First Quantum Minerals Limited

Ravensthorpe Nickel Operations

Phytophthora Dieback occurrence assessment



Disclaimer

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

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

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

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1 Summary

Glevan Consulting conducted an assessment of the new mining area of Hale Bopp along with a reassessment of the Sea Water Pipeline adjacent to Mason Bay Road and an assessment of the vegetation adjacent to the South Coast Highway in front of the nickel mine lease for the presence of the disease caused by Phytophthora Dieback. The assessment was conducted in November of 2013 by Liam Brown and Evan Brown of Glevan Consulting.

Currently Phytophthora Dieback is distributed along Mason Bay Road and the South Coast Highway. The infestation along the South Coast Highway has been extended to the west during this assessment. No spread was noted along Mason Bay Road. Significant spread was noted on the South Coast Highway and was confirmed with the positive results of soil and tissue samples, and is likely spread into the creek. This could impact operations at the mine site adjacent to the creek line. No new Phytophthora Dieback infestations were observed during this assessment.

The disease was expressing well during the assessment with fresh deaths observed within the Banksia and Xanthorrhoea species.

All vegetation within the mining area is considered protectable, all hygiene procedures should be continued to maintain healthy protectable areas across the mining area.

The validity of the hygiene boundaries mapped for this project is twelve months from the completion of this project. All boundaries should be reassessed by 11/2014 if activities are still occurring beyond this time.

2 Introduction

2.1 Background

Glevan Consulting was commissioned by First Quantum Minerals Limited to conduct an assessment of the Ravensthorpe Nickel Operations for the presence of Phytophthora Dieback. The assessment area is broken down into three areas, the first is located within the mining envelope and is a proposed mining pit called Hale Bopp. The second area is a reassessment of the sea water pipeline following Mason Bay Road from the coast to the mine site. The final area is a reassessment of the vegetation running along the South Coast Highway in front of the mine site. The main focus area of this survey area was the creek line which runs north south into the mining lease and potential rehabilitation sites.



Figure 1 - Project Area (Hale Bopp)

2.2 Location of Project Area.

The assessment area is located approximately 35 kilometres east of the Ravensthorpe town site.

2.3 Study team

The assessment was conducted by Liam Brown and Evan Brown of Glevan Consulting in November of 2013. Both team members are accredited by the Department of Environment and Conservation in the detection, diagnosis and mapping of the Dieback disease. This accreditation recognises the skills and experience of both employees working on the assessment.

3 Methods

3.1 Pre survey desktop study

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

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

3.2 Interpretation

During the assessment, the personnel involved in the field work determined the presence of Phytophthora Dieback based on symptoms and disease signatures displayed in susceptible vegetation. These symptoms may be supported through the recovery of Phytophthora from soil and tissue samples taken during the assessment.

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

Deaths of disease indicating species:

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

Chronology of deaths:

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

Pattern of deaths:

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

Environmental factors:

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

Other causes of indicator species death:

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

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

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

Vegetated area	Infested	Areas that have plant disease symptoms consistent
		with the presence of Phytophthora Dieback
	Uninfested	Areas free of plant disease symptoms that indicate
		the presence of Phytophthora Dieback.

Table 1 - Phytophthora Dieback occurrence categories

	Uninterpretable	Areas where indicator plants are absent or too few			
		to determine the presence or absence of			
		Phytophthora Dieback.			
	Unmappable	Areas that are sufficiently disturbed so that			
		Phytophthora Dieback occurrence mapping is not			
		possible at the time of inspection.			
	Not yet resolved	Areas where the interpretation process has not			
		confidently determined the status of the vegetation.			
Non-vegetated	Excluded	Areas devoid of vegetation are excluded from the			
area		assessment area.			

3.3 Demarcation of hygiene boundaries

Phytophthora Dieback infestations were demarcated with day-glow orange flagging tape. A single band of tape was tied to a suitable tree or shrub with the knot facing towards the infestation. The Uninterpretable boundaries were denoted with black and pink tiger tape. The taped boundaries were positioned approximately 15m outside the infested or uninterpretable areas, to provide the required buffer zone, and placed approximately 10-15m apart.

3.4 Soil and tissue sampling

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

Sampling was conducted using the following procedure:

- All digging implements used were thoroughly sterilised prior to use with methylated spirits. The implements were then allowed to dry so that the integrity of the sample was not compromised.
- The area around the base of the plant/s to be sampled was cleared of vegetative matter to aid the digging process.

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

3.5 Mapping

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

3.6 Limitations of disease mapping

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

The validity of the hygiene boundaries mapped for this project is twelve months from the completion of this project. All boundaries should be reassessed by 11/2014 if activities are still occurring beyond this time.

4 Results

4.1 Phytophthora Dieback occurrence distribution

Several previously identified infestations have been reassessed. Most are located on the pipeline route along Manson Bay Road and the boundary of the infestation adjacent to South Coast Highway was extended. Hale Bopp is a mosaic of uninfested, unmappable and uninterpretable vegetation. Three soil and tissue samples have been taken on the South Coast Highway in a creek line running towards the mining lease. These three samples have returned a positive result to *Phytophthora cinnamomi*.

