Infinite Blue Energy

Arrowsmith Hydrogen Project

Phytophthora Dieback occurrence and risk assessment – Version 0.27

Client	*Infinite Blue Energy*
Report name	*Arrowsmith Hydrogen Project*

This report has been prepared following the scope of work agreed upon between Infinite Blue Energy and Glevan Consulting and contains results and recommendations specific to the agreement. Therefore, results and advice in this report should not be referenced for other projects without the written consent of Glevan Consulting.

.

Executive Summary

The proposed Arrowsmith Hydrogen Project Stage 1, located approximately twenty-five kilometres south of Dongara, will have a maximum production rate of 45 tonnes (45,000kg) of hydrogen per day. The Project Area is an area with excellent renewable energy resources. The plant will produce hydrogen using renewable energy from solar (136MW) and wind (132MW). This energy source will displace an equivalent of 212,000 tonnes per annum of Co2 emissions. The project is expected to come online in 2025 and will serve the domestic Western Australian markets. (Infinite Blue Energy, 2021)

(Infinite Blue Energy, 2021)

Infinite Blue Energy requested advice from Glevan Consulting regarding the hygiene risks and any appropriate recommendations for hygiene measures associated with Stage 1 of the development.

The risk of introduction and spread of Phytophthora Dieback into and throughout the Project Area is determined by the likelihood of the event and the subsequent consequence of the event occurring. The consequence is determined by the impact of the pathogen on the susceptible vegetation within and immediately adjacent to the Project Area.

The activities throughout the Project Area, and without hygiene procedures, would place the project at being 'Almost Certain' to the introduction and spread of the pathogen through the entire Project Area.

It is expected that if Phytophthora Dieback were present in the Project Area or introduced to the Project Area, the disease impact would rate as Insignificant.

Based on DBCA ratings, the likelihood being “Almost certain”, and the consequence being “Insignificant”, the overall risk at the site is determined to be Low. Under these circumstances, the DBCA manual recommends standard hygiene practices to be adopted at the Project Area.

Table of Contents

List of Figures

List of Tables

1 Introduction

The proposed Arrowsmith Hydrogen Project Stage 1 (Project Area, Figure 1), located approximately twenty-five kilometres south of Dongara, will have a maximum production rate of 45 tonnes (45,000kg) of hydrogen per day. The Project Area is an area with excellent renewable energy resources. The plant will produce hydrogen using renewable energy from solar (136MW) and wind (132MW). This energy source will displace an equivalent of 212,000 tonnes per annum of Co2 emissions. The project is expected to come online in 2025 and will serve the domestic Western Australian markets. (Infinite Blue Energy, 2021)

Infinite Blue Energy requested advice from Glevan Consulting regarding the hygiene risks and any appropriate recommendations for hygiene measures associated with Stage 1 of the development.

