Koondrook-Perricoota Forest
Flood Enhancement Works

Appendix C
Ecology Assessment

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NSW Office of Water and Forests NSW

Koondrook-Perricoota Forest Flood Enhancement

Ecological Impact Assessment

December 2009

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 Proposed Development

The proposed Koondrook-Perricoota Forest Flood Enhancement Works (the project) have been designed to reinstate the critical process of flooding to the Koondrook-Perricoota Forest in order to improve the health of the forests and other floodplain ecosystems. The objective of the Koondrook-Perricoota Forest Flood Enhancement Works is to reinstate a more natural flood regime in the Koondrook-Perricoota Forest. In doing so, it would meet the key ecological objective of the project which is: "to provide an adequate water regime to a representative area of River Red Gum forest that has, or historically supported, a flood-dependent understorey" (DWE, 2008). The Forest is located on the floodplain of the Murray River (refer Figure 1) and incorporates the Koondrook State Forest (SF), Perricoota SF and adjoining areas of agricultural land that were purchased to facilitate the operation of the project.

The project involves the construction of a diversion channel and engineering structures to manage environmental flows from the Murray River to the Koondrook-Perricoota Forest. The scheme would be operated so as to mimic a natural flood regime and as such has been designed to allow regular flooding of the Forest under a range of operating scenarios. Possible scenarios include: larger managed floods diverting water every 3 to 4 years, inundating approximately 50% of the Forest for a period of up to 100 days; and smaller, more frequent flood events which would inundate smaller areas in lower lying portions of the Forest and for shorter durations.

The proposed works can be summarised as:

- Upstream structures to allow diversion of water into the Forest from Torrumbarry Weir and escape regulators at Swan Lagoon to prevent flows re-entering the Murray River;
- Downstream structures to prevent uncontrolled water leaving the Forest and to maximise return flows back to the Murray River. This includes a return channel to allow return flow back to the Murray River and a floodway to increase water returns to the Murray River. Downstream stop-log regulators would be required to control the flow of the water out of the Forest. A levee around the downstream perimeter of the Forest would be required to protect adjoining properties from flooding; and
- Temporary features associated with the construction phase of the project including access tracks, laydown areas, borrow pits and spoil disposal areas.
- A summary of the engineering works for the project is provided in below and locations shown in Figure 2 and Figure 3.

Key infrastructure features of the project are presented in Table 1.

Table 1 Key Features of the Project

Infrastructure	Description
Upstream structures	
Inlet channel	Construction of a 3.8 km long earth channel extending north from the Torrumbarry Weir pool on the Murray River to Bullock Head Creek.
Off-take regulator, dual fishway and turtle ramp	Construction of a gated regulator structure and a fishway within the inlet channel approximately 200 m from the Murray River.
River Road bridge structure	Upgrade of the access bridge across the inlet channel, at the intersection of Freemans Road and River Road.

Swan Lagoon structures	Two regulators and associated works at Swan Lagoon to control water flow between the Forest and the river.
Downstream structures	
Stop log regulators	Stop log regulators at Runner A, Barbers Creek, Cow Creek, Calf Creek and Thule Creeks to control downstream flows and protect surrounding property and infrastructure from flood waters during scheme operation.
Downstream levee	This would involve constructing a new levee connecting the regulators at Runner A, Barbers Creek, Cow Creek, Calf Creek, Thule Creek, and the return channel. It would also upgrade and extend the existing Barham flood protection levee. The role of the levee would be to retain flood waters within the Forest and protect surrounding infrastructure and property during managed flood events from floods.
Return channel and floodway	The floodway would increase the proportion of flows within the forest that can be returned directly to the Murray River by encouraging flood water to the Crooked Creek system. The return channel would deliver water from Crooked Creek to a regulator within the return channel.
Return channel regulator and junction structure	A gated regulator structure and drop down structure at the intersection of the return channel with the Murray River.

The natural flow regime within the Forest provides a guide to the water requirements of the existing ecological processes and communities. This regime is highly variable, and comprises floods of various magnitudes and durations, occurring at a range of frequencies. In general, small floods occur more frequently, and larger floods less frequently. It is highly desirable that the project provide a very flexible delivery mechanism that is capable of delivering a range of flood events, able to sustain a range of ecological processes and elements, for example:

- Frequent, low flows (but exceeding the commence to flow levels) to maintain the wetland habitats occurring in lagoons, depressions and flood runners;
- Less frequent floods of medium magnitude to maintain the extent of the Red Gum communities, with larger floods maintaining the extremities, and smaller floods supporting the core areas with flood dependent understorey communities;
- Flood events of long duration to cue and facilitate bird breeding; and
- Very large, infrequent flood events to provide an occasional boost to the fringing Black Box communities.

While predictive models provide some guidance, the exact ecological outcomes arising from operation of the project will be unknown until they have been operated in real time, under a range of antecedent conditions. In line with adaptive management principles, it will be important to be able to alter the operation of the structures, both during operations and from one operation to the next, in order to react to the ecological response observed. Furthermore, the exact nature of both unregulated and regulated river flows, and the quantum of environmental water available, is unknown. Flexible operation and the ability to capitalise on a variety of flow events is therefore an important element of structure design. For the purposes of this ecological impact assessment a single, indication operational scenario has been assessed (the proposed operating scenario) and is described in Section 9.1.

Potential effects associated with the project include:

- Removal, modification or disturbance of habitat within a maximum construction corridor of 206 ha;
- Managed inundation of approximately 17,000 ha of the floodplain under the indicative operational scenario; and

- Changes to the hydraulics of the flooplain which will affect the hydrology of the 32,000 ha Forest surrounding the proposed infrastructure.

1.2 Scope of Report & Environmental Assessment Requirements

The project is subject to the development and assessment processes and requirements of Part 3A of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act), with the Minister for Planning as the approval authority.

This ecological impact assessment report (EIA) has been prepared as a technical document to support the EA, and addresses the Environmental Assessment Requirements (EARs), which state that the EIA must satisfy the requirements for flora and fauna impact assessment in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC/DPI, 2005) under s.75f of the EP & A Act 1979.

The DEC/DPI (2005) guidelines identify important factors and key thresholds that must be considered by proponents and consultants when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A. The guiding principles for threatened species assessment outlined in the guidelines and addressed in the current assessment are as follows:

- "Maintain or improve' biodiversity values (i.e. there is no net impact on threatened species or native vegetation).
- Conserve biological diversity and promote ecologically sustainable development.
- Protect areas of high conservation value (including areas of critical habitat).
- Prevent the extinction of threatened species.
- Protect the long-term viability of local populations of a species, population or ecological community.
- Protect aspects of the environment that are matters of national environmental significance" (p.1, DEC/DPI, 2005).

