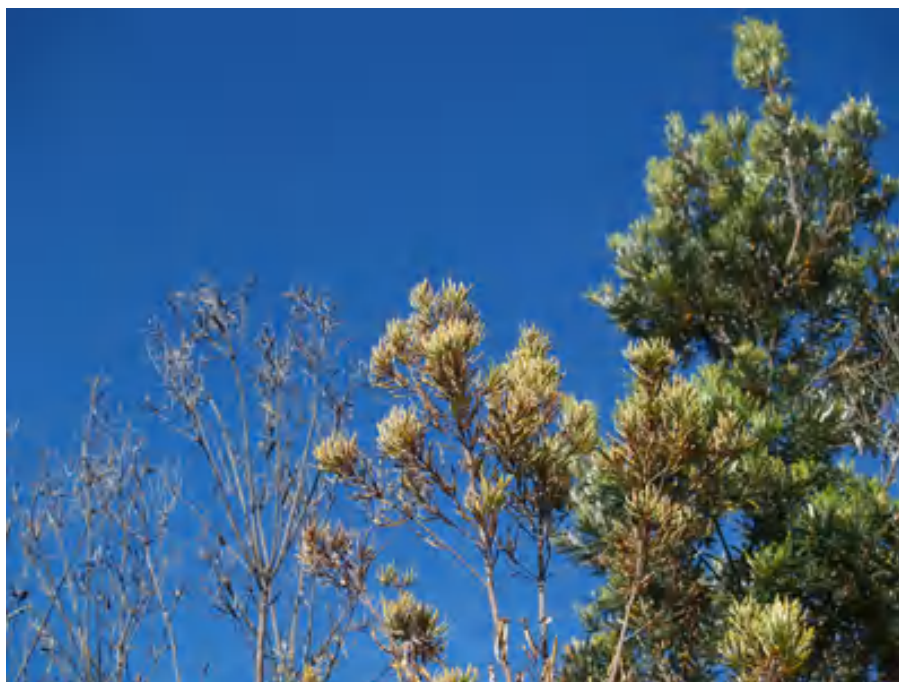


# A Study into the Risk of *Phytophthora Dieback* in Ten Peri-urban Reserves within the Shire of Denmark

July 2008



Commissioned by



Produced by Melinda Lyons



Supported by



and

The Denmark *Phytophthora cinnamomi* Working Group



## Executive Summary

Green Skills was commissioned as part of South Coast Natural Resource Management's (South Coast NRM) Project Dieback program to conduct an assessment into the presence of the pathogen *Phytophthora Dieback* within ten peri-urban reserves in the Shire of Denmark. Assessments were designed to identify healthy and infested reserves and to prioritise and develop recommendations for at least three requiring pathogen management. The assessment process and development of recommendations for the four reserves was assisted by the Denmark *Phytophthora cinnamomi* Working Group and the Shire of Denmark Natural Resource Management Officer.

Priority was calculated by evaluating the following factors: A) The variety and age range of susceptible species, B) The level of *Phytophthora Dieback* impact, C) The level of social and or cultural values and D) The ratio of vectors to square area.

As a result of the initial assessments four reserves were prioritised for management:

Mt Hallowell Reserve No 46618

Peace Street Reserve No 46688

Wilson Inlet Heritage Trail Foreshore Reserve (unallocated Crown Land below Reserve No 43923), and

Redgum Lane Reserve No 41224.

A summary of key recommendations within this report regarding priority reserves include:

1. All works within and around priority reserves to strictly adhere to ***Town Planning Scheme Policy No. 1 for Dieback Disease Management*** (Shire of Denmark, 1997) hygiene controls including but no limited to:
  - No soil movement or extraction within priority reserves
  - No operations (firebreaks, earthworks, fencing etc) within or around the vicinity of the *Phytophthora Dieback* free protection areas unless extremely dry soil conditions
  - No unauthorized vehicular access to priority reserves (closure of vehicular access where applicable)
2. Installation of Project Dieback signage at *Phytophthora Dieback* free protection areas and at *Phytophthora Dieback* infested areas
3. Installation of Project Dieback signage at entry to priority reserves to inform users of how to reduce risk of *Phytophthora Dieback* spread
4. Treatment of disease frontlines to stabilize disease movement (once points 1 – 3 have been implemented)
5. Develop annual monitoring and treatment program in *Phytophthora Dieback* free protection areas
6. Host *Phytophthora Dieback* awareness forum (compulsory attendance by Shire works staff and open invitation to community members)
7. Assess and develop *Phytophthora Dieback* management recommendations for remaining Shire of Denmark reserves which were not assessed within this study
8. Develop one initial community-based *Phytophthora Dieback* monitoring group for Redgum Lane Reserve No 41224.

## Study Team

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We would like to acknowledge and thank Joanna Young (Coordinator: Project Dieback) and Annabelle Bushell (Phytophthora Dieback Coordinator: South Coast NRM) for assisting the initial development and funding assistance for this report as well as ongoing mentoring support throughout the length of the project.

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## 1. WHAT IS PHYTOPHTHORA CINNAMOMI?

### 1.1 Introduction to Western Australia

*Phytophthora cinnamomi*, or Phytophthora Dieback, is an introduced plant disease. It is likely to have been spread throughout the southwest of Western Australia from early European settlement. Jarrah tree deaths were first recorded in the 1920s and it was in the mid-1960s that research was able to identify *P. cinnamomi* as the cause of such deaths (Podger, 1968).

### 1.2 Water Mould Pathogen

Phytophthora Dieback is a soil microorganism which attacks and rots the stems and roots of living plants. The rot limits the plants ability to take up water and nutrients and eventuates in the plants death. Phytophthora Dieback is a 'water mould' pathogen of the phylum Chromista which is spread in the movement of infested water, soil or plant material. It is not native to Australia and is believed to have been introduced to Western Australia with European settlers in the 1800s (Dieback Working Group, 2000).

### 1.3 Spread of the Pathogen in Western Australia

The microscopic flagellate spores are spread via surface or subsurface water flow. Hyphae spread by root to root contact, movement of soil due to human activities (vehicle tyres, on shoe treads, soil transport) or animal activity (is commonly associated with new infections). Clay and laterite soils which impede drainage, cause ponding and/or lateral spread of water can facilitate motile spore production and dispersal.

The arrival and spread of Phytophthora Dieback in Western Australia has had catastrophic consequence for the biota of a number of southwest Australian ecosystems as it has a very wide host range and severely impacts biodiversity. In addition, its presence requires stringent hygiene protocols when constructing roads, extracting soil, harvesting timber, mining and other industries as soil movement between infested and uninfested sites is the most significant cause of pathogen spread. There are several other species of *Phytophthora* sp. present in native vegetation in the south-west of Western Australia, including *P. citricola* and *P. megasperma*, but their extent and impact on native vegetation is slight in comparison to that of *P. cinnamomi*.

### 1.4 Requirements for Survival

Phytophthora Dieback lifecycle requires favourable environmental conditions to maintain its presence in the soil and therefore does not exist in regions that receive less than 400mm of annual rainfall. Warm moist conditions speed the production of millions of tiny zoospores that reproduce the pathogen. Unfavourable conditions result in production of chlamydospores which are the survival or resting phase of the pathogen. These spores are able to infect plants once warm moist conditions return. The optimum temperature for the growth of the pathogen is between 15 – 30°C and for sporulation is 25 – 30°C. Spores are unlikely to survive below 0°C or above 35°C (Glevan Consulting, 2006).

### 1.5 Combination of Fire and Phytophthora Dieback

A recent honours thesis "Role of Fire on *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia" suggests that fire in *Phytophthora* Dieback infested areas has the potential to increase both the severity and extent of disease to native plant communities, and impinge on the regeneration capabilities of susceptible species. Amongst other effects, fire reduces leaf litter and canopy cover which increases soil temperature thus making favourable conditions for the pathogen. The plant communities found to be most impacted by fire and the presence of *Phytophthora* Dieback are dominated by proteaceous species (i.e. *Banksia* sp., *Hakea* sp., *Dryandra* sp., *Adenanthos* sp.) (Moore, 2005). Many of the susceptible species regenerate primarily from seed after fire.

### 1.6 Plants Impacted

Forty percent of native species in Western Australia are susceptible to *Phytophthora* Dieback. This high percentage of susceptible species highlights the intensity of change that can and is occurring to local bush landscapes. Species which are generally the first to be impacted and thus used as an observation tool when monitoring health of bushland are called 'indicators'.

"The first indication that the pathogen has spread into a new area is the death of susceptible plant species. Many of these susceptible species can be used as 'indicator' species of disease. *Banksia grandis* is a good example of an 'indicator' species as once it is infected it dies rapidly and it is a large and obvious plant. Less susceptible species such as jarrah may show crown decline symptoms, including leaf yellowing and death of primary leaf-bearing branches.....Trees with such symptoms can take a number of years to decline and die." (CPSM, 2008).

Indicator species also include grasstree, zamia palms (Figure 1), *Hibbertia* sp., *Dryandra* sp. (now part of *Banksia* genus) and *Hakea* sp. (See Appendix 1: List of Common Indicator Species) (Department of Environment and Conservation, 2008).





Figure 1: *Macrozamia riedlei* or *Zamia* Palms are susceptible to *Phytophthora cinnamomi*

### 1.7 Treatment

Currently there is no method of eradication of Phytophthora Dieback however there are methods of treatment available to stimulate plants immunity. Treatment is either by stem injection or foliage spray with systemic fungicide phosphite (phosphonate). Treatment can be done at any time of year, but for syringe injection the best period appears to be early spring to autumn. Foliar spray can be effective from six months to two years, depending on the concentration, method of application, species of plant and environmental factors. Stem injection can control Phytophthora Dieback for at least four years in *Banksia* species (Dieback Working Group, 2000 and Moore, 2005).

## 2. WHY CONDUCT A STUDY INTO THE RISK OF PHYTOPHTHORA DIEBACK IN THE SHIRE OF DENMARK?

### 2.1. Ecological Value

The Shire of Denmark is within a region of the southwest coast of Western Australia that is rich in biological diversity. The area has been described as one of 34 biological hotspots of the world. Nearly 80% of the plant species of the south west are found nowhere else in the world, including many of the brightly-colored members of the genus *Banksia* which are Phytophthora Dieback susceptible (Conservation International, 2008). Approximately one third of the Shire of Denmark's 184 300ha is within the conservation reserve system of the newly gazetted 363 000ha Walpole Wilderness Area. This area was developed to form a world class network of interlocking reserves which aims to protect the biodiversity of the unique wilderness of the south coast (Department of Environment and Conservation, 2006).

### 2.2 Social and Economic Values

Hand in hand with these scientific attributes the region is host to a popular tourism market from Australia and internationally. Nature based tourism is becoming recognized as an important economic driver within Denmark and neighbouring shires.

### 2.3 Development Impacts

The region is also witnessing significant population expansion as people move to the southwest's less populated coastlines. This demand is stimulating land subdivisions, applying pressure on infrastructure and services in communities as well as placing pressure on natural environments.

With the increase in local population and visitor numbers there is now an important need to educate community members and visitors of the impacts of Phytophthora Dieback and to monitor and manage Phytophthora Dieback infested areas to combat Phytophthora Dieback compromise within healthy bushland.

### 2.4 Management Responsibilities

It is the Shire of Denmark's responsibility to maintain and manage reserves that are vested in it. These responsibilities include the protection and safety of users, management of firebreaks and reduction of fire hazards, control of weeds and pathogens, the maintenance of visual and recreational as well as future planning.

In 1996 the Shire of Denmark recognized the seriousness of the pathogen and its threat to the conservation, social, cultural and economic values of the Shire reserves, parklands and other adjacent areas. It was at this time that a Dieback Disease Policy was developed. In September 1997 the *Town Planning Scheme Policy No 1 for Dieback Disease Management* was adopted and highlighted the need to develop and implement a Phytophthora Dieback disease management program to minimise spread of the deadly *P. cinnamomi* spores.

Since the policy's adoption there have been a small number of studies and treatment works undertaken by independent contractors. However as this study highlights, Phytophthora Dieback remains an ongoing problem that is impacting our shire reserves and requires ongoing management.

### **3. AIM OF THIS STUDY**

This study was developed to identify healthy Phytophthora Dieback free areas and infested bush remnants within priority reserves of the Shire of Denmark. The study includes lists of recommendations for individual reserves as well as overall recommendations to assist the Shire of Denmark in maintaining the health of local bushland.

It is intended that this study will:

- Identify *Phytophthora cinnamomi* vulnerable reserves within the Shire of Denmark
- Identify areas of disease free vegetation that can be protected with appropriate management techniques
- Develop management recommendations for four priority reserves.

Extended outcomes of the study include:

- Installation of permanent monitoring points within at the four priority reserves to assist ongoing monitoring
- Capacity building of local NRM organizations to assist in the delivery of Phytophthora Dieback Services in the region
- Raising local community awareness of *Phytophthora cinnamomi* within the shire
- Encouragement of community involvement in monitoring and care of local reserves.

### **4. BACKGROUND RESEARCH**

Prior to conducting infield assessments a desktop survey was undertaken to collate previous research and infield data in relation to shire reserves. Information was also collated in regard to *Phytophthora cinnamomi*, its treatment and management within the state.

#### **4.1 Management Guidelines - Shire of Denmark**

Limited research information exists in regard to management of individual reserves apart from "Reserve Assessment Reports in the Shire of Denmark" (Press and Armstrong, 1998) and "Mt Hallowell Management Plans" (Shire of Denmark, 1995; Shire of Denmark, 2006; Green Skills, 2008 (being compiled at time of printing this report).

Reports in relation to Phytophthora Dieback within the Shire include "Management of Phytophthora Dieback" (Zuvela, 2002), and "Assessment for the Presence of *Phytophthora* sp.: Denmark Reserves" (Brown and Tuffnell, 2002) and the Shire of Denmark "Town Planning Scheme Policy No. 1 for Dieback Disease Management" (1997).

