

11 Ecology

Flora and Fauna – the EA shall include a flora and fauna impact assessment taking into consideration impacts on any threatened species, populations, ecological communities and/or critical habitat and any relevant recovery plan in accordance with the DECC's *Guidelines for Threatened Species Assessment* (2005). This assessment shall justify the need for clearing any vegetation and/or habitat features and include an evaluation of potential impacts on waterways, aquatic ecosystems or riparian zones, including any instream stormwater basins, potential for weed infestation, impacts to fish passage, and the provision of any compensatory habitat/biodiversity offsets.

This chapter presents the assessments of the potential impacts of the Project on terrestrial flora and fauna (Section 11.1), and aquatic flora and fauna (Section 11.2), in response to the requirements in the Director General's Requirements (DGRs).

11.1 Terrestrial flora and fauna

Ecowise Environmental and Biosis Research undertook terrestrial flora and fauna surveys and assessment. Surveys and assessments were undertaken in accordance with the DGRs and the Department of Environment, Climate Change and Water *Guidelines for Threatened Species Assessment* (DECC, 2005). This section provides a summary of the findings in the complete specialists' reports presented in appendices F, O and P (these include the general terrestrial flora and fauna study, an additional survey report for the Golden Sun Moth and a report specifically on the bulk water pumping station).

The key finding of these assessment is that no significant impacts on terrestrial flora or fauna are anticipated from the overall Project or from Stage 1 of the Project.

11.1.1 Scope of the terrestrial flora and fauna impact assessment

The terrestrial flora and fauna assessment has generally focussed on the areas affected by Stage 1 of the Project.

The specialist studies provided in appendices F, O and P present a detailed desktop and site assessment of the infrastructure works proposed for Stage 1 of the Project, while the other infrastructure elements of the concept plan for the Project have been assessed at a desktop level only, utilising the previous ecological surveys undertaken for the Googong township as part of the Googong Local Environmental Study (LES) supporting rezoning.

The levels of assessment undertaken for this assessment are considered appropriate due to the extensive ecological surveys and assessment previously undertaken, as well as the disturbed nature of the vegetation within the study area that have resulted from a long history of agricultural land use.

The scope of the assessment relates to the infrastructure required as part of Stage 1 of the Project. The permanent reservoirs on Hill 800 were also assessed in detail at this stage, as this site was originally part of Stage 1 of the Project, the site is the only major part of the concept plan not included in Stage 1 of the Project and the design of the reservoirs is sufficiently detailed.

Future assessments under the EP&A Act, potentially under Part 3A project application(s) or Part 4 development applications, would need to be undertaken for elements of the concept plan that are not part of Stage 1 of the Project. In terms of potential terrestrial flora and fauna assessments, these would need to consider:

- The potential impacts of mains pipework within neighbourhoods 2, 3, 4 and 5 of the Googong township (refer to Figure 5.1 for the indicative pipework routes). While the current study identifies that there are unlikely to be any significant impacts as a result of the Project, future studies should include an assessment of:
 - The existing environment at the time of the study, as development would proceed progressively over the next 25 years and the ecology has the potential to change over that time.
 - The context of the pipework in relation to the developing urban landscape of the Googong township and the impacts of the road network that pipelines would be associated with.
 - The final alignments of the pipework in relation to environmental features, such as watercourses, potential native species habitat (if present) and individual trees.
- The specific locations of sewage pumping stations 3 and 4, once these are determined, as well as any other sewage pumping stations or other water cycle infrastructure that may be required.

11.1.2 Assessment methodology

Literature and database review

A search of relevant databases and a literature review of local environmental assessments were undertaken. Databases searched relate to the entire study area and included the NSW Wildlife Atlas (DECCW, 2008–10) and the EPBC database (DEWHA, 2008–10). A number of studies previously prepared for the site and the vicinity have informed the ecological understanding of the site. The most relevant of these is an ecological investigation by the Johnstone Centre in 2004, conducted as part of the Googong LES. As described in Chapter 2, the LES determined that the revised extent of the Googong township would avoid environmentally sensitive areas.

Flora and fauna habitat assessment

The site was assessed in terms of habitat for native flora and fauna. Habitat attributes were used to classify the habitats found on site as being either in good, moderate or poor condition, as presented in Table 11.1.

Table 11.1 Condition categories used in flora and fauna habitat assessments

Condition	Attributes
Good	Vegetation contains a high number of indigenous species, assemblages of species and structural characteristics of the pre-European equivalent. Such vegetation has usually changed very little over time, is relatively undisturbed and displays resilience to weed invasion, due to intact ground cover, shrub and canopy layers. It displays a high level of breeding, nesting, feeding and roosting resources available, as well as a high richness and diversity of native fauna species.
Moderate	Vegetation generally retains its structural integrity, containing a moderate number of indigenous species, but has been highly disturbed, and has lost some component of its original species complement. Weed invasion is significant. The ground log and litter layer is somewhat intact and undisturbed. The site displays a moderate level of breeding, nesting, feeding and roosting resources available, as well as a moderate richness and diversity of native fauna species.
Poor	Vegetation has been subject to high levels of disturbance and has lost most of its original species. The vegetation is significantly modified structurally, and left with only a discontinuous canopy of the original tree cover, very few shrubs and very little of its original groundcover. Vegetation is dominated by exotic species, such as introduced pasture grasses or weeds, replacing much of the indigenous ground cover. The ground log and litter layer is disturbed and modified. The site displays a low level of breeding, nesting, feeding and roosting resources, as well as a low richness and diversity of native fauna species.

Vegetation communities and flora species surveys and assessment

Vegetation communities were identified and assessed in accordance with the condition categories presented in Table 11.1. Potential areas of endangered ecological communities (EECs) identified during the literature review were investigated and targeted during surveys. Field surveys, such as transects and meanders, also targeted threatened flora species that had the potential to occur in the area.

Assessments of significance were undertaken on relevant species and communities in accordance with the appropriate guidelines for assessment (see, for example, Section 6.3.3 of Appendix F for details of how the flora and fauna assessments were undertaken in accordance with the relevant guidelines for threatened species assessment under Part 3A of the EP&A Act).

Fauna species surveys and assessment

Targeted surveys were undertaken in areas of potential habitat for relevant threatened fauna species in accordance with DECCW survey and assessment guidelines. This included cage trapping, pit-fall trapping, artificial burrows and rock turning for reptile species, Golden Sun Moth surveys, diurnal point surveys for birds, frog surveys at farm dams, call playback for owl species, and Anabat detection for microchiropteran bats. A summary of the flora and fauna survey effort is provided in Table 11.2.

