Review of previous ecological assessments of the Nile Road project area

Prepared by Mark Wapstra, Environmental Consulting Options Tasmania (30 July 2015)

Preamble

Australian Bauxite's Nile Road project area has been subject to preliminary ecological investigations by Philip Milner Landscape Consultant Pty Ltd as follows:

- *Botanical & Fauna Habitat Survey of Proposed Drill Sites: Nile Road Target Area*. Philip Milner Landscape Consultant Pty Ltd for ABx4 Pty Ltd, 25 October 2010 (PMC 2010); and
- *Botanical & Fauna Habitat Survey: Nile Road Target Area*. Philip Milner Landscape Consultant Pty Ltd for ABx4 Pty Ltd, 5 October 2012 (PMC 2012).

Environmental Consulting Options Tasmania (ECOtas, Mark Wapstra) has been engaged to undertake the following tasks:

- review the ecological assessments and conclusions of PMC (2010, 2012);
- review the potential implications of the proposed project on threatened flora, specifically *Stackhousia subterranea* (grassland candles); and
- provide advice on a "way forward" in relation to key ecological issues (mainly threatened flora).

Peer review of previous ecological assessments

In my opinion, the initial ecological assessment of the proposed exploratory drill sites was thorough and identified the key ecological issues. It was clear that individual drill hole locations were surveyed in some detail and any threatened flora sites identified. Recommendations were made to protect sites close to drill holes but no individuals were identified as likely to be disturbed so no further permit/referral was required. A minor concern is that the habitats identified from the project area are potential habitat for a suite of species (mainly orchids) that do not necessarily "send up a flag" due to a paucity of database records i.e. if the standard 5 km buffer on a database search is used, several species that may be present are not identified. Most of these flower at the time of the surveys such that the targeted drill hole assessments were appropriate but others (e.g. Pterostylis commutata) flower much later. Whether they were missed is unknown but highly unlikely at the scale of any particular drill hole, simply because these species have highly fragmented and highly localised distributions such that the opportunity to detect a novel site is serendipitous and statistically unlikely. At the scale of exploratory drill hole activities, I do not think that additional timed targeted surveys were warranted.

In my opinion, the follow-up ecological assessment of further proposed exploratory drill sites was equally thorough and identified the key ecological issues. The conclusions and recommendations were similar to the initial survey.

Both ecological assessments complied with DPIPWE's *Guidelines for Natural Values Assessments, Reporting on the Impact of Proposed Activities on the Natural Values and Providing Recommendations for Mitigating Impacts on these Values* (DPIPWE 2009). Since that time, however, DPIPWE have released the revised *Guidelines for Natural Values Surveys - Terrestrial Development Proposals* (DPIPWE 2015). In effect, these state that ecological assessments may only remain valid for a period of two years (although this depends on the particular value e.g. vegetation types are unlikely to change on this period, but additional threatened fauna or flora may be present or detectable for some reason such as a disturbance event). In addition, DPIPWE have released *Survey Guidelines and*

Management Advice for Development Proposals that may impact on the Tasmanian Devil (Sarcophilus harrisii) (DPIPWE 2015). These require a higher level of assessment than has been undertaken to date. For example, as a minimum it needs to be demonstrated that a potential habitat assessment combined with a field assessment that has a minimum coverage of 30% of the project area has been undertaken. Furthermore, the Commonwealth Department of the Environment have released some species-specific sur vey guidelines in relation to threatened orchids, which may be applicable to the potential of the site to support species such as *Pterostylis commutata*, *Prasophyllum incorrectum*, *P. taphanyx*, *P. olidum*, *P. tunbridgense* and Caladenia anthracina – see *Survey Guidelines for Australia's Threatened Orchids: Guidelines for Detecting Orchids Listed as 'Threatened' under the Environment Protection and Biodiversity Conservation Act 1999* (CofA 2013). These require a higher level of survey than has been undertaken to date.

I concur with the conclusion of PMC (2012) that "should the Nile Road exploration program confirm a viable deposit of bauxite and the company proceeds with an application for a mining lease over the target then a more thorough botanical survey over an extended season will be necessary in order to more fully determine the conservation value of the ground stratum vegetation, particularly with continued mapping of the locations and extent of the threatened species of plants observed in the locality".

The initial surveys have only targeted drill hole locations, and been conducted on 14 & 18 October 2010 and 3 October 2012. The "problem" with the vegetation types present is that they are potential habitat for a suite of threatened flora that have ephemeral flowering habits, and no one survey date is appropriate to target all species. That said, 3, 14 & 18 October are "mid spring" and will detect the majority of species of concern, although potentially missing a few later spring/early summer species. In addition, while threatened flora populations may have been detected en route to and between drill hole locations, any extraction program will disturb larger areas and there is no guarantee that these have been subject to an appropriate level of survey for threatened flora.

In my opinion, once the most likely work footprint has been delineated, further botanical surveys are required in mid-October (essentially matching those already undertaken to get a further data point in time), mid- to late-November (to capture a suite of ephemeral species that are likely to respond to any spring rains and the warming conditions as summer approaches) and mid-January (to target a small number of summer-flowering orchid species).

It is clear to me that the key threatened flora species that will require a high level of management is *Stackhousia subterranea* (grassland candles). The site also supports a suite of other State-listed (but to date no Commonwealth-listed) threatened flora that I believe have a much lower level of management priority (lower conservation status, more widespread, more disturbance tolerant).

There are other ecological issues that will require resolution although I do not believe these are "fatal flaws". These include the fact that much of the project area is within a threatened vegetation type, and also supports potential habitat for threatened fauna. At this stage of information availability

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Review of conservation status of *Stackhousia subterranea* (grassland candles) and implications for Australian Bauxite's Nile Road project

Prepared by Mark Wapstra, Environmental Consulting Options Tasmania (30 July 2015)

Existing information

The previous ecological assessments have identified significant populations of *Stackhousia subterranea* (grassland candles) from the project area. This species is listed as endangered (Schedule 3) on the Tasmanian *Threatened Species Protection Act 1995* but is not listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. While there are other species of threatened flora (and other high conservation significance ecological issues) within the project area, it is clear that the management of *Stackhousia subterranea* is a key value that requires resolution.

The surveys undertaken to date have identified 27 patches equating to an area of occupation of 3,432 m^2 (based on radius estimates of the patches) and at least 3,200 "individuals" (see discussion below on abundance estimates). The site represents a significant range extension of around 11-12 km and now represents the most northerly subpopulations of the species in Tasmania. There is little doubt that this site supports one of the more important subpopulations of the species and is also important biogeographically. Given these parameters, developing a management regime for the project that takes appropriate account of the species will be a critical part of the project's approval process.

Note that the "starting point" for the current review is not that the project is "fatally flawed" because of the presence of an endangered plant species but to review all available and relevant information to arrive at a place that informed decisions can be made on how to progress the project, with no prior expectation of what such progress may be i.e. this is a very open and transparent document that can be used by ABx and be provided to approval agencies to better inform discussions.

Taxonomy and nomenclature

For many years, *Stackhousia subterranea* was listed as *Stackhousia gunnii* Hook.f., and the taxon considered endemic to Tasmania (e.g. Buchanan 2005). However, its nomenclature was recognised as potentially "illegitimate" but was "retained [in Buchanan (2005)] pending resolution". The revision to the species by Barker (2007) means that *S. subterranea* is no longer considered endemic (de Salas & Baker 2015), also occurring in South Australia and Victoria (Barker 2007). Barker (2007) stated that:

> "It became evident on examination of Tasmanian populations of *Stackhousia gunnii* Hook.f. in the field in 1995 that this species is conspecific with an unnamed mainland race of *S. monogyna* Labill. s.lat. This race is widespread in mallee habitats on calcareous loams on the southeastern Australian mainland (Barker 1986, 1999)".