In accordance with the DEC/DPI (2005) guidelines this assessment is designed to provide results and assessments to demonstrate that feasible alternatives have been considered, that the project has been designed to be consistent with the principles outlined above, and where there are impacts, that adequate mitigation measures and biodiversity offsets are implemented.

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

1.3 Definitions

The following definitions apply to this 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 and the area purchased for the western levee alignment as shown in Figure 1;
- '*the proposed operating scenario'*: one possible operating scenario which has been selected for assessment in this report. This scenario is described in the Preliminary Environmental Assessment (DoC, 2009) and relates to an entirely managed flood event, involving the maximum possible in-flows of 6000 ML/day via the inlet channel and maintaining a flood pool at 78.5m RL.

- *'the proposed flood pool'*: the flood level at RL 78.5 that would be maintained from approximately day 55 to day 110 of the proposed operating scenario based on DHI (2008) modelling.
- '*the Icon Site'* the Gunbower, Koondrook-Perricoota Forest, one of six 'Icon sites' recognised along the Murray River as part of the Living Murray Program. The site for this assessment includes the majority of the Icon Site.
- '*the Koondrook-Perricoota Forest*' the NSW State Forests which collectively form the NSW portion of the Gunbower, Koondrook-Perricoota Forest Icon Site;
- '*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 Forest;
- '*threatened biota':* threatened species, populations and ecological communities listed on the Schedules of the TSC Act and/or the EPBC Act;
- *'HBTs'*: 'hollow-bearing trees', trees which contain hollows that may be occupied by fauna;
- *'habitat trees':* trees that are an important habitat resource for fauna, including hollow bearing trees, standing dead trees, large or mature trees and/or trees which contained a nest or roost at the time of the site surveys.

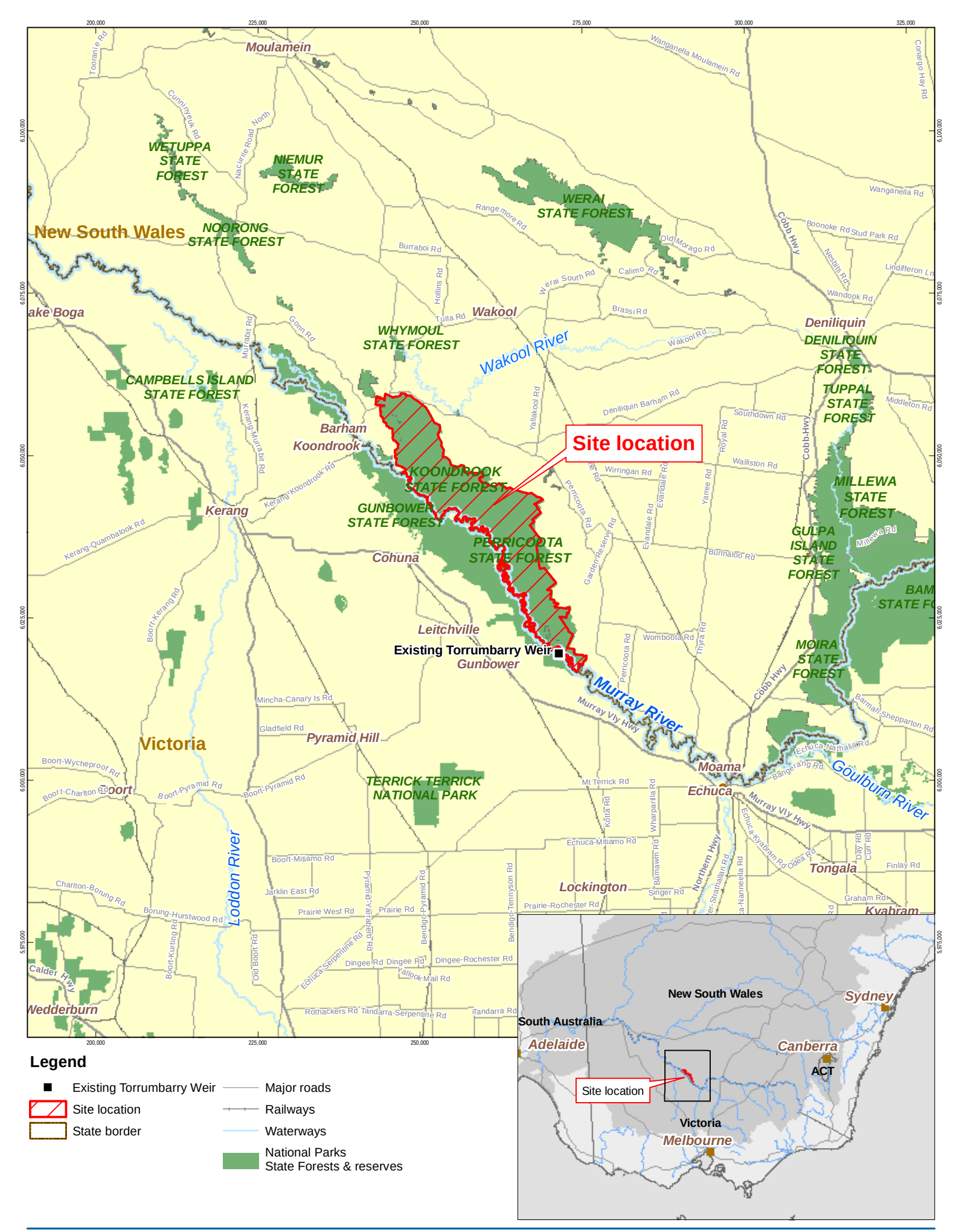
1.4 Relationship with Existing Reports

This ecological impact assessment report is a specialist Appendix to the GHD (2009) Koondrook-Perricoota Flood Enhancement Project Environmental Assessment (the EA). The EA provides:

- Information on the project, including the project need and alternatives considered;
- An assessment of the potential environmental impacts of the project in accordance with the Director-General's requirements dated 22 May 2009; and
- Information on the management and mitigation of impacts including a draft Statement of Commitments to minimise and manage potential environmental impacts.