The fauna assessment (Appendix F) identified that the Project would impact upon potential habitat for the Golden Sun Moth and any populations of the species (should it exist on site). As a result, further surveys were undertaken during the 2009 flying season (October to December) to provide detailed mapping of the potential habitat for the Golden Sun Moth and to determine the presence or absence of the species.

Combined with the 2008 survey, these additional surveys provide sufficient evidence as to whether the Golden Sun Moth is present on site (Tess Ward, DEWHA, pers comm, 2009). If the species was not found during the 2009 survey season, it would be concluded that the species does not occur within the study area and, due to the existing habitat fragmentation and the biology of the Golden Sun

Moth, the potential habitat within the study area would be unlikely to be recolonised naturally by other local populations.

Additional surveys at the bulk water pumping station (BWPS) site were undertaken as a result of an amended location for the connection to the exiting DN 1800 water supply main (as the original connection location posed potential technical issues, which were raised during consultation with ActewAGL). While the general area was surveyed in the 2008 study, for completeness an additional study of the amended BWPS location and access road was undertaken by Biosis (Appendix P). This study included a flora and fauna habitat assessment, as well as targeted surveys of the Hoary Sunray (a plant listed as Endangered on the EPBC Act).

Table 11.2 Flora and fauna survey effort

Survey	Techniques	Effort
Flora		
Flora habitat assessment	Transects/random meanders	32 person hours
Targeted flora species surveys	Transects/random meanders	160 person hours
Fauna		
Fauna habitat assessment and incidental records	Across the entire study area over the three month survey season	
Artificial burrows	Seven sets of 10 traps	Checked every 2–4 days between Nov and Jan (2008–2009)
Pit-fall traps	Seven sets of arrays (two traps each)	Checked daily for 21 days
Rock turning	Four locations	6.5 person hours
Cage traps	One transect of five traps	20 trap nights
Anabat detection	Four locations	1 night at each location
Diurnal bird surveys	Eleven locations	5.5 person hours
Owl surveys (call playback)	Two locations	0.5 person hours
Nocturnal frog surveys	One location	1 person hour
Golden Sun Moth (<i>Synemon plana</i>) surveys	<p>2008 survey Surveys conducted during appropriate weather conditions between 1000 and 1400 hours in association with checking pit-fall traps and burrows across the survey season.</p> <p>2009 survey Four days of 20 meander transects and 3 point counts. Pupae case searches were also undertaken.</p>	
Additional surveys at the proposed BWPS site (2010)		
Habitat assessment	Transects and targeted searches over 1 day (30 March 2010).	
Hoary Sunray (<i>Leucochrysum albicans</i> var. <i>tricolor</i>) surveys	Recording boundaries of populations using GPS – 1 day (13 April 2010).	

11.1.3 Existing environment

The Johnstone Centre (2004) mapped the habitat areas of the study area for the Googong LES. As a result of this study, the area proposed to be rezoned for the Googong township (see Figure 2.1 and Section 2.2) was restricted to disturbed, lower quality habitat areas. Figure 11.1 shows the different types of vegetation communities as described in the Johnstone Centre report. As noted above, areas of higher quality habitat comprising woodland and native grassland in the vicinity of the study area were excluded from potential development as part of the rezoning process. Over 95 per cent of the study area is classed as exotic grassland (agricultural land). As noted in the Johnstone Centre report, the vegetation communities in the vicinity of the study area are likely to include the two endangered ecological communities noted below and they include habitat for threatened flora and fauna species.

Vegetation communities

In terms of Stage 1 of the Project, the 2008 field surveys found that there are four vegetation communities within the subject site (see Figure 11.2). These communities are:

- Grasslands – exotic and native pasture.
- Disturbed and rehabilitated areas (associated with the existing Googong water treatment plant).
- Woodlands associated with Googong Creek.
- Roadside vegetation.

Throughout these areas, scattered remnant woodland trees provide additional habitat. All vegetation communities were considered to be in poor condition, with the exception of the woodlands associated with Googong Creek (outside the study area for the Project, but investigated as part of the 2008 ecological surveys), which were considered to be in moderate condition (refer to Table 11.1).

Endangered ecological communities

Two endangered ecological communities have the potential to occur within the study area:

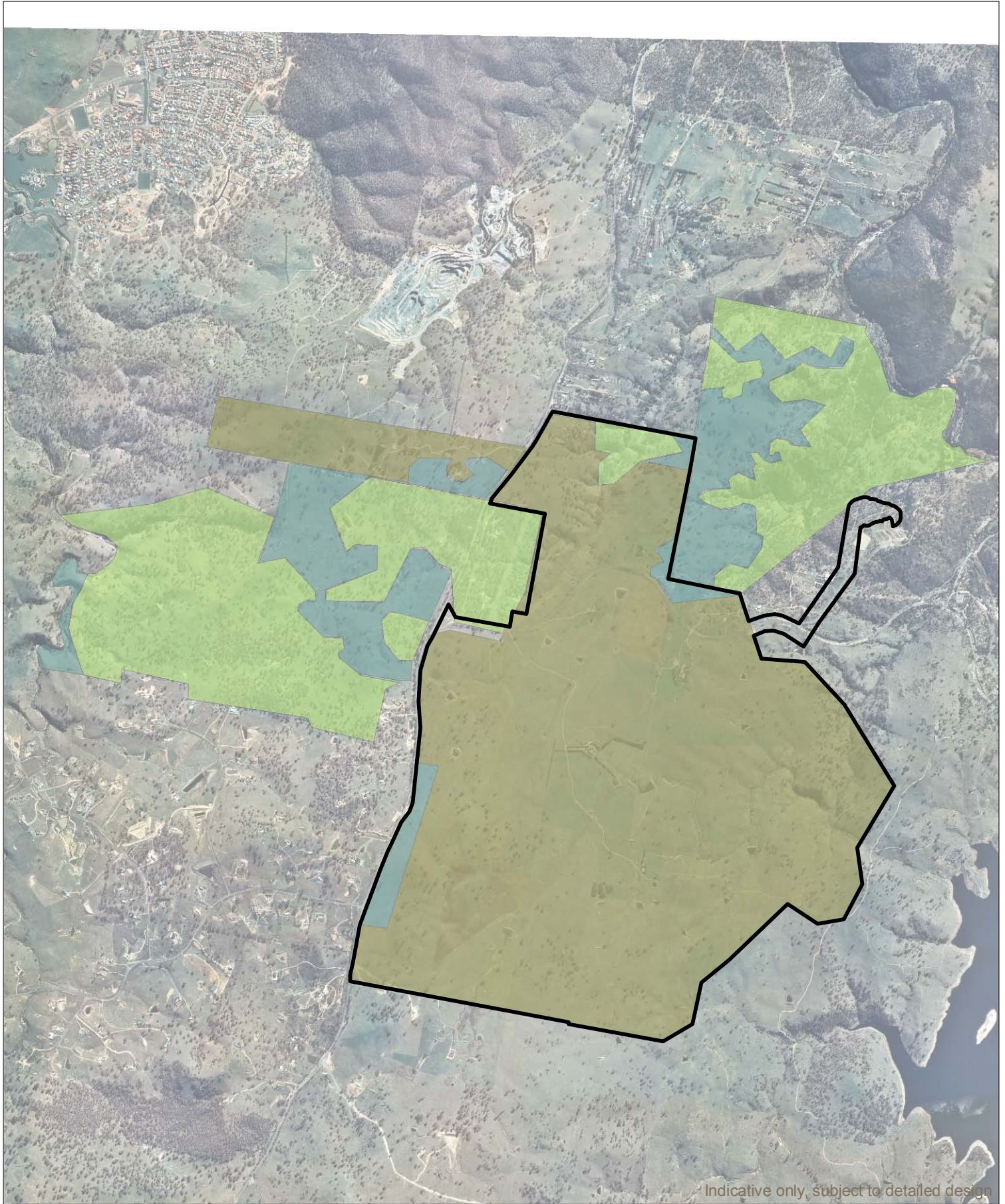
- Natural Temperate Grasslands of the Southern Tablelands of NSW and the ACT.
- White Box-Yellow Box-Blakely's Red Gum Woodlands and Derived Native Grasslands.

