# 8. Ecology

This chapter summarises the Ecological Impact Assessment report prepared for the project and included in Appendix C. The report addresses the Director-General's Requirements (DGRs) relating to ecology, which state that the Environmental Assessment must satisfy the requirements for flora and fauna impact assessment set out in the *Draft Guidelines for Threatened Species Assessment* (DEC/DPI, 2005).

Consideration was also given to the *Threatened Biodiversity Survey and Assessment Guidelines – Working Draft* (DEC 2004) with regards to the scope and timing of flora and fauna surveys.

## 8.1 Existing environment

### 8.1.1 Methodology

This section summarises the methods employed in the ecological impact assessment, including:

- Desktop assessment of available information, including previous reports and databases;
- Assessment of conservation significance of the flora and fauna and habitats of the study area;
- Site surveys were conducted in July and September 2009;
- Assessment of impacts according to published NSW and Commonwealth guidelines and relevant legislation; and
- Determination of appropriate measures to avoid, minimise or offset potential impacts on flora and fauna.

The methods employed for the field surveys are summarised below.

### 8.1.2 Site surveys

***Terrestrial ecology***

Two terrestrial flora and fauna surveys were performed: a preliminary survey and vegetation mapping exercise from 20-24 July 2009; and a targeted spring survey between 8 - 18 September 2009. This staged approach allowed for the spring survey effort and method to be designed around information collected in the preliminary survey.

The location of field survey quadrats and significant species, habitat and communities were captured with a handheld GPS unit. Survey effort summarised in Table 8-1. Full details of the field survey methodology are provided in Appendix C.

**Table 8-1 Terrestrial ecology survey methods**

| Field Survey | Date | Purpose | Methodology |
|---|---|---|---|
| Preliminary survey and Inland Grey Box Woodland mapping | 20-24 July 2009 | Map extent of Grey Box woodland EECs.<br>Survey for threatened species or their habitats. Preliminary flora and fauna surveys. | Vegetation mapping to ground-truth available vegetation mapping; habitat assessment; random meander flora surveys; diurnal bird counts; and opportunistic fauna observations. |
| Impact assessment survey and spring flora and fauna survey | 8-18 September 2009 | Targeted flora and fauna surveys.<br>Quantify direct impacts within the construction footprint for the project.<br>Determine if threatened species or their habitats occur or are likely to occur at the Forest.<br>Identify and describe sensitive receptors for operational (flooding) impacts.<br>Map ecosystem type, conservation significance and likely response to flooding. | Habitat assessment; refine vegetation mapping; systematic quadrat-based flora surveys; modified Biometric quantitative habitat assessments; diurnal bird counts; spotlighting; call playback; Anabat recording; harp trapping; active herpetofauna searches; motion-detecting camera surveys; and opportunistic fauna observations. |

***Aquatic ecology***

No targeted aquatic ecology site surveys were performed for this assessment due to the following considerations:

- Floodplain marshes and drainage lines at the Forest were dry throughout the period of this assessment and have been for many years;
- Extensive surveys of the Murray River adjacent to the Forest and comparable floodplain wetlands in the Central Murray have previously been conducted by academic institutions and Government agencies, particularly in connection with Icon Site assessments; and
- GIS analysis and hydrological modelling has been conducted across the entire site and is likely to provide a more accurate and comprehensive understanding of floodplain inundation than a field survey.

The available information, modelled data and habitat assessments are considered to be adequate for the purposes of assessing potential impacts on aquatic ecosystems.

### 8.1.3 Conservation significance

The conservation status of species and communities recorded across the study area was determined with reference to the following:

- The NSW *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* for State significance; and
- The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for National significance.

### 8.1.4 Study area definitions

The following terms are used in this chapter to describe the area of investigation for the Ecological Impact Assessment:

- '*the project'*: the proposed Koondrook-Perricoota Forest Flood Enhancement Works;
- '*the Forest'*: the area potentially affected by the construction and operation of the project including the Koondrook and Perricoota State Forests and the former Toorangabby property;
- '*study area'*: the area covered by the current assessment, including the Forest, surrounding areas, and portions of the natural environment potentially affected by the project and addressed in the literature review for this assessment;
- '*locality*': the area bounded by a ten kilometre radius around the site, which is used for database searches of previous threatened species records.

## 8.2 Existing flora

### 8.2.1 Flora species

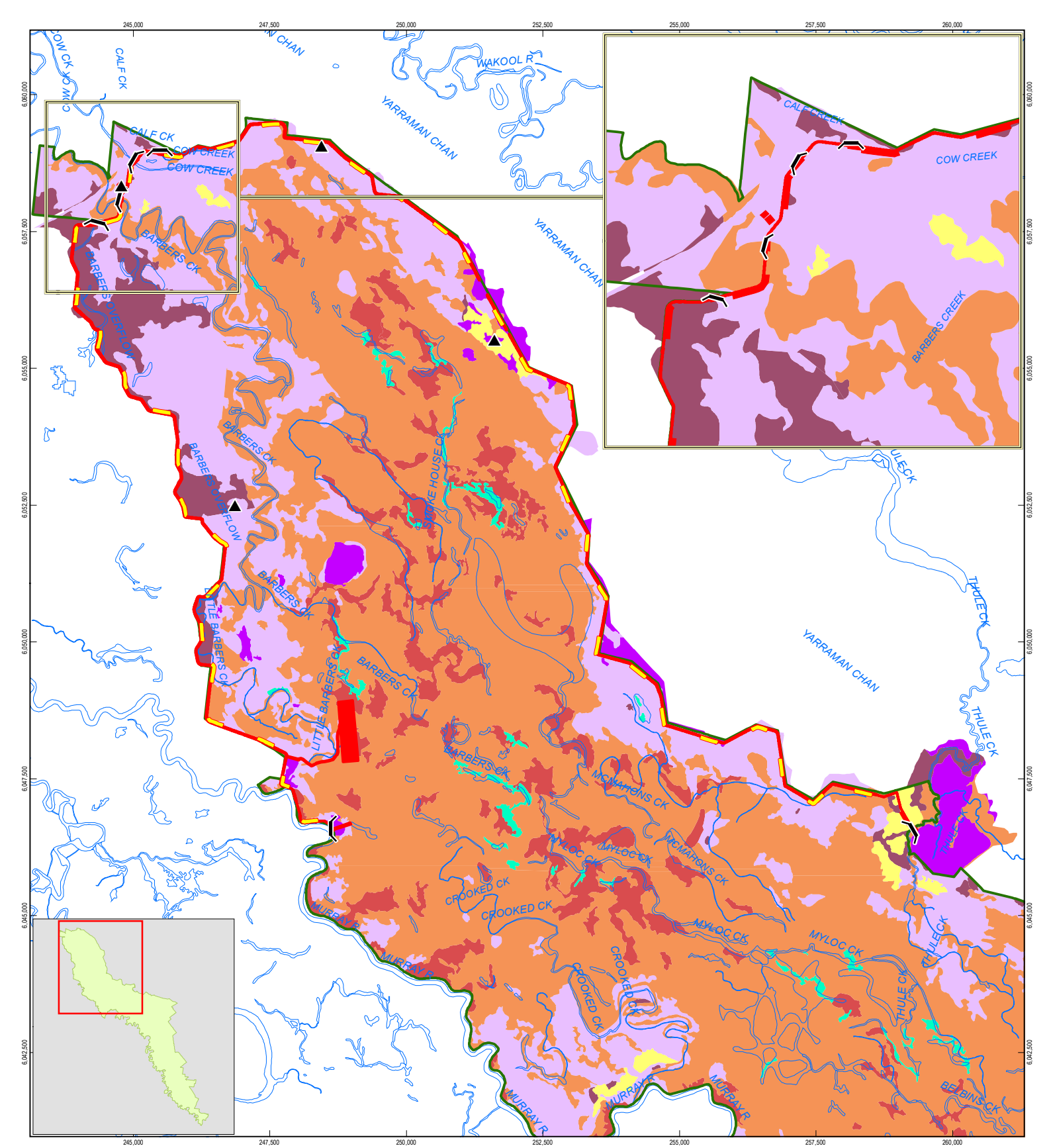
A total of 147 plant species (86 native) were recorded during the field survey. The Forest contains a large number of annual or ephemeral plant species and so species diversity would vary considerably throughout the year and between seasons. The Forest would also support a diverse assemblage of wetland and aquatic plant species during wet periods.

None of the flora species recorded is listed as threatened under the TSC and/or EPBC Acts. A number of other plant samples were only identified to Genus level because they did not have sufficient fertile material to permit identification. None of these samples are in the same Genera as any threatened plants that could potentially occur at the Forest.

The total plant species list recorded during the field survey is presented Appendix C.

### 8.2.2 Vegetation communities

Vegetation communities mapped within the upstream and downstream sections of the Forest are shown on Figure 8-1 and Figure 8-2**,** respectively and described below. The distribution of EECs recorded and mapped within the upstream and downstream sections of the Forest is presented in Figure 8-3 and Figure 8-4**.**




## Legend

- Turkey's nest dam
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

### Vegetation Types (Benson, 2006)

- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 250: Derived tussock grasslands

0 0.5 1 2
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Job Number 21-18573
Revision C
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# Figure 8.1 - Vegetation - downstream section

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

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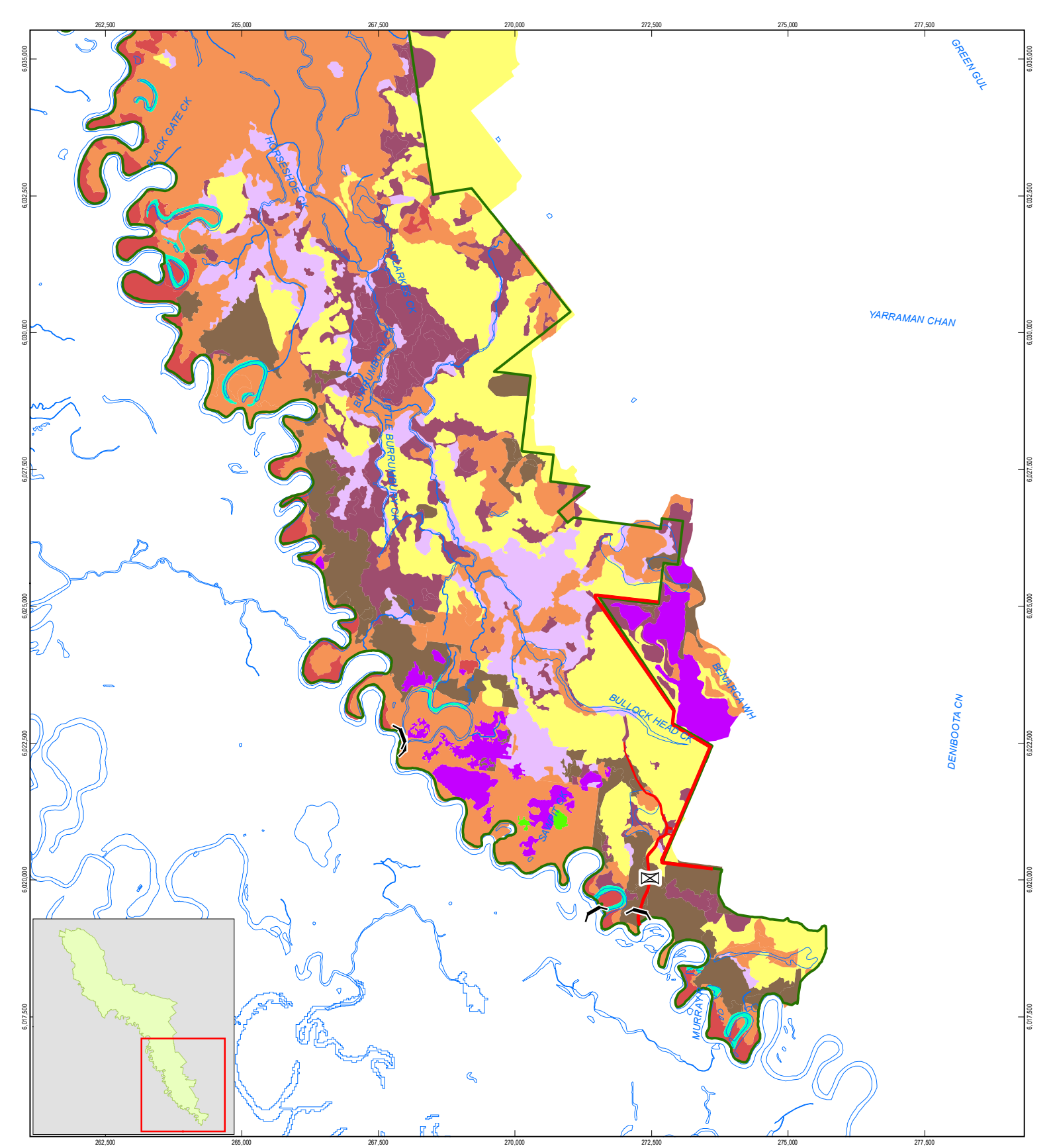
Data source: Forest NSW, DECCW, MWWG, StreetMap - Navigate, Drawn: Cwilson, cwilson




## Legend

- River Road bridge
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

### Vegetation Types (Benson, 2006)

- Comm ID 19: Cypress Pine woodland of dunes
- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 237: Riverine Inland Grey Box grassy woodland
- Comm ID 250: Derived tussock grasslands

0 0.5 1 2
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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| Job Number | 21-18573 |
| Revision | C |
| Date | 11 FEB 2010 |

# Figure 8.2 - Vegetation - upstream section

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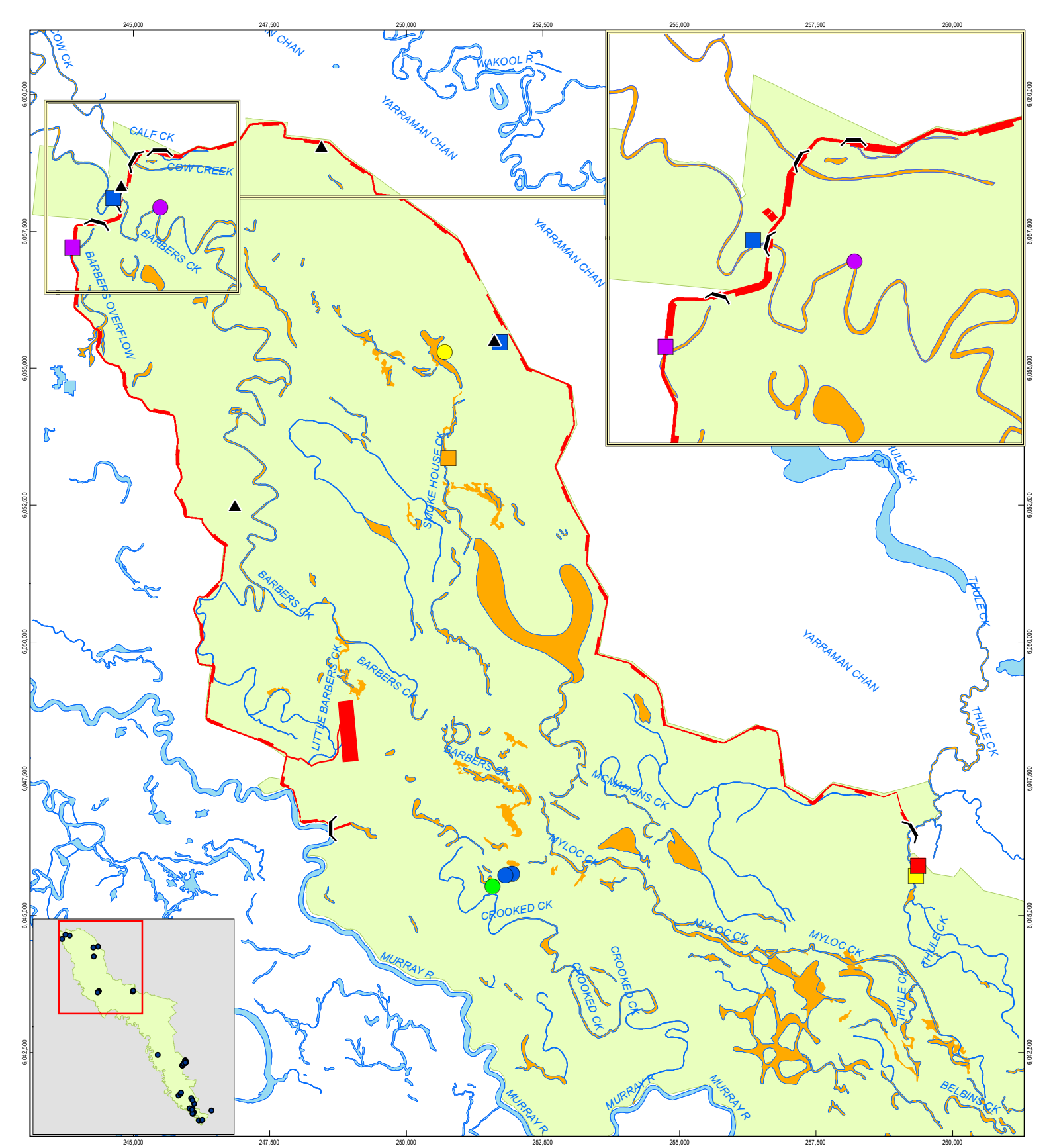
Data source: Forest NSW, DECCW, MWWG, StreetMap - Navigate, Drawn: Cwilson, cwilson




## Legend

- Turkey's nest dam
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

**Threatened species recorded at the site**

- Bush Stone Curlew
- Diamond Firetail
- Gilbert's Whistler
- Hooded Robin
- Large-footed Myotis (possible)
- Little Pied Bat (possible)
- Scarlet Robin
- Varied Sittella
- White-browed Woodswallow

- Murray River EEC

1:65,000 (at A3)

0 0.5 1 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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# Figure 8.3 - Conservation significance - downstream section

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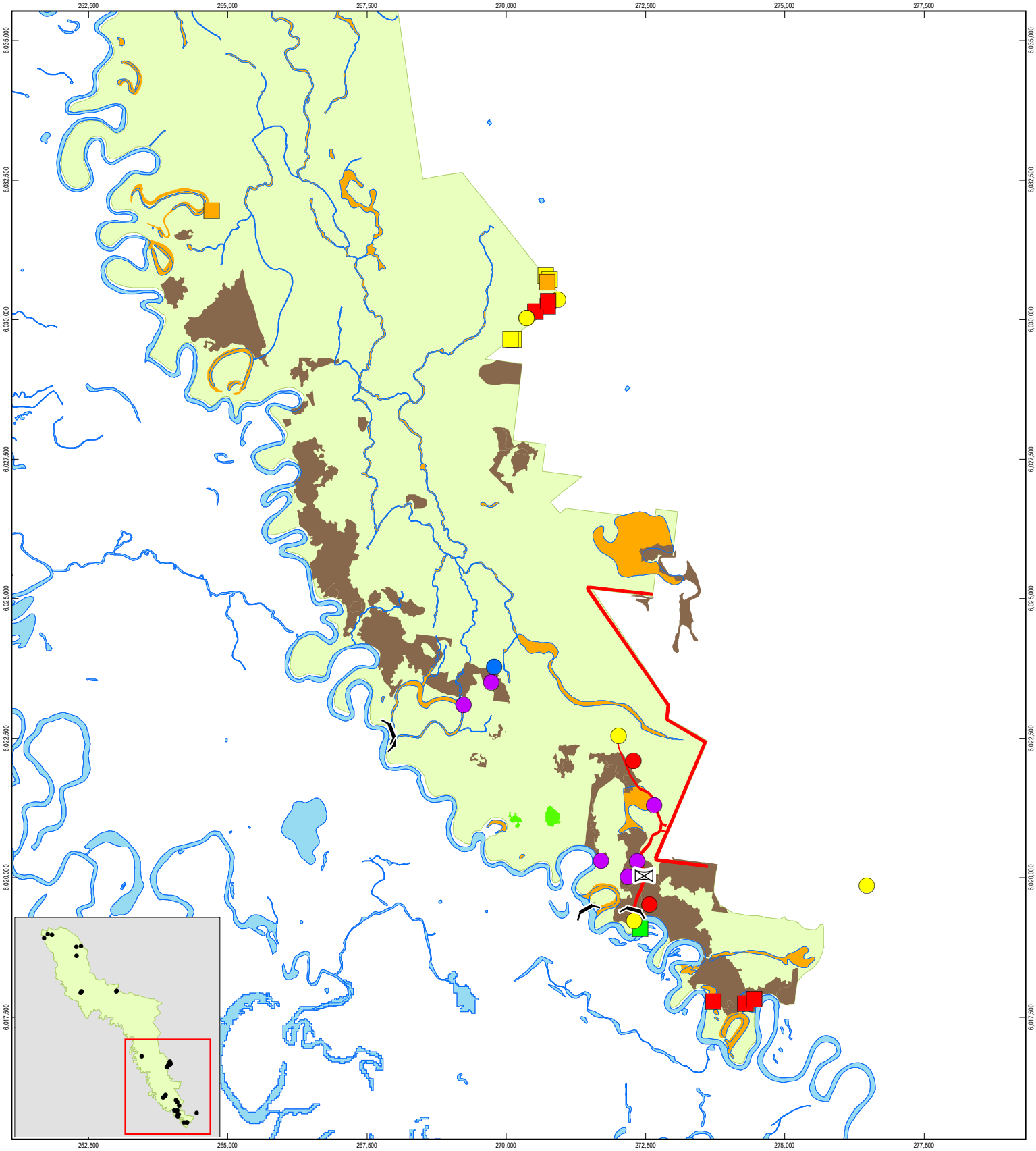
Data source: StreetMap - Navegate, Drawn: Cwilson, cwilson




## Legend

- River Road bridge
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

**Threatened species recorded at the site**

- Australasian Bittern
- Bush Stone Curlew
- Diamond Firetail
- Gilbert's Whistler
- Hooded Robin
- Large-footed Myotis (possible)
- Little Pied Bat (possible)
- Scarlet Robin
- Squirrel Glider (possible)
- Varied Sittella
- White-browed Woodswallow

- Murray River EEC
- Inland Grey Box Woodland EEC
- Sandhill Pine Woodland EEC

1:65,000 (at A3)

0 0.5 1 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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|---|---|
| Job Number | 21-18573 |
| Revision | B |
| Date | 11 FEB 2010 |

# Figure 8.4 - Conservation significance - upstream section

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Data source: StreetMap - Navegate, Drawn: Cwilson, cwilson

The majority of the Forest is covered by native vegetation. It is subject to ongoing disturbance from timber harvesting, road maintenance, grazing and other activities. As a result, t the vegetation communities feature a variety of successional stages and condition classes.

Broad vegetation types recorded at the Forest include:

- River Red Gum Forests;
- River Red Gum Woodlands;
- Black Box Woodlands;
- Inland Grey Box Woodland;
- Floodplain marshes;
- Sandhill Woodlands; and
- Derived Grassland and Herbland.

Detailed descriptions of the structure and floristics of these vegetation communities are provided in Appendix C and summarised below.

***River Red Gum Forest***

This broad vegetation type is comprised of three Benson (2006) vegetation communities:

- Community ID 2: River Red Gum-sedge dominated tall open forest in frequently flooded sites of the semi-arid warm climate zone.
- Community ID 5: River Red Gum herbaceous-grassy tall open forest of the inner floodplains of the lower NSW Southwest Slopes and Riverina Bioregions.
- Community ID 7: River Red Gum – herbaceous tall open forest mainly in the Riverina Bioregion.

Vegetation Community 5 and 7 occur across much of the floodplain throughout the Forest with 2 and 5 occurring along flood runners and on the banks of the Murray River. In the Forest, this vegetation community features a mono-specific canopy of River Red Gum *Eucalyptus camaldulensis*, which varies in height from 20 m to 40 m, depending on logging history, effects of grazing, site fertility and hydrology. The forest canopy dominated by *E. camaldulensis* ranges from poor to good condition, and in many areas shows significant signs of dieback, particularly throughout the more inland areas, most likely owing to water stress. Pockets of dense *E. camaldulensis* regeneration are scattered throughout the Forest, owing primarily to silvicultural activities.

A small tree layer characterised by *Acacia dealbata* is sometimes present, but mainly only near the Murray River and associated flood runners. The shrub layer is generally sparse, but in localised areas can comprise relatively dense thickets of *Exocarpos strictus*. The condition and diversity of the ground layer varies considerably across the study area in response to timber harvesting disturbance and/or weed invasion. A mixture of native and exotic grasses are widespread and include *Austrodanthonia* spp., *Austrostipa* spp., *Lolium* sp., *Cynodon dactylon*, and *Hordium* spp. Common herbaceous species include *Daucus glochidiatus*, *Helichrysum scorpidoides*, *Atriplex* spp, *Einadia nutans*, *Ranunculus sessiflorus, Senecio quadridentatus*,

*Wahlenbergia* spp., *Crassula* spp. and *Vittadinia* spp. Common weeds include *Echium plantagineum*, *Fumaria* spp., *Marrubium vulgare*, *Medicago* spp*., Stellaria media* and *Trifolium* spp.