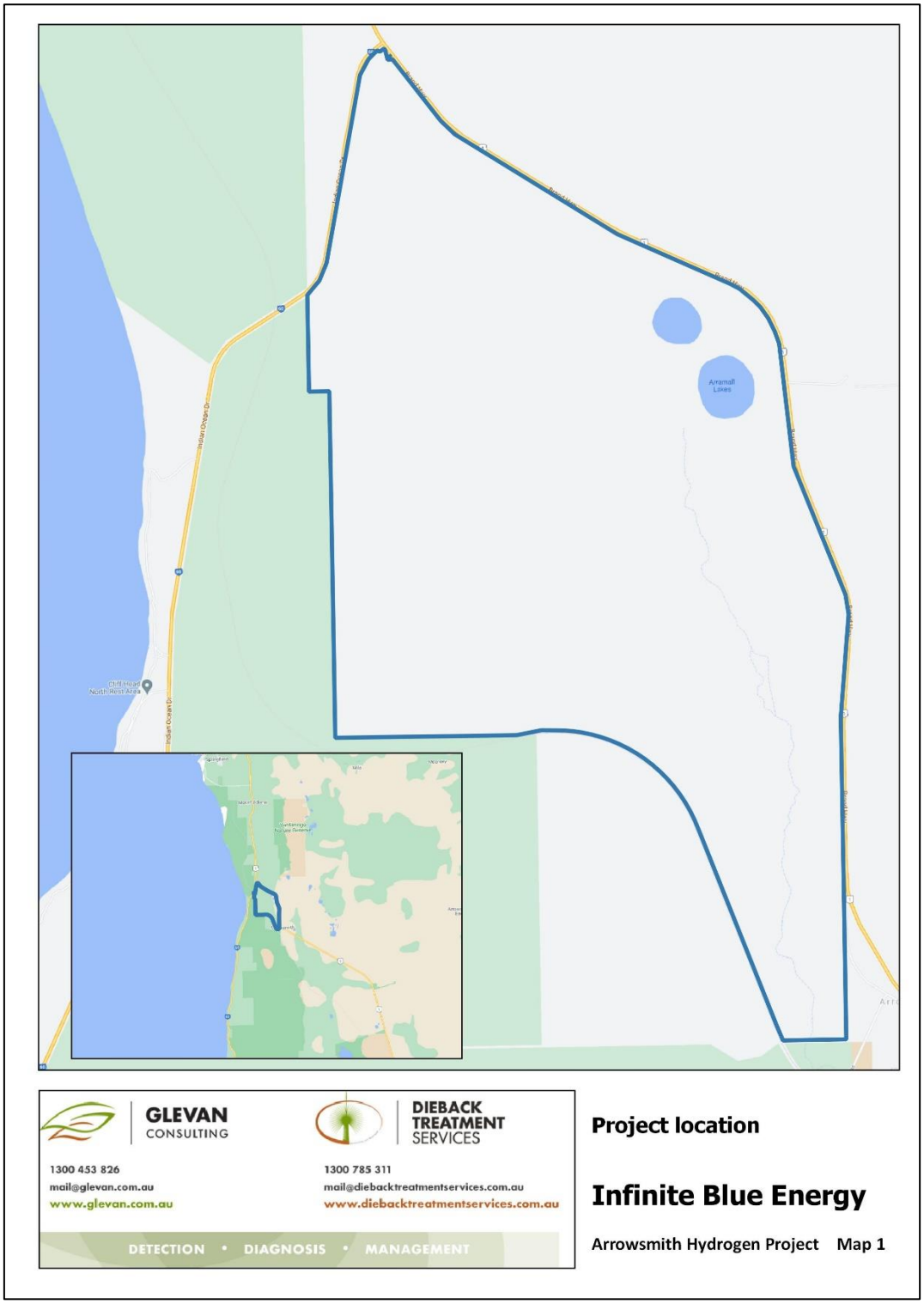

Figure 1 - Assessment area location

2 Risk assessment methodology

The risk of introduction and spread of Phytophthora Dieback into and throughout the Project Area is determined by the likelihood of the event and the subsequent consequence of the event occurring.

2.1 The assessment area

The vegetation within the Project Area has been mapped for vegetation type and vegetation condition.

Vegetation can only be assessed for the presence of Phytophthora Dieback if it contains plants susceptible to the pathogen; and that vegetation is in a condition for the disease to express, that is, not degraded.

Figure 2 shows the area containing vegetation of suitable condition using the Keighery rating (Table 1). This Figure, and Table 2, also shows the extent of vegetation with Phytophthora Dieback indicating species, particularly Banksia sessilis. Thus, the resultant overlay is the area that would express Phytophthora Dieback if it were present.

Table 1 - Keighery Vegetation Condition Scale (Keighery, 1994)

Scale		Vegetation condition
1	Pristine	Pristine or nearly so; no obvious signs of disturbance.
2	Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.

