Tecticornia Review

Wiluna Uranium Project

This report was prepared for:

Toro Energy Limited

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1 Executive Summary

Toro Energy Ltd (Toro) is proposing to develop uranium resources within the Wiluna Uranium Project comprising two prospective mining areas; Centipede and Lake Way. The two proposed mining areas are located south of the town Wiluna on the borders of Lake Way in Western Australia.

Lake Way is a large (460km^2) episodic playa lake in the Northern Goldfields region of Western Australia. It is one lake in a chain that makes up the Carey Palaeodrainage system, formed during the Tertiary Period, about 65 million years ago. The Carey Palaeodrainage system extends from Wiluna to the Eucla Basin in a south-easterly tending direction and has a very low gradient. Lake Way is normally dry, becoming inundated after occasional intense rainfall, sometimes after cyclonic events.

Toro has contracted Actis Environmental Services (Actis) to review past vegetation study reports of the Wiluna Uranium Project viewed in the context of current EPA guidelines for the assessment of terrestrial flora. It was understood that the focus was to be samphire (*Tecticornia*) vegetation. Actis has also been asked to comment on the groundwater dependency and conservation significance of samphire-dominated vegetation.

1. Review available vegetation survey reports and other relevant contextual information held by Toro (for example, soil data, groundwater data) and comment on the adequacy of vegetation surveys, viewed in the context of current EPA guidelines for terrestrial flora and vegetation assessment;
2. On the basis of available information, comment on the likely conservation significance of samphire-dominated vegetation communities which may be affected by implementation of the Wiluna project;
3. Comment on the nature of the 'groundwater dependency' of samphire-dominated vegetation which may be affect by implementation of the Wiluna project and the adequacy of Toro's current 'Groundwater Dependent Vegetation Management Plan' to detect or limit impacts on these vegetation communities;

Review of Surveys
There were two main vegetation reports (Niche Environmental Services in July 2011; Outback Ecology baseline survey 2007) plus one derivative report by Niche Environmental Services. Aquaterra's Lake Way Groundwater Impact Assessment in 2010 provided a discussion of the likely changes to groundwater from the mining. The work by Niche Environmental Services (Niche) incorporated all vegetation surveys.

The vegetation surveys at the Toro sites of Lake Way and Centipede and regionally were comprehensive and answered the EPA Guidelines for Flora and Vegetation assessment except with respect to the *Tecticornia* spp.

The survey of species richness by Niche was comprehensive within the proposed mining areas but, perhaps due to sterile material, samphire surveys at other locations outside the mining areas were inadequate to provide comparisons with the project areas.

Species composition or community structure would have been captured more successfully using multiple 3m by 3m quadrats in linear transects across the lake fringe profile instead of the more standard 30m by 30m quadrat. Niche used the standard 30m by 30m quadrat with walking transect between sites. It has been found that the standard sampling technique inadequately describes the changes in communities and may overlook some assemblages or species. Actis favours a 3m by 3m succession of quadrats from playa edge to terrestrial vegetation assemblages that have been used in at least one PER and several HDL proposals and reports.

The number of quadrats sampled by Niche and total species count indicates a comprehensive sampling of species richness but is weak on community structure. Otherwise the effort put into the project was excellent.

Conservation of Samphires

Both the Lake Way site and Centipede site survey areas have some similarity in their vegetation associations. Some similarity was also found in associations at some of the regional surveys – GB1, LK3 and Reg2-8. The samphires found most commonly at the Lake Way site and Centipede site are common elsewhere and were also found at many of the regional sites (with the exception of *Tecticornia* sp. Burnerbinmah – no priority ranking), though it was noted that samphire sampling was not successful at many of the 'regional' sites around Lake Way

Tecticornia sp. Lake Way (P1) was not found at any of the sites in the Centipede, Lake Way project area or regionally. It was found at two sites further south of Centipede. No vegetation association was listed with *Tecticornia* sp. Lake Way. The hydrogeological modelling (Aquaterra 2010b) states that groundwater drawdown effects will not reach the area where this plant is found and if no roads or exploration tracks enter this area it would be safe to assume that this plant will remain secure.

Samphire heathlands support a diverse and specialised fauna, such as dragons, spiders and insects (especially beetles). Continuity and extent of the samphire heathlands are an important consideration. It is not clear from the report how much of the Lake Way samphire heathland will be impacted.

It is unlikely that any of the species now growing at the Lake Way and Centipede sites will disappear permanently, especially if the top 20cm of overburden from mining (containing the seed bank) is kept in windrows of no more than a meter high, to be used in revegetation. Viability studies have not been carried out to ascertain the length of time samphire seeds remain viable but experience at Lake Carey has shown that (mass) samphire germination will take place every ten years or so when enough rain falls to leach salts from the soil and fill the lake with 'fresh' water. This happened in 2011.

Management Plan

A more comprehensive monitoring program which expands on the stated baseline and annual monitoring could be added, including the monitoring of groundwater movements in and outside of the drawdown area by a suitable method, for example nested piezometers or arrays of soil moisture meters. Nested piezometers have the advantage of measuring salinity stratification within the aquifer profile even if the water head remains constant.

As part of the annual monitoring there should be permanent vegetation transects as described in the Discussion and Recommendations (page 18). These should include photographs taken at a set distance and with a dated board in the photo.

Recovery and storage of topsoils and seed banks will be useful in the rehabilitation of mined areas.

2 Introduction

2.1 Client details

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2.2 Project Background

"Toro Energy Ltd (Toro) is proposing to develop uranium resources within the Wiluna Uranium Project. The project comprises two prospective mining areas; Centipede and Lake Way. The two proposed mining areas are located south and southeast of the town of Wiluna in Western Australia. In addition to the two prospective resources, Toro proposes to refurbish and upgrade an existing borefield which draws water from an aquifer located to the west of the town of Wiluna, referred to as the West Creek borefield. The project also includes ore processing facilities, access and haul roads, support infrastructure such as accommodation facilities and a water pipeline to convey water from the West Creek borefield to the processing plant.