The EA is structured as follows:

- Volume 1 – Main Report, which includes:
  - Part A Introduction and context;
  - Part B The project;
  - Part C Environmental values and impacts; and
  - Part D Conclusion and justification.
- Volume 2 – Appendices, which includes:
  - Appendix A - Director General's requirements;
  - Appendix B – Preliminary draft Operating Plan;
  - Appendix C – Ecology assessment (this report);
  - Appendix D – Hydrology assessment;
  - Appendix E – Water quality assessment; and
  - Appendix F – Heritage assessment.



Legend

- Existing Torrumbarry Weir
- Site location
- State border
- Major roads
- Railways
- Waterways
- National Parks
- State Forests & reserves

0 5 10 20
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 09 DEC 2009

Figure 1 Location of the project

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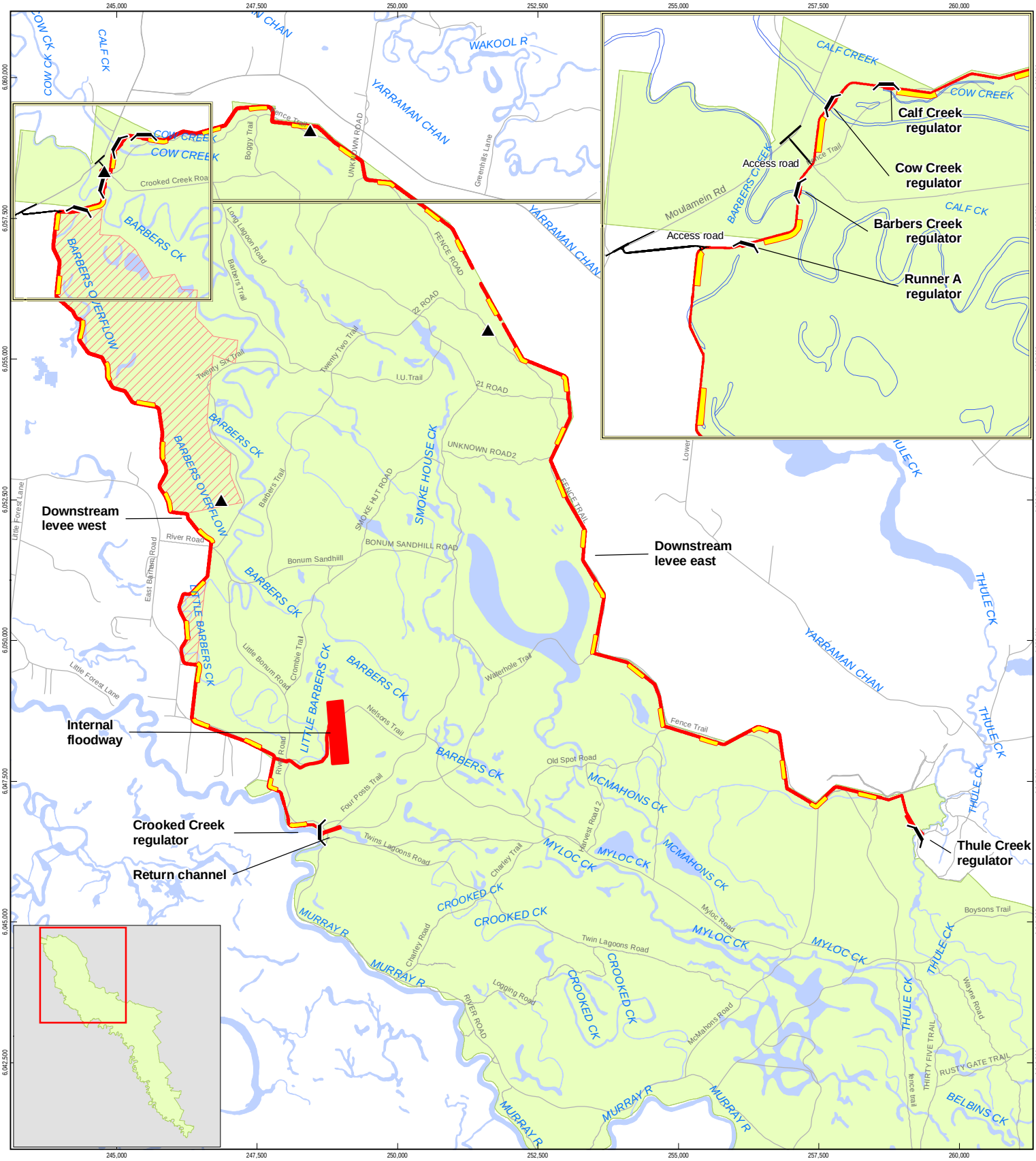
Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: StreetMap - Navegate, Drawn: Cwilson



Legend

- Turkey's nest dam
- Regulator
- Access Road Design
- Borrow pits
- Construction features
- Western levee alignment area
- Roads
- Waterway
- Koondrook Perricoota Forest Site

0 0.5 1 2
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: World Geodetic System 1984
Grid: Universal Transverse Mercator, Zone 55S