Barker (2007) created a new name for the taxon formerly known as *S. gunnii* because that name is illegitimate, being a later homonym (Barker 1969). It is predated by the earlier name *S. gunnii* Schldl. (Schlechtendal 1847), which is based on a different Tasmanian specimen collected by Ronald Gunn (no. 69), and is a synonym of *S. monogyna* Labill., in its strict sense (Barker 1969).

This information is provided because it has been long-recognised that while the Tasmanian entity may not be endemic and be quite widespread on the Australian mainland, it does not follow that it has a lower conservation concern. Indeed, "*Stackhousia gunnii*" has not been

regarded as a nationally threatened species (e.g. Briggs & Leigh 1988) but Tasmanian authorities long considered the taxon as "endangered" (e.g. Kirkpatrick et al. 1991). In fact, Gilfedder & Kirkpatrick (1998) highlighted that the taxon in Tasmania "could be reasonably expected to have at least some genetic differences from the mallee populations on the Australian mainland: and that "the taxonomic uncertainty [now resolved]…does not invalidate the importance of the Tasmanian populations for biodiversity conservation, but rather emphasises the importance of taxonomic and genetic research in conservation biology".

Distribution and habitat

Within Tasmania, *S. subterranea* occurs in the northern Midlands and Fingal Valley. Outside Tasmania, the species is apparently "widespread in calcareous mallee woodlands and associated more open vegetation of peninsular regions of South Australia to south-eastern Australia and Tasmania" (Barker 2007). There appears to be no notion that the taxon qualifies for listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999,* with Barker (2007) noting that "while the species overall is not at all endangered, being common in many parts of its range in mainland Australia, the endangered status accorded the Tasmanian populations in its diminished midlands habitats should surely be retained".

DPIPWE produced a formal Listing Statement, a requirement under the provisions of the Tasmanian *Threatened Species Protection Act 1995*, in 2009, which summarised the then understood distribution, habitat, population parameters, threats and management requirements (TSS 2009).

Based on TSS (2009), the species had extent of occurrence (minimum convex polygon around all sites) of 465 km2 and area of occupancy of less than 10 hectares, represented by 7-8 subpopulations (locations). Its habitat is described by TSS (2009) as "*Themeda triandra* grassland, or grassy woodland dominated by *Eucalyptus pauciflora*, *Eucalyptus rodwayi* or *Eucalyptus ovata* (Gilfedder & Kirkpatrick 1998)…most sites are on reddish-brown clay-loam soils formed on dolerite or basalt, with others variously on alluvium, sandstone and sand over dolerite…known sites occur within the altitude range 180 to 260 m, and are within the 650 mm annual isohyet, corresponding to the driest area in Tasmania". This description is essentially accurate but should be expanded to include the concept of grassy forest (i.e. forested areas with a denser canopy cover than implied by the "woodland" term) dominated by *Eucalyptus amygdalina* and/or *Eucalyptus viminalis* (this latter addition capturing the recently detected sites at Nile Road and near Conara that occur in the TASVEG mapping unit "*Eucalyptus amygdalina* inland forest and woodland on Cainozoic sediments").

DPIPWE's *Natural Values Atlas* database (as at 27 July 2015) holds 172 records (including some duplicates), considerably more than were present at the time of the production of the Listing Statement (TSS 2009). TSS (2009) listed 13 subpopulations but noted that "given that most occurrences are on private land and the major threat to the species involves a change in land use, the number of locations for the species is considered to be 7 or 8 using land tenure as a surrogate for 'location'". I do not agree with this statement and have constructed a revised table of subpopulations based on a more traditional concept of distance between recorded sites (using a minimum of 1 km), with extensive notes on my decision-making process.

Since the production of the formal Listing Statement (TSS 2009), several new subpopulations have been detected (two have been in areas subject to development proposals by ABx) and additional information gathered on previously known subpopulations. Table 1 presents this information, which is summarised below.

Extent of occurrence

Based on a corrected minimum convex polygon (which shifts the record that fell on Avoca to the "Benham" estate based on the information on the 1891 herbarium collection), the extent of occurrence is now 2,195 km^2. The extent of occurrence is a key criterion in the formal consideration of the conservation status of a species but its use needs to be qualified in some cases, especially where a projected extent includes large swathes of unsuitable habitat (e.g. sea). In the case of *Stackhousia subterranea*, TSS (2009) indicated an extent of occurrence of 465 km^2 so on the surface there has been a nearly a five-fold increase. The question is how "real" is this increase? Without some tedious data manipulation, it is difficult to reconcile precisely which subpopulations listed in the formal Listing Statement or database records in the *Natural Values Atlas* contributed to the reported extent of occurrence (TSS 2009). However, there are several new subpopulations that contribute to the increase in extent of occurrence including those at Nile Road and Tom Gibson Nature Reserve, but most critically the one near Brighton, a linear range extension of around 64 km. These range extensions all essentially include only lowland low rainfall parts of the State i.e. there are no new outliers that mean that the extent of occurrence includes swathes of sea, lakes, cities or upland areas known to be unsuitable for the species. Under the listing criteria, therefore, the revised estimate of the extent of occurrence is considered reasonable.

That said, I now consider the potential for range extensions and range infillings. With the detection of the new subpopulation near Brighton in 2009, prior to the publication of the formal Listing Statement (TSS 2009), the range of the species was extended approximately 64 km further south (Figure xxx), which suggests that there may be additional undetected subpopulations between Brighton (and indeed around Bridgewater-Brighton-Pontville-Tea Tree area itself) and just south of Tunbridge (the next nearest subpopulation). Extensive areas of potential habitat (native grasslands and grassy woodlands) have been surveyed in the greater Midlands region, suggesting that there may be a genuine distributional gap rather than merely a survey effort artefact. Indeed, TSS (2009) noted the extensive previous surveys of potential habitat, including targeted surveys for the species, as follows:

> "Gilfedder & Kirkpatrick (1994, 1996 & 1998) undertook targeted surveys for *Stackhousia subterranea* and other threatened grassland species during the period 1990 to 1994, with follow-up surveys of known sites in 2002 to 2003 (Gilfedder, pers. comm.). These surveys were preceded by the remnant vegetation studies of Kirkpatrick et al. (1988) and Fensham (1989). In the period since there have been numerous Bushcare extension surveys of private property in the Midlands (1998–2003), as well as roadside surveys conducted by the Tasmanian Department of Transport (reports held by the Biodiversity Conservation Branch, DPIW, Hobart)".

That range extensions and infillings continue to occur is noted, however. Indeed, ecological assessments of two Australian Bauxite projects (Fingal Rail and Nile) have resulted in new subpopulations being detected, one of which resulted in a significant range extension to the north (Nile), and the other confirmed a much earlier collection on the then northern edge of the range. In my opinion, there is a low to moderate likelihood of minor range extensions in the Nile and Fingal Valley areas and a moderate to high possibility of range infillings, especially within the core Tunbridge-Campbell Town range of the species, but also within the region between Brighton and Tunbridge. Targeted surveys of mainly private property would be required, however, with a certain degree of serendipity ("good" seasonal conditions combined with "right place-right time" scenario), for these range extensions and infillings to be realised.