Category	Area (ha)	% of total area
Infested (with <i>P. cinnamomi</i>)	0 ha	0 %
Uninfested	180.2 ha	70.3 %
Uninterpretable	43.8 ha	17.2 %
Unmappable	32.1 ha	12.5 %
TOTAL AREA	256.1 ha	

Table 2 - Area Summary for Hale Bopp

For the purposes of managing the location of the Phytophthora Dieback infestations along Mason Bay Road, the presence and absence can be assigned also to the pole numbers associated with the Sea Water Pipeline power line. The Phytophthora Dieback occurrence categories are summarised in the following table.

Pole numbers	Dieback Occurrence Category	Comments
354 - 341	Uninterpretable	Potential hygiene breach at pole 343.
341 – 315	Uninfested	Potential hygiene breach at pole 337,
		327 and 321.
315 – 242	Infested	Potential hygiene breach at pole 241.
242 – 227	Uninfested	Potential hygiene breach at pole 230.
227 – 218	Infested	
218 - 216	Uninfested	
216 - 178	Unmappable- Uninfested	Vegetation on edge of pasture.

Table 3 - Sea Water Pipeline pole numbers and Dieback occurrence

178 – 172	Uninfested
172 – 158	Unmappable
158 – 146	Infested
146 - 144	Uninfested
144 - 138	Uninterpretable
138 – 130	Uninfested
130 - 116	Uninterpretable
116 - 94	Uninfested

4.2 Soil and tissue samples

A total of 16 soil and tissue samples were taken during the assessment. Five samples returned a positive result for *Phytophthora cinnamomi*. All samples results are listed below.

Sample	Plant sampled	Easting	Northing	Result
1	Banksia lemanniana	258700	6270760	Negative
2	Banksia lemanniana	258755	6270777	Negative
3	Banksia lemanniana	258435	6271053	Negative
4	Banksia media	263481	6240530	Negative
5	Acacia sp.	263585	6240150	Negative
6	Banksia media	263542	6240640	Negative
7	Xanthorrhoea platyphylla	263260	6241366	Negative
8	Banksia media	262990	6241563	P. cinnamomi
9	Banksia media	267719	6241864	Negative
10	Banksia media	262628	6242005	Negative
11	Xanthorrhoea platyphylla	262376	6242405	Negative
12	Banksia media	259930	6249332	Negative
13	Banksia sp.	258742	6276847	P. cinnamomi
14	Xanthorrhoea platyphylla	258760	6276817	P. cinnamomi
15	Xanthorrhoea platyphylla	258768	6276806	P. cinnamomi
16	Xanthorrhoea platyphylla	261133	6275266	P. cinnamomi

Table 4 – Project Area Sample Summary

Locations are based on GDA94 Zone 51.

5 Discussion

5.1 Phytophthora Dieback occurrence distribution

Hale Bopp

Hale Bopp is a mosaic of uninfested, unmappable and uninterpretable vegetation. The majority of the area is uninfested and is dominated by many healthy plant indicator species. All uninfested is isolated to the ridge tops and mid slope areas. A portion of the assessment area contains farming paddock and has been classified as unmappable during the assessment. Due to the complete lack of indicator species and the high disturbance in the area it would not be possible to identify Phytophthora Dieback infestations in the area. The remaining area has been classified uninterpretable, this area is located lower in the landscape and does not contain enough plant indicator species to accurately identify any possible Phytophthora Dieback infestations.

Mason Bay Road Seawater Pipeline route

No new Phytophthora Dieback infestations were identified during this assessment. Previously identified and demarcated infestations have been reassessed.

While completing the assessment on Mason Bay Road it was noted that vehicles have been pulling off the road at inspection points. Since Mason Bay Road is open to the public it is not possible to control Phytophthora Dieback hygiene, however FQML employees working on the access points to the pipeline should not drive the vehicle off the shoulder and up to the vegetation from Mason Bay Road. Below are photos taken during the assessment showing vehicle movement from Mason Bay Road onto the pipeline corridor. All sites pictured below are within uninfested portions of the assessment area and therefore highlight opportunities to spread Phytophthora Dieback into uninfested vegetation. A recommendation of the report is to restrict all vehicles to Mason Bay Road.

Figure 2 - Inspection point at pole 343



During the previous assessment a sample was taken approximately 30 meters from inspection point at the bottom of the hill. Although this inspection point is in uninfested it has a high risk of pulling the infested soil onto the top of the hill and into the uninfested valley on the other side.

Figure 3 - Inspection point at pole 327



A large obvious water gaining site can be identified in this image covering the road during certain times of the year. Fresh deaths have been identified on the edge of the vegetation and have been samples but returned a negative result.

Figure 4 - Inspection point at pole 321



Vehicles are pulling into this inspection point located in uninfested vegetation after just exiting infested vegetation. The risk of introducing Phytophthora Dieback to this site is high especially during the wetter parts of the year.