#### **4.2 Management Guidelines - Western Australia**

Other valuable reference documents which contain Phytophthora Dieback management and treatment recommendations which should be read in compliment to this report include the "Managing Phytophthora Dieback: Guidelines for Local Government" (Dieback Working Group, 2008), "Managing Phytophthora Dieback in Bushland: A guide for Landholders and Community Conservation Groups" (Dunne, 2005), and "Dieback Management in LGA'S: Recommendation for Dieback Management" (Dunne, 2006).

## 5. STUDY AREA

Based on recommendations by the Shire of Denmark Natural Resource Management Officer, the Denmark *Phytophthora cinnamomi* Working Group and Green Skills, Phytophthora Dieback assessments were conducted within ten peri-urban shire reserves known to contain Phytophthora Dieback susceptible species. Reserves were chosen in areas that were seen to be facing likely threats from surrounding urban development and which were also of an adequate size to protect biological and habitat value (over 5ha).

Due to the limited scale of this project larger scale reserves outside of the urban development nodes were unassessed. It is recommended that they be included when planning future monitoring and assessment.

The ten reserves initially assessed were:

- Peace Street Reserve: Reserve No 46688
- Mt Hallowell Reserve: Reserve No A46618
- Happy Valley Road Reserve: Reserve No 36026
- Redgum Lane Reserve: Reserve No 41224
- Nr McNabb Road Reserve: Reserve No 34815
- Turner Road Reserve: Reserve No 13255
- Sheoak Drive Reserve: Reserve No 29560
- Shadforth/McLeod Street Reserve: Reserve No 35160
- Wilson Inlet Heritage Trail Foreshore Reserve: (unallocated Crown Land below Reserve No 43923)
- Nut Road Reserve: Reserve No 33921

(See Figure 2 below ).

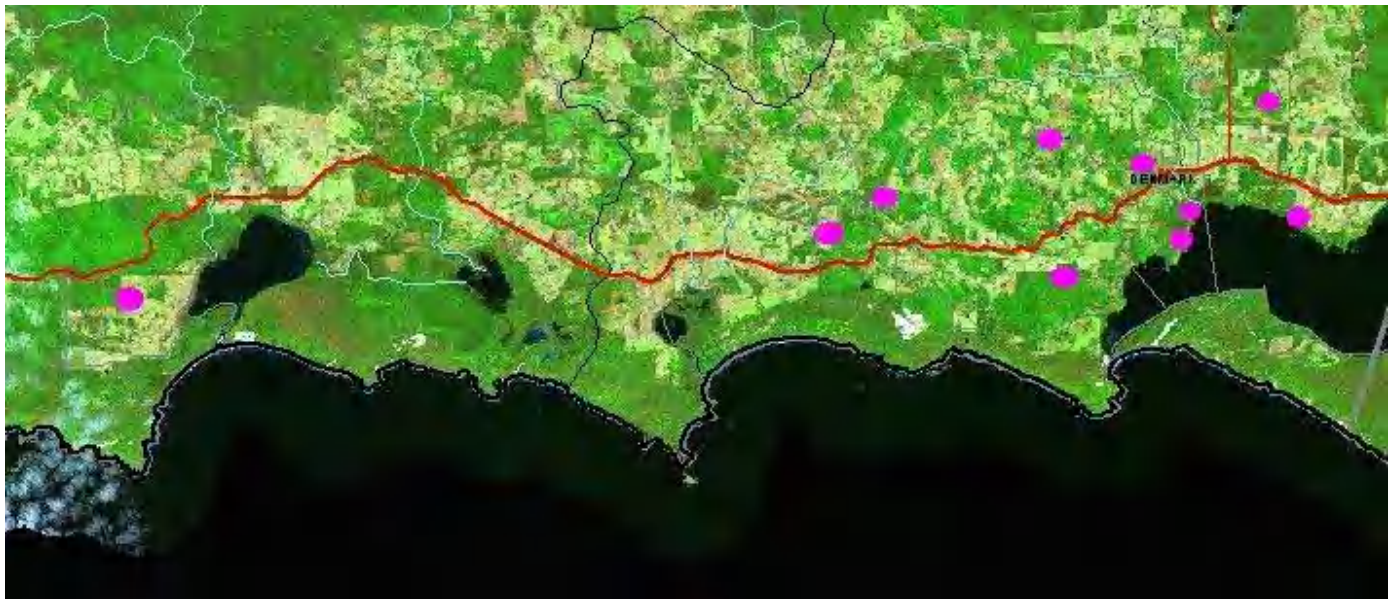


Figure 2: Location of initial ten assessment sites within the Shire of Denmark

## 6. ASSESSMENT METHODOLOGY

### 6.1 Aerial Photographs and Topographical Maps

Aerial photographs and contour maps were used as part of a desktop analysis of topographical features and vectors that could indicate pathogen spread (i.e. lowlands, waterways, roads, walk tracks or extraction pits) at each of the sites (NRM Info, 2008). Aerial photographs were also a useful indicator of vegetation density (dense vegetation can illustrate

a shady cool site in which Phytophthora Dieback expression is less prevalent or nonexistent, an open canopy may illustrate a site at which Phytophthora Dieback expression is occurring).

## 6.2 Field Assessment

By observing the general health and occurrence (or unusual absence) of indicator species the team was able to make an evaluation of the presence of the Phytophthora Dieback pathogen.

An infield site assessment sheet was used to record the values and features of the ten reserves. Aerial photographs and topographical maps were taken infield for continued reference (NRM Info, 2008).

The site assessment sheets recorded:

- Susceptible species and condition
- Estimated age of susceptible species
- % reserve impacted by Phytophthora Dieback
- Level of impact (H, M, L)
- Number of active fronts
- Vectors
- Soil type
- Other flora (rare, endangered, endemic)
- Fauna
- Weeds
- Topography
- Other values (heritage site, recreational, social)

Approximately an hour and a half was spent at each of the reserves.

## 6.3 Ranking in Order of Ability to Protect

While none of the reserves were found to be completely free of Phytophthora Dieback there are sections within them that are uninfested. Prioritization for protection was determined using the following method.

The highest value was placed in reserves which had:

- A) Both a wide variety and wide age range of susceptible species
- B) The least level of Phytophthora Dieback affect within the reserve

The next most important factor in determining ranking was:

- C) Social and cultural values (including level of recreation use and enjoyment, indigenous heritage value, community proximity for potential assistance to monitoring and treatment, overall education values within the reserve)

The final determinant of priority was:

- D) Evaluating the number of vectors compared to reserve size (high number of vectors to square area increases chance of spread)

Four of the ten reserves which ranked highly were chosen for further in-depth assessment (Figure 3).

- Mt Hallowell Reserve No 46618
- Peace Street Reserve No 46688
- Wilson Inlet Heritage Trail Foreshore Reserve (unallocated Crown Land below Reserve No 43923) and
- Redgum Lane Reserve No 41224

(Findings and recommendations for each of the four reserves follow within Section 7: Results.)





Figure 3: Top Four Ranked Reserves in the Shire of Denmark

#### 6.4 Quadrats, Transects and Frontlines

Quadrat, frontline and transect survey and monitoring methods were the same as those utilized by Zuvela in the 2002 paper "Management of Phytophthora Dieback".

Two permanent monitoring quadrats were established at each of the four reserves. Susceptible species surveys recorded the range, frequency and current health of plants at the quadrats. These quadrats have remained in place so that they can be used for future monitoring of reserve health. Initial surveys can be used as a baseline for future monitoring.

Permanent quadrat and transect points were recorded using GPS. Metal stakes tied with pink string have been located at the corner points / end points of each infield quadrat / transect. General location has also been marked on individual reserve maps within Section 7: Results.

An active frontline was only apparent at Peace Street Reserve No 46688 and GPS recordings were made along its path. Four transects of 20m length were established across the frontline and susceptible species along their length were recorded. Infested and uninfested areas of Phytophthora Dieback have also been illustrated within maps for Redgum Lane Reserve No 41224, Wilson Inlet Heritage Trail Foreshore Reserve and Mt Hallowell Reserve No 46618 however the expression (number of deaths) was very widely scattered and a frontline was not determined.

#### 6.5 Recommendation Methodology

Recommendations were designed around The Nature Conservancy model "Conservation Action Planning" (2005).

## 7. RESULTS

### 7.1 PEACE STREET RESERVE NO 46688

#### 7.1.1 Background

Peace Street Reserve No 46688 is one of eight reserves in the Peace St / Henwood Road area that has been a source of gravel extraction in the past. Reserve No 46688 covers an area of approximately 9.96ha. Its northern boundary runs along Peace Street, while its southern, western and part of its eastern boundary borders private properties.

There are two management reports written in relation to *Phytophthora Dieback* at the reserve (Zuvela, 2002) and (Brown and Tufnell, 2002).

Vegetation of the area includes *Phytophthora Dieback* susceptible plants such as *Banksia grandis*, *Bossiaea linophylla*, *Eucalyptus marginata*, *Hakea amplexicaulis*, *H. varia*, *Persoonia longifolia*, *Petrophile diversifolia*, *Xanthorrhoea gracilis*, and *X. preissii*.

The reserve contains a well used walk track that passes from east to west as well as a disused centrally located track which crosses from north to south. The reserve is a thoroughfare for private properties of the Highlands estate down to the town CBD. Bush walkers, horseriders and motorbike use is evident along the trails. Vehicle access is possible along the eastern boundary leading to an old gravel extraction pit in the south east corner. Motorcycle tracks are evident in this area.

The reserve falls on a steady gradient from 100m in the south west corner to 40m in the north east corner. Soil type is predominantly composed of gravelly sandy yellow duplex soils with areas of gravelly sand (Press and Armstrong, 1998). *Phytophthora Dieback* mapping within Figure 4 indicates that infestation is occurring on the lower northern slopes and on the south eastern boundary. Spread is likely to be slow movement by root to root contact and or infection through translocation of soil uphill.

#### 7.1.2 Values of the Reserve

The following values indicate that this site should be prioritised for ongoing environmental monitoring and management.

The reserve is:

- Home to significant stands of *Phytophthora Dieback* susceptible species
- Part of an important fauna and flora habitat in close proximity to the built up area of the townsite. Loss of *Phytophthora Dieback* susceptible species will cause major impacts to its habitat value
- Interlinking corridor for flora and fauna movement between others reserves to the north and south.
- DPcWG has been conducting phosphite treatment in this reserve for several years, in accordance with recommendations made by Glevan Consultants
- Used daily for recreational purposes - horse riding, walking
- Of ongoing educational value
- Currently more than one half of the reserve is uninfested
- Infection is down slope
- The area is home to impressive stands of *Banksia grandis*
- Site of the most eastern occurrence of *Eucalyptus guilfoylei* (yellow tingle)

#### 7.1.3 Site Assessment

Visual assessment was conducted throughout the reserve and potential *Phytophthora Dieback* vectors were identified include tracks and past gravel extraction sites (see Map 1: Peace Street Reserve *Phytophthora Dieback* Map).

The active *Phytophthora cinnamomi* frontline was recorded using GPS (Tables 1 - Appendix 3). Along this frontline four permanent monitoring transects were installed. Tables 2 - 9 in Appendix 3 record the GPS coordinates of each of the transects as well as susceptible species that are occurring along the length of the transect. Figure 4 shows the pathogens affect on a mature *Banksia grandis*.

Two permanent quadrats were also established at the reserve (Quadrat A and B). Appendix 4 illustrates the range and frequency of susceptible species within the two quadrats. Photos were taken at a permanent photo points at each quadrat as a base line visual record of quadrat health.



Figure 4: *Banksia grandis* death along the frontline Peace Street Reserve No 46688

#### 7.1.4 **Transect Observations**

Two of the transect areas were known to have had past treatment with phosphite. Susceptible species within infested section are displaying good health as a result.

Transect 4 (untreated area) displayed the most *Phytophthora* Dieback impact and recorded the least number of susceptible species. Treatment around this transect will assist the retention of species and assist in restoring a wider mix of canopy cover.

Ongoing monitoring of untreated *Phytophthora* Dieback free protection areas will ensure prompt treatment is applied should susceptible species begin to die.

#### 7.1.5 **Quadrat A - Observations**

The susceptible species survey within Quadrat A illustrated a site with a healthy mix of overstorey, mid and lower canopy (see Appendix 4: Table 10 and 11). The ground level of the site was cool (Figure 5). A cool, shaded site such as this is less favourable to production of *Phytophthora* zoospores and is more resilient than a site with an open canopy and sun exposed soil. However ongoing monitoring is still as important at such sites as *Phytophthora* Dieback introduction through root to root contact or transmission through moved soil can easily trigger deaths and an eventually opening of canopy.

This quadrat contains a large *Eucalyptus guilfoylei* (yellow tingle) of approximately 70 years of age (mid ground of Figure 5). This site is the most eastern occurrence of the tingle and, although unaffected by the pathogen, represents another reason why the site is a valuable asset to the Shire of Denmark.





Figure 5: Quadrat A Photo Point in Uninfested section of Peace Street Reserve No 46688

Susceptible species occurring in the site include a number of *Banksia grandis*, *Hakea* sp., *Leucopogon verticillatus*, *Persoonia longifolia* and both *Xanthorrhoea gracilis* and *X. preissii*.

#### 7.1.6 Quadrat B - Observations

This site is severely disturbed by *Phytophthora* Dieback. The overstorey has been opened up as a result of canopy deaths. Continued *Phytophthora* blooms are also removing species regrowth. Figure 6 illustrates the low level of regeneration and the difference in forest structure compared to the uninfested site upslope at Figure 5. With the opening of the forest canopy the soil is continually warmed by the sun, coupled with a moist climate, favourable conditions create zoospore blooms and fresh occurrences of deaths.