Neither of these communities was found during the surveys.

Threatened fauna species and their habitat

A total of 66 fauna species were recorded during the 2008 field surveys. Two threatened fauna species were identified during the 2008 surveys:

- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*). This species is unlikely to utilise the study area for roosting or breeding, as habitat features are very limited within the study area. This is particularly relevant with regards to the absence of caves within the study area, which this species requires for breeding. This species is more likely to inhabit the higher quality habitat areas to the north, east and west of the study area (for example, see Figure 11.1). It was not considered necessary to map the potential habitat for this species nor to consider it further, as the Project would not result in any perceptible impacts on this species.
- Pink-tailed Legless Lizard (*Aprasia parapulchella*). This species was found in the south-east of the study area, within the Montgomery's Creek corridor. Potential habitat for this species was also identified at Hill 800, although targeted surveys did not find any individuals and it is unlikely that a population would exist in that area of the site. The potential habitat for this species was mapped and is shown in Figure 11.2.



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig11-1

Source LES (Willana Assoc.)

- Exotic grassland and agriculture
- Native grassland
- Woodland and forest
- Study area 2010

1:32,000

0 250 500 750 1000m



Figure 11.1 Vegetation communities (adapted from Googong LES 2004)



While the Golden Sun Moth (*Synemon plana*) was not found during surveys, the potential habitat for this species was mapped during the study. It was considered that potential habitat for other threatened species was not relevant to map, as they were unlikely to be present or utilise the study area.

Further surveys (undertaken during the 2009 flying season) have been completed for the Golden Sun Moth and results are presented in Appendix O. These surveys found that neither Golden Sun Moths nor any pupae casings were present. Hence, it is concluded that the species does not occur within the study area and the potential habitat shown in Figure 11.2 is not of conservation value for this species.

In a submission to the NSW DoP (1 March 2010), and in a meeting with Manidis Roberts (9 March 2010), DECCW officers noted that they were of the opinion that there may be habitat for threatened woodland bird species that could be impacted as a result of the Project. During a subsequent site visit (24 April 2010), the areas potentially affected by the Project were discussed with DECCW officers and it was noted that woodland bird species would be unlikely to be affected by infrastructure associated with the Project.

Threatened flora species and their habitat

A total of 151 flora species were recorded during the 2008 field surveys. No threatened flora species were recorded during the surveys. However, during additional surveys at the BWPS site in 2010, the Hoary Sunray (*Leucochrysum albicans* var. *tricolor*) was found in the vicinity of the proposed access road for the pumping station. Further targeted surveys were then undertaken for this species at the site and details are provided in Appendix P. These targeted surveys located three populations of this species, which had colonised disturbed areas, including existing access tracks. The majority of individuals were found to be located more than 20 metres upslope of proposed work areas.

Weeds and disturbance

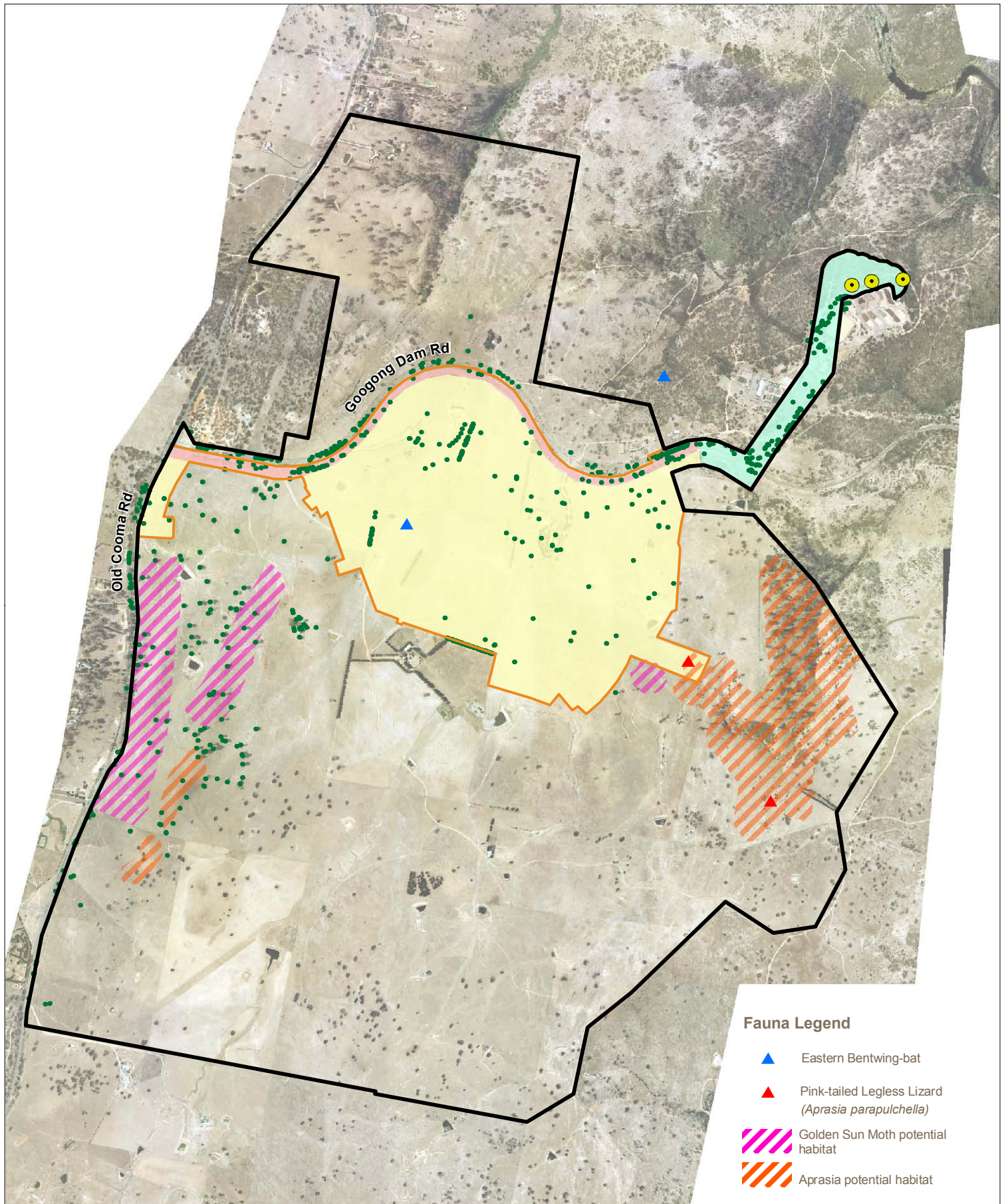
There is a high degree of disturbance throughout the study area due to past and present agricultural land uses and other development. As a result, a large array of invasive species was recorded during surveys, including 15 species that have been declared noxious weeds. A further 10 exotic species have been declared 'problematic' within the Yarrowlumla Development Control Plan 2002, which was used as a reference document for weeds in the region.

