in November 2000 (Glevan Consulting 2000). Reassessments were undertaken in November 2005 (Glevan Consulting 2005), November 2011 (Glevan 2012) and most recently spring 2014 (Glevan Consulting 2015). The results of the 2014 assessment are shown in Figure 1. Areas shown in red are dieback infested, and all other areas are considered to be dieback 'uninfested'.

The 2014 assessment showed that dieback spread was minimal over the three year period from 2011 to 2014. This is likely due to the sandy soils present at the airport which allow free drainage, and also the management measures which were initially implemented after the 2000 survey. JAH propose to undertake dieback reassessment at Jandakot Airport every three years. The next dieback survey will be conducted in 2017.

4.2 Laboratory Testing

Laboratory testing is usually undertaken in conjunction with dieback interpretation and can consist of soil and/or plant tissue samples collected from areas interpreted as dieback infested. There are two main methods of laboratory testing in use – baiting and DNA analysis.

Baiting involves placing the soil or tissue sample and a germinated seed under laboratory conditions which promote the growth of *P. cinnamomi*. The samples are left for a period of up to two weeks and the seedling assessed for *P. cinnamomi* infection (Glevan Consulting, 2005).

DNA analysis is a relatively new technique which is quicker and more accurate, however it is also more expensive. Medical technology is used to detect the DNA of *P. cinnamomi* in soil or plant tissue samples. This method detects *P. cinnamomi* even if it is in a dormant state, which the baiting method may not detect (Murdoch University, 2006).

In both testing methods it should be noted that a negative result does not mean that an area is free of dieback. This is because relatively small amounts of soil and tissue are collected for samples and *P. cinnamomi* is not evenly spread within infested soil. Anecdotal evidence suggests that tissue samples collected from suspected dieback infected plants have a higher rate of positive *P. cinnamomi* detection.

Soil and tissue samples were collected in both the 2000 and 2005 surveys and sampled using the baiting method. Five of twelve samples collected in 2000 were confirmed to contain *P. cinnamomi*, while only one of thirteen samples collected in 2005 tested positive for the presence of *P. cinnamomi*.

During the 2011 assessment, 22 samples were taken. Twenty one of the samples were taken outside of the known infestations, and all tested negative for the presence of *P. cinnamomi.* The other sample was taken purely as a 'control' from a known infestation where the presence of *P. cinnamomi* was confirmed during the 2005 assessment. Sampling of known infestations is not common practice, but in areas where pathogen dormancy may be a factor, it assists in confirming that the pathogen is being detected by the laboratory process, and that 'false negative' results are not being recorded. *P. cinnamomi* was recovered from the control sample, providing evidence that the pathogen will be recovered if present, and that false negative sample results are not being recorded.

During the 2014 assessment, 18 samples were taken outside of the 2011 dieback boundaries and one control sample was taken from a dieback area. No new Phytophthora Dieback infestations were identified and only minor adjustments were made to the boundaries of the five existing infestations. Minimal disease expression was evident during the assessment, and the lack of expression is most likely the result of ongoing phosphite treatment.

In addition to the scheduled site-wide dieback assessments, specific investigations have been conducted as required in response to dieback concerns. In December 2006 Murdoch University's Centre for Phytophthora Science and Management conducted DNA analysis on ten soil and one plant tissue samples collected from an uninterpretable area within the Stage 1 commercial area. The plant tissue sample tested positive but all the soil samples tested negative for *P. cinnamomi*. In 2008, 5 soil and tissue samples were taken from the Compass Road development area by Glevan Consulting. *P. cinnamomi* was not recovered from the vegetation assessed.

4.3 Bushland Condition

There appears to be a relatively strong correlation between bushland condition ratings (Ecoscape 2011) and the presence of *P. cinnamomi.* While the bushland condition within some of the infested sites is not markedly different from the uninfested areas, the vegetation associated with the infestations in Precincts 2 and 6 exhibited notably higher levels of disturbance than the surrounding uninfested areas (see Figure 2). In Precinct 2, there is also a significant overlap in the area identified as being a weed 'hotspot', and the area infested with *P. cinnamomi.*

4.4 Ongoing Monitoring

JAH will monitor the effectiveness of this Dieback Management Plan in minimising the spread of dieback via the proposed triennial surveys utilising interpretation and/or laboratory assessment. The methods used (including laboratory testing) will be based on the advice of the expert consultant contracted to undertake the dieback interpretation.

Ongoing bushland condition monitoring results (see CMP Section 4.2) will also be compared with dieback mapping as part of triennial dieback interpretation to determine any correlation between the two.

In addition, opportunistic observations throughout the conservation precincts can be made on a regular basis by the JAH Environment Manager and by other staff whilst undertaking works within or adjacent to Conservation Precincts. Suspected new infestations or suspected rapid spread of existing infestations will be entered into the JAH Safety Management System database as an Environment Incident and actioned accordingly.

5 Communication

JAH communicates the contents of this Dieback Management Plan to its stakeholders via the following methods:

- Dieback infested areas are identified via signage (see Table 1, DMP4)
- Publication of the DMP on the JAH website where it is accessible to all staff, tenants, contractors and members of the public
- Inclusion of relevant dieback management information within CEMP templates and Operational Environmental Management Plan (OEMP) templates
- Inclusion of dieback management information in relevant site inductions.

6 Reporting Requirements

Reporting against actions described in this plan will be included within the Jandakot Airport Annual Environment Report (AER). In line with the *Airports (Environmental Protection) Regulations 1996*, the AER will be submitted to the Department of Infrastructure and Regional Development by 28th October each year. A copy of the report will be provided to DOE by 28th October each year.

Reporting relevant to the DMP will also be included in an annual compliance report, as required under Condition 16 of EPBC 2009/4796, and published on the JAH website by 28th October each year.

7 Review and Amendment of Dieback Management Plan

As with the overarching Conservation Management Plan, the Dieback Management Plan is a 'live' document and as such will require regular review and amendment in order to meet practical requirements on site as changing circumstances demand.

Where amendments are unlikely to have a material impact on matters protected under the EPBC Act or the intent of EPBC 2009/4796 conditions of approval, copies of the amended plan, including appropriate rational and justification for each amendment, will be provided to DOE and DIRD. If DOE deem it necessary, the amended plan will be elevated for the Minister's approval.

Where amendments to the Dieback Management Plan impact matters protected under the EPBC Act or are deemed not to be in accordance with that approved by the Minister (ref Conditions 6 and 12 of EPBC 2009/4796 approval), the amended Plan will be submitted to DOE for review and approval by the Minister.

The JAH Environment Manager will review this Dieback Management Plan every three years to ensure that it is up to date and its control measures are effective. This review is planned to occur following the triennial dieback assessment, which will determine whether existing management measures have been effective in halting, or at least slowing, the spread of the disease. If required, new or amended management measures will be identified and included within the Dieback Management Plan.

However, if new relevant information comes to light before the three-yearly review is undertaken (e.g. a new infestation is identified, new or improved treatment methods are discovered etc.), a review of the Dieback Management Plan will occur before the scheduled action.

8 Summary of Actions

The Table below contains a list of summary actions relating to the Jandakot Airport Dieback Management Plan.

Table 1. Dieback Management Plan Summary of Actions.			
Action		**Responsibility**	**Timing**
Dieback Treatment			
DMP1	Undertake phosphite (or other appropriate) treatment of dieback infested areas utilising methods recommended by dieback experts (refer to DMP14).	JAH EM	2018 and then Triennially.
Dieback Management – Prevention and Containment			
Access			
DMP2	Inspect security fencing daily and repair immediately if necessary.	JAH ASOs	Daily
DMP3	Investigate the feasibility of hardening existing access tracks to act as a barrier across the relevant dieback category boundaries, where the dieback front is advancing significantly and additional control actions are required (as determined via triennial assessments).	JAH EM in consultation with JAH Operations Manager and JAH Facilities Manager.	Feasibility investigation to be completed within 6 months of the triennial assessment that initially identified the issue.
DMP4	Plan and implement works recommended within the feasibility investigation (DMP3).	JAH EM in consultation with JAH Operations Manager and JAH Facilities Manager.	Timing as recommended within feasibility investigation.
DMP5	Install (or if appropriate, relocate) dieback awareness/warning signs at all entry/exit tracks to infested areas and along adjacent tracks when a new dieback infestation is detected or an existing dieback infestation boundary has increased beyond the existing signage.	JAH EM.	Within 3 months of a new infestation being detected or an existing dieback front assessed as having increased beyond the existing signage.
DMP6	Inspect dieback signage and replaced/update if required.	JAH EM.	Annually (July each year).
Construction and Earthmoving			
DMP7	Prepare a JAH-approved CEMP or project-specific DMP for all construction and earthmoving activities. CEMPs and project-specific DMPs will be consistent with the JAH Contractor Dieback Hygiene Policy and Guidelines (Attachment 1).	JAH EM in liaison with contractors.	Prior to works commencing.
DMP8	Implement the JAH-approved CEMP or project-specific DMP for all construction and earthmoving activities prepared under DMP7.	Construction and earthmoving contractors	During construction and earthmoving works.
Drainage			
DMP9	Design new	JAH EM in consultation	Where relevant, to

Table 1. Dieback Management Plan Summary of Actions.			
Action		**Responsibility**	**Timing**
	developments/drainage works to avoid stormwater discharge from dieback infested or uninterpretable areas into uninfested bushland areas.	with contractors and JAH staff.	be included in CEMP prior to works commencing.
Landscaping and Revegetation			
DMP10	Revegetation shall be consistent with CMP Appendix D Bushland Rehabilitation and Revegetation Guidelines.	JAH EM	At all times
DMP11	Landscaping in developed areas shall be consistent with the Jandakot Airport Landscape Design Guidelines.	JAH EM	At all times
Research and Industry Consultation			
DMP12	Assess research proposals requesting access to Jandakot Airport dieback infestations in regards to feasibility, safety, relevance, impost on JAH resources, etc.	JAH EM	Timing of assessment to be agreed upon between JAH and relevant research institution requesting the access.
DMP13	Facilitate access by researchers to Jandakot Airport dieback infestations (subject to assessment and approval as described in DMP12).	JAH EM	Following receipt of request from a research institution or government agency.
DMP14	Consult with dieback organisations and/or professionals to ensure that the most appropriate prevention and treatment methods are being applied at Jandakot Airport.	JAH EM	Prior to undertaking phosphite (or other appropriate) treatment and during triennial review of the DMP.
Monitoring and Contingency Requirements			
DMP15	Undertake dieback reassessment.	JAH EM.	2017 then Triennially.
DMP16	Enter suspected new infestations or suspected rapid spread of existing infestations observed in between triennial dieback assessments into the JAH Safety Management System database as an Environment Incident.	JAH EM	Within 7 days of a suspected new infestation or rapid spread of an existing infestation being reported.
DMP17	Implement actions identified from the Environment Incident investigation process commenced under DMP16	JAH EM	In accordance with timing identified under Environment Incident investigation process.
Communication			
DMP18	Publish the amended DMP on the JAH website.	JAH EM	Within 4 weeks of DMP review completion (or, if applicable, within one month of

Table 1. Dieback Management Plan Summary of Actions.			
Action		**Responsibility**	**Timing**
			endorsement by relevant government regulator).
DMP19	Update the JAH CEMP and tenant OEMP templates with relevant dieback management information (only required if information within current CEMP and OEMP templates is not consistent with the current DMP).	JAH EM	Within 3 months of DMP review completion (or, if applicable, within one month of endorsement by relevant government regulator).
DMP20	Ensure all CEMPs and OEMPs submitted to JAH for review and endorsement adequately addresses dieback management, relevant to the activities proposed to be undertaken.	JAH EM	Prior to endorsing CEMP or OEMP.
DMP21	Include relevant dieback management information within inductions for contractors working across dieback boundaries (e.g. weed spraying contractors).	JAH EM	Ongoing – Inductions to be completed before works commence.
Reporting Requirements			
DMP22	Report against actions of the DMP within the Jandakot Airport Annual Environment Report (AER) and provide copies to DIRD and DOE.	JAH EM	28 October Annually.
DMP23	Report against actions of the DMP within an Annual Compliance Report (ref Condition 16 of EPBC 2009/4796) and publish on the JAH website.	JAH EM	28 October Annually.
Review and Amendment of DMP			
DMP24	Review and update (if required) DMP following triennial dieback survey.	JAH EM	June 2018, then Triennially.