Flood runners throughout the Forest generally have an open grassy habit with high weed invasion of grasses and herbs, bordered by large mature *E. camaldulensis*, which usually contain numerous hollows.

This vegetation community contains a relatively high number of hollow bearing trees and stags, though the number and locations of these have been influenced by both historic and more recent forestry practises. An average of three hollow bearing trees was recorded per 20 x 50 m quadrat on the floodplain, and 3.6 along flood runners and banks of the Murray River.

A number of the regulators as well as an extensive length of the downstream levee occur within this community.

***River Red Gum Woodland***

This broad vegetation type is comprised of three Benson (2006) vegetation communities:

- Community ID 7: River Red Gum – herbaceous tall open forest mainly in the Riverina Bioregion.
- Community ID 8: River Red Gum – Warrego Grass – Couch Grass riparian tall woodland of the semi-arid (warm) climate zone.
- Community ID 9: River Red Gum – wallaby grass tall woodland on the outer River Red Gum zone in the semi-arid (warm) climate zone.

River Red Gum Woodlands include vegetation types where *E. camaldulensis* and *E. largiflorens* co-occur. In the Forest, this vegetation community occurs on slightly higher elevations with intergrades between communities occurring along their margins. River Red Gum Woodland features a canopy of *E. camaldulensis* with influences of *E. largiflorens* occurring in parts, and varies in height from 16 m to 25 m depending on timber harvesting history, effects of grazing, site fertility and hydrology. The canopy ranges from poor to good condition with areas dominated by *E. camaldulensis* showing signs of stress whilst *E. largiflorens* appears generally in good condition. Regeneration in this community is less than within the forest community primarily owing to a lack of disturbance.

River Red Gum Woodland is largely devoid of a shrub layer although the shrub Weeping Pittosporum (*Pittosporum phylliraeoides*) occurs sporadically. The condition and diversity of the ground layer varies considerably across this community in response to timber harvesting disturbance, drought and/or weed invasion. A mixture of native and exotic herbs are abundant within this community and include *Crasula* spp., *Vittadinia* spp., *Cotula australis, Cotula bipinnata, Rhodanthe corymbiflora, Calandrinia eremaea*, and *Einadia nutans* with grasses including *Austrodanthonia* spp., *Cynodon dactylon, Austrostipa* spp., and *Lolium* sp., also occurring in varying densities. Areas of more open woodland dominated by River Red Gum contained higher densities of herbs and grasses than areas abutting *E. largiflorens* communities. This is most likely due to availability of light and hydrological factors.

River Red Gum Woodlands generally contain a high number of hollow bearing trees and stags per number of trees present, although average number of hollow bearing trees recorded per quadrat (2.25) was slightly less than for the River Red Gum Forest.

A number of regulators as well as a proportion of the downstream levee occur within this community.

***Black Box Woodland***

This vegetation community is composed of one vegetation type, as identified by Benson (2006):

- Community ID 13: Black Box – Lignum woodland of the inner floodplains in the semi-arid (warm) climate zone.

This vegetation community is dominated by Black Box and varies in height from 10 m to 20 m. High levels of coarse woody debris were present in some areas. The forest canopy dominated by Black Box is generally in good condition, probably owing to its greater drought tolerance when compared with River Red Gum. Pockets of dense Black Box regeneration are scattered throughout the study area. The shrub layer is generally sparse; however, in some areas *Muehlenbeckia florulenta* can be locally abundant. The condition and diversity of the ground layer varies across the study area but can be relatively herb-rich in areas though abundance is often low owing to the dry conditions. Common species include *Crassula* spp., *Enchylaena tomentosa*, *Marselia drummondii*, *Sclerolaena muricata* and *Einadia nutans*. The bryophyte cover is often relatively abundant, suggesting little disturbance to the ground layer. Weed cover is usually low to moderate.

This vegetation community contains a high number of hollow bearing trees; however, the size of hollows present within this community is generally small, owing to the nature of the tree species. The average number of hollow bearing trees recorded per quadrat was 4.5, higher than eucalypt forests largely due to a higher density of mature trees per quadrat which is related to the nature of the community and its timber harvesting history.

A considerable length of the downstream levee occurs within this community.

***Inland Grey Box Woodland***

This vegetation community is comprised of one vegetation classification group as identified by Benson (2006):

- Community ID 237: Riverine Inland Grey Box Grassy Woodland of the semi-arid (warm) climate zone.

Within the Forest, this vegetation community is dominated by Inland Grey Box *Eucalyptus microcarpa*, and varies in height from 20 m to 30 m. *Eucalyptus camaldulensis* is usually a co-dominant species, while *E. largiflorens* may also be present. The forest canopy dominated by *E. microcarpa* is generally in moderate to good condition with little to no signs of dieback within either of the canopy species of this community. Localised areas of dense *E. microcarpa and E. camaldulensis* regeneration are present within the study area. The shrub layer is generally sparse however dense patches of *Exocarpus stricta* occur along flood runners and sections of the community close to the edge of the Murray River. The condition and diversity of the ground layer varies across the study area, but generally comprises a range native and exotic annual and perennial herbs including *Einadia nutans, Encholaena tomentosa, Sclerolaena muricata,*

*Rhodanthe corymbiflora, Crassula* spp., *Cotula* spp., *Carex sp., Brachycome basaltica*, and *Myosurus minimus*. Weed cover is usually low to moderate.

Inland Grey Box Woodland within the Forest is consistent with the endangered ecological community (EEC) Inland Grey Box Woodland, which is listed under the TSC Act. This community is restricted to the eastern portion of the Perricoota State Forest, and is most extensive in the far south-eastern portion. It is associated with higher ground, on terraces at higher elevations, including on the natural levee adjacent to the Murray River.

Inland Grey Box Woodland contains a comparatively low number of hollow bearing trees, with an average number of one hollow bearing tree recorded per quadrat.

The locations of the inlet channel and River Road Bridge occur within this community.

***Sandhill Pine Woodland***

Sandhill Pine Woodland occurs as small fragmented and highly disturbed stands on the Bonum and Little Bonum Sandhills. The community stands at approximately 15 – 20 m in height and is dominated by Cypress Pine (*Callitris* spp.), with Grey Box and River Red Gum occurring less frequently. However, some stands lack a canopy stratum and only consist of a mixed ground layer of characteristic species present. The Cypress Pine is generally mature in age, with little to no signs of recruitment or regeneration. The shrub layer is generally absent. The condition and diversity of the ground layer varies across the study area, but is generally dominated by exotic grasses and weeds with some native herbs and grasses persisting depending on disturbance history. Dominant groundcover species include Stinging Nettle (*Urtica urens*), Cape Daisy (*Arctotheca calendula*), Small flowered Mallow (*Malva parviflora*), Squirrel-tailed Fescue (*Vulpia bromoides*), Patterson's Curse (*Echium plantagineum*), and Barley Grass (*Hordeum* sp.) with some sites also containing Flannel Cudweed (*Actinobole uliginosum*), Midget Greenhood (*Pterostylis mutica*) and *Crassula* spp. in higher densities.

Within the Forest, this community is in a highly disturbed state and is subject to high levels of weed infestation and impacts through clearing and grazing.

This vegetation community contains a low number of hollow-bearing trees with an average number of two hollow bearing trees recorded per 20 x 50 m. The hollows present are generally small, or occur within co-dominant Grey Box or River Red Gum trees.

There are no Sandhill Woodlands in the vicinity of the construction footprint and they occur on higher ground that would not be affected by the proposed flooding of the Forest (refer Section 8.5).

***Floodplain marshes***

The majority of Floodplain Marshes within the Forest were dry during the survey and contained terrestrial herbs and grasses equivalent to areas of Derived Grassland and Herbland described below. There were occasional stunted, terrestrial forms of wetland herbs such as Nardoo and *Triglochin* spp. as well as dormant rhizomes of sedges. In this condition it was not considered appropriate to describe or assess these communities in detail.

There were some Floodplain Marshes containing water in the southeast of the Perricoota Forest which appeared to be permanent wetlands associated with the weir pool above Torrumbarry Weir. There were two main types of marshes:

- Deeper wetlands with fringing reed beds of Narrow-leaved Cumbungi (*Typha domingensis*) surrounding open water areas with Ribbonweed (*Vallisneria americana*), Water-ribbons (*Triglochin procerum*) and Nardoo (*Marsilea drummondii*); and
- Shallow, closed wetlands vegetated with Water Pepper (*Persicaria hydropiper*), Common Couch (*Cynodon dactylon*), Water Couch (*Paspalum distichum*), Nardoo and Common Spike Rush (*Eleocharis acuta*).

***Derived grassland and herbland***

Dry-land, treeless communities within the Forest are the result of historical clearing of woodland and forest and subsequent suppression of regeneration by grazing. These areas are collectively described as 'Derived Grasslands and Herblands'. There are small clearings throughout the Forest associated with old log dumps, stock yards, water storages or camp sites. The largest clearings are generally associated with sandhills and represent highly modified forms of Sandhill Woodlands. Extensive areas of the former Toorangabby property contain grasslands derived from clearing of River Red Gum Forest and box woodlands.

The structure and species composition of Derived Grassland and Herbland varies significantly across the Forest in response to factors such as management history, geomorphology, hydrology and current site use. The field survey aimed to sample community variation to contribute to the overall plant species list for the Forest and to determine the conservation significance of Derived Grassland and Herbland within construction footprints. Examples included:

- Herbland – Occurs within cleared or open areas of River Red Gum woodland or modified Black Box woodland, and contains a high number of native and exotic herb species with a lower number of grasses and included such species as *Vittadinia cunneata, Vittadinia gracilis, Cotula bipinnata, Cotula australis, Einadia nutans, Atriplex* sp*., Trifolium* spp. and *Austrodanthonia* sp. Examples of this community can be found at the northern extent of the Forest near Cow Creek.
- Grassland – Occurs on cleared sandhills and within some areas of cleared open River Red Gum forest and woodland, and contains a mixture of native and exotic grasses with a low number of herbs including *Austrostipa* spp., *Austrodanthonia* sp., Barley Grass (*Hordeum* sp.) and Squirrel-tailed Fescue (*Vulpia bromoidies*). Examples of this community can be found on Toorangabby and on Bonum and Little Bonum Sandhills.
- Sedgeland - Occurs within areas of low lying depressions within the floodplain, including within dry flood runners and low lying swamp areas, and contains a mixture of sedges, grasses, and weeds including *Juncus* spp., *Carex* spp., and *Phragmites australis* and may be edged by *Exocarpus stricta*. Examples of this community can be found adjacent to the inlet regulator and in flood runners within Swan Lagoon and along Cow and Calf Creek.

This community mainly occurs as isolated pockets on clear, higher ground surrounded by forest, such as on sandhills and also as extensive areas in the former Toorangabby property where clearing has taken place. There are occasional isolated remnant trees, including Grey Box, River Red Gum, White Cypress (*Callitris glaucophylla*) and Bulloak (*Allocasuarina leuhmannii*) associated with adjacent communities.

### 8.2.3 Noxious weeds

The Forest contains six species declared as noxious weeds in Murray and Wakool LGAs as shown in Table 8-2 below.

**Table 8-2 Declared noxious weeds recorded during field surveys**

| Scientific Name | Common Name | Control category |
|---|---|---|
| *Lycium ferocissimum* | African Boxthorn | 4 |
| *Xanthium spinosum* | Bathurst Burr | 4 |
| *Rubus fruticosus* | Blackberry | 4 |
| *Asparagus asparagoides* | Bridal Creeper | 5 |
| *Marrubium vulgare* | Horehound | 4 |
| *Echium plantagineum* | Patterson's Curse | 4 |

Landowners and occupiers must control noxious weeds according to the control category specified in the *Noxious Weeds Act 1993.* Public authorities must control noxious weeds according to the control category to the extent necessary to prevent their spread to adjoining land.

For Category 4: 'the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority'. For Category 5: 'the requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with'.

## 8.3 Existing fauna

### 8.3.1 Fauna species

At least 144 vertebrate fauna species were recorded at the Forest during the site surveys, comprising:

- A high diversity (108 native species) of native birds, including four threatened species (Gilberts Whistler, Hooded Robin, Diamond Firetail and Australasian Bittern) and a further three species which are subject to a preliminary determination for listing under the TSC Act (Varied Sittella, Scarlet Robin and White-browed Woodswallow);
- A high diversity (15 species) of microbats, including 'possible' recordings of the threatened Large-footed Myotis (*Myotis macropus*) and Little Pied Bat (*Chalinolobus picatus*);
- A moderate diversity (10 species, 3 native) of terrestrial mammals;
- A moderate diversity (at least 3 species) of arboreal mammals. One glider (*Petaurus* sp.) recorded by spotlight may have been a threatened Squirrel Glider;
- A low diversity (6 species) and abundance of reptiles, probably attributable to the relatively cool weather during the survey;

- A limited diversity of frogs (3 species), low abundance and limited calling activity, probably attributable to the relatively cool weather during the field surveys and extended dry period preceding the field survey.

The full list of fauna species recorded during site surveys is presented in Appendix C, along with their conservation status and the broad habitat types in which they were recorded.

A greater diversity of fauna species was recorded during the current site surveys than in previous studies summarised by Webster (2008), however the overall number of species at the Forest is likely to be even greater. Fauna species records are summarised below, along with an assessment of previous records and the likely species richness of the Forest.

***Forest and woodland birds***

A relatively high diversity of native forest and woodland birds was recorded at the Forest (86 species) from a range of guilds (i.e. species with different niches or lifestyles). The number of both guilds and species recorded confirms that the study area contains valuable habitat resources, which support a diverse range of species requiring differing habitat attributes (Keast *et al*., 1985). Guilds and species observed included:

- Small insectivorous birds of woodland and forest canopies were recorded in large numbers across the Forest, such as several thornbill (*Acanthiza*) species, Weebill (*Smicrornis brevirostris*), Rufous Whistler (*Pachycephala rufiventris*) and Striated Pardalote (*Pardalotus striatus*);
- Small insectivorous birds of woodland and forest understoreys, such as White-browed Scrubwrens (*Sericornis frontalis*) and Superb Fairy-wrens (*Malurus cyaneus*). These were recorded less frequently, and were generally restricted to areas with dense understorey;
- Large, communal open forest and woodland birds such as the Little Raven (*Corvus mellori*) Australian Magpie (*Gymnorhina tibicen*) and White winged Chough (*Corcorax melanorhamphos*);
- A limited diversity of forest and woodland honeyeaters, dominated by large numbers of White-plumed Honeyeaters (*Lichenostomus penicillatus*) and occasional Brown-headed Honeyeaters (*Melithreptus brevirostris*). Little Friarbirds (*Philemon citreogularis*) and Noisy Friarbirds (*Philemon corniculatus*) occurred in River Red Gum Forests near the Murray River;
- Large granivorous birds, including the Sulphur-crested Cockatoo (*Cacatua galerita*), Galah (*Cacatua roseicapilla*) and Little Corella (*Cactua sanguinea*) which were noted roosting in very large numbers in River Red Gums. These species are likely to obtain a large proportion of their foraging resources from agricultural land outside the Forest;
- A moderate diversity of smaller parrots, including the Cockatiel (*Nymphicus hollandicus*) and Red-rumped Parrot (*Psephotus haematonotus*). Some individuals were noted roosting in hollows at the Forest;
- A diverse range of raptors, including species of open country such as the Nankeen Kestrel (*Falco cenchroides*) and Wedge-tailed Eagle (*Aquila audax*), woodlands and forests – the Brown Goshawk (*Accipiter fasciatus*) and Peregrine Falcon (*Falco peregrinus*), riparian

forests – the Grey Goshawk (*Accipiter novaehollandiae*) and wetlands - Swamp Harrier (*Circus approximans*) and Whistling Kite (*Milvus sphenurus*); and

- Nocturnal, predatory species, including large numbers of the Southern Boobook (*Ninox novaseelandiae*) and Tawny Frogmouth (*Podargus strigoides*).

Additional species within the Forest are likely to include cryptic species, migratory species and threatened species with limited population sizes and or distributions in the study area.

***Wetland birds***

A moderate diversity (22 species) of wetland birds was recorded at the Forest, including:

- Waterfowl such as the Australian Wood Duck (*Chenonetta jubata*), Grey Teal (*Anas gracilis*) and Pacific Black Duck (*Anas superciliosa*);
- Waders such as the White-necked Heron (*Ardea pacifica*), White-faced Heron (*Egretta novaehollandiae*) and the threatened Australasian Bittern (*Botaurus poiciloptilus*);
- Grallinules such as Purple Swamphen (*Porphyrio porphyrio*), Eurasian Coot (*Fulica atra)* and Dusky Moorhen (*Gallinula tenebrosa*)*;* and
- Diving birds such as the Great Cormorant (*Phalacrocorax carbo*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), Little Black Cormorant (*Phalacrocorax sulcirostris*) and Darter (*Anhinga melanogaster*).

No Snipe (Scolopacidae spp.) were recorded and the only Shorebird (Recurvirostridae, Charadriidae spp.) observed was the opportunistic and widespread Masked Lapwing (*Vanellus miles*).

Wetland bird species were largely restricted to the Murray River riparian strip and floodplain wetlands associated with the weir pool above Torrumbarry Weir in the far southeast of the Forest. Extensive areas of wetland habitat were noted across the broader floodplain, however these areas were dry and did not support any wetland birds during the field surveys.

The Murray River riparian corridor is likely to support a greater diversity of wetland birds than detected in this survey. Riparian and wetland habitats are difficult to access and sample without specialised equipment such as boats or planes, which were considered unnecessary for this study. Further, many wetland birds are shy and secretive and/or migratory or eruptive in response to seasonal weather conditions or flooding. The riparian edge of the Forest is likely to support a number of cryptic or migratory wetland birds, including Snipe and Shorebirds as well as additional species of waders and waterfowl. Wetland bird species recorded during the field surveys, as well as additional species predicted to occur, are likely to occur in greater numbers and across greater areas when the Forest is flooded.

***Mammals***

A total of ten terrestrial mammals were observed during site surveys. Diversity was dominated by exotic species (7 out of 10 species), though the most commonly observed species was the native Eastern Grey Kangaroo (*Macropus giganteus*). The three native terrestrial mammal species recorded were the Eastern Grey Kangaroo, Yellow-footed Antechinus (*Antechinus flavipes*) and Swamp Wallaby (*Wallabia bicolor*). Eastern Grey Kangaroos were observed in large numbers with mobs of up to 50 individuals frequently observed through the field surveys. Swamp Wallabies were less abundant and appeared to be confined to patches of forest and

woodland with denser understorey. Yellow-footed Antechinus were observed occasionally during early morning bird surveys, foraging in woody debris.

Two feral exotic mammal species were common within the Forest: the Red Fox *(Vulpes vulpes*) and European Rabbit (*Oryctolagus cuniculus*). Domestic cattle (*Bos taurus*) were locally abundant within the former Toorangabby property and would be present elsewhere in the Forest from time to time, in accordance with Forests NSW grazing strategies. An additional four feral exotic species were recorded occasionally.

Two arboreal mammals, the Common Brushtail Possum (*Trichosurus vulpecular*) and the Common Ringtail Possum (*Pseudocheirus peregrinus*) were frequently observed during spotlighting surveys. Common Brush-tailed Possums appeared to be abundant across the Forest whereas Common Ringtail Possums appeared to be locally abundant in the southeast corner of Perricoota State Forest.

Two Gliders (*Petaurus* sp.) were observed by spotlight on separate evenings in Inland Grey Box Woodland in the southeast of the study area. This genus is difficult to identify to species level by spotlight and so it was not possible to determine if it was a Sugar Glider (*Petaurus breviceps*) or the TSC Act listed Squirrel Glider (*Petaurus norfolkensis*). There are records of both the Sugar Glider (GHD, 2009a) and the Squirrel Glider in the Forest (DECCW, 2009a, GHD, 2009b).

Based on known distributions and previous records, the Forest is unlikely to support many mammal species in addition to those recorded during the field survey.

***Microbats***

A total of 15 species of microbat were recorded at the Forest, through harp traps or Anabat recordings with varying confidence levels. Eight species of microbat were recorded, based on identifications in the hand or 'definite' records on Anabats. The Little Forest Bat (*Vespadelus vulturnus*), Gould's Wattle Bat (*Chalinolobus gouldii*), White-striped Freetail Bat (*Tadarida australis*) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*) were the most common and widespread of these species.

Some of the Anabat recordings described as "possible" calls were in a frequency range that could potentially indicate threatened species of microbat, including the Large-footed Myotis and Little Pied Bat, both listed as vulnerable species under the TSC Act. The Large-footed Myotis is known to occur but is considered rare in River Red Gum Forests along the Murray River, potentially due to paucity of cave/bridge roosting resources (Williams, R., Ecotone, pers. comm.). Local populations are likely to roost in River Red Gums (GHD, 2009b). Both of these species have previously been recorded in the locality (DECCW, 2009a) and so can be considered likely to occur within the Forest based on habitats present and tentative recordings.

Some Anabat recordings were identified to the level of *Nyctophilus* sp. as is typical for this genus. Based on regional distributions and habitat availability these calls could correspond to the Greater Long-eared Bat (*Nyctophilus timoriensis*) which is listed as a vulnerable species under the TSC Act. This species has not previously been recorded in the Central Murray area (GHD, 2009b) or the locality (DECCW, 2009a). Further, Forests NSW bat specialists have performed a number of impact assessment and research surveys in the region and have come to the conclusion that the species is not likely to occur in the River Red Gum Forests of the Central Murray (Law, B. Forests NSW, pers. comm.).

### *Reptiles*

A total of six native reptile species were recorded, comprising three skinks, a dragon, a goanna and a turtle.

The majority of reptiles observed during the field survey were Shinning Skinks (*Cryptoblepharus carnabyi*) and Garden Sun-skinks (*Lampropholis guichenotti*). These small, opportunistic species were frequently observed foraging in leaf litter and woody debris and are common and widespread in NSW. A limited number and diversity of other reptiles were recorded at the Forest, probably due to the mild to cool weather preceding the field surveys. A Redthroat Skink (*Morethia boulengeri*), Bearded Dragon (*Pogona barbata)* and an unidentified Goanna (*Varanus* sp.) were recorded as single individuals.

A number of Eastern Long-necked Tortoise (*Chelodina longicollis*) were observed as recently dead individuals or shells. It is not clear whether this represents an abundant local population with high turnover, or another adverse environmental factor having a negative effect on the local population.

The diversity of native reptiles at the Forest is likely to be considerably greater than recorded in the current survey or reported by Webster (2008). A total of 20 reptile species are known from the NSW Central Murray State Forests Ramsar Site, comprising 16 terrestrial species, three turtles and a wetland-dependant skink (Leslie, 2002 quoted in GHD, 2009a). Based on habitat assessments and regional distributions, River Red Gum Forests and box woodlands at the Forest are likely to support a greater diversity of native skinks (Scinidae spp.) and elapid snakes than have been recorded. Sandhill Woodlands may support an additional suite of reptiles, associated with sandy substrates, such as native dragons (Agamidae spp.) and burrowing skinks, though the lack of native understorey plants in these areas may limit their habitat value.

### *Frogs*

A limited diversity of native frogs was recorded at the Forest, typically in small numbers or in restricted areas. Overall, there was a low abundance of frogs and limited calling activity, which is probably attributable to the relatively cool weather during the field surveys and extended dry period preceding the field survey. The Common Eastern Froglet (*Crinia signifera*) and Plains Froglet *(Crinia parainsignifera)* were locally abundant and calling in the far southeast of the Forest. These frogs were associated with semi-permanent water in Floodplain Marshes and reedbeds flanking the Murray River above Torrumbarry Weir.

Spotted Marsh Frogs (*Limnodynastes tasmaniensis*) were recorded beneath woody debris near surface water in Calf Creek, just outside the western boundary of the Forest.

It is likely that there are local populations of the three frog species recorded in the current survey, and a number of other frog species, across the Forest. Native frogs are likely to persist near permanent water or in burrows, hollows or beneath woody debris and emerge to forage and breed during wet periods. Based on previous records for the Central Murray, the Forest is also likely to support the Peron's Tree Frog (*Litoria peronii*) and up to five additional species of marsh or burrowing frogs (*Myobatrachidae* spp.), potentially including the threatened Sloane's Froglet (GHD, 2009a; Leslie, 2002).

### 8.3.2 Fauna habitats

Habitat assessments were conducted across the entire study area to determine the conservation significance of fauna habitats and to assess the potential presence of native fauna (and especially threatened species) not directly observed during the surveys. These habitat descriptions informed the assessment of the likely native species diversity of the Forest, provided above, as well as the assessment of which threatened biota are likely to occur, provided in Section 8.3.3.