Number of subpopulations

As stated above, TSS (2009) listed 13 subpopulations with quite scant population information for each but were more confident to suggest the species is represented by 7 or 8 "locations", a concept I do not wholly adhere to. My revised analysis of data held in DPIPWE's *Natural Values Atlas* database indicates that the number of subpopulations can be interpreted as around at least 16 confirmed subpopulations. As with TSS (2009), there are some qualifications to this statement. Some of the sites have scant database information and are not supported by voucher specimens at the Tasmanian Herbarium, although tend to be from reliable observers. I have not included the more dubious of the unconfirmed sites in this tally of possible subpopulations. It is also noted that some of the subpopulations could be further divided if a less conservative approach to defining a "location" were taken (e.g. sites on "Fosterville" could be considered as separate subpopulations if they are separated by proper pasture, and the discrete patches along the verge of Tunbridge Tier Road are quite distinct and separated by unsuitable habitat, or at least habitat that has been well surveyed and the species not detected).

Population abundance

The "number of mature individuals" is a key criterion in the formal consideration of the conservation status of a species but its use needs to be qualified for some species. For example, for a threatened species such as *Epacris barbata*, a "mature individual" is quite easily defined as "not a seedling" and a "plant with flowers and/or fruit" (as a very rough guide). Unfortunately *Stackhousia subterranea* does not lend itself to "easy" counts of the number of individuals (mature or otherwise) in any particular patch for a number of reasons. Firstly, it is a short-lived perennial herb (often actually described as an "annual", although this is not strictly the case), perhaps living for 2-3 years. Secondly, it has a creeping rhizome (underground stem) from which aerial flowering shoots are produced in spring (usually between September and November but this is very much dependent on seasonal and site conditions), making estimating abundance outside the flowering season impossible. Thirdly, there is no published information on how many closely grouped flowering shoots may comprise one plant or indeed how far apart flowering shoots from any one rhizome can be.

TSS (2009) estimated the total population size in Tasmania to be "between 10,000 and 50,000 with subpopulation estimates ranging from 10s to 10,000s". Even with the new subpopulations, these estimates are not substantially different, mainly because of the large variation on estimates at any one subpopulation. This arises because most database records, especially those prior to the 2000s, do not have any supporting abundance information, with only a scant amount gleanable from published literature (e.g. Gilfedder & Kirkpatrick 1998), although it is noted that in compiling the formal Listing Statement, DPIPWE did seek and receive considerable information from Gilfedder on population estimates from the 1990s through to the early 2000s. Many records with population estimates simply state values such as "10s" or "100s" or (300+), meaning any sums of the available abundance estimates are "fuzzy". In addition, most estimates that are presented must be regarded only as an estimate of the visible flowering shoots and not a true representation of the actual number of mature individuals.

TSS (2009) also noted that the abundance can "fluctuate from year to year by at least two orders of magnitude i.e. 100s to 10,000s", which means that any abundance estimate needs to be carefully considered i.e. should the lower or upper estimate be accepted as the true estimate of the Statewide abundance.

Area of occupancy

The "area of occupancy" is another key criterion in the formal consideration of the conservation status of a species and its use can be more important, for many species, than a consideration of the number of mature individuals. This is considered the case for a species such as *Stackhousia subterranea* where any estimates of population abundance are highly caveated. However, arriving at a realistic estimate of the area of occupancy is also fraught with difficulties for this species.

For example, the subpopulation near Conara occupies an area of approximately 20 m^2 based on a visual estimate of the area occupied by flowerings stems of roughly 4 x 5 m. The site at Nile Road is represented by 27 patches, all of which were estimated with an approximate radius (to the nearest metre), allowing an area of occupancy to be estimated of 3,432 m^2 (a false precision). This latter site could be better regarded as a series of virtually interconnected patches and the area of occupancy estimated by a minimum convex polygon around the patches (so akin to a mini "extent of occurrence" within which the species is well-mapped). If this approach is taken, that subpopulation would be estimated to occupy around 32 ha (i.e. close to 100 times the area of occupancy). Obviously, any such estimates of area of occupancy have a significant impact on the assessment of the conservation status of a species, which have a number of nominal thresholds (e.g. 10 ha, 50 ha, etc.).

Taking a more conservative approach and basing the estimates of area of occupancy of any particular subpopulation as the sum of any specific patch size estimates (or simply accepting the estimates provided in the *Natural Values Atlas*), I now estimate the area of occupancy of the species to be about 6 ha. This estimate only includes subpopulations with abundance "data" so is an under-estimate. That said, it is unlikely that the estimate is out by orders of magnitude because most sites without population data are historical and appear to have been represented by small patches and a low number of individuals.

Reservation status

The reservation status of a species is not usually taken into account in an analysis of its conservation status under the Tasmanian *Threatened Species Protection Act 1995*. In the case of *Stackhousia subterranea*, it is clearly a species that occurs mainly on unreserved private property, most subject to primary productive uses (predominantly "rough grazing"). The species is formally reserved in the Township Lagoon Nature Reserve (one of the larger subpopulations), Tom Gibson Nature Reserve (small subpopulation only) and under a private conservation covenant at the Campbell Town Golf Course (small subpopulation only). Some sites occur on the verge of public roads and are presumably managed by the Department of State Growth (although local government is often involved in management activities such as slashing tall grass and controlling weeds). These sites are not regarded as "reserved" although management authorities are likely to be aware of the appropriate management requirements of the species and the persistence of the subpopulations is reliable.

Conservation status

Stackhousia subterranea is currently listed as endangered (Schedule 3) on the Tasmanian *Threatened Species Protection Act 1995*. It was originally listed in 1995 as *Stackhousia gunnii*. TSS (2009) noted that the species qualified under criterion B as the species extends less than 500 km^2, has an area of occupation of less than 10 ha, a severely fragmented distribution, with extreme fluctuations in the number of mature individuals and an observed

and projected continuing decline in the quality of habitat and number of mature individuals due to agricultural activities (TSS 2009).

A number of these "triggers" that placed the species in the endangered category have clearly changed since the production of the formal Listing Statement (TSS 2009). There is a formal requirement to review the status of all species listed on the Tasmanian *Threatened Species Protection Act 1995*, as follows:

> Division 2 - Listing of threatened flora and fauna
>
> 13. Lists of threatened flora and fauna
>
> (6) SAC [Scientific Advisory Committee] must, at least once in each period of 5 years, review each taxon listed in Schedules 3, 4 and 5 and recommend to the Minister any variation of those Schedules considered appropriate.

To the best of my knowledge, there has not been a formal review of the status of *Stackhousia subterranea* since SAC considered the Listing Statement. However, DPIPWE, as the administrators of the Tasmanian *Threatened Species Protection Act 1995*, are in discussion on the most appropriate way to resource a review of all species, and there have been several recommendations made by SAC on various species without a formal review process (i.e. species have been considered on a case-by-case basis). It is clear that *Stackhousia subterranea* has not become "more threatened" since 2009, with most subpopulations having been re-assessed to some level (see Table 1) and them being extant and with similar (or higher) abundance estimates. This means that any review of the status of the species will either confirm the endangered status (if the various thresholds are still not reached) or suggest a downlisting to the vulnerable category (a downgrading to the rare category or a complete removal of the list is not a likely scenario and is not considered further herein).