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Date	01 FEB 2010

Figure 2 - Site layout downstream section

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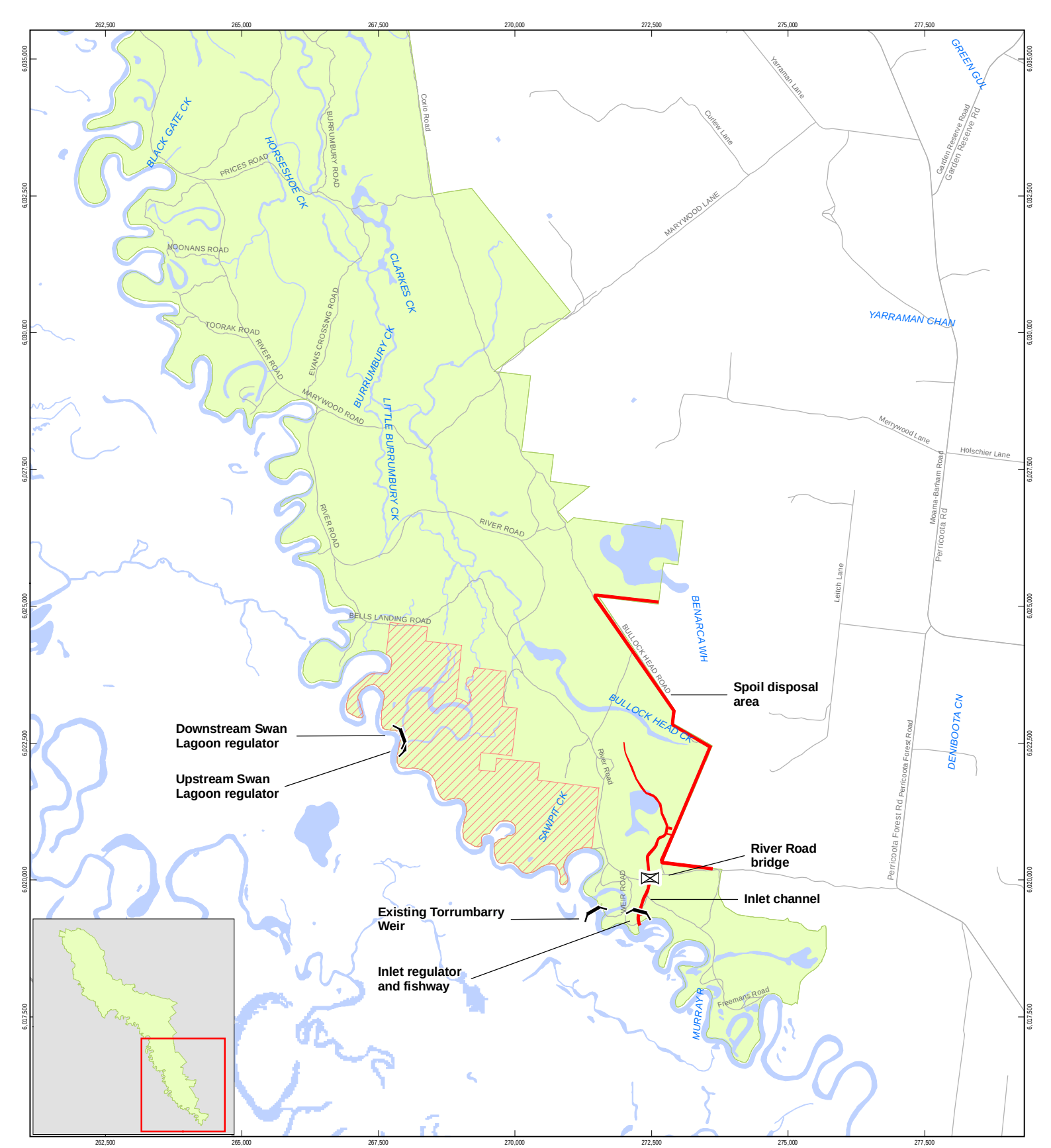
Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

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



Legend

- River Road bridge
- Regulator
- Construction features
- Toorangabby Boundary
- Roads
- Waterway
- Koondrook Perricoota Forest Site

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	01 FEB 2010

Figure 3 - Site layout upstream 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

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

2. Site Description

2.1 Overview

The site for this project includes the Koondrook and Perricoota State Forests and other lands purchased in order to facilitate the operation of the project (the Forest). These additional lands include the 871 ha Toorangabby property, which was formerly a private lease surrounded by the Perricoota State Forest. The former Toorangabby property contains the Swan Lagoon and the mouths of the Burrumbury Creek and therefore the locations of the two proposed Swan Lagoon Regulators. The site location is shown on Figure 1.

The Forest covers around 32 000 hectares on the northern floodplain of the Murray River downstream of Torrumbarry Weir, between Echuca and Koondrook-Barham. Of this approximately 17, 700 ha may be flooded by the proposed works. It is recognised for its many environmental, social and economic values. Ecological values include extensive stands of River Red Gum forest, foraging and breeding habitat for waterbirds and habitat for threatened flora and fauna species. The Forest is listed as a wetland of international importance under the Ramsar wetland convention as one of three groups of State Forests that make up the NSW Central Murray State Forests Ramsar Site. The Forest also forms part of the Gunbower-Koondrook-Perricoota River Red Gum Forest, which is one of six Icon sites identified under the Murray-Darling Basin Ministerial Council's (MDBMC) Living Murray Initiative.

The Forest is located within the Riverina Bioregion[1] (Thackway and Cresswell, 1995; DEWHA, 2008). The Riverina is located within the Murray Fans (RIV3) Biogeographical Subregion (DEWHA, 2008; Morgan and Terrey, 1992) and has a dry, semi-arid climate. The characteristics of the Murray Fans Biogeographical Subregion are summarised in Table 2 below.

The Forest contains a variety of vegetation types which are mainly defined by geomorphic position and flood regime. Riparian fringes of drainage lines and lower areas of the floodplain support River Red Gum (*Eucalyptus camaldulensis*) forest. Higher, less frequently flooded portions of the floodplain support Black Box (*Eucalyptus largiflorens*) woodland with an understorey of flood-tolerant grasses and saltbushes. The highest, rarely flooded upper areas of the floodplain contain Inland Grey Box (*Eucalyptus microcarpa)* woodlands. There are also forms of Inland Grey Box Woodland where the species co-occurs with River Red Gum which are closer to the river but occur on rarely flooded terraces and levees and/or sandy, free-draining soils. The most frequently inundated channels; drainage depressions and oxbow lagoons support floodplain marshes, including reed beds, sedgelands and wet-grasslands. There are small areas of sandy soils on higher ground, such as source-bordering dunes, which support White Cypress Pine (*Callitris glaucophylla)* woodland.

The Forest is dominated by floodwater-dependant ecosystems that are currently experiencing moisture stress as a result of changed flow regimes, owing mainly to a century of river regulation, exacerbated by the recent prolonged drought. Adverse changes to the natural hydrology of the Forest have significantly reduced the ecological health and productivity of the Forest. The current health and condition of floodplain ecosystems is described further in Section 5.6.

Land surrounding the Forest is less influenced by floodwaters and features vegetation more typical of semi-arid zones. In many instances this is due to construction of levees on the private property/State Forest boundary. These levees were generally constructed to protect agricultural land from undesirable flooding.

[1] "Bioregions" as defined by DECCW (2008) are large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems. A bioregion characterises large-scale geophysical patterns across Australia.

The floodplain beyond the Forest is dominated by cleared agricultural land with patches of Black Box and Grey Box woodlands. These grade into grassy *Eucalyptus* woodlands, saltbush (*Maireana* spp.) shrubland and native grasslands on surrounding alluvial plains (Benson *et al.,* 2006). Agriculture in the region relies heavily on irrigation water from the Murray River and its effluents.