3	Very good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
6	Completely degraded	The structure of the vegetation is no longer intact, and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Table 2 - Extent of susceptible vegetation

Item	Hectares	% of total area
Project Area	1,929	100%
Development Envelope	657	34%
Extent of vegetation susceptible to Phytophthora	409	21%
Extent of vegetation interpretable to Phytophthora	392	20%
Development within interpretable vegetation	~125	6%

2.2 Phytophthora Dieback

Phytophthora Dieback is a key threatening process for the biodiversity of southwest Western Australia. Phytophthora Dieback refers to the disease caused by soil-borne plant pathogens from the genus *Phytophthora*. Forty-two *Phytophthora* species have been identified in Western Australia (Forest and Ecosystem Management (FEM), 2017).

The observable disease (Phytophthora Dieback) is the result of interaction between the pathogen (Phytophthora species) and the vegetation hosts (susceptible plant species within the vulnerable areas). The site's environmental conditions significantly affect the pathogen's ability to survive or flourish and spread over time. All land with an annual average rainfall of more than 400 millimetres is considered vulnerable to Phytophthora Dieback.

This vulnerable area has many different bioregions with specific characteristics. Climate and geology are two formative factors of these characteristics, which are highly significant in determining each Phytophthora species' pathogenicity and resulting disease impact levels.

2.2.1 The Pathogen

The microscopic *Phytophthora* plant pathogens are water moulds that live in soil and infest plant material and can be spread by any mechanism in which infested soil, plant material or water is moved into uninfested areas. Although *Phytophthora* can be spread by native and feral animals, in surface and subsurface water or by root to root contact, human activities can move it further and faster than any other means of spread. Consequently, vehicles and equipment must remain free from infected plant material and soil when moving beyond infested areas. (Forest and Ecosystem Management (FEM), 2017)

The life cycle of Phytophthora species is a continuous cycle of infection, sporulation and then further infection. Thus, it is readily vectored by animals and human activity, allowing for rapid invasion into new areas.

2.2.2 Host

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

The plant host is a highly variable component of disease development. Sites may range from having no susceptible hosts to being highly susceptible to the pathogen.

2.2.3 Environment

Two fundamental environmental characteristics influencing Phytophthora Dieback development are rainfall and soil type.

Areas vulnerable to Phytophthora Dieback are defined as native vegetation which occurs west of the 400 mm rainfall isohyet. The correlation of increased Phytophthora Dieback impact with increased annual rainfall is generally applicable.

Specific soil properties influence Phytophthora Dieback development within the vulnerable areas:

- Moisture is critical for Phytophthora Dieback to survive in the soil and for sporangia production
- Soil pH affects the growth and reproduction of the pathogen. The calcareous sands closest to the coast are alkaline and hostile to *Phytophthora cinnamomi.*
- Fertile soils are less favourable to Phytophthora Dieback because the richness of nutrients aids strong host resistance, good soil structure allows water movement and drainage, and high organic matter provides antagonistic microflora.
- Coarse-textured soils have larger pore spaces which favour dispersal of spores

The optimum temperature for *P. cinnamomi* sporulation is 21 to 30°C, peaking at 25°C, but some sporangia can still be produced at temperatures as low as 12°C. The optimum growth range is 15 to 30°C and temperatures lower than 5°C or greater than 35°C are unfavourable for the persistence of survival of spores and the vegetative mycelia of *P. cinnamomi* (Department of Parks and Wildlife, 2015).