In practice, even if a species such as *Stackhousia subterranea* may meet the criteria for a downlisting, a formal nomination (which can be made by anyone under the provisions of the Act) would need to be made to SAC and the assessment process followed. This can take many months (even years). The "true" conservation status of a species should be taken into account in any development of appropriate land management prescriptions. While the Section 51 of the Tasmanian *Threatened Species Protection Act 1995* does not discriminate in the permit requirements based on the status of a species, under the associate Regulations, DPIPWE can adhere conditions to permits that can take account of any relevant information and tailor a permit to reflect the status of a species and the anticipated impact of a land use proposal. As an example, if a species currently listed as rare has been considered by SAC and recommended for delisting but the Minister has not yet made a final determination, DPIPWE will still need to issue a permit to "take" the species where present but need not apply any specific conditions (e.g. *Lepidium pseudotasmanicum*). Conversely, if DPIPWE are aware that a species currently listed as rare should be listed in higher category, permit conditions can reflect this information (e.g. *Pterostylis falcata*). In this case, if the analysis of information available for *Stackhousia subterranea* indicates the species should be considered as vulnerable rather than endangered, this needs to be taken into account in the development of any management conditions for sites supporting the species that may be disturbed (a general term). That said, whether a species is formally listed as endangered or vulnerable is somewhat moot if it is really "on the cusp" of the categories.

DPIPWE provide a set of *Guidelines for Eligibility for Listing under the Threatened Species Protection Act 1995* (SAC 2008), which can be applied to the available information on *Stackhousia subterranea*. The information on the endangered and vulnerable categories are copied verbatim (with only minor formatting changes) from the *Guidelines* with an analysis against the various criteria provided in square brackets and coloured text.

CRITERION (1) – ENDANGERED

An extant taxon of native flora or fauna may be listed as endangered if it is in danger of extinction because long-term survival is unlikely while the factors causing it to be endangered continue operating. (Section 15(1) of the Act). The following criteria (A–D) may provide evidence of the level of threat. In order to be considered as endangered at least ONE of the criteria A–D should apply.

(A) Total population reduction in the form of EITHER of the following:

1. an observed, estimated, or inferred reduction of at least 50% over the last 10 years or within the past three generations of the species, whichever is the longer (to a maximum of 100 years), based on (and specifying) any ONE of the following:

a. direct observation;

b. an index of abundance appropriate for the taxon;

c. a decline in area of occupancy, extent of occurrence and/or quality of habitat;

d. actual or potential levels of exploitation; or

e. the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

[There has been extensive clearance of potential habitat throughout the Midlands since the 1800s (e.g. Fensham 1989) and an unknown number of subpopulations have presumably been lost "historically". More recently, areas of potential habitat have been lost (e.g. conversion of native grassland to intensively managed crops) and/or managed without the potential for the species' presence taken into account (e.g. intensive grazing of "rough pasture"). It is, however, difficult to demonstrate, on the available information, a decline of at least 50% in the last 10 years, and as such this Sub-criterion is not met].

2. a reduction of at least 50%, projected to be met within the next ten years or the next three generations, whichever is the longer (to a maximum of 100 years), based on (and specifying) any one of (b), (c), (d), or (e) above.

[Unless there is a significant shift in land use policy, it is difficult to demonstrate, on the available information, a decline of at least 50% in the next 10 years. A possible increasing threat to the species is from larger-scale irrigation projects, although the majority of the "Midlands" schemes are complete and the direct threats from such schemes to the species not realised. An indirect threat from the increased irrigation capacity may arise from an increase in intensive irrigation such as automated irrigation, which could extend to "rough pasture", the prime potential habitat of Stackhousia subterranea. In addition, at least two bauxite extraction projects are in development that could affect the species, but a loss of the species is not predicted for one of these sites (Fingal Rail) and the purpose of this analysis is to ensure that the other (Nile Road) does not result in an unacceptable loss to the species. On this basis, at this stage of analysis, this Sub-criterion is not met.].

[Sub-criteria 1 or 2 are not meaning Criterion A of the endangered category is not met. This is in accordance with the assessment presented in the formal Listing Statement (TSS 2009)].

(B) Extent of occurrence estimated to be less than 5,000 km^2 or area of occupancy estimated to be less than 500 km^2 for mobile taxa (occurrence less than 500 km^2 or occupancy less than 0.1 km^2, i.e. 10 hectares, for sessile taxa), and any TWO of the following apply:

[*Stackhousia subterranea* is considered under the "sessile taxa" category above so the relevant thresholds are extent of occurrence less than 500 km^2 and area of occupancy less than 10 ha. The analysis has clearly indicated the species has an extent of occurrence greater than 500 km^2 (estimated at 2,195 km^2). However, it still occupies much less than 10 ha (estimated at around 6 ha). On the basis of the revised information, Criterion B is still met.

It was on the basis that the species extended less than 500 km^2 and occupied less than 10 ha that TSS (2009) could consider the additional sub-criteria of Criterion B. As such, I re-consider the sub-criteria below because the revised area of occupancy estimate is somewhat "fuzzy' (see discussion under this topic in the preceding section of this document)].

1. severely fragmented or known to exist at no more than five locations

[TSS (2009) considered the species to have a "severely fragmented distribution" (obviously the "known to exist at no more than five locations" concept is not applicable). The *Guidelines* define "severely fragmented as:

> "a situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a low probability of recolonization.
>
> For flora, fragmentation is considered relevant if:
>
> a. it increases the risk of disease or weed invasion by increasing edge effects; or
>
> b. it increases inbreeding effects, or decreases reproductive output by reduced pollinator visitation or by decreasing cross compatibility (e.g. because of a decreasing number of S alleles in subpopulations)".

Based on this definition, even with the increased number of subpopulations, *Stackhousia subterranea* is reasonably regarded as having a severely fragmented Statewide population].

2. Continuing decline, inferred, observed or projected, in any one of the following:

a. extent of occurrence;

b. area of occupancy;

c. area, extent and/or quality of habitat;

d. number of locations or subpopulations; or

e. number of mature individuals.

[There is a measurable increase in sub-criteria a, b, d and e, although there is some evidence of continued decline in the area, extent and/or quality of habitat (sub-criterion 2.c.), but demonstrating this in a measurable sense is problematic because we are dealing very much with the concept of "potential habitat" and not known sites, for which there is no evidence of measured declines. TSS (2009) suggested there was a decline in the quality of habitat and number of mature individuals "due to agricultural activities", although there is little supporting evidence of this. That said, SAC tend to take a conservative approach with this type of sub-criterion because the guidelines are not meant to be interpreted in a strictly literal sense i.e. a precautionary approach should be taken where these is little supporting evidence. I believe this should be regarded as an "inferred" continued decline rather than "observed or projected"].

3. Extreme fluctuations in any one of the following:

a. extent of occurrence;

b. area of occupancy;

c. number of locations or subpopulations; or

d. number of mature individuals.