Table 2 Characteristics of the Murray fans Biogeographical Subregion

Subregion	Climate	Geology	Characteristic landforms	Typical soils	Vegetation
Murray Fans	Semi-arid. Hot, dry summers. Cool, dry winters.	Quaternary alluvial sediments. Clay and sand with source bordering dunes, lakes and swamps.	Relatively confined alluvial fan constrained by sediments from northern Victorian rivers, the Murrumbidgee fan and the Cadell fault. Meandering channels, floodplains, source-bordering dunes, overflow lakes and swamps.	Red brown earths, grey clays and deep sands.	Extensive River Red Gum forests on channels and low floodplains. Inland Grey Box and Black Box with saltbush on high floodplains and terraces. White Cypress Pine on dunes, sandy levees and lunettes. Common reed, cumbungi and grasses in marshes.

Source: (Morgan and Terrey, 1992)

2.2 Geology, Soils and Topography

The Forest is composed of Quaternary alluvial sediments on the floodplain of the Murray River and associated anabranches. It is made up of three main geological units:

- Floodplain clays, composed of unconsolidated grey brown micaceous silty clay, silt, sand, gravel;
- Sand dunes, composed of unconsolidated locally mobile pale orange yellow siliceous sand; local abundant micaceous and lithic grains; and
- Claypans and drainage lines composed of mostly clay, silt and fine sand.

Rock outcrop is absent.

The general terrain of the Forest is extremely flat, with a regional east-west slope of some 0.2 m per kilometre (Bacon *et al.,* 1993). Alluvial formations are the dominant landscape features. Quaternary alluvial features include modern and ancestral river channels, floodplains, backplains, swamps, lakes and lunettes. The current hydrological and geomorphic system has been active for about 5,000–10,000 years BP (before present). Compared with previous periods, the modern Murray River is relatively narrow, and carries medium-sized sand, silt and clay instead of coarse sand and gravel (Rutherford, 1990).

2.3 Climate

The Forest is located in the Riverina bioregion, which has a warm, semi-arid climate. The nearest Australia Bureau of Meteorology (BOM) open meteorological station is at Deniliquin (Wilkinson St) approximately 50 km from the Forest. At Deniliquin: mean annual rainfall is 404 mm; mean daily maximum temperature is 32.5 degrees Celsius in January and 14.4 in July; mean daily minimum temperature is 15.7 degrees Celsius in January and 3.4 in July. Summers are very hot and rainfall is consistently low throughout the year (mean annual rainfall of 404 mm). Typical of semi-arid regions, rainfall is highly variable between years (BOM, 2008). The last decade has been characterised by a severe drought.

Mean daily evaporation exceeds mean monthly rainfall through the summer months. The average annual rainfall of 404 mm and mean annual deficit of 1075 mm between rainfall and evaporation mean that floodwater contributions are required to support the moisture requirements of forests and wetlands (Leslie, 2001). Vegetation communities at the Forest primarily depend on soil-moisture derived from floodwaters, with some contribution from access to groundwater from prior streams.

Climatic conditions in the catchment for the Murray River and its tributaries, which determines the timing, extent and duration of flooding, are of much greater importance to the Forest than local rainfall. The most important component is winter and spring rainfall and snow melt in the Great Dividing Range in the upper catchment of the Murray River, hundreds of kilometres to the east. The Forest receives flows from the Murray River downstream of the Murray-Goulburn junction and so rainfall and runoff in the Goulburn-Broken catchment, together with flows from the upper Murray, are important for wetland inundation.

The major river systems of the Murray catchment are all to some degree, affected by regulation. A system of dams, weirs and storages has dramatically altered the hydrology of the rivers and associated floodplains such that managed releases of water have assumed an increasingly greater influence on the timing and magnitude of river flows than rainfall and runoff (MDBC, 2004).

2.4 Hydrology

The Murray River defines the hydrology of the Forest via flow into effluent streams across the Forest and overbank flow onto the floodplain during flood events. Surface flooding restores soil moisture reserves necessary for tree growth and sustains large wetland habitats. Groundwater systems (underlying sandy aquifers of prior stream origin), generally only influence-localised areas, but are important to forest health where they do. Their ecological significance is secondary to overland flooding (MDBC, 2007).

Floods occur as two main types of flow pattern:

- Channel flow, which features inundation of effluent streams, channels, depressions or leads. Occurs primarily as through-flows with limited overbank flow and ponding in depressions during moderate increases in flow; and
- Broad-area flooding, which features inundation of broad areas across the floodplain. These events occur as lateral, overbank flow from channels, which spread over broader areas and ponds in depressions or returns to channels when flow recedes (MDBC, 2005; Maunsell, 1992a).

Other River Red Gum Forests in the region feature a system of regulators on their effluents to provide for efficient transfer of river flow downstream and to avoid unfavourable flooding of the forests (GHD, 2009a). None of the effluents that lead to flooding of the Forest currently have regulators. This is because typical river flows in the Murray River in this reach of the river are well below commence-to-flow sill levels (GHD, 2009a).

Murray River flow as it relates to the hydrology of the Forest is measured at the MDBA station downstream of Torrumbarry Weir and is expressed in mega litres per day at downstream Torrumbarry Weir (ML/day). Water enters the Forest in the southeast, via the two inflow effluents to Swan Lagoon, when flow in the Murray River exceeds 17,000 ML/day (DECC, 2008c). Water passes through the first 15 km of the system via several deep, well-defined channels known as the Burrumbarry Creeks. These channels then break down into a myriad of smaller, interlinked runners covering an area of approximately 4,500 ha. Progressive filling of these flood runners occurs at flows of between 18-20,000 ML/day (DECC, 2008c). These runners eventually coalesce into several defined streams, the largest of which is Myloc Creek. The Myloc flows westward in conjunction with subsidiary runners, before becoming Barbers Creek, the primary drainage system for the western end of the Forest (i.e. the Koondrook Forest). In addition to the Myloc, a second flow runs northwesterly, without a defined channel, eventually forming the secondary drain of Cow Creek (Wyatt, 1992).