9 Glossary

AER	Annual Environment Report
ASO	Airport Services Officer
CEMP	Construction Environmental Management Plan
CMP	Conservation Management Plan
DEC	Department of Environment and Conservation. On 1 July 2013 the Department of Environment and Conservation separated into two agencies, the Department of Parks and Wildlife (DPAW) and the Department of Environment Regulation (DER).
DEWHA	Department of Environment, Water, Heritage and the Arts (now DOE)
DIRD	Department of Infrastructure and Regional Development (previously DIT)
DIT	Department of Infrastructure and Transport (now DIRD)
DMP	Dieback Management Plan
DOE	Department of the Environment (previously DEWHA and DSEWPaC)
DPAW	Department of Parks and Wildlife (formerly DEC).
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Previously DEWHA and now DOE)
EPBC	Environmental Protection and Biodiversity Conservation Act 1999
JAH	Jandakot Airport Holdings
JAH EM	Jandakot Airport Holdings Environment Manager
OEMP	Operational Environmental Management Plan
OM	Operations Manager
SMS	Safety Management System (an access database used by JAH to record all Incidents).

10 References

Cardno BSD (2005), *Jandakot Airport Land Caladenia huegelii (Declared Rare Flora) Search*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

DEC (1999) *Phytophthora cinnamomi and the disease caused by it. Volume III – Phosphite Operations Guidelines.* Department of Environment and Conservation.

Dieback Working Group (2005), *Managing Phytophthora Dieback in Bushland*, published by WWF Australia.

Ecoscape (2011). *Jandakot Airport Weed Assessment and Bushland Condition,* unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

Essential Environmental (2015), *Jandakot Airport Local Water Management Strategy*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

Glevan Consulting (2000), *Jandakot Airport Interpretation for Phytophthora (Dieback) Species*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

Glevan Consulting (2005), *Jandakot Airport Dieback Assessment*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

Glevan Consulting (2012), *Jandakot Airport Dieback Assessment*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

Glevan Consulting (2015), *Jandakot Airport Triennial Phytophthora Dieback occurrence assessment*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

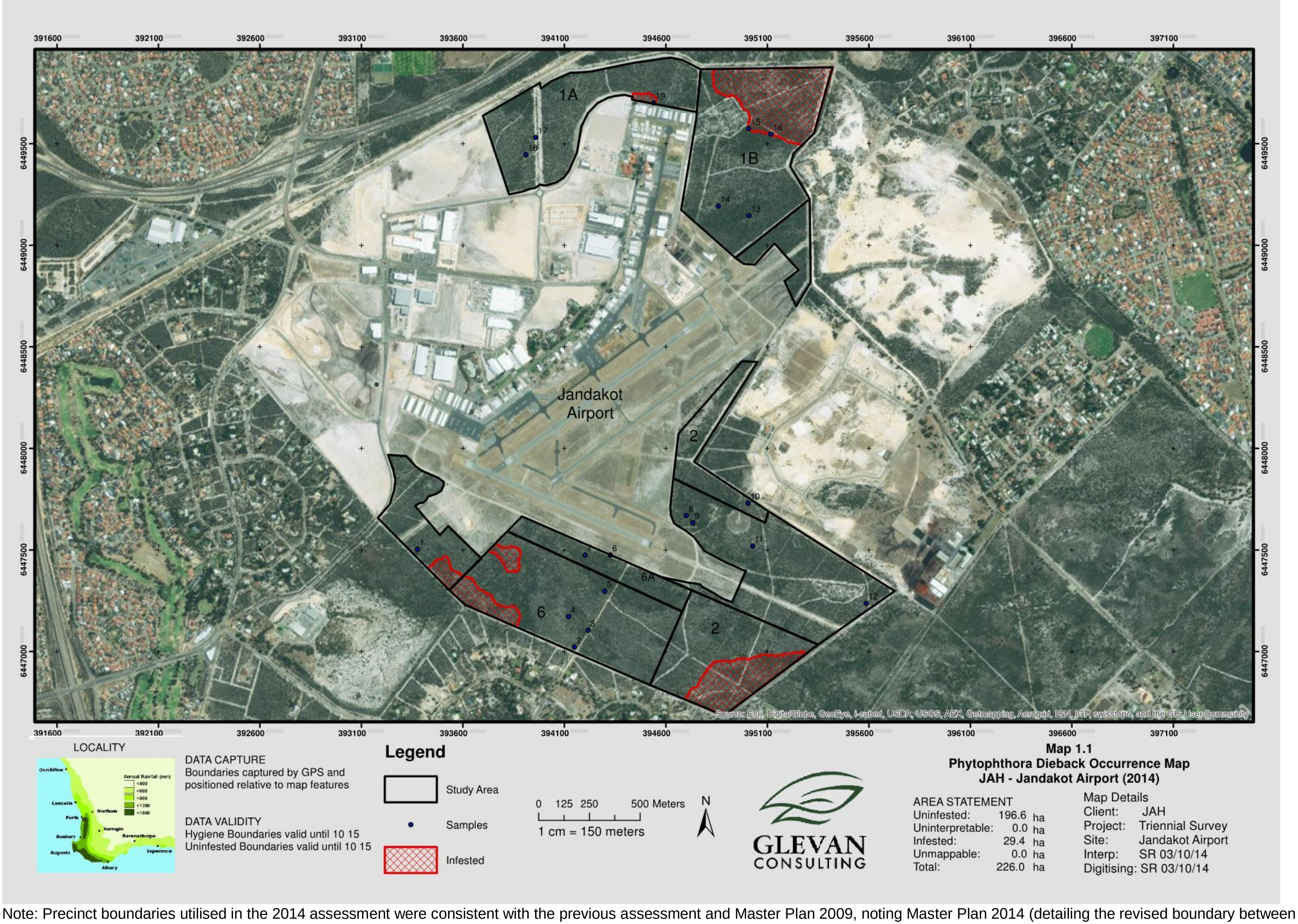
Groves, E., Hardy, G. & McComb, J. (date unknown), *Western Australian Natives Resistant to Phytophthora cinnamomi*, unpublished report prepared by for Murdoch University.

Groves, E., Hardy, G. & McComb, J. (date unknown), *Western Australian Natives Susceptible to Phytophthora cinnamomi*, unpublished report prepared by for Murdoch University.

Murdoch University Centre for Phytophthora Science and Management Diagnostic Facility (Murdoch University) (2006), *Development of a Soil Sampling Regime for Jandakot Airport Holdings Pty Ltd*, unpublished report prepared for Jandakot Airport Holdings Pty Ltd.

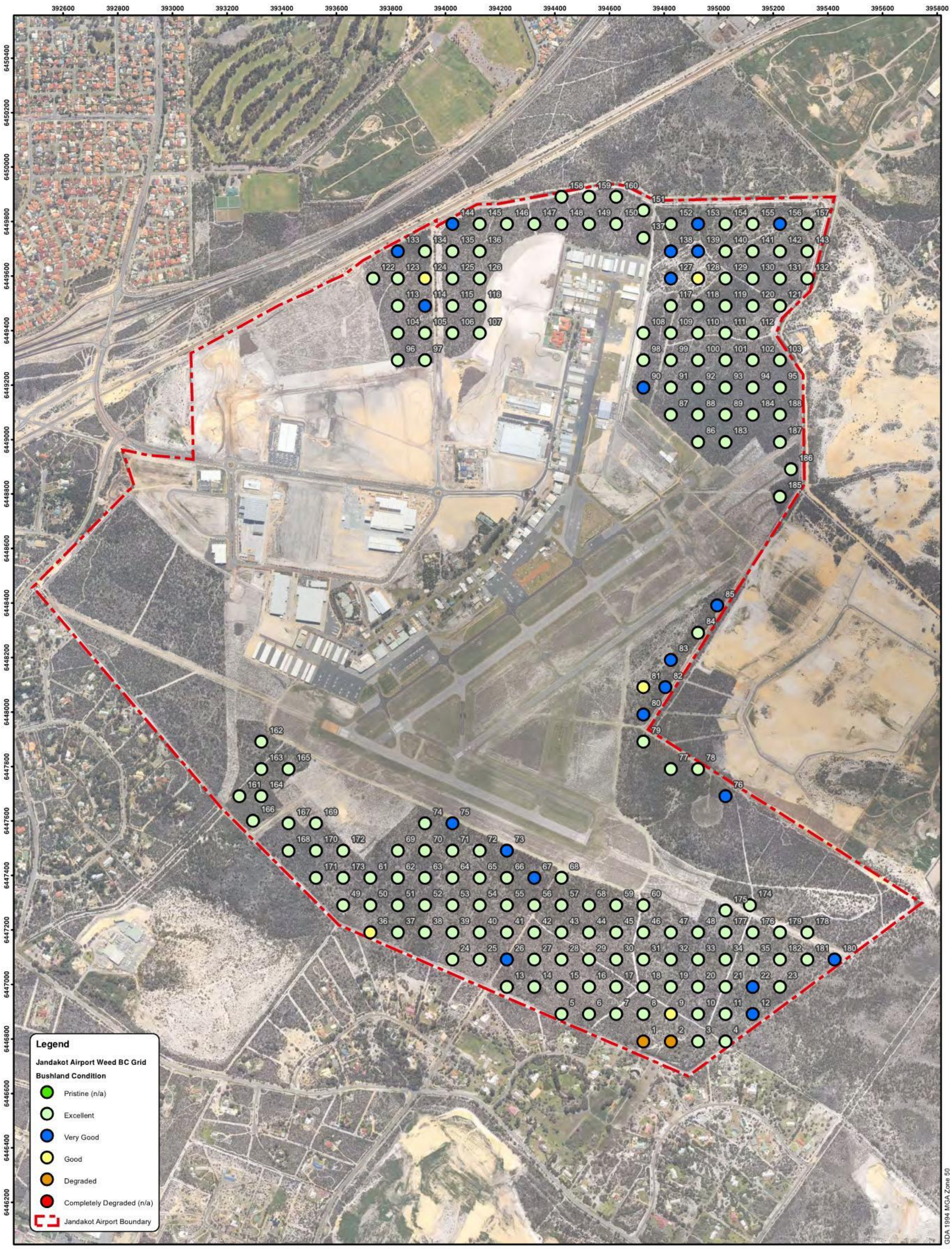
Shearer BL, Hill TC (1989) Diseases of *Banksia* woodlands on the Bassendean and Spearwood Dune systems. *Journal of the Royal Society of Western Australia* **71**, 113–114.