[TSS (2009) considered there to be "extreme fluctuations in the number of mature individuals". While numbers obviously fluctuate from year to year, I do not regard the species as properly demonstrating the intent of the "extreme fluctuations" sub-criterion. There are clearly not extreme fluctuations in extent of occurrence, area of occupancy and number of locations or subpopulations (all of these have increased). In my opinion, "extreme fluctuations" is applicable to annual/ephemeral herbs such as *Aphelia* spp. and *Stylidium* spp., which are "there one year, gone the next" and when they are present, there could be 10s of

1000s to millions, but at other times, be apparently absent or just a few individuals. Some orchids also meet this concept, where in the absence of disturbance such as fire, the species is apparently absent but after a fire there may be 100s to 1000s, often only for a very short period. There is little formal evidence to suggest that *Stackhousia subterranea* undergoes this nature of "extreme fluctuation" in the total population, although some subpopulations may experience apparent fluctuations, but whether these are "extreme" or not would require substantially more data to demonstrate that a one-year dip in numbers is not within the "norm". In my experience, SAC take a conservative approach to this issue and are likely to accept that there is "inferred" evidence of extreme fluctuations in the number of mature individuals, based on the expert advice previously provided for the Listing Statement (TSS 2009)].

(C) Total population estimated to number fewer than 2,500 mature individuals and…

[Criterion C is not met because all available estimates indicate a population of at least 10,000 mature individuals (TSS 2009). The sub-criteria of Criterion C are not considered in any detail.].

(D) Total population extremely small or area of occupancy very restricted. EITHER:

1. total population estimated to number fewer than 250 mature individuals; OR

2. total population with an area of occupancy less than 0.01 km^2 (1 hectare), and typically in five or fewer locations that provide an uncertain future due to the effects of human activities or stochastic events, and thus capable of becoming extinct within a very short time period.

[Criterion D is not met because all available estimates indicate a population of at least 10,000 mature individuals (TSS 2009) and an area of occupancy well in excess of 1 ha (TSS 2009)].

In my opinion, despite some quite significant range extensions and infillings in recent years *Stackhousia subterranea* still meets the criteria for the endangered category under Criterion B (area of occupancy less than 10) and sub-criterion 1 (severely fragmented distribution), subcriterion 2.c. (inferred continued decline in the quality of habitat), and sub-criterion 3.d. (extreme fluctuations in number of mature individuals).

Implications for the Nile Road project

The proposed Nile Road bauxite extraction project area supports a number of ecological values that will require resolution.

Vegetation types

Any forested areas will support "*Eucalyptus amygdalina* inland forest and woodland on Cainozoic sediments" (TASVEG code: DAZ), which is listed as threatened under Schedule 3A of the Tasmanian *Nature Conservation Act 2002*. None of the vegetation types identified to date are listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Some of the native grassland areas have a high priority for conservation management but are not formally listed under either Act.

The legislative and policy implications of clearing State-listed threatened native vegetation for mineral exploration and extraction is somewhat complex. I provided a detailed analysis of the implications of this for the Fingal Rail project area (ECOtas 2014) and the reader is referred to this. In summary, I believe the extraction will be possible and technically will not

require additional "permits" or "conditions" related to the listed status of the vegetation type. It is reasonable, however, to expect that disturbed areas will need to be rehabilitated to a similar vegetation type, which I believe is practical.

Threatened fauna

At this stage of assessment, no specific sites of threatened fauna have been identified but the project area supports potential habitat of a number of species listed on the Tasmanian *Threatened Species Protection Act 1995* and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Based on aerial imagery and images in PCM (2010, 2012), I do not believe that the management of potential habitat of threatened fauna presents as a "fatal flaw" to bauxite extraction.

Further ore body-level assessments for the presence of potential dens of the Tasmanian devil are likely to be required under the revised *Survey Guidelines and Management Advice for Development Proposals that May Impact on the Tasmanian Devil (Sarcophilus harrisii)* (DPIPWE 2015), although are unlikely to be onerous. Assessments of hollow-bearing trees for the presence of roost/nest sites of the masked owl may also be required at the ore body-level but again, it is unlikely that these surveys will be onerous or reveal "fatal flaws" (based on the apparent mainly regrowth nature of the forest).

Based on the available information, I do not believe that the project will trigger the *Significant Impact Guidelines* (CofA 2013) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and a referral to the Commonwealth Department of the Environment is unlikely to be required. Technically, a permit is unlikely to be required under Section 51 of the Tasmanian *Threatened Species Protection Act 1995* (because the Act does not deal with "potential habitat"), although agencies such as DPIPWE (EPA, PCAB) are likely to provide project-level guidelines.

Threatened flora

In my opinion, the known and potential presence of threatened flora, as listed on the Tasmanian *Threatened Species Protection Act 1995* and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, presents the most significant potential constraint for the extraction of bauxite at the Nile Road project area.

At this stage, only State-listed species are present and the relatively low potential for Commonwealth-listed species means that the project will not trigger the *Significant Impact Guidelines* (CofA 2013) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and a referral to the Commonwealth Department of the Environment is unlikely to be required. This would need to be reviewed if further surveys detected any EPBCA-listed species, although it is reasonable to assume that any such occurrences are likely to be localised and practically avoided.

A permit under Section 51 of the Tasmanian *Threatened Species Protection Act 1995* will be required because State-listed species are known to be present. Some species are clearly widespread and common (e.g. *Arthropodium strictum*) and will not pose a constraint: SAC has recommended the delisting of this species so DPIPWE are unlikely to impose strict (or any) permit conditions. *Hypoxis vaginata* is in a similar situation although there has been no formal recommendation to delist the species (experience indicates that it is disturbance-tolerant and will re-colonise heavily disturbed sites). The highly localised nature of *Scleranthus fasciculatus* indicates that micro-site management may be appropriate (e.g. avoid site), although if further surveys detect additional patches, this could be reviewed (this would be the benefit of a broader level survey). The presence of the annual

herb *Triptilodiscus pygmaeus* is of greater concern, although it is a "disturbance-phile" and can colonise disturbed ground. It is likely to be "manageable" under a regime of "protect some, disturb some" with some monitoring in place. Its presence can be indicative of a suite of other annually-flowering herbs such as *Aphelia pumilio*, *A. gracilis*, *Hyalosperma demissum*, *Siloxerus multiflorus* and others, although surveys to date (PCM 2010, 2012) have not detected these. Broader surveys may find these species within the ore extraction/disturbance footprint of the project but I do not think they will present as a "fatal flaw".

In relation to all threatened flora, further ore-body level surveys are recommended that extend the drill hole-level surveys already undertaken, and also take account of other works areas (access roads and tracks, processing areas, office sites). Given the suite of potential threatened flora present, including several orchid species not highlighted by a standard 5 km database buffer, several surveys are recommended to maximise the opportunity to detect such species. The surveys for orchids in particular will need to meet the intent of the draft Commonwealth survey guidelines, which essentially mean grid-based assessments in some detail. In addition, given that several (27) patches of *Stackhousia subterranea* have already been detected, further patches are likely and surveys should extend beyond the extraction/disturbance footprint to provide context to any management prescriptions.

The following recommendations are made for further surveys:

- undertake targeted botanical surveys in mid-October, mid- to late-November and mid-January to target the suite of species potentially present;
- target surveys to the most likely ore body extraction sites but also include anticipated infrastructure elements of the project (access roads and tracks, processing areas, office site, maintenance areas, etc.) and ensure a minimum 50 m buffer is surveyed around each disturbance area (this meets the Tasmanian devil survey guidelines but also would reveal the broader distribution of threatened flora beyond areas likely to be disturbed); and
- ensure the most likely potential habitat for EPBCA-listed threatened orchids (open grasslands areas, rockplate grassland areas and grassy/heathy woodland parts of the forested area that are herb-rich i.e. not heavily browsed) are surveyed in a higher level of detail.