Downstream of Swan Lagoon are a number of other oxbow lagoons, several of which have associated natural effluents that form secondary inflow points at very high flows in the Murray. The most significant of these are Horseshoe Lagoon and Dead River Lagoon. As river levels rise higher, an increasing number of these smaller channels begin to flow (flows of approximately 25-30,000 ML/day). Substantial broad area flows occur when the flows exceed the channel capacity of the Murray River (>30,000ML/day). This progressive inundation of the Forest is illustrated in Figure 4. Outflow from the Forest occurs primarily via Thule Creek, about halfway through the Forest and through Barbers, Calf and Cow Creeks at its western end. During large floods, water also drains out of Axe and Pothole Creeks and floods into adjoining private properties (MDBC, 2007b; Wyatt, 1992). Monthly Murray River flow at Torrumbarry Weir over the period 2000-2008 is shown in Figure 5 with flood events highlighted in grey (inundation of flood runners), light blue (small flood) and dark blue (large flood). Mean monthly flows in the Murray River below Torrumbarry Weir have been significantly lower since January 1997 than those observed over the previous 20 years. The lack of high, flooding flows (defined as mean monthly flow > 30,000 ML/day and shaded in blue) during the last 10 years is particularly striking. Under the current regime the Forest does not receive sufficient flooding to maintain the ecological health and productivity of the forests and the Forest is in a state of decline (Turner and Kathuria, 2008l; MDBC, 2007_c). The current health and condition of floodplain ecosystems is described further in Section 5.6.

River regulation has been implicated in the steady decline of ecosystem health of the Forest and other River Red Gum Forests in the Central Murray over the last 75 years (GHD, 2009a; MDBC, 2007). In this heavily regulated system, access to environmental flows is critical to the ongoing health and ecological productivity of the Forest. Forests NSW, the MDBA and other regulatory authorities integrate the management of environmental flows for the maintenance of natural ecosystems with consumptive water allocations.

Forest managers may access and utilise environmental water from a range of sources. Examples include the Living Murray program (TLM). TLM aims to recover an average of up to 500 GL/yr of water to improve environmental flows and achieve ecological objectives at six Icon Forests along the Murray River. These include Gunbower-Koondrook-Perricoota Forest (containing the Forest). Use of the water is governed by the Environmental Watering Group who considers a range of factors, including ecological need and water availability to collectively determine where and for what purpose water should be used in any given year.

Figure 4 Progressive Inundation of Koondrook-Perricoota Forest (GHD, 2009a)

