INDEPENDENT REVIEW, WILUNA EXTENSION
PROPOSAL: ASSESSMENT OF POTENTIAL IMPACTS
ON SAMPHIRE VEGETATION COMMUNITIES

This report was prepared for:
Toro Energy Limited
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1 Executive Summary

Toro Energy Limited proposes to develop two satellite mine pits, a water supply borefield and a nominal 100km long access/haul road to extend uranium mining and processing activities approved under Ministerial Statement 913 and Commonwealth approval number EPBC 2009/5174.

The OEPA has recommended that Toro should engage an independent expert to review aspects of project documentation related to the assessment of project impacts on samphire vegetation.

Toro Energy invited the author (Bindy Datson/actis Environmental Services) to conduct an independent review and to provide advice on matters related to environmental studies and environmental management of samphires at the proposed Toro Extension at Lake Way and Lake Maitland.

Documents relating to the Toro Extension (see Heading 6, page9) were supplied by Toro and ecologia which were read and notes were taken on pertinent points. There have been a number of consultants’ reports over a number of years (from 2007 to 2015) describing vegetation in the project areas. This review concentrates on the samphire communities of the Millipede project and more importantly, the Lake Maitland project and does not include other terrestrial vegetation.

A two-day familiarisation visit to site at Lake Way and Lake Maitland was undertaken on the 17th and 18th of March.

- This independent review has generally concluded that: the PER characterisation of the extent and values of samphire communities potentially impacted by implementation of the Wiluna Extension is adequate; the studies either initiated by Toro or sourced by consultants for Toro are scientifically robust and probably represent the bulk of information publicly available on the subject of samphire ecology. The commitments made by Toro in its Environmental Management Plan to ongoing monitoring and to further Tecticornia survey and research are in accordance with current scientific knowledge and consistent with contemporary practice.
- The majority of samphire species found at Lake Way are common and found elsewhere.
- Although the relative impacts on samphire vegetation communities are greater at Lake Maitland, it is reasonable to expect to find all or most of the species present on the portion of Lake Maitland to be mined elsewhere in the chain of pans to the south. Having said this, it is also quite possible that these potentially ‘new’ species are unique to the Lake Maitland ‘chain’;
- There is little risk of significant loss of biodiversity or ecological function at either a local or regional scale at Centipede/Millipede; There is a potential risk of loss of biodiversity or ecological function at a local scale at Lake Maitland as there are several samphire species potentially affected that have uncertain identity and that appear to live in associations. There is potential for these species to be limited to Lake Maitland because of speciation due to isolation.

The review also provides comment on questions relating to methods for predicting distribution of Tecticornia species and discusses the potential for impacts on samphire vegetation from hydrological changes that could arise as a result of implementing the proposed Wiluna Extension Project.
2 Introduction

2.1 Client details

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2.2 Project Background

Toro Energy Limited proposes to develop two satellite mine pits, a water supply borefield and a nominal 100km long access/haul road to extend uranium mining and processing activities approved under Ministerial Statement 913 and Commonwealth approval number EPBC 2009/5174.

The Wiluna Extension Proposal was referred to the EPA in February 2014. A scoping document prepared for the proposal by the Office of the EPA was approved in February 2015. Toro energy conducted investigations in accordance with the scoping document and prepared an environmental review document (PER), which was exhibited publicly from 16 November 2015 to 8 February 2016.

On March 10 2016 the Office of the EPA finished compiling submissions received on the Wiluna Extension PER and forwarded the comments to Toro Energy.

In addition to providing Toro with a compilation of public and regulator comments, the OEPA has recommended that Toro should engage an independent expert to review aspects of project documentation related to the assessment of project impacts on samphire vegetation.

Toro Energy invited the author (Bindy Datson/actis Environmental Services) to conduct an independent review and to provide advice on matters related to:
- The environmental studies carried out to characterise samphire vegetation in the project area, and
- The management measures proposed by Toro to avoid, minimise and rehabilitate impacts to samphire vegetation in the project area.
3 Scope and Objectives of Review

Scope of work
This independent review relates to botanical investigations and impact assessment for activities proposed by Toro in connection with the Wiluna Uranium Extension Proposal. The particular questions on which Toro sought the author’s opinion were:

1. Has the Wiluna Extension PER adequately characterised the extent and values of samphire communities potentially impacted by implementation of the Wiluna Extension proposal?
2. Has the Wiluna Extension PER provided a scientifically robust estimation of potential impacts on samphire vegetation?
3. Are the measures proposed by Toro to avoid, mitigate, monitor and rehabilitate impacts on samphire communities appropriate, based on current scientific knowledge and consistent with contemporary practice?
4. What is the most appropriate way to estimate the likely distribution of species for which there are only a small number of reliable specimens? Are there surrogate measures (for example, ground elevation or soil type) that would serve as robust predictors of where particular species might or might not occur?
5. What is the evidence (if any) for impacts on samphire vegetation as a result of changes in depth to groundwater at Lake Way or Lake Maitland? Under natural conditions, is there evidence of seasonal impacts on vegetation health, distribution, recruitment or persistence? Would similar impacts apply as a result of water abstraction arising as a result of mining activities over a period of years?
6. What is the evidence (if any) for impacts on samphire vegetation as a result of surface water inundation at Lake Way or Lake Maitland? Is there a relationship between, for example, ground elevation or contributing catchment area and samphire zonation?
7. Are Tecticornia in the project area restricted through the Lake Way and Lake Maitland playas? How likely is it that the Tecticornia species recorded to date are restricted to the project’s development envelope or disturbance footprint? Are there any features of the development envelopes that are unique to Lake Way or Lake Maitland? Or are the environmental conditions found in the development envelopes also present outside the development envelopes?
8. Given the environmental factors that affect samphire distribution and health the author is invited to comment on the application of the precautionary principle and the principal of conservation of biological diversity and ecological integrity to the assessment of potential project impacts on samphire vegetation. Do the activities proposed represent a material risk of significant loss of biodiversity or ecological function at a local or regional scale?
4 Methods

Toro Energy invited the author (Bindy Datson/actis Environmental Services) to conduct an independent review and to provide advice on matters related to environmental studies and environmental management of samphires at the proposed Toro Extension at Lake Way and Lake Maitland.

Documents relating to the Toro Extension (see Heading 6, page9) were supplied by Toro and ecologia which were read and notes were taken on pertinent points.

A two-day familiarisation visit to site was undertaken on the 17th and 18th of March. The following areas were inspected:

- proposed Millipede mining operations area at Lake Way
- proposed mining operations areas at Centipede and Lake Way (approved under Ministerial Statement 913)
- proposed mining operations area and borefield at Lake Millipede
- Toro exploration rehabilitation areas at Lake Way and Lake Maitland

Photographs (from page 37) were taken of samphires in the rehabilitation sites and the proposed mine footprint, including some individuals of Priority3 *Tecticornia cymbiformis* at Lake Maitland of which there was some identification confusion.

On Friday 1st April a meeting was held at Toro’s offices with Lisa Chandler (representing Toro Energy) and Shaun Grein and Melissa Hay from ecologia Environment to discuss initial findings of the independent review.
5 Statement of Reviewer’s Qualifications and Experience

My passion is natural salt lakes, especially the halophilic and halotolerant flora and fauna. I emphasise natural salt lakes as in Western Australia there are many lakes that have become saline as a result of land clearing. I became interested in the members of the Salicornieae tribe of the Chenopodiaceae because these plants have many species in Western Australia, some of which have been recently discovered and not yet named. When I began researching these plants (commonly known as Samphires) in 1998 I discovered that other than the 1980 ‘A revision of the Australian species of Salicorniaceae’ by Paul Wilson of the WA Herbarium there was very little information available. I began drawing the specimens I was collecting and writing notes about them, including soil sample data from beneath the plants.

The resulting information became a monograph published by the Western Australian Department of Conservation in 2002.

Since 1997 I have been working as a private consultant with my husband Mark Coleman specialising almost exclusively in Salt Lake research and monitoring (actis Environmental Services). This work has mostly been in the Goldfields region of Western Australia on various lake systems. We have done some work for the Western Australian Department of Conservation on saline lakes in the Wheatbelt region but found this work to be less satisfying as the lakes are all degraded or compromised.

In recent years my interests have expanded to include the aquatic invertebrates found in the Goldfields lake systems, especially the crustaceans. Many of the lakes we are asked to evaluate have had no previous research and it is common for us to find undescribed species of Brine Shrimp and sometimes Samphires.

Publications:

‘Understanding Species Zonation of Samphires (Salicorniaceae) in the Goldfields of Western Australia’ B. Datson, actis Environmental Services Website, October 2002 (Revised 2007)


‘Lake Carey: A 10 Year Overview, Final Report October 2013, Prepared for the Lake Carey Catchment Management Group (LCCMG)’
6 Summary of Information Considered

A number of documents were made available for this review. They included:

- Tecticornia Survey, Ecologia 2015
- Modelling Analysis of the Impact of Mine Dewatering on Soil Water Availability to the Samphire Vegetation on the Fringe of Fortescue Marsh
- Fortescue Marsh: Synthesis of eco-hydrological knowledge-Final Report (Updated 2013)
- Vegetation Health Monitoring and Management Plan – Cloudbreak Life of Mine Expansion Project
- Drought tolerances of three stem-succulent halophyte species of an inland semiarid salt lake system Victoria A. Marchesini, Chuanhua Yin, Timothy D. Colmer and Erik J. Veneklaas
- Executive Summary (from RPS, 2011: Lake Maitland Uranium Project – Water Supply Investigation)
- Soil seed banks of fringing salt lake vegetation in arid Western Australia – density, composition and implications for post mine restoration using topsoil, Etten et al
- Identification of Tecticornia voucher specimens for Toro Energy Ltd, Dr Kelly A. Shepherd

These documents were read and notes taken of portions thought relevant to the concerns of the OEPA. Some of these notes are in the Appendix of this report.
7 Results of Review

There have been a number of consultants’ reports over a number of years (from 2007 to 2015) describing vegetation in the project areas. This review concentrates on the samphire communities of the Millipede project and more importantly, the Lake Maitland project and does not include other terrestrial vegetation.