To develop the resources Toro need to submit a mining application within which a summary of environmental impacts is provided. One area for which potential impacts require an assessment relates to flora and vegetation. Toro contracted Niche Environmental Services (Niche) to undertake studies over the proposed centipede and Lake Way mining areas and the West Creek borefield. This work was carried out in April to June and September to October 2010." (Niche Environmental Services)

The vegetation in the study area was identified in the WA Herbarium. Some of these plants, mostly from samphire dominated communities, are still awaiting identification and in some cases taxonomic description.

Toro has contracted Actis Environmental Services (Actis) to review past vegetation study reports of the Wiluna Uranium Project viewed in the context of current EPA guidelines for the assessment of terrestrial flora. It was understood that the focus was to be samphire (*Tecticornia*) vegetation. Actis has also been asked to comment on the groundwater dependency and conservation significance of samphire-dominated vegetation.

3 Scope of Work

1. Review available vegetation survey reports and other relevant contextual information held by Toro (for example, soil data, groundwater data) and comment on the adequacy of vegetation surveys, viewed in the context of current EPA guidelines for terrestrial flora and vegetation assessment.;
2. On the basis of available information, comment on the likely conservation significance of samphire-dominated vegetation communities which may be affected by implementation of the Wiluna project;
3. Comment on the nature of the "groundwater dependency" of samphire-dominated vegetation which may be affect by implementation of the Wiluna project and the adequacy of Toro's current "Groundwater Dependent Vegetation Management Plan" to detect or limit impacts on these vegetation communities;

4 Review of vegetation surveys and other reports

4.1 Assessment of the Flora and Vegetation at the Toro Energy Wiluna Uranium Project: Lake Way, Centipede and West Creek borefield

This report was prepared for Toro by Niche Environmental Services in July 2011. It is contained in Appendix E of Toro's ERMP. Actis's review relates only to aspects of the previous vegetation studies involving characterisation of *Tecticornia* spp. communities at or near Lake Way and to the assessment of possible impacts of the Wiluna project on *Tecticornia* spp. vegetation. Niche's assessment also incorporated data from the Outback Ecology baseline survey (2007).

The level of assessment for the Toro Wiluna Project was set by the EPA at Environmental Review and Management Programme (ERMP). An ERMP is the highest level of assessment set by the EPA. Based on this a Level 2 survey as defined by the EPA (2004) was considered an appropriate level of survey and is the most comprehensive survey prescribed by the EPA with the central requirement being a quadrat-based survey over proposed areas of disturbance.

A Level 2 survey is comprised of:

- Desktop review including searches of DEC databases, EPBC Act Protected Matters database and reviews of publically available ecological information.
- Site visit for
    - Reconnaissance survey with objective of:
        - Verifying desktop information
        - Flora census, especially presence of conservation flora
        - Vegetation condition
        - Delineation and description of vegetation
        - Identifying impacts
    - Quadrat-based vegetation survey to assist with:
        - Placing vegetation in local and regional context by collecting data in manner consistent with known or recommended levels of sampling effort and quadrat sizes – a minimum of 2 quadrats per vegetation unit is recommended.

The report contains the following:

- Overview of survey sites for regional context
- Findings of desk-top review
- Methods
- Summary of flora, vegetation description, assessment of vegetation condition, extent, and conservation significance and
- Assessment of survey adequacy

The areas covered by Niche in the course of their survey were:

- Centipede, 874ha
- Lake Way project, 2,324ha
- West Creek Borefield, 12,300ha
- Regional – Lake Way and other salt lake systems

A desk top study was undertaken prior to the field work which included:

- Protected Matters database – Environmental Protection and Biodiversity Conservation (EPBC) Act 1999
- DEC Threatened Flora database, WA Herbarium database, Declared Rare and Priority Flora List
- DEC Threatened Ecological Communities, Priority Ecological Communities
- Relevant reports/publications relevant to survey area.

The Centipede survey area covered about 874 ha – 533 ha vegetation and 341 ha bare lake playa. Of the 533 ha of surveyed vegetation, 473 ha will be cleared for the mining project. Within the Centipede survey area there were six vegetation units, including Low Heath D of *Tecticornia* spp. 304 ha of the survey area comprised *Tecticornia* spp., 277.5 ha or 91.2% of which will be removed in the course of mine clearing.

The Lake Way survey area covered about 2,324 ha – 1,984 ha of which was vegetated and 300 ha was bare lake playa. Of the 1,984 ha of vegetation, 679 ha will be cleared for the mining project. Within the Lake Way survey area there were eight vegetation units, including Low Heath D of *Tecticornia* spp. 396 ha of the survey area comprised *Tecticornia* spp., 216.2 ha or 54.6% of which will be removed in the course of mining.

West Creek Borefield had no *Tecticornia* spp.

Tecticornia vegetation units were considered to be the most important of the vegetation associations, largely due to the potential extent of impact to these units.

Priority Taxa recorded during the survey included *Tecticornia* sp. Lake Way (P1). Targeted searches were completed within the survey areas and regionally which found that this species was only recorded in areas from which collections had been made previously – about 4.5km south of the Centipede survey area. *Tecticornia* sp. Lake Way is found in different samphire associations than those found at Centipede and Lake Way projects.