Until the findings of these surveys have been undertaken, it is difficult to describe in detail management prescriptions that could be developed to allow bauxite extraction and appropriate protection of threatened flora species. In my opinion, there are likely to be practical solutions that can be devised to progress this project. I believe there is an opportunity to utilise ABX's rehabilitation skills and experience from other sites to develop a program of monitoring the impacts of disturbance on several species of threatened flora. There may be opportunities for novel, at least in the Tasmanian context, solutions such as topsoil stripping and stockpiling of sites supporting threatened flora followed by replacement after extraction (this would obviously need to involve a monitoring component).

The main species of concern is *Stackhousia subterranea*, hence the detailed preceding analysis. Based on the mapping of the patches and the initially supplied ore body map, some patches will be impacted while others will be undisturbed. Finding an acceptable balance between "loss"/protection will be critical to the project, which is why an analysis of the number of additional patches beyond those already identified needs to be undertaken following further field surveys. In fact, it may be prudent (with landowner permission) to extend the surveys for Stackhousia subterranea to beyond the bauxite extraction project area to other grassy forest/woodland on the property, with the intention of detecting additional subpopulations further extending the range of the species.

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Table 1. Revised subpopulation summary for *Stackhousia subterranea* in Tasmania (green text highlights new information noty included in the formal Listing Statement)

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
1	Township Lagoon	Township Lagoon Nature Reserve	Tunbridge	1978 1983 1984 2005 – from TSS (2009) 2009 2011	1978 – no data 1983 – no data 1984 – no data 2005 – **1 ha** (TSS 2009) 2009 – **0.2 ha** 2011 – **1 ha**	1978 – no data 1983 – no data 1984 – no data 2005 – **100s** (TSS 2009) 2009 – **10-100** 2011 – **1,000**	There are just 6 records in the *Natural Values Atlas* for the Township Lagoon site, although it is well know the species occurs in scattered patches across the western half of the reserve. The first formal collection was in 1978. In 2011, Threatened Plants Tasmania undertook surveys and estimated numbers up to 1,000 individuals over c. 1 ha but did not provide specific point locations to the *Natural Values Atlas.* Any older records that technically fall outside the reserve probably represent database artefacts as all are labelled with the lagoon location. TSS (2009) indicates a subpopulation at this site with the year last seen as 2005 but there is no supporting data in the *Natural Values Atlas* for this year.
2	Midland Highway, south of Tunbridge	Department of State Growth	Tunbridge	1983 1984	1983 – no data 1984 – no data	1983 – no data 1984 – no data	This subpopulation, represented by 3 database records but no voucher specimens, does not appear as a subpopulation in TSS (2009). Given that two of the records represent the former Department of Transport database, presumably the sites are from the highway verge, although they are shown as being on either side of the highway. Determining the veracity of these records has some importance because until recently they represented the southernmost extent of the species in Tasmania (now represented by the population near Brighton).

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							A database record positioned between this cluster of three records and confirmed sites along Tunbridge Tier Road from 1993 also appears dubious and most likely represents a separate road verge point.
3a	Midland Highway, first batter north of Tunbridge Tier Road junction (west side)	Department of State Growth	Tunbridge	1961 2000 2012	1961 – no data 2000 – no data 2012 – given as "80-90" m and "107 m", presumably referring to the length of the patch along the top of the batter, assuming a 5 m wide strip of 100 m, this is **0.05 ha**	1961 – no data 2000 – no data 2012 – two of 4 data points for 2012 give abundance as "2" and "16" – **18**	The record from 1961 (W.D. Jackson), which is vouchered, is technically positioned on the eastern side of the Midland Highway. This record should be shifted to the western side as all evidence indicates the species is absent from the eastern side. Note that the various point locations along Tunbridge Tier Road and the Midland Highway at the junction of Tunbridge Tier Road are considered as one subpopulation, although the species clearly occurs as discreet patches in suitable habitat separated by relatively long stretches of unsuitable habitat because the surveys by DPIPWE and Threatened Plants Tasmania have been quite intensive. TSS (2009) indicated that the Tunbridge Tier Road subpopulation occupied **2 ha** and supported **100s** of individuals and was last seen in 2005, although there are no formal records from this year for any site along the road (see 3a-e).
3b	Midland Highway, second batter north of Tunbridge Tier Road junction (west side)	Department of State Growth	Tunbridge	1988 2013	1988 – no data 2013 – no data	1988 – no data 2013 – **1**	The record from 1988 (D.I. Morris) is labelled "Tunbridge, above road cutting N of Tunbridge Tier Road turnoff", which presumably refers to the second rise north of the junction rather than the first (where there is a cluster of records – see 3a). That record is vouchered at the Tasmanian Herbarium. The 2013 record, of just 1 plant, is more accurately located and supports

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							the notion that the species occurs on both the first and second cuttings north of the Tunbridge Tier Road junction.
3c	Tunbridge Tier Road (west)	Department of State Growth Private property	Tunbridge	1985 2014	1985 – no data 2014 – 276 m^2 for 11 records – **0.0276 ha**	1985 – no data 2014 – **551** for 11 records	The 1985 record is indicated as "hill on N side of Tunbridge Tier Road", which is presumably on private property. The records from 11 Sep. 2014 and 26 Oct. 2014 comprise 14 points, most with data, indicating the species occurs on both sides of the road verge.
3d	Tunbridge Tier Road (middle)	Department of State Growth Private property?	Tunbridge	1985 2014	1985 – no data 2014 – 33 m^2 for 5 records – **0.0033 ha**	1985 – no data 2014 – **67** for 5 records	The 1985 record technically lands on private property but is more likely to have been collected from the road verge. The records from 26 Oct. 2014 comprise 5 points, all with data, indicating the species occurs on both sides of the road verge.
3e	Tunbridge Tier Road (east)	Department of State Growth Private property?	Tunbridge	1984 1985 1990 2009 2014	1984 – no data 1985 – no data 1990 – no data 2009 – no data 2014 – 87 m^2 for 12 records – **0.0087 ha**	1984 – no data 1985 – no data 1990 – no data 2009 – no data 2014 – **152** for 13 records	Some of the earlier records technically land on private land but all are assumed to be from the immediate road verge. The records from 26 Oct. 2014 comprise 13 points, all with data, indicating the species occurs on both sides of the road verge.
4	Midland Highway between Tunbridge and Ross	Department of State Growth	Ellinthorp	1952	unknown	unknown	This subpopulation is not listed in TSS (2009) but represents the second earliest formal collection of the species in Tasmania. The herbarium sheet is labelled "Midland Highway at 70 mile peg, between Tunbridge and Ross" implying a very specific location and most likely a virtual road verge collection.
5	Tunbridge "paddock"	Private property	Tunbridge	2007 – from TSS (2009)	**2 ha** – as given in TSS (2009)	**10,000s** – as given in TSS (2009)	I cannot reconcile this subpopulation listed in TSS (2009) with any particular other location but it is clearly a significant site with a large number of

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							individuals across a large area, contributing a significant part of the Statewide population and therefore critical in any analysis of conservation status. There is no supporting data in the *Natural Values Atlas* dated 2007 (apparently when this subpopulation was last seen) with numbers of the order of 10,000s. The "Tunbridge paddock" was one of the formal transect locations of Gilfedder & Kirkpatrick (1998).
6a	Knobby Ridge, NW Tunbridge	Private property	Tunbridge	1999	1999 – no data	1999 – no data	This data point does not appear to correspond to any locations mentioned in Gilfedder & Kirkpatrick (1998) nor to any subpopulations included in TSS (2009), although the position of the point lands on a likely location.
6b	NW end of Knobby Ridge, NW Tunbridge	Private property	Tunbridge	1999	1999 – no data	1999 – no data	As above – sites approximately 1 km from each other.
7	Near Lagoon, c. 1.5 km SSW	Private property	Ellinthorp	1999	1999 – no data	1999 – no data	There are two data points, collected on 10 Nov. 1999 by R. Nicholson (considered a reliable observer), one with a precision of 25 m, the other 100 m, perhaps indicating they are the same record, although they are more than 100 m apart suggesting separate location. No data is supplied with the Natural Values Atlas record and the sites are not vouchered at the Tasmanian Herbarium. This site was not included in TSS (2009).
8	Near Lagoon, c. 1 km W	Private property	Ellinthorp	2005	2005 – no data	2005 – **100s**	There is one data point, collected on 1 Nov. 2005 by D. Sprod (considered a reliable observer). The site is sufficiently far from the other Near Lagoon records to be considered a separate subpopulation.