The species survey, while indicating a cross section of susceptible plants, found that the age range was between young saplings to seedling. Average height of susceptible species was 1 - 1.5 metres. Most noted species within the survey area were *Banksia grandis*, other *Banksia* sp., *Eucalyptus* sp., *Hakea* sp., *Leucopogon* sp., and *Xanthorrhoea gracilis* and *X. preissi* (see Appendix 4: Table 10 and 11).



Figure 6: Quadrat B –Survey of Susceptible Species in Infested Zone Peace Street Reserve No 46688



### 7.1.7 Recommendations

- All works within and around reserve to strictly adhere to **Town Planning Scheme Policy No. 1 for Dieback Disease Management** (Shire of Denmark, 1997) hygiene controls including but not limited to:
  - No soil movement or extraction within reserve
  - No operations (earthworks, fencing etc) within or around the vicinity of the Phytophthora Dieback free protection areas unless extremely dry soil conditions (see Map 1: Peace Street Reserve Phytophthora Dieback Map)
  - No unauthorized vehicular access to reserve
  - All road verge activity along Peace Street to follow hygiene guidelines. Road verge is extremely infested and threat of Phytophthora Dieback distribution to other areas needs to be prevented
- Fire can increase the severity of disease in this infested site. Therefore other methods of fuel load reduction within infested area to be investigated
- Closure of vehicle access into reserve from Peace Street and trail bike access from surrounding reserve entries including Christina Crescent
- Installation of Project Dieback signage at Phytophthora Dieback free protection areas and at Phytophthora Dieback infested areas
- Installation of Project Dieback signage at entry to tracks through reserve to inform users of how to reduce risk of Phytophthora Dieback spread
- Treatment of susceptibles along disease frontlines to stabilize disease movement (after above hygiene and signage recommendations implemented)
- Annual monitoring and, as necessary, treatment program in Phytophthora Dieback free protection areas. Regular monitoring will ensure plants are treated on an as needs basis rather than blanket coverage (either stem injection or foliar spray)
- Traditional owners to be consulted and invited to participate in any monitoring and treatment activity
- Establishment of “Friends of Peace Street Reserve” to assist in ongoing monitoring (suggested gradual introduction of Friends of Groups for all peri-urban reserves at NRM Officer discretion)

All recommendations to be read in conjunction with Section 8: Overall Recommendations in this report.

## 7.2 WILSON INLET HERITAGE TRAIL RESERVE (UNALLOCATED CROWN LAND BELOW RESERVE NO 43923)

### 7.2.1 Background

This reserve consists of the old rail reserve running along the northern edge of the Wilson Inlet. It is approximately 8.4ha in area. The western boundary begins from Inlet Drive while the eastern boundary begins at Rudyard Place. The southern edge of the reserve is bordered by the Wilson Inlet foreshore apart for 1.5kms at the western end (passes through Reserve 12232 and borders the northern edge of Reserve 24452). The northern boundary runs along Reserves 390661, 39067, 2286, 43923 and sections of private property.

Vegetation of the area includes Phytophthora Dieback susceptible plants such as *Banksia attentuata*, *B. grandis*, *B. seminuda*, *Bossiaea linophylla*, *Casuarinas* sp., *Eucalyptus marginata*, *Hakea amplexicaulis*, *H. oleifolia*, *Persoonia longifolia*, *Macrozamia riedlei*, and *Xanthorrhoea preissii*.

The study area is in the eastern half of the reserve. Susceptible species quadrats are in close proximity to Lake View Place (see Map 2: Wilson Inlet Foreshore Reserve Phytophthora Dieback Map). Watershed runs in a southerly direction toward the inlet. The heritage trail is a potential vector for the human spread of Phytophthora Dieback along the trail. Oppositely it also diverts downhill watershed to culverts and drains under the trail and isolating potential watershed infection.

Vehicular access to the site is available along the rail trail, from a public thoroughfare through Springdale Heights, through the reserve from the trotting grounds, and from Rudyard Place. Vehicle access is limited to works vehicles. Access by foot is available through various private blocks, the Heritage Trail, various adjoining trails from the trotting track and golf course, and via Lake View Place at Springdale.

Soil type in the quadrat areas was sandy humus podzol with lateritic duricrust (Press and Armstrong, 1998).

### 7.2.2 Value of the Reserve

The following values indicate that this site should be prioritised for ongoing environmental monitoring and management.

The reserve is:

- Home to significant stands of Phytophthora Dieback susceptible species including mature stands of the red flowering variety of *Banksia seminuda* (little is known of this red flowering variety with few surveyed occurrences. It may be of botanical significance in the future and worthy of protection)
- An important habitat for a wide mix of flora and fauna. Loss of Phytophthora Dieback susceptible species will cause major impacts to its habitat value
- An important corridor linkage between private bush blocks and reserves to the north and the Wilson Inlet
- Enjoyed daily for recreational purposes - horse riding, walking and bike riding
- Of ongoing educational value – evident in the cultural and environmental interpretative information placed at picnic huts and dotted along the trail
- A site that is included in an overall heritage value study along the Wilson Inlet Foreshore. The study is being conducted by traditional owners and the Department of Indigenous Affairs (evaluation still occurring at the time of printing this report). Bush tucker sources and ceremonial materials have been identified at the site by traditional owners.
- A site currently being included in the updating of the “Wilson Inlet Foreshore Management Plan – Denmark to Hay River” (Waters and Rivers Commission, 2002). This management plan is a series of four Wilson Inlet foreshore management plans being updated by consultants Green Skills at the time of printing this report.

### 7.2.3 Site Assessment

Visual assessment was conducted along the length of the reserve. There are sections of infested and uninfested bush on the lower southern side of the trail. Infestation appears in patterns below culverts and drains. Infestation is also apparent on the northern side of the trail within private bush blocks and Reserve 43923. The pathogen appears to be spreading downhill. One possible vector of introduction is during road works to establish the Springdale Heights development and the access trail from Lake View Place to the Wilson Inlet foreshore edge.

Recent deaths appear to be a result of post infection blooms rather than movement of a frontline into a Phytophthora Dieback free area. Two permanent quadrats were established at the reserve (Quadrat C and D). Appendix 5 illustrates the range and frequency of susceptible species within the two quadrats. Photos were taken at a permanent photo point at each quadrat to begin a visual record of quadrat health.

#### 7.2.4 *Quadrat C - Observations*

Quadrat C was constructed in a thicket of *Banksia seminuda* on the northern side of the heritage trail in an area showing signs of current Phytophthora Dieback impact (See Figure 7 and 8).

Fourteen healthy *Banksia seminuda* plants were recorded, another three were dying and eight were dead (see Appendix 5: Susceptible Species Survey Table 12 and 13). The age of the dead plants was from one to five years. Four mature trees between ten and thirty years are still surviving in the quadrat (the younger trees diametrically smaller root system makes them more vulnerable to the deadly collaring of the Phytophthora Dieback rot as it spreads along roots and through the soil).

Outside of the quadrat canopy restructuring has already occurred with the loss of *Banksia* overstorey and more open low woodland beginning to replace forest composition. Mature *Banksia* trunks are laying dead on the ground while the only living evidence of *Banksias* are young saplings 1 – 1.5m high (Figures 9 and 10).



Figure 7: Quadrat C –dead, flagging and healthy *Banksia seminuda* illustrating gradual loss of overstorey



*Figure 8: Quadrat C- photo point showing dead Banksia sp. in mid-ground*



*Figure 9: Deaths of susceptible species causing an open woodland affect*





Figure 10: Mature *Banksia* sp. fallen to the ground

#### 7.2.5 **Quadrat D - Observations**

Quadrat D was chosen due to a significant number of the susceptibles *Macrozamia riedlei* within the area (see Appendix 5: Susceptible Species Survey, Table 12 and 13). These plants were a food source for the Noongar inhabitants of the south west region and are worthy of retention for their cultural value. Other susceptible species which were found within the quadrat were *Leucopogon capitellatus* and *Podocarpus drouynianus*.

Two *Macrozamia* sp. deaths were recorded in the survey and four *Leucopogon* sp.. The quadrat is on the southern side of the heritage trail and is close to an underground culvert. Plant deaths were noticed outside the survey area in direct line of the culvert flow (Figure 11).



Figure 11: A dead *Patersonia occidentalis* below the drainage area of a culvert

### 7.2.6 Recommendations

- All works within and around priority reserves to strictly adhere to **Town Planning Scheme Policy No. 1 for Dieback Disease Management**, (Shire of Denmark, 1997) hygiene controls including but not limited to:
  - No soil movement or extraction within reserve
  - No operations (firebreaks, earthworks, fencing, etc) unless extremely dry soil conditions
  - No unauthorized vehicular access to reserves (closure of vehicular access where applicable)
- Firebreaks to be maintained during dry conditions. Fire can increase the severity of disease in this infested site. Other methods of fuel load reduction other than prescribed burning are investigated. Fire management should minimise disturbance in area around Quadrat C due to large older *Banksias* which may not survive fire. Fire in this region will also negatively impact on canopy cover and leaf litter causing a rise in soil temperature and pathogen presence. Cool mosaic burning further east of this site to manage fuel load and assist seed germination is recommended
- Installation of Project Dieback signage at Phytophthora Dieback free protection areas and at Phytophthora Dieback infested areas
- Installation of Project Dieback signage at entry to priority reserves to inform users of how to reduce risk of Phytophthora Dieback spread
- NOTE Investigate educational signage overlaps between cultural heritage survey recommendations, foreshore management plan recommendations and this study to aid the potential development of a collocated signage
- Immediate treatment of susceptibles within and around Quadrat C site to stabilize disease movement and assist retention of unusual occurrence of red flowering *Banksia seminuda* (after above hygiene and signage recommendations implemented)
- Develop ongoing annual monitoring and treatment program around Quadrat C and future identified Phytophthora Dieback free protection areas
- Traditional owners to be consulted and included in any treatment activity
- Full extent of Wilson Inlet Foreshore Heritage Trail to be surveyed in wet weather conditions to identify areas of muddy and wet pothole areas. Such wet areas need to be surfaced with limestone and or potholes filled to reduce risk of wet soil collecting on shoes, tyre treads and subsequent redistribution of pathogen
- Future culvert design along the Wilson Inlet Foreshore Heritage Trail should divert toward already infested areas rather than introducing water borne pathogen to uninfested sites. Consultation with Green Skills and the DPcWG Group recommended
- NRM Officer to support the development of community-based monitoring along Wilson Inlet Foreshore Heritage Trail and or establishment of "Friends of Wilson Inlet Foreshore Heritage Trail"

All recommendations to be read in conjunction with Section 8: Overall Recommendations in this report.

## 7.3 Redgum Lane Reserve No 41224

### 7.3.1 Background

This reserve covers an area of 10.6ha. The east and west sides of the reserve are predominantly bordered by private residential blocks. The north border connects to unallocated crown land which buffers the sewerage treatment works. The southern border connects to Crowea Road Reserve. There are many access routes into the reserve from several suburban streets many of them wide enough for a vehicle. Access routes include Braidwood Elbow, Anning Road, Redgum Lane, and Blue Wren Lane. The Bibbulman Track also traverses the reserve from north to south.

The most elevated point in the reserve is a fairly central ridge. Contour lines show the direction of water flow to the north and south of the ridgeline (see Map 3: Redgum Lane Reserve Phytophthora Dieback Map).

The vegetation is jarrah-marri tall open forest. Susceptible species within the reserve include *Banksia grandis*, *Bossiaea linophylla*, *Dasyogon bromelifolia*, *Eucalyptus marginata*, *Leucopogon capetillatus*, *L. verticillatus*, *Persoonia longifolia*, *Xanthorrhoea gracilis*, and *X. preissii*.

Yellow duplex soils dominate the reserve and deeply weathered granite outcrops are present (Press and Armstrong, 1998).

### 7.3.2 Value of the Reserve

The following values indicate that this site should be prioritised for ongoing environmental monitoring and management.

The reserve is:

- Home to significant stands of Phytophthora Dieback susceptible species including mature stands of *Eucalyptus marginata*, *Banksia grandis* and *Persoonia longifolia*
- It has important fauna and flora habitat values and is a natural corridor linkage between crown reserves to the north and Crowea Road reserves and Wilson Inlet Foreshore to the south
- Used daily for recreational purposes - horse riding, walking and bike riding
- Traversed by the Bibbulman Track. "Friends of the Bibbulman Track" are involved in maintenance of this section of track
- Of ongoing educational value – there is a visible frontline below each side of the ridge which will be a useful educational tool clearly representing the affect of Phytophthora Dieback.

### 7.3.3 Site Assessment

This reserve contains a wide range of flora species at risk from Phytophthora Dieback, including mature stands of *Banksia grandis*. The centrally located ridgeline is currently uninfested and preventative management will assist its protection.

Private property adjacent to the reserve is also suffering from Phytophthora Dieback and landowners indicate their own concerns about Phytophthora Dieback in the reserve and spread into their properties.

Dumping of garden refuse and soil is apparent in Phytophthora Dieback infested areas.

Two permanent quadrats (Quadrat E and F) were established at the Reserve. Table 14 and 15 within Appendix 6 illustrates the range of susceptible species within the two quadrats and the number of deaths observed.

Photos were taken at a permanent photo points at each quadrat to begin a visual record of quadrat health (Figure 12 and 13).





Figure 12: Uninfested Quadrat E (photo point NE toward NW)

#### 7.3.4 Quadrat E – Observations

The susceptible species survey within Quadrat E illustrated a site with a healthy mix of overstorey, mid and lower canopy (Figure 12 and Appendix 6). On the right of the photo there is a healthy and mature *Persoonia elliptica* which has a trunk diameter of 8cm.

The ground level of the site was cool and shaded site (less favourable to production of *Phytophthora* zoospores). Ongoing monitoring is still as important at such sites as *Phytophthora* Dieback introduction through root to root contact or transmission through moved soil can easily trigger deaths and cause eventual opening of canopy caused by pathogen.