The reasons for describing Lake Maitland samphire communities as warranting more attention than the Millipede communities are:

- that the Millipede project is an addition to the Centipede project which has already received Ministerial approval subject to the commitments outlined in Toro’s PER and conditions imposed under Ministerial Statement 913 and there is no reason to expect that Millipede should have unique impacts associated with it.
- Millipede and Centipede Projects are situated beside the comparatively large Lake Way and as such will have little impact on the Lake and its processes whereas the proposed Lake Maitland project encompasses a comparatively large part of the much smaller Lake Maitland.
- During various surveys of Lake Maitland samphire communities several species were found to be sufficiently ‘different’ to warrant further investigation.

The following section addresses questions that have been asked regarding the adequacy of studies conducted at Millipede and Lake Maitland.

7.1 Samphire Community Characterisation

Has the Wiluna Extension PER adequately characterised the extent and values of samphire communities potentially impacted by implementation of the Wiluna Extension proposal?

There have been a number of field studies undertaken at Lake Way and Lake Maitland between 2007 and 2015, that have contributed to the information provided in the Wiluna Extension PER. These have been conducted by several different consultant ecologists with varying degrees of experience in identifying samphires in the field. The earlier samphire field studies were undertaken as part of an overall ‘baseline’ study and as such focus was shared between different disciplines.

Later studies focussed on the samphire communities to be directly and indirectly impacted by mining activities. Transects were installed at various locations around Lake Way and Lake Maitland and samphire species identified where possible. Species that could not be identified readily were sent to the WA Herbarium to be identified by the resident samphire specialist, Dr Kelly Shepherd. Dr Shepherd identified several Tecticornia species that were similar to known species but sufficiently different to warrant further investigation.

Existing historical vegetation community descriptions by Beard J.S. et al. are not sufficiently detailed for describing samphire communities, consequently each samphire community was described (ecologia 2015) and given a number value. These descriptions and resulting maps are detailed and appear to be comprehensive.

It was noted in an earlier draft of ecologia’s Cumulative Impact Assessment that the map ‘Tecticornia units at Lake Maitland’ omitted Unit T5, T. cymbiformis, from the central part of the lake – see ‘Priority Flora at and in the vicinity of the project area’ map. ecologia stated in the ‘Cumulative Impact Assessment’:

“Tecticornia cymbiformis (Priority 3) ……At the project area it has been recorded at one confirmed location as the dominant component of the fringing vegetation at a small salt pan approximately 7 km to the north-west of Lake Maitland. This is not within the direct or indirect impact areas. It should be noted that approximately 60 unvoucheded individuals were recorded by ecologia within the direct impact area.
at Lake Maitland and the haul road but are not included as they were not confirmed by the Western Australian Herbarium.”

During the author’s site visit in March 2016 several *T. cymbiformis* GPS locations previously surveyed by *ecologia* Environment were visited and the plants’ identities confirmed (see Figure 9 and Table 1). This being the case, the map ‘Tecticornia units at Lake Maitland’ has now been revised to include these Priority3 species and the map ‘Priority Flora at and in the vicinity of the project area’ can be assumed to be correct, though only a few sites were ground-truthed.

The author considers that the characterisation of the extent and values of samphire communities potentially impacted by implementation of the Wiluna Extension to be adequate.

### 7.2 Samphire Vegetation Impacts

**Has the Wiluna Extension PER provided a scientifically robust estimation of potential impacts on samphire vegetation?**

There are potentially two types of impact on samphire vegetation in the project areas. The first and larger impact will be the removal of vegetation for the pit and mine infrastructure. This is a given and is covered in the next Heading 7.3, page 12.

The second potential impact on samphire vegetation in the project areas is pit or borefield dewatering drawdown. There have been several reports both for Toro and for Fortescue Metal’s Cloudbreak Mine which has some physical and vegetative similarities to the Wiluna Extension project.

#### 7.2.1 Samphire Drought Tolerance and Groundwater Dependency

*Ecologia’s* ‘Extension to the Wiluna Uranium Project Response to EPA Submissions’ sums up the key points from Toro’s, Fortescue’s and others’ studies regarding Tecticornia groundwater dependency adequately by saying:

- Tecticornia species are not directly dependent on groundwater but rather utilise the vadose zone between groundwater and the surface.
- The morphology of the species indicates some drought tolerance, but it is not known if all species have the same drought tolerance, as different species inhabit different zones in the vertical landscape.
- Tecticornia species are likely to tolerate 0.5m groundwater fluctuations as natural variation in groundwater depth in the Wiluna area is at least 0.5m.
- The independent reviewer for subterranean fauna studies (Stuart Halse, Bennelongia) has noted that “depths of groundwater recorded during stygofauna sampling and shows some large variations were observed during stygofauna sampling, with water levels in August 2010 often being quite low after a moderately prolonged drought (e.g. 0.9 m lower than the highest groundwater level at bore NLW22). Most changes were much smaller ...However, overall it appears that the Millipede (and probably the Lake Maitland) area experiences natural variations in baseline water levels of more than 0.5 m.”

The author agrees with these key points and finds them entirely reasonable.
7.2.2 Samphire tolerance to dewatering drawdown effects

The Office of the EPA has asked Toro to consider the relevance for Toro’s proposed activities at Lake Way and Lake Maitland of observations recorded at existing mining areas at Lake Carey, as both of the mining operations areas included in the Wiluna Extension Proposal lie within the Carey palaeochannel.

*actis* has for some time been involved in monitoring of samphire vegetation systems at Lake Carey and has documented the results of that work in a report to the Lake Carey Catchment Management Group (2013). The OEPA provided a copy of the Lake Carey Year 10 Review Report to Toro.

The conditions at Lake Carey do not necessarily match those at Lake Way - the dewatering bores for the Wallaby Mine at Lake Carey were dewatering a major bifurcation of the Carey Palaeochannel as the resource is deep. Effects from the Wallaby dewatering were seen 5km (‘upstream’) from the dewatering bores. Plants died when moisture disappeared from the vadose zone (between groundwater and the soil surface) and soil mobilisation occurred after plants died; plants that were covered in mobilised sediments were those that grew back after rain, in a different zone from the original pre-dewatering vegetation. Soil mobilisation occurred as dry playa sediments deflated and plants which would normally stabilise dune material died.

Lake Maitland is a surface expression of the Carey Palaeochannel and it follows that if deep dewatering bores accessed the deep palaeo sediments a similar problem could arise. This however, is not the case at Lake Way and Lake Maitland where the resources are shallow and dewatering will be from sumps, not dewatering bores. The borefield at Lake Maitland is sufficiently far away from the Lake to not have any influence on the Lake vegetation.

In the ‘Rev9 Toro Wiluna Extension Cumulative Impact Assessment’ the map ‘Tecticornia dominated vegetation at Lake Maitland’ shows the projected 0.5m groundwater drawdown to extend over the entire project area, including the proposed reinjection area to the south of the project. If reinjection of groundwater was necessary and was successful it would follow that the drawdown effect would be less in that local area.

In the Toro PER under ‘Closure and Rehabilitation’ it is stated that mining at Lake Maitland would be undertaken progressively with voids being backfilled with overburden as they were used. If this is the case that the pit dewatering is localised and mobile it could be assumed that conditions would be similar to the natural groundwater fluctuations that samphires can tolerate. Toro has advised that dewatering of active mining panels will be achieved by pumping from sumps. Completed panels will be backfilled as soon as practicable and will not be actively dewatered, except to the extent required to prevent inflow to neighbouring active panels.

The studies either initiated by Toro or sourced by consultants for Toro are scientifically robust and probably represent the bulk of information publically available on the subject of samphire ecology.

7.3 Avoid, Mitigate, Monitor impacts on Samphires

Are the measures proposed by Toro to avoid, mitigate, monitor and rehabilitate impacts on samphire communities appropriate, based on current scientific knowledge and consistent with contemporary practice?

The Toro Energy Public Environmental Review (PER) and Toro Energy Environmental Management Plan (EMP) were consulted for the above.

As stated in Toro’s PER, Closure and Rehabilitation: “Most of the land on which mining would occur at Millipede and Lake Maitland has native vegetation except for minor areas of existing disturbance associated with roads and access tracks and some cleared areas from previous mining trials”.
It is also stated that “Closure and rehabilitation at both Millipede and Lake Maitland would be carried out progressively, in the manner of a strip mining operation, with voids created by mining being backfilled using residue and overburden from active mine pits. This would be in addition to any operational footprint associated with the already approved activities at Centipede and Lake Way”.

In the Toro PER Executive Summary it is stated: “Management Measures - Implementation of Mine Closure and Rehabilitation Plan incorporating design features and management measures for the safe and effective operation of the mine and TSF, the progressive rehabilitation of mine pits and closure of uranium mining and processing facilities (whether planned or unplanned). Conducting further research expanding knowledge on Tecticornia”.

“Outcome - Implementation of the Mine Closure and Rehabilitation Plan would ensure the land is returned as close as practicable to its pre-mining use”.

“Offset Commitments
As an already agreed offset, Toro would implement a Survey and Research Plan to further the knowledge of Tecticornia species. The outcomes of the research would be applied to conservation of Tecticornia and rehabilitation of any Tecticornia vegetation communities disturbed by implementation of this Proposal”.

Toro EMP states that: “Prior to the commencement of operations, a series of monitoring sites would be established. These sites would be permanent and established in close proximity to areas to be disturbed and analogue sites located in areas that would not be impacted. The aim of the sites would be to allow for comparisons between communities inside and outside the impact area and to be able to account for regional impacts, such as drought.

As areas are rehabilitated, quadrats would also be established to enable the success of the rehabilitation to be measured. These quadrats would be permanent and monitored at least annually to assess whether a functioning ecosystem is returning.”

The Toro EMP commits to baseline, annual and rehabilitation monitoring of vegetation using permanent quadrats and photographic records. This should be carried out by botanists/ecologists competent in the identification of samphires. Toro also commits to a Tecticornia Survey and Research Plan by specialists from DPaw and others, to be implemented prior to the commencement of operations to further identify local Tecticornia species and methods of rehabilitation and restoration post mining. This is in accordance with current scientific knowledge and consistent with contemporary practice.