The regional surveys were focussed on salt lake systems in the region surrounding Lake Way. Quadrats were surveyed at the following lake systems:

- Lake King
- Lake Ward
- Lake Miranda
- Unnamed lake systems east of Wiluna

231 specimens were collected from Centipede, Lake Way and other salt lake systems. Of the 231 specimens 168 specimens of *Tecticornia* spp were identified. Of these specimens 21 *Tecticornia* were listed; 13 of these were identified to species and sub-species level, three had an affinity to known species and four were undescribed other than working names. Specimens are still held at the WA Herbarium pending identification.

Niche found "that substrate was linked to differences in species within samphire vegetation units. In addition to the potential for species to vary between sites, the restriction in distribution due to habitat specificity limits the extent of these units. Based on these factors, samphire vegetation units potentially have a high level of conservation significance."

The key relevant criteria (Niche) for determining groundwater dependant vegetation in the Centipede and Lake Way survey areas were:

- The groundwater or capillary fringe above the water table is likely to be within the rooting depth of any of the vegetation;
- A proportion of the vegetation remains green and is likely to be physiologically active during extended dry periods;
- The vegetation associated with the subsurface groundwater is different in terms of species composition and phenology to the surrounding vegetation; and
- The annual use of water by vegetation is considered to be significantly greater than the annual rainfall.

Potentially Groundwater dependant vegetation in the survey areas was identified as:

- Centipede survey area – fringing *Melaleuca xerophila* and Low Heath D *Tecticornia* spp.

- Lake Way survey area – fringing *Melaleuca xerophila*, Dwarf Scrub C *Cratystylis subspinescens* and Low Heath D *Tecticornia* spp.

4.2 Lake Way Groundwater Impact Assessment

This double report was prepared for Toro by Aquaterra (2010b). They dealt with each of the two projects, Lake Way and Centipede, on a stand-alone basis. Both reports detailed the assessment of possible impacts that the operation of the mines would have on the hydrogeology of the adjacent areas. The following issues were dealt with:

- Predicted pit dewatering volumes
- Predicted cones of dewatering drawdown
- Predicted ground water recovery
- Predicted movement of solutes
- Predicted concentrations of chemicals along flow paths

As far as the report's importance to the groundwater dependant vegetation, the immediate issue is dewatering drawdown effect. Two dewatering drawdown scenarios were described, one without physical intervention and one with the construction of barriers to prevent ingress to or egress of water from the pit(s).

Both projects have some underlying palaeochannel; Centipede is in the 'delta' of the Abercrombie Creek palaeochannel and the south west corner of the Lake Way project is over a main bifurcation of the Carey palaeochannel. It is understood that the uranium mineralisation is in calcrete and gravel layers that are a maximum of 15m thick but average about 5m thick – the majority of mining will involve excavation to a depth of about 10m. It appears that the Abercrombie palaeochannel sand is separated from the uranium calcrete body by about 22m (thickness is variable) of cohesive clay and as such there would be low transmissivity between the two. Lake Way mine does not have comprehensive data on thickness of sediment layers but the clay layer beneath the calcrete uranium body is assumed to be between 5 to 10m thick. As dewatering water will be collected from sumps in the pits, not bores (to be confirmed by Toro), it is assumed that there will be minimal, if any, interaction with palaeochannel water.

Using information from numerous bores and drill holes groundwater modelling was developed to assess potential impacts from groundwater dewatering. The results of this modelling indicated that if 10m deep cut-off walls were utilised both dewatering volumes and dewatering drawdown effects would be minimal or confined to the pits.

With cut-off walls in place at Centipede, the 0.2m and 0.5m drawdown contours would follow the mine perimeters except the 0.2m contour would extend 500m north-east below Lake Way and about 1km to the south-east.

If the cut-off walls were not utilised, after 12 years of dewatering Centipede the 0.2m drawdown contour is predicted to extend a maximum distance of 4.3km west (to Abercrombie Well) and 6km east (beneath Lake Way). The 0.5m contour is expected to extend 3.8km west and 4km east; the 1m drawdown will extend about 3km west and about 2km east.

With the cut-off walls in place at Lake Way mine the 0.1m drawdown contour is expected to extend to about 3.3km north-west towards Lake Violet and about 400m south beneath Lake Way; the 0.5m contour would follow the mining area to the north and east and extend 600m into Lake Way.

If the cut-off walls were not utilised, the Lake Way 0.1m drawdown contour would extend about 5km north-west towards Lake Violet and 4km north-east to Lake Uramurdah. The 0.5m contour would extend between 1.5km to 2.5km away from the mine.

4.3 Lake Way and Centipede Baseline Vegetation and Flora Survey

Prepared for Toro by Outback Ecology Services (2007). This report described a baseline flora and vegetation survey over areas containing ore bodies at the Lake Way and Centipede project areas. 62 survey quadrats were at Lake Way study area and 46 survey quadrats were at the Centipede study area. No quadrats were outside of the study area. The following areas were covered:

- Vegetation species recorded
- Vegetation associations – defined and grouped
- Vegetation structure
- Declared Rare and Priority Flora
- Threatened Ecological Communities – no TECs in areas surveyed; one 'at risk' ecosystem in area
- Vegetation condition
- Weeds

4.4 Comments on the adequacy of vegetation surveys, viewed in the context of current EPA guidelines for terrestrial flora and vegetation assessment

The vegetation surveys at the Toro sites of Lake Way and Centipede and regionally were comprehensive and answered the EPA Guidelines for Flora and Vegetation assessment except with respect to the *Tecticornia* spp.

Due to perhaps the time of the year or inexperience in sampling *Tecticornia* spp., many of the samples collected were 'sterile' i.e. there were no seeds or flowers to identify the plants by. The Niche report states that additional survey work is required to complete taxonomic work on *Tecticornia* spp.

During the Niche 2010 surveys a total of 231 samples were collected but only 168 samples could be identified. Out of the 168, 21 samphires were identified, five of which need taxonomic work to resolve their identity. The unresolved specimens are still held at the WA Herbarium.