The habitat assessment also included a quantitative survey of habitat features and resources. Fauna habitat resources at the Forest are described below in terms of their likely value to native fauna with specific reference to threatened species previously recorded in the study area.

***Forests and woodlands***

Forests and woodlands at the Forest provide a valuable habitat resource for native fauna, particularly in the context of the surrounding region which has been extensively cleared for agriculture. These vegetation types provide shelter and roost sites, foraging habitat and actual food resources.

Forests and woodlands at the Forest are in relatively poor condition with regards to tree health and understorey structure and composition (MDBC, 2008) but are generally in good condition with regards to their habitat value for native fauna. These vegetation communities contain mature trees forming a canopy within a forest or woodland structure (Specht, 1980) basically equivalent to undisturbed examples of these vegetation types (Benson et al., 2006). This vegetation structure provides foraging substrate for a range of terrestrial and arboreal species as well as microbat species that forage above, within and below the canopy. There are good quantities of large, mature habitat trees at the Forest, which are discussed in greater detail below.

*Eucalyptus* spp. at the Forest are nectar- and seed-bearing and would provide foraging substrate and a food resource for native fauna, including arboreal mammals and potentially, threatened and migratory species, including the Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Xanthomyza phrygia)*. River Red Gums would provide nectar resources as well as foraging substrate for a diverse range of arboreal species. River Red Gum is an important feed tree species for Koalas, however is not considered to limit the distribution of the species in the Riverina (DEC, 2004). Some species are obligate roosters or nesters in River Red Gums but rely on other species for foraging resources. Notably, Squirrel Gliders are dependant on nectar-bearing understorey species and Box woodlands (DEC, 2004).

The understorey is in moderate to poor condition with limited areas containing dense growth of native shrubs, tussock grasses and herbs. Native grasses provide a superior food resource to exotic pasture for many native birds, including threatened species such as the Diamond Firetail, which were observed locally in areas containing good cover of native grasses. Dense shrubby understoreys provide important shelter for many native fauna species, such as small terrestrial mammals and small insectivorous birds. Notably, the threatened Gilberts Whistler is probably restricted to limited areas of the Forest that contain a dense shrubby understorey of Dwarf Cherry.

### *Wetlands*

There are substantial areas of wetland habitat at the Forest, including the River Red Gum forests and Floodplain Marshes. The majority of these wetland habitats were dry during the field survey and contained terrestrial herbs and grasses or bare earth. In this condition, the majority of the Forest would not support any species of wetland dependant fauna. All of these areas are naturally intermittent or ephemeral types of wetlands (GHD, 2009a) and would support wetland plants and animals during flood periods.

There were some Floodplain Marshes containing water in the southeast of the Perricoota State Forest above Torrumbarry Weir. These wetlands currently support a healthy and diverse assemblage of wetland species, including plants, waterfowl, wading birds and frogs. Based on their structure and condition they are also likely to support a healthy aquatic ecological community. These semi-permanent wetlands are likely to provide a significant refuge for wetland fauna during extended dry periods and facilitate their dispersal across the Forest during flood events. These wetlands are remote from proposed infrastructure and are unlikely to be directly affected by the project.

### *Habitat trees*

Habitat trees assessed in this report include hollow bearing trees, stags, nest trees and roost sites. These resources may be significant for threatened species in the locality (DECCW, 2009b). Tree hollows are important for native fauna: an estimated 15% of all terrestrial vertebrate fauna in Australia are dependent upon tree hollows and for many of these species no other habitat resource represents an adequate substitute (Gibbons and Lindenmayer, 2002). Hollow bearing trees are important as roosts for many microbat species, with large hollows usually required for maternity roosts (Law and Anderson 2000; B. Law B. Law unpubl. data cited in Law, 1997). Large trees with suitable breeding hollows are a critical resource for the Barking Owl (NPWS, 2003). Sufficient numbers of suitable hollow bearing trees close to suitable foraging habitat are a critical resource for the Squirrel Glider (DECCW, 2009b).

The quantitative habitat tree survey conducted during the field surveys yielded the following data:

- A total of 532 habitat trees within the footprints for fixed project infrastructure that were surveyed in detail including the locations of the regulators and channels;
- An estimated 1,820 habitat trees within the footprints for project infrastructure that had not been located at the time of the survey and/or were too large to survey in detail. This equates to approximately 4.1 per hectare; and
- An estimated 132,300 habitat trees across the Forest.

The density, type and likely conservation significance of habitat trees varies across the Forest with factors such as vegetation type, topographic position and disturbance history. This inherent variation must be considered when assessing the estimates of habitat tree numbers and densities provided above. The field survey sampled a range of vegetation types and condition classes and would incorporate spatial variation in habitat tree density and thus provide a reasonable estimate of numbers at the Forest.

Section 6 of Appendix C provides a detailed breakdown of habitat tree counts and densities in the various sampling locations, including a general description of the Forest as a guide to the

likely reasons for this variation. The greatest densities of habitat trees are associated with the locations of the regulators. This is because the regulators coincide with the drainage lines that feature the most productive forest and have been excluded from harvesting in recent decades (GHD, 2009a; Leslie, unpub.) and thus contain a greater density of large trees including habitat trees. Accurate counts were obtained in these areas. Densities are lower along the downstream levee, which includes shorter, less productive Black Box Woodlands and disturbed land at the margins of the forest and thus lower densities of habitat trees. Estimated counts were obtained for the downstream levee, spoil disposal area and the proposed borrow pits.

Overall, the study area is likely to contain sufficient quantities of hollow bearing trees and other habitat tree resources to support local populations of hollow-dependant fauna including:

- Provision of diurnal roost sites for tree-roosting microbats, including the threatened Large-footed Myotis and Yellow-bellied Sheathtail Bat and arboreal mammals, potentially including the threatened Squirrel Glider;
- Potential breeding hollows for the Barking Owl;
- Breeding hollows for the large numbers of cockatoo species observed roosting and nesting during the field surveys; and
- Breeding hollows for other native parrots, including the Red-rumped Parrot observed nesting during the field surveys and potentially also threatened species such as the Major Mitchells Cockatoo and Turquoise Parrot.

***Rock outcrops and fragments***

The Forest is located entirely on a floodplain composed of Quaternary Alluvium and does not contain rock outcrops, caves or platey rock fragments. The Forest would not support any species of threatened fauna dependant upon such habitat resources. Excavations and natural depressions within the project area featured shallow clayey sides and did not contain fissures, caves or overhangs large or sheltered enough to provide suitable sites for maternity colonies or diurnal roost sites for microbats. Hollow bearing trees may provide an adequate alternative habitat resource for some cave-roosting fauna – for instance they may provide diurnal roosts for the Large-footed Myotis or other threatened microbats in this context (Williams, R. pers. comm.; Ecotone, 2009b).

***Woody debris***

The Forest contains large amounts of standing and fallen dead timber which would provide shelter and foraging resources for native invertebrates, reptiles and small terrestrial mammals. Yellow-footed Antechinus were observed sheltering and foraging in woody debris during site surveys. Woody debris is known to be significant habitat resource for this species. Ground substrate, including woody debris, is also an important resource for ground dwelling native birds, including the threatened Bush Stone Curlew (*Burhinus grallarius*).

***Patch sizes and connectivity***

At a regional scale, the Forest comprises a single, basically intact patch of about 32,000 ha. The Forest has excellent connectivity to the south with the Gunbower Forest, separated only by the Murray River. The Gunbower Forest provides about 18,000 ha of additional floodplain habitats similar to those at the Forest. The Murray River provides a near-continuous habitat

corridor for wetland, aquatic and riparian biota through the Forest. Floodrunners and lagoons within the Forest provide good connectivity between wetland and aquatic habitat in the Murray River and the floodplain. At present, none of these drainage lines are obstructed by regulators or other infrastructure, though the height of the river bank isolates the floodplain under the current flow regimes (GHD, 2009a). The Forest has good habitat connectivity with large patches of floodplain vegetation to the west, in outlying portions of the Koondrook State Forest, other State Forests and River Red Gum Forests on private land. Native vegetation cover to the east, southwest and north is patchy and discontinuous due to extensive clearing for agriculture.

At a local scale, habitat in the study area is partially fragmented by historical clearing, roads and gaps created by timber harvesting. These gaps are small and discontinuous and do not significantly isolate any areas of native vegetation. Habitat within the Forest is extensive enough to support permanent local populations of threatened fauna known to be limited by patch sizes, including the Hooded Robin, Barking Owl and Diamond Firetail.

***Koala habitat assessment***

*State Environmental Planning Policy No.44 –Koala Habitat Protection* (SEPP 44) does not apply to Part 3A of the EP&A Act, as discussed in Section 3. Nonetheless, the Koala is known from the study area (DECCW, 2009a), is listed in the DGRs for the project and SEPP 44 provides an accepted methodology for the identification of Koala habitat. Therefore an assessment of koala habitat was conducted according to the methodology provided in SEPP 44.

The Forest represents 'Potential Koala habitat', as River Red Gum is a Schedule 2 feed tree species and dominates native vegetation types at the Forest. In addition, the other canopy species recorded, Black Box and Inland Grey Box, are secondary food tree species for the Koala within the Western Slopes and Plains Koala Management Area (DECC, 2008).

Core Koala habitat is defined under SEPP 44 as 'an area of land with a resident breeding population of Koalas, evidenced by attributes such as breeding females and recent sightings and historical records of a population'. Targeted surveys for Koalas and searches for signs of recent Koala activity were conducted in the GHD July and September 2009 site surveys. No evidence of the species was detected.

There are two previous records of the species from within the Koondrook State Forest from 2007. Koala populations in the Murray region occur as isolated scattered records and are thought to be the result of introductions of the species. (Miller, G., Forests NSW pers. comm.). Records from within State forests in the Murray region are thought to be dispersing males from nearby populations (G. Miller Forests NSW pers. comm.). The Recovery Plan for this species (DECC, 2008) identifies that introduced populations along the Murray and Murrumbidgee are thought to be relatively secure, with most populations in the area being maintained or expanding. Given the limited number of Koala observations at the Forest and the introduced, dispersive nature of regional populations, the Forest is not considered to comprise core Koala habitat as defined under SEPP 44.

The assessment of impacts on the Koala with respect to the TSC and EP&A Acts is summarised in Section 8.3.3 and provided in full in Appendix C.

### 8.3.3 Conservation significance

This section summarises the results of the desktop assessment, targeted surveys and habitat assessments to identify the threatened biota and Matters of National Environmental Significance that are likely to occur at the Forest and are likely to be affected by the project (directly or indirectly). Threatened fish and aquatic ecosystems are discussed separately.

***Threatened flora species***

The desktop literature review indicates that 11 threatened plant species have been recorded (three species), or are predicted to occur (eight species) in the locality. DECCW (2009a) Wildlife Atlas threatened species records from the locality of the Forest are shown on Figure 8-5. None of these species were recorded during site surveys. The majority of these species are considered unlikely to occur as they have limited ranges and/or habitat requirements that are not present at the Forest. These include species associated with Mallee or Saltbush vegetation communities, which do not occur within the Forest or the adjoining floodplain of the Murray River.

There is suitable habitat for four threatened plant species at the Forest. These species are presented in Table 8-3 along with their conservation status, the nature of their previous occurrence in the study area, the vegetation communities and habitats in which they are likely to occur and the potential for impacts arising from the project.

**Table 8-3 Threatened flora species potentially present within the Forest**

| Scientific name | Common name | EPBC Act | TSC Act | Nature of previous records | Likelihood of occurring at the Forest | Likelihood of Impacts |
|---|---|---|---|---|---|---|
| *Amphibromus fluitans* | Floating Swamp Wallaby-grass | V | V | Recorded within 10 km of the Forest (Vennell and Nias, 2005). | Possible (permanent to semi-permanent swamps with fluctuating water levels) | Direct impacts unlikely due to the dryness of the Forest. Positive impacts likely through proposed flooding. |
| *Austrostipa wakoolica* | - | E | E | Predicted, based on habitat surrogates [2](DEWHA, 2009a). | Possible (floodplain of Murray River tributaries) | Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*. |
| *Lepidium monoplocoides* | | E | E | Predicted, based on habitat surrogates (DEWHA, 2009a). | Possible but unlikely due to dearth of recent records (seasonally moist to waterlogged sites, including Black Box woodland) | Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*. |

| Scientific name | Common name | EPBC Act | TSC Act | Nature of previous records | Likelihood of occurring at the Forest | Likelihood of Impacts |
|---|---|---|---|---|---|---|
| *Swainsona murrayana* | | V | V | Predicted, based on habitat surrogates (DEWHA, 2009a). | Possible (black box woodland, floodplains, depressions. Also known from moderately grazed or cultivated paddocks) | Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*. |

* During construction period only.

Although not detected during site surveys, these species of threatened plants may colonise habitat at the Forest in the future or may exist in the soil seed bank or as dormant individuals. The full list of threatened plant species considered in this assessment, including their habitat requirements and conservation status is presented in Appendix C.

### *Endangered flora populations*

No endangered flora populations are known to occur within the study area, the locality or in the Murray Fans CMA sub-region (DECCW, 2009b).

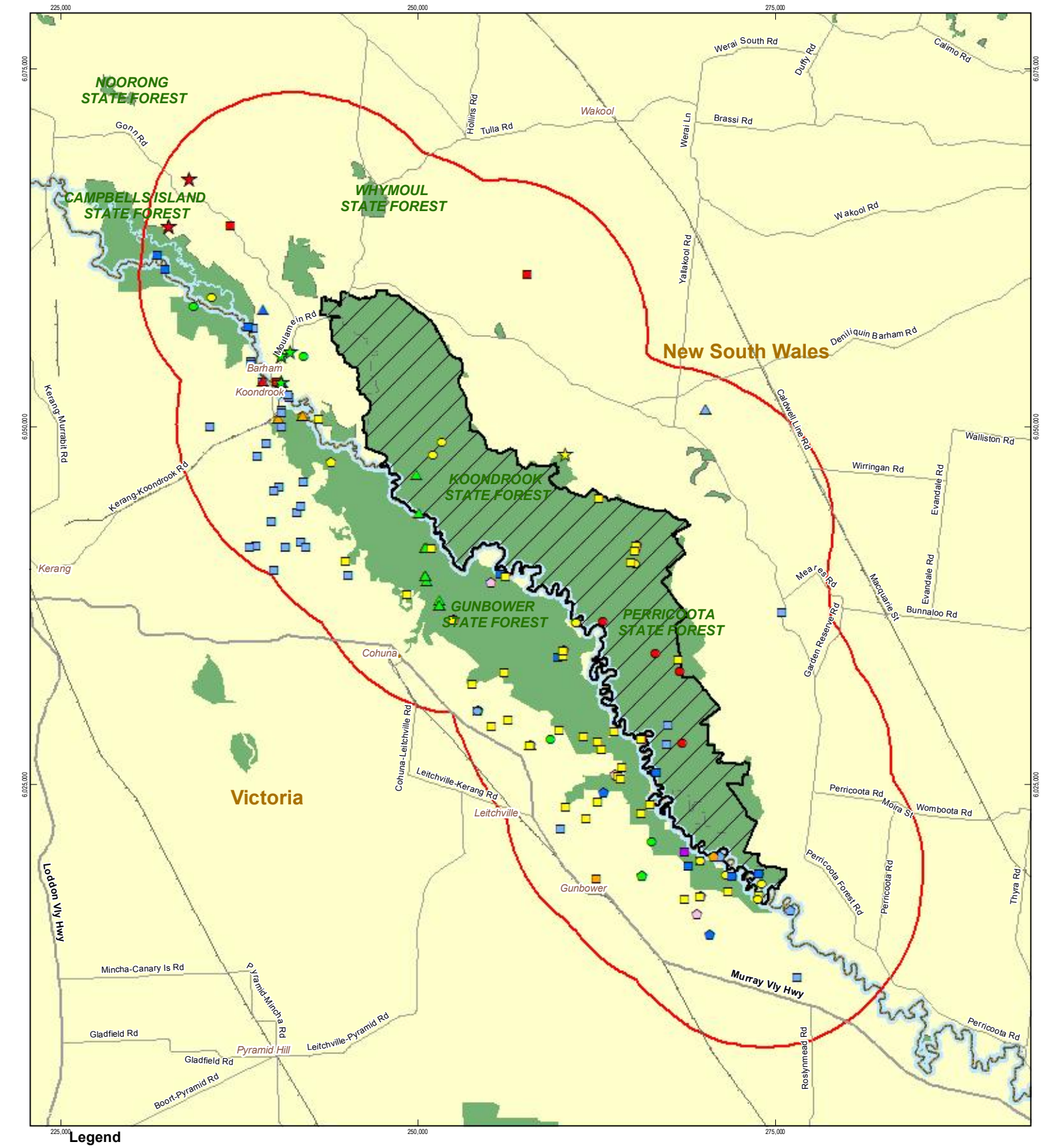
### *Endangered ecological communities*

The desktop literature review indicates that five EECs listed under the TSC Act and/or the EPBC Act are known or predicted to occur in the locality of the Forest. The full list of EECs known from the region, including their habitat requirements and conservation status, is presented in Appendix C.

Two EECs, namely Grassy Box-gum Woodland and Weeping Myall Woodland, can be reliably excluded from occurring at the Forest based on their known distributions and the absence of suitable habitat. There is potentially suitable habitat for Buloke Woodland at the Forest, and some isolated patches of representative species were noted during site surveys. Areas of Buloke Woodland habitat at the Forest are extensively degraded, remote from project construction footprints and above the proposed inundation area and so these isolated remnants were not mapped or assessed in detail. The remaining two EECs were confirmed as occurring at the Forest and are described below.

### *Inland Grey Box Woodland*

Inland Grey Box Woodland in the Southwest Slopes bioregion is listed as an EEC under the TSC Act. All areas mapped as Riverine Inland Grey Box Woodland Grassy Woodland within the Forest qualify as this EEC due to the presence of Inland Grey Box *Eucalyptus microcarpa* as the dominant canopy species and a characteristic understorey of native grasses and herbs, consistent with the Scientific Committee Determination for the EEC (DECCW, 2009d).




## Legend

- 10km radius of site
- Koondrook Perricoota Forest Site
- State Border

### Threatened Flora

- Eucalyptus leucoxylon subsp. pruinosa
- Maireana cheelii
- Wilsonia rotundifolia

### Threatened Fauna

- Australasian Bittern
- Barking Owl
- Black-chinned Honeyeater
- Bridled Nailtail Wallaby
- Brown Treecreeper
- Brush-tailed Bettong
- Brush-tailed Phascogale
- Bush Stone-curlew
- Diamond Firetail
- Gilbert's Whistler
- Grey Falcon
- Grey-crowned Babbler (eastern subspecies)
- Hooded Robin
- Koala
- Large-footed Myotis
- Little Pied Bat
- Magpie Goose
- Murray Cod
- Pink Robin
- Plains-wanderer
- Regent Honeyeater
- Rufous Bettong
- Silver Perch
- Sloane's Froglet
- Speckled Warbler
- Squirrel Glider
- Superb Parrot
- White-browed Woodswallow

1:250,000 (at A3)

0 2.5 5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

GHD

CLIENTS | PEOPLE | PERFORMANCE

NSW Department of Commerce
Koondrook-Perricoota Flood Enhancement Works EA

| | |
|---|---|
| Job Number | 21-18573 |
| Revision | B |
| Date | 09 DEC 2009 |

# Figure 8.5: Threatened species records in the locality

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z001_DECC_ThreatenedSpecies.mxd

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Data source: StreetMap - Navigate, DECC Wildlife Atlas, Cwilson

Areas mapped as Derived Grassland or Herbland at the Forest are probably a result of historic removal of trees rather than natural environmental factors. Some of these areas would comprise Inland Grey Box Woodland habitat within the description provided by the Scientific Committee Determination for the EEC (DECCW, 2009d). Therefore treeless lands surrounded by, or in the immediate vicinity of, Inland Grey Box Woodland were mapped as the community and are treated as the EEC for the purposes of this assessment.

***Sandhill Pine Woodland***

A stand of White Cypress Pine dominated vegetation in the former Toorangabby property was sampled in the field survey and would qualify as the EEC Sandhill Pine Woodland. The Forest contains a number of other sandhills that would have historically supported either of the EECs Sandhill Pine Woodland or Buloke Woodland and may currently qualify as degraded forms of the EECs or their habitat. These geomorphic settings are extensively degraded by historical clearing and grazing and many now contain derived grassland and herbland with severely modified canopy, shrub layer and groundcover. This is typical of both EECs in the region as vegetation diversity and structure have been extensively modified by the history of timber harvesting, grazing and soil erosion (DECCW, 2009b; Benson et al., 2006).

There are no Sandhill Pine Woodlands or sand dune habitats in the vicinity of the construction footprint and they occur on higher ground that would not be affected by the proposed flooding of the Forest.

***Threatened terrestrial fauna species***

A total of 12 threatened fauna species and a further three preliminary-listed species are known, or are highly likely to occur at the site based on the site surveys or other recent survey records, including:

- Four threatened species of birds (Gilberts Whistler, the Hooded Robin, Diamond Firetail and Australasian Bittern) and a further three species which have a preliminary listing as threatened species under the TSC Act (the Varied Sittella, Scarlet Robin and White-browed Woodswallow) recorded during site surveys;
- Recent DECCW (2009a) Wildlife Atlas records of the Koala and Barking Owl at the site;
- Recent Summer-Autumn records of the Black-chinned Honeyeater (MDBC, 2008);
- Late 2008 Anabat recordings of the Yellow-bellied Sheathtail Bat (GHD, 2009b);
- Observations of Bush-stone Curlews by land owners near the northwestern boundary of the site (Tyers, H, pers. comm.);
- 'Possible' Anabat recordings of the Large-footed Myotis and Little Pied Bat during site surveys; and
- Gliders (*Petaurus* sp.) recorded by spotlight in the site survey that may have been the threatened Squirrel Glider and a November 2008 record of this species, all within Box woodlands in the Perricoota State Forest (GHD, 2009b).

Threatened species recorded during the current site surveys are shown on Figure 8-3 and Figure 8-4.

The desktop review indicates the potential presence of additional threatened fauna species that are known or predicted to occur in the locality. DECCW (2009a) Wildlife Atlas threatened species records from the locality are shown on Figure 8-5. The full list of threatened fauna previously recorded from the locality, including their conservation status, habitat requirements, the nature of previous records and likelihood of occurrence is presented in Appendix C. A review of the nature of specific habitat requirements of these species and the habitat present within the study area allowed a number of these species to be eliminated as having a low likelihood of occurrence at the Forest.

Threatened fauna species recorded or likely to occur at the Forest are presented in Table 8-4 along with their conservation status, the nature of their previous occurrence in the study area, the habitats in which they are likely to occur and the potential for impacts arising from the project.

A further 21 threatened fauna species may possibly occur at the site based on the presence of suitable foraging and roosting habitat. There is no evidence, such as recent records within the Forest or specific important habitat resources, which suggests that the Forest regularly supports local populations of any of these species, either on a permanent or seasonal basis. However, these fauna species may occur in habitat at the site on an occasional, transient or opportunistic basis.

### *Endangered fauna populations*

No endangered fauna populations are known to occur in the locality of the Forest or in the Murray Fans CMA sub-region (DECCW, 2009b).