7.4 Distribution Estimation and Predictors

What is the most appropriate way to estimate the likely distribution of species for which there are only a small number of reliable specimens? Are there surrogate measures (for example, ground elevation or soil type) that would serve as robust predictors of where particular species might or might not occur?

Samphires typically grow in zones away from a wetland, often sharply delineated where elevation changes rapidly (see Figure 2, page 35) In some cases, such as with Tecticornia cymbiformis, one would not look on the lowest part of the playa for that species but on an area somewhat elevated from the lowest portion. The majority of the (several) species found at Lake Maitland however, are growing mixed together on the vegetated Lake playa with little predictable zoning. There is some zonation of vegetation units or associations as can be seen in the map ‘Vegetation units at Lake Maitland, Maps 1 and 2’ in Rev 5 1625 Toro Tecticornia memo.

It has been found that often species grow in association with certain others and if you see some there is a fair chance there will be the others in that group also. This is probably the case at Lake Maitland where if
for instance Tecticornia sp. Sunshine Lake was to be targeted one would look for \textit{T. peltata}, \textit{T. sp. aff globulifera} (small) and \textit{T. sp. aff undulata} (broad articles) which were found together in the complex named T2. An ecologist familiar with samphires would know that \textit{T. peltata} is commonly found in the lower zone and in hypersaline conditions so would search for \textit{T. Sunshine Lake} there and look for the associated species.

The answers to the above questions are mixed. \textbf{The most appropriate way to estimate likely distribution of species for which there are only a small number of reliable specimens is to establish the exact location where the originals were found and the species they were associated with then search similar locations, looking for the associated species.} This would be difficult to do in a desk top study – it would be guess work at best.

As mentioned above in the case of \textit{T. cymbiformis} it could be assumed that this species might be found around the Lake at the same elevation as the specimens already identified but this would not be a robust predictor and again just an educated guess. A map showing elevations and soil types would need to be very precise – most contour maps would be too coarse to show the small elevations relating to zonation changes and soil mapping again would be too broad. At best contour maps would give an indication of where to begin looking for a particular species (if their habitat was known). \textbf{There are no surrogate measures to serve as robust predictors} especially if these measures were intended as an alternative to field work – as an aid to field work they could be useful.

It is recommended that the same ecologists who have already become familiar with the samphires at Lake Maitland (and Lake Way) be used to do further studies at Lake Maitland as they will ‘have their eye in’ and be able to find the target species more quickly than a botanist or ecologist unfamiliar with samphires.

\textbf{7.5 Groundwater Impacts on Samphires}

\textbf{What is the evidence (if any) for impacts on samphire vegetation as a result of changes in depth to groundwater at Lake Way or Lake Maitland? Under natural conditions, is there evidence of seasonal impacts on vegetation health, distribution, recruitment or persistence? Would similar impacts apply as a result of water abstraction arising as a result of mining activities over a period of years?}

Multiple studies were undertaken at the Fortescue Marsh (a similar habitat to Lake Way/Lake Maitland) which indicate that the water balance dynamics of the marsh are principally controlled by surface water inflows from the greater marsh catchment, as dictated by episodic flooding events. The flood events replenish a shallow aquifer system in the Tertiary sediments beneath the marsh, which is gradually depleted by direct surface evaporation and evapotranspiration by the fringing vegetation communities. In periods of prolonged drought, the shallow watertable reaches a pseudo-steady state set by the evaporation extinction depth in the lowest parts of the marsh basin. The fringing vegetation is dominated by samphire communities which exhibit zonal species distribution patterns influenced by soil water and salinity dynamics, depth to watertables and flooding frequency’.\footnote{Fortescue Marsh: Synthesis of Eco-Hydrological Knowledge 2013}

The overall findings of these studies suggest that groundwater drawdown of up to 3 m would not introduce any significant adverse impact on the samphire communities near the northern fringes of the Fortescue Marsh. Surface water inputs (i.e. rainfall and flood waters) are likely to maintain soil moisture levels sufficient to meet samphire water use requirements under all but extreme climate regimes.

These findings relate to Fortescue Marsh, not Lake Way and Lake Maitland even though there are similarities. ‘Natural variation in the depth to groundwater in the Wiluna area is in the order of 0.5m over the annual cycle. Even if \textit{Tecticornia} species did exhibit a level of occasional groundwater reliance,
plants of this genera are likely to be tolerant of natural groundwater fluctuations of at least 0.5m at Lake Way and Lake Maitland and up to 2m at Fortescue Marsh.²

As can be seen in the paper ‘Drought tolerances of three stem-succulent halophyte species of an inland semi-arid salt lake system’, by V. Marchesini et al, samphires are well designed for drought tolerance with succulent articles (leaves) and woody roots. They are arid zone plants which are able to withstand heat, cold, drought and often hypersaline conditions and are able to quickly recover once rain arrives by growing fine white adventitious roots and initiating rapid shoot growth (B Datson obs).

After monitoring samphires at Lake Carey for 13 years, cyclical changes were observed over time. There were few deaths of mature plants during drought though these plants were reduced to a few desiccated articles (leaves) and woody stems. After rain these mature plants recovered rapidly and produced new articles and flowers. After large rain events there was mass germination of samphires, especially on the Lake Playa – the majority of which died over time as the area dried out again. The same mature plants were observed during the 13 years of monitoring, with few changes other than dry articles during drought and swollen articles and flowers during wet times.

As has been mentioned previously, the Wallaby Mine dewatering caused a change in the shoreline vegetation up to 5km from the Mine. The samphire community changed with species in the dunes disappearing and zonation changing with all species now represented on the Lake playa. Samphires in the dunes were replaced with Atriplex and Frankenia species. This is an extreme example of dewatering impact and it is not expected that this will happen at Lake Maitland for the reasons explained previously in Heading 7.2.

Both the Millipede/Centipede and the Maitland mines will overlie parts of the Carey palaeochannel. However, both mining and dewatering will be from the superficial aquifer and will not penetrate the clayey aquitard overlying the palaeochannel sands. Dewatering of the permeable palaeochannel sands and gravels is not proposed. The Lake Maitland borefield also does not draw on the palaeochannel sands.

### 7.6 Inundation and Zonation of Samphires

What is the evidence (if any) for impacts on samphire vegetation as a result of surface water inundation at Lake Way or Lake Maitland? Is there a relationship between, for example, ground elevation or contributing catchment area and samphire zonation?

**Lake Way**

Lake Way is a large playa lake which periodically floods after heavy rain resulting from the breakdown of cyclones. There will be no detrimental effect from Lake Way surface water inundation on the samphires at Centipede/Millipede as they are at an elevation away from the Lake. There could be germination of samphire species at the edge of the lake resulting from the influx of fresh water and germination of samphires in the project area also.

**Lake Maitland**

Under normal circumstances surface water inundation at Lake Maitland would be the trigger for plant growth and recruitment. With the onset of the mine/s and some restriction of water flow through the lake, some water may pond and perhaps overtop remnant vegetation. It has been observed at Lake Carey that samphires will tolerate partial inundation for a period of about one month if the water is relatively fresh - <50g/L. It is unlikely that water will remain ponded for more than a month at Lake Maitland unless there is an extreme rain event.

As can be seen in the diagram in Figure 2 page 35, there is a definite relationship between ground elevation and samphire zonation.

² Extension to the Wiluna Uranium Project Response to EPA Submissions – Tecticornia Groundwater Dependency - ecologia
7.7 Samphire Environmental Restrictions

Are Tecticornia in the project area restricted through the Lake Way and Lake Maitland playas? How likely is it that the Tecticornia species recorded to date are restricted to the project’s development envelope or disturbance footprint? Are there any features of the development envelopes that are unique to Lake Way or Lake Maitland? Or are the environmental conditions found in the development envelopes also present outside the development envelopes?

Lake Way and Lake Maitland are quite different with one being a large bare playa Lake (with numerous islands) and the other a much smaller lake with a largely vegetated playa.

Lake Way

Because Lake Way is so large and the project area comparatively small there is reason to believe that species found in the Centipede/Millipede area will be found elsewhere at Lake Way. It is noted that the vegetation transect locations match the occurrence of novel, potentially novel and Priority species – one would assume that these plants would also occur in the large distances between transects and elsewhere in suitable habitats around the Lake. The majority of samphire species found at Lake Way are common and found elsewhere.

There is a possibility (small) that the novel and potentially novel species are present because the conditions that allowed uranium to collect in the area also are conducive to these species, however that is conjecture at best with no science to back it up. The species present at the Lake Way deposit at the northern end of the Lake are also growing on uranium rich ground and are different species to the ones present at Centipede and Millipede. There is a small possibility that there is an association between samphire species and mineralisation – perhaps that is an opportunity for a future study?

Lake Way is quite similar to Lake Carey (‘downstream’ in the Carey Palaeochannel) and with a very few exceptions most species at Lake Carey are spread around the Lake in various associations and densities. The exceptions are sometimes in wetland pans away from the Lake and in one case the species is hidden between some islands. It would follow that given the similarities between the two lakes, species distribution would also be similar.

As it was not possible to view much of Lake Way during the site visit the above is only an educated guess.

Lake Maitland

This is a much smaller Lake with only a small portion of bare playa compared to the size of the Lake; most of the Lake playa is vegetated. As with Lake Way the novel and potentially novel species occurrence exactly matches the transects. It could safely be assumed that with the playa being largely vegetated, species occurring in the transects also occur on the rest of the Lake – and in fact this homogenous mix of species was noted during the site visit.

It appears (from the map ‘Priority Flora at and in the vicinity of the project areas’) that the search for the priority species *T. cymbiformis* and *Tecticornia* Sunshine Lake was not restricted to transects; apparently the searching focussed on known habitats and was exhaustively carried out.

Because wetlands and lakes in this arid landscape have been physically isolated from each other for such a length of time it is common to find ‘new’ species of both flora and aquatic fauna in them. As stated in Dr Shepherd’s report samphires are closely related to each other and speciated a comparatively short time ago (and appear to hybridise readily).

Lake Maitland is not wide (under 10km) but extends southwards as a series of pans for up to 60km. It is entirely reasonable to expect to find all or most of the species present on the portion of Lake Maitland to
be mined elsewhere in the chain of pans to the south. Having said this, it is also quite possible that these potentially ‘new’ species are unique to the Lake Maitland ‘chain’.