Species Richness:
The survey of species richness by Niche was comprehensive within the proposed mining areas but, perhaps due to sterile material, samphire surveys at other locations outside the mining areas were inadequate to provide comparisons with the project areas. Quadrats within the Lake Way and Centipede sites had a species richness of between 2 and 8 but 'regional' surveys returned 1-6 species.

Species Composition:
Species composition or community structure would have been captured more successfully using multiple 3m by 3m quadrats in linear transects instead of the standard practice 30m by 30m quadrats. Niche used the standard 30m by 30m quadrant with walking transect between sites. It has been found by *actís* and reported in various publications (Datson, B.: 'Understanding Species Zonation of Samphires (Salicornieae) in the Goldfields of Western Australia', 2005 and Datson, B.: 'Samphires in Western Australia: A field guide to Chenopodiaceae Tribe Salicornieae', Dept of Conservation, 2002) that samphire assemblages change radically across the dune or fringe profile, soil type and groundwater composition. It has been found that the standard sampling technique inadequately describes the changes in communities and may overlook some assemblages or species. *actís* favours a 3m by 3m succession of quadrants from playa edge to terrestrial vegetation assemblages. The number of quadrants sampled by Niche and total species count indicates a comprehensive sampling of species richness but is weak on community structure. Otherwise the effort put into the project was excellent.

5 Samphires – conservation and groundwater-dependency

5.1 Palaeodrainage Systems

Lake Way is a large (460km^2) episodic playa lake in the Northern Goldfields region of Western Australia. It is one lake in a chain that makes up the Carey Palaeodrainage system, formed during the Tertiary Period, about 65 million years ago. The Carey Palaeodrainage system extends from Wiluna to the Eucla Basin in a south-easterly tending direction and has a very low gradient. Lake Way is normally dry, becoming inundated after occasional intense rainfall, sometimes after cyclonic events.

The Carey Palaeochannel is continuous from beginning to end but does not express at the surface for the whole length. Large lakes such as Lake Way and Lake Carey and smaller lakes and wetlands punctuate the palaeochannel along its length but are commonly fringed by sand and gypsum dunes that prevent the flow of surface runoff between lakes. There is some subterranean flow through the palaeodrainage system via sands and gravels but it is very slow (Johnson et al (1999)).

Study of the transmissivity of playa lake sediments undertaken by Actis at Lake Carey over a number of years has found that pumping groundwater from local palaeochannel aquifers in the lake playa causes a local drawdown of all aquifers around the bore to the surface of the playa. At Lake Carey there is interchange between the aquifers (palaeochannels, clays, calcrete and alluvium). Actis is not aware of the degree on interconnection – if any – between the various subsurface strata at the Lake Way playa.