FIGURE 1. JANDAKOT AIRPORT PHYTOPHTHORA CINNAMOMI OCCURRENCE 2014



Note: Precinct boundaries utilised in the 2014 assessment were consistent with the previous assessment and Master Plan 2009, noting Master Plan 2014 (detailing the revised boundary between Precinct 1A and 1B) was yet to be approved at the time of assessment.

FIGURE 2. VEGETATION CONDITION MAPPING 2011



Map 3

Sep 2011

Jandakot Weed and Bushland Condition Survey

Bushland Condition

prepared for Jandakot Airport Holdings

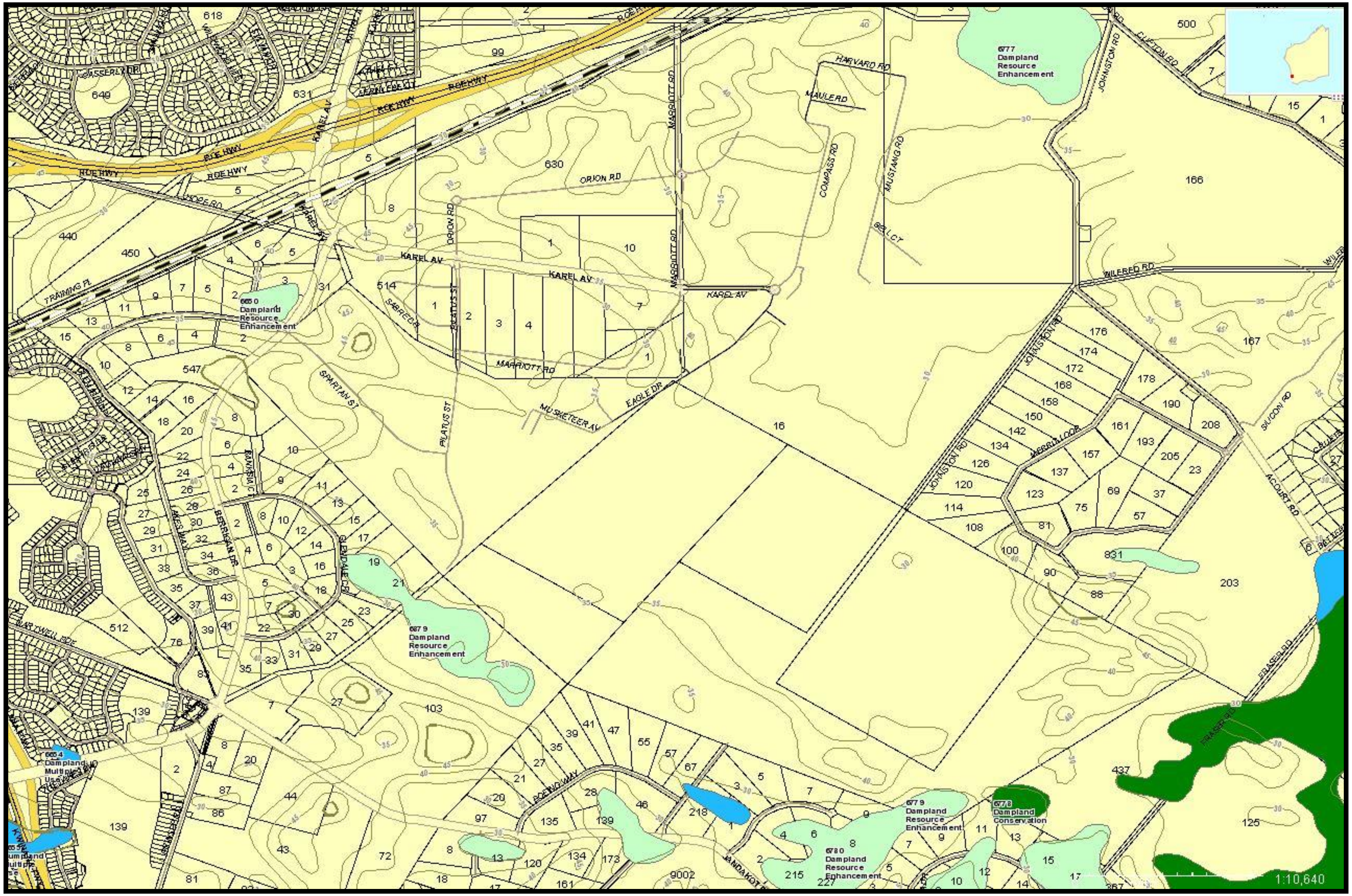
0 100 200 300 400 500 Metres

1:12,000 @ A3

Project No. 2701-11

ecoscape

FIGURE 3. DAMPLANDS



Source: WA Atlas, Landgate 2015.

Attachment 1. JAH Contractor Dieback Hygiene Policy and Guidelines

DIEBACK HYGIENE POLICY

The objective of dieback management is to protect all vegetation within Jandakot Airport by minimizing the risk of introducing and spreading *Phytopthora cinnamomi.*

BACKGROUND

Phytophthora cinnamomi, also known as 'dieback' or 'jarrah dieback', is a soil-borne pathogen that kills a wide range of plant species in the southwest of WA by destroying their root systems. *P. cinnamomi* causes disease in a range of vegetation communities and affects a diverse range of plants. Native plant communities particularly at risk from *P. cinnamomi* include those dominated with Banksia species – such as the vegetation at Jandakot Airport.

A number of known dieback infested areas exist at Jandakot Airport. These areas have been mapped and Jandakot Airport Holdings aims to ensure that dieback is not spread via unhygienic practices from these areas into uninfested areas either elsewhere on the Airport estate or offsite.

Similarly, Jandakot Airport Holdings aims to ensure that unhygienic practices do not result in new dieback infestations being introduced to the airport from off-site sources.

SPREAD

Dieback can spread:

- by water (drainage, irrigation or groundwater flow)
- in soil (transported by bulk soil deliveries, containers, shoes, tools, vehicles and other equipment)
- by the movement of infected plants and plant materials.

Natural spread dieback is generally slow and is achieved through movement of the pathogen along plant root systems or, on a faster scale, through the movement of microscopic spores in surface and sub-surface water flows, and by animals.

Human-related vectors can disperse the pathogen much more quickly and are believed to be the primary reason for the widespread distribution of dieback in WA. <u>Any activity that transfers soil and plant material (either intentionally on non-intentionally) from one location to another is a potential vector.</u> Examples of activities that can contribute to the spread of the pathogen include:

- road construction and civil works
- earth moving
- vegetation clearing
- revegetation activities
- off-road/four-wheel driving.

CONTRACTOR CONSTRUCTION/DIEBACK MANAGEMENT PLANS

In order to ensure that appropriate hygiene controls are in place to prevent dieback spread, contractors undertaking activities that can contribute to the spread of dieback will need to address dieback management within a project-specific Construction Environment Management Plan (CEMP) or Dieback Management Plan (DMP).

BASIC DIEBACK HYGIENE MANAGEMENT MEASURES AND GUIDLEINES

- Where possible, schedule activities that involve soil disturbance for dry summer months (November – March) or dry conditions.
- Minimise soil disturbance – consider mowing, slashing or use herbicide, rather than ploughing and grading, whenever possible.
- When undertaking works across dieback category boundaries (i.e. in areas that include both infested and uninfested), where possible complete activities in the uninfested part of the bushland, before moving to the infested part of the bushland.
- In the uninfested parts of the estate/bushland:
  - ➢ Do not bring in soil/sand/gravel. If it is required, it should be obtained from certified phytophthora-free sources.
  - ➢ Landscape supplies should be sourced from either certified phytophthora-free sources or accredited Nursery Industry Association suppliers.
  - ➢ Prevent vehicles and machinery entering bushland. If they must enter, they must be free of soil and mud, and restricted to a hard, dry surface wherever possible.
  - ➢ Vehicles are to be cleaned off-site prior to initially accessing the airport for works. If vehicles temporarily leave site, they must be re-cleaned before returning unless they have remained on sealed roads in low-risk areas (e.g. trucks that make multiple daily journeys to cart sand from Jandakot airport development areas to off-site storage facilities).
  - ➢ Footwear to be free of mud and soil when entering bushland.
  - ➢ Any water used in earthworks etc. must be from approved sources (e.g. mains supply, approved bores etc.)
- In the infested parts of the estate/bushland
  - ➢ Prevent vehicles and machinery entering. If they must enter, restrict them to hard, dry surfaces and vehicles are to be free of soil and mud when exiting the infested bushland.
  - ➢ Do not remove soil/sand/gravel from the infested part of the bushland. If it must be removed, it must be placed at a site that is also infested with *P. cinnamomi* or managed in accordance with the approved CEMP or project-specific DMP.
  - ➢ Footwear must be free of mud and soil when exiting the bushland.

GUIDELINES FOR CLEANING EQUIPMENT AND VEHICLES

Cleaning will be easier and more effective if completed at a depot or designated cleaning area prior to accessing the airport. In instances where on-site cleaning must occur (e.g. prior to exiting dieback infested areas), the below guidelines are provided to assist in the development of a CEMP or project-specific DMP.

Field-based cleaning requires:

- A hard, well-drained surface (e.g. road or ramp) that is well away from native vegetation. Any wash-down effluent (water, mud and slurry) must be collected on-site and must not be allowed to drain into uninfested bushland.
- Minimise water use to remove soil and mud from equipment/vehicles. This can be achieved by preferentially dry cleaning techniques e.g. stiff brushes.

- Pay particular attention to mudflaps and tyres.
- Do not drive through effluent generated from cleaning when exiting the washdown facility.

Guidelines for cleaning footwear

- Try to remove mud and soil when it is dry. Remove as much mud and soil as possible with a stiff brush or stick and minimise the amount of water used.
- Collect all mud and soil removed and dispose of at a site that is infested with *P. cinnamomi*.