The portion of Lake Maitland out of the influence of mining would be the obvious place to conduct further studies to ascertain the extent of the uncertain species.

There is no evidence to indicate that conditions within the proposed development envelopes within Lake Way (on one hand) or Lake Maitland (on the other) do not also occur on other parts of the respective playa lakes. The impact area at Lake Maitland represents a larger proportion of the existing samphire cover than the impact footprint affecting samphire units at Lake Way.

7.8 Loss of Biodiversity or Ecological Function

Given the environmental factors that affect samphire distribution and health the author is invited to comment on the application of the precautionary principle and the principal of conservation of biological diversity and ecological integrity to the assessment of potential project impacts on samphire vegetation. Do the activities proposed represent a material risk of significant loss of biodiversity or ecological function at a local or regional scale?

As stated previously Lake Way and Lake Maitland are quite different with one being a large bare playa Lake (with numerous islands) and the other a much smaller lake with a largely vegetated playa.

Lake Way

As described in the previous Heading 7.2, Lake Way is a large playa lake and Toro’s project area is comparatively small. If construction of roads, infrastructure and excavation of pits is carried out without excessive encroachment onto remnant vegetation and rehabilitation of areas affected in the construction of same is carried out in a timely and effective fashion there is reason to believe that the samphire vegetation will begin to grow again in these areas, especially once there has been high rainfall after rehabilitation. Toro has committed to leaving the landform as close as possible and practicable to the original pre-mining form at mine closure. This being the case, there is reason to believe that the biological diversity and ecological integrity of this area will eventually return to a state similar to the original.

There is little risk of significant loss of biodiversity or ecological function at either a local or regional scale at Centipede/Millipede.

Lake Maitland

There is no doubt that mining activities will have an effect on Lake Maitland – the vegetated playa will be scalped above the proposed pits, Lake sediments disturbed/removed and potentially some of the Priority species of T. cymbiformis will be damaged or destroyed. Other disturbances will come from the construction of roads and infrastructure such as accommodation and flood protection works.

If, as for the Millipede/Centipede project construction of roads and infrastructure is carried out without excessive encroachment onto remnant vegetation (avoiding known individuals of T. cymbiformis) and rehabilitation of areas affected in the construction of same is carried out in a timely and effective fashion, samphires in these areas should recolonise over time, especially after rain. This recolonization can be slow as was seen in the rehabilitation sites visited, but will happen eventually (see Figure 12 and Figure 13, page 43).

The pits on the lake bed require removal of portions of the samphire community containing many of the potentially novel samphire species. It would be unrealistic to expect that only the targeted high uranium yield areas would be directly impacted, with machinery entering and exiting carrying loads of overburden sediments to be stored on pads. This will probably result in the disturbance of a larger proportion of the Lake bed in the disturbance footprint than just the pit shell. Toro has committed to
leaving the landform as close as possible and practicable to the original pre-mining form. This will comprise progressive infilling of the pits and land-forming as the resource is removed.

It should be possible to store the material taken from the surface of the Lake – both vegetation and surface sediments – in a separate heap from the underlying sediments. The surface layer of the sediments (about 2cm deep) will contain the resting eggs/cysts of the Lake’s aquatic invertebrates (Fairy Shrimp, Brine Shrimp, Clam Shrimp and Ostracods, among others) and the vegetation will have seeds for rehabilitation. The underlying sediments are largely sterile and should only be used as fill. After pit infilling and land-forming, the surface sediments and vegetative matter should be spread evenly over the surface. Toro’s proposed mining technique (using a surface miner) is very selective and would lend itself to a shallow soil salvage operation.

Post-mining Lake Maitland will not be the same as pre-mining but could be similar in function if care is taken to preserve the surface sediments and vegetative material (samphires).

Careful progressive infilling of pits to resemble the pre-mining playa and spreading of surface sediments and samphire material on the surface should provide the conditions conducive to rehabilitation of both samphires and aquatic invertebrates (not my brief but still important). This will be accelerated after large rain events.

Dr Kelly Shepherd made this comment:
“It is evident that different species of Tecticornia cannot be accurately and consistently identified in the field and that voucher specimens should be collected for all data points. It should also be noted that voucher specimens need to be collected at the appropriate times, as fertile specimens with mature fruits and seeds are required for identification and sterile specimens cannot be accurately identified in most cases”.

There is a potential risk of loss of biodiversity or ecological function at a local scale at Lake Maitland as there are several samphire species potentially affected that have uncertain identity and that appear to live in associations. There is potential for these species to be limited to Lake Maitland because of speciation due to isolation.
Figure 1 – Diagram of Goldfields Palaeodrainage System
8 Appendix

8.1 Selected Notes from Reports

8.1.1 Identification of Tecticornia voucher specimens
for Toro Energy Ltd, Dr Kelly A. Shepherd

The purpose of this project was to confirm identifications of Tecticornia specimens collected from the Lake Way region in 2014–15 by Ecologia/Engenium on behalf of Toro Energy Limited. A total of 254 specimens was examined and identified.

Conservation status
Two taxa with a Priority 3 conservation status were confirmed (T. cymbiformis and Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)); however, it should also be noted that the unknown entity Tecticornia sp. aff globulifera (small) has some similarity to the Priority 1 species Tecticornia globulifera recently described in 2011 from the Pilbara region. Furthermore, there is some further variation evident within Tecticornia sp. aff globulifera (small), as specimens attributed to this entity were included by Engenium under two different tag names (Tecticornia halocnemoides s.l. sp. D and Tecticornia halocnemoides s.l. sp. A) and I note some of the specimens in the latter group possibly have larger seeds.

Background
Samphires are among the most salt tolerant land plants known and are considered a ‘key-stone’ group as they usually comprise the dominant vegetation in habitats along coastlines, estuaries and inland salt lakes. Until recently the Australian samphires represented six genera; however, molecular and morphological data now support the recognition of only two genera in Australia namely Sarcocornia and an expanded Tecticornia which includes the former genera Halosarcia, Pachycornia, Sclerostegia and Tegicornia (Shepherd et al. 2004; Shepherd & Wilson 2007).

These plants have a highly modified and reduced morphology with no true leaves but succulent articles. They also have tiny flowers comprising a single anther and ovary. They are considered to be one of the most taxonomically challenging groups in Australia for the following reasons.

1. Morphologically cryptic and variable.
The characteristic reduced morphology typical of samphires limits the availability of diagnostic characters that are easy to see with the naked eye. Because of this reduced morphology many species appear superficially similar (evidenced by the same field tag-name being applied to multiple species in Table 3). Fruits and seeds in particular are useful for delimiting taxa but they are so small (the majority of seeds are < 1.5 mm long) it is difficult to observe critical differences without a microscope.

Their succulent form can also radically change when dried, so field knowledge is often lost when looking at herbarium specimens. Moreover, plants exhibit morphological plasticity, whereby young seedlings or new seasonal growth can appear quite different in size and colour to adult plants or older branches.

Therefore, specimens collected from different parts of the same plant, and from the same taxon growing in different parts of the same marsh, can appear quite different. This is one of the factors that contributes to the difficulty in gaining a sound understanding of what constitutes ‘typical’ morphology for any given taxon.

2. Biologically complicated
Molecular evidence suggests the genus Tecticornia likely underwent a recent and rapid radiation in Australia and species are genetically closely related (Shepherd et al. 2004). It is hypothesised (and is somewhat confirmed by chromosome data) that this relatedness ensures that many taxa may readily
hybridise when they co-occur. Thus at times it is difficult to determine what comprises a taxon, as opposed to variation that may be due to the presence of hybrids and intergrades.

A chromosome study of Australian samphires (Shepherd & Yan 2003) revealed that many species are polyploids, in that they have multiple sets of chromosomes. Moreover, the ploidy level may vary even within a single species as specimens of Tecticornia indica subsp. bidens were found to be diploid, triploid or tetraploid (i.e. have 18, 27 or 36 chromosomes). It is unclear if ploidy variation within a taxon has a corresponding impact on morphology. For example, do plants with larger numbers of chromosomes have larger seeds (as reported in other plant groups)? Or does the variation in seed size etc. in any given group represent taxonomically meaningful differences?

3. Taxonomic knowledge is not complete
Even though samphires dominate saline landscapes detailed information about their basic biology is lacking and a significant number of potentially new taxa require resolution. There are a number of potentially new phrase-named taxa currently listed on the WA Census (as seen on FloraBase) but little information is available to the general public about these taxa or what features delineate them or how to identify them. Moreover, there are considerably more potential entities that do not match the type specimens of known species and are considered to be new; most of these have not been taxonomically assessed in any detail.

All of these unknowns represent significant challenges to both stakeholders and land managers as little information can be determined about the distribution or conservation status of many taxa.

Summary
It is clear from the identifications provided by Engenium that in many instances species of Tecticornia were correctly identified in the laboratory. This generally occurred when a species was taxonomically well delineated, there is good descriptive information available and the taxon does not include significant morphological variation. This clearly supports the fact that if there are good (fertile) collections and a sound taxonomic framework available, skilled identification botanists can identify species of Tecticornia with a good degree of accuracy.

However, in taxonomically problematic groups, particularly where there are potentially new entities (e.g. phrase-named species) or groups that are variable and have not been adequately assessed and quantified (i.e. include multiple potential new taxa, as seen in the T. halocnemoides and T. undulata groups), multiple entities have been included under the same identification.

It is also clear that there may be more taxa than expected in these saline habitats as there were some sterile specimens present. While some of these specimens may simply represent non-flowering material of taxa already sampled, there were a few specimens included under the T. halocnemoides group that had a distinctively different epidermis. As none of these were fertile at the time of collection when all other species had flowers and or seeds, this entity may flower at a different time of the year and may well be new. Moreover, the less well-defined groups that have not been investigated in any detail may comprise more than one taxon (e.g. two possible forms of Tecticornia sp. aff globulifera (small)). Therefore, the current identification of 25 taxa may represent an underestimate of the number of samphire species in the study area.