**Table 8-4 Threatened fauna species and their habitats recorded or likely to occur within the Forest**

| Scientific name | Common name | TSC Act | EPBC Act | Nature of previous records | Likelihood of occurring at the Forest | Likelihood of impacts |
|---|---|---|---|---|---|---|
| *Botaurus poiciloptilus* | Australasian Bittern | V | - | Previous Record (DECCW, 2009a) | **Present** –recorded in the Gunbower State Forest immediately across the Murray River from the Forest. Would probably forage at the Forest, especially during flood events. | Potential for displacement of individuals and removal of habitat within small areas of floodplain marsh and drainage lines in surface disturbance areas. |
| *Burhinus grallarius* | Bush Stone-curlew | E | - | Observations by land owners adjoining the Forest (Tyers, H., pers. comm.) | **Likely** –historical records adjoining the Forest and suitable habitat throughout the Forest. | Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance and inundation areas. |
| *Chalinolobus picatus* | Little Pied Bat | V | - | Previous Record (DECCW, 2009a) | **Likely** – Possible Anabat recording in the current survey. | Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (hollow bearing trees) within forest and woodland in surface disturbance areas. |
| *Melanodryas cucullata* | Hooded Robin | V | - | Recent Record (GHD, 2009b) | **Present**. Multiple records during site surveys, mainly in box woodlands. | Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas. |
| *Melithreptus gularis gularis* | Black-chinned honeyeater (eastern sub-species) | V | - | Recent Record (MDBC, 2008) | **Present** – not recorded during site surveys but occurs at the Forest on a seasonal, migratory basis (Webster, 2008; MDBC, 2008). | Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas. |
| *Myotis adversus* | Large-footed Myotis | V | - | Previous Record (GHD, 2009b) | **Likely** – Possible Anabat recording in the current survey and known from similar River Red Gum forests in the region. | Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (hollow bearing trees) within forest and woodland in surface disturbance areas. |

| Scientific name | Common name | TSC Act | EPBC Act | Nature of previous records | Likelihood of occurring at the Forest | Likelihood of impacts |
|---|---|---|---|---|---|---|
| *Ninox connivens* | Barking Owl | V | - | Previous Record (Parker, *et al*. 2007) | **Likely** – previous records within the Forest (Parker, *et al*. 2007) and extensive areas of suitable foraging and roosting resources. | Potential for displacement of individuals and removal of habitat and important habitat resources (hollow bearing trees) within forest and woodland in surface disturbance areas. |
| *Pachycephala inornata* | Gilbert's Whistler | V | - | Recent Record (GHD, 2009b) | **Present**. Multiple records during site surveys, exclusively in forest and woodland with dense understorey, mainly of Dwarf Cherry. | Potential for displacement of individuals and removal of habitat within limited areas of suitable woodland habitat in surface disturbance areas. |
| *Petaurus norfolcensis* | Squirrel Glider | V | - | Previous Record | **Likely** –recent record at the Forest, tentative observations during site surveys. | Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (hollow bearing trees) within forest and woodland in surface disturbance areas. |
| *Phascolarctos cinereus* | Koala | V | - | Previous Record (DECCW, 2009a) | **Likely** –historical records at the Forest. Fragmented, but expanding introduced population known from the Riverina. | Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas. |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail Bat | V | - | Recent record (GHD, 2009b). | **Likely** – recorded at the Forest in late 2008 (GHD, 2009b). | Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (hollow bearing trees) within forest and woodland in surface disturbance areas. |
| *Stagonopleura guttata* | Diamond Firetail | V | - | Recent record (GHD, 2009b). | **Present** - Recorded during site surveys and in late 2008 (GHD, 2009b) in box woodlands. | Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas. |

### 8.3.4 Aquatic ecological communities

The EEC 'Aquatic ecological community in the natural drainage system of the lower Murray River catchment' (Murray River EEC) includes all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River below the Hume Weir (DII, 2009). There is an extensive network of drainage lines and floodplain marshes at the Forest that all comprise part of this EEC (refer Figure 8-3 and Figure 8-4).

Two threatened aquatic fauna species are likely to occur at the Forest:

- The Murray Cod, which is listed as Vulnerable under the EPBC Act; and
- The Silver Perch, which is listed as Vulnerable under the TSC Act.

Local populations of the Murray Cod and Silver Perch are known from the Murray River adjacent to the Forest. It is therefore possible that individuals of these species, including adult fish, juveniles, larvae and/or spawn, would enter the Forest during flood events and might potentially breed in the Forest, depending on the timing and duration of flood events. The project would remove or modify small amounts of aquatic habitat for these species at the locations of the proposed regulators and would remove habitat resources for the species associated with floodplain vegetation within the construction footprint.

The desktop review indicates the potential presence of an additional two threatened fish species (Macquarie Perch and Murray Hardyhead) which are known or predicted to occur in the locality of the Forest. These species are presented in Appendix C along with their conservation status, habitat requirements and the nature of previous records and likelihood of occurrence at the Forest. A review of the distributions and habitat requirements of these species concludes that they are unlikely to occur at the Forest.

### 8.3.5 Matters of National Environmental Significance

Under the EPBC Act any action which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Minister for the Environment, Heritage and the Arts.

A Protected Matters Search (DEWHA, 2009) was performed to identify 'matters of national environmental significance' of relevance to the project and the results are presented in Appendix C. The NSW Wildlife Atlas (DECC, 2009b) also revealed records of EPBC Act listed threatened species previously recorded in the locality (refer Figure 8-5). Matters of national environmental significance that are likely to be affected by the project are discussed below.

#### Threatened flora species

No threatened plants were recorded at the Forest. There is suitable habitat for four EPBC Act listed plant species at the Forest: *Amphibromus fluitans*, *Austrostipa wakoolica*, *Lepidium monoplocoides* and *Swainsona murrayana*. These four species are also listed under the TSC Act.

### Endangered ecological communities

The Protected Matters Search Tool lists four EECs listed under the EPBC Act that could potentially occur at the Forest. All of these EECs are also listed under the TSC Act and their relevance to this assessment is described in Section 8.3.3 above. In summary:

- Two EECs, Grassy Box-gum Woodland and Weeping Myall Woodland, can be reliably excluded from occurring at the Forest based on known distributions and the absence of suitable habitat;
- There are patches of potentially suitable habitat for Buloke Woodland at the Forest, however these patches are extensively degraded, remote from project construction footprints and above the proposed inundation area and so were not mapped or assessed in detail;
- There is a stand of Sandhill Pine Woodland in the former Toorangabby property as mapped in Figure 8-3. This stand is remote from project construction footprints and above the proposed inundation area; and
- There are areas of the TSC Act listed EEC Inland Grey Box Woodland at the Forest that would qualify as the threatened ecological community currently nominated to be listed as the EEC 'Inland grey Box Grassy Woodland' on the schedules of the EPBC Act (DEWHA, 2009c).

### Threatened fauna Species

No EPBC Act listed fauna species were recorded during site surveys and there is no evidence such as recent records or important habitat resources to suggest that local populations occur at the Forest.

Based on desktop and habitat assessments five EPBC Act listed fauna species are likely to occur at the Forest on an occasional or opportunistic basis:

- *Xanthomyza phrygia* Regent Honeyeater;
- *Lathamus discolor* Swift Parrot;
- *Rostratula benghalensis* s. lat. Australian Painted Snipe;
- *Dasyurus maculatus* Spotted-tailed Quoll; and
- *Polytelis swainsonii* Superb Parrot.

### Migratory species

The Forest provides habitat for a number of migratory bird species protected under the provisions of International treaties and/or the EPBC Act, including:

- 13 bird species listed under international agreements (Japan Australia Migratory Bird Agreement or China Australia Migratory Bird Agreement);
- Seven migratory terrestrial bird species, including two species also listed as threatened species under the EPBC Act; and
- At least a further 29 species belonging to bird families recognised as migratory under the EPBC Act.

The project would remove habitat for these migratory species within construction footprints. The proposed environmental watering of the Forest would potentially affect the timing and nature of usage of the habitats at the Forest by many of these species. Potential affects include triggering flood-induced migration, foraging or breeding activity.

**Threatened aquatic species**

One threatened aquatic fauna species is likely to occur at the Forest: the Murray Cod.

The desktop review indicates three threatened fish species are predicted to occur in the locality of the Forest. However, a review of the nature of specific habitat requirements of these species, and the habitat present led to the conclusion that these three fish species have a low likelihood of occurrence at the Forest.

**Wetlands of international importance (Ramsar wetlands)**

The Forest includes part of the NSW Central Murray State Forests Ramsar Wetland and so this Ramsar site would be directly affected by the project. Forests NSW has tenure over this land and administers the NSW Central Murray State Forests for timber production, biodiversity conservation, recreation and other purposes. The Forest comprises 83,966 ha of riverine floodplain within the Ramsar Wetland composed of three geographically discrete but interrelated units: the Millewa Forests, the Werai Forests, and the Koondrook Forests (GHD, 2009a). The Millewa Forests and Werai Forests are both upstream and hydrologically separated from the Forest (refer to Figure 2-2). The project would affect approximately 16,000 ha of the Ramsar Wetland within the Koondrook Forests through direct construction impacts and operational changes to the hydrology of the Forest and ecosystem processes.

The Forest is in the immediate vicinity of the Victorian Gunbower Forest Ramsar Wetland which lies immediately across the Murray River from the Koondrook and Perricoota State Forests. The Kerang Wetlands Ramsar site is less than 30 km from the Forest, also on the Victorian side of the Murray River.

The Forest also falls within the catchments of a number of other Ramsar Sites which are downstream of the Forest along the Murray River, including:

- Hattah-Kulkyne Lakes;
- Riverland;
- Banrock Station Wetland Complex; and
- Coorong and Lakes Alexandrina and Albert.

The project is unlikely to result in construction impacts on any Ramsar Wetlands other than the NSW Central Murray State Forests. The project has the potential to cause indirect impacts through changes to the hydrology of the Murray River and impacts on ecosystem components of these wetlands such as waterbirds and fish.

## 8.4 Construction impacts

### 8.4.1 Construction footprints

This impact assessment is based on indicative infrastructure locations and construction footprints and methods described in Section 6.3. The magnitude and duration of impacts arising from the project would vary with the type of infrastructure as follows:

- Permanent removal of native vegetation and habitat, such as the locations of regulators, or permanent modification of native vegetation habitat, such as the downstream levee, which would contain regenerating native understorey vegetation, and the inlet channel, which would contain regenerating native understorey, including wetland herbs and grasses; and
- Areas of temporary removal of native vegetation and habitat, such as construction laydown areas, floodway and borrow pits which are likely to regenerate into native vegetation communities.

The locations and detailed design of project infrastructure and final construction details would not be finalised until a construction contractor is engaged. Therefore, this impact assessment is based on indicative infrastructure footprints that have been located within a construction corridor. Indicative footprints for the proposed project infrastructure are summarised in Table 8-5 along with an evaluation of the extent, magnitude and duration of potential impacts arising from construction. The locations of infrastructure are constrained to within metres of their indicative location and would not extend beyond the construction corridor. Estimates of the extent of native vegetation clearing within infrastructure footprints are also provided in Table 8-5 below.

### 8.4.2 Vegetation clearing and construction impacts

Native vegetation within the footprint is shown on Figure 8-1 and Figure 8-2 and threatened biota is shown on Figure 8-3 and Figure 8-4. The removal of native vegetation and habitat resources is likely to have negative impacts on native species, populations and ecological communities within the Forest. The nature, duration and magnitude of these likely impacts are assessed below.

***Flora species***

Vegetation clearing for the project would remove large numbers of mature River Red Gum and Black Box and moderate numbers of Inland Grey Box. Mature trees have value within plant populations as sources of seed. There are extensive areas of these species at the Forest and the removal of a small proportion of mature individuals would not threaten the persistence of local populations. With respect to River Red Gum and Black Box: these species mainly rely on floodwaters to disperse seeds (GHD, 2009a) and so the removal of seed trees would be unlikely to result in any additional impacts. The project would not remove any threatened tree species though it would remove plant species that are a component of the EEC Inland Grey Box Woodland, as discussed below.

Construction of the project would damage or remove understorey plants within the surface disturbance area, noting that many understorey species of floodplain communities are only present after flood events. The project would have direct impacts within a maximum surface disturbance area of 206 ha. Any vegetation clearing required in these areas would remove non-

threatened native plants and noxious and environmental weeds. A proportion of this area is disturbed, cleared, subject to severe weed infestation and/or or severely drought affected, contains very little native vegetation cover, and has little habitat value for native plants.

It is likely that flora populations would persist in the soil seed bank and in alternative habitat outside the surface disturbance area. Populations of extremely rare plants, or those with restricted distributions would be more vulnerable to negative effects arising from direct removal. Construction is highly unlikely to remove a significant proportion of any threatened plant populations and is unlikely to remove any adult/above-ground individuals based on the following considerations:

- No threatened plants or populations were recorded within construction footprint areas; and
- Threatened plants that are likely to occur at the Forest are flood or rainwater dependant and are unlikely to occur at present, nor through the construction period, given prevailing site conditions.

Construction activities may remove habitat for the four threatened plant species likely to occur at the Forest and potentially dormant individuals or seeds.

## Table 8-5 Construction footprints for project infrastructure and evaluation of impacts

| Project Infrastructure | Vegetation community type | Area within disturbance footprint (ha) | Temporary disturbance footprint (ha) | Permanent disturbance footprint (ha) | Impact |
|---|---|---|---|---|---|
| Borrow pits | Total | | 44.31 | | Modification of native vegetation and habitat within footprint situated in disturbed areas as far as is practicable. Vegetation would be allowed to regenerate. |
| | Comm ID 10: River Red Gum - Black Box woodland | 10.81 | | | |
| | Comm ID 13: Blackbox - Lignum woodland | 1.79 | | | |
| | Comm ID 250: Derived tussock grasslands | 1.92 | | | |
| | Comm ID 2: River Red Gum-sedge tall open forest | 0.40 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 4.72 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 24.67 | | | |
| Downstream levee | Total | | 69.55 | 69.55 | |
| | Comm ID 10: River Red Gum - Black Box woodland | 19.45 | | | Permanent removal of tall, highly significant riparian River Red Gum Forest. |
| | Comm ID 13: Blackbox - Lignum woodland | 1.05 | | | |
| | Comm ID 250: Derived tussock grasslands | 3.21 | | | |
| | Comm ID 2: River Red Gum-sedge tall open forest | 0.58 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 7.06 | | | |

| Project Infrastructure | Vegetation community type | Area within disturbance footprint (ha) | Temporary disturbance footprint (ha) | Permanent disturbance footprint (ha) | Impact |
|---|---|---|---|---|---|
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 38.20 | | | |
| Downstream stop log regulators | | 2.60 | 2.60 | | Permanent removal of vegetation and habitat within infrastructure footprint. |
| | Comm ID 10: River Red Gum - Black Box woodland | 0.29 | | | |
| | Comm ID 13: Blackbox - Lignum woodland | 0.24 | | | |
| | Comm ID 250: Derived tussock grasslands | 0.08 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 0.74 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 1.26 | | | |
| Haul road | | | 2.70 | | Permanent removal of vegetation and habitat within infrastructure footprint |
| | Comm ID 10: River Red Gum - Black Box woodland | 0.03 | | | |
| | Comm ID 13: Blackbox - Lignum woodland | 0.11 | | | |
| | Comm ID 250: Derived tussock grasslands | 0.17 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 0.99 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 1.39 | | | |

| Project Infrastructure | Vegetation community type | Area within disturbance footprint (ha) | Temporary disturbance footprint (ha) | Permanent disturbance footprint (ha) | Impact |
|---|---|---|---|---|---|
| Inlet channel, and inlet regulator and fishways | | 14.39 | 14.39 | 14.39 | Permanent removal or modification of native vegetation, including Inland Grey Box Woodland EEC. Understorey vegetation would be allowed to regenerate within the channel. |
| | Comm ID 10: River Red Gum - Black Box woodland | 2.30 | | | |
| | Comm ID 13: Blackbox - Lignum woodland | 1.68 | | | |
| | Comm ID 237: Riverine Inland Grey Box grassy woodland | 8.37 | | | |
| | Comm ID 250: Derived tussock grasslands | 0.40 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 1.46 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 0.19 | | | |
| Internal floodway | | | 29.94 | | Modification of native vegetation and habitat within footprint. Vegetation would be allowed to regenerate. |
| | Comm ID 2: River Red Gum-sedge tall open forest | 12.31 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 16.62 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 1.02 | | | |

| Project Infrastructure | Vegetation community type | Area within disturbance footprint (ha) | Temporary disturbance footprint (ha) | Permanent disturbance footprint (ha) | Impact |
|---|---|---|---|---|---|
| Return channel, return channel regulator and exit structure | | 1.06 | 1.06 | | Permanent removal of vegetation within footprint, the majority of which is exotic grassland. |
| | Comm ID 250: Derived tussock grasslands | 0.69 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 0.07 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 0.30 | | | |
| Site facilities | | | 0.77 | | Modification of native vegetation and habitat within footprint. Vegetation would be allowed to regenerate. |
| | Comm ID 10: River Red Gum - Black Box woodland | 0.26 | | | |
| | Comm ID 237: Riverine Inland Grey Box grassy woodland | 0.26 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 0.25 | | | |
| Spoil disposal area | | | 38.97 | | Modification of native vegetation and habitat through spreading of approximately 500 mm of spoil material. Disturbance would be concentrated on the existing levee.<br>During construction planning, the spoil disposal area would be refined to avoid impacts on Inland Grey Box Woodland as far as practicable. |

| Project Infrastructure | Vegetation community type | Area within disturbance footprint (ha) | Temporary disturbance footprint (ha) | Permanent disturbance footprint (ha) | Impact |
|---|---|---|---|---|---|
| | Comm ID 10: River Red Gum - Black Box woodland | 3.85 | | | |
| | Comm ID 13: Blackbox - Lignum woodland | 30.79 | | | |
| | Comm ID 237: Riverine Inland Grey Box grassy woodland | 4.06 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 0.28 | | | |
| Swan lagoon regulators | | | 0.15 | 0.15 | Permanent removal of tall, highly significant riparian River Red Gum Forest. |
| | Comm ID 2: River Red Gum-sedge tall open forest | 0.02 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 0.13 | | | |
| Turkey's Nest Dams | | | 1.47 | | Modification of native vegetation and habitat within footprint, situated in disturbed areas as far as is practicable. Vegetation would be allowed to regenerate. |
| | Comm ID 13: Blackbox - Lignum woodland | 0.17 | | | |
| | Comm ID 250: Derived tussock grasslands | 0.18 | | | |
| | Comm ID 7: River Red Gum - herbaceous tall open forest | 0.03 | | | |
| | Comm ID 9: River Red Gum - wallaby grass tall woodland | 1.10 | | | |
| **Total** | | | **205.92** | **87.75** | |

### *Vegetation communities*

Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including:

- Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state;
- Permanent removal or modification of approximately 88 ha of native vegetation within project infrastructure footprints; and
- Removal of approximately 532 habitat trees counted within confirmed infrastructure footprints and potential removal of habitat trees within a further 100 ha of construction footprints that had not been located at the time of the survey.

The site contains approximately 31,000 ha of native vegetation and habitats that would not be removed or modified.

The majority of the Forest contains native vegetation communities and so the majority of this disturbance area would involve the removal or modification of native vegetation. The relative extent of disturbance of vegetation types is presented inTable 8-5 .The project would remove a maximum of about 8 ha of the EEC Inland Grey Box Woodland. This area is based on the commitment to refine the location of the spoil disposal area to avoid impacts on this community as far as practicable. The significance of impacts on this EEC is assessed in Section 8.8 and Appendix C.

Disturbance and regeneration regimes are part of the ecology of many native forests. River Red Gum Forests are relatively resilient to disturbance since natural regeneration coincides with floods and seedling recruitment is greatest in clearings created by storms, wildfire or severe floods under natural conditions (Di Stefano, 2001) or in gaps created by timber harvesting in managed forests (GHD, 2009a). Floodplain Marshes and Black Box Woodlands also contain many native plant species with reproductive cycles geared to flood events (GHD, 2009a). Therefore the proposed flooding of the Forest is likely to facilitate the regeneration of native vegetation in areas that are not required to be permanently cleared or modified for project infrastructure.

### *Fauna*

The project would cause displacement or mortality of fauna that are within the surface disturbance area for construction. The project may also interrupt or prevent breeding for one season if species are breeding within or near disturbance footprints during construction. Given the extent of native vegetation at the Forest, it is likely that fauna populations would persist in alternative habitat outside the surface disturbance area and would reoccupy disturbed areas as the forest regenerates. The magnitude of likely impacts would vary between types of fauna.

Birds are relatively mobile and so most individuals would be able to avoid vegetation clearing or construction operations. Most individuals directly affected by the project would be temporarily displaced rather than killed. There is approximately 31, 000 ha of similar habitat within the Forest that could provide refuge and/or alternative habitat for displaced fauna. Some mortality of less mobile individuals, such as nestlings, old or sick birds may occur. Birds breeding in, or in the vicinity of the surface disturbance area may have breeding disrupted for one season. These

direct impacts would affect limited numbers of individuals and would be isolated in time and space and so would be unlikely to threaten the survival of any local populations of any bird species.

Macropods and other large terrestrial mammals are likely to readily avoid vegetation clearing or construction operations and so individuals directly affected by the project would be displaced rather than killed. There may be some mortality of mammals less able to avoid the disturbance. These would include smaller terrestrial mammals, nocturnal species and especially arboreal mammals and microbats which may be sheltering in felled trees. There may be mortality of individuals sheltering in woody debris, tree hollows, and crevices or under bark. Displaced individuals would be vulnerable to predation since they would be disturbed in daylight hours and would experience energy costs, increased risk of predation and increased competition for resources (especially for alternative hollows). This may result in impacts beyond the disturbance area by favouring aggressive or generalist species.

The persistence of diverse and abundant bat populations in operating State forests throughout the study area (e.g. Forests NSW, 2006; Law and Anderson, 1999), which are periodically subject to the removal of a portion of the available habitat suggests that bat populations are successfully maintained in habitat outside surface disturbance areas. The mobility of microbats and low energy cost of flight would facilitate successful dispersal after disturbance and re-colonisation of regenerating areas. Therefore, although individual bats would be susceptible to short term impacts from vegetation clearing and especially removal of hollow bearing trees, bat populations would probably be resilient to these effects.

Displacement or mortality due to construction impacts would affect limited numbers of individuals and would be unlikely to threaten the survival of any local populations of any fauna species.

More significant negative effects on fauna populations may arise from removal of habitat for permanent project infrastructure and changes to vegetation structure and the quality of habitat in regenerating vegetation. Impacts on habitats are discussed below.

There is likely to be moderate, ongoing impacts on fauna utilising adjacent areas of habitat during construction associated with noise and other disturbances. Disruptive human activities already occur at the Forest associated with Forests NSW timber harvesting operations. Forests NSW activities are widely dispersed in time and space. Construction activities would increase the overall amount of human activity in the forest but also impose a more concentrated and prolonged impact period. The surrounding locality is extensively disturbed by agricultural activities. Larger, more mobile fauna currently occupying the Forest are likely to be adapted to these disturbances. There are likely to be impacts upon smaller, less mobile fauna in the immediate vicinity of the proposed works.

## Habitats

### Removal of habitat

The project would have a direct negative effect on habitat for native flora and fauna through vegetation clearing as described above. Impacts would include reduced shelter or roost sites, foraging habitat and actual food abundance. This clearing would have additional negative effects on the quality of habitats in the broader locality through edge effects, fragmentation of habitat and the disruption of vegetated habitat corridors which are discussed below.

Construction of project infrastructure would permanently remove some foraging resources for native fauna. *Eucalyptus* species would provide nectar resources as well as foraging substrate for a diverse range of arboreal species. It is likely that foraging substrate and resources removed for temporary infrastructure would regenerate relatively quickly. Closed canopies and fibrous bark develop in as little as 10 years (Vesk *et. al*., 2008). Given the permanent removal of 88 ha of habitat within the 32,000 ha of similar habitat at the Forest, retained vegetation outside of surface disturbance areas is likely to provide sufficient alternative foraging resources for local populations of native biota. This magnitude of removal of habitat is unlikely to threaten the persistence of any species at the Forest. There is no evidence that the project would remove a significant proportion of any critical foraging resources for any rare or threatened species or populations.

Habitat trees, including hollow bearing trees, stags, nest trees, and roost trees, are an important resource for hollow-dependent native fauna. Obligate hollow users are amongst the most vulnerable species of fauna to the effects of vegetation clearing. The project would remove additional hollow bearing trees from habitats which have already undergone partial removal of these resources. The crucial factor with respect to impacts on the hollow-bearing tree resource is the amount of time it takes for suitable hollows to form. Various studies cited by Gibbons and Lindenmayer (1997) noted minimum ages of 85 to 162 years for hollow-bearing trees suitable for arboreal mammals or cockatoos. Significant and/or long term impacts on hollow-dependant fauna may arise if the hollow bearing trees resource retained outside of disturbance areas is not sufficient to maintain local populations.

Based on the field survey results, construction may result in the following impacts on the habitat tree resource at the Forest:

- Removal of 532 habitat trees within the footprints for fixed project infrastructure that were surveyed in detail, including the locations of the regulators and channels; and
- Removal of an estimated 1,820 habitat trees within the footprints for project infrastructure that had not been located at the time of the survey and/or were too large to survey in detail.

The density, type and likely conservation significance of habitat trees varies across the Forest with factors such as vegetation type, topographic position and disturbance history. The greatest intensity of habitat tree removal is associated with the locations of the regulators since drainage lines contain a greater density of large trees, including habitat trees. Accurate counts were obtained in these areas.

Densities of hollow bearing trees are lower along the downstream levee, which includes areas of shorter, less productive River Red Gum vegetation, Black Box Woodlands, immature regrowth and disturbed land at the margins of the forest. Estimated counts were obtained for the

downstream levee, spoil disposal area and features such as the proposed borrow pits. These estimates are conservative, since the average density included areas of intact vegetation with high habitat tree abundance whereas in practice these features would be sited in disturbed, cleared land as far as is practicable.

Based on these estimates, the proposed construction would remove 2,352 habitat trees. Applying the same estimation method across the Forest, equates to approximately 1.8 percent of the estimated 132,300 habitat trees across the Forest.