Guidelines for sterilising

Sterilisation of equipment, footwear and vehicle tyres can be used as an extra precaution. Sterilisation of nursery equipment using steam is common practice; however the use of steam is not practical in the field. The following sterilisation methods can be used in the field.

- Spray methylated spirits on small hand tools and footwear covering all surfaces and allowing a few minutes for it to soak into all soil material.
- Spray diluted bleach (sodium hypochlorite) onto equipment and footwear allowing a few minutes before rinsing the bleach off using water. Dilute bleach so that solution contains 1% active ingredient sodium hypochlorite. Be sure to follow any of the manufacturer's safety instructions provided on the bleach container.
- Phytoclean® or other effective disinfectants can be used in footbaths, washdown facilities and during the cleaning of equipment. See the manufacturer's details for directions.

Attachment 2. Jandakot Airport Flora Species Dieback Susceptibility

S = Dieback Susceptible; R = Dieback Resistant
Taken from information compiled by E.Groves, G.Hardy and J.McComb, Murdoch University. Species list reviewed by Mark Brundrett, 2011.

Acacia applanata	
Acacia huegelii	*R*
Acacia pulchella	*R*
Acacia saligna	*R*
Acacia stenoptera	*S*
Acacia willdenowiana	
Adenanthos cygnorum	*S*
Adenanthos obovatus	*S*
Allocasuarina fraseriana	*S*
Allocasuarina humilis	*S*
Amphipogon laguroides	
Amphipogon turbinates	
Anigozanthos humilis	
Anigozanthos manglesii	*R*
Aotus sp. procumbent	
Arnocrinum preissii	
Astartea fascicularis	*R*
Astroloma xerophyllum	*S*
Austrodanthonia occidentalis	
Austrodanthonia pilosa	
Austrostipa compressa	
Baeckea camphorosmae	*R*
Banksia attenuata	*S*
Banksia grandis	*S*
Banksia ilicifolia	*S*
Banksia littoralis	*S*
Banksia menziesii	*S*
Banksia nivea	*S*
Baumea articulata	
Beaufortia elegans	
Beaufortia squarrosa	
Boronia busselliana	
Boronia crenulata	*R*
Boronia ramosa	
Bossiaea eriocarpa	*S*
Brachyloma preissii	
Burchardia congesta	*R*
Caladenia discoidea	
Caladenia flava	

Caladenia huegelii	
Caladenia longicauda	
Calectasia narragara	
Calytrix angulata	
Calytrix flavescens	*R*
Calytrix fraseri	
Calytrix strigosa	
Cassytha flava	*R*
Cassytha glabella	*R*
Cassytha racemosa	
Centrolepis aristata	
Centrolepis drummondiana	
Centrolepis humillima	
Chamaescilla corymbosa var. corymbosa	
Chordifex microcodon	
Comesperma calymega	*R*
Conospermum triplinervium	*S*
Conostephium minus	
Conostephium pendulum	*S*
Conostephium preisii	
Conostylis aculeata	*R*
Conostylis aurea	
Conostylis caricina ssp. Caricina	
Conostylis juncea	
Conostylis setigera ssp. Setigera	*R*
Crassula colorata	
Croninia kingiana	
Cryptostylis ovata	*R*
Cyanicula gemmata	
Cyathochaeta avenacea	*R*
Dampiera linearis	*R*
Danthonia pilosa	
Dasypogon bromeliifolius	*S*
Daviesia gracilis	
Daviesia incrassata	*S*
Daviesia juncea	
Daviesia nudiflora	
Daviesia physodes	*S*
Daviesia triflora	

Desmocladus fasciculatus	*R*
Desmocladus flexuosus	*R*
Dianella revoluta	*S*
Dielsia stenostachya	
Diuris corymbosa	
Diuris emarginata	
Diuris laxiflora	
Drosera erythrorhiza	*R*
Drosera macrantha	
Drosera menziesii ssp. Penicillaris	
Drosera paleacea ssp. Paleacea	
Drosera pulchella	
Eremaea asterocarpa	
Eremaea pauciflora	
Eriostemon spicatus	*R*
Eucalyptus gomphocephala	*R*
Eucalyptus marginata	*S*
Eucalyptus rudis	*R*
Eucalyptus todtiana	*S*
Euchilopsis linearis	
Euchiton sphaericus	
Eutaxia virgata	
Gastrolobium capitatum	
Gnaphaluim sphaericum	
Gompholobium confertum	
Gompholobium scabrum	
Gompholobium tomentosum	*R*
Gonocarpus pithyoides	
Goodenia pulchella	
Haemodorum paniculatum	*R*
Haemodorum spicatum	
Hardenbergia comptoniana	*R*
Hemiandra pungens	*R*
Hensmania turbinata	
Hibbertia aurea	
Hibbertia huegelii	*S*
Hibbertia hypericoides	*S*
Hibbertia pachyrrhiza	
Hibbertia racemosa	*R*
Hibbertia subvaginata	
Homalosciadium homalocarpum	
Hovea trisperma	*R*
Hyalosperma cotula	
Hypocalymma angustifolium	*R*
Hypocalymma robustum	*S*

Hypolaena exsulca	
Hypolaena pubescens	
Jacksonia furcellata	*S*
Jacksonia sternbergiana	*S*
Juncus kraussii	
Kennedia prostrata	*R*
Kunzea ericifolia	*S*
Laxmannia ramosa	
Laxmannia squarrosa	
Lechenaultia biloba	*R*
Lechenaultia expansa	
Lechenaultia floribunda	
Lepidosperma angustatum	
Lepidosperma effusum	
Lepidosperma longitudinale	
Lepidosperma scabrum	*R*
Lepidosperma squamatum	*R*
Lepidosperma tenue	*R*
Leporella fimbriata	*R*
Leptocarpus canus	
Leptocarpus tenax	
Leptomeria empetriformis	
Leptospermum erubescens	*R*
Lepyrodia muirii	
Leucopogon australis	*S*
Leucopogon constephioides	*S*
Leucopogon insularis	
Leucopogon kingianus	
Leucopogon nutans	*S*
Leucopogon oxycedrus	*S*
Leucopogon pendulus	*R*
Leucopogon polymorphus	*S*
Leucopogon propinquus	*S*
Leucopogon pulchellus	*S*
Leucopogon racemulosus	
Leucopogon strictus	
Levenhookia stipitata	
Lobelia tenuior	
Lomandra caespitosa	
Lomandra endlicheri	
Lomandra hermaphrodita	
Lomandra micrantha	
Lomandra nigricans	*R*
Lomandra odora	*S*
Lomandra preissii	*R*

Lomandra purpurea	
Lomandra suaveolans	
Loxocarya cinerea	*S*
Loxocarya pubescens	
Loxycarya fasciculata	
Loxycarya flexuosa	
Lyginia barbata	
Lyperanthus nigricans	
Lysinema ciliatum	*S*
Lysinema elegans	
Macrozamia riedlei	*S*
Melaleuca incana	
Melaleuca preissiana	*R*
Melaleuca scabra	*S*
Melaleuca seriata	*R*
Melaleuca systena	
Melaleuca thymoides	*S*
Mesomelaena pseudostygia	
Mesomelaena stygia	*R*
Mesomelaena tetragona	*R*
Microtis media	
Millotia tenuifolia	*R*
Mitrasacme paradoxa	
Monotaxis grandiflora	
Neurachne ps.	
Nuytsia floribunda	*R*
Patersonia occidentalis	*S*
Perricalymma ellipticum	*S*
Persoonia saccata	*R*
Petrophile linearis	*S*
Philotheca spicata	
Phlebocarya ciliata	*R*
Phlebocarya filifolia	
Phyllangium paradoxum	
Pimelea angustifolia	
Pimelea imbricata	
Pimelea rosea	
Pimelea sulphurea	
Pithocarpa pulchella	
Platysace compressa	*S*
Platytheca galioides	
Podotheca angustifolia	
Podotheca chrysantha	
Poranthera microphylla	
Prasophyllum parvifolium	

Pterostylis pyramidalis	
Pterostylis recurva	
Pterostylis vittata/sanguinea?	
Pultenaea reticulata	
Pyrorchis nigricans	
Quinetia urvillei	
Regelia ciliata	
Regelia inops	
Restio microcodon	
Restio stenostachyus	
Ricinocarpus glaucus	
Scaevola paludosa	
Scaevola repens	
Schoenus brevisetis	
Schoenus curvifolius	*R*
Schoenus efoliatus	
Schoenus globifes	
Schoenus rodwayanus	
Scholtzia involucrata	*S*
Senecio lautis ssp. Maritimus	
Siloxerus humifusus	
Sowerbaea laxiflora	
Stackhousia monogyna	
Stirlingia latifolia	*S*
Stylidium brunonianum	*R*
Stylidium carnosum	
Stylidium guttatum	
Stylidium junceum	*S*
Stylidium piliferum	*R*
Stylidium repens	
Stylidium schoenoides	*S*
Synaphea spinulosa	
Synaphea sp.	
Tetratheca setigera	*S*
Thelymitra campanulata	
Thelymitra crinita	
Thelymitra fuscolutea	
Thysanotus arbuscula	
Thysanotus manglesianus	
Thysanotus multiflorus	
Thysanotus patersonii	
Thysanotus sparteus	
Thysanotus thyrsoideus	*S*
Thysanotus triandrus	
Trachymene pilosa	

Tricoryne elatior	*R*
Tricoryne tenella	
Tripterococcus brunonis	
Verticordia drummondii	
Wahlenbergia preissii	
Waitzia suaveolens	
Xanthorrhoea preissii	*S*
Xanthosia huegelii	*R*

Attachment 3. 2014 *Phytophthora cinnamomi* Occurrence Assessment

JAH

Jandakot Airport

Triennial Phytophthora Dieback occurrence assessment – Version 0.2

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.

Author Simon Robinson

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 remnant vegetation within the Jandakot Airport Study Area for the presence of Phytophthora Dieback. The assessment was conducted from 22-09-2014 to 03-10-2014 by Simon Robinson.

The study area has been assessed previously by Glevan Consulting of several occasions, and most recently in 2011, as part of Jandakot Airport Holdings' (JAH) commitment to undertaking Phytophthora Dieback assessments on a triennial basis. The study area has been reduced in size since the 2011 assessment, due to the clearing of two significant sections in the north west of the study area, and now comprises a total of 226 hectares. The study area was assessed in its entirety, with no areas excluded from the assessment.

No new Phytophthora Dieback infestations were identified during the assessment, and only minor adjustments were made to the boundaries of the five existing infestations. Minimal disease expression was evident during the assessment, and the lack of expression is most likely the result of phosphite treatment which occurred in 2012 and 2013. A significant amount of vegetation decline not related to Phytophthora Dieback was observed during the assessment, and 19 soil and tissue samples were taken to assist with the diagnosis of these areas.