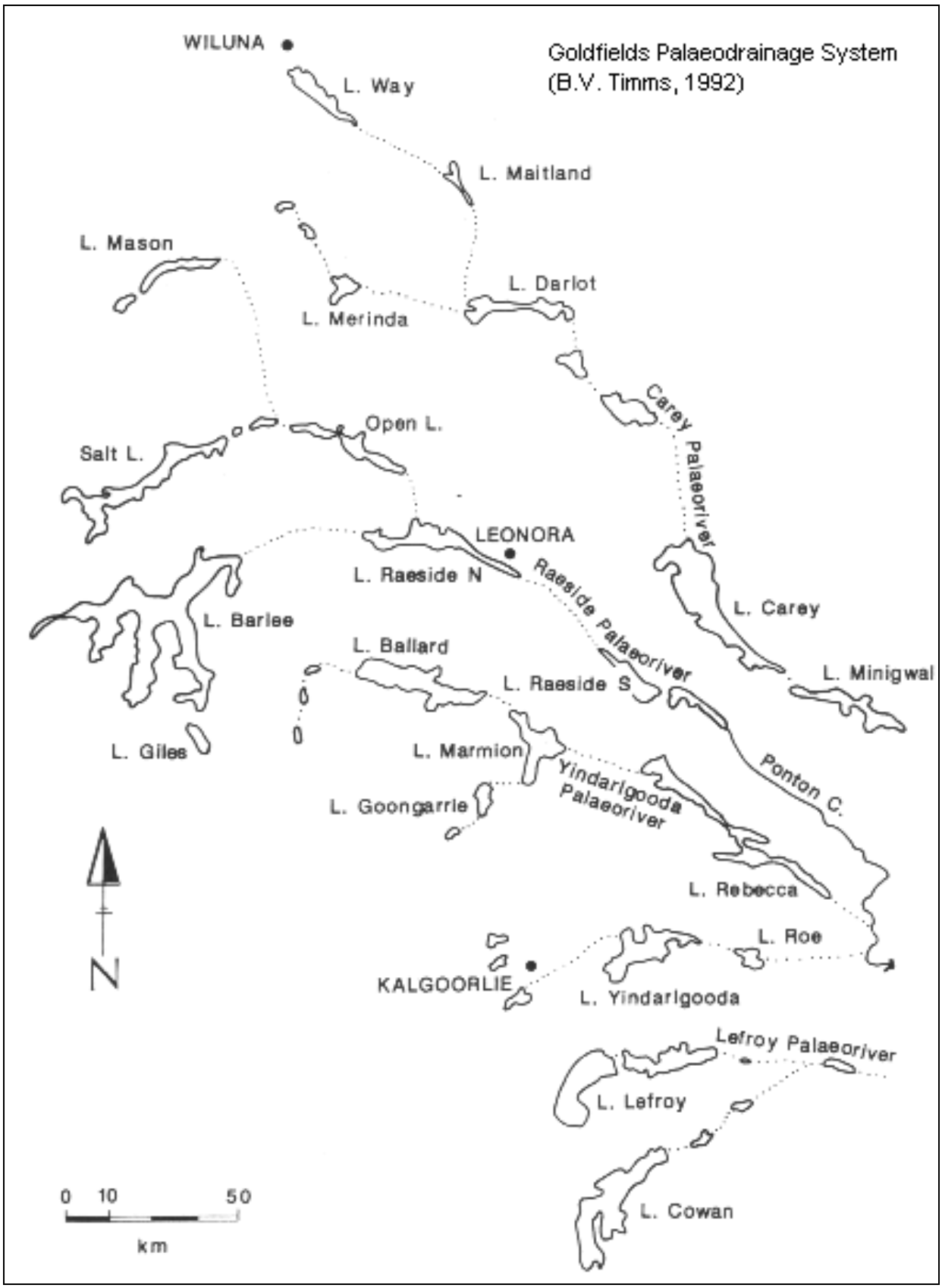

Figure 1 – Diagram of Goldfields Palaeodrainage System

5.2 Samphire zonation and groundwater dependency

Samphires are succulent sub shrubs and shrubs associated with wetlands or periodically inundated damplands. Often the ground they are growing in is saline, though they need fresh water to germinate (Purvis et al 2007). Following is an extract from 'Understanding Species Zonation of Samphires (Salicornieae) in the Goldfields of Western Australia' (B Datson, 2005).

"The saline wetlands of the Goldfields are all linked to ancient drainage systems, or Palaeochannels, which are relics of rivers that used to drain into the Eucla Basin, to the southeast (Johnson/ Commander, 1999). These saline wetlands are predominantly large bare expanses of clay playa surrounded by gypsum or sand dunes and accompanying clay pans. There are some exceptions to this – Lake Raeside is more a series of pans linked by drainage channels than one single lake, for instance. The water in the Palaeochannels is hyper saline; up to 280g/L, however the water on the surface varies from being fresh enough to support tadpoles and Shield Shrimps, to a salt crust.

Samphires are closely associated with these saline lakes and their surrounding clay pans, each species growing in the portion of the lake shoreline or pan that meets its needs (see Figure 2). It is evident that many samphire species have evolved to grow in specific areas, under certain conditions, and are in reality quite fragile and susceptible to change. The species found on lake beaches are often quite different to those found on adjacent Aeolian plateaux or dunes and again on the surrounding fresh water clay pans.

Samphire species appear to have evolved to fill different niches in the environments they inhabit. The individual species grow in their preferred zones. For instance, *Tecticornia indica* subsp. *bidens* is nearly always found in well-drained soils – at Lake Carey, in the northern Goldfields, it is always found at about one meter above the lake playa. *Tecticornia halocnemoides* subsp. *caudata*, on the other hand is rarely found growing more than a few centimetres above the lake playa and is often found out on the waterlogged saline clays. Most Samphire species fall somewhere in between these two extremes, showing tendencies toward one or other end of the scale.

The principal factors that affect species zonation seem to be drainage, or soil moisture, and salt load, or salt concentration. Other factors that affect where a particular species will grow are soil composition (gypsum, sand, limestone or clay) and temperature (tropical species, subtropical species. The other factor that may affect species zonation is pH. Most species sampled were growing in soils with a pH7 or over. Exceptions to this were *T. lylei*, which has only been found in soil with a pH6, *T. lepidosperma* in soils with a pH6-7 and *Sarcocornia blackiana* and *Tecticornia disarticulata*, which have been found in soils with a pH6-8.5."

Observed impacts of dewatering:
Several vegetation (samphire) transects have been monitored annually at Lake Carey since 1999 (B. Datson 1999-2011) and it has been found that the dewatering drawdown effect at one site extended for about 5km of northern shoreline because an arm or bifurcation of the main palaeochannel was dewatered in the course of mine operations. The effects seen were soil mobilisation, both on the lake playa and in the lake dunes expressing as dust storms and during wet periods as gully erosion. Vegetation zonation in the dunes and on the playa changed with samphires moving off the dunes and onto the playa, or close to the edge of the playa. Dune vegetation became dominated by Atriplex and Frankenia species instead. This is an extreme example of dewatering drawdown effect.

Other vegetation transects at Lake Carey that could have been potentially affected by dewatering drawdown have not shown the same effects. Two transects are adjacent to a discharge which would keep the lake sediments damp, negating the drawdown effect. One transect has suffered some drawdown effect with some soil mobilisation but no zonation changes and another does not appear to have suffered any changes at all. The transects with moderate or little drawdown effect are adjacent to minor arms or tributaries of the Carey Palaeochannel, not the main channel.

It has been noted at a number of sites that if a drawdown area on a lake playa is enclosed by a bund, within a year there has been samphire germination – the playa sediments become less saline, allowing germination.

It appears that the mechanical effect of dewatering is a reduction in cohesive forces in the vadose zone which in turn makes the shallow sediments more susceptible to wind erosion, reduction in salinity and subsequent colonisation by more terrestrial species.

It appears from the Aquaterra 2010b report that mining at the Lake Way and Centipede projects will take place in shallow, mainly calcrete bodies containing the uranium which will average 10m deep. Groundwater will be collected from sumps, not bores (to be confirmed by Toro) and there is low transmissivity between these ore-containing bodies and the palaeochannels beneath. This is not the case at Lake Carey, where deep bores dewater below the palaeochannel. That being the case it is unlikely that the same extreme effects seen at Lake Carey will occur at Lake Way, especially if the 10m deep cut-off walls are used.