The majority of the subject site is characterised as 'grasslands', with 30–40 per cent bare ground and a dominance of non-native species. Section 5.2.2 of Appendix F details the extent of exotic species and the degradation of habitat within each of the vegetation communities.

11.1.4 Construction impacts and mitigation measures

Potential impacts

Many potential impacts associated with construction of the Project and Stage 1 of the Project would be avoided through the careful selection of the site for the Googong township and the placement of infrastructure so as to avoid sensitive areas. This approach would progress through the detailed design and construction phases for each piece of infrastructure (eg pipelines would be aligned to avoid the removal of hollow-bearing trees).



Fauna Legend

- ▲ Eastern Bentwing-bat
- ▲ Pink-tailed Legless Lizard (*Aprasia parapulchella*)
- ▨ Golden Sun Moth potential habitat
- ▨ *Aprasia* potential habitat

Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig11-2

Source Ecowise, Biosis, J Easthope & Assoc.

- Trees included in aborist study
- Hoary Sunray population
- Grassland with scattered trees
- Disturbed and rehabilitated area
- Roadside vegetation
- Subject site
- Study area

1:20,000

0 150 300 450 600m



Figure 11.2 Vegetation communities, flora and fauna

Potential impacts on terrestrial flora and fauna during construction of the Project would include:

- Disturbance of habitat for native flora and fauna species or ecological communities, including the removal of rock and some hollow-bearing trees. Indicative levels of disturbance and tree removal associated with water cycle infrastructure elements are:
 - Water recycling plant site (including the recycled water pumping station) – about 1.58 hectares to be disturbed and up to 10 trees to be removed.
 - Interim reservoir area and access road – about 0.2 hectares to be disturbed and up to five trees to be removed.
 - Permanent reservoir area – about 1.33 hectares to be disturbed and up to five trees to be removed.
 - BWPS site and access road – about 0.45 hectares to be disturbed and up to 15 trees to be removed.
 - Sewage pumping station (SPS) sites – about 0.08 hectares to be disturbed and up to five trees to be removed at each site.
 - Pipelines – about 29,000 metres of pipeline, including Stage 1 of the Project pipelines:
 - Potable water mains – corridor up to 20 metres wide and about 4,950 metres long.
 - Recycled water mains – corridor up to 20 metres wide and about 3,600 metres long.
 - Sewage mains – corridor up to 20 metres wide and about 1,500 metres long.
- Disturbance to foraging or breeding resources for threatened species.
- Impacts on the Pink-tailed Legless Lizard habitat in the vicinity of Hill 800 and SPS2.
- Impacts on the Hoary Sunray in the vicinity of the BWPS access road.
- Weed incursion.

The potential for edge effects to result from the construction of the Project would be minimal, particularly in the context of the urban landscape of the township and when compared to the existing land use. The management and mitigation measures described below, particularly with regards to weed control, would further reduce or alleviate potential edge effects.

Appendix F (Chapter 6) provides further details of the potential impacts of Stage 1 of the Project and the permanent reservoirs at Hill 800. Appendix P (Chapter 5) provides an assessment of impacts of the BWPS, which is predominantly relevant to Stage 1 of the Project, as the majority of works that modify the existing environment would occur during the construction of Stage 1 of this pumping station.

Mitigation and management measures

The key mitigation and management measures would be to:

- Implement an avoidance philosophy (described above), whereby the Googong township and the Project would be developed on disturbed land, and sensitive environmental areas would be avoided. In particular, impacts on the Pink-tailed Legless Lizard and Hoary Sunray would be avoided by the appropriate siting of infrastructure, as follows:
 - SPS2 would be located upslope, away from the potential habitat for the Pink-tailed Legless Lizard and a minimum 20-metre separation would be provided during construction and operation of Stage 1 of the Project.

- The BWPS and access road would be located outside the recorded locations of the Hoary Sunray and measures would be implemented to avoid disturbance (see the recommendations provided in Chapter 6 of Appendix O).
- Implement a flora and fauna management plan (which would contain management and mitigation measures). This plan would detail:
 - The installation of exclusion fencing, signage and other relevant protection measures in particular areas, which would be undertaken under the supervision of an appropriately qualified ecologist as part of pre-construction surveys (see Figure 11.3) in the vicinity of SPS2 (to avoid impacts on the Pink-tailed Legless Lizard; and in the vicinity of the BWPS site and associated access road (to avoid impacts to the Hoary Sunray).
- Weed management measures, such as bush regeneration, weed spraying and construction equipment washing procedures.
- Guidelines for the removal of hollow-bearing trees.
- Monitoring and reporting regimes.

Appendix F (Chapter 7) provides further details of the impact amelioration measures that should be provided within a flora and fauna management plan for Stage 1 of the Project. Appendix P (Chapter 6) provides recommendations specific to the BWPS site, which is predominantly relevant to Stage 1 of the Project. Chapter 6 of Appendix O provides specific recommendations regarding the Golden Sun Moth; however, as this species is not present on site, these recommendations relate to landscaping and weed management measures.