2.3 Likelihood of pathogen introduction

The likelihood of the introduction of the pathogen is influenced by the following factors (DBCA, 2017):

The importation of raw material	Raw material refers to any material in which dieback can survive and be transported in a viable form. Raw material includes, but is not restricted to, Basic Raw Material (BRM), soil, mulch, vegetative material, and seedlings for revegetation.
Access	Any access to a site provides the opportunity to introduce the pathogen, and the more frequent the access, the higher the probability. Frequent and repeated access dislodges leaf litter exposing the soil, increasing the chances of being picked up by tracked machinery and tyres and inadvertently moved.
The complexity of activity	The likelihood of introducing or spreading the pathogen generally increases as the complexity of an activity increases.
The spatial extent of activity	As the extent of the proposed disturbance activity increases, the likelihood of introducing or spreading the pathogen increases. When managing an activity

	with a significant extent, specific areas can have different risk ratings. In this scenario, consideration can be given to dividing the activity into separate management units, managing each section according to the assessed risk rating.
Duration of activity	A disturbance activity with an extended duration will likely increase the risk of dieback spread.
Drainage	The risk of spreading the pathogen increases as the amount of water at the site increases. Water might be intentionally brought to the site for operational purposes (e.g. for a road-grading operation) or unintentionally brought to the site or concentrated at the site through changes to natural drainage resulting from the disturbance activity.
Unmanaged access	A disturbance activity may result in unmanaged access to a site being made easier. Unmanaged access will increase the likelihood of spreading dieback.

The activities throughout the Project Area, without hygiene procedures, would place the project at potentially being 'Almost Certain' to the introduction and spread of Phytophthora depending on environmental and climatic conditions.

2.4 The consequence of pathogen introduction

The possible consequence of introducing or spreading the pathogen due to a disturbance activity is determined by considering the:

The area put at risk.	This is established by estimating the protectable vegetation downslope of the activity and assessing which area has the potential to be infested with the pathogen. When no Phytophthora Dieback occurrence information is available, it is presumed that all area downslope of the activity (including the activity) is protectable and that the activity has the potential to infest the entire area.
The predicted impact at the site.	The impact of the pathogen at a site can be predicted according to environmental conditions. This will include the rainfall experienced at the site, the vegetation structure and inclusion of plants susceptible to the pathogen, and the suitability of the soil.

The impact of the disease caused by Phytophthora species on vegetation is dependent on the hosts present and the environment. The Project Area contains suitable host species for Phytophthora; however, the rainfall and soil structure will affect the impact.

The environmental conditions at the Project Area, such as low rainfall, sandy calcareous soils which provide good water drainage, and unsuitable pH, reduce the risk of infestation by *Phytophthora cinnamomi* to very low.

While the average rainfall of the area (487 mm (Bureau of Meteorology, n.d.)) is within the vulnerable zone, and the Project Area does not have suitable soil composition to support the disease caused by *P. cinnamomi*, other Phytophthora pathogens, principally *P. arenaria* and *P. multivora* may cause limited disease, if present. *Phytophthora. arenaria* has been recorded within 15 km from the Project Area, albeit on non-calcareous soils. This does not infer the range of *P. arenaria* but rather the historic sampling effort.

Whereas *P. cinnamomi* forms a visible and indiscriminate path of destruction through entire plant communities under suitable conditions, *P. arenaria* has a more limited impact, selectively killing species belonging predominantly to the family Proteaceae. Furthermore, the incidence of *P. arenaria* (causing disease) is usually episodic following extreme rainfall events (Rea, Burgess, Hardy, Stukely, & Jung, 2011). The impact of putatively native Phytophthora species on susceptible vegetation within the Geraldton Sand Plains is limited or possibly beneficial (Shaw, 2020)

The calcareous sands closest to the coast are favourable to *P. multivora.* (Forest and Ecosystem Management (FEM), 2017)

P. multivora has been recovered from samples taken from Banksia species (Scott, Burgess, Barber, Shearer, & Stukely, 2009), some of which will occur within the Project Area. Despite *P. multivora* being able to establish on drier sites, it has less impact on vegetation than *P. cinnamomi* (Conservation Commission of Western Australia, 2010). Glevan Consulting has assessed thousands of hectares of the Geraldton Sand Plain over many years. During those assessments, *P. multivora* has been recovered from over twenty locations. Most sites have been observed in subsequent years, and those sites do not exhibit increasing impact. Therefore, it would be assumed that the impact of any *P. multivora* infestation within the Project Area would be similar.