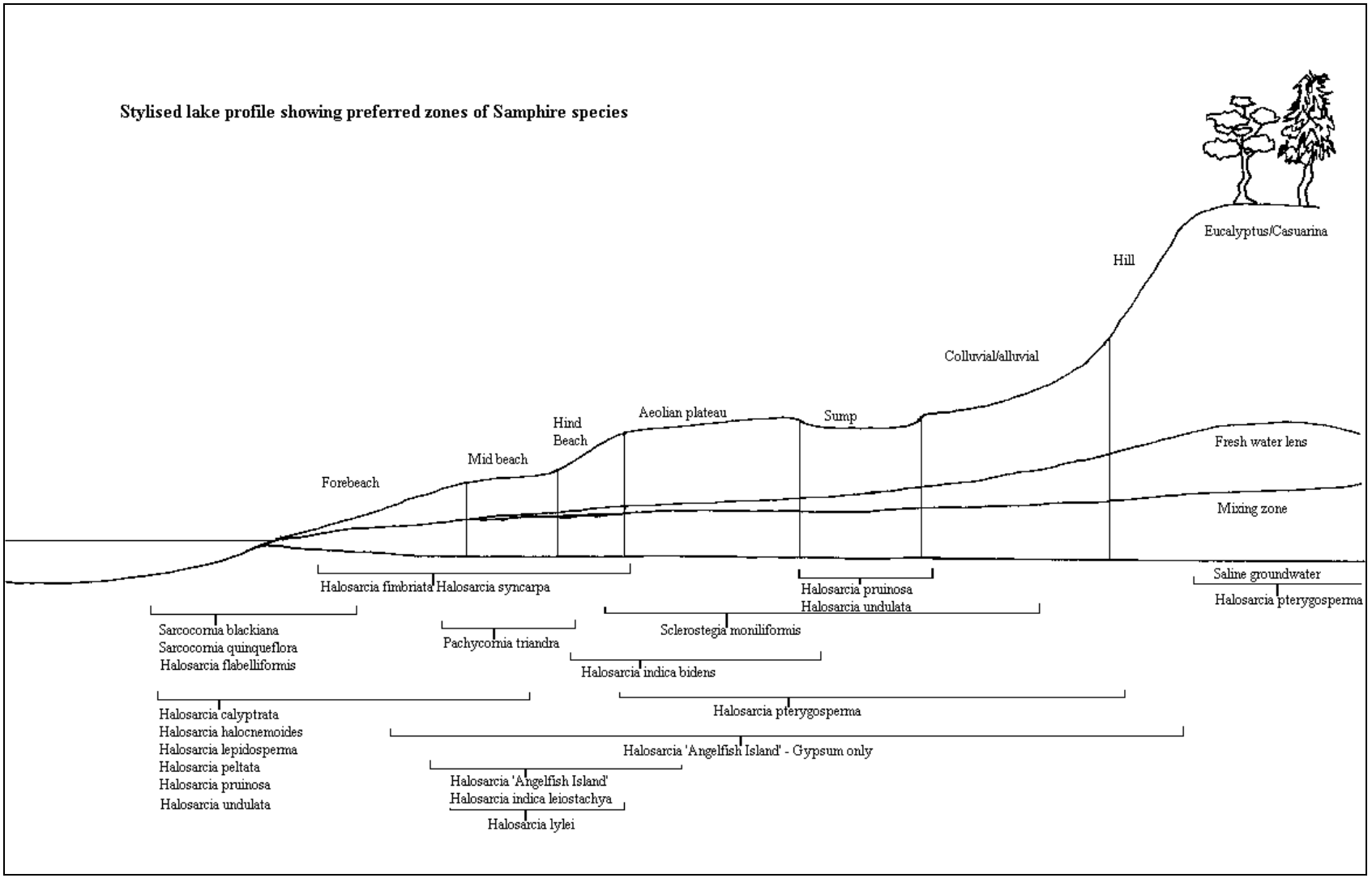

Figure 2 – Stylised lake profile showing preferred zones of samphires – note: *Halosarcia* spp and *Sclerostegia* spp are now *Tecticornia* spp[1]

[1] The figure above was taken from 'Samphires in Western Australia: A field guide to Chenopodiaceae Tribe Salicornieae', Dept of Conservation, Datson, B. 2002, and relates to vegetation at Lake Carey, some of which are found at Lake Way. The profile is relevant to vegetation at other lakes, with different species substituted.

5.3 Samphire Conservation Significance

The samphires found at the Lake Way site, Centipede site and regionally fall into groupings or vegetation associations. Both the Lake Way site and Centipede site survey areas have some similarity in their vegetation associations. Some similarity was also found in associations at some of the regional surveys – GB1, LK3 and Reg2-8. The samphires found most commonly at the Lake Way site and Centipede site are common elsewhere and were also found at many of the regional sites (with the exception of *Tecticornia* sp. Burnerbinmah – no priority ranking). It appears that sampling of many of the sites around Lake Way either did not find any samphires or collected sterile material.

Tecticornia sp. Lake Way (P1) was not found at any of the sites at Centipede, Lake Way project area or regionally. It was found at two sites further south of Centipede. No vegetation association was listed with *Tecticornia* sp. Lake Way. It appears from hydrogeological modelling (Aquaterra 2010b) that groundwater drawdown effects will not reach the area where this plant is found and if no roads or exploration tracks enter this area it would be safe to assume that this plant will remain secure.

Much of the surveyed samphire habitat at the Lake Way and Centipede sites will be cleared for mining. The final landforms at closure will be very similar to the pre-mining landform as described in the ERMP. As such this land will become available for samphire rehabilitation post mining. Many samphires are colonisers and will germinate readily if soil containing a seed bank is placed in a similar position in the landscape to where they were growing previously. It is unlikely that any of the species now growing at the Lake Way and Centipede sites will disappear permanently, especially if the top 20cm of overburden from mining (containing the seed bank) is kept in windrows of no more than a meter high, to be used in revegetation.