11.1.5 Operational impacts and mitigation measures

Potential impacts

Potential impacts on terrestrial flora and fauna during operation would be minor, as the operation and maintenance of the Project would be unlikely to have any direct effects on the terrestrial environment. Potential indirect impacts on terrestrial species may be associated with the use and discharge of recycled water, as well as the emergency discharge of water not treated to licence conditions. These potential impacts are outlined in Chapter 7 (see especially Section 7.5.4).

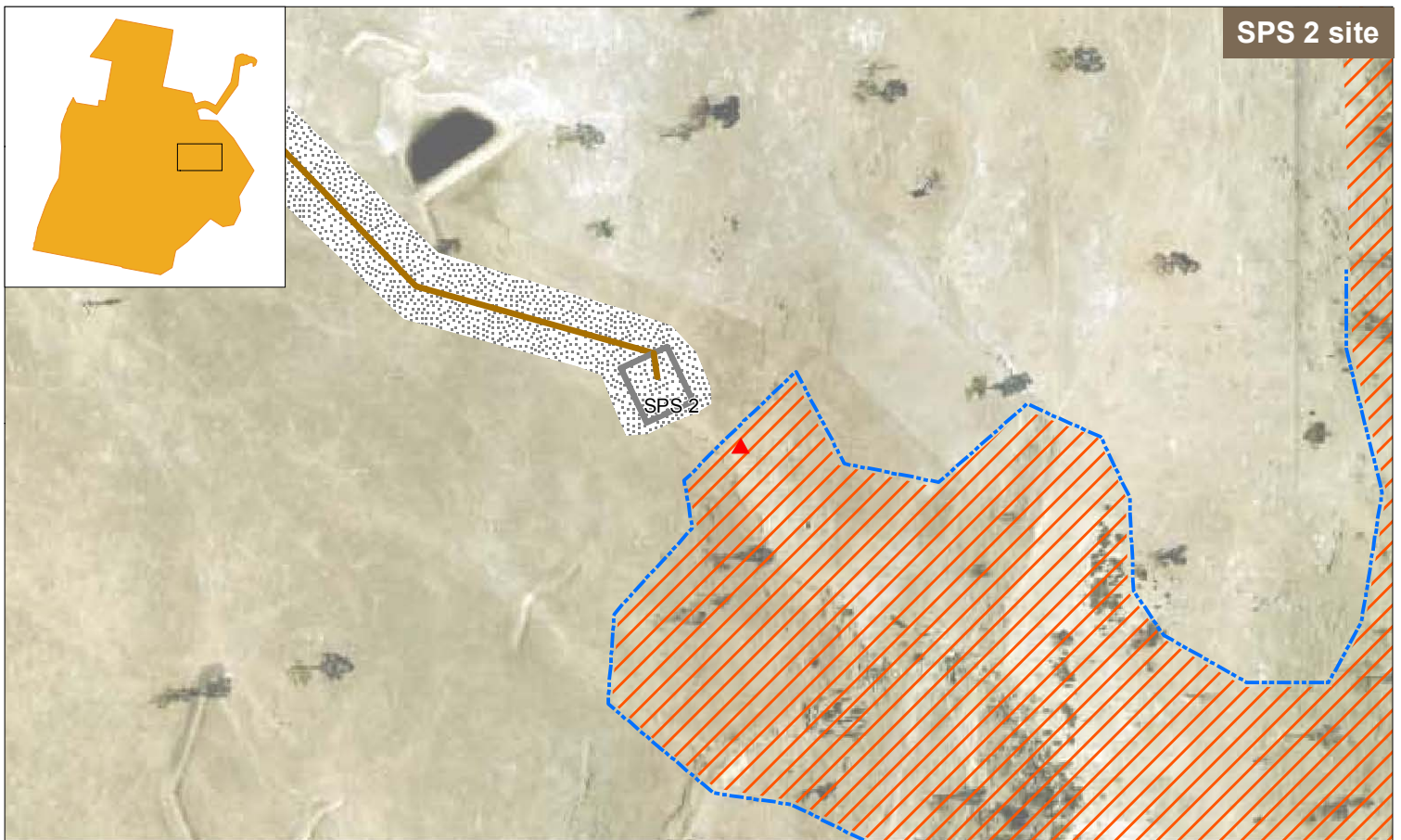
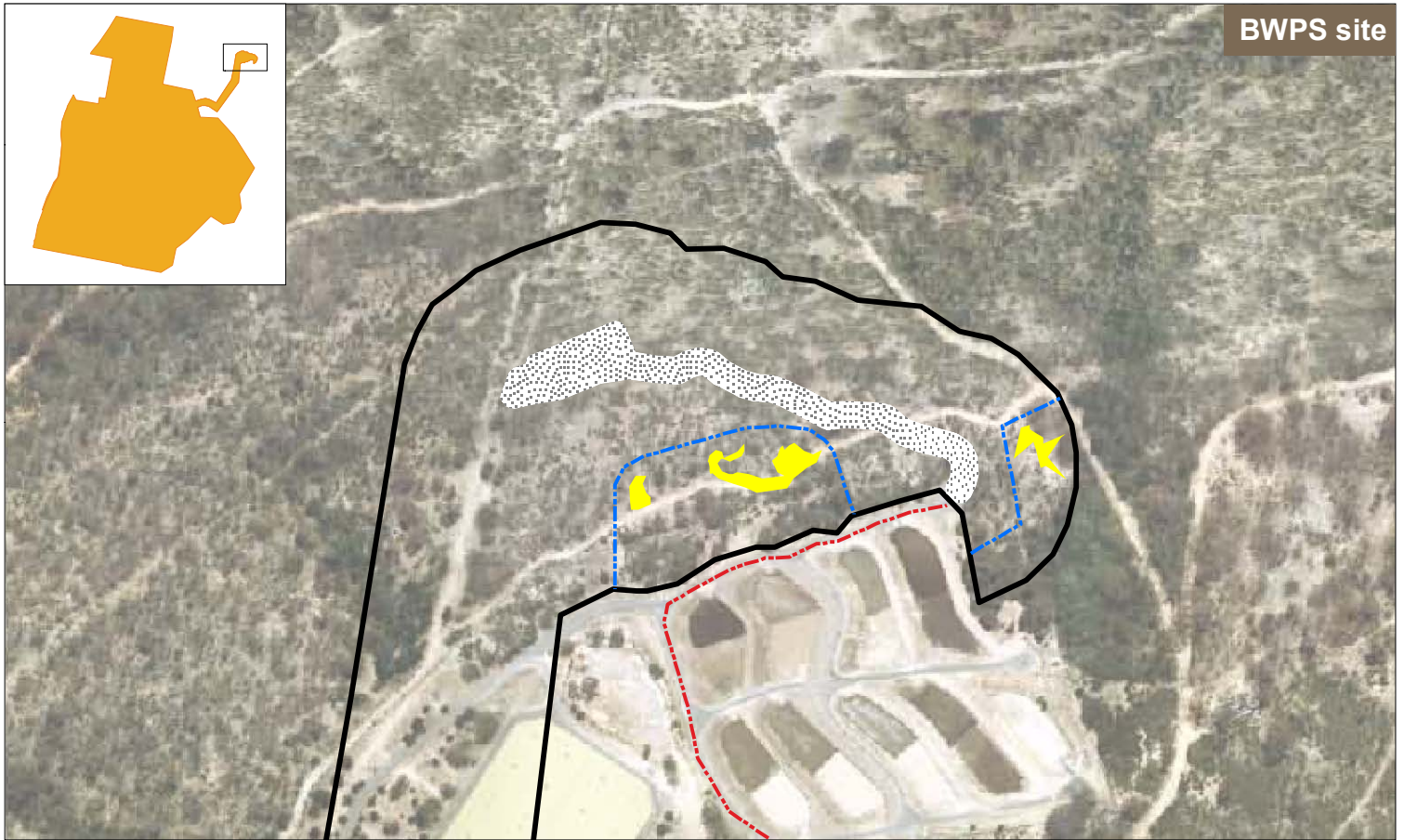
The potential for edge effects to occur from the operation of water cycle infrastructure would be minimal, particularly in the context of the Googong township and when compared with the existing land use.