The distribution of hollow bearing trees is also important. Where hollow bearing trees are clumped, the number of hollows available for occupation is less than where such trees are retained in a more even, or random distribution because the social and territorial behaviour of a number of hollow-dependent fauna exclude individuals from hollows which would otherwise be available. In addition, the distance between hollow-bearing trees must not exceed typical home range movements (Gibbons and Lindenmayer, 1997). Thus, despite the presence of alternative hollows outside surface disturbance areas, the removal of hollow bearing trees has impacts on fauna populations at the time of disturbance and potentially over longer time scales.

Project infrastructure has relatively small and/or linear disturbance footprints. The infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. These gaps would result in a relatively minor increase in energy costs and risks of travelling for hollow-dependant fauna. Gaps between habitat trees are also unlikely to exceed typical home range movements of any hollow-dependant fauna.

Project infrastructure would remove habitat trees in potentially significant positions in the landscape, notably large hollow-bearing River Red Gums at the locations of regulators. hollow bearing trees close to drainage lines or surface water are particularly significant for many hollow-dependant fauna (Gibbons and Lindenmayer, 1997), including threatened species known from the Forest such as the Barking Owl and Large-footed Myotis (DECCW, 2009b). The project is unlikely to remove a significant proportion of hollow bearing trees close to water given the extensive network of intermittent water bodies at the Forest and approximately 50 km of Murray River riparian strip adjoining the Forest. Significant impacts may occur if a nesting hollow or maternity roost is removed; however it is not possible to predict or effectively mitigate these potential impacts.

Precisely determining the significance of impacts associated with habitat tree removal is difficult, since on the one hand, a proportion of the habitat trees to be removed would not be suitable for fauna occupation, whilst some individual habitat trees may have particular significance for local populations. The removal of approximately 1.8 percent of the potential habitat tree resource at the Forest is unlikely to comprise the removal of a significant proportion of the total resource, such that any local populations of fauna would experience significant negative impacts.

Impacts associated with the removal of hollow bearing trees would be partially offset by the environmental watering of the Forest. The proposed inundation may help to secure the supply of hollow bearing trees at the Forest in the longer term by improving the health of River Red Gums and Black Box. The potential for positive impacts is increased by the known concentration of hollow bearing trees along drainage lines and depressions due to high productivity and exclusion of timber harvesting from these areas in recent decades (GHD, 2009a) and the likely significance of hollow bearing trees in these settings to threatened fauna (DECCW, 2009b) since these are also the areas most likely to experience benefits from

environmental watering. Further, large mature and over-mature River Red Gums (which are most likely to be hollow-bearing) have proven most susceptible to the effects of drought in recent years (Jurskis, 2007). Removal of habitat trees during construction of the project would be mitigated by improvements to the long term security of the habitat tree resource through the proposed environmental watering.

**Modification of habitat**

Clearing would fragment native vegetation and create new edges along areas of retained vegetation which would be exposed to additional edge effects. Edge effects refer to the impact of clearing on neighbouring areas of remnant vegetation. Negative impacts may include an increase in incursion of weeds, sedimentation or access for predators.

Vegetation structure modifies microclimates through the degree of canopy closure, canopy height, vegetation density and structural stratification. Structural changes as a result of the project may fragment habitat and have a considerable effect on microclimate through edge effects. Following construction, the intensity of light at the soil surface and on plants would be greater in the disturbance area than in undisturbed vegetation. These changes would occur in the disturbance area as well as adjacent edges of remnant vegetation and may alter the plant and animal communities which occur there.

The severity of edge effects arising from the project would vary significantly with the context of the environment to be disturbed. Some of the project infrastructure, most notably the downstream levee, would be constructed at the margins of patches of habitat. These areas are already substantially modified by edge effects associated with clearing for agriculture and Forests NSW tracks. These existing disturbances have resulted in visible edge effects in native vegetation such as reduced canopy tree foliage cover and infestation of the understorey with exotic species. The proposed channels and regulators are located in areas of near-intact native vegetation and so this would increase the likely severity of edge effects on local populations.

The project would impose these changes to vegetation structure and microclimate on limited portions of the study area. Some portions of construction footprints (e.g. borrow pits, laydown areas) would be allowed to regenerate and so over time the native vegetation would regain its pre-disturbance characteristics. There are substantial areas of undisturbed woodland and forest habitats outside of the surface disturbance area, including areas completely excluded from timber harvesting (GHD, 2009a). These areas would provide refuges for flora and fauna that were negatively affected by changes to vegetation structure and microclimate. The Forest is extensive and features a variety of forest types at various successional stages due to ongoing forest management activities (GHD, 2009b) and a mix of microhabitat types. Local populations of native biota are likely to be tolerant of this disturbance regime. In this context, changes to vegetation structure and microclimate within the project construction footprint are unlikely to have a significant negative effect on any local flora or fauna populations.

**Fragmentation of habitat**

The project would modify or remove a maximum of 206 ha of habitat. The modified construction footprint would constitute a partial barrier to regional movements of migratory fauna species by increasing the area of non-viable habitat that they need to traverse. Migratory species often rely on ‘stepping stones’ of suitable foraging and roosting habitat during migrations. By removing a maximum of 206 ha of habitat, the project would increase the distance between suitable

patches. All of the gaps created would be small (less than 100 m across) which would be minor in the context of the overall 32,000 ha of near-intact native vegetation at the Forest. The project would create relatively small gaps between areas of intact habitat. The magnitude of gap created would vary with the type of infrastructure according to three main types:

- Areas of temporary habitat disturbance, such as laydown areas and borrow pits - the topsoil and the soil seed bank would be retained and so disturbance areas would not comprise a gap in habitat with respect to plants or vegetation communities. Regenerating areas would contain habitat features such regenerating vegetation, leaf litter and woody debris that wood provide shelter for fauna traversing these areas.
- Permanently modified habitat, such as the downstream levee would contain habitat features such as regenerating understorey vegetation, leaf litter and woody debris that wood provide shelter for fauna traversing these areas; and
- Permanently removed habitat, such as regulators.

Vegetation clearing increases the spacing between patches of fauna habitat, which is likely to increase the energy costs for fauna travelling and feeding and would also increase the risks of predation or accident (Bauer *et al*, n.d.). Negative effects of reduced habitat integrity would be localised and specific to different groups of fauna. Negative effects would be greatest on arboreal fauna. There would also be impacts on smaller, terrestrial animals as these species would rely on trees for shelter. There would be relatively minor effects on mobile fauna such as birds, microbats and large terrestrial mammals. Conversely, creation of gaps and tracks may favour some species, such as larger microbats, which prefer open habitats for foraging or travelling (Law, 2004).

Intact native vegetation would be retained outside the surface disturbance area and would likely provide adequate connectivity for local fauna populations.

The project would not isolate any vegetation or wildlife corridors outside of immediate surface disturbance areas. The Murray River riparian corridor is an important wildlife corridor at the regional scale. The project would remove native vegetation directly adjoining this wildlife corridor, which would result in a minor modification by reducing the overall extent of habitat. The habitat removal is limited in extent relative to the overall width of the corridor and would not isolate or disconnect any vegetation patches. Viable alternative routes through the corridor would be maintained in native vegetation upslope of project infrastructure as well as within the Murray River and on the opposite bank. In this context, the project would be unlikely to significantly reduce the potential for fauna movement through the corridor.

### 8.4.3 Indirect impacts

***Contamination of surface waters***

Potential sources of contaminated surface water include:

- Runoff from areas stripped of vegetation;
- Runoff from soil stockpiles;
- Runoff from hardstand areas, including roads, processing areas and site facilities;

- Leakage or spillage of hydrocarbon products from vehicles, wash down areas and workshops,
- Refuelling bays and fuel, oil and grease storages.

There are a number of sensitive aquatic habitats in close proximity to project infrastructure, including the Murray River, smaller drainage lines and floodplain marshes. These areas are all sensitive to adverse impacts on water quality potentially arising from the project.

The overall risk of significant soil erosion and water pollution during construction is considered to be very low because of the following factors:

- The Forest is a depositional environment, with low rainfall and very low relief;
- The broader site is maintained as a native forest environment and would have a substantially lower erosion hazard than, for example, cleared agricultural landscapes. Localised increases in erosion hazard as a result of construction would be limited in extent and in most cases there would be buffers of intact vegetation between the disturbance footprint and aquatic habitats;
- Within the Forest, the road network of primary and secondary roads is already established and any additional access roads would principally be short, temporary tracks; and
- Soil protection measures and techniques would be implemented during and following construction.

***Sediments, dust and runoff***

Floodplains of the Murray River are low contributors to the catchments of local drainage systems due to a combination of low rainfall and flat terrain. This, together with the low gradient of the Murray River, means that the Forest contains depositional rather than erosional landforms. Accordingly, activities such as road construction, vegetation clearing, excavation and construction, which may result in adverse erosion or sedimentation in steeper or higher rainfall environments, are not considered a significant threat in the study area (GHD, 2009a). GHD (2009b) field assessment of erosion hazard and evidence of negative effects at the Forest did not locate any appreciable instances of point source erosion associated with roads and there were negligible differences in potential road erosion sources between recently harvested or unlogged areas of forest.

Potential indirect impacts to flora and fauna from construction activities include dust and vehicle exhaust emissions generated from construction vehicles and equipment.

***Roads and access***

Collisions with wildlife (especially macropods, arboreal mammals, owls, corvids and raptors) within the Forest are possible, particularly at dusk and dawn when macropods are active. The Forest currently experiences light to moderate vehicle traffic depending on the location and extent of timber harvesting activities. Multiple road-kills were noted during the field survey, mainly Eastern Grey Kangaroos. The project would increase the risk of vehicle collisions with fauna at the Forest for the duration of the construction activities.

***Duration of impacts***

The construction activities are estimated to take about 8.5 months (MacMahon, 2009).

Long-term impacts on native fauna would include the loss of ecological functions and habitat resources that take a long time to develop. These include:

- Mature hollow-bearing trees;
- Feed trees, since trees must reach full sexual maturity to produce large volumes of blossom and fruit;
- Structurally diverse vegetation, with a number of age classes and mature emergents; and
- A healthy soil seed bank, with sufficient number and diversity of propagules to allow the native vegetation to regenerate following disturbances such as bushfire.

Provided the mitigation measures outlined in Section 8.7 are adopted; in particular the remediation of portions of the Forest not containing permanent infrastructure, the project is unlikely to result in permanent or irreversible impacts on native biodiversity. This includes local populations of native flora and fauna, which are likely to persist in retained and remediated vegetation in the locality and recolonise the Forest after construction has finished.

### 8.4.4 Construction impact evaluation

The evaluation of impacts involves identifying the magnitude and extent of impacts, along with the significance of the impacts as related to the conservation importance of the native biota likely to be affected (DEC/DPI, 2005). The evaluation of construction impacts arising from the project is summarised in Table 8-6, with reference to the DEC/DPI (2005) guidelines for Part 3A Environmental Assessments.

**Table 8-6 Evaluation of construction impacts arising from the project**

| Guideline (DEC/DPI, 2005) | Relevance to project |
|---|---|
| *The magnitude and extent of impacts* | Ground disturbance from the project would affect a maximum of 206 ha of the Forest.<br><br>Most animals would readily escape harm from vegetation clearing and construction. Flora and fauna populations would persist in retained vegetation outside the disturbance area. Reproduction at population scale is unlikely to be disadvantaged by injury to individuals. Any disruption to reproduction would only be for the one season.<br><br>Impacts on individual species would occur through removal of specific habitat resources. The project would remove habitat resources that take a long time to develop, such as hollow-bearing trees. There is the potential for negative impacts on fauna which rely on these resources. The project would remove a small proportion of the overall amounts of these resources available at the Forest. |
| *Impacts will be more significant if…* | |
| *areas of high conservation value are affected;* | The Forest contains a number of TSC/EPBC Act listed biota and their habitats.<br><br>The Forest is part of the NSW Central Murray State Forests Ramsar site, which is recognised internationally for its very high conservation significance.<br><br>The Forest has high conservation value in the context of the extensively cleared native vegetation of western NSW. The Forest contains near-intact native vegetation communities, a moderate to high diversity of native plants and animals and valuable habitat resources. |
| *individual animals and/or plants and/or subpopulations that are likely to be affected by the project play an important role in maintaining the long-term viability of the species, population or ecological community;* | The Forest contains a significant proportion of Australia's River Red Gum dominated vegetation communities (approximately 32,000 ha).<br><br>The study area also contains a significant proportion of Black Box dominated vegetation communities and floodplain forms of the Inland Grey Box Woodland EEC. |

| Guideline (DEC/DPI, 2005) | Relevance to project |
|---|---|
| *habitat features that are likely to be affected by the project play an important role in maintaining the long-term viability of the species, population or ecological community;* | The project would remove intact native vegetation including an area of EEC. It would also remove important habitat resources that take a long time to develop, including tree-hollows, which play an important role in maintaining the long term viability of many fauna species (Gibbons and Lindenmayer, 1992).<br><br>In terms of gross areas of habitat, the resources to be directly removed or modified would play a relatively minor role in maintaining local populations of native biota. This is because the habitat affected would comprise a small portion of the habitat resources available in the Forest. |
| *the duration of the impacts are long term;* | Displacement and/or mortality of fauna populations within disturbance footprints are short term.<br><br>Vegetation and habitat removal varies from short term to permanent, depending on project infrastructure proposed at particular locations.<br><br>Removal of some habitat resources (e.g. hollow bearing trees) is long term. |
| *the impacts are permanent and irreversible.* | Impacts within immediate project infrastructure footprints are permanent and irreversible.<br><br>Impacts within construction footprints are readily reversible through flood-induced regeneration of native vegetation. |

## 8.5 Operational impacts

This section describes the potential impacts on floodplain ecology from the operational phase of the project. This impact assessment is based on the operational regime described in the *Preliminary Operating Plan Draft Version 1 - September 2009* which is summarised in Section 6.4 and included in Appendix B.

### 8.5.1 Operational regime

The extent and duration of inundation under the proposed operating scenario, based on DHI (2008) modelling, is shown on Figure 8-6. Note that this modelled flood extent does not include the north-western portion of the Forest site. This is because the downstream levee was re-aligned through this section after the hydrological model had been run. Therefore the hydrological modelling and interpretation of operational impacts presented in this report does not include empirical assessment of this area. The available modelling data covers the majority of the Forest and is considered to provide a suitable basis for this assessment.

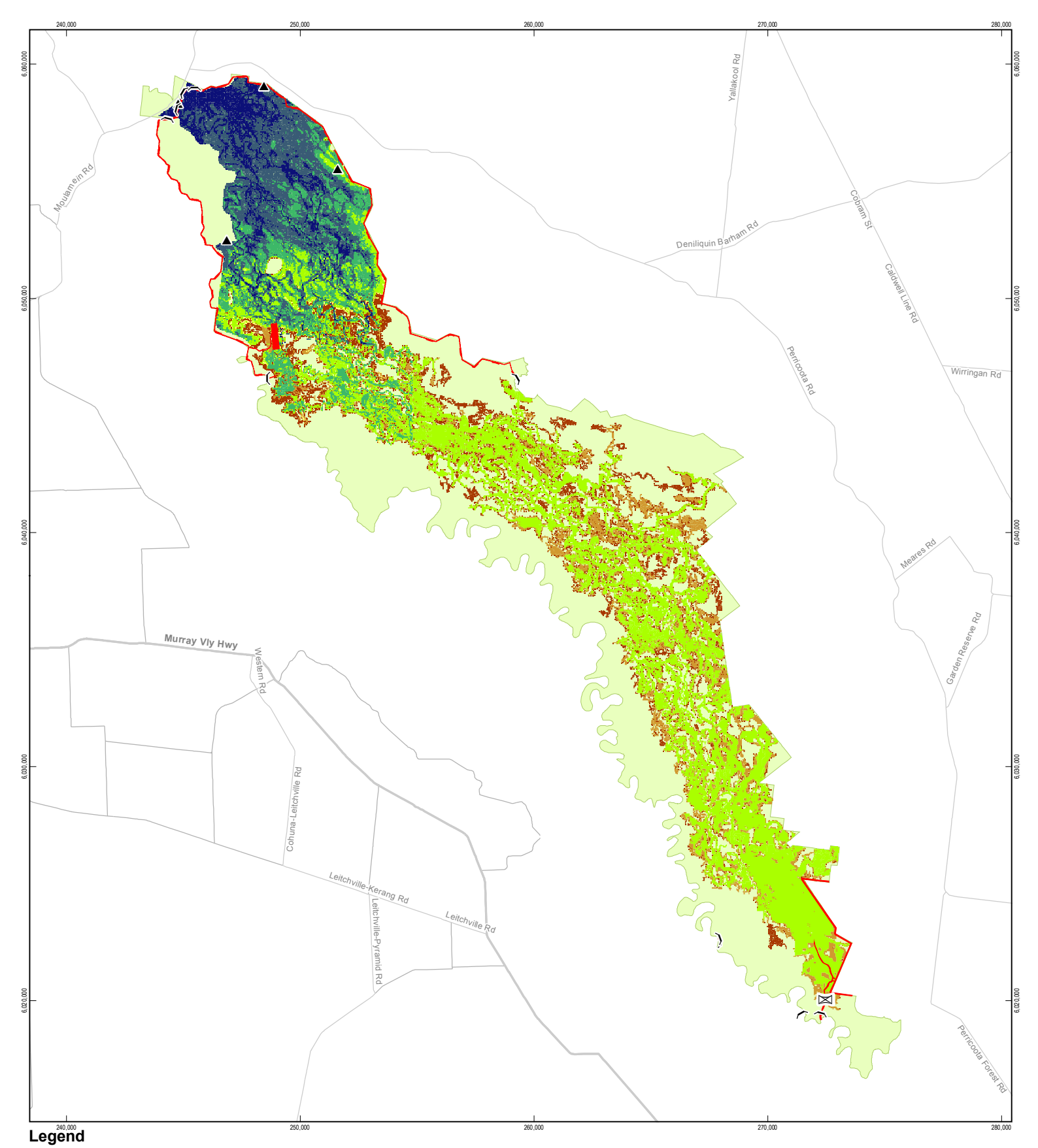
### 8.5.2 Floodplain ecosystem responses

Cycles of wetting and drying affect the physical, chemical and biological processes and functions of floodplain ecosystems. Of relevance to the operational impact assessment of the project are the general ecological processes that can be expected to occur during three distinct phases of the operation: filling; inundated state; and recession. The timing of these stages as they relate to the operation of the project is as follows:

- Filling:
  - Day 001 - Start filling at 6,000 ML/day
  - Day 045 – Maximum extent of inundation achieved. Inflow reduced to 3,400 ML/day
- Inundated state:
  - Day 055 – Flood pool height reaches 78.5m AHD. Inflows adjusted to maintain pool height. Flooded area constant to Day 100
  - Day 100 - Inflow ceased
- Recession:
  - Day 110 - Dewatering of pool begins
  - Day 220 - Pool empty.

The total area of inundation and the relative extent of vegetation communities inundated through these stages are described in detail in Appendix C.

Biological processes expected throughout these phases are summarised below along with potential negative impacts.




## Legend

- Turkey's nest dam
- River Road bridge
- Regulator
- Major roads
- Construction features
- Koondrook Perricoota Forest Site

**TotalDays**

- 0 - 29
- 30 - 58
- 59 - 87
- 88 - 116
- 117 - 145
- 146 - 174
- 175 - 203

1:150,000 (at A3)

0 1 2 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

| | |
|---|---|
| Job Number | 21-18573 |
| Revision | B |
| Date | 01 FEB 2010 |

# Figure 8.6 - Inundation duration within the maximum inundated area

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z023_FloodingDuration.mxd

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Data source: Dept of Commerce, Drawn: Cwilson, cwilson

### *Filling*

The arrival of floodwaters waterlogs sediments and releases nutrients from sediments into floodwaters (Boon, 2006). The release of nutrients and subsequent "boom" in productivity act as cues for organisms to process nutrients and commence growth, breeding and dispersal (Boulton and Brock, 1999).

Identified potential negative impacts during this phase include (Ecological Associates, 2009):

- Rapid passage of water through channels and natural watercourses results in accelerated erosion of bed and banks and results in increased turbidity;
- Diversion of eggs, larvae and juvenile fish from the Murray River to the forest and depletion of native recruits in the Murray River;
- Reduction in flow pulses in the Murray River which act as a trigger for breeding of large-bodied native fish and a subsequent reduction in regional fish populations; and
- Diversion of introduced fish species (e.g. Carp, Eastern Gambusia) into the flooded forest and associated impacts on water quality and fish.

### *Inundated state*

The productivity of a flood event is maintained through the inundation period (depending on conditions of light, temperature and nutrients released into the water column) and in response organisms continue to experience enhanced growth and feeding opportunities, breeding activity and development of young (Boulton and Brock, 1999).

Identified potential negative impacts during this phase include (Ecological Associates, 2009):

- Anaerobic nature of waterlogged soil negatively impacts on terrestrial plant species that are intolerant of inundation; including terrestrial grasses and forbs, shrubs and trees (e.g. Inland Grey Box) causing reduced productivity and death of individuals;
- If inundation persists beyond tolerances of "floodplain" species (e.g. River Red Gum, Black Box, Lignum) negative impacts such as reduced productivity and death of individuals can occur;
- Inundation acts as a shock to stressed River Red Gum and tree death ensues;
- Drought conditions result in reduced productivity in the inundated forest and resources are insufficient to sustain waterbird breeding;
- Calm, warm conditions can lead to algal blooms. This may not cause ecological effects on site, but may be detrimental to river health if returned to the River;
- Calm weather, warm conditions and high mobilisation of organic carbon stores can result in a blackwater event where dissolved oxygen concentrations are significantly reduced and can impair health or cause the death of aquatic fauna such as invertebrates, fish and tadpoles;
- Carp breed after being carried onto the floodplain in inflowing waters. Adults feed acting as competition to native species and disturbing sediment beds and aquatic plants, increasing turbidity, which in turn negatively impacts on visual feeders such as turtles, tadpoles and native fish;

- Eastern Gambusia that entered with floodwaters prey upon native fish (juvenile and adult) and tadpoles resulting in decreased breeding success and recruitment; and
- Terrestrial animals (mammals, reptiles) become concentrated on islands on the floodplain, which are also occupied by predators such as foxes and cats; increasing the effects of predation.

***Recession***

The recession of floodwaters and subsequent drying of the soil results in concentration of nutrients and salts in depressional wetlands, storage of nutrients in the soil, completion of growth, foraging and breeding activities by wetland biota, germination of floodplain flora and dispersal or aestivation of wetland and aquatic fauna (Boulton and Brock, 1999).

Identified potential negative impacts during this phase (Ecological Associates, 2009) include:

- A rapid rate of falling water can leave plants and animals with insufficient time to complete breeding cycles leading to reduced breeding success and recruitment; egg and seed bank depletion;
- A rapid fall and presence of barriers to lateral movement can leave fish stranded on the floodplain and unable to return to the river; and
- A rapid return to dry soil condition results in reduced eucalypt seedling success (Jensen, 2008).

### 8.5.3 Duration of inundation

It is thought that wetland plants are more affected by flooding constraints and wetland animals by drying constraints (Mendelssohn and Batzer, 2006). This is reflected in the potential impacts of flood duration on the biota of the Forest, where the greatest identified risk to vegetation is from inundation for too great a period and for waterbirds, fish and other fauna from inundation for too short a period of time (Ecological Associates, 2009).

**Vegetation**

Inundation of the floodplain changes the soil structure and creates anoxic conditions within the waterlogged sediment. Wetland and floodplain plants have varying degrees of tolerance to anoxic soil conditions and, in general, terrestrial plants are intolerant of prolonged inundation. The known inundation tolerances (and requirements) of key vegetation communities within the study site are provided in Table 8-7. Exceeding these tolerances can lead to decreased health; death of individuals and changes in community composition and extent; depending on the degree to which these tolerances are exceeded.