It is also evident that different species of Tecticornia cannot be accurately and consistently identified in the field and that voucher specimens should be collected for all data points. It should also be noted that voucher specimens need to be collected at the appropriate times, as fertile specimens with mature fruits and seeds are required for identification and sterile specimens cannot be accurately identified in most cases.
8.1.2 Soil seed banks of fringing salt lake vegetation in arid Western Australia
density, composition and implications for postmine restoration using topsoil, Etten et al

Although studies of seed banks in arid ecosystems are commonplace, they are lacking for the large arid zone of Western Australia. Across the six major plant communities fringing a large salt lake within this zone, topsoil (0–5 cm depth) was collected from 12 to 36 sites per community. Samples were dried, spread out on a bed of vermiculite in seedling trays and placed in a wellwatered glasshouse to determine the readily germinable component of the soil seed bank. Subsamples of topsoil were treated with smoke water, hot water or flooding to help determine seed bank of species with dormancy mechanisms. As with other studies of arid seed banks, large numbers of grasses and forbs emerged from the topsoil, with relatively small numbers of woody perennial species and hummock grasses (Triodia spp.) present, even in communities where such species were dominant. There were, however, a few exceptions where a reasonable density of dominant trees/shrub seed was present in topsoil. Soil treatment generally had limited effect on composition and density of emergent seedlings. Although floristic similarity between soil seed banks and corresponding above-ground vegetation was modest, there were clear differences in soil seed bank composition between communities. The implications of the results for using topsoils to restore landforms of the study area after mining or other disturbance are discussed.

8.1.3 ‘Drought tolerances of three stem-succulent halophyte species of an
inland semiarid salt lake system’

Victoria A. Marchesini, Chuanhua Yin, Timothy D. Colmer and Erik J. Veneklaas

As the soil dried out, the three species showed similar reductions of transpiration, osmotic potential and photochemical efficiency. Shoot growth was depressed more than root growth. Tissue water loss from portions of the succulent shoots accounted for ~30% of transpiration during severe drought stress. There was no osmotic adjustment. Shoot tissue concentrations of Na+ and Cl– tended to increase during drought, and those of K+ decreased; however, these changes were not always statistically significant. Chlorophyll concentration decreased but betacyanin concentration increased. Despite occupying distinct positions in a water and salinity gradient, the three Tecticornia species had remarkably similar responses to soil water deficit.

8.1.4 Tecticornia survey Ecologia 2015

Priority Tecticornia Taxa

The Priority 1 taxon, Tecticornia sp. Lake Way (P. Armstrong 05/961) was recorded from one location in Lake Way and is apparently restricted to a small outwash plain approximately 5 km south of the Millipede and Centipede deposits. Due to the extensive targeted searches and a likely restricted habitat it is given a low likelihood of suitable habitat within the project area.

The Priority 1 taxon, Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867) was recorded frequently at both Lake Maitland and Lake Way. At Lake Maitland it was recorded in the smaller salt pans towards the southern end of the lake, and at Lake Way it was recorded along the very edge of the bare salt lake. Because of this it is considered to have a high likelihood of additional habitat outside the project area.

Tecticornia cymbiformis (Priority 3) appears to be isolated to the one small salt pan to the west of Lake Maitland and the upper edge of the main bed of Lake Maitland itself. Because of this, it has been given a low likelihood of additional habitat outside of the project area.
**Novel Tecticornia Taxa**
Of the 13 novel or potentially novel Tecticornia taxa, two: Tecticornia sp. aff. pruinosa (inflated bracts) and Tecticornia sp. aff. Burnerbinmah (inflated fruit), are considered at risk as they appear restricted to habitats that are not widespread and were both only recorded at one location at the project area.

**Known Tecticornia Taxa**
Most of the known taxa are widespread in Western Australia and have a high likelihood of occurrence outside the project area. Four taxa are considered range extensions and are discussed individually below.

**Significance of Tecticornia taxa**
The location, number and potential for occurrence inside and outside the impact areas for each of the 33 Tecticornia entities are discussed in Table 3.2 and discussed below.

**Priority Tecticornia Taxa**
The Priority 1 taxon, Tecticornia sp. Lake Way (P. Armstrong 05/961) was recorded from one location in Lake Way and is apparently restricted to a small outwash plain approximately 5 km south of the Millipede and Centipede deposits. Due to the extensive targeted searches and a likely restricted habitat it is given a low likelihood of suitable habitat within the project area.

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**Known Tecticornia Taxa**
Most of the known taxa are widespread in Western Australia and have a high likelihood of occurrence outside the project area. Four taxa are considered range extensions and are discussed individually below.

Tecticornia halocnemoides subsp. catenulata is known from approximately 200 km west of the project area and represents a slight range extension from the vouchered specimens at the WAH. It was recorded at 11 locations at the Centipede and Lake Way deposits and is considered to have a high likelihood of occurrence outside the project area.

Tecticornia moniliformis is known from approximately 400 km south of the project area and represents a large range extension from the vouchered specimens at the WAH. It was recorded commonly at the Centipede and Lake Way deposits on the main lake bed and minor tributaries and is therefore considered to have a high likelihood of occurrence outside the project area.

Tecticornia pterygosperma subsp. pterygosperma is known from approximately 200 km south of the project area. It was recorded at one location at Lake Maitland, on a small salt pan to the south of the main lake bed. As this habitat occurs extensively outside the project area, it is considered that this taxon has a high likelihood of occurrence outside the study areas.

Tecticornia tenuis is known from approximately 500 km south-west and 1,000 km north-east of the project area. It represents a significant bridging record from the vouchered specimens at the Western...
Australian Herbarium (WAH). It was recorded at three locations from Lake Way on the floodplain to the south of Millipede which occurs well beyond the survey area and therefore has a high likelihood of occurrence outside the project area.

**Lake Way: Millipede and Centipede**

Two broad Tecticornia complexes were delineated from the 3 x 3 m quadrats at Lake Way: T3 and T4.

**T3**: The section in the north of Millipede and based on opportunistic collections by ecologia, most of Centipede, incorporates the edge of the main lake bed and has ten statistically distinct Tecticornia units recorded. Within these ten units, the most abundant units (T-F and T-HA) each represent 28% of the quadrats sampled which have therefore been combined and mapped as one complex: T3 (Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) (+/-T. indica, T. sp. aff. undulata (broad articles), T. sp. aff globulifera (small) and Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)) sparse low shrubland).

**T4**: The section of Lake Way to the south of the Millipede deposit incorporates vegetation units associated with a small tributary that runs from the main lake bed. Four statistically distinct Tecticornia vegetation units were recorded with the most abundant unit (T-BB) recorded at 50% of the quadrats surveyed in this area (Table 3.5) which have therefore been combined and mapped as one complex: T4 (Tecticornia sp. Burnerbinmah (D. Edinger et al. 101) and Tecticornia sp. aff globulifera (small) (+/-T. indica subsp. Leiostachya and Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate') sparse low shrubland).

**Lake Maitland**

Two broad Tecticornia communities were delineated from the 3 x 3 m quadrats at Lake Maitland: T1 and T2.

**T1**: The northern section of Lake Maitland incorporates the main lake bed with six statistically distinct Tecticornia vegetation units recorded. Within these six vegetation units, the most abundant unit (T-JA) was recorded at 72% of the quadrats in this area. Based on the most dominant Tecticornia taxa as well as field observations, the main lake bed has been mapped as one complex: T1 (Tecticornia laevigata, T. sp. aff globulifera (small) and T. sp. aff. undulata (broad articles) sparse low shrubland).

**T2**: The southern section of Lake Maitland incorporates a trail of smaller salt pans that runs south from the main lake bed for approximately 30 km. Seven statistically distinct Tecticornia vegetation units were recorded and the two most abundant units (TJ-B and T-L) were recorded at 34% and 26% of the quadrats in this area, respectively. These statistically-defined units are very similar in species composition and have therefore been mapped as one complex: T2 (Tecticornia peltata, T. sp. aff globulifera (small), T. sp. aff. undulata (broad articles) and T. sp. Sunshine Lake (K.A. Shepherd et al. KS 867) sparse low shrubland) (Table 3.5). As there was more dissimilarity in the statistical analysis of the quadrats in this area, it is likely to represent a higher variation of communities in these smaller salt pan areas.

**Number, location and habitat of Tecticornia taxa (Lake Maitland)**

**Tecticornia sp. Sunshine Lake** (K.A. Shepherd et al. KS 867) Priority 1 86 (10) 116 (14) 0

**Lake Way**: Was recorded on the edge of the main saltlake and minor tributaries. Appears to be mostly restricted to the very edge of Tecticornia communities bordering on the bare lake bed.

**Lake Maitland**: Common on the small salt pan trail that runs south from the main lake bed. High likelihood of additional habitat. The trail of small salt pans extends well beyond the survey area at Lake Maitland and was recorded on multiple locations on the edge of the salt ake at Lake Way.

**Tecticornia cymbiformis** Priority 3 5,480 (25) 0 0

**Lake Maitland**: Scattered along the upper edge of the main lake bed and forming part of the vegetation community of a small salt pan to the west of Lake Maitland. Low likelihood of additional habitat. Seems to be isolated to the one small salt pan to the west of Lake Maitland and the upper edge of the main lake bed.
**Tecticornia** aff. *halocnemoides* s.l. 'large ovate seed aggregate' Novel n/a 67 (8) 51 (5) 0
Lake Way: Common on the edge of the main saltlake and minor tributary to the south of millipede/centipede.
Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature.

**Tecticornia** aff. *halocnemoides* s.l. 'tuberculate seed' Novel n/a 55(6) 0 0
Lake Maitland: Common on the main lake bed and trail of small salt pans that run to the south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature.

**Tecticornia** sp. aff *globulifera* (small) Novel n/a 342 (30) 126 (10) 0
Lake Way: Very common on the edge of the main lake bed and minor tributaries.
Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature.

**Tecticornia** sp. aff *laevigata* (nonrotated fruitlets) Novel n/a 53 (8) 55 (5) 0
Lake Maitland: Common on the main lake bed and the small salt pan trail that runs south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature.

**Tecticornia** sp. aff *pruinosa* (inflated bracts) Novel n/a 5 (1) 0 0
Lake Maitland: Scattered in the main lake bed. **Low likelihood of additional habitat.** Only recorded on the main lake bed.