This quadrat contains five mature *Eucalyptus marginata* (jarrah) with trunk diameters ranging between 20 to 40cm (see Appendix 6: Table 14 and 15).



Figure 13: Infested Quadrat F (photo point SW toward NE)



### 7.3.5 *Quadrat F – Observations*

The susceptible species survey within Quadrat F showed a significant number of deaths within the quadrat (see Appendix 6: Table 14 and 15). Figure 13 illustrates the opening of canopy structure. Species impacted include a number of mature *Banksia* sp. and *Hakea* sp. as well as many lower canopy shrubs including *Leucopogon* sp., *Macrozamia* sp., *Pattersonia* sp. and *Xanthorrhoea* sp..

The ground level of the site has become open and more favourable to continued production of *Phytophthora* zoospores.

### 7.3.6 *Recommendations*

- All works within and around priority reserves to strictly adhere to **Town Planning Scheme Policy No. 1 for Dieback Disease Management**, (Shire of Denmark, 1997) hygiene controls including but not limited to:
  - No soil movement or extraction within reserve
  - No operations (firebreaks, earthworks, fencing, etc) unless extremely dry soil conditions
  - No unauthorized vehicular access to reserves (closure of vehicular access where applicable)
- As the Phytophthora Dieback Free Protection Area within the ridge of this reserve is the best example of healthy bushland within all of the small peri-urban reserves assessed its maintenance as Phytophthora Dieback free needs to be highly valued
- Resurface firebreak / Bibbulman track within reserve leading to and throughout Phytophthora Dieback free protection area to ensure the track contains no wet boggy areas. Currently there are sections of seepage across the Bibbulman track which could be a potential vector. Make ongoing investigations into the potential use of limestone in strategic points along track (use of Phytophthora Dieback free gravel / limestone imperative)
- Firebreaks to be maintained during dry conditions. Fire can increase the severity of disease in this infested site. Other methods of fuel load reduction in the Phytophthora Dieback Free Protection Area to be investigated. Fire in this area will negatively impact on canopy cover and leaf litter causing a rise in soil temperature
- Stormwater drainage from Braidwood Elbow is contributing to increased impact of PC in the north east corner of the reserve. Recommend an assessment by Shire Engineer to investigate diversion techniques
- There is a criss cross of trails within the reserve and previous recommendations have advised the reduction of entries and trails for preservation of the blocks integrity. Conversations with adjoining private properties highlighted that there is regular vehicle traffic through the reserve, which may contribute to the spread of *Phytophthora cinnamomi* in wet conditions
- Local area education campaign about the values and threats to the local reserve to help negate dumping of garden refuse and entry into infested bush
- Installation of Project Dieback signage at Phytophthora Dieback free protection areas and at Phytophthora Dieback infested areas
- Installation of Project Dieback signage at entry to priority reserves to inform users of how to reduce risk of Phytophthora Dieback spread
- Develop ongoing annual monitoring and treatment program around Phytophthora Dieback free protection areas
- Traditional owners to be consulted and included in any treatment activity
- NRM Officer to support the development of community-based monitoring within reserve and or establishment of “Friends of Group”

All recommendations to be read in conjunction with Section 8: Overall Recommendations in this report.

## 7.4 Mt Hallowell Reserve No 46618

### 7.4.1 Background

Mt Hallowell is the largest reserve vested under the Shire of Denmark. It is approximately 532ha in area. It is bordered by private property to the north, south, east and west. It is situated approximately 5kms south west from the townsite of Denmark. Access is via Harrington Break, Heather Road, the Sheila Hill Memorial Trail off Ocean Beach Rd, Illuka Avenue or Monkey Rock car park off Lights Road.

Previous studies regarding *Phytophthora* Dieback have mapped infestation along the northern boundary's strategic fire access route as well as within an area bordering Heather Road.

Vegetation of the area includes *Phytophthora* Dieback susceptible plants such as *Andersonia caerulea*, *Banksia grandis*, *Banksia ilicifolia*, *B. littoralis*, *B. quercifolia*, *Bossiaea linophylla*, *Dasypogon bromeliifolius*, *Eucalyptus marginata*, *Hakea amplexicaulis*, *H. ruscifolia*, *Hibbertia amplexicaulis*, *Persoonia elliptica*, *P. longifolia*, *Petrophile diversifolia*, *Macrozamia riedlei*, *Xanthorrhoea gracilis*, and *X. preissii*.

Vehicular access along the northern boundary of the reserve is through locked gateways at each end of the firebreak. The area of reserve which borders the Heather Road urban development is open to vehicular access at all times. Motorcycle use is common within both surveyed sections of reserve.

A number of tracks criss-cross the Heather Road section of the reserve including the well used Bibbulman Track, Sheila Hill Memorial Trail, the strategic firebreak and other narrow tracks.

An old trail running west from Harrington Break, along the north side of Mt Hallowell was observed and may be the original vector for *Phytophthora* Dieback introduction to the north side of the Reserve. This track is now overgrown and not used.

The firebreak adjacent to Harrington Break Estate (eastern boundary of reserve) would seem to be the main vector for spread along that edge.

Bush either side of the northern strategic firebreak is thick and impenetrable ensuring use is limited to the firebreak.

Soil type along the northern boundary is a mix of sandy humus podzol including moist and peaty flats and creek valleys (Press and Armstrong, 1997). The well drained nature of these sandy soils makes *Phytophthora* Dieback difficult to detect as it does not present in a contiguous fashion. The soils along the firebreak next to Heather Road are predominantly clay loam and expression of *Phytophthora* Dieback deaths are within close proximity to one another.

Topography indicates three sections of the firebreak on the northern boundary are crossed by first order streams. These streams run seasonally during the wet months of the year (autumn through to spring). These seasonal crossings are areas where the *Phytophthora* pathogen can be transported across the landscape by natural water flow and by soil movement (i.e. vehicles and foot traffic).

The study area of the northern boundary slopes shallowly to the north and the area beside Heather Road slopes more steeply to the south east (see Map 4: Mt Hallowell Reserve *Phytophthora* Dieback Map).

### 7.4.2 Values of the Reserve

The following values indicate that this site should be prioritised for ongoing environmental monitoring and management.

The reserve is:

- Home to at least 38 *Phytophthora* Dieback susceptible species which is one quarter of the 151 *Phytophthora* Dieback indicator species recorded by the Department of Environment and Conservation (DEC)
- Home to 17 vegetation types which contain *Phytophthora* Dieback species susceptible to *Phytophthora cinnamomi*
- The largest reserve in Shire of Denmark and therefore an important habitat for retention of a wide mix of flora and fauna. Loss of *Phytophthora* Dieback susceptible species will cause major impacts to its habitat value
- Used daily for recreational purposes - horse riding, walking and bike riding. The groups "Friends of Mt Hallowell Reserve" and "Friends of the Bibbulman Track" enjoy the reserve
- Traversed by the Bibbulman Track and the Sheila Hill Memorial Walk Trail

- Currently one of a number of sites being investigated for the presence of short range endemics. The study is being conducted by the WA Museum on behalf of the Biodiversity Inventory Program funded by South Coast NRM. The study which will be completed in June 2008
- Lizard traps have been found on granite monadnocks illustrating indigenous heritage and the educational value of the site
- On Register of National Estate
- A site of ongoing research value

#### 7.4.3 Site Assessment

Visual assessment was conducted from the far eastern end of the northern firebreak to the western end of the firebreak and along the edge of the reserve bordering Heather Road (see Map 4: Mt Hallowell Reserve Phytophthora Dieback Map). Both areas contain past and present impacts of the pathogen with no determinable frontline (Figure 14).

Past Phytophthora Dieback mapping (Shire of Denmark, 1995) shows Phytophthora Dieback presence in two sections along the northern border of the reserve and on the northern side of Heather Road. Infection has now spread along the extent of the northern border and crossed upslope of the firebreak. Phytophthora Dieback affect is also noted along the eastern border of the reserve next to Harington Break estate. Phytophthora Dieback is evident in private properties within this estate.

Phytophthora Dieback impact within the reserve is presenting in a typical striped or finger fashion following the natural fall of the land. *Phytophthora* presence is more noticeable in the valleys and dips in the landscape and fewer deaths are occurring on valley ridges and high points in the landscape.

Two permanent quadrats were also established at the reserve (Quadrat G and H). Appendix 7 illustrates the range of susceptible species within the two quadrats.

Photos were taken at a permanent photo points at each quadrat to begin a visual record of quadrat health.



Figure 14: Recent *Banksia grandis* death isolated from an apparent frontline

#### 7.4.4 Quadrat G - Observations

A wide variety of susceptible species are contained within this significant reserve. The frequency and range of species found is contained within Table 17 of Appendix 7.

Figure 15 shows the density and thus coolness of this uninfested quadrat.

The site contains a high number of *Crowea*, *Hibbertia*, *Leucopogon*, *Monotoca* and *Xanthorrhoea* species.

The quadrat is close to the north eastern infested corner of the reserve. Topography of the hillside slopes down from the Phytophthora Dieback free protection area. This indicates that introductions of the pathogen to this quadrat would be via root to root contact following the contour of the hill or brought down from upslope. No current vectors exist upslope.



Figure 15: North East Photo point Quadrat G showing the coolness of the site

#### 7.4.5 Quadrat H – Observations

Quadrat H has a high number of deaths within its small 10m x 10m quadrat. All together 53 plants were recorded as dead. The highest frequency of deaths at any of the four priority sites.

Deaths of four *Banksia grandis*, two *Hakea amplexicoris* and six *Persoonia* varieties were recorded amongst the larger shrubs and trees. *Leucopogon* varieties, *Hibbertia amplexicaulis*, *Monotoca tameriscina* and *Petrophile diversifolia* were some of the lower canopy plant deaths recorded.

#### 7.4.6 Recommendations

- All works within and around priority reserves to strictly adhere to **Town Planning Scheme Policy No. 1 for Dieback Disease Management**, (Shire of Denmark, 1997) hygiene controls including but not limited to:
  - No soil movement or extraction within reserve
  - No operations (firebreaks, earthworks, fencing, etc) within or around the vicinity of the Phytophthora Dieback free protection areas unless extremely dry soil conditions
  - No unauthorized vehicular access to reserve (closure of vehicular access where applicable).
- Firebreak maintenance along north south firebreak between Harington Break private properties and Mt Hallowell Reserve to be done in dry soil conditions to reduce risk of soil disturbance and pathogen redistribution. Firebreak maintenance a long northern firebreak to be done in dry soil conditions only for the same reasons. Firebreaks behind Heather Road to also to carried out in dry soil conditions
- Drainage works along north south firebreak between Harington Break private properties and Mt Hallowell Reserve to be designed to eliminate runoff into Mt Hallowell Reserve to reduce surface water flow carrying Phytophthora Dieback further west into reserve
- Investigate building of raised bridges at two stream crossings at western end of reserve
- All earthworks, road verge work, street sweeping from Harington Break entry, and Heather Road entry to follow **Town Planning Scheme Policy No. 1** hygiene guidelines. Road verges upon entry to these roads and throughout Harington Break estate extremely likely to be infested and threat of Phytophthora Dieback distribution to other areas needs to be prevented
- Installation of Project Dieback signage at Phytophthora Dieback free protection areas and at Phytophthora Dieback infested areas

- Installation of Project Dieback signage at entry to priority reserves to inform users of how to reduce risk of Phytophthora Dieback spread. Also potential site of footbath at access to northern firebreak
- Develop annual monitoring and treatment program in Phytophthora Dieback free protection areas and along frontlines (once hygiene and signage protocols in place)
- Traditional owners to be consulted and included in any treatment activity
- Encourage “Friends of Mt Hallowell Reserve” to assist in monitoring

All recommendations to be read in conjunction with Section 8: Overall Recommendations in this report.

## 8. OVERALL RECOMMENDATIONS

The following tables outline how to reduce Phytophthora Dieback threats through a series of solutions and implementation strategies. Timescales indicate the suggested frequency of implementing strategies. A list of stakeholders highlights the many members of the community who need to be involved in hygiene and management recommendations.