**Table 8-7 Inundation requirements and tolerances of key species within vegetation communities in the study area.**

| Community | Key species | Known inundation tolerance |
|---|---|---|
| Inland Grey Box woodland | Inland Grey Box (*Eucalyptus microcarpa*) | Inland Grey Box is intolerant of prolonged water-logging (Vesk *et al*. in press). |
| Derived tussock grasslands | Herbland - e.g. *Vittadinia cunneata, Vittadinia gracilis, Cotula bipinnata, Atriplex sp.* | Terrestrial species intolerant of flooding, but likely to survive in the seed bank and re-emerge after the flood recedes. |
| | Grassland – e.g. *Austrostipa* spp*., Austrodanthonia* sp | Terrestrial species intolerant of flooding, but likely to survive in the seed bank and re-emerge after the flood recedes. |
| | Sedgeland – e.g. *Juncus* spp., and *Phragmites australis* | Emergent aquatic species tolerant of inundation. *Phragmites australis* is tolerant of permanent inundation up to a depth of 1 – 1.5 m (Roberts and Marston, 2000).<br>Juncus species are tolerant of flooding for up to 8 months providing the plant is not totally submerged. |
| Black Box – Lignum woodland | Black Box (*E. largiflorens*) | Inundation for < 4 months (Roberts and Marston, 2000), with an ideal inundation in the region of 30 – 60 days, but tolerance for up to 180 days (Murray Flow Assessment Tool – MFAT; MDBA, 2009). |
| | Lignum (*Muehlenbeckia florulenta*) | Up to 12 months, permanent inundation eventually leads to death of plants (Roberts and Marston, 2000). |
| River Red Gum forests | River Red Gum | Mature healthy trees can tolerate up to 24 months continuous flooding (Roberts and Marston, 2000). Optimum for the region is between 30 and 250 days (MFAT; MDBA, 2009). |
| Shallow Marsh | Aquatic herbs, sedges, forbs | Tolerant of continuous inundation (< 30 cm for some species). However, maximum floral diversity in fluctuating or seasonal water regimes (Roberts and Marston, 2000). |

Vegetation types within the proposed inundation area are shown on Figure 8-7. Up to 52% of vegetation at the Forest would be inundated by the project. The relative extent of vegetation types at the Forest inundated by the project is presented in Table 8-8.

**Table 8-8 Percentage area of vegetation Inundated at the Forest**

| Vegetation Type | Inundated area (ha) | Total area (ha)[1] | Extent of inundation (%)[1] |
|---|---|---|---|
| Comm ID 2: River Red Gum-sedge tall open forest | 1,136 | 1,942 | 59 |
| Comm ID 7: River Red Gum - herbaceous tall open forest | 11,104 | 17,799 | 62 |
| Comm ID 9: River Red Gum - wallaby grass tall woodland | 2,639 | 5,280 | 50 |
| Comm ID 10: River Red Gum - Black Box woodland | 904 | 1,357 | 67 |
| Comm ID 13: Black Box - Lignum woodland | 1,549 | 3,106 | 50 |
| Comm ID 237: Riverine Inland Grey Box grassy woodland | 189 | 951 | 20 |
| Comm ID 250: Derived tussock grasslands | 46 | 372 | 12 |
| Comm ID 12: Shallow depressional marsh | 140 | 240 | 58 |
| Comm ID 19: Cypress Pine woodland of dunes | 0 | 10 | 0 |
| Floodplain Marshes[2] | 1,217 | 1,622 | 75 |
| **Total** | **17,707** | **31,058** | **57** |

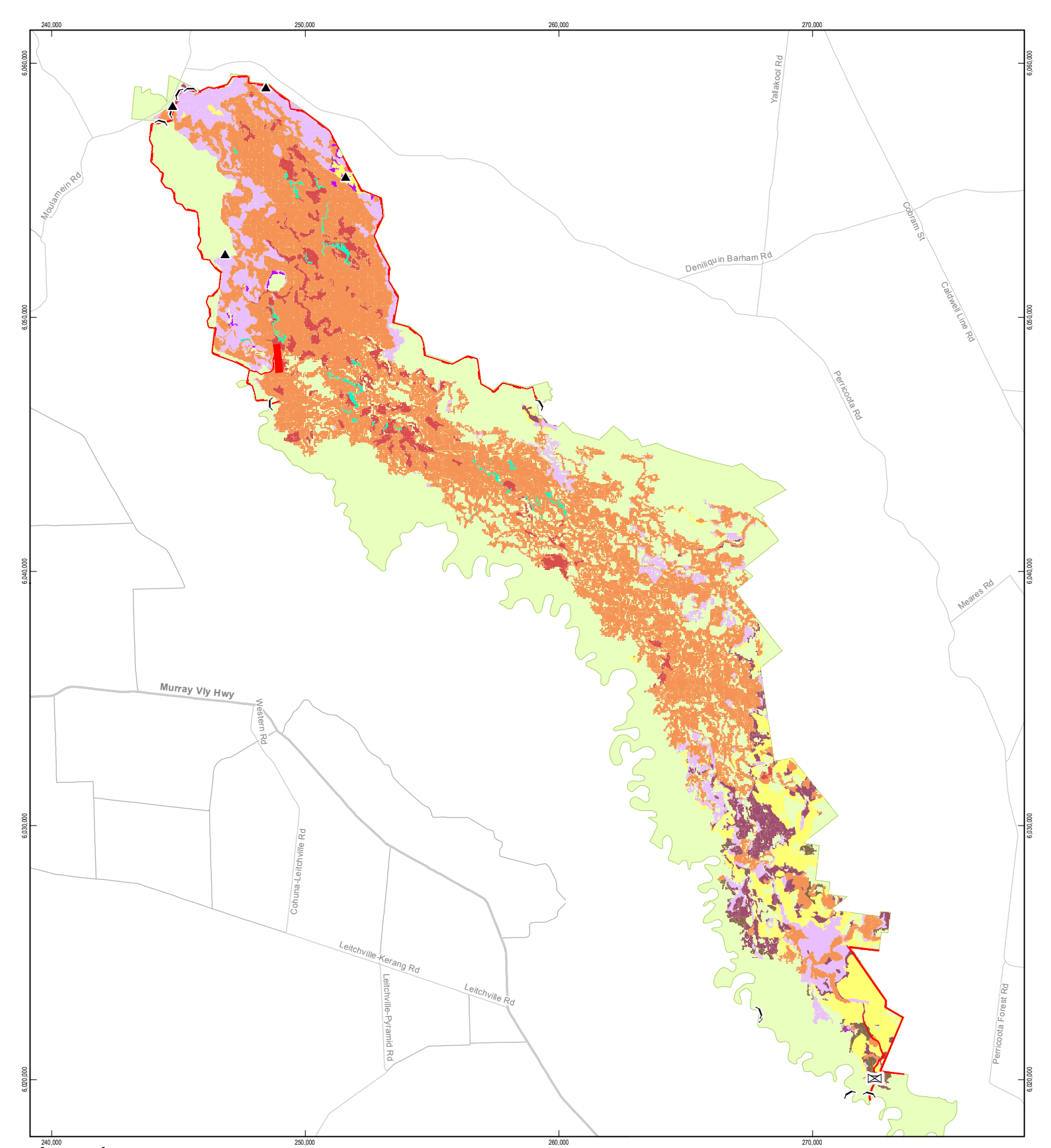
1 – The total and inundated areas do not include portions of the project site adjacent to the western levee alignment area as these were not covered by the available hydrological data.

2 - Floodplain Marshes are not included in the total area of vegetation because they were mapped separately and may overlap with other vegetation types.

Not all of these areas would experience prolonged inundation. Due to the flat topography of the Forest, the area of inundation decreases rapidly with a drop in water level. The duration of inundation across the floodplain for the modelled scenario is shown on Figure 8-6. A comparison of the modelled duration of inundation against the tolerances provided in Table 8-7 resulted in the following assessment of potential impacts from inundation duration to vegetation communities:

***Inland Grey Box Woodland***

Hydrological modelling indicates that approximately 190 hectares of Inland Grey Box Woodland would be inundated, out of approximately 951 ha at the Forest (i.e. approximately 20%), of which 180 hectares would be inundated for more than 30 days. Under natural conditions, large floods inundate this community but it is generally on higher, less frequently flooded levees and terraces (Benson et al., 2006) and may occur on more free draining, sandy soils. Inclusion of terrestrial vegetation in the inundation footprint was identified as a very high project risk by Ecological Associates (2009) who anticipated it would result in the degradation of vegetation and habitat, including Inland Grey Box Woodland.




## Legend

- ▲ Turkey's nest dam
- River Road bridge
- Regulator
- Major roads
- Construction features
- Koondrook Perricoota Forest Site

**Vegetation Types Within the Maximum Inundated Area**

- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 237: Riverine Inland Grey Box grassy woodland
- Comm ID 250: Derived tussock grasslands

0 1.25 2.5 5
Kilometers
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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GHD
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NSW Office of Water
Koondrook-Perricoota Flood Enhancement Works

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# Figure 8.7 - Vegetation types within the maximum inundated area

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Empirical studies on Inland Grey Box have concluded that lifecycle functions such as seed production are severely impacted by high soil water contents, which was used as an indicator of the poor inundation tolerance of this species (Vesk *et al*. in press). Duration of inundation sufficient to cause long term impacts to the health or death of individual Inland Grey Box trees is not known with certainty. There is no direct evidence of mortality of the species through inundation that could be used to determine a maximum frequency or duration that could be tolerated.

Ecological Associates related aerial photographs and mapped flood extents to vegetation mapping to infer patterns of flood tolerance in the Victorian Gunbower forests (Cooling, M., Ecological Associates, pers. comm.). The authors found that Inland Grey Box Woodland appeared to have a similar distribution relative to historical flood extents, and therefore similar tolerance of inundation, to Black Box Woodland (Cooling, M., Ecological Associates, pers. comm.). Based on comparisons with known tolerances of Black Box, it can be inferred that Inland Grey Box Woodland would tolerate inundation for < 4 months, i.e. 120 days (Roberts and Marston, 2000), with a maximum tolerance of up to 180 days (Murray Flow Assessment Tool – MFAT; MDBA, 2009). Based on DHI (2008) modelling of the indicative scenario, no Inland Grey Box Woodland at the Forest would be inundated for greater than 120 days. Therefore the proposed inundation is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland.

***Derived tussock grasslands***

Hydrological modelling indicates that 46 hectares of this community would be inundated for a sufficient period of time to result in the death of annual, terrestrial plants. However, the seedbank would survive and the community may benefit in terms of species diversity and productivity following the recession of the flood. In addition, impacts for sedge dominated communities are likely to be wholly positive.

***Black Box – Lignum woodland***

Hydrological modelling indicates that a total of 1,550 hectares of this community would be inundated for a maximum duration of 180 days. This is within the tolerance of this plant community (MFAT; MDBA, 2009) and as such the effects to this community are expected to be beneficial, with no predicted negative impacts.

***River Red Gum forests***

Hydrological modelling indicates that over 13,000 hectares of River Red Gum forest and woodland would be inundated. The duration of the flood would be between 30 and 200 days for the majority of the area, which is considered optimum for this species (MFAT; MDBA, 2009). Although Ecological Associates (2009) indicated a risk from inundation of stressed mature trees, evidence from elsewhere has indicated that even severely stressed trees with little canopy benefit from flooding. For example, environmental watering at Hattah Lakes in 2005 resulted in flooding of stressed River Red Gums that had been dry for nearly a decade. Mature, stressed River Red Gums that were nearly leafless responded with a flush of growth (Mallee CMA, 2009). Similarly, environmental watering of the Chowilla Floodplain in 2005 and 2006 resulted in improvements in tree health in even very stressed, leafless trees with inundation durations of 30 to > 200 days (Alderidge *et al*., 2006). The impacts to stressed River Red Gum individuals should also be considered in the context of expected responses to continued dry

conditions. It could be expected that in the absence of inundation these trees would deteriorate in condition and eventually large numbers of tree deaths could occur.

Impacts to understorey communities have also been studied in similar systems. In Chowilla, environmental watering resulted in a change in community composition in floodplain understorey from terrestrial species to flood tolerant or wetland species (Nicol *et al*., 2009). While this may be seen as an impact to the terrestrial phase of these communities, under natural flooding conditions, it would be expected that during inundation wetland species would emerge; with species composition cycling with wet and dry water regimes. Any shift towards a more natural regime may be considered as generally positive.

It is predicted that the impacts to this community would be beneficial with little or no negative impacts compared with current conditions.

***Floodplain marsh communities***

Hydrological modelling indicates that over 1,200 hectares of floodplain marsh would be inundated for varying durations. As this community is dominated by wetland species, the only negative impacts that could be expected may be from areas that are not inundated for a sufficient period of time to allow for the completion of lifecycles of non-perennial species. Approximately 100 hectares would be inundated for < 60 days, which may be insufficient for all species within these areas to flower and set seed. However, the vast majority of these communities would be inundated for > 60 days and over 400 hectares would be inundated for more than 120 days. As such the majority of the effects to this community are expected to be beneficial.

***Waterbirds***

The major stressor to fauna arising from inundation duration is the risk that drying would occur prior to the completion of lifecycle stages such as breeding. In terms of the current project, the only identified risk by this pathway was to waterbirds (Ecological Associates, 2009).

Waterbirds breed in response to flooding in relation to nesting habitat as well as available food resources. There is evidence to suggest that waterbird breeding occurs when food resources are at a maximum (Kingsford and Norman, 2002), which depending on the season and diet of the species, can lag behind the commencement of inundation for periods of 4 weeks to 7 months. Once breeding has commenced, many Australian waterbirds require surface water to remain in and around nesting sites until offspring are independent feeders (Jaensch, 2002). Drying prior to this can lead to abandonment of nests and young by parents or insufficient food resources for successful fledging. It is suggested that inundation for a minimum of four months would be required to allow for courting/mating, nest site selection and building, incubation and raising of young to independence (Jaensch, 2002).

There is little recent information regarding nesting waterbirds within the Forest (Webster, 2008), but historical records provide an indication of the suite of species for which breeding could be supported in a flood event. Preferred nesting sites and inundation requirements for waterbird species previously recorded breeding in the Forest are similar and the Forest predominantly supports birds that nest in trees or shrubs. There would be large areas of woodland and forest that would remain inundated for a sufficient time to allow for successful waterbird breeding. Over 10,000 ha of River Red Gum forest and woodland would be inundated for more than three

months, of which over 4,000 hectares would remain inundated for 4 months. Smaller areas (approximately 600 ha) would remain inundated for approximately 6 months.

Given the multiple lines and levels of evidence (empirical studies, case studies and a suite of species) it is considered very unlikely that the operational phase of the project would result in a net negative impact on waterbirds compared to the current condition.

### 8.5.4 Timing of inundation

The maximum benefits from inundation are likely to be experienced from commencement of inundation in spring and inundation continuing to mid-summer. However, a spring / summer flood event increases the likelihood of three negative impacts of the operational phase of the project: creation of a blackwater event, recruitment of pest fish species (e.g. Carp) and promotion of algal blooms.

#### *Blackwater*

Blackwater is defined as flood waters with sufficient dissolved organic carbon to give the water a dark "tea" colour associated with reduced dissolved oxygen concentrations (Howitt *et al*., 2007). The phenomenon is natural and has been recorded on Australian floodplains from times prior to river regulation (Howitt *et al*., 2007).

Production of a blackwater event is affected by a number of factors including the amount of leaf litter on the floodplain, type and age of leaf litter, period since last flood and temperature (Howitt *et al*., 2007). Modelling of the potential for blackwater has been undertaken for the proposed operational scenario and is summarised in Section 10. Results indicated that in the first year of inundation there is likely to be a large release of dissolved organic carbon from the litter that has accumulated on the floodplain over the long inter-flood interval. This is expected to result in a decrease in dissolved oxygen to < 2 mg/L during the later stages of the flood.

On the basis of this modelling, there is the potential for significant impacts on native fish and other aquatic fauna (e.g. tadpoles, Murray Crayfish and Yabbies). Australian native fish are considered to require at least 2 mg/L of dissolved oxygen to survive and health may be impacted at concentrations below this (Gerkhe, 1988).

However, despite the likely short term negative impacts to aquatic fauna, blackwater events are a part of the naturally occurring processes that are characteristic of floodplain inundation in Australia. The mobilisation of carbon from the floodplain to the river is an important process and may be a significant source of carbon for the river, maintaining productivity in the long term (Gawne *et a*l., 2007).

As detailed in Section 6.4 and Section 10, the project has been designed to enable flexible operations to minimise potential adverse impacts such as those associated with blackwater events. The seasonality of the flood event is the main factor determining whether a blackwater event occurs, with events more likely if large scale flooding occurs over summer when water temperatures are higher. To minimise the potential for blackwater events to occur, preference would be given to initiating flood events in winter and spring when water temperatures are lower.

The blackwater modelling did not consider the dilution effect of blackwater in the Forest being mixed with the receiving water in the Murray River and Barbers Creek/ Wakool River. As

indicated in Section 10, blackwater would be diluted by the receiving waters and this would reduce the potential for impacts on aquatic ecology.

A site specific blackwater model would be developed to provide a predictive tool for operation of the project. This model would be progressively refined based on the results of monitoring undertaken to evaluate the ecological response to flood events.

***Pest fish species***

Carp and Oriental Weatherloach are the main invasive species that may take advantage of the flooded forest with the extent of impacts strongly dependant on the season and frequency of inundation (NTA, 2009).

Carp (*Cyprinus carpio*) are widespread around the Murray Darling Basin. Carp have been implicated in decline of native fish populations and the degradation of river systems through damage to riverbanks, aquatic macrophytes, increasing turbidity and predation of native biota and competition with native fish for food and habitat (Stuart and Jones, 2000). The Barmah-Millewa River Red Gum forests have been noted for the abundance of Carp, which utilise the inundated floodplains for spawning and recruitment (Stuart and Jones, 2006). Carp have been implicated in the decline of native fish populations and the degradation of river systems.

Depending on natural flooding and forest health, the time between managed inundations arising from the project would vary between one and four years. The operational scenario assessed in this report would only be initiated every three to five-5 years and smaller flood events would be managed to avoid prolonged or too-frequent inundation. The proposed operation is intended to achieve a more natural sequence of flooding frequency and duration, which may return the competitive advantage to the indigenous species which are well adapted to the opportunistic wetting and drying cycles associated with Australian river systems (NTA, 2009).

The operational phase of the project has the potential to result in increased recruitment of Carp and other pest species. This negative impact must be considered in the context of net gains for native fish and other biota.

***Algal blooms***

Phytoplankton populations often exist in a quasi equilibrium where primary production is balanced by losses (Evans and Parslow, 1985) and phytoplankton populations are stable. A bloom can therefore be defined as a departure from this balance, when production exceeds losses and therefore leads to an increase in biomass. Algal blooms are a natural feature of aquatic ecosystems and occurred prior to river regulation. However, the frequency and intensity of algal blooms across many wetland types in Australia has increased in the last 100 years.

Inundation of the floodplain is likely to result in the release of dissolved organic carbon from the leaf litter and stain the water with tannins, which has an effect of reducing light within the water column. In open water bodies, this may competitively advantage blue-green algae such as *Microcystis* and *Anabaena* that can regulate their buoyancy. However, the Forest is predominantly covered by woodland and forest, which, even in conditions of tree stress, provides canopy and a reduction in light reaching the water's surface, which reduces light for all algal species. This leaves only relatively small areas of open wetland, which may be susceptible to algal blooms.

In any case, an algal bloom within the floodplain ecosystem itself is unlikely to cause serious adverse effects. Temporary wetland systems such as floodplains are adapted to "boom and bust" cycles associated with wetting and drying (Boulton and Brock, 1999). An increase in algal growth adds to productivity and would ensure sufficient food resources to enable successful breeding of waterbirds, fish and other biota.

The risk of developing algal blooms following inundation of the forest has been assessed as low (GHD, 2009c). As such, the ecological implications from increased algal growth on both the floodplain and the Murray River are considered negligible.

### 8.5.5 Barriers to fish movement

Ecological Associates (2009) assessed the risk of trapping large big-bodied fish within the floodplain as a moderate risk. Species at risk include the threatened Murray Cod, which is present in the Murray River adjoining the Forest and may move onto the floodplain, and potentially breed during flood events.

The FPTF has been involved in the review of the project and provided recommendations on fish passage which have been incorporated into the design. The recommendations involve design of structures to ensure that large-bodied native fish, including Murray Cod, can enter and leave the floodplain including:

- At the inlet regulator:
  - overshot gates have been used to ensure the safe passage into the floodplain;
  - a Denil fishway specifically designed for passage of large bodied fish to return to the river;
  - a separate fishway, specifically designed to allow small-bodied fish (e.g. 20-100 mm long), including juvenile Murray Cod, to return to the river. The fishway is a vertical-slot fishway with small pools and low water velocities and turbulence, designed for the poor swimming ability of small fish;
- At the outlet regulators:
  - stoplogs or a gate, providing overshot passage of fish downstream back to the river. Flow through Barbers Creek regulator during managed inundation of the forest via a deep dissipating pool specifically designed for fish passage would be provided on the downstream side of the Barbers Creek Regulator.

The provision of these structures is likely to minimise the trapping of large bodied fish species within the floodplain.

### 8.5.6 Isolation of terrestrial habitat

Inundation of the floodplain would form a temporary network of islands on higher ground. Ecological Associates (2009) suggested these would provide good nesting habitat for freshwater tortoises; but that the concentration of predators in these areas (foxes and cats) would increase the risk of predation of eggs.

There are three freshwater tortoise species likely to occur within the Koondrook-Perricoota Forest; Broad Shelled Tortoise (*Chelodina expansa*), Long-necked Tortoise (*Chelodina*

*longicollis*) and Murray River Tortoise (*Emydura macquarii*), all of which lay eggs in sandy soils near water. Fox (and cat) predation is a significant threat to all three species. For example, monitoring of Murray River Tortoise nesting sites along the Murray River in South Australia showed that over 93% of eggs were taken by foxes (Thomson, 1983).

The concentration of predators on islands may represent an increased risk to all fauna that utilise the limited land available during the peak of the flood. This includes waterbirds that nest near the ground or in the soil, reptiles and small ground dwelling mammals as well as freshwater tortoises. However, the concentration effect on introduced predators would be limited, can be mitigated by a fox and cat control program prior to inundation and must be considered in the context of the benefits to fauna from the flood (see sections 9.10 and 9.11).

### 8.5.7 Loss of flow pulse

Flow or flood pulses are thought to be important spawning cues for native fish such as Golden and Silver Perch (King *et al*. 2009). The operational scenario for the flood enhancement project involves calling water specifically for the project to be released from upstream water storages. Therefore, the project is not likely to alter current flow patterns in the river or change the frequency or magnitude of potential flood pulses in the Murray River. As a consequence, impacts to regional native fish populations via this mechanism are likely to be negligible.

### 8.5.8 Potential beneficial impacts

The operation phase of the project would have a number of beneficial ecological impacts. These are described briefly below, together with conditions to optimise them.

#### *Vegetation*

There is significant evidence that the vast majority of vegetation communities within the Koondrook-Perricoota floodplain are in less than optimal condition as a result of reduced flood frequency and duration (GHD 2009a; FNSW, 2008a). The flood enhancement project has been designed to improve the ecological condition of the forest communities and as such, there are numerous predicted benefits from the operational phase of the project.

The MFAT (MDBA, 2009) provides an indication of the optimal inundation durations and timing for the three dominant forest vegetation communities. A comparison of these with the predicted inundation regime for the operational scenario indicates that large areas of the project area would be provided with an almost optimal hydrological regime (Table 8-9) indicating that very large areas of forest would be provided with beneficial inundation durations.

**Table 8-9 Areas of forest community predicted to be inundated for optimal and tolerance durations of inundation as predicted by the MFAT for the Koondrook-Perricoota zone of the Murray River**

| Community | MFAT inundation preferences (MDBA, 2009) | Approximate area (ha) of community predicted to be inundated (DHI, 2008) to match preferences | Approximate percentage of area of community in the Forest (%) | Total area in the Forest (ha) |
|---|---|---|---|---|
| Black Box woodland (includes Black Box-Lignum woodland and River Red Gum – Black Box Woodland) | Optimal: 30 – 60 days | 590 | 13 | 4,463 |
| | Tolerance: 60 – 180 days | 1,700 | 38 | |
| River Red Gum Woodland | Optimal: 30 – 150 days | 1,800 | 34 | 5,280 |
| | Tolerance: 150 – 720 days | 720 | 14 | |
| River Red Gum Forest | Optimal: 30 – 250 days | 10,000 | 51 | 19,742 |
| Floodplain marshes* | Any inundation favourable. | 1,217 | 75 | 1,622 |

* The 'optimal' and 'tolerance' range for floodplain marshes varies with plant species composition. However, any inundation is likely to be beneficial.

The MFAT (MDBA, 2009) also predicts the optimal timing of inundation for each of these communities as follows (noting that a flood at any time of the year is still likely to be beneficial):

- Black Box woodland – October to January;
- River Red Gum woodland – August to November; and
- River Red Gum forest – August to September.

Expected responses to inundation by forest vegetation communities include (Jenson, 2009; MDBA, 2009; Alderidge, 2006; Nicol, 2009; Roberts and Marston, 2000):

- Trees and Shrubs (Lignum, Black Box, River Red Gum):
  - Increase in leaf area and canopy condition (possibly flush of epicormic growth);
  - Increased root growth;
  - Flowering and seed production; and
  - Germination of seedlings of tree species (on wet soil following flood recession).
- Germination of wetland plants from the seed bank (during inundation);
- Replenishment of seed bank with wetland plant species (on recession of flood); and
- Increase in diversity and productivity of inundation tolerant and dependant plant species.