**Tecticornia** sp. aff *undulata* (broad articles) Novel n/a 360 (39) 107 (12) 0
Lake Way: Common on the main lake bed and minor tributaries.
Lake Maitland: Very common on the main lake bed and on the trail of small salt pans to the south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature.

**Tecticornia** aff. *halocnemoides* (unusual epidermis) Potentially novel n/a 3 (30) 0 0
Lake Maitland: Scattered at one location in the trail of small salt pans that run to the south. **High likelihood of additional habitat.** The trail of small salt pans extends well beyond the survey area at Lake Maitland.

? **Tecticornia** sp. aff *globulifera* (small) Potentially novel n/a 1 (20) 1 (5) 0
Lake Way: Scattered on the main lake bed.
Lake Maitland: Scattered on the trail of small salt pans that run to the south. **High likelihood of additional habitat.** Not specific to any uncommon landscape feature and recorded regionally.

It could be suggested that a further survey be conducted to locate more populations of the unnamed species collected, away from the influences of mining and dewatering. The target species would be at the least: **Tecticornia cymbiformis** and **Tecticornia** sp. aff *pruinosa* (inflated bracts) which have only been collected from the portions of the lake bed to be mined or have the potential to be covered by infrastructure. The other potentially new species at Lake Maitland appear to have been found in the chain of small salt pans to the south of Lake Maitland and appear to be away from mining and dewatering influences.

**Tecticornia** sp. aff. *Burnerbinmah* (inflated fruit) found at Lake Way in a small tributary south of the project would also be a target species for further population locations.
8.1.5 Assessment of Tecticornia Communities – Ecologia

Previous Survey Work
There have been a number of flora and vegetation surveys completed for the Wiluna Uranium Project and the Extension to the Wiluna Uranium project, including:
- Outback Ecology (2007) conducted the baseline vegetation and flora survey at the Lake Way and Centipede deposits;
- Outback Ecology (2009) conducted the baseline vegetation and flora survey for Lake Maitland;
- Niche (2011) conducted another phase of survey at Lake Way and Centipede, including the resurveying of Outback (2009) quadrats and an additional borefield area known as West Creek;
- Niche (2014) conducted the baseline flora and vegetation survey for the Millipede deposit;
- ecologia (2015b) conducted the baseline flora and vegetation survey for the haul road; and
- ecologia (2015a) conducted a vegetation community consolidation across all the Project areas (not including Tecticornia communities).

The work completed on the Tecticornia communities during the Outback Ecology (2007 and 2009) and Niche (2014) surveys cannot be used for analysis due to potentially inconsistent identifications and lack of available data.

The Tecticornia identifications from the Niche (2011) survey of Lake Way and the (ecologia 2015b) surveys were identified by senior research scientist Dr. Kelly Shepherd of the Western Australian Herbarium, and are used as in this report.

8.1.6 Extension to the Wiluna Uranium Project Response to EPA Submissions – Tecticornia Groundwater Dependency - Ecologia

Key Points
- Soil conditions at Christmas Creek/northern fringe of Fortescue Marsh and at Lake Way/Lake Maitland are similar.
- Groundwater conditions (including depth to water and salinity) are also similar
- Several of the dominant Tecticornia species, including Tecticornia indica subsp. bidens, Tecticornia indica subsp. leioestachya and Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) are common to all three locations (ie Fortescue Marsh, Lake Way, Lake Maitland)
- The Tecticornia species have morphological characteristics (ie low LAI, low transpiration rate, shallow root architecture) that are not typical of groundwater dependent species
- Published and unpublished technical literature suggests possible linkages between Tecticornia zonation and submergence tolerance, but not between zonation and drought tolerance
- It is likely that EWR’s of Tecticornia species are met by periodic surface recharge of the vadose zone
- Other environmental water requirements (related to seedling emergence, for example) are triggered by fresh water inputs from rainfall events and are not influenced by changes in groundwater regimes
- Natural variation in the depth to groundwater in the Wiluna area is in the order of 0.5m over the annual cycle. Even if Tecticornia species did exhibit a level of occasional groundwater reliance, plants of this genera are likely to be tolerant of natural groundwater fluctuations of at least 0.5m at Lake Way and Lake Maitland and up to 2m at Fortescue Marsh.
• Samphire communities within the 0.5m drawdown contour and outside the direct disturbance footprint should be monitored to confirm that possible changes in groundwater hydrology are not affecting vegetation health.

Conclusions
The dominant Tecticornia species of the samphire communities that occur on the fringes of the Fortescue Marsh also occur within both of the Millipede and Lake Maitland Development areas (ie *Tecticornia indica* subsp. *bidens*, *Tecticornia indica* subsp. *leiostachya* and *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552). Additionally, the associated soil types and salinity levels of the three sites also closely correspond. Empirical data and results of ecohydrological studies on these species undertaken at Fortescue Marsh concluded that a 3m groundwater drawdown at Fortescue Marsh is unlikely to affect the survival of Tecticornia species. Based on the results of HYDRUS modelling at Fortescue Marsh, a conclusion could be drawn that the Environmental Water Requirements (EWR’s) of Tecticornia species within the Millipede and Lake Maitland development areas (including those within the 0.5m groundwater drawdown contour) are likely to be met by surface water inputs which maintain the soil moisture sufficient to meet water use requirements under all but extreme climatic conditions. On this basis and the EPA’s indicating its acceptance that samphire communities on the fringes of Fortescue Marsh can tolerate a groundwater drawdown of up to 3m, it can be argued that the Tecticornia species present within the Millipede and Lake Maitland development areas are unlikely to be groundwater dependent and as a consequence any proposed groundwater drawdown is unlikely to significantly affect their health and survival.

Statements relating to the dewatering impacts associated with the Wallaby Pit of Barrick Gold’s Granny Smith mine on samphire communities on the fringes of Lake Carey in the Lake Carey 10 Year Review Report (Lake Catchment Management Group, 2013) are related more to the impacts of dune sediment mobilisation and deposition on Tecticornia species than any direct groundwater drawdown impacts on Tecticornia ecophysiology.

8.1.7 Flora and Vegetation Consolidation and Conservation Assessment – Ecologia

**GUIDING PRINCIPLES**

This flora and vegetation consolidation assessment was undertaken to supplement previous surveys that are undergoing an Environmental Impact Assessment process in WA and is required to address the following government legislation:

- EPAs Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002); and

Specifically, this report will provide:

- A review of background information used for the flora and vegetation conservation assessment (including literature and database searches);
- Maps and details of any significant flora identified in the literature review;
- An inventory of vegetation types occurring at the project areas, incorporating recent published and unpublished records; and
- A map and detailed description of vegetation types (to NVIS Level V: Association) occurring in the project areas and an assessment of which vegetation units represent Threatened or Priority Ecological Communities.

**DATABASE SEARCHES**

Using the shapefile of the haul road of the Extension to the Wiluna Uranium Project area a search of the DPaW Threatened and Priority Ecological Communities Database (Search reference 25-0514EC) with a
50 km buffer was undertaken in September 2014, to locate TECs and PECs previously recorded in the vicinity of the project areas.

**Nationally Listed Threatened Ecological Communities**

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (DEC 2010). At a national level, flora and Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. A search of the EPBC protected matters search tool was undertaken to locate matters of national environmental significance.

**State Listed Threatened Ecological Communities**

DPaW also maintains a list of state listed TECs which are further categorised into three subcategories, much like those of the EPBC Act. Within the Western Australian classification, an ecological community will be listed as Vulnerable "when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future”. A search of the DPaW state listed TEC Database for the project areas was conducted.

**State Listed Priority Ecological Communities**

DPaW maintains a list of Priority Ecological Communities (PEC). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

**CONSOLIDATION OF DATA**

A number of finer scale surveys have been conducted for the Wiluna Uranium Project and the Extension to the Wiluna Uranium Project (see Section 2.1). Data from the flora and vegetation surveys listed below was used to conduct the flora and vegetation consolidation:

- Outback Ecology (2009) - Lake Maitland: baseline vegetation and flora surveys;
- Niche (2011) - Assessment of the flora and vegetation of: Lake Way, Centipede and West Creek Borefield;
- Niche (2014) - Assessment of the flora and vegetation of: Millipede;
- ecologia (2015c) - Millipede to Lake Maitland Haul Road Level 2 flora and vegetation assessment; and
- ecologia (2015a) – Assessment of *Tecticornia* associated with Lake Way and Lake Maitland. There have been 10 separate phases of flora and vegetation assessments conducted at or in the vicinity of the project areas which will be included for the vegetation consolidation (Table 3.1). Five hundred and six quadrats (all 30 x 30 m) were surveyed at and

**8.1.8 Cumulative Impact Assessment Ecologia**

**New and Potentially New Taxa**

Seven new and seven potentially new *Tecticornia* taxa have been identified from specimens collected from Lake Way and Lake Maitland (Niche 2011; Shepherd 2015) (Table 3.2) and include:

- Potentially new taxa (^ = Niche 2011): ?*Tecticornia* sp. aff. *globulifera* (small), *Tecticornia* aff. *halocnemoides* (unusual epidermis), *Tecticornia* sp. aff. *laevigata^\textsuperscript{a}, Tecticornia* sp. aff. *pruinosa^\textsuperscript{a}, Tecticornia* sp. aff. *undulata^\textsuperscript{a}, Tecticornia* sp. halocnemoides beaked seed aggregate^\textsuperscript{a}, *Tecticornia* sp. nov^\textsuperscript{a}.