The Dieback mapping performed during this assessment is valid for 3 years and will expire in October 2017. It is recommended however, where clearing and development works are still occurring beyond 12 months that any Dieback boundaries associated with the works be reassessed.

It is also recommended that a Hygiene Management Plan be devised for use during the scheduled clearing and construction activities.

2 Introduction

2.1 Background

Glevan Consulting was commissioned by JAH to conduct an assessment of the remnant vegetation within the Jandakot Airport Study Area for the presence of Phytophthora Dieback. Under the EPBC Conditions of Approval and JAH's Dieback Management Plan, it is a requirement that Phytophthora Dieback occurrence mapping is conducted at Jandakot Airport every three years. The updated occurrence mapping will also provide boundaries for the phosphite treatment program scheduled for 2015, and clearing activities scheduled for 2015/16.

2.2 Location of Study Area.

Jandakot Airport is located on Eagle Drive, within the suburb of Jandakot, approximately 15 km south of Perth CBD and comprises approximately 622 ha. The study area for the assessment is comprised of the 226 ha of remnant vegetation surrounding the airport facilities (Figure 1).

Figure 1 - Study Area

2.3 Study team

The assessment was conducted by Simon Robinson of Glevan Consulting in September and October of 2014. Mr Robinson is accredited by the Department of Parks and Wildlife (DPaW) 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 environment 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.

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 plant communities with almost 100% susceptibility. 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 which occur 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* locations retained by Glevan Consulting and Vegetation Health Services (DPaW) were searched to determine previous recoveries of *Phytophthora* within the project area.

Previous Phytophthora Dieback Occurrence reports and maps pertaining to the study area were also studied prior to undertaking the field work.

4.2 Interpretation

Based on the considerations of Section 3 'Phytophthora Dieback', 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.

<u>Deaths of disease indicating species:</u>
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.

<u>Chronology of deaths:</u>

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.
	Unmappable	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

Phytophthora Dieback infestations were demarcated with day-glow orange flagging tape. A single band of tape was tied to a suitable tree with the knot facing towards the infestation. The taped boundaries were positioned on, or within 3 metres of the perceived disease front, and placed approximately 10 -15m apart.

4.4 Soil and tissue sampling

Suspicious sites can have 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.

Samples were processed at the Department of Parks and Wildlife's Vegetation Health Service (VHS) laboratory in Kensington using the *Eucalyptus sieberi* cotyledon baiting method. The laboratory provides a dedicated, specialist scientific service for the detection and identification of Phytophthora species from samples associated with Western Australia's forest and conservation estate, timber harvesting and mining activities, private industry and research.

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 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.

4.6 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 boundaries mapped for this project is three years from the completion of this project (10/2017). However, for areas in which operations are occurring i.e. clearing, it is recommended that the boundaries be rechecked after 12 months.

5 Project area environmental data

5.1 Rainfall

The average annual rainfall recorded for Jandakot Airport over the past 40 years is 826mm (Bureau of Meteorology, 2014) which, combined with several months of average soil temperatures above 21 degrees Celsius, provides favourable conditions for sporulation and increased disease activity.

5.2 Soil types

The soil within the study area appeared to be consistent with that normally observed on the Bassendean dune system. The soils are old, free draining, heavily leached, nutrient deficient and acidic, with very little clay and silt content. The interdunal depressions are subject to seasonal waterlogging, and have poor drainage, providing high moisture conditions for extended periods, which are very favourable to the pathogen.

5.3 Vegetation structure

The vegetation is typical Swan Coastal Plain Banksia woodland featuring *Banksia menziesii* and *Banksia attenuata* over a species rich understorey of Proteaceous and Myrtaceous shrubs and grass trees. Such vegetation has relatively high susceptibility to Phytophthora Dieback and generally provides good levels of disease expression, assisting in the detection and mapping of infested areas.

The combination of the above environmental factors suggests that if Phytophthora Dieback was present within the study area, it would be readily detected and mapped.

6 Results

6.1 Phytophthora Dieback occurrence distribution

Disease distribution was observed to be almost identical to the 2011 survey, with only minor changes made to the existing boundaries. Five infestations, comprising a total of 29.4 ha were observed during the assessment, and the remaining 196.6 ha of the study area was found to be uninfested.

The vast majority of the infested vegetation within the study area correlates directly with water-gaining sites, and the disease has not spread significantly beyond these water-gaining areas. No new infestations were identified during the assessment.

Table 2 - Area Summary

Category	Area (ha)	% of total area
Infested (with *P. cinnamomi*)	29.4 ha	13 %
Unmappable	0.0 ha	%
Uninfested	196.6 ha	87 %
TOTAL AREA	226.0 ha	

6.2 Disease expression

Disease expression was variable across the study area, but was generally found to be subtle or non-perceptible. It appears likely that disease expression has been supressed by the application of phosphite on and around the disease front in recent years.

6.3 Soil and tissue samples

A total of 19 soil and tissue samples were taken during the assessment. Samples one to 18 returned a negative result for the presence of *P. cinnamomi*, while sample 19 (control sample), tested positive for the presence of *P. cinnamomi* (Table).

Table 3 – Project Area Sample Summary

Sample	Plant sampled	Easting	Northing	Result
1	***Xanthorrhoea preissii***	**393374**	**6447504**	***Negative***
2	***Banksia attenuata***	**394156**	**6447024**	***Negative***
3	***Xanthorrhoea preissii***	**394220**	**6447100**	***Negative***
4	***Xanthorrhoea preissii***	**394122**	**6447176**	***Negative***
5	***Xanthorrhoea preissii***	**394300**	**6447290**	***Negative***
6	***Xanthorrhoea preissii***	**394320**	**6447470**	***Negative***
7	***Banksia attenuata***	**394200**	**6447475**	***Negative***
8	***Xanthorrhoea gracilis***	**394700**	**6447650**	***Negative***
9	***Xanthorrhoea preissii***	**394730**	**6447633**	***Negative***
10	***Xanthorrhoea preissii***	**395000**	**6447730**	***Negative***
11	***Xanthorrhoea preissii***	**395035**	**6447520**	***Negative***
12	***Xanthorrhoea preissii***	**395585**	**6447237**	***Negative***
13	***Xanthorrhoea preissii***	**395020**	**6449140**	***Negative***
14	***Xanthorrhoea preissii***	**394860**	**6449190**	***Negative***
15	***Xanthorrhoea preissii***	**395010**	**6449571**	***Negative***
16	***Xanthorrhoea preissii***	**395115**	**6449550**	***Negative***
17	***Xanthorrhoea preissii***	**393956**	**6449525**	***Negative***
18	***Xanthorrhoea preissii***	**393905**	**6449445**	***Negative***
19	***Banksia attenuata***	**394540**	**6449702**	***Positive***

7 Discussion

7.1 Phytophthora Dieback occurrence distribution

A total of five infestations comprising a total of 29.4 ha were observed and mapped during the assessment. All the infestations had been previously mapped, and no new infestations were identified during the assessment. Disease distribution was observed to be almost identical to the 2011 survey, with only minor changes made to the existing boundaries. The remaining 196.6 ha of the study area was found to be uninfested.

The vast majority of the infested vegetation within the study area correlates directly with water-gaining sites, and the disease has not spread significantly beyond these water-gaining areas. Water-gaining sites are usually subject to seasonal waterlogging or inundation, providing ideal conditions for the survival and sporulation of the pathogen. Spread of the disease is generally faster within high moisture sites, where the disease is transported by water and does not rely on root to root contact to be transmitted.

The spread of the disease from these infested water-gaining sites now appears to be relatively slow, as it is likely that the pathogen has already spread throughout the areas that are subject to seasonal waterlogging/inundation, and is now slowly spreading autonomously (root to root contact) away from the immediate water-gaining areas. This is a favourable situation in terms of management. Not only should natural rates of spread continue to be low, but the movement of the disease front should be predictable and easily monitored.

The smaller of the two infestations in Precinct 6 (Map 1) is not associated with a water-gaining site, however it is also characterised by heavily reduced biomass, particularly towards the infestation centre. Interestingly, no fresh indicator species deaths (ISD's), or any evidence of disease activity since the previous survey were observed within this infestation.

The complete lack of disease activity at the time of the survey, and the negative sample result recorded during the previous survey (Glevan Consulting, 2011,) caused the interpreter to question the status of the area. However, it was noted that this area was treated with phosphite in January 2013, and it is likely that this treatment is still providing very effective 'protection' for the susceptible plants in the area. Moreover, a check of historical sample data confirms that a positive sample result has been recorded within this area during a much earlier survey (Glevan Consulting, 2000), and as such, the infested status has been retained.

The small infestation adjacent to the main access road in Precinct 1A exhibited relatively good disease expression, with several fresh indicator species deaths observed, and a perceptible disease front. Although not technically a water-gaining site, the infested area is located in a small depression in the landscape, and the disease has not spread significantly outward from this low-lying area.

As the study area is under Dieback Management, the risk of further disease introduction or spread is minimal. Disease spread within the study area appears to be confined to autonomous movement (root to root contact). There is no evidence of the pathogen being spread by vehicles or wildlife. Several vehicle tracks and kangaroo trails were observed to intersect the infested areas, but there was no evidence that the disease has been spread as a result.

7.2 Disease expression

Disease expression was variable across the study area, but was generally found to be subtle or non-perceptible. It appears likely that disease expression has been supressed by the application of phosphite on and around the disease front conducted in March 2012 and January 2013. This treatment has meant that many susceptible plants on the disease front, that would otherwise have perished, have survived, greatly reducing the number of ISD's present.

Phosphite (also known as phosphonate) is a biodegradable fungicide that can increase a plant's own natural defences, and help susceptible species survive in infested areas. CALM trials in Swan Coastal Plain *Banksia* Woodland have found that aerial applications of 30-60 l/ha of 40% phosphite can give effective protection for up to 3 years (DEC 1999).

A significant amount of vegetation decline not related to *P. cinnamomi* was observed throughout the study area. The characteristic pattern normally associated with the presence of *P. cinnamomi* was not observed at these sites, and the plant deaths appeared to be largely scattered, random and 'staged'. This is consistent with observations made during the 2011 survey, in which drought was considered to be the most likely cause of the vegetation decline observed.

In general, the actual *P. cinnamomi* infestations were readily distinguished from the other areas of vegetation decline. In addition to strongly correlating with the very high risk water-gaining sites, the infested areas also exhibited significantly reduced biomass, especially towards the older, central part of the infestation where the highly susceptible species were almost completely absent. Identifying and delineating the actual boundaries (the disease front) of these infestations however, was considerably more difficult.

The presence of significant numbers of non-Phytophthora related indicator species deaths near the actual infestation boundaries meant that the distinction between Phytophthora related deaths, and unrelated deaths, was not always obvious and consideration of other evidence was necessary. The combination of reduced biomass and the previously delineated boundaries were used to best estimate the location of the disease edge in these areas. The adjustment of the boundary included calculations based on the time elapsed since the previous survey, in conjunction with knowledge of disease spread rates on the Swan Coastal Plain sands.