2.5 Overall risk rating

The following risk rating table is extracted from the DBCA Management Manual (DBCA, 2017):

Table 3 - Risk rating table

	CONSEQUENCE				
LIKELIHOOD	**Insignificant**	**Minor**	**Intermediate**	**Significant**	**Severe**
Almost certain	**Low**	**High**	**High**	**High**	**High**

Likely	**Low**	**High**	**High**	**High**	**High**
Possible	**Low**	**Moderate**	**High**	**High**	**High**
Unlikely	**Low**	**Moderate**	**Moderate**	**High**	**High**
Very unlikely	**Low**	**Low**	**Moderate**	**Moderate**	**High**

As stated previously, the three components of the disease triangle are required for Phytophthora Dieback to be present. Suitable vegetation exists in the Project Area (Figure 2). However, the Project Area is underlain by calcareous soils, with surface limestone evident through the area.

The DBCA Interpreter's Manual states that "The calcareous sands (Spearwood and Quindalup) closest to the coast are alkaline and hostile to *Phytophthora cinnamomi",* and that in these soil types, viable *Phytophthora cinnamomi* inoculum may be present, but there will be no signs of Phytophthora Dieback disease.

For these reasons, it is expected that if Phytophthora Dieback were present in the Project Area, the disease impact would rate as Insignificant.

Based on Table 3, the likelihood being "Almost certain", and the consequence being "Insignificant", the overall risk at the site is determined to be Low, even in the areas of the Project Area covered by susceptible vegetation. Under these circumstances, the DBCA manual recommends standard hygiene practices to be adopted at the Project Area.