In addition to the taxa listed above, Shepherd (2015) concluded that in taxonomically problematic species, multiple entities have been included under the same identification and therefore the current number of *Tecticornia* taxa is likely to be an underestimate of the actual number of samphire in the project areas. Locations of new and potentially new taxa are shown on Figure 3.2 and Figure 3.3 respectively and maps showing the distribution of each individual taxon are provided in Appendix A.
**Tecticornia Taxa**

All *Tecticornia* species are considered significant at the project areas due to the difficulty in field survey, reduced morphology and lack of taxonomic clarification of the genera (Shepherd 2015). An assessment of *Tecticornia* associated with Lake Way and Lake Maitland was conducted by *ecologia* (2015a) with the identifications undertaken by Senior Research Scientist at the Western Australian Herbarium, Dr. Kelly Shepherd (Shepherd 2015). Dr. Shepherd concluded that field identifications are not reliable and only specimens that had been vouchered could reliably be used for impact assessment purposes. Therefore, any numbers of *Tecticornia* taxa presented in this report are based on vouchered and identified collections only. The *Tecticornia* assessment conducted by *ecologia* (2015a) presents the results of both vouchered and field references. In addition to the *Tecticornia* that are Priority Flora, new taxa, potentially new taxa or range extensions, there were 14 additional known species recorded (Table 3.2).

Map ‘Priority Flora’ P11 – doesn’t show *T. cymbiformis* on Lake Maitland

*Tecticornia cymbiformis* (Priority 3) is restricted to saline soils along the edges of creeklines, and has previously been recorded across the Gascoyne, Murchison and Yalgoo IBRA bioregions. The closest previous record is approximately 100 km to the north-east of the project. At the project area it has been recorded at one confirmed location as the dominant component of the fringing vegetation at a small salt pan approximately 7 km to the north-west of Lake Maitland. This is not within the direct or indirect impact areas. It should be noted that approximately 60 unvouchered individuals were recorded by *ecologia* within the direct impact area at Lake Maitland and the haul road but are not included as they were not confirmed by the Western Australian Herbarium.

*Tecticornia sp. aff. Burnerbinmah* (inflated fruit) was recorded at a single location in Abercrombie Creek which drains into Lake Way adjacent to the Centipede and Millipede deposits. Known from a single record, the habitat specificity of this taxon is uncertain, but targeted surveys of similar tributaries around Lake Way may detect additional populations. The one location of this species will be directly impacted by the project. This record is close to the southern boundary of the proposed impact area at the Millipede Deposit and will be avoided where possible.

**Discussion of Impacts**

The cumulative impacts to *Tecticornia* dominated vegetation at Lake Way and Lake Maitland are 789.2 ha (6.9%) and 561.8 ha (9.8%) respectively. If water draw down is included, the impact calculations are 1,859.3 ha (16.3%) and 2,168.2 ha (37.8%) respectively.

**SOURCES OF INFORMATION**

The vertebrate fauna assemblage and fauna habitats of the study area have been assessed across several previous fauna assessments. Reports used for the current cumulative impact assessment include:

- *ecologia* (2015e): Lake Maitland Level 2 Vertebrate Fauna & Targeted Reptile Survey; and
- *ecologia* (2015f): Millipede to Lake Maitland Haul Road Fauna Assessment. Fauna habitat mapping has been completed for the Lake Way and Centipede areas (Outback Ecology 2011b), for the Millipede to Lake Maitland haul road (*ecologia* 2015f) and for Lake Maitland (*ecologia* 2015e). Habitat mapping has not been previously completed for the haul roads linking the existing Wiluna Project areas; habitat extent within these areas was estimated based on aerial imagery.
8.1.9 Toro Environmental Management Plan

Monitoring
Prior to the commencement of operations, a series of monitoring sites would be established. These sites would be permanent and established in close proximity to areas to be disturbed and analogue sites located in areas that would not be impacted. The aim of the sites would be to allow for comparisons between communities inside and outside the impact area and to be able to account for regional impacts, such as drought.

As areas are rehabilitated, quadrats would also be established to enable the success of the rehabilitation to be measured. These quadrats would be permanent and monitored at least annually to assess whether a functioning ecosystem is returning.

Monitoring Programmes
During the life of the Project, ongoing flora and vegetation monitoring would occur. This monitoring would include:
- Annual flora and vegetation community surveys for vegetation condition to assess the difference between the impact and non-impact quadrats;
- Six monthly monitoring along established transects for weeds in disturbed areas, along roads and in rehabilitated areas;
- Annual monitoring of quadrats for species richness, density and abundance;
- Annual monitoring of tree health at the two borefields where drawdown has the potential to lead to tree death, especially in prolonged periods of reduced rainfall; and
- The *Tecticornia* research plan would be implemented during rehabilitation to revegetate disturbed lake and lake play areas with *Tecticornia* species of provenance.

Vegetation Condition and Baseline Monitoring
Annual monitoring would occur at the quadrats established prior to construction of the Project. Monitoring would occur in spring or post-rainfall, so that short lived herbs and annual species can be captured in the surveys. Photographs would be taken of the quadrat from a designated point (to be established) and an assessment of the plant health and diversity made. This system would enable comparisons of the quadrats to be made to past years or over the life of the Project and enable a timeline of the quality of the quadrat to be established.

The reason for having quadrats inside and outside proposed disturbance areas is to assess the natural variance of ecosystem composition, which may be impacted by:
- Local and regional fires;
- Local and regional rainfall;
- Drought; and
- Temporal changes in climate.
All monitoring that is done as part of the mine closure process would be detailed in the Mine Closure and Rehabilitation Plan.

Rehabilitation Monitoring
The Project intends to progressively rehabilitate disturbed areas. The goal is to rehabilitate areas as soon as possible after they are no longer required to ensure that the Project’s footprint remains as limited as possible. Rehabilitation monitoring would occur immediately once areas have been rehabilitated to initially consider issues, such as local gamma radiation levels, the depth of topsoil and the adequacy of topsoil coverage, to assess whether the ground has been physically returned to a condition suitable for the recovery of the ecosystem.

Annual surveys would commence one-year post rehabilitation to assess whether species are returning to disturbed areas. Surveys would assess species diversity and abundance, the presence of weeds and evidence of grazing. Ongoing monitoring would assess how the composition of the ecosystem is changing and analog sites in similar vegetation types and ecosystems would be used to gauge how the rehabilitation was progressing.
The *Tecticornia* Survey and Research Plan would be implemented prior to the commencement of operations. This plan has been designed to both further identify local *Tecticornia* species and to identify methods to rehabilitate and restore *Tecticornia* populations across the Project area. The research and monitoring will be undertaken in accordance with the *Tecticornia* Survey and Research Plan and carried out by specialists from the Department of Parks and Wildlife (DPaW) and other research organisations and universities.

**Interpretation of Results**
The results of the monitoring would be included in the Project’s Annual Environmental Report (AER) and would discuss:
- Any changes in vegetation noted in the photographic record of the quadrats;
- Any decline in community health, including plant deaths and plants showing major signs of stress;
- Any unpredicted decline in plant health inside the direct impact areas;
- Any new occurrences of weeds in monitoring areas; and
- Results of rehabilitation, where relevant.

All the photographs taken of quadrats across the year would be made available in the AER. Toro has committed to making all monitoring results and information public, and would publish the results of the monitoring on its website.

**Trigger Levels**
The trigger levels relevant to vegetation that would determine when contingency actions are required are outlined in Table 4.4.

**Contingencies**
Where changes in plant health occur for reasons beyond the control of Toro, i.e. drought or fire, no contingency response is possible. Where changes in plant health are seen and which can be attributed to the Project, then the following remedial actions would be taken:
- If groundwater drawdown is found to be greater than the modelled scenarios, then the real time monitoring results would be used to recalibrate the model and new scenarios would be established. The dewatering plan and mine plan would be revised such that mining can occur using the new dewatering scenarios while maintaining the commitment not to drawdown more than 0.5 m at the original 0.5 m drawdown contour.
- If vegetation decline is due to dust impacts, additional dust control measures will be put in place.
- If vegetation decline is due to saline or hypersaline water escaping from haul roads, further engineering systems including drains and sumps would be constructed to capture this water.
- If weed infestations are found to be increasing and/or new species are found within the Project area, the weed control procedure would be revised. Further, stricter weed hygiene measures would be put into place.
- If plant health is seen to be declining at either of the borefields, the borefield operating strategy would be revised, and further sources of water sought. The water balance for the Project would also be reviewed to seek further water use efficiencies.
8.1.10 Toro PER

Closure and Rehabilitation
Most of the land on which mining would occur at Millipede and Lake Maitland has native vegetation except for minor areas of existing disturbance associated with roads and access tracks and some cleared areas from previous mining trials. Closure and rehabilitation at both Millipede and Lake Maitland would be carried out progressively, in the manner of a strip mining operation, with voids created by mining being backfilled using residue and overburden from active mine pits. This would be in addition to any operational footprint associated with the already approved activities at Centipede and Lake Way.

At cessation of all site activities, final landforming and revegetation would be completed in accordance with the approved Mine Closure and Rehabilitation Plan (MCRP). A conceptual MCRP has been included as Appendix 3, and closure and rehabilitation at Millipede and Lake Maitland are discussed further in Section 16.

Lake Maitland
The mining method would be the same as that proposed for Millipede and at the already assessed Centipede and Lake Way deposits (EPA Assessment 1819 and EPBC 2009/5174) with no drilling or blasting required. The mining rate would be sufficient to provide 1.3 Mtpa of ore to the processing plant. The uranium deposit proposed to be mined is located along the western margin of Lake Maitland and is essentially crescent-shaped with three arms representing the palaeodrainage channels extending towards the north-west. The deposit is approximately 6 km long (north-south) and up to 4 km wide (east-west). The uranium mineralisation is flat-lying and thin, averaging 1.9 m (range 0.5 m to 4.5 m) in thickness. It generally occurs within a single coherent horizon located 1.5 m to 5.0 m below the surface of Lake Maitland. The mineralisation occurs predominantly as carnotite, a hydrated uranyl vanadate and is primarily hosted within the carbonates and calcareous clays, the magnesium clays, as well as in the upper parts of the kaolinitic clays, clayey sands and sandy clays. The gypsiferous clays and carbonaceous mudstone contain only low levels of uranium mineralisation.

The uranium and vanadium contained in the Lake Maitland ore body originated, respectively, in the Archaean granitic and greenstone country rocks from which the transported lake sediments are derived. Precipitation of carnotite occurred as transporting fluids become depleted in carbonate and concentrated in vanadium through evaporation.