7.3 Soil and tissue sampling strategies

As per the 2011 survey, a significant number (18) of samples were taken to eliminate *P. cinnamomi* as the cause of the unexplained decline, and all tested negative for the presence of *P. cinnamomi*. To further rule out *P. cinnamomi* as the cause, a 'control sample' (sample 19) was taken provide evidence that 'false negative' sample results are not being recorded. The sample was taken in a known and very well defined infestation that contained obvious expression and fresh ISD's. The sample produced a positive result for the presence of *P. cinnamomi,* supporting the view that if Phytophthora Dieback was present in the other plants sampled, it would almost certainly be detected in the laboratory.

Samples 15 and 16 were associated with the infestation in precinct 1B and were taken to determine whether a number of fresh *X. preissii* deaths observed were representative of disease spread, or related to factors other than Phytophthora Dieback. The samples returned negative results, indicating that the deaths are not related to Phytophthora Dieback.

As a precaution, the Dieback boundary was adjusted (moved back between 5m and 15m over a section approximately 70m in length) to incorporate the sample sites, and has not been re-adjusted back to the original position (to reflect the negative sample results). The decision to maintain the adjusted boundary was based on it being a relatively minor adjustment, and there is also a possibility that another pathogenic organism has caused the plant deaths.

7.4 Management of soil and plant material during clearing operations

Top-soil and plant material can be buried at a suitable depth beneath the area from which it has been removed. This is thought to be the easiest and most cost-effective method of disposing of infested soil and plant material. However, if this is not practicable, it is recommended that the vegetation be stockpiled in an appropriate area until such time as it can be burned. The topsoil will need to be disposed of at an appropriate receiver site.

Potential issues associated with burning the material include the hazard posed by conducting a large fire in the near vicinity of an airport (visibility issues for aircraft pilots), and the large volumes of smoke potentially affecting residents in nearby suburbs (may be difficult to get council approval). Timing would be crucial for such an exercise, as it would require cool weather, with minimal wind during burning off season, on a day when there is little or no airport traffic.

Another possible option for disposal of the woody vegetative material is to offer the material to a company such as Simcoa to be used to produce charcoal and ultimately silica. The material would need to be transported from Jandakot Airport via truck, meaning that hygiene measures relating to the transport and storage of the material would apply. The trucks transporting the material should remain in the Dieback-free areas when being loaded, and trucks must enter the Dieback areas, they must be cleaned down when re-entering the Dieback-free areas. It is also important that the material be well secured to the truck, and that material cannot fall from the truck during transport.

Mulching of the plant material is not recommended as it will likely be difficult to find a suitable receiver site.

8 Recommendations

- Devise a Phytophthora Dieback Hygiene Management Plan to be implemented during scheduled clearing and construction activities.

- Following clearing and levelling, a ’green bridge’ can be created across infested areas to facilitate unrestricted movement of vehicles across Dieback boundaries. The bridge must be constructed of material of a suitable type and depth so as to prevent vehicles breaking through the bridge and into the underlying infested material.

- Revegetation of infested areas that have been cleared should consist of non-susceptible species or species with low susceptibility.

- Where practicable, soil and plant material collected during clearing operations within infested areas, should be buried at an appropriate depth immediately beneath where it was removed.

- Where burying infested material, or transporting the infested material offsite is not practicable, vegetation should be stockpiled in an appropriate area, and burned when possible. The infested soil may be deposited at an appropriate (infested) receiver site, either onsite, or offsite.

- Soil and plant material of infested or unknown dieback status should not be introduced to the uninfested sections of the study area.

- Soil and plant material should not be transported from the infested sections of the study area for use at any other protectable area. Infested soil can however be used beneath the pavements of new runways and taxiways where there is no natural vegetation in the immediate vicinity (i.e. areas that are currently the cleared runway offshoot areas).

- Soil movement within each category is permissible, but should not occur across category boundaries, except where the source is uninfested.

- Vehicles and machinery should be clean upon entry to the site, and when moving from infested areas into uninfested areas.

9 Bibliography

Bureau of Meteorology, *Climate Statistics for Australian Locations*. Available from: http://www.bom.gov.au/climate/averages/tables/cw_009172.shtml [24 November 2014].

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

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 (2011). *Jandakot Airport P.c Assessment 2011.* Unpublished report for Jandakot Airport Holdings.

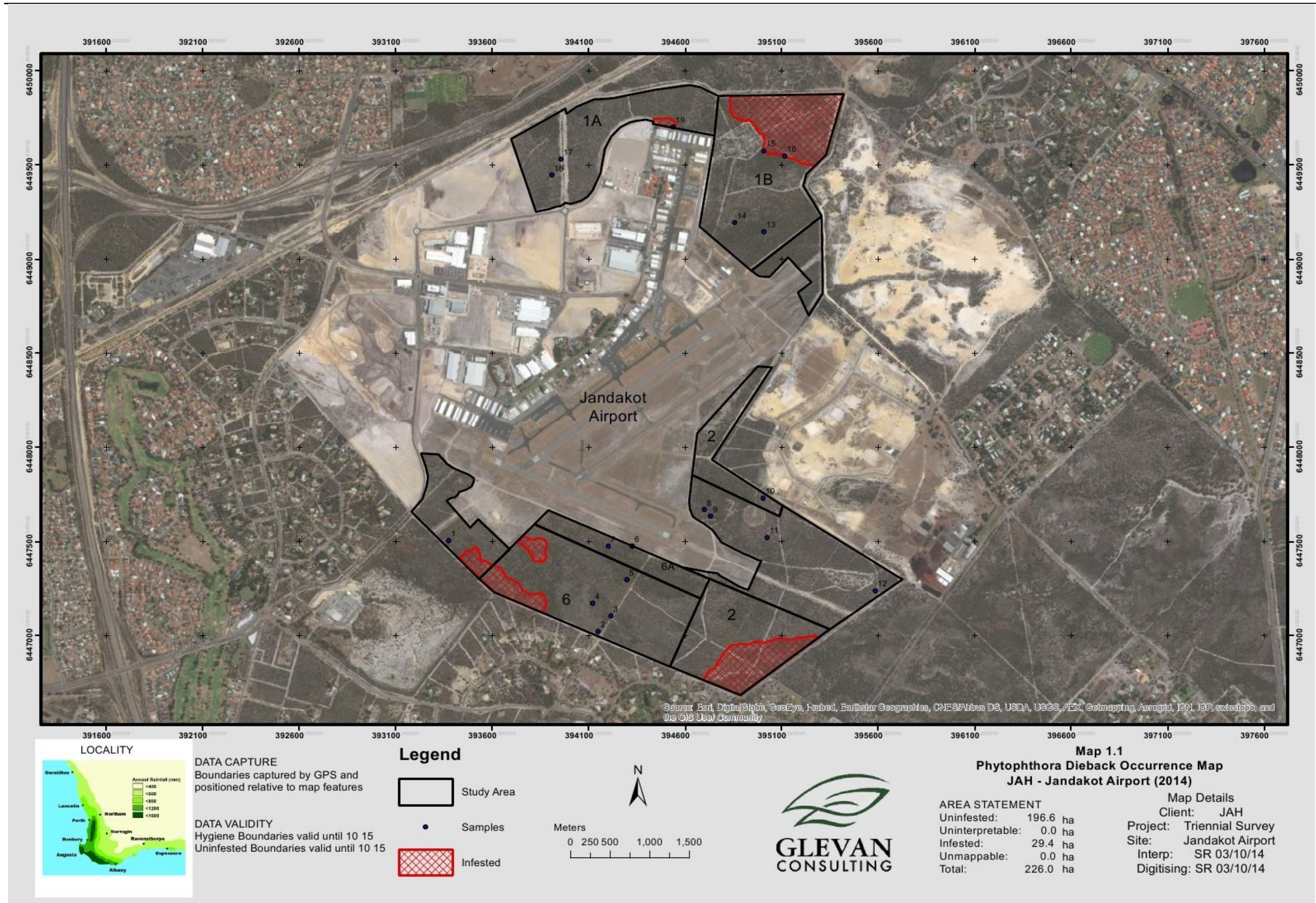
Glevan dieback Consultancy Services (2000). *Jandakot Airport Interpretation for Phytopthora (dieback) species*. Unpublished report for Jandakot Airport Holdings.

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.

10 Appendix – Phytophthora occurrence map



Client: Jandakot Airport Holdings

Project: Dieback Management Plan Update

Location: Jandakot Airport

Phytophthora cinnamomi occurrence assessment

Report compiled by Simon Robinson of Glevan Consulting

GLEVAN CONSULTING

Disclaimer

This report has been prepared in accordance with the scope of work agreed between Jandakot Airport Holdings 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 to Jandakot Airport Holdings 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	Reviewed and approved by
Final	SR	21-05-2012	EB
Version 2			

Table of Contents

Executive Summary

Glevan Consulting conducted an assessment for the presence of the disease caused by *Phytophthora cinnamomi* in the nominated sections of remnant vegetation and amenity gardens within the Jandakot Airport Study Area. Five previously identified infestations were reassessed and demarcated. A total of 31 samples were taken during the assessment. One sample tested positive for the presence of *P.cinnamomi*, and three samples were found to contain *Phytophthora nicotianae*. No new *P. cinnamomi* infestations were identified during the assessment.

Study Team

The assessment and project management were conducted by Simon Robinson from Glevan Consulting between November 2011 and January 2012.

Introduction

Glevan Consulting was commissioned by Jandakot Airport Holdings (JAH) to conduct an assessment of the nominated sections of remnant vegetation and amenity gardens within the Jandakot Airport study area for the presence of the disease caused by *P. cinnamomi*. Jandakot Airport is located approximately 15 km south of Perth CBD and comprises approximately 622 ha.

The assessment was undertaken to facilitate an update of the existing Dieback Management Plan. The Dieback Management Plan forms part of the Conservation Management Plan (CMP), which assists in the protection of several nominated 'Conservation Areas'. The Conservation Areas are as follows:

- Precinct 1A: Proposed Conservation, 31 ha;
- Precinct 1B: Existing Conservation, 47 ha;
- Precinct 2: Existing Conservation, 39 ha.

In addition to the Conservation Areas, several 'Future Development Areas' were also assessed, including an area (Precinct 5) soon to be cleared of vegetation and topsoil recovered for use by the Department of Environment and Conservation (DEC). The Future Development Areas are as follows:

- Precinct 5: Future Development, 40 ha;
- Precinct 6: Future Development, 43 ha;
- Precinct 6A: Future Development, 10 ha.

Three runway undershoot/overshoot areas were also assessed. In addition, several small sections of remnant vegetation and landscaped areas within the developed section of the study area were also assessed, contributing to a total study area of approximately 242 ha.