Accordingly, the potential impacts on terrestrial species are anticipated to be insignificant.

Potential impacts on water quality and soils are assessed in chapters 7 and 9, respectively.

Mitigation and management measures

Terrestrial flora and fauna management would be included within an operational environmental management plan (OEMP) for the Project that would detail emergency, spill and maintenance procedures, as well as monitoring and reporting regimes.











Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig11-3

Source Ecowise, Biosis, J Easthope & Assoc.

-  Access road and construction footprint
-  Hoary Sunray population
-  Study area boundary
-  Exclusion fence (approximate)
-  Access route to BWPS site
-  Sewage rising main
-  Pink-tailed Legless Lizard record
-  Pink-tailed Legless Lizard potential habitat

1:3,500

0 30 60 90 120m



Figure 11.3 Threatened flora and fauna protection measures

11.1.6 Conclusions

This assessment has found that:

- Provided the above management and mitigation measures are implemented, there is unlikely to be a significant impact upon any threatened species or endangered ecological communities.
- The design of the water cycle infrastructure has led to the avoidance of the habitat for the Pink-tailed Legless Lizard and the populations of the Hoary Sunray. The Golden Sun Moth would not be affected, as the species has not been found in extensive surveys and the identified potential habitat would not be of conservation value for the species.

Mitigation and management measures are reinforced in the statement of commitments (F1–F3) in Chapter 18.

11.2 Aquatic ecology

The methodology used in this assessment included monitoring the main parameters (such as fish ecology, macroinvertebrate ecology, riparian and aquatic vegetation) to assess the aquatic health of the existing environment and determine the extent of potential impacts on the aquatic environment during construction and operation.

This assessment finds that potential construction and operation impacts are not likely to be significant, as effects on the flows and water quality of local watercourses would be minor and appropriate management measures would be implemented.

11.2.1 Scope of the aquatic ecology assessment

The aquatic ecology assessment addresses both the Project and Stage 1 of the Project.

The primary potential for impacts on aquatic ecology as a result of the Project relate to the ongoing discharge of excess recycled water within the stormwater discharge into Googong Creek (at Googong Dam Road), which eventually flows into the Queanbeyan River. Googong Creek is a degraded, low-flow, ephemeral drainage line that has no aquatic ecology characteristics or values that can be assessed. Therefore, the majority of this aquatic ecology assessment relates to the Queanbeyan River.

Section 4.3.2 presents the options explored for the discharge of excess recycled water. In 2008, Ecowise undertook a study of aquatic ecology in the Queanbeyan River. This assisted in the selection of the final discharge location for excess recycled water.

Many of the potential aquatic ecology impacts that could occur as a result of discharge of excess recycled water into this catchment have been avoided through the selection of the discharge location and the resultant dilution and further treatment of the recycled water within the stormwater management system. Section 5.4 discusses how the stormwater management system operates and Section 7.5.4 details the proportion of recycled water within the stormwater flows.

The assessment provided in this section should be considered in the context of the staging of the Googong township. The township would be developed in stages over about 25 years, with a gradual increase in population and therefore a gradual increase in the production (and use) of recycled water. This assessment relates generally to the potential impacts of the concept plan (ie the Project as a whole), as the potential impacts related to Stage 1 of the Project would be similar in type, but smaller in scale, than those of the Project as a whole.

11.2.2 Existing environment and assessment methodology

The existing aquatic environments potentially impacted by the Project are already subject to the impact of poor land practices and intensive agriculture within the catchment. Section 7.2 discusses in detail the existing environmental characteristics of the catchments and sub-catchments of the study area and these are shown in Figure 7.2. Figure 7.3 shows the study area within the wider drainage and catchment system of the region, including the ephemeral drainage lines within the study area and the proximity of the Queanbeyan River, which is the only major watercourse in the area.

In order to assess the impact of the Project on aquatic ecosystems, a preliminary aquatic assessment was conducted (Ecowise, 2008). This study specifically investigated whether excess recycled water should be discharged directly into the Queanbeyan River, as originally proposed. While the discharge location has now been altered to be up-catchment and within the Googong township, it is still relevant to consider the downstream environment of the Queanbeyan River.

The following section describes the assessment methods, and the key findings of the existing aquatic environment of the Queanbeyan River. For the purposes of this assessment, the following two monitoring sites on the Queanbeyan River were used (one above, and one below the confluence of Googong Creek and Queanbeyan River) and are shown in Figure 7.3:

- Site QBN 704 – about one kilometre downstream of Googong Dam, about two kilometres upstream of the confluence.
- Site QBN 703 (Wickerslack Lane) – about two kilometres downstream of the confluence.

The main parameters monitored as performance indicators to assess the aquatic health of the surrounding waterways include:

- Fish ecology.
- Macroinvertebrate ecology. (Macroinvertebrates are small animals and generally include insects, crustaceans, molluscs, arachnids and annelids.)
- Riparian and aquatic vegetation.

It is proposed that regular monitoring of these parameters and sites is undertaken before and during construction, as well as during operation of the Project.

Fish ecology

NSW Fisheries was consulted pursuant to section 34A of the EP&A Act prior to preparation of the Googong Local Environmental Study (LES). NSW Fisheries has advised that the Queanbeyan River was once a known habitat for Macquarie Perch (*Macquaria australasica*), which is listed as a vulnerable species in accordance with the *Fisheries Management Act 1994*. NSW Fisheries has advised that any draft local environmental plan prepared for the study area should make reference to the fact that Macquarie Perch were once known to live in the Queanbeyan River and that the precautionary principle should be adopted when preparing design requirements (Willana, 2007).