Waste rock produced by mining would be stockpiled next to the pit in controlled areas or backfilled progressively into the pit as part of rehabilitation. Topsoil would be stripped and stockpiled separately for rehabilitation. At closure, the surface topography would be similar to the pre-mining landscape. Progressive rehabilitation at Lake Maitland may include hauling waste from Centipede and Millipede to ensure land forms at mine closure at Lake Maitland resemble, as much as practicable, land forms that existed before mining.

It is proposed that tailings generated from the processing of ore mined at Lake Maitland would be stored in mined-out voids at the Millipede deposit. Due to the similar nature of the two deposits and also the consistent processing methodology, the tailings from the Lake Maitland and Millipede deposits would be of a very similar composition.

Lake Maitland
There is a shallow groundwater table between 1 m and 3 m below the natural ground level and the uranium deposit generally occurs below the groundwater table. Pit dewatering would be required ahead of and during mining and would be undertaken in a manner similar to that proposed for the already assessed Centipede and Lake Way deposits (EPA Assessment 1819 and EPBC 2009/5174) and at Millipede. This would include the installation of barriers to minimise the amount of water to be pumped from the pits during mine dewatering.
There would be no discharge of mine water to surface water. During routine operations, as much water as possible from pit dewatering would be used as part of the operational water supply. For any excess water from pit dewatering, Toro has investigated the options of downstream aquifer reinjection and pumping to the processing plant adjacent to Millipede/Centipede. For the reinjection process, Toro has identified suitable aquifers into which the water could be returned and this is further discussed in Section 13.

In the event that a significant rainfall event occurred during mining, there would be sufficient on-site storage capacity to retain incident rainfall until it could be used, evaporated or demonstrated to be of appropriate quality for controlled release to the environment. If accumulated surplus rainwater was within the range of natural water quality, approvals would be sought for discharge of surplus rainwater. Toro would only seek to discharge water in circumstances where the discharge water complied with criteria to ensure there was no adverse environmental impact.

**Groundwater Quality**

Toro proposes to reinject surplus water from dewatering of mine pits at Lake Maitland. The strategy that has been proposed is to avoid clearing of land for the construction of evaporation ponds or (alternatively) discharging of surplus water from mine dewatering, as currently happens at some other Western Australian mining operations in the Goldfields region. The reinjection of hypersaline water into fresh water systems has the potential to cause local increases in the salinity of shallow groundwater, which could reduce the suitability of the shallow aquifer for some subterranean fauna.

**Management, Monitoring and Follow-up**

In this PER, monitoring programs are proposed to deal with uncertainties associated with the impact predictions and mitigation. In general, monitoring is used to test and verify impact predictions and determine the effectiveness of mitigation. Monitoring is also used to identify unanticipated effects and implement adaptive management. Typically, proposed monitoring includes one or more of the following categories:

- **Compliance Inspection**: Monitoring the activities, procedures and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval and company commitments;
- **Environmental Monitoring**: Monitoring to track conditions or issues during the mine and plant life and implementation of adaptive management; and Extension to the Wiluna Uranium Project Public Environmental Review Page 8-11
- **Follow-up**: Programs designed to test the accuracy of impact predictions, reduce uncertainty, determine the effectiveness of mitigation and provide appropriate feedback to operational management for adopting new mitigation designs, policies and practices.

These monitoring programs form part of the environmental management system for the Wiluna Uranium Project, including its extension. If monitoring or follow-up detect impacts different to those predicted or highlight the need for improved or modified mitigation, adaptive management would be implemented in consultation with regulatory authorities. This could include increased monitoring, changes in monitoring plans or additional mitigation.

Toro’s plans for progressive rehabilitation and maintaining open areas at a minimum would ensure that topsoil removed during mining can be directly returned as soon as possible. This would minimise stockpiling and ensure that natural biological processes in the soil are resumed as quickly as possible.

Where use of topsoil inside the target timeframe is not possible, stockpiling would continue until a suitable use area was available. To prevent the loss of topsoil and subsoil, stockpile locations have already been identified. They would be located outside areas prone to surface water flows, to prevent possible erosion. Topsoil and subsoil stockpiles would be orientated north-east to southwest to minimise exposure to the local winds. A monitoring program assessing the biological activity of stockpiles would be implemented.
OFFSETS

PropONENT Studies and Investigations

As a result of the assessment of Toro’s proposal for mining at Centipede and Lake Way, and on the recommendation of the EPA, the Minister for Environment applied an offset in his Ministerial Decision as a condition of approval of that proposal (EPA Report 1437; Ministerial Statement No. 913).

This offset requires Toro to implement a survey and research plan with a minimum total monetary value of $900,000 to conserve and improve scientific knowledge of Tecticornia species. Implementation of the Tecticornia Survey and Research Plan is expected to deliver outcomes that lead to the successful conservation and rehabilitation of Tecticornia species at Centipede and Lake Way and Toro would extend the plan to mining at Millipede and Lake Maitland should this Proposal be approved.

Toro has undertaken significant studies into the impacts that this Proposal may have on the environment. The outcomes of these studies have been reported on in this PER. When viewed in both a local and regional context, Toro does not believe any impacts have been identified that cannot be effectively mitigated through avoidance, minimisation and rehabilitation such that there would be no material residual impact on the environment from implementation and subsequent closure of the Proposal.

The uncertainty surrounding Tecticornia species has been somewhat resolved by the additional work undertaken by Toro, Ecologia and the Western Australian Herbarium to inform this assessment of the proposed extension to the Wiluna Project. Although some potentially new species have been identified, the mapping of these species suggests that their distribution is widespread and not limited to direct impact areas associated with the Proposal. This field study, combined with the Tecticornia Survey and Research Plan that would be implemented prior to the commencement this Proposal should it be approved, will further define the extents of various species, and will also identify methods to rehabilitate disturbed areas. The survey and research plan is likely to be ongoing in some form throughout the life of the Proposal to provide information for continuous testing and refining until an effective rehabilitation method is developed. It is therefore considered unlikely that there would be any residual impacts on Tecticornia species, communities and populations post mine closure.

Commitments

As an already agreed offset, Toro would implement a Survey and Research Plan to further the knowledge of Tecticornia species. This was a requirement of Ministerial Statement No. 913 for the approval of mining at Centipede and Lake Way. Should the extension to the Wiluna Uranium Project be approved, Toro would further develop the plan to cover the impacts of mining at Millipede and Lake Maitland. This would be done in consultation with DPaW and include research into the most appropriate survey methodology for Tecticornia sp. and vegetation communities and research into the taxonomy of relevant species complexes to allow future survey and impact assessment. The outcomes of the research would also be applied to conservation of Tecticornia and rehabilitation of any Tecticornia vegetation communities disturbed by implementation of this Proposal.

The Commonwealth Government may also have offset requirements pursuant to the EPBC Act. Toro will undertake further consultation with the Commonwealth Department of Environment to ensure that any Commonwealth offset requirements in relation to the Proposal are addressed.
Figure 2 - Stylised lake profile showing samphire zonation - note Genera have changed since this drawing was made with most now Tecticornia; species are unchanged.
8.2 References


8.3 Photographs, site visit

Figure 3 - Millipede, P1 Orebody

Figure 4 - Millipede North, T. lepidosperma poss P2
Figure 5 - Millipede Orebody vegetation, Tecticornia Moniliformis top, T. aff undulata (?) bottom P1
Figure 6 – Millipede/Centipede, Lake Way, looking west

Figure 7 – Millipede/Centipede, looking east towards Lake Way
**Figure 8** - Lake Maitland, *Lawrencia helmsii* top and *Tecticornia indica* subsp *bidens* (P4 Dunna Dunna 2)
Figure 9 - Lake Maitland, *Tecticornia cymbiformis* (Cymi)
Figure 10 - Lake Maitland, very old track through samphire - 1070s? (P3 South TP1)

Figure 11 - P3 South TP1
Figure 12 - Rehabilitation of test pit - 5 years old (Test Pit 1)

Figure 13 - Rehabilitation of test pit - 5 years old (Test Pit 1)
Figure 14 - Centipede revegetation trials (Centipede vegetation)

Figure 15 - Centipede revegetation trials - cattle footprints (Centipede revegetation)
Figure 16 - Tecticornia cymbiformis and Atriplex sp. (cymbi 3)
### 8.4 GPS Locations and Maps, Site Visit

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**Table 1** - GPS locations site visit
Figure 18 - Lake Way, Site Visit Locations
Figure 19 - Lake Way, Site Visit Locations
Figure 20 - Lake Maitland, Site Visit Locations
Figure 21 - Lake Maitland, Site Visit Locations
8.5 Endnotes

i There have been a number of flora and vegetation surveys completed for the Wiluna Uranium Project and the Extension to the Wiluna Uranium project, including:
- Outback Ecology (2007) conducted the baseline vegetation and flora survey at the Lake Way and Centipede deposits;
- Outback Ecology (2009) conducted the baseline vegetation and flora survey for Lake Maitland;
- Niche (2011) conducted another phase of survey at Lake Way and Centipede, including the resurveying of Outback (2009) quadrats and an additional borefield area known as West Creek;
- Niche (2014) conducted the baseline flora and vegetation survey for the Millipede deposit;
- ecologia (2015b) conducted the baseline flora and vegetation survey for the haul road; and
- ecologia (2015a) conducted a vegetation community consolidation across all the Project areas (not including Tecticornia communities).

ii Studies regarding potential impacts on samphire vegetation include:
- Vegetation Health Monitoring and Management Plan – Cloudbreak Life of Mine Expansion Project, Fortescue
- Executive Summary (from RPS, 2011: Lake Maitland Uranium Project – Water Supply Investigation)
- Soil seed banks of fringing salt lake vegetation in arid Western Australia – density, composition and implications for postmine restoration using topsoil, Etten et al
- Drought tolerances of three stem-succulent halophyte species of an inland semiarid salt lake system, Victoria A. Marchesini, Chuanhua Yin, Timothy D. Colmer, and Erik J. Veneklaas
- Fortescue Marsh: Synthesis of eco-hydrological knowledge-Final Report (Updated 2013)
- Modelling Analysis of the Impact of Mine Dewatering on Soil Water Availability to the Samphire Vegetation on the Fringe of Fortescue Marsh
- Extension to the Wiluna Uranium Project Response to EPA Submissions – Tecticornia Groundwater dependency–Ecologia