### *Waterbirds*

Beneficial impacts to waterbirds are anticipated relating to both breeding and foraging habitat. Waterbird nesting requirements for species previously recorded breeding within the Forest indicate that the vast majority of birds require inundated woody vegetation to a minimum depth of 30 cm for 3 to 4 months. The operational scenario indicates that over 9,000 hectares of woody vegetation would be inundated to a depth of greater than 30 cm and some 4,000 hectares would remain inundated for over four months. A spring / summer flood event not only would provide optimum timing for waterbird breeding within this inundated area, but due to increased temperatures and therefore productivity, require less of a lag time for waterbird breeding events to commence (MDBA, 2009).

Foraging habitats for waterbirds are based on food preferences, bill shape and morphology and size of the waterbird (Kingsford and Norman, 2002). Wading species of birds generally require inundated foraging areas with a water depth of < 30 cm (Jaensch, 2002). At the peak of the flood event approximately 7,000 hectares of the Forest would be inundated to a depth of < 30 cm. This would include large areas under canopy as well as smaller, open areas, providing for feeding and foraging of a number of waterbird species (including international migratory wading species).

Deeper areas on the floodplain and in the channels provide foraging habitat for dabbling ducks and diving species of birds such as cormorants, gulls and terns. At peak inundation, over 5,000 hectares would be inundated to a depth of > 1m, providing foraging habitat for a number of water bird species. Feeding and foraging would be enhanced by the pulse of productivity expected upon inundation.

### *Native fish*

Understanding of native fish use of flooded wetland habitats is in its infancy in Australia. However, evidence from some empirical studies and monitoring of environmental watering at Barmah-Milawa, Hattah Lakes and Chowilla Floodplain have indicated that a number of species benefit from floodplain inundation, either directly by using the inundated habitat on the floodplain or indirectly by increased productivity in the river channel following the release of carbon from the floodplain surface.

A number of native fish are known to use inundated floodplain habitats and it is likely that the increased productivity in the floodplain following inundation is beneficial to some native fish species. The role of the floodplain in providing spawning habitat is less certain and the results of research in comparable floodplain systems in Victoria has indicated that there is little difference in spawning and recruitment in native fish in years of flood as opposed to years when water remains within the river channels (King *et al*., 2003; King *et al*., 2009).

However, results from Barmah Forest indicate that the floodplain, channels and wetland habitats within the forest system are important for native fish and a diversity of habitats is the key to maintaining native fish diversity. The operational phase of the project would inundate a number of habitats within the system, including channels and waterways, open water bodies, floodplain wetlands and marshes and inundated forest areas as well as a significant amount of woody debris in localised areas. This would provide a diversity of habitat for both spawning and foraging of native fish.

***Other fauna***

Evidence from other environmental watering events at icon sites on the Murray River such as Hattah, Chowilla and Barmah have indicated that reinstating a wetting and drying cycle can result in benefits for aquatic biota such as frogs and freshwater tortoises. Increased abundance and diversity of frogs, tortoises, yabbies and crustaceans was recorded at Chowilla three months after inundation (Aldridge *et al*., 2006) and increased abundances of tortoises and frogs were observed in Hattah Lakes following environmental watering (Mallee CMA, 2009).

Three species of freshwater tortoise are likely to inhabit Koondrook-Perricoota. Of these, one (Long-necked Tortoise) is a habitat generalist and is capable of using a variety of wetland habitats as well as overland migration (Chessman, 1984). The remaining two (Broad Shell Tortoise and Murray River Tortoise) prefer deep, calm permanent waterways (Chessman, 1988). The main advantage to these species may be the increase in productivity upon inundation, which would allow for a build up of reserves prior to breeding. It is possible also that the inundation of floodplain depressions would provide suitable foraging and nesting habitat for these species.

A similar case could also be made for frogs within the system. Although there is limited data on the frog species that may be present in the system (or could potentially utilise the area during inundation) the operational phase is likely to result in suitable habitat. The majority of native, wetland frogs in south-eastern Australia prefer inundated vegetated habitat for breeding and foraging. Flooding of the forest would result in approximately 1,000 hectares of inundated shallow marsh, which should provide suitable habitat for frog breeding.

The project would result in increased productivity and watering of a large area (approximately 17,000 hectares) of the Koondrook-Perricoota floodplain. This would not only provide increased resources and habitat for aquatic and wetland dependant flora and fauna, but should result in flow on effects to terrestrial species. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001). The increase in productivity with an increase in flower, fruit, seed and insect resources on the floodplain has the potential to benefit a wide range of species through the food web.

## 8.6 Key threatening processes

### 8.6.1 Identification of key threatening processes

A 'key threatening process' is defined under the TSC Act as '*a threatening process specified in Schedule 3*' of the Act. A 'threatening process' is defined as *'a process that threatens, or may have the capability to threaten the survival or evolutionary development of species, populations or ecological communities*'. A number of TSC Act listed key threatening processes are also listed as a key threatening process under the FM Act and/or the EPBC Act.

The proposed activity would directly contribute to the operation of seven key threatening processes:

- Clearing of native vegetation;
- Loss of hollow-bearing trees;

- Removal of dead wood and trees;
- The degradation of native riparian vegetation along New South Wales watercourses;
- The introduction of fish to fresh waters within a river catchment outside their natural range;
- Instream structures and other mechanisms that alter natural flow; and
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands.

A number of key threatening processes are currently operating at the Forest, given the modified landscapes and vegetation communities present in portions of the Forest and direct observation of feral species. The project may indirectly contribute to the following:

- Predation, competition and/or grazing by feral fauna including the key threatening processes:
  - Predation and competition by the European Red Fox;
  - Competition and grazing by the feral European Rabbit;
  - Predation by feral cats;
  - Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*);
  - Herbivory and environmental degradation caused by feral deer; and
- Invasion of native plant communities by exotic perennial grasses.

Two additional, broad scale key threatening processes may be indirectly affected by the operation of the project:

- Ecological consequences of high frequency fires; and
- Human-caused climate change.

### 8.6.2 Assessment of direct contribution to key threatening processes

***Clearing of native vegetation***

Clearing, as defined in the key threatening processes final determination, is the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long term modification, of the structure, composition and ecological function of a stand or stands.

The project would contribute to the operation of this key threatening process through the permanent removal or modification of native vegetation within project infrastructure and construction footprints, affecting a maximum of 88 ha. However, negative impacts would be offset by the environmental watering of 17,000 ha of equivalent habitats within the inundation area. The inundation would extend over approximately 16,000 ha for a period of about 100 days.

Construction activities outside these areas would utilise existing tracks and clearings as far as is practicable and would not affect a sufficient proportion of any vegetation strata to result in permanent loss or long-term modification of a stand. Therefore activities in the broader construction corridor would not contribute to the operation of the key threatening process.

***Loss of hollow-bearing trees***

A detailed assessment of the impacts of the project on hollow-bearing trees is provided in Section 8.3.2. The project would remove a portion of the hollowing bearing tree resource. This may increase the operation of this key threatening process and result in negative impacts on hollow-dependant fauna.

Based on the survey of habitat trees at the Forest, and extrapolation of the estimated number of hollows across the entire project site, the project may remove approximately 1.8% of the habitat trees within the Forest. Impacts associated with the removal of hollow bearing trees would be partially offset by the environmental watering of 17,000 ha of the Forest. The proposed inundation may help to secure the supply of hollow bearing trees at the Forest in the longer term by improving the health of River Red Gums and Black Box. On this basis, the project would not comprise a significant contribution to the operation of this key threatening process.

***Removal of dead wood and trees***

Construction would remove a number of standing dead trees and this impact is assessed with hollow bearing trees above. Construction would also remove or modify fallen woody debris within infrastructure footprints. Measures to mitigate impacts on debris-dependant fauna and conservation of the woody debris resource include salvage of woody debris within construction footprints and replacement within areas of alternative habitat. Additional resources would be 'created' through the clearing of hollow bearing trees and stags that would also be replaced in adjacent areas of retained and regenerating vegetation. A portion of the woody debris generated by clearing would be placed in waterways to create 'snag' habitat in line with advice from DPI Fisheries.

Temporary access tracks and construction laydown areas would be constructed so as to avoid standing dead trees as far as is practicable. Where dead trees or large deposits of dead wood intersect with proposed access tracks they would be moved, however they would be replaced in adjacent areas of native vegetation and so their habitat value would be largely maintained.

Based on the above, the proposed construction and associated management and mitigation measures would not significantly increase the operation of this key threatening process.

***Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands***

Alteration to natural flow regimes refers to reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. Three human processes have predominantly altered flows in streams, rivers and their floodplains and wetlands in NSW. These are: building of dams, diversion of flows by structures or extraction and alteration of flows on floodplains with levees and structures.

The project would directly contribute to all three processes by:

- Building regulators across natural drainage lines;
- Diversion of flows through construction of the intake regulator and Torrumbarry cutting and extraction from the Murray River; and
- Alteration of flows across the floodplain through the downstream levee, floodway and the system of regulators.

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. These alterations have caused a large number of species, populations or ecological communities that rely on river flows for their survival to become threatened. As detailed in Section 5, the long term effects of river regulation have significantly altered the flood regime of the Forest.

Three major factors mitigate the potential for negative impacts arising from alterations to hydrology due to the project:

- The hydrology of the Forest, the Murray River and associated catchments have been extensively modified by river regulation and the current situation is not characteristic of 'natural flow regimes';
- The hydraulics of the Forest (i.e. the geomorphology and built structures that dictate hydrology) does not permit 'natural flow regimes' onto the floodplain under current and modelled future Murray River flow regimes; and
- The project infrastructure is designed to facilitate delivery of water in order to achieve a more natural flow regime and the proposed operation of the project would aim to simulate natural conditions as far as is practicable.

The project is not likely to have any significant negative impacts on aquatic and wetland habitats within the Forest or downstream. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the Forest. Therefore the project is likely to reduce the effect of this key threatening process which is currently operating on the Forest.

***Instream structures and other mechanisms that alter natural flow***

The project involves the construction of instream structures that control flow including the regulators, channels and downstream levee. Mechanisms that alter natural flow regimes include the operation of the above structures will include reducing or increasing flows; altering the seasonality of flows; changing the frequency, duration, magnitude, timing, predictability and variability of flow events; and changing the rate of rise or fall of water levels. The installation and operation of instream structures that alter natural flows may result in negative impacts on many threatened species, populations and ecological communities.

Provision for fish passage has been incorporated into the engineering design and Operating Plan for the project. Based on advice from the FPTF, the structures have been specifically designed to ensure that native fish can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). Other key factors for fish passage include the timing of flood events and management of flows. Purposeful management of the project would include mimicking the timing of natural flow regimes, variability and pulsing and providing sufficient time during the flooding recession phase to allow fish to move from the floodplain to the river (FPTF, 2009). Ecological Associates (2009) determined that the proposed inundation is likely to provide a highly productive small fish habitat on the floodplain and return small fish to the Murray River in significant numbers via the Return Channel and Barbers Creek. However, there is a residual risk that the project would trap some large-bodied native fish, including threatened species (refer Section 8.5.5).

The Swan Lagoon regulators and downstream stop log structures have been designed to allow for fish passage during an uncontrolled flood. All structures would be fully open in an

uncontrolled flood to allow the flood to operate with minimal change from the current situation (FPTF, 2009). The proposed structures are designed to provide appropriate velocities of water flow for upstream fish passage and specific measures are being designed to provide a low velocity/turbulence corridor at the abutments at each downstream stop log regulator structure to facilitate upstream fish passage (FPTF, 2009).

Notwithstanding potential impacts on fish passage during managed floods, the overall intent of the project is to facilitate delivery of water in order to achieve a more natural flow regime. The proposed operation of the project would aim to simulate natural conditions as far as is practicable. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the site. Therefore the project is unlikely to increase the operation of this key threatening process in a way that would threaten the survival of any native biota.

***The degradation of native riparian vegetation along NSW water courses***

Construction would involve impacts on native riparian and floodplain vegetation within a maximum construction corridor of 206 ha. The Forest contains approximately 32,000 ha of native riparian and floodplain vegetation that would not be removed or modified.

Operation of the scheme would inundate up to 17,000 ha of the Forest, with approximately 16,000 ha being inundated for about 100 days. Adaptive management of the project would aim to avoid negative ecological impacts as far as is practicable. The Forest is dominated by flood-dependant biota and so the proposed inundation is expected to have net positive impacts. Negative impacts of vegetation and habitat removal would be offset by positive impacts from the environmental watering of 17,000 ha of equivalent habitats within the inundation area.

Therefore the project, when considered in its entirety, would not contribute to the operation of this key threatening process.

***The introduction of fish to fresh waters within a river catchment outside their natural range***

The operational phase of the project has the potential to result in increased recruitment of Carp and other pest species into the Forest. Exotic species, especially Carp, are a large component of fish populations in the Murray River. Carp have been implicated in the decline of native fish populations and the degradation of river systems. Floodplains and especially frequently inundated marshes support large breeding populations of the Carp and may have a negative effect on the Murray River fish population through recruitment (Macdonald and Crook, 2006; Jones and Stuart, 2007).

The project would not introduce any exotic fish species to ‘virgin’ catchments, beyond ephemeral aquatic habitats at the Forest which almost certainly would have supported these species during previous wet phases. Therefore the project is likely to comprise a minor contribution to the operation of this key threatening process.

### 8.6.3 Assessment of indirect contribution to key threatening processes operating at the Forest

***Predation, competition and/or grazing by feral fauna***

The assessment pertains to the following key threatening processes:

- Predation and competition by the European Red Fox;
- Competition and grazing by the feral European Rabbit;
- Predation by feral cats;
- Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*); and
- Herbivory and environmental degradation caused by feral deer.

The project may affect the impact of feral fauna on natural environments through increased edge effects. Fragmentation of vegetation stands may exacerbate the impacts of these introduced predators on native fauna. Gaps in habitat facilitate the movement of large, exotic species into native vegetation and may increase the risk of predation for native fauna. Construction would contribute to edge effects through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. In the context of the existing network of access tracks and harvest areas within the Forest and extensively cleared rural lands adjacent to the Forest, the gaps created by the project would have a minor effect.

Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The project would not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.

Feral animal control would be undertaken in accordance with the Riverina ESFM Plan which is currently being implemented at the Forest.

The project is unlikely to increase the numbers of these pest species nor increase the susceptibility of native ecosystems to their effects. Therefore the proposed activity would not increase the operation of this key threatening process.

***Invasion of native plant communities by exotic perennial grasses***

Construction may increase the operation of this key threatening process in the study area by disturbing the soil and understorey vegetation and potentially, by transmitting grass seeds on vehicles or equipment. The project would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. Therefore it is likely that the area of environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed, cleared land. The remainder of the Forest is partially disturbed by Forests NSW access tracks and ongoing timber harvesting and grazing activities. In this context construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality.

The proposed flooding would transmit weed propagules into the Forest and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed

infestation at the Forest. This effect would be balanced by positive effects to the health of native vegetation. Inundation is likely to have net positive impacts for moisture-loving species of key threatening process include the moderate to good cover of native perennial grasses at the Forest and the ongoing management of weeds and tactical grazing systems as part of broader management activities undertaken by Forests NSW at the Forest (GHD, 2009b). Given these mitigating factors and the existing degree of weed infestation at the Forest, the proposed activity is likely to result in a relatively minor increase in the operation of this key threatening process.

### 8.6.4 Assessment of indirect contribution to broad-scale key threatening processes

***Ecological consequences of high frequency fires***

The project would not involve any purposeful increases in the frequency, intensity or extent of fires. There may be minor increases in the risk of fires associated with increased vehicle traffic and human activity in the forests during the construction phase. Inundation of the Forest would cause a dramatic reduction in the risk of wildfire for the duration of managed floods but may increase the risk in the medium term due to increased fuel loads arising from increased growth of floodplain vegetation.

These risks of increased fire frequency are minor and would be mitigated by the purposeful detection and control of wildfires as part of Forests NSW's general management of the study area.

***Human-caused climate change***

The distribution of many species, populations and communities is determined by climate and many species would be adversely affected unless populations were able to move across the landscape. Species at risk include those with long generations, poor mobility, narrow ranges, specific host relationships, isolated and specialised species and those with large home ranges (Hughes & Westoby 1994).

The project is unlikely to contribute to the operation of this key threatening process, or increase the effect of resultant impacts on native populations or environments, because:

- The project would disturb a small area of vegetation (approximately 206 ha) relative to the amount that would experience increased productivity through environmental watering (approximately 17,000 ha). Nor would the project result in the significant production of greenhouse gases (refer Greenhouse in GHD 2009c);
- The project would have a minor effect on patch sizes and connectivity of habitat; and

The project would not result in significant cumulative impacts by increasing the operation of negative effects of human-caused climate change, including drought or adverse changes to hydrology. The project is likely to reinstate a more natural flood regime and result in net positive impacts on ecosystems which have been adversely affected by changes to hydrology (refer Section 9).

## 8.7 Mitigation measures

The mitigation of adverse effects arising from the project has been presented according to the hierarchy of avoidance; mitigation and offsetting of impacts, consistent with the approach outlined in the DEC/DPI (2005) guidelines.

Potential impacts of the project on native biota and their habitats would be greatest in the surface disturbance area. These impacts would be greatest during the construction phase due to direct habitat loss and modification. There is also the potential for impacts on habitat outside the disturbance area during the longer-term operational phase of the project. Specific mitigation measures have been incorporated into the proposal design to minimise such impacts on the environment, and in particular to reduce potential impacts on downstream aquatic environments and on threatened species and their habitats. The potential adverse impacts of the project on flora and fauna and their habitats on site and on surrounding lands would be further reduced through use of construction and operational environmental management plans.

The project would result in some unavoidable residual adverse impacts on some elements of the natural environment, including the clearing of Inland Grey Box Woodland and removal of habitat for threatened fauna. Where residual impacts occur they need to be offset to satisfy the requirements of the DEC/DPI (2005) guidelines for assessments under Part 3A of the EP & A Act.

An offset package has been developed to address these residual adverse impacts to achieve an overall 'maintain or improve' outcome for biodiversity conservation. This offset package was developed in consultation with DECCW. The following sections detail the mitigation measures and offset package recommended for the project.

### 8.7.1 Avoidance of impacts

Where possible, the location of infrastructure has been selected to minimise environmental impacts, particularly through siting a substantial component of the downstream works on the alignment of an existing levee. However, the majority of project infrastructure locations are constrained by site topography and hydrology and there is no feasible alternative. Notably, it was not possible to avoid clearing of Inland Grey Box Woodland along the alignment of the inlet channel as this structure needed to be sited at a topographic low between the Torrumbarry Weir pool and Barbers Creek. Construction areas that are not subject to engineering constraints, such as access roads, spoil disposal sites and laydown areas would be placed outside of the Inland Grey Box Woodland and outside intact native vegetation as far as is practicable.

The project would be operated in accordance with an Operating Plan. One of the key functions of this plan is to ensure that watering events are managed to minimise the potential for adverse environmental impacts associated with factors such as:

- Potential blackwater events, by initiating floods in winter-spring; and
- Water bird breeding, by noting commencement of breeding as a potential cue for managed floods and by prolonging floods to facilitate completion of the breeding cycle.

### 8.7.2 Mitigation of construction impacts

The mitigation of potential impacts is based on the following measures:

- Presence of a suitably qualified ecologist or Wires-accredited fauna management officer (or equivalent) during the construction period;
- A pre-clearance survey of construction footprints focussed on locating individuals, and especially roosts of threatened species;
- Habitat trees should be monitored for fauna during clearing operations;
- Habitat trees with resident fauna should be avoided as far as practicable by postponing clearing through these areas;
- An appropriate methodology for felling habitat trees should be adopted using 'sensitive construction techniques';
- Hollow-bearing habitat trees should be replaced in nearby revegetation areas;
- Ensure the fullest separation possible of 'clean' and 'dirty' water runoff;
- Minimise the area of disturbance, thus minimising the volume of 'dirty' water runoff;
- Runoff from disturbed and rehabilitated areas to be diverted through sediment control devices prior to discharge in to the natural system;
- Minimise handling of soils through direct replacement onto progressive rehabilitation areas and careful selection of soil stockpile locations, where possible;
- Original topsoil should be retained and stockpiled to assist in future remediation of disturbed areas of the Forest;
- Minimise handling of soils during periods of high soil moisture (i.e. during or immediately following wet climatic conditions);
- Restrict vehicle access on topsoil stockpiles once created, to minimise compaction, erosion and transfer of weeds;
- Topsoil stockpiles would be positioned away from direct surface water runoff;
- Topsoil stockpiles should be sown with indigenous native grasses of local provenance as soon as is practicable to minimise the amount of bare earth available for the recruitment of weeds;
- Setting appropriate speed limits for construction traffic to limit dust generation;
- Setting appropriate speed limits for construction traffic to reduce the risk of fauna road fatalities;
- Restrict access into adjacent remnant vegetation during construction by appropriate marking / fencing of surface disturbance footprint;
- Stockpiles of fill or vegetation should be placed in existing cleared areas;
- Installation of a vehicle wash down facility (to minimise weed seed dispersal);
- Progressive rehabilitation of disturbed vegetation to limit the potential for colonisation by weeds;
- Monitor and control Noxious Weed species in line with legislative obligations;

- Perform ongoing monitoring of weed infestation on and adjoining the Forest; and
- Habitat enhancement, including the placement of logs and tree trunks for ground fauna shelter sites. Hollow-bearing trees with evidence of occupation identified in the pre-clearing surveys and removed during construction should be relocated into adjoining revegetation areas to mitigate the loss of habitat resources.

### 8.7.3 Mitigation measures for aquatic ecology

The following sections outline monitoring programs that would be implemented during operation of the project. This monitoring would be undertaken during flood events when the project is operated and possibly during flood events when the project is not operated. This would enable the impacts of operation of the project to be compared to those that occur during flood events when the project is not operated.

The Operating Plan would include adaptive management principles and this would involve considering the results of the aquatic ecology monitoring programs to plan and implement flood events to minimise adverse impacts on the aquatic ecosystem.

***Fish and aquatic invertebrates***

The Lower Murray River EEC comprises dozens of species of fish and aquatic invertebrates that are characteristic of the Murray River channel, effluent streams, billabongs, lagoons and floodplains such as are found within and adjacent to the Forest. Many of these species have a passive, early larval lifecycle phase which drifts with the water flow. As a result, they are likely to enter the forest involuntarily with the diverted water. Many also undertake upstream and downstream migrations.

It is highly likely that the operation of the project would entrain quantities of these species and various lifecycle phases. The significance of the impact of entrainment into or out of the Forest would be qualified and quantified to inform the future management and operational changes required to mitigate the impact to ensure no significant adverse impact upon threatened species.

The fish and invertebrate monitoring program developed in consultation with NSW Industry and Investment would be further refined with partner agencies prior to implementation and would involve:

- Monitoring within the inlet channel downstream of the inlet regulator during inflow periods to determine the species, numbers and size range of fish and aquatic invertebrates entering the Forest;
- Sampling within the Forest several times during each flood event (1 site per 1,000 ha flooded and/or key sites to be determined in consultation with NSW Industry and Investment) to determine changes to the community structure, survival and growth; and
- Sampling at each of the discharge points into the Murray River, Barbers Creek, Thule Creek and Cow Creek during the recession phase of flood events to determine the species, numbers and size range of fish exiting the Forest.

***Stranding native fish***

It is likely that native fish species would persist or reside within residual aquatic habitats (pools) and channels within the Forest during and post flood recession. These refuges are likely to have variable persistence and capacity to maintain threatened fish species and communities, dependant upon operations and flows. The impact of stranding and response of fish to the flood cessation needs to be quantified. The significance of this impact would inform the management and operational changes to mitigate the impact to ensure no significant impact on threatened species.

The monitoring outlined above for fish and aquatic invertebrates would allow the response of fish to flood operations to be monitored and would provide the basis for identification of opportunities to minimise impacts.

***Pest Fish***

Operation of the project may create or augment opportunities for spawning and dispersal of pest fish species (carp and Weatherloach in particular). The detection and management of such events would inform the management and operational changes required to mitigate the impact to ensure no significant impact on threatened species.

The quantification aspects required to address this issue are included within the monitoring program for fish and aquatic invertebrates.

### 8.7.4 Offsetting impacts

***Approach***

The DEC/DPI (2005) guidelines identify important heads of consideration or key thresholds that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act. These guiding principles include the requirement that the project must 'improve or maintain' biodiversity values (i.e. there is no net impact on threatened biota or native vegetation).