Macroinvertebrate ecology

ACTEW is licenced by Environment ACT to supply residents of the ACT and Queanbeyan with water from the Cotter and Queanbeyan River catchments. As a condition of this licence, ACTEW undertakes an annual ecological health monitoring program.

As part of ACTEW's licence, the performance objective for the Queanbeyan River is 'not to impair the Ecological Health from the current status'. The current ecological state of the river is described as 'slightly to moderately impaired condition', when applying macroinvertebrate observed and expected

ratio (O/E) monitoring tests for all sites on the Queanbeyan River below Googong. The O/E ratio on macroinvertebrate composition, and abundance is assessed using the rapid bio-assessment protocols defined in the *ACT Australian River Assessment System (AusRivas) Sampling and Processing Manual* (Nichols et al, 2000). The AusRivas model predicts the macroinvertebrates expected to occur at a test site on the basis of its environmental attributes. When a test site is sampled, the fauna observed are compared to the model's expectations for the habitat, and the resulting (O/E) score is regarded as an integrated indicator of river health. The AusRivas O/E score is responsive to a variety of environmental effects, including water quality, habitat conditions, and changes in flow regime.

Various O/E categories (bands) are used to provide a measure of the overall condition and severity of disturbance. Table 11.3 provides the AusRivas banding of ecological health of assessed sites on the basis of macroinvertebrate taxa collected.

Table 11.3 AusRivas banding scheme

Band	Description	Taxa observed/expected ratio	Taxa Interpretations
X	More biologically diverse than reference	O/E greater than 90th percentile of reference sites used to create the model. (>1.12)	More families found than expected. Potential biodiversity 'hot-spot' or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
A	Similar to reference	O/E within range of central 80% of reference sites used to create the model. (0.87–1.12)	Expected number of families within the range found at 80% of the reference sites.
B	Significantly impaired	O/E below 10 th percentile of reference sites used to create the model. Same width as Band A. (0.63–0.87)	Fewer families than expected. Potential impact either in water and/or habitat quality resulting in a loss of families.
C	Severely impaired	O/E below Band B. Same width as band A. (0.39–0.63)	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
D	Extremely impaired	O/E below Band C down to zero. (<0.39)	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

Source: *Ecowise, 2008*

The results from the two monitoring sites are shown in Table 11.4 and Table 11.5. Table 11.5 shows that the two sites are recording 'A', 'B' and 'C' level AusRivas scores, based on macroinvertebrate composition (taxa richness) and abundance of specific macroinvertebrate families and genera.

Table 11.4 Performance criteria for monitoring sites used in the environmental flows monitoring program

Site code	Site location	AusRivas rating of Ecological Health	Performance Indicator
QBN 704	About 2 km upstream of the intersection of Googong Creek and Queanbeyan River.	0.6–0.85	Significantly impaired.
QBN 703	Wickerslack Lane, about 2 km downstream of the intersection of Googong Creek and Queanbeyan River.	0.6–0.85	Significantly impaired.

Table 11.5 Summary results of ecological health monitoring of Queanbeyan River relevant to planning of future discharges upstream of Wickerslack Lane

Site code and location	Autumn 2003		Autumn 2004		Autumn 2005		Autumn 2006	
	O/E Ratio	AusRivas Band	O/E Ratio	AusRivas Band	O/E Ratio	AusRivas Band	O/E Ratio	AusRivas Band
QBN 704 – 1 km downstream of Googong Dam	0.54	C	0.7	B	0.61	C	0.64	B
QBN 703 – Wickerslack Lane	OEM*	-	OEM	-	1.03	A	0.96	A

*OEM – outside the experience of the model

Broadly, these results indicate that there has not been a major decline (between 2003 and 2006) in ecological health at site QBN 704 downstream of the Googong Dam. However, river health does appear to improve further downstream at site QBN 703.

Although taxa richness results for the Queanbeyan River sites have been consistently low over the past few years, the exception has been the Wickerslack Lane site (QBN 703) where, during autumn 2005, nine more taxa were recorded in 2003 and 2004 – a total of 23 taxa. This was reflected in the O/E value of 1.03, which gives the site a 'reference condition' health rating (Band 'A').

In contrast, in 2005, site QBN 704, which is one kilometre downstream of Googong Dam, recorded a much lower diversity (13 taxa) and a greater number of predicted missing taxa (seven missing taxa including six from the sensitive taxa groups). This resulted in an AusRivas 'C' band classification and a health rating of 'severely impaired compared to reference condition' with fewer taxa recorded than expected'. However, the condition at QBN 704 improved to the 'B' band in 2006.

Further details, such as composition of the detected macroinvertebrate taxa (family, genus, and species) and 'missing taxa' at each of the monitored sites are provided in the series of Ecowise reports (Ecowise, 2008) (refer Appendix F). These are important for comparison in any future monitoring of potential impacts.

Riparian and aquatic vegetation

NSW Fisheries has advised that the degradation of native riparian vegetation is listed as a key threatening process by the *Fisheries Management Act 1994*.

Several of the watercourses within the Googong development area contain steeply sloping banks and are more densely vegetated than the surrounding farmland (see Figure 7.1). These areas act as wildlife corridors accommodating many varieties of native animals, and are considered both visually and environmentally sensitive.

A physical habitat assessment was conducted as part of the ecological health monitoring. It considers physical site characteristics that indicate 'ecological health', including: riparian vegetation and macrophytes (aquatic plants that grow in or near water). Results of the habitat assessment are shown in Table 11.6.

Table 11.6 Status of riparian and macrophytes at Queanbeyan River sites

	2005	2006	2005	2006
	QBN 704		QBN 703	
Riparian vegetation				
Left bank width	3	20	10	20
Right bank width	10	15	2	5
Vegetation type % cover of riparian zone				
Trees (>10 m height)	10	5	10	10
Trees (<10 m height)	40	35	85	60
Shrubs	5	10	5	40
Grasses/ferns/sedges	60	40	40	40
Shading of river %	6–25	6–25	6–25	6–25
Native vegetation %	60	75	90	90
Exotic vegetation %	40	25	10	10
Bare ground above water mark, left bank %	40	10	10	5
Bare ground above water mark, right bank %	40	30	5	10
% Reach covered by				
Periphyton %	<10	35-65	<10	<10
Moss %	<10	<10	<10	<10
Filamentous Algae %	<10	<10	<10	<10
Macrophytes %	65-90	65-90	<10	<10
Macrophytes				
Submerged/floating	<i>Potamogeton</i>	<i>Potamogeton</i>		
Emergent	<i>Typha orientalis</i>	<i>Eleocharis, Juncus, Typha orientalis</i>	<i>Cyperus Juncus, Typha schaeenoplectus</i>	<i>Cyperus, Typha, Persicaria</i>

Source: Ecowise, 2008.