	THREAT	SOLUTION	ASSIST SOLUTION	TIME SCALE	STAKEHOLDERS
<b>1</b>	<b>VEHICLE movement of pathogen</b>	1.1 Ensure access to reserves by authorised vehicles only	Gated and locked entry routes	Always locked when not being accessed	<ul style="list-style-type: none"> <li>• Shire Works Depot</li> <li>• FESA</li> <li>• Fire Brigades</li> <li>• Community Groups</li> <li>• Traditional Owners</li> <li>• Government Organisations</li> <li>• Rangers</li> <li>• Fire Control Officer</li> <li>• Works Departments (Telstra, Western Power)</li> <li>• Contractors (Earthworks, Planners, Landscapers, Surveyors, Developers, Property Maintenance, etc)</li> </ul>
			Closure / minimisation of entry routes	Shire discretion	
		1.2 Ensure entering vehicles clean of pathogen	Access to clean down equipment at site	During wet conditions and if vehicle is carrying soil on body	
			Clean soil off vehicle of before entry to known infested site. (follow hygiene recommendations in Town Planning Scheme Policy No. 1 for Dieback Disease Management)	During wet conditions and if vehicle is carrying soil on body	
		1.3 Ensure exiting vehicles clean of pathogen	Access to clean down equipment at site	During wet conditions and if vehicle is carrying soil on body	
			Clean before exiting known infested site. (follow hygiene recommendations in Town Planning Scheme Policy No. 1 for Dieback Disease Management)	During wet conditions and if vehicle is carrying soil on body	
		1.4 Limit vehicle movement between infested / non infested areas	Close and revegetate unnecessary tracks / fire breaks	Shire discretion	
			Signpost crossovers between infested and uninfested zone	Annual monitoring of frontline	
			Any new access tracks designed to avoid infested uninfested zone cross over	Shire discretion	
			Develop laminated map which delineates Phytophthora Dieback free protection areas and infested areas within priority reserves for authorized vehicles (Shire, Fire Brigades, Community Groups)	Within June 2008 –June 2009	
		1.5 Limit access to dry soil conditions	Restrict gate access to dry soil conditions	Shire discretion	

	THREAT	SOLUTION	ASSIST SOLUTION	TIME SCALE	STAKEHOLDERS
2	SOIL / GRAVEL / MULCH / PLANTS movement of pathogen	2.1 Identify shire activities which could move or introduce pathogen via soil (i.e. revegetation, maintenance, slashing, drainage, etc)	Introduced soil to be purchased from accredited supplier and or tested to be guaranteed as <i>Phytophthora</i> free	Every situation where soil is introduced	<ul style="list-style-type: none"> <li>• Shire Works Depot</li> <li>• Contractors (Earthworks, Planners, Landscapers, Surveyors, Developers, Property Maintenance, etc)</li> <li>• Community Groups</li> <li>• Traditional Owners</li> <li>• Government Organisations</li> </ul>
			In cases of revegetation at or around priority reserves soil of seedlings to be guaranteed <i>Phytophthora</i> free or implement direct seeding	Every revegetation situation where soil is introduced	
			Monitor reserve for illegal introduction of soil and remove access points or implement penalties	Shire discretion	
			Maintenance activities ( fencing, slashing, weeding, track construction, flora and fauna surveys etc) in priority reserves to minimise soil disturbance, be undertaken in dry soil conditions, have clean equipment before and after entering infested area, dispose of material at approved disposal site (Shire Tip), (follow hygiene recommendations in Town Planning Scheme Policy No. 1 for Dieback Disease Management)	To be followed during every weeding activity	
		2.2 Identify community activities which could move or introduce pathogen via soil (i.e. illegal soil dumping, recreation which causes soil disturbance / distribution)	Enforce penalties for illegal dumping as deterrent	Shire discretion	
			Encourage community friends of groups to assist in monitoring and reporting of disturbances within reserves	Within June 2008 –June 2009	
			Implement biannual education campaign to raise awareness of <i>Phytophthora</i> Dieback spread and implications (Shire publication, Denmark Bulletin, Workshop, etc)	To begin within June 2008 –June 2009	
			Review current drainage features around priority reserves to investigate potential threats	To begin within June 2008 –June 2009	

	THREAT	SOLUTION	ASSIST SOLUTION	TIME SCALE	STAKEHOLDERS
3	WATER movement of pathogen	3.1 Drainage and runoff around reserves to be engineered to remove threat of spread	Any observed drainage threats to be redesigned and implemented	Within June 2009 –June 2010 subject to identified threats (see 2.2 above)	<ul style="list-style-type: none"> <li>• Shire Works Depot</li> <li>• Contractors (Earthworks, Planners, Landscapers, Surveyors, Developers, Property Maintenance, etc)</li> <li>• FESA</li> <li>• Fire Brigades</li> <li>• Developers</li> <li>• Works Departments (Telstra, Western Power)</li> <li>• Community Groups</li> <li>• Traditional Owners</li> </ul>
			Drainage and runoff of reserves, developments, estates, etc to be designed to cause least additional flow of ground water across surrounding priority reserves	At planning level for any new or revised drainage projects	
		3.2 Fire control operations to access water from scheme or bores when working in 4 priority reserves (including mop up, prescribed burn, emergency or training exercises)	Fire control operators to be made aware of priority reserves and to identify clean water sources for each reserve	Fire control operators to include Phytophthora Dieback Awareness Training in regular training sessions	



	THREAT	SOLUTION	ASSIST SOLUTION	TIME SCALE	STAKEHOLDERS	
<b>4</b>		4.1 Recommend that the 1997 Policy no. 1 for Dieback Disease Management be assessed and revised	All stakeholders to participate in the assessment to ensure collective awareness of issues are discussed and incorporated into guidelines	Within June 2008 –June 2009	<ul style="list-style-type: none"> <li>• Shire Works Depot</li> <li>• FESA</li> <li>• Fire Brigades</li> <li>• Community Groups</li> <li>• Traditional Owners</li> <li>• Government Organisations</li> <li>• Rangers</li> <li>• Fire Control Officer</li> <li>• Works Departments (Telstra, Western Power)</li> <li>• Contractors</li> </ul>	
		4.2 Users to have immediate access to hygiene and management information	Develop laminated summary of Phytophthora Dieback Disease Management for all authorised vehicles (Shire, Fire Brigades and Community Groups)	Within June 2008 –June 2009		
			Distribute reference copies of “ Town Planning Scheme Policy No. 1 for Dieback Disease Management t” and “Dieback Management in LGA’S” to authorized users			
			4.3 Install signage to inform users of infested and uninfested areas and hygiene suggestions	Install Project Dieback signage at infested, uninfested entry points		Within June 2008 –June 2009
			4.4 Public Information Workshops	Elect education officer and provide list of educational roles required to be completed on an annual basis (programs designed for particular interest groups)		To begin in 2008 and on as needs basis. Shire / community group discretion
			4.5 Regular Media Information	Elect education officer and provide list of educational roles required to be completed on an annual basis		Annual to Biannual article in Denmark Bulletin, Albany papers, Shire, Bulletin and Community Group Websites
			4.6 Mail out hygiene and awareness information to properties bordering priority reserves, local developers, contractors, community groups	Elect education officer and provide list of educational roles required to be completed on an annual basis		Annual to Biannual article in Denmark Bulletin, Albany papers, Shire, Bulletin and Community Group Websites
	<b>Limited EDUCATION AND AWARENESS in community</b>					

	THREAT	SOLUTION	ASSIST SOLUTION	TIME SCALE	STAKEHOLDERS
5	Lack of Routine TREATMENT PROGRAM	5.1 Phosphite treatment program within four priority reserves	Develop regular monitoring program of quadrats, transects and frontlines in 4 priority reserves	Within June 2008 –June 2009 and annual basis thereafter	<ul style="list-style-type: none"> <li>• Shire of Denmark</li> <li>• Contractors</li> <li>• Community Groups</li> <li>• Traditional Owners</li> <li>• Government Organisations</li> </ul>
			Develop a foliar spray schedule	Within June 2008 –June 2009 and then 2 yr basis (determined by monitoring evidence)	
			Develop a stem injection schedule	Within June 2008 –June 2009 and then on a 3 – 5 yr basis (determined by monitoring evidence)	

**NOTE** – The following reports are acknowledged for their assistance in developing the above recommendations – “Assessment for the Presence of *Phytophthora* sp.: Denmark Reserves” (Brown and Tufnell, 2002), “Managing Phytophthora Dieback: Guidelines for Local Government “(Dieback Working Group, 2008), “Management of Phytophthora Dieback: Peace Street Reserve, Denmark” (Zuvela, 2002).

## 9. MONITORING AND MEASURING SUCCESS

The goal of Phytophthora Dieback management within the Shire of Denmark reserves should be to protect examples of vulnerable vegetation in the long term. The most important thing to monitor is the vegetation condition of these areas.

As previously mentioned all of the ten peri-urban reserves contain species that are of conservation value and are susceptible to Phytophthora Dieback. Four of these reserves were prioritized for their unique crossovers of environment, economics, culture and social values.

Management recommendations within this report have been designed for individual reserves basis as well as at an holistic level. As recommendations are actioned it will be the role of stakeholders to reflect on the success of the solutions they are implementing. This can be done by:

- **Regular field monitoring** – Field monitoring can identify the frequency, health, and age of susceptible species, such knowledge will then influence treatment areas and schedules
- **Annual audits of field practices**– An awareness of access and hygiene practices will ensure timely improvements or changes are implemented

As a result of regular monitoring and auditing the need for further treatment, education and training within the community will be identified.

Regularly measuring the success of actions will ensure that time and money is used to greatest affect.

## 10. CONCLUSION

This study has found that *Phytophthora cinnamomi* is within all of the Shire reserves assessed and continues to affect vegetation health. Its presence is changing species composition and forest structure and threatening genetic diversity, fauna and flora habitats, as well as social, cultural and economic assets.

Four reserves have been identified, through a thorough assessment process, as priority areas requiring active Phytophthora Dieback protection. The areas of healthy bushland within these reserves have been mapped to assist protective treatment works.

Recommendations within this report have been designed to assist the Shire of Denmark in management of reserves impacted by the pathogen. Recommendations include vigilant monitoring and treatment alongside regular consultation with stakeholders to raise awareness of the impacts of the pathogen. Further monitoring is suggested within larger scale reserves outside of the urban development nodes with the Shire of Denmark (not included in this assessment).

Promotion of hygiene protocols has been emphasized as an important factor in minimizing spread within and beyond local reserves. All operations within priority reserves are to be conducted in dry soil conditions and access to the Phytophthora Dieback Free Protection Areas is to be tightly controlled by locked gates and closed tracks.

The use of Project Dieback signage is recommended at infested and Phytophthora Dieback free sections of reserves as well as at entries to tracks.

Although many of the recommendations are specific to the four priority reserves it should be remembered that hygiene and protection practices need to be adopted when working within all Phytophthora Dieback affected areas.

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## 13. APPENDICES

### Appendix 1: List of Common Indicator Species

1. <i>Platysace compressa</i>	57. <i>Jacksonia horrida</i>	111. <i>Hakea pandanicarpa</i> subsp. <i>crassifolia</i>
2. <i>Allocasuarina fraseriana</i>	58. <i>Nemcia pulchella</i>	112. <i>Hakea prostrata</i>
3. <i>Allocasuarina humilis</i>	59. <i>Pultenaea reticulata</i>	113. <i>Hakea ruscifolia</i>
4. <i>Evandra aristata</i>	60. <i>Sphaerolobium medium</i>	114. <i>Hakea trifurcata</i>
5. <i>Dasyopogon bromeliifolius</i>	61. <i>Dianella revoluta</i>	115. <i>Hakea undulata</i>
6. <i>Lomandra odora</i>	62. <i>Pinus radiata</i>	116. <i>Isopogon alcornis</i>
7. <i>Lomandra sonderi</i>	63. <i>Podocarpus drouynianus</i>	117. <i>Isopogon axillaris</i>
8. <i>Pteridium esculentum</i>	64. <i>Adenanthos barbigerus</i>	118. <i>Isopogon formosus</i>
9. <i>Hibbertia amplexicaulis</i>	65. <i>Adenanthos cuneatus</i>	119. <i>Isopogon latifolius</i>
10. <i>Hibbertia hypericoides</i>	66. <i>Adenanthos cygnorum</i>	120. <i>Isopogon sphaerocephalus</i>
11. <i>Hibbertia inconspicua</i>	67. <i>Adenanthos detmoldii</i>	121. <i>Isopogon uncinatus</i>
12. <i>Hibbertia lineata</i>	68. <i>Adenanthos linearis</i>	122. <i>Isopogon tripartitus</i>
13. <i>Hibbertia montana</i>	69. <i>Adenanthos meisneri</i>	123. <i>Lambertia echinata</i>
14. <i>Hibbertia quadricolor</i>	70. <i>Adenanthos obovatus</i>	124. <i>Lambertia ericifolia</i>
15. <i>Hibbertia subvaginata</i>	71. <i>Adenanthos sericeus</i>	125. <i>Lambertia orbifolia</i>
16. <i>Andersonia caerulea</i>	72. <i>Banksia attenuata</i>	126. <i>Lambertia inermis</i>
17. <i>Andersonia echinocephala</i>	73. <i>Banksia baueri</i>	127. <i>Persoonia elliptica</i>
18. <i>Andersonia heterophylla</i>	74. <i>Banksia baxteri</i>	128. <i>Persoonia longifolia</i>
19. <i>Andersonia lehmanniana</i>	75. <i>Banksia brownii</i>	129. <i>Petrophile scirifolia</i>
20. <i>Astroloma microcalyx</i>	76. <i>Banksia coccinea</i>	130. <i>Petrophile diversifolia</i>
21. <i>Astroloma xerophyllum</i>	77. <i>Banksia grandis</i>	131. <i>Petrophile linearis</i>
22. <i>Conostephium pendulum</i>	78. <i>Banksia ilicifolia</i>	132. <i>Petrophile serruriae</i>
23. <i>Leucopogon australis</i>	79. <i>Banksia littoralis</i>	133. <i>Petrophile squamata</i>
24. <i>Leucopogon capitellatus</i>	80. <i>Banksia menziesii</i>	134. <i>Petrophile striata</i>
25. <i>Leucopogon concinnus</i>	81. <i>Banksia nutans</i>	135. <i>Stirlingia latifolia</i>
26. <i>Leucopogon conostephioides</i>	82. <i>Banksia occidentalis</i>	136. <i>Synaphea petiolaris</i>
27. <i>Leucopogon flavescens</i>	83. <i>Banksia occidentalis</i> subsp. <i>formosa</i>	137. <i>Xylomelum angustifolium</i>
28. <i>Leucopogon gracillimus</i>	84. <i>Banksia oreophila</i>	138. <i>Xylomelum occidentale</i>
29. <i>Leucopogon nutans</i>	85. <i>Banksia praemorsa</i>	139. <i>Loxocarya cinerea</i>
30. <i>Leucopogon parviflorus</i>	86. <i>Banksia prionotes</i>	140. <i>Crowea angustifolia</i>
31. <i>Leucopogon propinquus</i>	87. <i>Banksia quercifolia</i>	141. <i>Lasiopetalum floribundum</i>
32. <i>Leucopogon revolutus</i>	88. <i>Banksia seminuda</i>	142. <i>Lasiopetalum glabratum</i>
33. <i>Leucopogon verticillatus</i>	89. <i>Banksia speciosa</i>	143. <i>Pimelea suaveolens</i>
34. <i>Monotoca tamariscina</i>	90. <i>Banksia sphaerocarpa</i>	144. <i>Tremandra stelligera</i>
35. <i>Styphelia tenuiflora</i>	91. <i>Banksia telmatiaea</i>	145. <i>Xanthorrhoea drummondii</i>
36. <i>Patersonia umbrosa</i>	92. <i>Conospermum stoechadis</i>	146. <i>Xanthorrhoea gracilis</i>
37. <i>Patersonia occidentalis</i>	93. <i>Dryandra arctotidis</i>	147. <i>Xanthorrhoea nana</i>
38. <i>Patersonia rudis</i>	94. <i>Dryandra armata</i>	148. <i>Xanthorrhoea preissii</i>
39. <i>Acacia campyophylla</i>	95. <i>Dryandra bipinnatifida</i>	149. <i>Xanthorrhoea platyphylla</i>
40. <i>Acacia pulchella</i>	96. <i>Dryandra formosa</i>	150. <i>Macrozamia riedlei</i>
41. <i>Beaufortia anisandra</i>	97. <i>Dryandra mucronulata</i>	
42. <i>Eucalyptus marginata</i>	98. <i>Dryandra lindleyana</i>	
43. <i>Eucalyptus staeri</i>	99. <i>Dryandra nivea</i>	
44. <i>Hypocalymma robustum</i>	100. <i>Dryandra pteridifolia</i>	
45. <i>Kunzea sulphurea</i>	101. <i>Dryandra seneciifolia</i>	
46. <i>Melaleuca scabra</i>	102. <i>Dryandra serra</i>	
47. <i>Melaleuca subfalcata</i>	103. <i>Dryandra sessilis</i>	
48. <i>Scholtzia involucrata</i>	104. <i>Dryandra squarrosa</i>	
49. <i>Verticordia nitens</i>	105. <i>Dryandra tenuifolia</i>	
50. <i>Bossiaea eriocarpa</i>	106. <i>Grevillea wilsonii</i>	
51. <i>Bossiaea aquifolium</i>	107. <i>Hakea ambigua</i>	
52. <i>Bossiaea ornata</i>	108. <i>Hakea baxteri</i>	
53. <i>Daviesia decurrens</i>	109. <i>Hakea cucullata</i>	
54. <i>Daviesia rhombifolia</i>	110. <i>Hakea oleifolia</i>	
55. <i>Daviesia polyphylla</i>		
56. <i>Gompholobium knightianum</i>		