Samphire heathlands support a diverse and specialised fauna, such as dragons, spiders and insects (especially beetles). Continuity and extent of the samphire heathlands are an important consideration. It is not clear from the report how much of the Lake Way samphire heathland will be impacted.

5.4 Groundwater Dependent Vegetation Management Plan

A Groundwater Dependant Vegetation Environmental Management Strategy Document (EMSD) is included in the ERMP2 (Section 6-1).
It has been prepared based on:

- Toro's Environment Policy
- Toro's Indigenous Relations Policy
- Relevant Commonwealth and Western Australian legislation
- Other legal obligations
- Identified potential direct and indirect environmental impacts from risk assessments
- Consultants reports
- Relevant permits and standards and
- Toro's commitment to continuous improvement

It was developed to:

- Outline the existing information available in relation to Groundwater Dependant Vegetation (GDV) relevant to the Project Area
- Identify and assess potential impacts on GDV from Project activities
- Describe proposed management and monitoring strategies
- Demonstrate reporting, auditing and review mechanisms
- Outline procedures for consultation and complaints and
- Guide the development of other site specific plans and procedures relevant to the Project

It covers the following elements of the Project:

- Construction and mining of the Lake Way and Centipede deposits
- Construction and operation of a processing, packing and handling facility

- Development of the West Creek Borefield and
- General infrastructure

Niche described a number of vegetation units as being GDV. The vegetation unit of interest to this report is the *Tecticornia* spp Heath and Dwarf Scrub. Clearing, groundwater abstraction, drought and changes to groundwater characteristics were listed as potential threats to this community.

Toro's key objectives in relation to GDV are:

- Minimise clearing of GDV; and
- Maintain the condition of GDV located over aquifers from which groundwater would be abstracted

Management actions include:

- Clearing of GDV only when necessary, (audits, vegetation surveys,)
- Baseline and annual monitoring, review groundwater extraction volumes and climate data

5.4.1 Comments on Toro's Groundwater Dependent Vegetation Management Plan

The EMSD is comprehensive in its preamble but minimal in its objectives and management actions.

Perhaps a more comprehensive monitoring program which expands on the stated baseline and annual monitoring could be added and as part of the review of groundwater extraction include monitoring the drawdown of the affected aquifer(s) on the lake playa. Monitoring the aquifer(s) outside of the drawdown area to be used as a control.

As part of the annual monitoring there should be permanent vegetation transects within and outside of the drawdown area as described in the Discussion and Recommendations (page 18). These should include photographs taken at a set distance and with a dated board in the photo.

6 Discussion and Recommendations

Sampling

The samphire communities at the Lake Way and Centipede projects are the units most affected by the proposed mining operations. The greatest impact will be from clearing, where 54% of the surveyed extent of the vegetation unit will be cleared at Lake Way project and 91.2% of the surveyed vegetation unit will be cleared at Centipede. Considering the fact that these plants (and to a lesser extent the *Melaleuca* belt) are the majority of vegetation affected by the mining it would be logical to expect most vegetation sampling to take place in these areas. While the project areas did have sampling from samphire communities, (and at the time of sampling it was probably thought sufficient), because of sterile material and uncertain identification the samphire sampling was not as comprehensive as it could have been.

Samphires fall into two groups – those that hold onto their seeds and those that drop their seed heads once ripe. Samphires are almost impossible to identify without seeds or flowers. To complete a successful vegetation sampling of these species they need to be sampled with ripe seed, which may entail site visits at different seasons.

To ensure that the samphire associations seen at the Lake Way and Centipede projects are present at other locations at Lake Way it would be responsible to sample samphire associations away from the project areas. If the same samphire species and associations were found in areas away from mining influences it would be safe to assume that they would replace those lost from the mining areas.

It would be also useful to understand the extent of the clearance within the context of the habitat type for Lake Way.

Monitoring

It was noted that for the ERMP vegetation studies 30m by 30m quadrats were used for samphire sampling. These quadrats are standard procedure for EPA Guideline sampling and have their value especially in vegetation units where there is no zonation. For samphire monitoring it has been found that numerous quadrats in a transect covering samphire zonation from playa to dunes gives better results, especially if zonation changes over time. 3m by 3m quadrats in a transect that can reach any length have been found to be useful. If samphire vegetation remains the same over a distance the transect can be stopped and resumed when the samphire species change.

At least two transects should be placed in each mine area with at least four transects at other places around the lake (depending on access) where the vegetation is similar.

It is suggested that some estimates of diversity and health (coverage) be included in the monitoring areas.

Dewatering Drawdown

If Toro operated the pits without cut-off banks it would be safe to assume that there would be effects seen from the dewatering drawdown. These may include re-zonation of samphires, loss of samphires and soil mobilisation, especially in times of drought.

If Toro operates the pits with cut-off banks there will still be drawdown effects but these will be greatly reduced compared to the alternative. There may be some re-zonation of samphires, especially onto the playa and perhaps some soil mobilisation at Lake Way project.

To monitor drawdown it is recommended to place nested piezometers in the drawdown area and outside the drawdown zone.

Revegetation

Post mining the samphire community will re-establish in the disturbed areas. They may not have the same zonation as pre-mining and may not establish where the pits have been backfilled with mine waste material as the soil chemistry and perhaps drainage will be different. Over time the groundwater level will stabilise in the area though may always be different to pre mine levels. When clearing the site soil from mine overburden, especially the top 20cm should be stored carefully in windrows of not more than 1m high to be used for revegetation.