The physical site assessment results indicate relatively healthy macrophytes and native tree cover associated with both monitoring sites. Although this information is somewhat variable and dependent on site specific features (such as pools, riffle zones and sand bars) they are useful as 'baseline' for any future monitoring of potential impacts of the discharges to the Queanbeyan River at the proposed site.

11.2.3 Construction impacts and mitigation measures

Potential impacts

The majority of potential construction impacts relevant to aquatic ecology have been addressed in earlier sections of this report (see Section 7.4).

An indirect impact on aquatic ecology could result from increased soil erosion, runoff and sedimentation from construction areas. Erosion can lead to the degradation of soil substrates, the smothering of riparian and aquatic vegetation, and eutrophication (eutrophication describes the over-fertilisation of waterways with nutrients and the changes that occur as a result). This has the potential to degrade local water quality and impact on the quality of aquatic habitats.

Mitigation and management measures

To mitigate potential impacts during construction, the following measures would be implemented:

- In areas of highly erodible stream banks within the study area, riparian zones would be revegetated with species of local provenance to increase stability.
- Sediment and erosion control measures would be implemented.
- Riparian buffer zones would be implemented and maintained along drainage line corridors within the study area to ensure future development does not result in any harmful impacts. The appropriate buffers have been defined in consultation with the Department of Water and Energy and are incorporated into the masterplan for Googong township.

11.2.4 Operational impacts and mitigation measures

Key issues

The key aspect of the existing environment to note regarding the potential operational impacts on aquatic ecology is that Googong Creek and Montgomery's Creek are ephemeral drainage lines that do not flow throughout the majority of the year. Both creek systems have been affected by a history of agricultural land use in the area. The proposed stormwater management system (incorporating water-sensitive urban design measures addressing both Googong Creek and Montgomerys Creek catchments) would provide increased water quality outcomes for a range of parameters (see Table 7.3).

In assessing the potential operational impacts of the Project on aquatic ecology, the following key issues were considered, taking into account operational impacts on water quality and hydrology (Section 7.5):

- Impacts of increased water flow on aquatic flora and fauna in the Queanbeyan River.
- Impacts of any changes in water quality on aquatic flora and fauna in the Queanbeyan River.
- Management of riparian vegetation, weeds and invasive scrub in Googong Creek and Montgomery's Creek.

Impacts of changes to water flow on aquatic ecology

Changes to surface water flows are covered in Section 7.5.4. During low flow periods (summer and autumn) there would be little change to the existing ecology of the Googong Creek. Periods of low-flow are an integral part of the life cycle of some aquatic species, and can also represent periods of stress for

many stream biota (CRC, 2004). In winter, due to higher variability and flow rate, changes in aquatic ecology are likely to be minor. There would be a typical shift from lentic (standing water) to lotic (running water) species, an increase in riparian vegetation, as well as an increase in numbers and biomass of macroinvertebrates and the fish that rely on them for food (CRC, 2004).

Regular monitoring at the site where the Googong Creek meets the Queanbeyan River would occur throughout the construction and operational stages of the Project.

Impact of change in water quality on aquatic flora and fauna

It has been concluded from modelling of key water quality parameters – such as nitrogen, phosphorus, total suspended solids and total dissolved solids (conductivity) – that potential changes to aquatic ecology, if they occur, are not likely to be significant (Browns, 2010 and Agsol, 2010). These parameters would be regularly monitored throughout the operational stages of the Project.

As discussed in Section 7.1, the potential impacts on water quality relate mainly to the minor increases in the quantities of nitrogen and phosphorus being discharged into the Googong Creek and Queanbeyan River after treatment through the integrated water cycle. Given that the increase in nutrient loads are minor, and that the timing of discharge generally correlates with existing flows in the Googong Creek, there is only a small possibility that the change would have an impact on algal blooms and aquatic weeds.

The other major parameter of water quality that has been modelled is salinity (conductivity). According to the ANZECC (2000) guidelines, salinity tolerance varies significantly between aquatic species. Literature and previous studies suggest that adverse biological effects are likely to occur (in Australian rivers) if salinity is increased to around 1000mg/L total dissolved solids (Agsol, 2010). It should be noted that aquatic and riparian plants become salt sensitive with salinities of 1000 to 2000mg/L. As discussed in Section 7.5.3, the average salt concentration in the recycled water is 660mg/L, which would then be diluted within the stormwater system prior to discharge into Googong Creek (Figure 7.5 shows the seasonal levels of dilution).

The risk of discharge of untreated effluent to the environment is considered low and only related to emergency events (concurrent failure of the primary system and back-up system). Specifically, emergency storage is provided at SPSs and at the WRP (see Section 5.3.3). In addition, the layout of the WRP has been designed to allow for a flow control facility to be constructed in the future, if required. As noted in Chapter 5, wet weather flows would be treated in the same manner as dry weather flows by the WRP negating consideration of wet weather bypass situations.

Management of riparian vegetation, weeds and invasive scrub in creeks

The overhanging vegetation associated with Googong Creek downstream of the site includes several invasive species, which could potentially spread by seed dispersal via discharged water flow. These need to be surveyed, mapped and managed by selective removal. Of particular note are large bushes of African Boxthorn (*Lycium ferocissimum*), which are spread along the creek. These measures can be integrated with other assessments that may be required before the creek is used for any discharges.

Weed management and bush regeneration measures would occur throughout the study area in accordance with landscape and stormwater management plans to ensure that invasive species are discouraged within Montgomery's Creek, Googong Creek and other watercourses (Chapter 7 of Appendix F discusses management measures for invasive species).

11.2.5 Proposed monitoring

In order to monitor potential ongoing impacts on aquatic ecology through construction and during operation, a monitoring site would be located where Googong Creek meets the Queanbeyan River (see Figure 7.3). Section 7.3 details the water quality monitoring that would be undertaken at this site. The site would also monitor aquatic ecology and would commence about 12 months prior to construction to ensure sufficient data is collected. This is proposed as it is an important aspect of the adaptive management process and would guide mitigation measures during construction and operation, as it allows for the results of the monitoring to influence what measures should be implemented.

11.2.6 Conclusion

The potential construction and operational impacts of the Project on aquatic ecology would not be significant and would be mitigated through appropriate measures.

The parameters specified in the DGRs relating to aquatic ecology have been assessed and monitored to understand the existing aquatic environment. Ongoing monitoring would occur to ensure that the quality of the existing environment is maintained and that management measures are adapted accordingly.

Mitigation and management measures are reinforced in the statement of commitments (A1, A2 and WQ1–WQ5) in Chapter 18.