From Department of Environment and Conservation, 2008

**Appendix 2: List of Currently Known Susceptibles**

1. <i>Acacia campylophylla</i>	72. <i>Banksia repens</i>	141. <i>Gompholobium polymorphum</i>	208. <i>Leucopogon cymbiformis</i>	277. <i>Thyrtomene saxicola</i>
2. <i>Acacia myrtifolia</i>	73. <i>Banksia seminuda</i>	142. <i>Grevillea calliantha</i>	209. <i>Leucopogon distans</i>	278. <i>Thysanotus thyrsoideus</i>
3. <i>Acacia stenoptera</i>	74. <i>Banksia speciosa</i>	143. <i>Grevillea cirsiifolia</i>	210. <i>Leucopogon distans</i>	279. <i>Tremandra stelligera</i>
4. <i>Actinostrobos pyramidalis</i>	75. <i>Banksia sphaerocarpa</i>	144. <i>Grevillea crithmifolia</i>	211. <i>Leucopogon elegens</i>	280. <i>Trymalium ledifolium</i>
5. <i>Adenanthos barbiger</i>	76. <i>Banksia telmatiaea</i>	145. <i>Grevillea saccata</i>	212. <i>Leucopogon flavescens</i>	281. <i>Verticordia densifolia</i>
6. <i>Adenanthos cumminghamii</i>	77. <i>Banksia tricuspis</i>	146. <i>Grevillea tripartita</i>	213. <i>Leucopogon gibbosus</i>	282. <i>Verticordia huegelii</i>
7. <i>Adenanthos cuneatus</i>	78. <i>Banksia verticillata</i>	147. <i>Hakea ambigua</i>	214. <i>Leucopogon gracillimus</i>	283. <i>Verticordia nitens</i>
8. <i>Adenanthos cygnorum</i>	79. <i>Banksia victoriae</i>	148. <i>Hakea baxteri</i>	215. <i>Leucopogon nutans</i>	284. <i>Xanthorrhoea nana</i>
9. <i>Adenanthos detmoldii</i>	80. <i>Beaufortia anisandra</i>	149. <i>Hakea cucullata</i>	216. <i>Leucopogon obtectus</i>	285. <i>Xanthorrhoea brevistyla</i>
10. <i>Adenanthos dobagii</i>	81. <i>Beaufortia micrantha</i>	150. <i>Hakea flabellifolia</i>	217. <i>Leucopogon oxycedrus</i>	286. <i>Xanthorrhoea drummondii</i>
11. <i>Adenanthos ellipticus</i>	82. <i>Boronia fastigiata</i>	151. <i>Hakea lehmanniana</i>	218. <i>Leucopogon parviflorus</i>	287. <i>Xanthorrhoea gracilis</i>
12. <i>Adenanthos filifolius</i>	83. <i>Boronia revolute</i>	152. <i>Hakea marginata</i>	219. <i>Leucopogon polymorphus</i>	288. <i>Xanthorrhoea platyphylla</i>
13. <i>Adenanthos ileiticus</i>	84. <i>Bossiaea eriocarpa</i>	153. <i>Hakea oleifolia</i>	220. <i>Leucopogon propinquus</i>	289. <i>Xanthorrhoea preissii</i>
14. <i>Adenanthos meisneri</i>	85. <i>Bossiaea ornata</i>	154. <i>Hakea pandanicarpa</i> ssp.	221. <i>Leucopogon pulchellus</i>	290. <i>Xylomelum angustifolium</i>
15. <i>Adenanthos obovatus</i>	86. <i>Brachysema papilio</i>	155. <i>Hakea pendanicarpa</i> ssp.	222. <i>Leucopogon revolutus</i>	291. <i>Xylomelum occidentale</i>
16. <i>Adenanthos oreophilus</i>	87. <i>Calothamnus villosus</i>	156. <i>Hakea prostrata</i>	223. <i>Leucopogon verticillatus</i>	
17. <i>Adenanthos pungens</i> & ssp.	88. <i>Chamelaucium erythrochlora</i>	157. <i>Hakea trifurcata</i>	224. <i>Lomandra odora</i>	
18. <i>Adenanthos sericeus</i>	89. <i>Chamelaucium griffinii</i>	158. <i>Hakea undulata</i>	225. <i>Lomandra sonderi</i>	
19. <i>Agonis linearifolia</i>	90. <i>Chamelaucium roycei</i>	159. <i>Hibbertia acerosa</i>	226. <i>Loxocaryx cinerea</i>	
20. <i>Agrostocrinum scabrum</i>	91. <i>Conospermum stoechadis</i>	160. <i>Hibbertia amplexicaulis</i>	227. <i>Lysinema conspicuum</i>	
21. <i>Allocasuarina fraseriana</i>	92. <i>Conospermum todii</i>	161. <i>Hibbertia commutata</i>	228. <i>Lysinema cillatum</i>	
22. <i>Allocasuarina humilis</i>	93. <i>Conospermum triplinervium</i>	162. <i>Hibbertia desmophylla</i>	229. <i>Macrozamia riedlei</i>	
23. <i>Allocasuarina thuyoides</i>	94. <i>Conostephium pendulum</i>	163. <i>Hibbertia furfuracea</i>	230. <i>Melaleuca scabra</i>	
24. <i>Andersonia axilliflora</i>	95. <i>Crowea angustifolia</i>	164. <i>Hibbertia huegelli</i>	231. <i>Melaleuca subfalcata</i>	
25. <i>Andersonia caerulea</i>	96. <i>Dampiera alata</i>	165. <i>Hibbertia hypercoides</i>	232. <i>Melaleuca thymoides</i>	
26. <i>Andersonia heterophylla</i>	97. <i>Darwinia collina</i>	166. <i>Hibbertia inconspicua</i>	233. <i>Monotoca tamariscina</i>	
27. <i>Andersonia lehmanniana</i>	98. <i>Darwinia macrostegia</i>	167. <i>Hibbertia lineata</i>	234. <i>Nemcia pulchella</i>	
28. <i>Andersonia pinaster</i>	99. <i>Darwinia meeboldii</i>	168. <i>Hibbertia montana</i>	235. <i>Opercularia vaginata</i>	
29. <i>Andersonia simplex</i>	100. <i>Darwinia oxylepis</i>	169. <i>Hibbertia montana</i> var. <i>major</i>	236. <i>Patersonia babianoides</i>	
30. <i>Aotus ericoides</i>	101. <i>Darwinia squarrosa</i>	170. <i>Hibbertia quadricolor</i>	237. <i>Patersonia rudis</i>	
31. <i>Aotus passerinoides</i>	102. <i>Darwinia wittwerorum</i>	171. <i>Hibbertia rhadinopoda</i>	238. <i>Patersonia umbrosa</i>	
32. <i>Astroloma cilatum</i>	103. <i>Dasyopogon bromeliifolius</i>	172. <i>Hibbertia stellaris</i>	239. <i>Pattersonia occidentalis</i>	
33. <i>Astroloma xerophyllum</i>	104. <i>Daviesia decurrens</i>	173. <i>Hovea elliptica</i>	240. <i>Pericalymma ellipticum</i>	
34. <i>Banksia aculeata</i>	105. <i>Daviesia incrassata</i>	174. <i>Hovea pungens</i>	241. <i>Persoonia elliptica</i>	
35. <i>Banksia ashbyi</i>	106. <i>Daviesia inflata</i>	175. <i>Hybanthus floribundus</i>	242. <i>Persoonia longifolia</i>	
36. <i>Banksia attenuata</i>	107. <i>Daviesia megacalyx</i>	176. <i>Hypocalymma robustum</i>	243. <i>Petrophile biloba</i>	
37. <i>Banksia audax</i>	108. <i>Daviesia physodes</i>	177. <i>Hypocalymma strictum</i>	244. <i>Petrophile divaricata</i>	
38. <i>Banksia baueri</i>	109. <i>Daviesia preissii</i>	178. <i>Isopogon attenuatus</i>	245. <i>Petrophile diversifolia</i>	
39. <i>Banksia baxteri</i>	110. <i>Daviesia pseudaphylla</i>	179. <i>Isopogon axillaris</i>	246. <i>Petrophile drummondii</i>	
40. <i>Banksia brownii</i>	111. <i>Daviesia rhombifolia</i>	180. <i>Isopogon baxteri</i>	247. <i>Petrophile ericifolia</i>	
41. <i>Banksia burdettii</i>	112. <i>Dianella revoluta</i>	181. <i>Isopogon buxifolius</i> var. <i>obovatus</i>	248. <i>Petrophile linearis</i>	
42. <i>Banksia calyeyi</i>	113. <i>Dryandra falcata</i>	182. <i>Isopogon formosus</i>	249. <i>Petrophile longifolia</i>	
43. <i>Banksia candolleana</i>	114. <i>Dryandra plumosa</i>	183. <i>Isopogon sphaerocephalus</i>	250. <i>Petrophile media</i>	
44. <i>Banksia coccinea</i>	115. <i>Dryandra pteridifolia</i>	184. <i>Isopogon teretifolius</i> var.	251. <i>Petrophile seminuda</i>	
45. <i>Banksia cucinata</i>	116. <i>Dryandra anatona</i>	185. <i>Isopogon trilobus</i>	252. <i>Petrophile serruriae</i>	
46. <i>Banksia dryandroide</i>	117. <i>Dryandra arctotidis</i>	186. <i>Isopogon uncinatus</i>	253. <i>Petrophile squamata</i>	
47. <i>Banksia elderiana</i>	118. <i>Dryandra armata</i>	187. <i>Jacksonia floribunda</i>	254. <i>Petrophile stricta</i>	
48. <i>Banksia gardneri</i> & var.	119. <i>Dryandra bipinnatifida</i>	188. <i>Jacksonia furcellata</i>	255. <i>Pimelea suaveolens</i>	
49. <i>Banksia goodii</i>	120. <i>Dryandra cirsioides</i>	189. <i>Jacksonia horrida</i>	256. <i>Platysace compressa</i>	
50. <i>Banksia grandis</i>	121. <i>Dryandra formosa</i>	190. <i>Jacksonia spinosa</i>	257. <i>Podocarpus drouynianus</i>	
51. <i>Banksia hookeriana</i>	122. <i>Dryandra ionthocarpa</i>	191. <i>Jacksonia sternbergiana</i>	258. <i>Scaevola calliptera</i>	
52. <i>Banksia ilcifolia</i>	123. <i>Dryandra lindleyana</i>	192. <i>Kunzea ericifolia</i>	259. <i>Scholtzia involucrata</i>	
53. <i>Banksia laevigata</i>	124. <i>Dryandra mimica</i>	193. <i>Kunzea sulphurea</i>	260. <i>Sphenotoma dracophylloides</i>	
54. <i>Banksia laricina</i>	125. <i>Dryandra montana</i>	194. <i>Labichea punctata</i>	261. <i>Sphenotoma gracile</i>	
55. <i>Banksia lemmaniana</i>	126. <i>Dryandra mucronulata</i>	195. <i>Lambertia echinata</i> & ssp.	262. <i>Sphenotoma squarrosorum</i>	
56. <i>Banksia lindleyana</i>	127. <i>Dryandra nivea</i>	196. <i>Lambertia fairallii</i>	263. <i>Stirlingia latifolia</i>	
57. <i>Banksia littoralis</i>	128. <i>Dryandra pteridifolia</i>	197. <i>Lambertia inermis</i>	264. <i>Stirlingia tenuifolia</i>	
58. <i>Banksia lufftzi</i>	129. <i>Dryandra plumosa</i>	198. <i>Lambertia multiflora</i>	265. <i>Stylidium amoenum</i>	
59. <i>Banksia media</i>	130. <i>Dryandra quercifolia</i>	199. <i>Lambertia orbifolia</i>	266. <i>Stylidium junceum</i>	
60. <i>Banksia menziesii</i>	131. <i>Dryandra seneciifolia</i>	200. <i>Lambertia uniflora</i>	267. <i>Stylidium schoenoides</i>	
61. <i>Banksia micrantha</i>	132. <i>Dryandra serra</i>	201. <i>Lasiopetalum floribundum</i>	268. <i>Stylidium spathulatum</i>	
62. <i>Banksia nutans</i>	133. <i>Dryandra serratuloides</i>	202. <i>Latrobea genistoides</i>	269. <i>Styphelia tenuiflora</i>	
63. <i>Banksia occidentalis</i>	134. <i>Dryandra serratuloides</i>	203. <i>Latrobea hirtella</i>	270. <i>Synaphea petiolaris</i>	
64. <i>Banksia oligantha</i>	135. <i>Dryandra sessilis</i>	204. <i>Leucopogon australis</i>	271. <i>Synaphea polymorpha</i>	
65. <i>Banksia oreophila</i>	136. <i>Dryandra squarrosa</i> & ssp.	205. <i>Leucopogon capitellatus</i>	272. <i>Tetrarrhena laevis</i>	
66. <i>Banksia petiolaris</i>	137. <i>Dryandra tenuifolia</i>	206. <i>Leucopogon concinnus</i>	273. <i>Tetratheca hirsuta</i>	
67. <i>Banksia pilostylis</i>	138. <i>Eucalyptus marginata</i>	207. <i>Leucopogon conostephioides</i>	274. <i>Tetratheca pilosa</i>	
68. <i>Banksia praemorsa</i>	139. <i>Eucalyptus todtiana</i>		275. <i>Tetratheca setigera</i>	
69. <i>Banksia prionotes</i>	140. <i>Evandra aristata</i>		276. <i>Thomasia grandifolia</i>	
70. <i>Banksia pulchella</i>				
71. <i>Banksia quercifolia</i>				