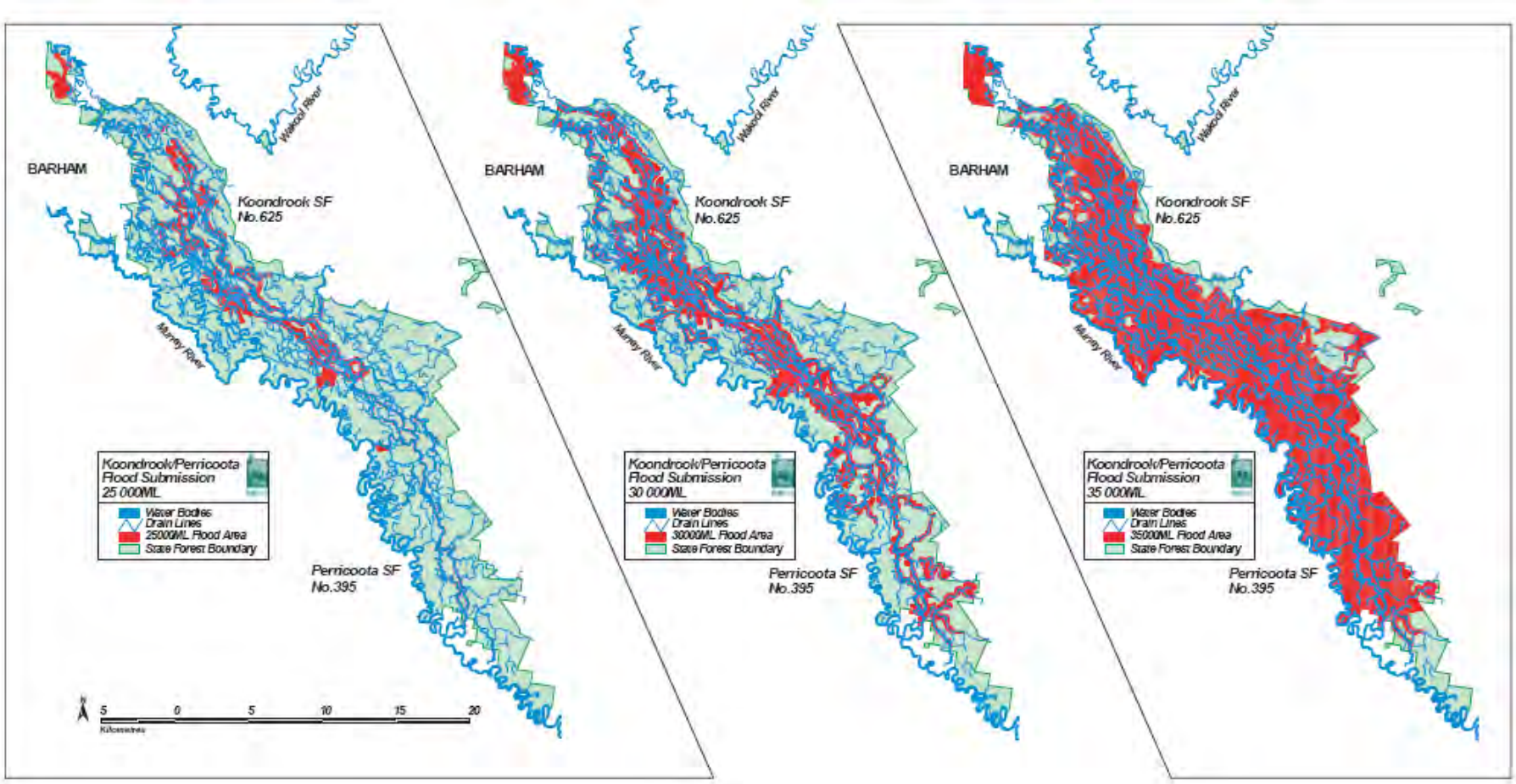


Figure 5 Torrumbarry Weir Flow with Flood Events Shaded in Blue, 1990-2008 (MDBA, 2008)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
May	6,577	5,045	4,480	10,129	5,971	5,555	5,481	4,132	4,332	4,306	4,672	3,892	3,385	3,234	4,157	3,567	5,491	2,863	2,310
June	5,397	3,332	7,252	9,183	6,778	8,113	4,908	6,726	2,991	3,422	4,573	3,513	4,441	2,746	3,441	3,176	6,208	2,058	
July	5,698	4,317	5,795	8,066	4,925	20,448	5,345	4,222	3,410	8,100	5,981	3,388	3,968	2,914	5,977	3,367	2,180	3,487	3,268
Aug	23,474	12,425	6,463	19,495	6,573	29,357	24,266	2,267	4,941	5,456	9,132	3,941	3,464	5,441	8,327	5,867	5,353	6,056	2,086
Sept	44,261	11,088	8,619	29,929	5,439	43,189	48,168	5,731	5,973	7,896	10,084	3,158	3,421	12,117	7,507	7,289	6,447	4,501	
Oct	49,379	31,483	32,594	49,707	6,285	9,204	32,225	7,938	5,148	11,273	21,719	4,482	6,983	13,780	8,106	11,832	5,280		
Nov	23,877	31,463	55,228	58,196	7,381	5,484	46,635	3,059	11,300	3,640	21,045	5,586	7,489	6,507	5,779	7,915	4,650	2,997	
Dec	14,624	3,814	44,017	38,359	7,771	9,666	24,671	5,964	8,698	4,145	37,018	4,464	8,238	5,520	7,951	12,337	5,944	5,493	
Jan	5,232	4,105	4,974	38,909	10,454	4,732	4,992	5,897	4,280	4,392	4,100	11,059	3,771	8,139	6,544	6,489	7,429	4,823	6,744
Feb	4,717	5,502	5,379	20,780	7,858	5,246	4,503	4,006	4,018	3,719	4,057	4,758	4,659	5,321	5,243	4,951	5,267	4,944	6,755
Mar	6,310	4,305	5,155	8,549	6,944	5,912	4,537	4,763	4,390	4,015	4,269	4,794	4,393	5,525	6,038	10,678	6,082	4,968	4,478
Apr	4,326	4,218	4,341	7,448	8,251	4,036	4,874	4,498	3,469	4,237	3,290	3,849	3,417	3,996	4,729	4,310	5,268	3,124	3,157

	<16,000 ML/day	In channel flow
	16,000-30,000 ML/day	In channel flow via Burrumbary Ck
	30,000-35,000 ML/day	Murray River Overbank flow
	>35,000 ML/day	Broad area flooding of River Red Gum Forests

2.5 Landuses

The majority of the Forest is gazetted as State Forest. State Forests are administered in accordance with the *Forestry Act 1916* and the regulations associated with that Act. Forests NSW develops and implements a range of policies as guided by the objectives of this legislation, in accordance with the principles of ecologically sustainable forest management (DPI – Forests, 2008_a).

The NSW Government has identified that the overriding intention of forest management across all tenures is the maintenance and enhancement of all forest values in the environmental, social and economic interests of the State. The regulatory regime is embodied through compliance with and, where necessary, approvals and licences from the Commonwealth and NSW. The Forest has been purposefully managed for timber production for over 100 years and currently features a suite of multiple use forest management activities including:

- Timber harvesting and associated silvicultural activities;
- Hydrological management, through maintenance of effluent sills;
- Infrastructure construction and maintenance, including roads, culverts and drainage works;
- Weed and pest management;
- Fire management;
- Grazing, including purposeful management for economic gain, fuel load reduction and weed management;
- Apiary;
- Biodiversity management, including managing flood regimes of wetlands, targeted fencing and exclusion of grazing and harvesting;
- Management of public recreation uses;
- Scientific research; and
- Public education.

FNSW and the then Murray-Darling Basin Commission (MDBC[2]) jointly purchased Toorangabby, a property in the southeast of the Forest, which contains Swan Lagoon. Lower Toorangabby comprises 817ha and was purchased (settled) on January 6 2007. 813.8 ha was gazetted as an addition to Perricoota State Forest on February 16 2007, the remainder (roads and creeks including Swan Lagoon) was gazetted on August 5 2009. The property was added to the NSW Central Murray State Forests Ramsar Site by virtue of its crown ownership and location/description immediately (Broekman, L, FNSW, pers. comm.).

This parcel of land contains Swan Lagoon and the commencement of the two Burrumbury Creek effluents. Water that leaves the Murray River via the two entry points into Swan Lagoon then via the two Burrumbarry Creeks accounts for the vast majority of water entering the forests and so this land purchase is very important to the operation of the project (Thompson, M., FNSW, pers. comm.).

Tenure of the surrounding land is predominantly freehold title. Parcels of public land other than State Forest also adjoin the Forest in New South Wales (NSW), which are managed by the NSW Department of Lands and the Livestock Health and Pest Authorities. The Murray River marks the southern boundary of the Forest and the southern bank is the State border. The opposite bank mostly contains public land managed by the Victorian Department of Sustainability and Environment.

[2] the Murray-Darling Basin Commission (MDBC) is now known as the Murray-Darling Basin Authority (MDBA).

The administrative bodies responsible for Aboriginal interest in the Forest and surrounding lands are the Cumergunja Local Aboriginal Land Council, Moama Local Aboriginal Land Council, the Deniliquin Local Aboriginal Land Council and the Barapa Barapa and Yorta Yorta groups. A number of other groups may have connections and interests in the Forest or a particular area, including native title claimants, knowledge holders (such as elders groups) and Aboriginal corporations (FNSW, 2008).

3. Legislative Framework

3.1 Environmental Planning & Assessment Act 1979

The *Environmental planning and Assessment Act* (EP&A Act) forms the legal and policy platform for development assessment and approval in NSW and aims to, *inter alia*, 'encourage the proper management, development and conservation of natural and artificial resources'. The proposal is a major project according to the provisions of Part 3A of the EP&A Act, with the Minister for Planning as the approval authority for the Project Application.

3.2 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) provides legal status for biota of conservation significance in NSW. The Act aims to, *inter alia,* 'conserve biological diversity and promote ecologically sustainable development'. It provides for:

- The listing of 'threatened species, populations and ecological communities' (threatened biota) with endangered species, populations and communities listed under Schedule 1, 'critically endangered' species and communities listed under Schedule 1A, vulnerable species and communities listed under Schedule 2;
- The listing of 'Key Threatening Processes' (KTPs) (under Schedule 3);
- The preparation and implementation of Recovery Plans and Threat Abatement Plans; and
- Requirements or otherwise for the preparation of Species Impact Statement (SIS).