A *P. cinnamomi* occurrence assessment is the first step in developing an effective management plan for the pathogen. Assessments can assign four possible categories to landscape of a study area. These categories are; Unmappable, Infested, Uninfested and Uninterpretable.

The following table describes *P. cinnamomi* 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. Category Definitions

<table>
<tr><td>Unmappable
Areas that are sufficiently disturbed so that P. cinnamomi 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 rowspan="3">Mappable
Natural undisturbed vegetation. P. cinnamomi 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 P. cinnamomi.</td></tr>
<tr><td>Uninfested</td><td>Areas that a qualified person has determined to be free of plant disease symptoms that indicate the presence of the pathogen P. cinnamomi</td></tr>
<tr><td>Uninterpretable</td><td>Areas where indicator plants are absent or too few to determine the presence or absence of disease caused by P. cinnamomi</td></tr>
</table>

Once *P. cinnamomi* occurrence information has been assessed, protectable and unprotectable management categories can be overlayed on occurrence information to further simplify the management of the area. All infested area is unprotectable.

Unmappable, Uninterpretable and Uninfested may be given protectable or unprotectable status depending on local variations and influences.

This report will give results of the *Phytophthora* Dieback occurrence assessment, stating infested, uninfested and unmappable area. Recommendations of protectable area will also be made, but the final rationalisation of protectable area categories is best done by JAH in consultation with Glevan Consulting.

P. cinnamomi is an introduced soil-borne pathogen (water mould) that causes the death of a vast and diverse range of plant species in South West Western Australia through a disease known as 'Dieback'. The disease enters through the plant roots, gradually breaking down the structure of the roots, ultimately causing roots to 'rot'. As a result of this 'root rot', the vascular system (xylem and phloem) in the root region of the plant is destroyed and the ability to transport water and nutrients is lost along with it. Additional information on the Disease is provided in Appendix 2.

Method

DEC accredited Dieback Interpreter Simon Robinson of Glevan Consulting traversed the study area on foot. Glevan Consulting uses methods prescribed in the manual "*Phytophthora cinnamomi* and disease caused by it, Volume II Interpreter Guidelines for detection, diagnosis and mapping, DEC 2001"

Results

Five infestations, comprising a total of 29.3 ha were observed and demarcated during the assessment. The remaining 212.7 ha of the study area were observed to be uninfested.

Table 2. Area Statement

CATEGORY	AREA (ha)	% of total area
Infested *(Phytophthora cinnamomi)*	29.3	12.1
Uninterpretable	0.0	0.0
Uninfested *(Phytophthora cinnamomi* Free)	212.7	87.9
Unmappable	0.0	0.0
TOTAL AREA	**242.0**	100.0

Sample Results

A total of thirty one samples were taken during the assessment. Only sample 21, which was taken as a 'control' in a known infestation, tested positive for the presence of *P. cinnamomi*. Samples 22 to 31 were taken in the amenity gardens and small sections of remnant vegetation within the developed section of Jandakot Airport. Three of these samples were found to contain *Phytophthora nicotianae* (Table 3). Samples locations are indicated on map 1.1.

Table 3. Species Sample List and Analysis Results

Sample	Species	Other Species Deaths	Vector	Pattern	Other Possible causes of Death	Expected Result	Actual Result
1	*Xanthorrhoea preissii*	*Banksia attenuata*	Yes	Yes	Drought	Negative	Negative
2	*X. preissii*	*Banksia attenuata*	Yes	Slight	Drought	Negative	Negative
3	*X. preissii*	*Banksia menziesii*	Yes	Slight	Drought	Negative	Negative
4	*X. preissii*	*Banksia attenuata*	Yes	Slight	Drought	Negative	Negative
5	*Banksia attenuata*	*Banksia menziesii*	Yes	Yes	Drought	Negative	Negative
6	*X. preissii*	*Banksia attenuata*	Yes	Yes	Drought	Negative	Negative
7	*X. preissii*	*Banksia menziesii*	Yes	Slight	Drought	Negative	Negative
8	*X. preissii*	*Banksia attenuata*	Yes	Slight	Drought	Negative	Negative
9	*B. attenuata*	*Banksia menziesii*	Yes	No	Drought	Negative	Negative
10	*B. attenuata*	*Stirlingia latifolia*	Yes	No	Drought	Negative	Negative
11	*Lomandra sonderi*	*Stirlingia latifolia*	Yes	Yes	Drought	Positive	Negative
12	*X. preissii*	*Banksia attenuata*	Yes	Slight	Drought	Negative	Negative
13	*X. preissii*	*Banksia attenuata*	Yes	No	Drought	Negative	Negative
14	*X. preissii*	*Banksia attenuata*	Yes	No	Drought	Negative	Negative
15	*L. sonderi*	*Stirlingia latifolia*	Yes	Slight	Drought	Negative	Negative
16	*Stirlingia latifolia*	*Lomandra sonderi*	Yes	Slight	Drought	Negative	Negative
17	*B. attenuata*	*Banksia menziesii*	Yes	No	Drought	Negative	Negative
18	*B. attenuata*	*None*	Yes	No	Drought	Negative	Negative
19	*B. attenuata*	*Banksia menziesii*	Yes	Slight	Drought	Negative	Negative
20	*L. sonderi*	*Banksia attenuata*	Yes	No	Drought	Negative	Negative
21	*X. preissii*	*Banksia attenuata*	Yes	Yes	None	Positive	Positive
22	*X. preissii*	*None*	Yes	No	Failed transplant	Negative	*P. nicotianae*
23	*X. preissii*	*None*	Yes	No	Failed transplant	Negative	Negative
24	*X. preissii*	*B. attenuata*	Yes	No	Drought	Negative	*P. nicotianae*
25	*B. attenuata*	*X. preissii*	Yes	No	Drought	Negative	Negative
26	Potting mix/soil	NA	NA	NA	NA	Negative	Negative
27	Mulch	NA	NA	NA	NA	Negative	*P. nicotianae*
28	*X. preissii*	*None*	Yes	No	Drought	Negative	Negative
29	*X. preissii*	*E. marginata*	Yes	No	Drought	Negative	Negative
30	*X. preissii*	*None*	Yes	No	Drought	Negative	Negative
31	*L. sonderi*	*None*	Yes	No	Drought	Negative	Negative

Discussion

Infested Areas

No new infestations were identified during the assessment. The existing infestations in Precincts 1A, 1B, 2 and 6 were reassessed and demarcated accordingly (Map 1.1). The three largest infestations within the study area were observed to correlate almost directly with *Melaleuca preissiana* Woodland. This Woodland is typically indicative of low-lying, water-gaining areas.

These water-gaining sites are usually subject to seasonal waterlogging or inundation, providing ideal conditions for the survival and sporulation of the pathogen. Spread of the disease is generally faster within high moisture sites, where the disease is transported by water and does not rely on root to root contact to be transmitted.

The spread of the disease from these infested water-gaining sites now appears to be relatively slow, as it is likely that the pathogen has already spread throughout the areas that are subject to seasonal waterlogging/inundation, and is now slowly spreading autonomously (root to root contact) away from the immediate water-gaining areas. This is a favourable situation in terms of management. Not only should natural rates of spread continue to be low, but the movement of the disease front should be predictable and easily monitored.

The smaller of the two infestations in Precinct 6 is not associated with a water-gaining site, however it is also characterised by heavily reduced biomass, particularly towards the infestation centre. Disease spread in this infestation is also slow and the pathogen has not spread significantly in the six years since the last assessment.

The small infestation adjacent to the main access road in Precinct 1A exhibited relatively good disease expression, with several fresh indicator species deaths observed. Although not technically a water-gaining site, the infested area is located in a small depression in the landscape. The infestation appears to be largely confined to the depression and has not spread significantly outward from this low-lying area. Vehicles were observed parking on the verge adjacent to the infested area. The probability of these vehicles collecting infested material and transporting it to uninfested areas is likely to be very minimal, but a risk nonetheless.

Other pathogens

Phytophthora nicotianae was recovered from two samples (22 & 24) taken in heavily disturbed remnant vegetation near the JAH Administration building. Another sample (27) taken from the mulch pile within the JAH Nursery was also found to contain *P. nicotianae*. The pathogenicity of this species is considered to be much lower than that of *P. cinnamomi*, but it does appear to have caused the death of at least two *Xanthorrhoea preissii* specimens (samples 22 &24).

Due to the levels of disturbance at the site associated with samples 22 and 24, the infestation boundaries cannot be accurately delineated, so the entire (small) section of remnant vegetation should be treated as infested. Hygiene measures should also be taken by ground staff when moving between the infested area and uninfested areas. Tools and boots should be free of soil and plant material before travelling to other sites.

Disease Vectors

As the study area is under Dieback Management, the risk of further disease introduction or spread is minimal. Disease spread within the study area appears to be confined to autonomous movement (root to root contact). There is no evidence of the pathogen being spread by vehicles or wildlife. Several vehicle tracks and kangaroo trails were observed to intersect the infested areas, but there was no evidence that the disease has been spread as a result.

Other Vegetation Decline

A significant amount of vegetation decline not related to *P. cinnamomi* was observed throughout the study area. *Phytophthora cinnamomi* was eliminated as the cause of the decline because the characteristic pattern normally associated with the presence of the pathogen was not evident at these sites. The plant deaths appeared to be largely scattered, random and 'staged', which is not consistent with *P. cinnamomi* related disease expression. Drought appears to be the most likely cause of the vegetation decline observed.

A significant number of samples were taken to eliminate *P. cinnamomi* as the cause of the decline, and all tested negative for the presence of *P. cinnamomi*. To further rule out *P.cinnamomi* as the cause, a 'control sample' (sample 21) was taken in a known infestation to provide evidence that 'false negative' sample results were not being recorded. The sample returned a positive result, providing further assurance that *P. cinnamomi* is not responsible for the vegetation decline observed.

For the most part, the actual *P. cinnamomi* infestations were readily distinguished from the other areas of vegetation decline. In addition to strongly correlating with the very high risk water-gaining sites, the infested areas also exhibited significantly reduced biomass, especially towards the older, central part of the infestation where the highly susceptible species were almost completely absent.

Demarcation

Unlike previous assessments, a 15m buffer zone was not applied to the demarcation. To facilitate future phosphite treatment, the actual disease edge was demarcated during the assessment. This provides a boundary in the field between the infested and uninfested areas where phosphite treatment can begin and also allows disease front movement to be more accurately monitored.

The presence of drought-related indicator species deaths near the actual infestation boundaries meant that accurate delineation of the disease edge was at times problematic. The combination of reduced biomass and the previously delineated boundaries were used to best estimate the location of the disease edge in these areas.

Phosphite treatment

Phosphite (also known as phosphonate) is a biodegradable fungicide that can increase a plant's own natural defences, and help susceptible species survive in infested areas. CALM trials in Swan Coastal Plain *Banksia* Woodland have found that aerial applications of 30-60 l/ha of 40% phosphite can give effective protection for up to 3 years (DEC 1999). Treatment via trunk injection methods and knapsack sprayers are suitable for smaller areas, and may afford even longer protection than aerial spraying methods. Phosphite is also the only chemical that can be safely applied to extensive areas of native flora without posing a significant threat to non-target species of plants and animals (DEC 1998).