From "Western Australian Natives Susceptible to *Phytophthora cinnamomi*" Compiled by Groves, E., Hardy, G. & McComb, J., Murdoch University (date unknown)

**Appendix 3: Plotting the Frontline and Placement of Permanent Transects Peace Street Reserve No 46688**

Point	Easting	Northing	Notes
1	531147	6131349	Dead <i>Xanthorrhoea gracilis</i>
2	531166	6131353	Dead <i>Hakea amplexicaulis</i>
3	531193	6131384	Dead <i>Hakea amplexicaulis</i>
4	531229	6131397	Dead <i>Banksia grandis</i>
5	531244	6131377	Dead <i>Banksia grandis</i>
6	531250	6131373	Dead <i>Banksia grandis</i>
7	531272	6131388	Dead <i>Banksia grandis</i>
8	531303	6131391	Dead <i>Xanthorrhoea gracilis</i>
9	531315	6131904	Dead <i>Petrophile</i> sp
10	531351	6131390	Dead <i>Banksia grandis</i>
11	531390	6131383	Dead <i>Banksia grandis</i>
12	531414	6131348	Dead <i>Persoonia longifolia</i>
13	531404	6131319	Dying <i>Banksia grandis</i>
14	531406	6131300	Dying <i>Banksia grandis</i>
15	531413	6131282	Dead <i>Banksia grandis</i>
16	531440	6131285	Edge of Gravel Pit

Table 1: GPS Coordinates for the Active Frontline within Peace Street Reserve No 46688

Point	Easting	Northing
S1	531162	6131361
M1	531168	6131356
E1	531159	6131346

Table 2: GPS Location of Transect One Untreated Area of Reserve

Susceptible Species along Transect One	Distance in metres from S1
<i>Xanthorrhoea gracilis</i>	1.2
<i>Leucopogon capitellatus</i>	1.6
<i>Xanthorrhoea gracilis</i>	2.5
<i>Hakea amplexicaulis</i>	3.8
<i>Xanthorrhoea gracilis</i>	5
<i>Xanthorrhoea gracilis</i>	6
<i>Hakea amplexicaulis</i>	8.3
<i>Leucopogon capitellatus</i>	10
<i>Leucopogon capitellatus</i>	11
<i>Hakea amplexicaulis</i>	12.2
<i>Leucopogon capitellatus</i>	13.7
<i>Leucopogon capitellatus</i>	14.7
<i>Xanthorrhoea gracilis</i>	15.8
<i>Leucopogon verticillatus</i>	17
<i>Leucopogon verticillatus</i>	18.5
<i>Hakea amplexicaulis</i>	19
<i>Pattersonia occidentalis</i>	19.5

Table 3: Susceptible Species along Transect One - Untreated Area of Reserve



Point	Easting	Northing
S2	531284	6131404
M2	531278	6131395
E2	531275	6131382

Table 4: GPS Location of Transect Two - Treated Area of Reserve

Susceptible Species along Transect Two	Distance in metres from S2
<i>Persoonia longifolia</i>	0.6
<i>Bossiaea linophylla</i>	0.9
<i>Persoonia longifolia</i>	2.1
<i>Petrophile diversifolia</i>	3.7
<i>Hakea</i> sp.	
<i>Leucopogon verticillatus</i>	3.9
<i>Dryandra nivea</i>	4.6
<i>Petrophile diversifolia</i>	4.9
<i>Allocausarina fraseriana</i>	7.5
<i>Persoonia longifolia</i>	8.1
<i>Persoonia longifolia</i>	9.3
<i>Xanthorrhoea preissii</i>	12
<i>Hakea amplexicaulis</i>	15.6
<i>Dryandra nivea</i>	16.8
<i>Dryandra nivea</i>	17.4
<i>Dryandra nivea</i>	17.8
<i>Dryandra nivea</i>	18.9
<i>Hakea amplexicaulis</i>	19.2

Table 5: Susceptible Species along Transect Two - Treated Area of Reserve

Point	Easting	Northing
S3	531380	6131385
M3	531374	6131377
E3	531366	6131368

Table 6: GPS Location of Transect Three - Treated Area of Reserve (Spray Only)

Susceptible Species along Transect Three	Distance in metres from S3
<i>Bossiaea linophylla</i>	0.7
<i>Leucopogon capitellatus</i>	1
<i>Bossiaea linophylla</i>	2.3
<i>Eucalyptus marginata</i>	2.8
<i>Dryandra nivea</i>	5.1
<i>Dryandra nivea</i>	5.8
<i>Dryandra nivea</i>	8.5
<i>Petrophile diversifolia</i>	8.9
<i>Leucopogon capitellatus</i>	11
<i>Leucopogon capitellatus</i>	13.8
<i>Bossiaea linophylla</i>	14.8
<i>Bossiaea linophylla</i>	15.9
<i>Hakea amplexicaulis</i>	16.1
<i>Hakea amplexicaulis</i>	16.2

Table 7: Susceptible Species along Transect Three - Treated Area of Reserve (Spray Only)

Point	Easting	Northing
S4	531397	6131340
M4	531387	6131338
E4	531381	6131332

Table 8: GPS Location of Transect Four

Susceptible Species along Transect Four	Distance in metres from S4
<i>Bossiaea linophylla</i>	0.4
<i>Bossiaea linophylla</i>	8.8
<i>Persoonia longifolia</i>	11.3
<i>Leucopogon capitellatus</i>	12.4
<i>Xanthorrhoea preissii</i>	15.2
<i>Bossiaea linophylla</i>	
<i>Leucopogon capitellatus</i>	18.6

Table 9: Susceptible Species along Transect Four

**Appendix 4: Quadrat A and B Surveys - Peace Street Reserve No 46688**

GPS Locations		Eastings	Northings
<b>Quadrat A</b>	Quadrat A1/ site of photo point looking 345'	531164	6131186
	Quadrat A2	531173	6131178
	Quadrat A3	531187	6131193
	Quadrat A4	531166	6131198
<b>Quadrat B</b>	Quadrat B1 /Photo Point - B1 at 310' NW	531160	6131260
	Quadrat B2	531169	6131261
	Quadrat B3	531173	6131270
	Quadrat B4	531162	6131270

Table 10: Quadrat A and B GPS Locations

Susceptible Species	Quadrat A – Healthy	Quadrat B - Infested	Dead
<i>Acacia pulchella</i>		18	1
<i>Astroloma pallidum</i>		10	
<i>Banksia grandis</i>	11	10	1
<i>Banksia</i> sp.		64	1
<i>Billardia varifolia</i>	5		
<i>Bossiaea linophylla</i>	1	7	
<i>Eucalyptus marginata</i>		2	
<i>Eucalyptus</i> sp.	11	14	
<i>Hakea amplexicaulis</i>	7	8	
<i>Hakea varia</i>	21	3	
<i>Hibbertia amplexicaulis</i>	3	12	
<i>Isopogon sphaerocephalus</i>		9	
<i>Leucopogon</i> sp.	12	30	1
<i>Leucopogon verticillatus</i>	23	3	
<i>Pattersonia occidentalis</i>		14	
<i>Persoonia longifolia</i>	24	10	
<i>Petrophile</i> sp.	1	1	
<i>Petrophile diversifolia</i>	1		
<i>Synaphia</i> sp.		4	
<i>Xanthorrhoea gracilis</i>	56	27	
<i>Xanthorrhoea preissii</i>	13	16	
<b>TOTAL DEATHS</b>			<b>4</b>

Table 11: Number of Susceptible Species within Quadrat A (Uninfested) & B (Infested) Peace Street Reserve No 46688

**Appendix 5: Quadrat C and D Surveys - Wilson Inlet Heritage Trail (unallocated Crown Land No 43923)**

GPS Locations		Eastings	Northings
<b>Quadrat C</b>	Quadrat C1 / Photo Point - C1 toward NW	537089	6129583
	Quadrat C2	537080	6129587
	Quadrat C3	537097	6129588
	Quadrat C4	537090	6129582
<b>Quadrat D</b>	Quadrat D1/ Photo Point - D4 diagonal to D2	537369	6129171
	Quadrat D2	537361	6129177
	Quadrat D3	537373	6129180
	Quadrat D4	537371	6129175

Table 12: Quadrat C and D GPS Locations

Susceptible Species	Quadrat C - Infested	Dead	Quadrat D - Infested	Dead
<i>Banksia seminuda</i>	17	8	1	
<i>Bossiaea linophylla</i>			4	
<i>Eucalyptus marginata</i>	1			
<i>Hibbertia amplexicoris</i>	10			
<i>Hibbertia furfuracea</i>	1		2	
<i>Leucopogon capitellatus</i>	49		20	4
<i>Leucopogon parviflorus</i>	8			
<i>Macrozamia riedlei</i>			13	2
<i>Montoca tamariscina</i>			1	
<i>Persoonia longifolia</i>	1			
<i>Podocarpus drouynianus</i>			49	1
<i>Xanthorrhoea preissii</i>	2			
<b>TOTAL DEATHS</b>		8		7

Table 13: Number of Susceptible Species within Quadrats C (Infested) and D (Infested)  
Wilson Inlet Heritage Trail Foreshore Reserve

**Appendix 6: Quadrat E and F Surveys - Redgum Lane Reserve No 41224**

GPS Locations		Eastings	Northings
<b>Quadrat E</b>	Quadrat E1 / NW	532501	6129096
	Quadrat E2 / SW	532513	6129095
	Quadrat E3 / SE	532512	6129095
	Quadrat E4 / NE	532508	6129106
<b>Quadrat F</b>	Quadrat F1 / NW	532428	6129121
	Quadrat F2 / SW	532420	6129120
	Quadrat F3 / SE	532421	6129127
	Quadrat F4 / NE	532431	6129129

Table 14: Quadrat E and F GPS Locations

Susceptible Species	Quadrat E– Healthy	Quadrat F - Infested	Dead
<i>Adenanthos obovatus</i>	9		
<i>Agonis hypericifolia</i>		119	4
<i>Banksia grandis</i>	4	14	3
<i>Dasypogon bromelifolia</i>	18		
<i>Eucalyptus marginata</i>	10	15	
<i>Hakea ruscifolia</i>		4	1
<i>Hakea varia</i>	3		
<i>Hibbertia amplexicaulis</i>	20	4	
<i>Leucopogon australis</i>		2	
<i>Leucopogon capetillatus</i>	1	4	
<i>Leucopogon parviflorus</i>	3		
<i>Leucopogon verticillatus</i>	8	10	4
<i>Macrozamia riedlei</i>		1	4
<i>Monotoca tameriscina</i>		13	
<i>Pattersonia occidentalis</i>	12	63	1
<i>Persoonia elliptica</i>	4		
<i>Persoonia longifolia</i>	15		
<i>Pultenaea reticulata</i>	2		
<i>Xanthorrhoea gracilis</i>	7	2	
<i>Xanthorrhoea preissii</i>	8	6	1
<b>TOTAL DEATHS</b>			<b>18</b>

Table 15: Number of Susceptible Species within Quadrats E (Infested) and F (Infested) Redgum Lane Reserve No 41224

Appendix 7: Quadrat G and H Surveys - Mt Hallowell Reserve No 46618

GPS Locations		Eastings	Northings
<b>Quadrat G</b>	Quadrat G1 (photo point looking SE) NW	529076	6127284
	Quadrat G2 (photo point looking NE) SW	529071	6127277
	Quadrat G3 (uninfected site) SE	529079	6127272
	Quadrat G4 NE	529087	6127280
<b>Quadrat H</b>	Quadrat H1 NW	529161	6127241
	Quadrat H2 SW	529151	6127240
	Quadrat H3 SE	529143	6127234
	Quadrat H4 NE	529163	6127237