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							This site was not included in TSS (2009).
6	"Merton Vale"	Private property	Ellinthorp	1 Nov. 1992 9 Nov. 1993 2005 – from TSS (2009) 13 & 23 Nov. 2010	1992 – no data 1993 – no data 2005 – no data 2010: Ford Run Paddock – 14 records with a minimum area of 1,800 m^2 – **0.18 ha** 2010: Tin Dish Paddock – 18 records with a minimum area of 3,542 m^2 – **0.35 ha**	1992 – no data 1993 – **100s** 2005 – no data 2010: Ford Run Paddock – 14 records with a minimum of **308** individuals 2010: Tin Dish Paddock – 18 records with a minimum of **2,975** individuals	TSS (2009) indicates a subpopulation on "Merton Vale" with the year last seen as 2005 but there is no supporting data in the *Natural Values Atlas*. It is not known if the population estimate of "100s" relates to 1993 or 2005 but the 1993 record has "hundreds" included in its information. The *Natural Values Atlas* records labelled as "Merton Vale" are difficult to reconcile. The record from 9 Nov. 1993 is labelled "Merton Vale" and nominally placed on the property homestead but almost certainly refers to the now mapped locations in the "Ford Run Paddock" and "Tin Dish Paddock". The record from 1 Nov. 1992 is not labelled with a location but is from the same reliable collector as the 9 Nov. 1993 record and it seems reasonable that the collector re-visited the same approximate site. TSS (2009) indicates the last year the "Merton Vale" subpopulation was observed was 2005 but there is no supporting data in the *Natural Values Atlas* for this. There are, however, numerous records from 13 & 23 Nov. 2010 for the "Tin Dish Paddock" and the "Ford Run Paddock".
6?	Auburn Road	Private property	Ellinthorp	1993	**0.025 ha** – as given in TSS (2009)	**<50** – as given in TSS (2009)	Gilfedder & Kirkpatrick (1993) refer to this site as one of the known populations but there is no supporting data in the Tasmanian Herbarium or the *Natural Values Atlas* labelled as "Auburn Road". Depending where the site is could marginally affect the extent of occurrence of the species (but most likely it falls within the

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							minimum convex polygon created by other sites).
7	"Preston"	Private property	Jacobs	4 Nov. 2002 3 Nov. 2014	2002 – "localised", 3 x 3 m – **0.0009 ha**, given as 0.0001 ha in TSS (2009) 2014 – 2 sites with larger patch indicated as 30 x 30 m – **0.09 ha**	2002 – **c. 10** 2014 – 2 sites with 100 and 100-500 plants (total – **200-600**)	The original collection was by Mark Wapstra on 4 Nov. 2002 (the *Natural Values Atlas* includes a false duplicate labelled as 3 Nov. 2002, which should be removed). The collection label indicates a "localised" patch of "c. 10 plants", later translated in the *Natural Values Atlas* a 0.0001 ha (based on an entry of 3 x 3 m) and <10 plants.
8a	"Fosterville" northern end	Private property	Jacobs	4 &17 Nov. 2011	2011 – (no data for 17th) 6 patches on 4th estimated at 749 m^2 – **0.075 ha**	2011 – 2 records from 17th (1 & 2 individuals) – **3**; 6 records from 4th counted as up to **18,000**	TSS (2009) does not include any subpopulations from the "Fosterville" property, although it is clear that there were pre-2009 records from the Fosterville-Merton Vale-Ashby Road area. The Ashby Road site is included below as subpopulation 8b and records specifically attributed to the "Merton Vale" property as subpopulation 6. Several of the subpopulations listed for "Fosterville" are sufficiently far apart to be considered as separate subpopulations but I have taken a conservative approach and considered them as part of one larger subpopulation.
8b	Ashby Road	unknown	Jacobs	6 Nov. 1991	1991 – no data	1991 – no data	TSS (2009) does not indicate a subpopulation from "Ashby Road" and none of the listed subpopulations correspond to this location. Given the apparent accuracy of the record in being placed on the road, it assumed this represents a road verge patch.
8c	"Fosterville" ("Ovenden Plain")	Private property	Jacobs	1984 1991 2011	1984 – no data 1991 – no data 2011 – **0.0001 ha**	1984 – no data 1991 – no data 2011 - **10**	The 1984 record (of no "fixed" date as it is indicated as 1/11 suggesting sometime in November but unlikely to be the 1st) coincides with the more accurate record of 1991 (6 Nov. 1991), which is labelled as "Ovenden Plain, west of Campbell Town". The

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
							relationship of these records to others on "Merton Vale" and "Fosterville" are not properly understood. A record that falls close to these records is from 2011 (TSS) and has reliable data.
8d	"Fosterville" (west of Ashby Road)	Private property	Jacobs	1984 1991	1984 – no data 1991 – no data	1984 – no data 1991 – no data	The 1984 record (of no "fixed" date as it is indicated as 1/11 suggesting sometime in November but unlikely to be the 1st) coincides with the possible more accurate record of 1991 (1 Nov. 1991), both of which are unlabelled as to location. TSS (2009) does not indicate any subpopulations that correspond to these records.
8e	"Fosterville" (near Macquarie River)	Private property	Jacobs	2011	2011 – 2 records of 10 m^2 and 150 m^2 – **0.016 ha**	2011 – 2 records of 2 and 200 individuals – **202**	This appears to be a new site, unrelated to others on the property.
9	Campbell Town Golf Course	Private property (subject to conservation covenant)	Campbell Town	2001 – from TSS (2009) 3 & 5 Nov. 2009 20 Oct. 2014	2001 – **1 ha** (TSS 2009) 2009 – 8 patches, only 2 indicate 1 x 1 m area – **0.0008 ha** 2014 – no data	2001 – **10s** (TSS 2009) 2009 – 8 patches with **34** plants 2014 – no data	The *Natural Values Atlas* does not have any records from 2001, as indicated in TSS (2009).
10	north of Campbell Town	Private property (informal cemetery "reserve")	Jacobs	1984 1993 2003	1984 – no data 1993 – no data 2003 – **0.01 ha** (TSS 2009)	1984 – no data 1993 – no data 2003 – **<20** (TSS 2009)	The 1984 record (of no "fixed" date as it is indicated as 1/11 suggesting sometime in November but unlikely to be the 1st) actually falls c. 725 NNW of the private cemetery where the 1993 record is indicated. Both the 1984 and 1993 represent the same site and the 1984 grid reference should be shifted to that of the 1993 record. The *Natural Values Atlas* has not data from 2003 and this should be added.
11	"Wanstead"	Private property	Conara	6 Nov. 1996 2007 – from TSS (2009) 24 Nov. 2009 22 & 27 Oct. 2014	1996 – no data 2007 – **1 ha** (TSS 2009) 2009 – no data 2014 – no data	1996 – no data 2007 – **1,000s** (TSS 2009) 2009 – no data 2014 – no data	The *Natural Values Atlas* does not have any data from 2007, which is indicated in TSS (2009), and this should be added to provide a complete picture of the subpopulation.