South Coast Highway

During previous assessments, Glevan Consulting have identified Phytophthora Dieback Infestations along South Coast Highway. Although these infestations are outside the mining lease and assessment area they do pose a significant risk due to their position in the landscape. One infestation which has again been sampled this year has likely spread into the creek line running north south into the mining lease and a potential rehabilitation site. Although the creek line and associated vegetation would be classified as Unmappable, three positive samples have been taken approximately 100 meters upslope of the creek line. Due to subtle and very patchy expression in this area it was not possible at the time of the assessment to accurately identify and demarcate the disease edge however it is believed the Phytophthora Dieback has spread into the creek line. These positive sample results will also affect the Mason Bay Road detour. In the event of flooding this road may become inundated with water and may therefore be possible to spread the *Phytophthora cinnamomi* pathogen along the road.

Below is an image of the area showing the three positive samples in relation to the creek.



Figure 5 - South Coast Highway Sample Sites

5.2 Soil and tissue sampling strategies

Three samples have been taken on the South Coast Highway to prove the existence of Phytophthora Dieback and the potential threat to the mining lease through the creek running north to south into the mining lease. These three samples have returned a positive result to *Phytophthora cinnamomi*, however at the time of the assessment it was not possible to accurately identify the edge of the infestation, this area has not been demarcated.

Three soil and tissue samples have been taken in the new Hale-Bopp mine development area, all three samples were *Banksia lemanniana* and were located higher in the landscape and were suspected to be drought related. All three samples returned a negative result.

6 Recommendations

- Soil and plant material of infested or unknown dieback status should not be introduced to uninfested or unmappable sections of the study area.
- Soil and plant material should not be transported from the infested or unmappable sections of the study area for use at any other protectable area site.
- Soil movement within each category is permissible, but should not occur across category boundaries, except where the source is uninfested.
- Vehicles and machinery should be clean upon entry into any of the site categories (except infested), and when moving across category boundaries. Moving from uninfested areas into other categories does not require clean down measures.
- Restrict access, where possible, to dry soil conditions only. Where vehicles or machinery are required to access the area during, or shortly after rainfall, they must carry clean down equipment, and remove any soil or plant material at designated hygiene points.
- Vehicles should be restricted to Mason Bay Road at all times. If for safety reasons, the vehicle is required to be parked off Mason Bay Road, the vehicle will be parked at a place downslope of the adjacent vegetation.

7 Bibliography

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8 Appendix – Phytophthora occurrence map of Hale Bopp





9 Appendix – Seawater Pipeline South (Mason Bay Road)

Map 1.1 Phytophthora Dieback Occurrence Map Seawater Pipeline - Mason Bay Road Map Details



Client:	FQ	ML		
Project:	Site Assessment			
Site:	Sea Water Pipeline -			
	M	ason Bay Road		
Interpretation:	LB	23/11/13		
Digitising:	LB	20/02/14		
DATA VALIDITY Hygiene Bounda Uninfested Boun	ries v darie	valid until 11/14 s valid until 11/14		

DATA CAPTURE Boundaries captured by GPS and positioned relative to map features



Map 1.2 Phytophthora Dieback Occurrence Map Seawater Pipeline - Mason Bay Road

Legend



LOCALITY

Client: Project: Site:

FQML Site Assessment Sea Water Pipeline -

	M	lason Bay Road
Interpretation:	LB	23/11/13
Digitising:	LB	20/02/14
DATA VALIDITY Hygiene Boundar Uninfested Bound	ries v darie	valid until 11/14 es valid until 11/14
DATA CAPTURE Boundaries captu positioned relativ	ired e to	by GPS and map features

Map Details



Map 1.3 Phytophthora Dieback Occurrence Map Seawater Pipeline - Mason Bay Road

Legend



LOCALITY

Client: Project: Site:

FQML Site Assessment Sea Water Pipeline -

	M	ason E	Bay Ro	ad
Interpretation:	LB	23/11	/13	
Digitising:	LB	20/02	/14	
DATA VALIDITY Hygiene Boundar Uninfested Bound	ries v darie	valid un s valid	til 11/14 until 11	1 /14
DATA CAPTURE Boundaries captu positioned relativ	ired e to	by GPS map fea	and atures	

Map Details



Map 1.4 Phytophthora Dieback Occurrence Map Seawater Pipeline - Mason Bay Road

Legend

Phytophthora Dieback Occurrence



LOCALITY

Client: Project: Site:

FQML Site Assessment Sea Water Pipeline -Mason Bay Road



	M	ason Bay Road
Interpretation:	LB	23/11/13
Digitising:	LB	20/02/14
DATA VALIDITY Hygiene Boundar Uninfested Bound	ries v darie	valid until 11/14 es valid until 11/14
DATA CAPTURE Boundaries captu positioned relativ	ired e to	by GPS and map features

Map Details

10 Appendix – Introduction to Phytophthora

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

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

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





This relationship is also described in Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia Part 2 - National Best Practice Guidelines / Appendix 3 as the disease pyramid (O'Gara, et al. 2005). This figure includes the additional element of time to demonstrate the progressive impact of the disease on susceptible vegetation.



Figure 7 - Disease pyramid

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

The impact of the pathogen on the Australian economy is significant, and is estimated to cost between \$160 million (Carter 2004) and \$200 million annually (EPA 2011).

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