Figure 3 - Samphire juveniles

7 Appendix

7.1 Species List

Tecticornia calyptrata
Tecticornia cymbiformis
Tecticornia doleiformis
Tecticornia halocnemoides subsp. *catenulata*
Tecticornia indica subsp. *bidens*
Tecticornia indica subsp. *leiostachya*
Tecticornia laevigata
Tecticornia moniliformis
Tecticornia peltata
Tecticornia pruinosa
Tecticornia pterygosperma subsp. *denticulata*
Tecticornia tenuis
Tecticornia undulata
Tecticornia sp. aff. *laevigata*
Tecticornia sp. aff. *pruinosa*
Tecticornia sp. aff. *undulata*
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)
Tecticornia sp. *halocnemoides* beaked seed aggregate
Tecticornia sp. Lake Way (P. Armstrong 05/961)
Tecticornia sp. nov.

It can be seen in the tables below (Table 1, Table 2 and Table 3) that the samphires found at Lake Way, Centipede and regionally fall into groupings or vegetation associations. The Lake Way and Centipede survey areas have some similarities in vegetation associations with *Tecticornia indica* subsp. *bidens*, *Tecticornia* sp aff *pruinosa* and *Tecticornia laevigata* common to both sites. *Tecticornia* sp. aff. *undulata*, *Tecticornia peltata* and *Tecticornia* sp (*halocnemoides* beaked seed aggregate) was also common at the Lake Way sites but not at the Centipede sites. In the latter *Tecticornia moniliformis* and *Tecticornia halocnemoides* subsp *catenulata* were common but not in the Lake Way sites. Somewhat similar associations to Lake Way sites were found at some of the regional surveys – GB1, LK3 and Reg2-8. The samphires found most commonly at Lake Way site and Centipede site are common elsewhere and also found at many of the regional sites. An exception to this is *Tecticornia* sp. Burnerbinmah.

Tecticornia sp. Lake Way was not found at any of the sites at Lake Way project area or Centipede. It was found at two sites further south of Centipede. No vegetation association was listed with *Tecticornia* sp. Lake Way.

Table 1 - *Tecticornia* spp per site Lake Way (Niche Environmental)

Species	LW19	LW21	LW23	LW24	LW25	LW27	LW33	LW35	LW37	LW39	LW41	LW70	LW71	LW18	LW2-1	LW2-3	LW2-4	LW17
Tecticornia indica subsp. Bidens	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Tecticornia sp aff pruinosa	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x
Tecticornia laevigata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Tecticornia sp. aff. undulata	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Tecticornia peltata	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		
Tecicornia sp (halocnemoides beaked seed aggregate)	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Tecticornia sp. Burnerbinmah	x			x	x	x	x			x		x		x				x
Tecticornia moniliformis						x												
Tecticornia halocnemoides subsp catenulata								x										
Tecticornia aff laevigata															x	x	x	x
Tecticornia pruinosa																		x
Tecticornia sp. aff. pruinosa														x				
Tecticornia calyptrata				x														
Tecticornia sp Lake Way																		
Tecticornia undulata																		
Tecticornia sp nov																		
Tecticornia cymbiformis																		
Tecticornia doleiformis										x								
Tecticornia indica subsp leiostachya																		x
Tecticornia sp Dennys Crossing								x										
Tecticornia count per Site	7	6	6	8	7	8	7	8	6	8	6	7	6	7	5	5	2	8

Table 2 - *Tecticornia* spp per site Centipede (Niche Environmental)

Species	Ce1	Ce2	Ce13	Ce14	Ce15	Ce16	Ce18	Ce25	Ce47	Ce51
Tecticornia indica subsp. Bidens	x	x	x	x	x	x	x	x	x	x
Tecticornia sp aff pruinosa	x	x	x	x	x	x	x	x	x	x
Tecticornia laevigata	x	x	x	x	x	x	x	x	x	x
Tecticornia sp. aff. undulata						x	x			
Tecticornia peltata						x				
Tecicornia sp (halocnemoides beaked seed aggregate)										
Tecticornia sp. Burnerbinmah	x					x		x	x	x
Tecticornia moniliformis	x	x	x	x	x	x	x	x	x	x
Tecticornia halocnemoides subsp catenulata	x	x	x	x	x	x	x	x	x	x
Tecticornia aff laevigata			x	x					x	
Tecticornia pruinosa										
Tecticornia sp. aff. pruinosa		x								
Tecticornia calyptrata										
Tecticornia sp Lake Way										
Tecticornia undulata										
Tecticornia sp nov										
Tecticornia cymbiformis										
Tecticornia doleiformis										
Tecticornia indica subsp leiostachya										
Tecticornia sp Dennys Crossing										
Tecticornia count per Site	6	6	6	6	5	8	6	6	7	6

Table 3 - *Tecticornia* spp per site Regional (Niche Environmental)

Species	Reg17	Reg26	Reg44	Reg45	Reg46	LM2	GB1	GB2	LK3	Reg2-7	Reg2-8
Tecticornia indica subsp. Bidens						x	x	x	x	x	
Tecticornia sp aff pruinosa						x	x		x		x
Tecticornia laevigata			x				x				x
Tecticornia sp. aff. undulata							x	x	x	x	x
Tecticornia peltata									x		
Tecicornia sp (halocnemoides beaked seed aggregate)											x
Tecticornia sp. Burnerbinmah											
Tecticornia moniliformis						x					
Tecticornia halocnemoides subsp catenulata											
Tecticornia aff laevigata	x										x
Tecticornia pruinosa							x	x	x		
Tecticornia sp. aff. pruinosa											x
Tecticornia calyptrata							x	x			
Tecticornia sp Lake Way				x	x						
Tecticornia undulata	x										
Tecticornia sp nov		x									
Tecticornia cymbiformis						x					
Tecticornia doleiformis											
Tecticornia indica subsp leiostachya											
Tecticornia sp Dennys Crossing											
20											
Tecticornia count per Site	2	1	1	1	1	4	6	4	5	2	6

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