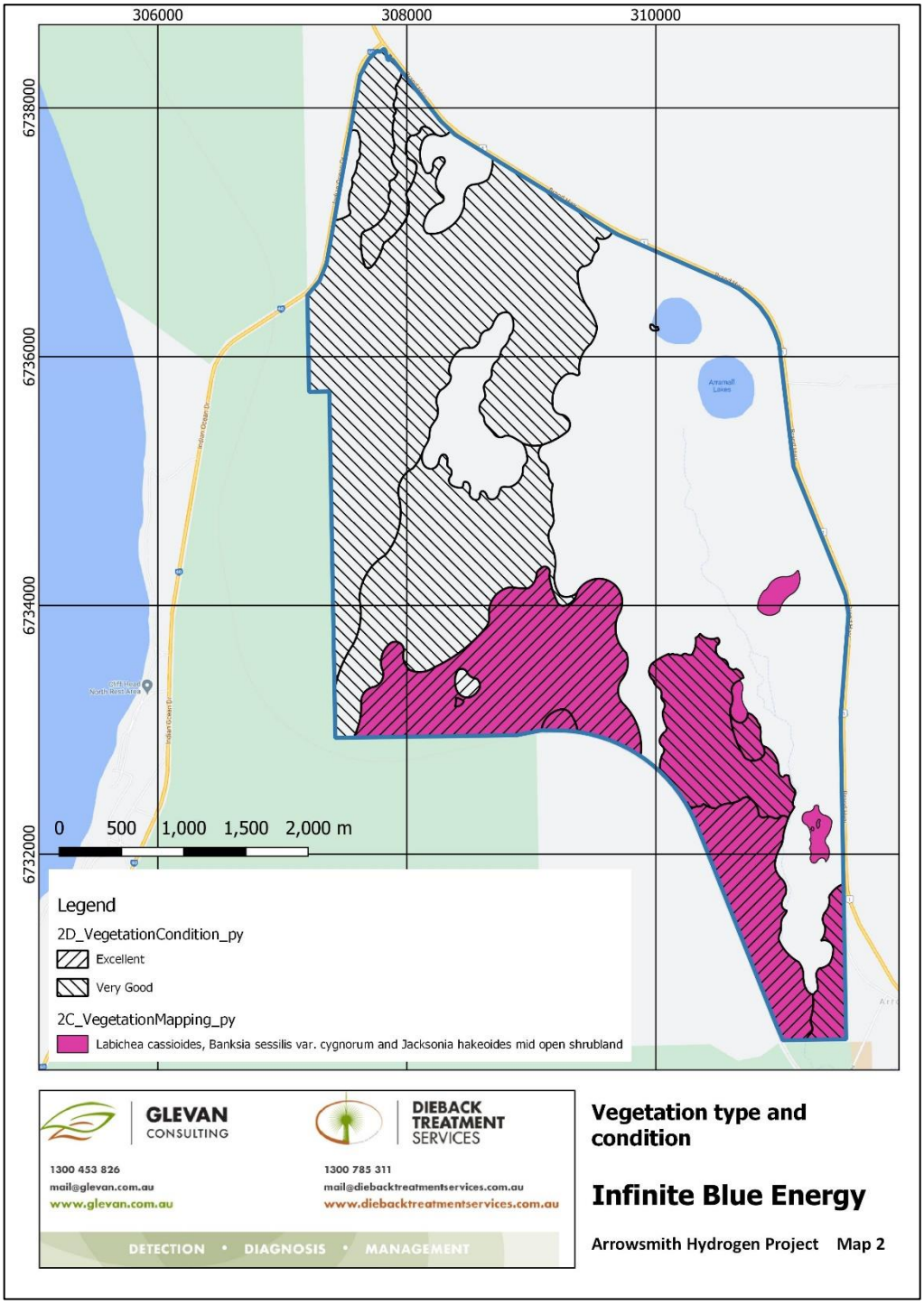

Figure 2 - Vegetation type and condition

3 Standard Hygiene Recommendations

The following minimum conditions should be applied to the Project Area:

- All personnel have completed Green Card training, if possible;
- All potential carriers (machinery, vehicles, footwear, equipment, tools) arrive clean at the site;
- Regard all-natural areas as protectable unless known otherwise;
- Plan to operate in vegetated areas before operating in cleared areas (where relevant);
- Schedule work (as far as possible) in dry soil conditions;
- Avoid driving through areas where pathogens may exist and adhere to vehicles (i.e. low-lying areas, boggy creeks, puddles);
- Carry information and equipment for minor, unplanned hygiene compliance; and
- Report any observed breaches of hygiene to supervisors (DBCA, 2017).

4 Bibliography

Bureau of Meteorology. (n.d.). *Average annual, seasonal and monthly rainfall*. Retrieved from Average annual, seasonal and monthly rainfall

Conservation Commission of Western Australia. (2010). *Performance assessment of Phytophthora dieback management on lands vested in the Conservation Commission of Western Australia.*

DBCA. (2017). *Phytophthora Dieback Management Manual.*

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

Forest and Ecosystem Management (FEM). (2017). *Phytophthora DIeback Management Manual.* Department of Biodiversity, Conservation and Attractions (DBCA).

Infinite Blue Energy. (2021). *Arrowsmith Hydrogen Plant Stage 2*.

Keighery, B. (1994). *Bushland Plant Survey: a Guide to Plant Community Survey for the Community.* Wildflower Society of WA (Inc.).

Rea, A., Burgess, T., Hardy, G., Stukely, M., & Jung, T. (2011). Two novel and potentially endemic species of Phytophthora associated with episodic dieback of Kwongan vegetation in the south-west of Western Australia. *Plant Pathology*, 60,1055-1068.

Scott, P., Burgess, T., Barber, P., Shearer, B., & Stukely, M. (2009). Phytophthora multivora sp. nov., a new species recovered from declining Eucalyptus, Banksia, Agonis and other plant species in Western Australia. *Persoonia*, 22, 1-13.

Shaw, C. (2020). *Damping off within natural and disturbed kwongan plant communities.* Thesis submitted for the degree of Doctor of Philiosophy (Unpublished).