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
12	4.8 km west of Epping Forest	Tom Gibson Nature Reserve	Cleveland	14 Oct. 2012	50 m^2 – **0.005 ha**	50 ("rough estimate")	This is a new subpopulation since TSS (2009), found within the Tom Gibson Nature Reserve, an area that has been subject to numerous dedicated botanical assessments over many decades but that continues to reveal new species and sites of threatened flora, suggesting that there may be further sites in this quite large reserve. At the time, this record represented a range extension of c. 19 km (to the nearest sites near Conara) and still represents the northwesterly limit of the species in Tasmania.
13	north of Nile Road	Private property	Nile	16 Nov. 2012	27 patches (3,432 m^2 based on radius estimates of patch size) – **0.34 ha**	27 patches (**3,203+**, with 4 patches indicates as "+", presumably meaning many 10s more)	This is a new subpopulation since TSS (2009). It represents a reasonably significant range extension to the northwest from the "Packston Reserve" subpopulation of 11-13 km (the new subpopulation extends along a broad ridge for 1-2 km) and to the northeast from another new subpopulation (xxx), since TSS (2009), also of around 13 km. It also adds a considerable area to the extent of occurrence, and 1,000s of individuals to the Statewide population. The detection of this subpopulation does lend weight to a supposition that further patches may occur in this part of the State. The site currently represents the northernmost limit of the species in Tasmania.
14a	Esk Main Road	Private property TSS (2009) lists this site as "rail reserve" but only the	Diamond	1988 1995	1988 – no data 1995 – no data TSS (2009) – no data	1988 – no data 1995 – **c. 40** TSS (2009) – no data	The 1988 record (D.I. Morris, 17 Sep. 1988) is noted as "Esk Main Road, c. 4.5 km east of Conara picnic area, where road crosses railway line. Railway reserve". The mention of a "railway reserve" probably indicates that the species was collected from the long-used pull-off known as the

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
		nearby "Packston Reserve" is an informal reserve.					"Packston Reserve" rather than from the actual rail corridor itself (especially since it is mentioned as "where road crosses railway line". The 1995 (D.I. Morris, 12 Nov. 1995) is noted as "near bridge over railway line, 6 km east of Conara on Avoca road". Again, this is assumed to be the "Packston Reserve" because it is likely that the collector simply –revisited his original site of collection. Both records have a nominal precision of ± 100 m in the *Natural Values Atlas* but place the records at slightly different locations and away from the "Packston Reserve". For the purposes of this analysis, the records have been shifted to the approximate centre of the "Packston Reserve" (542190mE 5369520mN) and shown with a precision of ± 1,000 m because herbarium staff did not GPS locations and only created latitude/longitude references from 1:100,000 maps, which were later converted to 13-figure easting/northing references i.e. a false precision).
14b	Esk Main Road	Private property	Diamond	15 Nov. 2011	2011 – **0.002 ha**	2011 – **150-200**	This is a new patch, first detected by ABx staff, and confirmed by Mark Wapstra on 15 Nov. 2011, at which time 150-200 flowering stems in about 4 x 5 m were observed. The site is immediately east of an existing track through the private forest. The site is less than 1 km from the "Packston Reserve", the presumed location of the 1988 and 1995 collections so is not properly regarded as a separate subpopulation. However, the species has not been detected at this latter location since 1995 (despite some intensive surveys in 2011).

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
15a	St Pauls River (Royal George Road crossing)	Private property	Roys	1984 (Kirkpatrick) 1993 (Gilfedder)	1984 – no data 1993 – no data TSS (2009) = **1 ha**	1984 – no data 1993 – c. 40 TSS (2009) – **100s**	TSS (2009) does not state the source of the area occupied and abundance data in the *Natural Values Atlas*.
15b	"Benham" property	Private property	Hanleth?	7. Nov. 1891	unknown	unknown	This subpopulation was not listed in TSS (2009) nor mentioned in Gilfedder & Kirkpatrick (1998) but represents the earliest formal collection of the species from Tasmania. The *Natural Values Atlas* indicates a precision of 1,000 m but in reality the precise collection site will never be known because the "Augustus Simson" herbarium does not indicate any more information other than "Benham property", which could have referred quite a wide area (the nominal grid reference in the *Natural Values Atlas* should be adjusted and my analysis in this document places the revised location on the "Benham" homestead at 561220mE 5372060mN, also somewhat nominal of course, and at best should be indicated with a precision of ± 5,000 m, given the historical extent of the "Benham" estate and potential habitat once and still present). The site is nominally greater than 1 km from the extant site further south along Royal George Road but cannot be reasonably interpreted as a separate subpopulation due to the paucity of locality information (although it is unlikely to directly correlate with the 1984/1993 location).
16	Crooked Billet Creek, Brighton	Rail reserve/private property	Broadmarsh	15, 19 & 20 Oct. 2009 8 Oct. 2013	Described as "distributed along top of cut and just extending into adjacent paddock" with one record indicated as 30 m^2 – **0.003 ha**	Records indicated as 200-300, 1, 1 and 200-300, assume to be **200-300**	New since TSS (2009); range extension of c. 64 km to south; large addition to extent of occurrence.

No.	Subpopulation	Tenure	1:25,000 mapsheet	Year(s) seen	Area occupied (ha)	Abundance	Comments
17?	"Fingal picnic area"	"Rail reserve"	unknown	unknown	unknown	unknown	Gilfedder & Kirkpatrick (1998) indicate that a known population referred to by them as "Fingal picnic area" was re-sampled as part of their research. There are no supporting voucher specimens held at the Tasmanian Herbarium and no records in the *Natural Values Atlas* for this site, which would represent a significant easterly range extension beyond the currently understood range of the species. This site has not been included in any analysis of extent of occurrence, area of occupancy or number of subpopulations.
18?	"Interlaken Road"	"Road reserve"	unknown	unknown	unknown	unknown	Gilfedder & Kirkpatrick (1998) indicate that a known population referred to by them as "Interlaken Road" was re-sampled as part of their research. There are no supporting voucher specimens held at the Tasmanian Herbarium and no records in the *Natural Values Atlas* for this site, which would represent a significant southwesterly range infilling/extension beyond the currently understood range of the species. This site has not been included in any analysis of extent of occurrence, area of occupancy or number of subpopulations.
19??	"Rattrap"	"Road reserve"	Tunbridge	pre-1998 2003 – from TSS (2009)	2003 – **0.01 ha** (TSS 2009)	2003 – **<10** (TSS 2009)	Gilfedder & Kirkpatrick (1998) refer to one of their formal transect sites as "Ratrap" and that this is in a "road reserve" – it is presumed to refer to one of the sites along Tunbridge Tier Road, although there is no supporting voucher specimens or *Natural Values Atlas* records labelled "Rattrap" and no Gilfedder records from Tunbridge Tier Road at all and only one from Kirkpatrick (but from 1984).