Recommendations

- Soil from infested areas, or areas of unknown dieback status should not be introduced to uninfested areas.

- Vehicle movement through the areas of remnant vegetation should be restricted to dry soil conditions where possible. Where access is required, vehicles should be clean on entry, and inspected at the designated hygiene points (where tracks intersect infested/uninfested boundaries). Any loose soil or plant material should be removed.

- Apply phosphite treatment to susceptible species along the disease edge. The mortality rate along the disease front can be significantly reduced with the use of phosphite. Periodic treatment with phosphite will enable susceptible species along the disease front to defend against the pathogen for significantly longer periods of time, and further reduce the impact of the disease.

- Consider revegetation of high-impact infested areas with non-susceptible species or with seed taken from susceptible species that have demonstrated resistance to the pathogen. *Eucalyptus marginata* (Jarrah), *Eucalyptus todtiana* (Prickly bark) and *Nuytsia floribunda* (W.A Christmas tree) can be used to revegetate areas that have suffered significant overstorey decline.

- Ground staff should ensure that tools and boots are free of soil and plant material before moving from an infested area to an uninfested area.

References

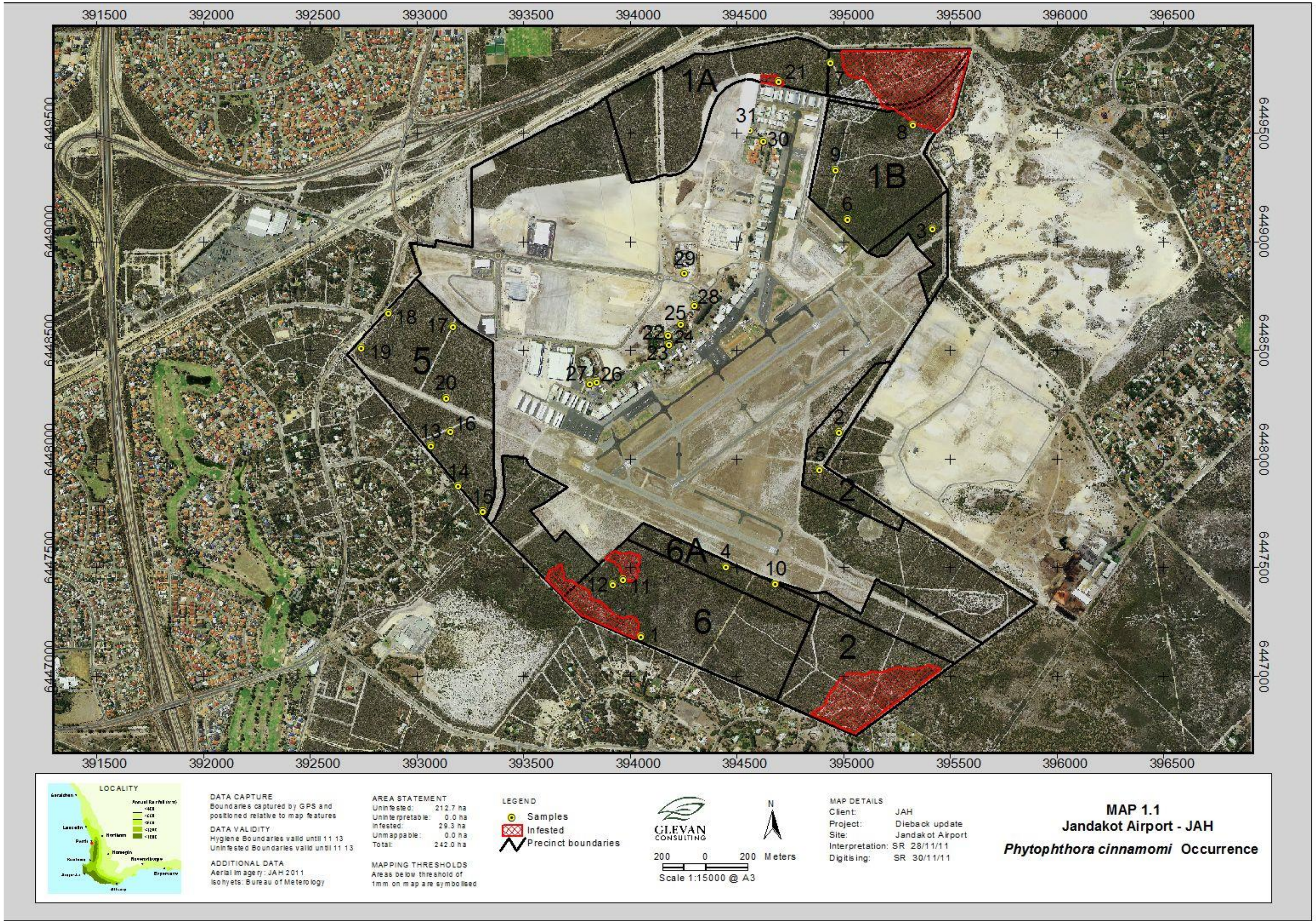
DEC (1998) *Control of Phytophthora and Diplodina Canker in Western Australia*. Department of Environment and Conservation.

DEC (1999) *Phytophthora cinnamomi and the disease caused by it. Volume III – Phosphite Operations Guidelines.* Department of Environment and Conservation.

DEC (2001) *Phytophthora cinnamomi and the disease caused by it. Volume II - Interpreter Guidelines for Detection, Diagnosis and Mapping*. Department of Environment and Conservation.

DEC (2003) *Phytophthora cinnamomi and the disease caused by it. Volume I – Management guidelines*. Department of Environment and Conservation.

Appendix 1 – Maps



Appendix 2 – *Phytophthora cinnamomi* (Dieback)

Phytophthora cinnamomi is an introduced soil-borne pathogen (water mould) that kills a diverse range of plant species in South West Western Australia. Jarrah Dieback, the name given to the disease associated with *P. cinnamomi* is actually something of a misnomer. The Jarrah *(Eucalyptus marginata*) *is susceptible to P. cinnamomi*, but it also demonstrates a degree of resistance to the pathogen (that most susceptible species appear to lack), and hence it is often observed to gradually 'die back'. Most susceptible species however, do not gradually dieback, but rather experience a 'sudden death' in which the entire plant dies at once.

P. cinnamomi is thought to have been introduced to Western Australia shortly after European colonization and has since produced a complex mosaic of infected and uninfected areas throughout the southwest of the State. The spread of the pathogen accelerated after World War II with the use of heavy machinery being used for road building and logging activities and unknowingly spreading infected soil.

The life cycle of *P. cinnamomi* depends on moist conditions that favour the survival, sporulation and dispersal of the spores. The pathogen is not capable of photosynthesis and must extract food from living plant tissue. It does this via a mass of microscopic threadlike mycelium that forms the body of the organism that grows through host tissue. The mycelia continue to grow within the host tissue when the ambient moisture content is above 80%. The mycelia may be transported in soil and host tissue and then deposited where it may infect new hosts. During favourable (warm, moist) conditions, the mycelium, are capable of producing the millions of tiny spores that reproduce the pathogen. Two spore types are produced;

Zoospores

Zoospores are very small spores that can actively swim very short distances towards new hosts and initiate new infections. They are short-lived and fragile but produced in large numbers, and are the mode for the spread of the disease from one plant to the next. Zoospores can also be carried along in moving water over large distances. As they move through the soil zoospores lodge on plant roots, infect them, and in susceptible plants produce mycelia. The mycelium grows, feeding on the host, rotting the roots and cutting off the plant's water supply. The mycelium may grow from plant to plant via root-to-root contact points and/or root grafts.

Chlamydospore

Chlamydospores are larger spores that are tough and long-lived (within dead plants and the soil). They are produced under unfavourable conditions and are the resistant resting phase of the pathogen. They may be transported in soil or roots and then germinate to cause a new infection when they encounter favourable conditions. The chlamydospores produce mycelium and zoospores.

When conditions are warm and moist, microscopic spore sacks called sporangia and thick walled chlamydospores are produced vegetatively from mycelia strands that form the body of the pathogen in the soil or host tissue. The sporangia release motile zoospores in free water to infect host roots. Following infection, the pathogen invades root bark and forms lesions that may extend in to the plants stem collar. In susceptible species, the infection of roots and collar will result in the death of the host.

Mycelia of different mating types may grow together inducing the production of thick walled sexual spores called oospores. The two recognised mating types are known as either A1 or A2, and only one of these mating types (A1) is known to occur in WA. As a result, the pathogen cannot reproduce sexually in WA and relies on vegetative reproduction for survival and dispersal.

P. cinnamomi has a very wide host range, with at least 1000 species from taxonomically diverse families reported as hosts, almost half of which have been recorded from research in Australia. Indigenous species most affected belong to four families:

- Proteaceae
- Epacridaceae
- Papilionaceae/Fabaceae
- Myrtaceae

It has been estimated that approximately 1500 to 2000 species of the estimated 8000 species of vascular plants in the South West of WA may be susceptible to the degree that successful infections result in the death of the host. It is important to note however that not all genera within a family or all species within a genus are necessarily susceptible. Some species of *Eucalyptus,* for example*,* are highly resistant (including Karri, Marri, Wandoo and Tuart) while others, such as Jarrah, are affected but have the ability to resist the invasion of the pathogen under certain conditions (Tissue moisture content < 80%).

The survival of any *Phytophthora* species is dependent upon the presence of a combination of the pathogen, host and suitable environmental conditions. The optimum temperature for the growth of the organism is between 15°C and 30°C while the optimum temperature for sporulation is 25°C to 30°C. Temperatures less than 0°C and greater than 35°C are unfavourable to the survival of the spores and mycelium of *P. cinnamomi*.

Infertile soils are more compatible to *P. cinnamomi* where there is a good movement of water and little biomass with few antagonistic microflora. The soil texture allows for the easy lateral movement of the motile zoospores and the easy development of mycelium. Native vegetation that has adapted to the infertile soils through a large surface area of root matter is at greater risk of infestation.

Clay and laterite are significant components of some soil types of the southwest and may act as impeding layers and cause subsurface ponding, which can facilitate the production of spores. These soils tend to drain laterally, further spreading the zoospores. The moisture content of the soil must be at a level that provides for aerobic environmental conditions. Saturated soils may become anaerobic and will not contain the oxygen levels required for the production of sporangia.

In some areas that are environmentally suited to the establishment, survival and reproduction of the pathogen, the spread of *Phytophthora* infections has reached epidemic proportions. These areas are generally in areas receiving more than 800mm of rainfall annually. In areas receiving between 600-800mm, the occurrence of *P. cinnamomi* is less extensive and confined to water-gaining sites in the landscape.

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