This ecological impact assessment describes the potential impacts of the project on native biota, including measures to avoid or mitigate those impacts described above. A detailed assessment of the 'improve or maintain' test is provided in Table 8-10 in the consideration of the Part 3A key thresholds presented below. The outcome of this assessment is as follows:

- Positive impacts, including environmental watering of approximately 17,000 ha of the Forest and associated ecological benefits for floodplain biota;
- Negative impacts, including removal or modification of native vegetation and habitat within a construction footprint of 206 ha;
- Mitigation of impacts through environmental management systems during construction and purposeful operation of infrastructure and adaptive management during inundation; and
- Resultant residual negative impacts arising from the project on terrestrial vegetation that would not directly benefit from the environmental watering of the Forest, including the permanent removal of about 8 ha of Inland Grey Box Woodland.

A biodiversity offset is required to accompany the project application in order to satisfy the requirements of the DEC/DPI (2005) guidelines and Part 3A of the EP&A Act, with regards to achieving an 'improve or maintain' outcome. The purpose of the offsets strategy is to address residual impacts on Inland Grey Box Woodland and associated terrestrial species that would not directly benefit from the proposed environmental watering of the Forest.

A biodiversity offset comprises one or more appropriate actions that are put in place to counterbalance specific impacts on biodiversity. Appropriate actions are considered to be long-term management activities that aim to improve biodiversity conservation. This can include legal protection of land (i.e. an offset site) to ensure security of management actions and remove threats (DECC, 2008). The biodiversity offset strategy outlined in this report was prepared with reference to the *Principles for the Use of Biodiversity Offsets in NSW* (DECC, 2008) and includes the identification of:

- An offset site;
- Appropriate management actions to improve the biodiversity value of the Forest; and
- Titling arrangements to ensure legal protection of the Forest.

A draft offset strategy was agreed to with DECCW during a teleconference on 17 November 2009. The offset strategy presented in this report incorporates recommendations arising from DECCW review and discussions with the Project Team.

***Offset site***

An offset site for the project was identified within the former Toorangabby property in the Perricoota State Forest. The Toorangabby property was purchased and added to the State Forests Estate in the early planning stages of the project because it contains the locations of the Swan Lagoon regulators. The titling and management of other portions of the former Toorangabby for biodiversity conservation is an additional use of the land. The Toorangabby property is a gazetted addition to the Perrocoota State Forest and has been incorporated into the Ramsar site. The offset site is shown on Figure 8-8.

The offset site is 149 ha in area and contains appropriate 'like for like' vegetation communities including 94 ha of Inland Grey Box Woodland plus additional habitat for terrestrial fauna in other native vegetation communities. Benson (2006) vegetation types at the site include approximately:

- 94 ha of Comm ID 237: Riverine Inland Grey Box grassy woodland (EEC);
- 37 ha of Comm ID 7: River Red Gum - herbaceous tall open forest; and
- 17 ha of Comm ID 250: Derived tussock grasslands.

The site would offset the clearing of 8 ha of Inland Grey Box Woodland with the conservation and improvement of 94 ha of Inland Grey Box Woodland i.e. an offsets ratio of approximately 11.5 to 1.

The Toorangabby property has been extensively cleared and degraded by historical timber harvesting and sheep grazing. The Inland Grey Box Woodland is in moderate condition, however River Red Gum dominated communities have been extensively cleared and degraded and converted to derived tussock grasslands in some areas. The project provides the opportunity to improve the condition of the Forest through a change in management regime.

### *Management*

The DECC (2008) offsetting principals require the improvement of condition and biodiversity values at offset sites through management. This would be achieved at the offset site through the following measures:

- Maintenance of site boundaries and exclusion of potentially damaging activities;
- Conversion from sheep grazing to tactical cattle grazing;
- Management of weeds and pest fauna; and
- Facilitated regeneration of historically cleared and modified River Red Gum vegetation types through exclusion of timber harvesting and delivery of environmental water.

DECCW agreed that offset area would be managed in accordance with the Forest Management Zoning 3A – Harvest Exclusion, and the principles of the Riverina Ecologically Sustainable Forest Management Plan. Sustainable grazing would occur under Forest NSW's grazing strategy, and fire, pest and weed management would also occur in accordance with the Riverina Ecologically Sustainable Forest Management Plan.

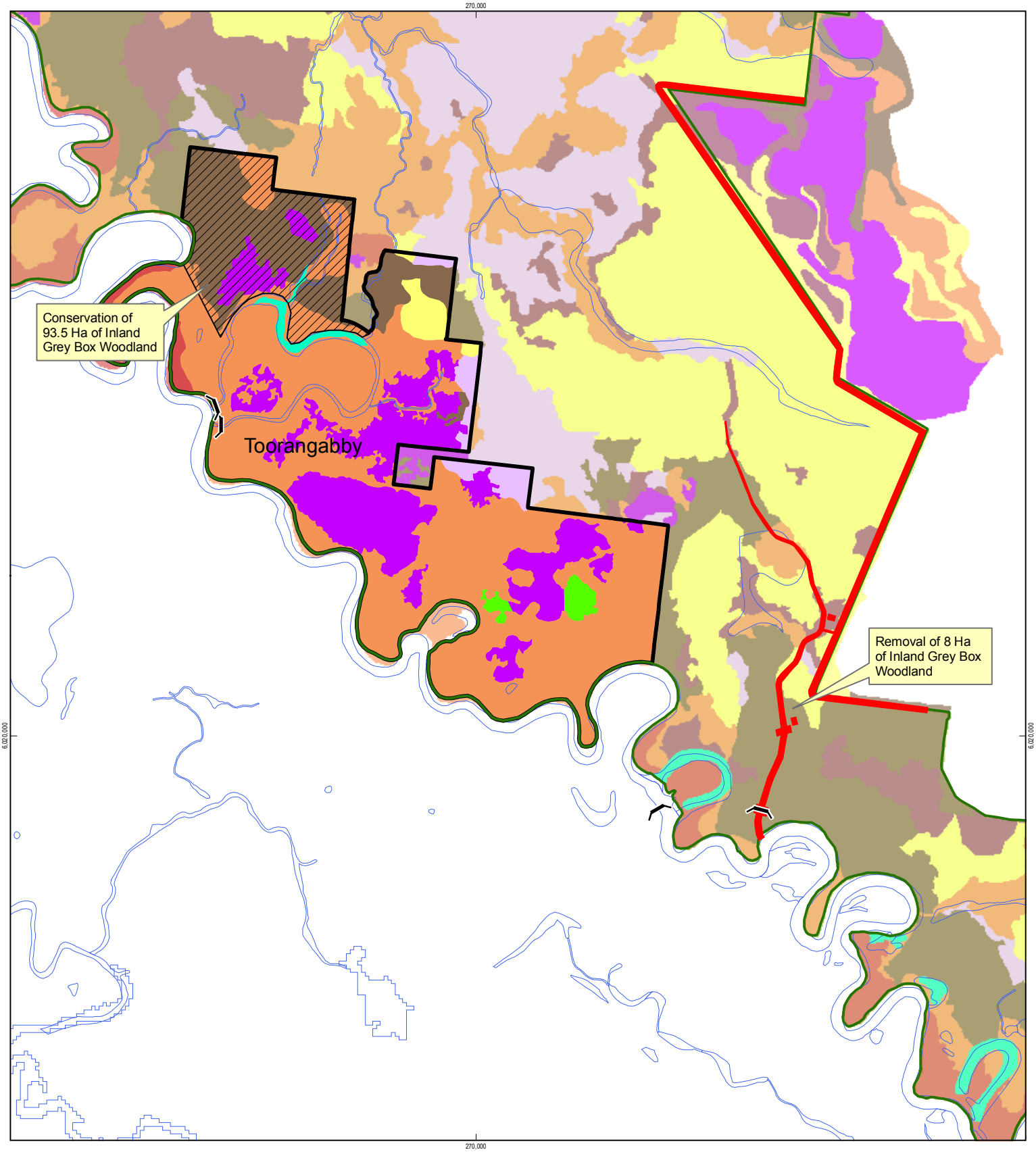
Grazing would be undertaken within the offset area to manage fine fuel loads to reduce wildfire hazard. Forests NSW considers this to be the most practical fuel reduction method available in River Red Gum forests as prescribed burns would be likely to have a negative effect on this species.

Grazing would occur in accordance with the *Grazing Strategy for the Riverina Region* (Leslie, 2000). This strategy expands on Forests NSW objectives for ecologically sustainable grazing in the region and provides for site specific grazing management plans and environmental impact assessment for potentially sensitive areas. It includes management measures to mitigate potential impacts of grazing in the context of other activities undertaken within State Forests. These include defined stocking rates, exclusion areas around sensitive areas, and tactical grazing strategies. As such, these plans incorporate measures to manage potential cumulative impacts associated with the project.

The Toorangabby property has been extensively cleared and degraded by historical timber harvesting and sheep grazing. In discussions with DECCW it was agreed that implementation of Forests NSW management procedures, in particular FMZ 3A, would lead to a long term improvement in ecological condition and biodiversity values relative to continued management as a pastoral property if it was not purchased for the project. As this change in management procedures would improve ecological condition, the offset strategy is consistent with DECC (2008) offsetting principles.

### *Titling*

The offset site would be managed within the Forests NSW Estate. Conservation of the offset site in perpetuity would be ensured by titling the Forest FMZ 3a within FNSW's Forest Management Zone (FMZ) system. FMZ is a land based classification system that identifies and defines the primary management intent across the various components of the landscape. FMZ 3a – Special Prescription, allows only "Activities consistent with the area's nominated special value". Timber harvesting and removal of forest products is excluded. Activities consistent with the area's nominated special value are permitted, such as weed and pest management and tactical grazing.




## Legend

- River Road bridge
- Regulator
- Construction features
- Koondrook Perricoota Forest Site
- Proposed Offset Site
- Toorangabby Boundary

**Vegetation Type Toorangabby**

- Comm ID 19: Cypress Pine woodland of dunes
- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 237: Riverine Inland Grey Box grassy woodland
- Comm ID 250: Derived tussock grasslands

1:29,018 (at A3)

0 0.25 0.5 1

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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GHD

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number 21-18573
Revision C
Date 01 FEB 2010

Figure 8.8 - Proposed offset site

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z019_ToorangabbyVegetation_RevB.mxd

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Data source: Dept of Commerce, Drawn: Cwilson, cwilson

## 8.8 Assessments of significance of impacts

### 8.8.1 TSC Act Listed threatened biota

***Threatened flora species***

The project would not directly impact any known populations of threatened flora species. It would remove potential habitat for four threatened flora species that are known or predicted to occur in the study area.

An evaluation of the magnitude, extent and significance of impacts of the project on threatened flora species and their habitats following the assessment criteria identified in the *Guidelines for Threatened Species Assessment under Part 3A of the EP & A Act* (DEC and DPI 2005) – (a Part 3A AoS) has been undertaken and is provided in Appendix C.

The outcome of this assessment is that the project is not likely to have a significant negative effect on local populations of *Amphibromus fluitans, Austrostipa wakoolica, Lepidium monoplocoides* or *Swainsona murrayana*.

***Endangered Ecological Communities***

One EEC listed under the TSC Act is present at the Forest and would be affected by the project: Inland Grey Box Woodland.

A Part 3A AoS has been undertaken for this EEC and is provided in Appendix C.

The outcome of this assessment is that the project is unlikely to have a significant negative effect on local populations of Inland Grey Box Woodland based on the following considerations:

- Construction would permanently remove approximately 8 ha of Inland Grey Box Woodland which is a minor proportion (0.84%) of the approximately 951 ha of Inland Grey Box Woodland at the Forest;
- The project would maintain approximately 32, 000 ha of near-continuous native vegetation around the disturbance footprint. Ecosystem functions necessary to the maintenance of the EEC, such as pollination, seed fall and germination of plants, are likely to continue around and/or across gaps in habitat created by the project infrastructure footprints; and
- Operation of the project would modify approximately 189 ha of the community (i.e. approximately 20%) through inundation. Despite some evidence that inundation may have some negative effects on the health of Inland Grey Box trees (Vesk et. al., in prep) there is indirect evidence that Inland Grey Box Woodland can tolerate inundation for up to 4 months (Cooling, M. pers. comm., Roberts and Marston, 2000) i.e. less than 120 days. Based on DHI (2008) modelling of the indicative scenario no Inland Grey Box Woodland at the Forest would be inundated for greater than 120 days. Therefore the project is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland.

The proposed offset strategy described in Section 8.7.3 would further mitigate negative impacts on local populations of the EEC. The proposed conservation and management of 94 ha of Inland Grey Box Woodland within the offset site would compensate for the removal of approximately 8 ha of the community and produce a net gain in the viability of Inland Grey Box Woodland at the Forest in the long term.

### 8.8.2 Threatened fauna species

***Affected threatened fauna***

A total of 11 threatened fauna species and a further three species that have a preliminary listing as threatened species under the TSC Act are known, or are highly likely to occur at the Forest, based on the field surveys or other recent survey records. The project has the potential for negative effects on these species or their habitats. The project would involve direct or indirect impacts within a construction footprint of 206 ha and a proposed inundation of 17,000 ha of potential habitat for threatened fauna.

Part 3A AoSs have been undertaken for threatened fauna and are provided in Appendix C. Where appropriate, multiple species of threatened fauna are grouped according to similar ecological characteristics and impacts on common habitat resources are presented together. The outcome of these assessments is that the project is unlikely to impose 'a significant effect' on any affected threatened fauna species, including the:

- Threatened woodland birds, Hooded Robin, Gilbert's Whistler, Diamond Firetail or Black-chinned Honeyeater;
- Microbats Large-footed Myotis, Yellow-bellied Sheathtail Bat and Little Pied Bat;
- Koala;
- Squirrel Glider;
- Australasian Bittern;
- Barking Owl;
- Bush Stone-curlew;
- Silver Perch;
- Murray River EEC; and
- Preliminary-listed woodland birds White-browed Woodswallow, Varied Sittella and Scarlet Robin.

***Other mobile threatened fauna***

The project would remove potential habitat for additional threatened fauna species which may utilise habitat at the Forest, at least on occasion or on an opportunistic basis. An evaluation of the magnitude, extent and significance of impacts on local populations of these species and their habitats following the assessment criteria identified in DEC (2005) and DPI (2005) guidelines has been undertaken, based on a general consideration of the likelihood of impacts on these species.

The project is unlikely to have a significant negative affect on any mobile threatened fauna based on the following considerations:

- Construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of any fauna populations, given the construction footprint of 206 ha within the 32, 000 ha of similar habitat at the Forest that could potentially be occupied by mobile fauna;

- Inundation of a portion of the Forest may limit some species access to preferred habitat and so may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated both within and outside the project site. Mobile fauna populations are likely to utilise alternative habitat and reoccupy the inundation area after flood recession;
- Construction would remove some valuable habitat resources, including habitat trees, but would affect a minor proportion of resources available in the locality and may help to secure the habitat tree resource in the longer term through environmental watering of mature River Red Gums;
- There is no evidence that any specific habitat resources that would be removed by the project or significantly adversely affected by flooding are critical to the maintenance of any mobile threatened fauna populations. Many species are likely to benefit from a general increase in floodplain health and productivity as a result of flooding; and
- Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (within 206 ha) compared to the overall area of similar habitats at the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). This magnitude of impacts is not likely to comprise a significant negative effect on any populations of mobile threatened fauna.

### 8.8.3 Critical habitat

There is no recommended or declared critical habitat on the DECCW NSW Critical habitat register (DECCW, 2009e) or the DPI critical habitat register (DPI, 2009b) in the locality or of relevance to the assessment of the project.

### 8.8.4 Matters of National Environmental Significance

The matters of national environmental significance listed under the EPBC Act of potential relevance to the Forest are described in Section 8.3.4. An assessment of the significance of impacts on these matters of national environmental significance is provided below.

Based on the assessments presented above the project may result in impacts the following Matters of National Environmental significance listed under the EPBC Act:

- The threatened plant species *Amphibromus fluitans, Austrostipa wakoolica*, *Lepidium monoplocoide*; and *Swainsona murrayana*;
- The preliminary listed Endangered Ecological Community Inland Grey Box Woodland;
- Murray Cod;
- Mobile threatened fauna species that may occur at the Forest on an occasional or opportunistic basis;
- Migratory species;
- The NSW Central Murray State Forests Ramsar site; and
- Other Ramsar sites within the same catchments as the Forest.

The project would remove or modify habitat for EPBC Act listed biota occurring in the Forest and directly modify a Ramsar site, which comprises impacts on matters of national environmental significance. A detailed assessment of the significance of these impacts on matters of national environmental significance is provided in Appendix C in accordance with the DEH (2006) *Significant Impact Guidelines* and is summarised below.

***Flora***

The four EPBC Act listed flora potentially affected by the project are also listed under the NSW TSC Act. AoSs for these species using the NSW DEC/DPI (2005) guidelines have been performed and included in Appendix C. The outcome of these assessments is that the project is unlikely to have a significant impact on these threatened flora species or their habitats.

***Endangered Ecological Communities***

Inland Grey Box Woodland, which has a preliminary listing under the EPBC Act, is also listed under the NSW TSC Act. An AoSs for this EEC using the NSW DEC/DPI (2005) guidelines has been performed and included in Appendix C. The outcome of this assessment is that the project is unlikely to have a significant impact on Inland Grey Box Woodland at the Forest.

***Aquatic fauna***

One EPBC Act-listed aquatic fauna species is likely to occur at the Forest: the Murray Cod. An AoS for the Murray Cod has been prepared in accordance with the DEH (2006) guidelines and included as Appendix D. The outcome of this assessment is that the project is unlikely to have a significant impact on the Murray Cod.

***Mobile terrestrial fauna***

A number of other threatened fauna species listed under the EPBC Act are known or predicted to utilise habitat in the Forest on an occasional or opportunistic basis. The project would remove potential habitat for these species. An evaluation of the magnitude, extent and significance of impacts of the project on local populations of these species and their habitats following the assessment criteria identified in NSW DEC/DPI (2005) guidelines has been undertaken, based on a general consideration of the likelihood of impacts on these species. The outcome of this assessment is that the project is unlikely to have a significant negative affect on any mobile threatened fauna.

***Migratory species***

An AoS for impacts on listed migratory species is provided in Appendix C, including:

- A description of the importance of habitat at the Forest for listed migratory species; and
- Evaluation of the significant impact criteria for migratory species.

The assessment concludes that the project is unlikely to impose ‘a significant impact’ on any of the listed migratory fauna species known from the Forest.

***Potential impacts on Ramsar sites***

Approval is required under the EPBC Act for an action occurring within or outside a declared Ramsar wetland if the action has, would have, or is likely to have a significant impact on the ecological character of the Ramsar wetland. An assessment of the significance of potential

impacts on Ramsar sites is provided in Appendix C. It is concluded that the project is unlikely to impose a significant negative effect on the:

- NSW Central Murray State Forests Ramsar site;
- Victorian Gunbower Forest Ramsar site; and
- Other Ramsar sites within the catchments of the Murray River.

***EPBC Act assessment***

On the basis of the assessments undertaken, it is concluded that the project is unlikely to impose a significant effect on any matters of national environmental significance.

## 8.9 Conclusion

Pursuant to DEC/DPI (2005) assessment guidelines development applications under Part 3A must contain a justification of the project based on the following key thresholds. With regard to the thresholds listed in the guidelines:

- the proposal, 'including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts' would maintain or improve biodiversity values;
- The project is not likely to reduce the viability of any local populations of threatened biota;
- The project is not likely to accelerate the extinction of any threatened biota; and
- No listed critical habitat would be removed or adversely affected as a result of this project.

With regard to the maintenance or improvement in biodiversity values, a summary of the key impacts, (positive and negative), proposed mitigation measures and proposed offset measures (for residual impacts following mitigation), is provided below in Table 8-10 and Table 8-11 or terrestrial impacts and for aquatic impacts.

## Table 8-10 Comparison of ecological impacts, mitigation and offsets on terrestrial ecosystems

| Positive Impacts | Negative Impact | Mitigation | Offset |
|---|---|---|---|
| Environmental watering of approximately 17,000 ha of the Forest and associated ecological benefits for floodplain biota, including:<br>◗ improved health of River Red Gums, Black Box and associated understorey species;<br>◗ improved health of floodplain marshes and growth and reproduction opportunities for associated wetland biota;<br>◗ migration and breeding opportunities for waterbirds, frogs and other floodplain biota; and<br>◗ improved habitat resources for floodplain biota, including many terrestrial fauna, due to a general increase in floodplain health and productivity. | ◗ Potential displacement or mortality of native biota within a construction corridor of 206 ha.<br>◗ Removal of native vegetation including:<br>– Permanent removal of 8 ha of Inland Grey Box Woodland;<br>– Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state;<br>– Permanent removal or modification of approximately 88 ha of native vegetation within project infrastructure footprints; and.<br>◗ Removal of 532 habitat trees for permanent project infrastructure and potential removal of additional habitat trees within the remaining construction corridor.<br>◗ Isolation, displacement or degradation of flooding-intolerant flora, fauna and vegetation communities within 17,000 ha maximum inundation area. | ◗ Remediation and revegetation of construction laydown areas.<br>◗ Habitat enhancement in remediated areas through placement of hollow trees and fallen timber.<br>◗ Pre-clearing surveys for (and salvage of) resident native fauna.<br>◗ Soil and surface water management and avoidance of off site impacts.<br>◗ Improved long-term security of the habitat tree resource, including hollow bearing trees, through watering of drought-stressed over-mature River Red Gums.<br>◗ Purposeful operation of infrastructure and adaptive management to avoid negative impacts during the proposed inundation. | Residual negative impacts on terrestrial vegetation that would not benefit from environmental watering of the Forest, including permanent removal of about 8 ha of Inland Grey Box Woodland. Therefore an offsets strategy has been developed in consultation with DECCW that would include:<br>◗ A 149 ha offset site containing appropriate 'like for like' vegetation, including 94 ha of Inland Grey Box Woodland plus additional habitat for terrestrial fauna in cleared and River Red Gum communities;<br>◗ Management for conservation, in perpetuity, under secure tenure as FMZ 3a within the FNSW Estate; and<br>◗ Improvement of condition through:<br>– conversion from Sheep grazing to tactical Cattle grazing;<br>– management of weeds and pest fauna; and<br>– facilitated regeneration of cleared and River Red Gum vegetation through exclusion of timber harvesting and delivery of environmental water. |

## Table 8-11 Comparison of ecological impacts, mitigation and offsets on aquatic ecosystems

| Positive Impacts | Negative Impact | Mitigation | Offset |
|---|---|---|---|
| ◗ Environmental watering of approximately 17,000 ha of the Forest and likely ecological benefits including:<br>– increased productivity of wetlands and two-way transfer of organisms, carbon, nutrients and habitat resources between Murray River and floodplain;<br>– provision of additional floodplain aquatic habitat in flooded vegetation;<br>– improved health of in stream habitats and floodplain marshes and growth and reproduction opportunities for associated aquatic biota; and<br>– migration and breeding opportunities for native fish, crustaceans and invertebrates. | ◗ Removal or modification of habitats including:<br>– instream and riparian habitat within regulator footprints;<br>– loss of habitat resources within 88 ha of floodplain vegetation to be removed; and<br>– loss or degradation of habitat resources within a construction corridor of 206 ha.<br>◗ Likely blackwater events and resultant mortality of aquatic fauna.<br>◗ Potentially reduced fish passage and risk of mortality associated with infrastructure.<br>◗ Likely increased numbers and distribution of pest aquatic fauna, especially Carp. | ◗ Highly unlikely to cause injury, displacement or mortality of native biota within construction corridor due to prolonged dry conditions at the Forest.<br>◗ Remediation and revegetation of construction laydown areas.<br>◗ Retention of fallen timber and habitat enhancement through placement of snags in aquatic habitat.<br>◗ Surface water management and avoidance of off site impacts.<br>◗ Soil management and avoidance of erosion and sedimentation impacts.<br>◗ Provision of fish passage according to FPTF recommendations.<br>◗ Purposeful operation of infrastructure and adaptive management to avoid negative impacts during the proposed inundation. | ◗ The environmental watering of approximately 17,000 ha of the site and likely ecological benefits would offset the likely negative impacts arising from the project.<br>◗ Negative effects of the project are likely to affect a limited proportion of local populations of aquatic biota and may be mitigated through purposeful operation and adaptive management. Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of aquatic biota outside the site.<br>◗ Therefore the project would 'improve or maintain' aquatic biodiversity values and an offsets strategy is not required for aquatic ecosystems. |

## Table 8-12 Comparison of ecological impacts, mitigation and offsets on terrestrial ecosystems

| Positive Impacts | Negative Impact | Mitigation | Offset |
|---|---|---|---|
| Environmental watering of approximately 17,000 ha of the Forest and associated ecological benefits for floodplain biota, including:<br>◗ improved health of River Red Gums, Black Box and associated understorey species;<br>◗ improved health of floodplain marshes and growth and reproduction opportunities for associated wetland biota;<br>◗ migration and breeding opportunities for waterbirds, frogs and other floodplain biota; and<br>◗ improved habitat resources for floodplain biota, including many terrestrial fauna, due to a general increase in floodplain health and productivity. | | | |