Table 16: Quadrat G and H GPS Locations

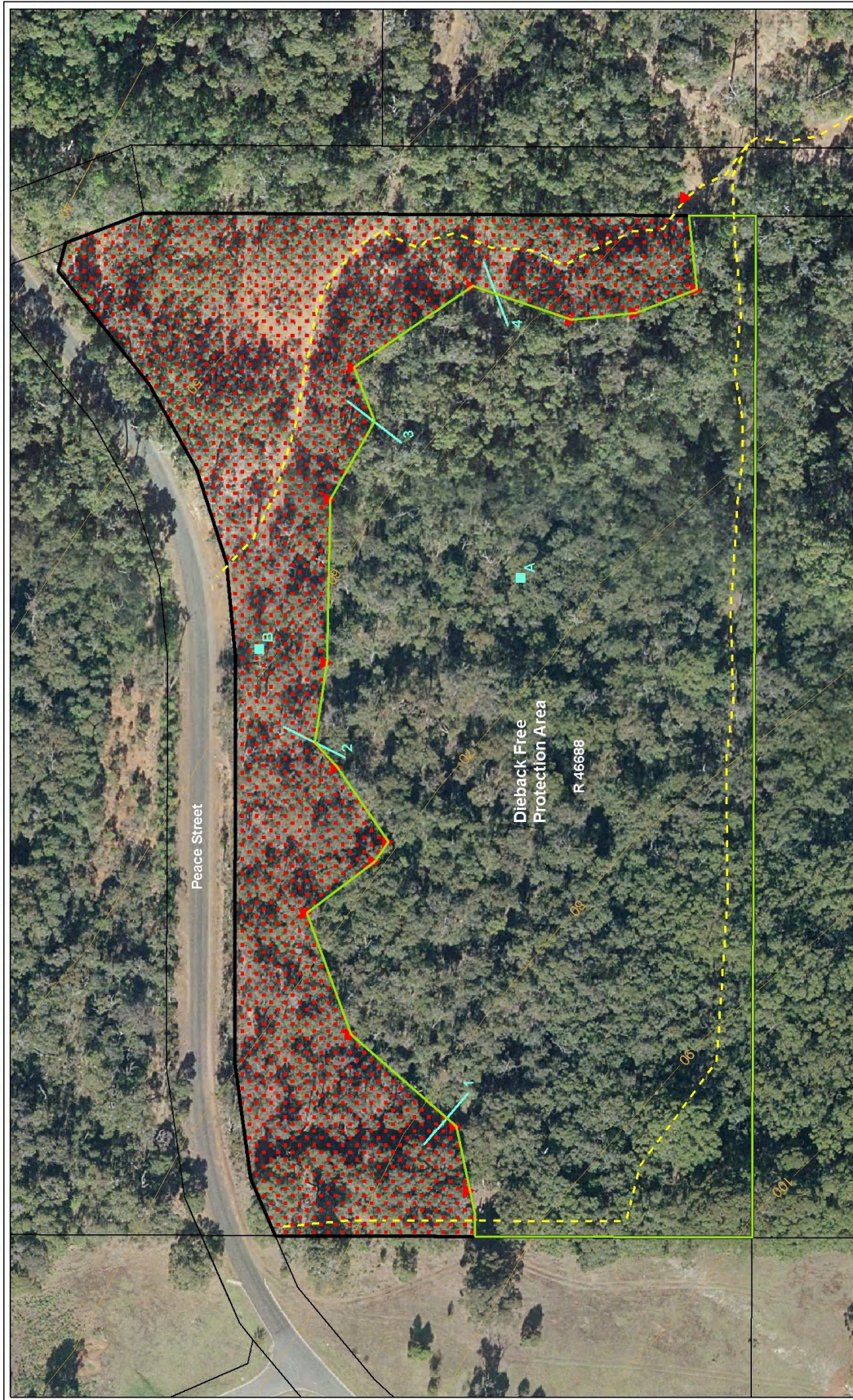
Susceptible Species	Quadrat G– Uninfested	Quadrat H– Infested	Dead
<i>Adenanthos obovatus</i>			
<i>Agonis hypericifolia</i>		76	2
<i>Banksia grandis</i>	15	19	4
<i>Bossiaea linophylla</i>	10	13	
<i>Conostylus setigera</i>	1		
<i>Crovea angustifolia</i>	21	10	
<i>Dryandra nivea</i>	9		
<i>Dryandra serra</i>		3	
<i>Eucalyptus marginata</i>	1	11	
<i>Eucalyptus</i> sp.			
<i>Hakea amplexicaulis</i>		16	2
<i>Hakea ruscifolia</i>	4		
<i>Hakea varia</i>	17	3	
<i>Hibbertia amplexicaulis</i>	46	19	5
<i>Hibbertia furifuracea</i>	4		
<i>Hovea chorizemafolia</i>	17	15	
<i>Hovea elliptica</i>		18	
<i>Isopogon</i> sp.	19	6	2
<i>Jacksonia horrida</i>	7		
<i>Leucopogon capetillatus</i>	14	3	3
<i>Leucopogon parviflorus</i>	2	4	
<i>Leucopogon verticillatus</i>	4	6	1
<i>Monotoca tamariscina</i>	44	16	21
<i>Patersonia occidentalis</i>	2		
<i>Persoonia elliptica</i>		9	3
<i>Persoonia longifolia</i>	7	5	3
<i>Petrophile diversifolia</i>		13	3
<i>Petrophile diversifolia</i>	10		
<i>Pultenaea reticulata</i>		1	
<i>Xanthorrhoea preissii</i>	50	6	4
<b>TOTAL DEATHS</b>			<b>53</b>

Table 17: Number of Susceptible Species within Quadrats G (Infested) and H (Infested) Mt Hallowell Reserve No 46618

## **Appendix 8: Phytophthora Dieback Maps of Priority Reserves**

*Map 1: Peace Street Reserve Dieback Map*





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# Peace Street Reserve Dieback Map

- Reserve Boundary
- Cadastre
- Dieback Free Protection Area
- Dieback Infested Area
- Deaths - Dieback
- Quadrats (corr)
- Transect
- Walk Track
- 10m Contours

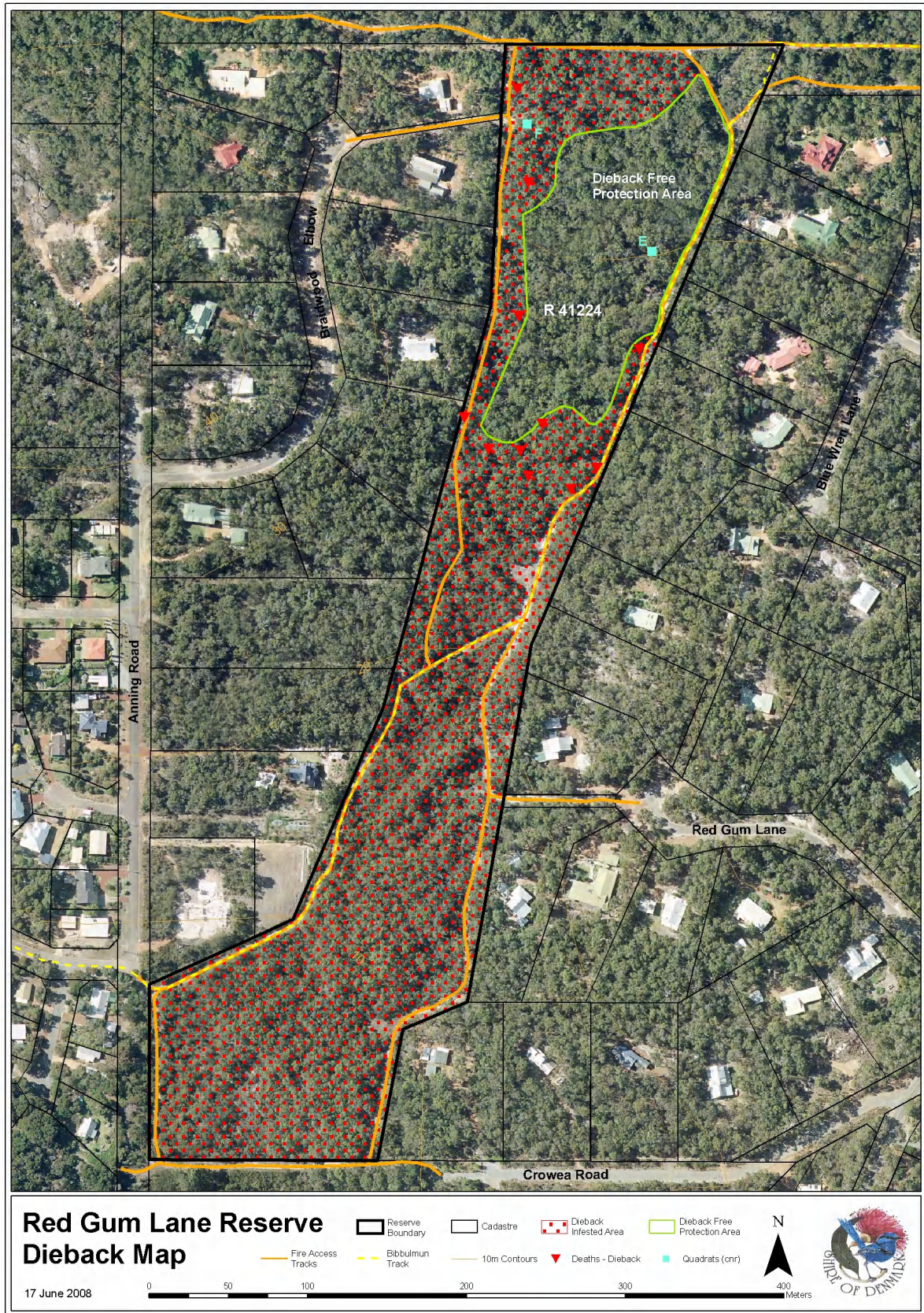


*Map 2: Wilson Inlet Foreshore Reserve Dieback Map*



*Map 3: Redgum Lane Reserve Dieback Map*

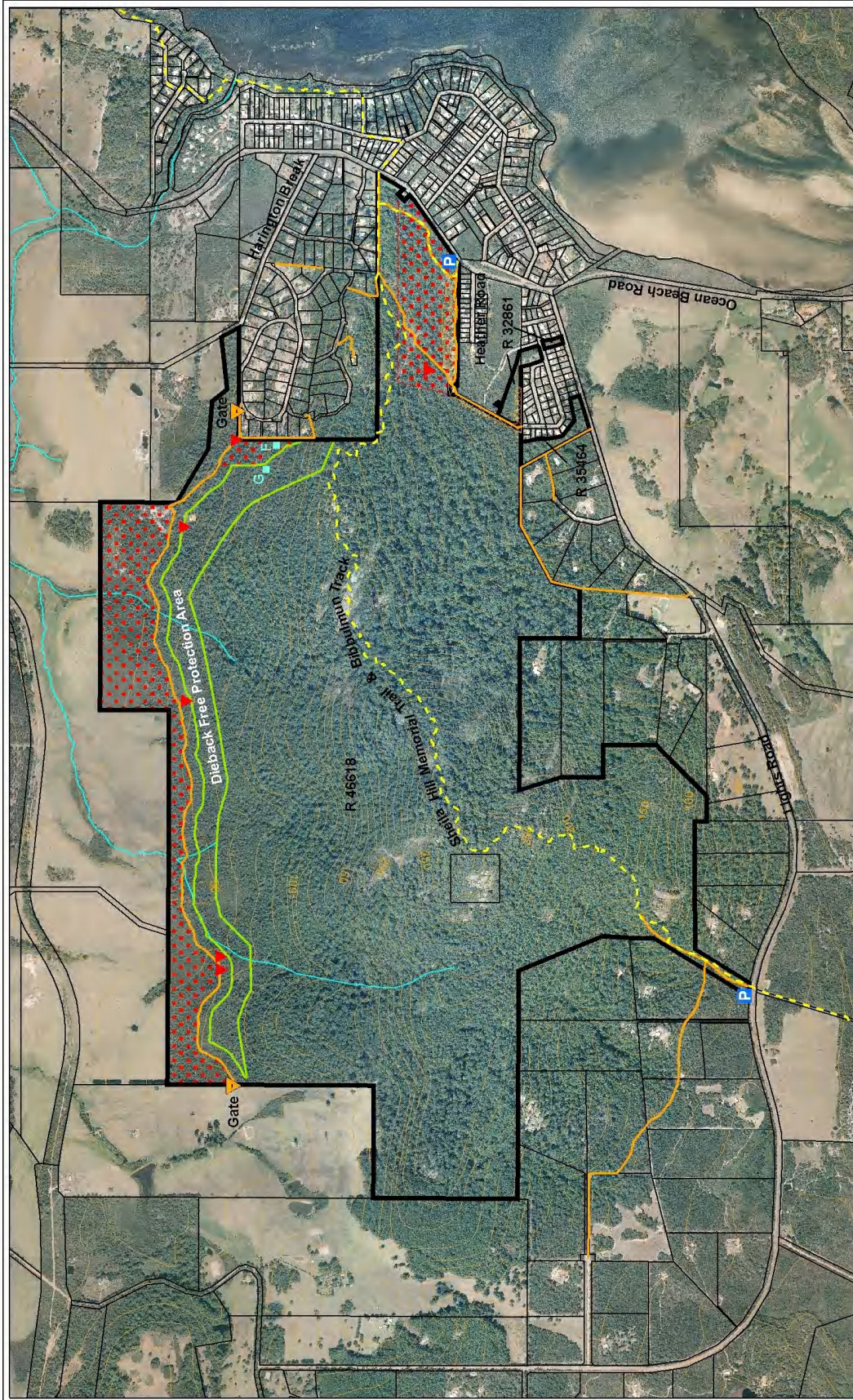




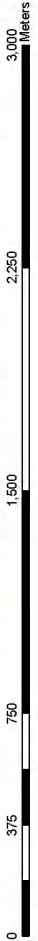


*Map 4: Mount Hallowell Reserve Dieback Map*





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# Mount Hallowell Reserve Dieback Map

- Reserve Boundary
- Cadastral
- Fire Access Tracks
- Walk Tracks
- Low Fuel Area
- Car Parking
- Dieback Free Protection Area
- Dieback Infested Area
- Deaths - Dieback
- Quadrats
- 10m Contours
- Creek Lines