The TSC Act has been addressed in the current assessment through:

- Desktop assessment to identify the threatened biota that have been previously recorded within the locality of the Forest and hence have the potential to occur at the Forest and be affected by the project;
- Targeted field surveys for threatened biota;
- Habitat assessments, to determine whether habitat features and resources for threatened biota are present within the Forest, and hence whether threatened biota are likely to occur and be affected by the project;
- Identification of KTPs operating within the Forest, in terms of the extent, timing and severity of their operation;
- Assessment of the extent to which the project will affect the operation of any KTPs within the Forest;
- Development of suitable impact mitigation and environmental management measures for threatened biota, where required; and
- Assessment of potential impacts on threatened biota.

3.3 Fisheries Management Act

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) aims to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations.

The FM Act lists threatened species of freshwater fish, aquatic invertebrate and macroinvertebrate species, endangered populations and aquatic ecological communities and key threatening processes. Potential impacts on species, populations and communities subject to the FM Act are assessed in Appendix C. Section 5A assessments of significance have been prepared for 'affected aquatic entities'. These assessments have concluded that the project incorporating measures to avoid or mitigate impacts is likely to avoid significant impacts on affected aquatic entities.

The project would involve activities that meet the definition of 'dredging' or 'reclamation' under Clause 198A of the *Fisheries Management Act 1994*. Under Section 201(1) of the FM Act, a person must not carry out dredging or reclamation work except under the authority of a permit issued by the Minister. The project does not require a permit under Section 201(1) of the FM Act because it is subject to approval under Part 3A of the EP&A Act and Section 75U(1) of the EP&A Act applies.

Under Clause 199 of the FM Act, the proponent is required to notify the Minister for Fisheries before it carries out or authorises the carrying out of dredging or reclamation work. The notice must be given in writing and the proponent must consider any matters raised by the Minister within 28 days after the notice is given.

As the project involves construction of regulators that function as weirs, the proponent is required to notify the Minister for Fisheries in accordance with Section 218(5) of the FM Act. If the Minister requests, the proponent must include a suitable fishway or bypass. Consultation has been undertaken with the Fish Passage Task Force (FPTF) which includes a representative from the NSW Department of Industry and Investment – Fisheries regarding the need for structures to provide for fish passage.

3.4 Native Vegetation Act 2003

The NSW Government released the regulations for the *Native Vegetation Act 2003* (NV Act) on 14 November 2005, which came into effect on 1 December 2005. The NV Act regulates the clearing of native vegetation on all land in NSW except for land listed in Schedule 1 of the Act. Excluded land under Schedule 1 of the Act includes National Parks and other conservation areas, State Forests and reserves, and urban areas.

The majority of the Forest is State Forest and exempt from the NV Act. Portions of the Forest on recently acquired freehold land outside the State Forests are also exempt because according to s.75U(e) of the EP&A Act, an authorisation under Section 12 of the NV Act to clear native vegetation is not required for a project approved under Part 3A. Hence, the NV Act does not apply to the current proposal.

3.5 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act), provides for the declaration of noxious weeds by the Minister of Agriculture. Noxious weeds may be considered noxious on a National, State, Regional or Local scale. All private landowners, occupiers, public authorities and Councils are required to control noxious weeds on their land under Part 3 Division 1 of the NW Act. As such, if present, noxious weeds within the Forest should be controlled in accordance with the control category specifications.

3.6 State Environmental Planning Policy 44 – Koala Habitat Protection

State Environmental Planning Policy 44 (SEPP 44) aims to encourage the 'proper conservation and management of areas of natural vegetation that provide habitat for Koalas to ensure a permanent free-living population over their present range and reverse the current trend of Koala population decline'.

Schedule 1 of SEPP 44 lists the local government areas (LGAs) to which SEPP 44 applies. The Forest is within the Council of the Shire of Wakool and Murray Shire Council. These LGAs are listed under Schedule 1.

SEPP 44 requires that, before granting consent for Development Application under Part 4 of the EP and A Act, on land over 1 hectare in area, a consent authority must be satisfied as to whether or not the land is 'potential' and 'core' Koala habitat.

As the project is a major project subject to Part 3A of the EP and A Act, SEPP 44 does not technically apply. Notwithstanding, the general principles of the SEPP have been considered.

Under the SEPP, potential Koala habitat is defined as 'an area of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component'. Schedule 2 lists the main koala feed tree species.

Core Koala habitat, is defined 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'.

As discussed in Section 4, the principles of SEPP 44 were addressed through targeted surveys for Koalas and Koala feed trees and searches for signs of recent Koala activity.

3.7 Environment Protection and Biodiversity Conservation Act

The purpose of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is to ensure that actions likely to cause a significant impact on 'matters of national environmental significance' undergo an assessment and approval process. Under the EPBC Act, an action includes a project, undertaking, development or activity. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Minister for the Environment, Water, Heritage and the Arts.

In January 2007 the Commonwealth and NSW governments signed a Bilateral Agreement which allows DEWHA to accredit the assessment regimes under Part 3A, Part 4 and Part 5 of the EP&A Act for assessment purposes under the EPBC Act. The Bilateral Agreement applies only to proposals that the Commonwealth Environment Minister has determined are controlled actions under the EPBC Act, with the exception of nuclear actions (DoP, 2007).

The EPBC Act identifies matters of national environmental significance as:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

The Administrative Guidelines for the EPBC Act (DEH, 2006) set out criteria intended to assist in determining whether an action is controlled and hence requires approval. In particular, the Guidelines contain criteria for determining whether a proposed action is likely to have a 'significant impact' on a matter of national environmental significance (NES). Should the proponent deem the proposal likely to have a significant

impact on a matter of NES, a referral to the Commonwealth Minister for the Environment would be undertaken to obtain a determination as to whether the proposal is a 'controlled action' requiring Commonwealth approval.

The EPBC Act has been addressed in the current assessment through:

- Desktop review to determine the threatened and migratory species or ecological communities listed under the Act that have been previously recorded within the locality of the Forest and hence could occur, subject to the habitats present;
- Targeted field surveys for species and ecological communities listed under the Act;
- Development of suitable impact mitigation and environmental management measures for threatened species and ecological communities, where required;
- Assessment of potential impacts on the Ramsar wetland; and
- Assessment of potential impacts on threatened species.

4. Methodology

4.1 Desktop Assessment

4.1.1 Overview

Desktop assessment is an important component of this EIA given the size, complexity and temporal variability of the Forest. The primary aims of the desktop literature review and assessment were to:

- Describe the existing environment of the Forest in a way that encompasses temporal change in response to climatic and hydrological variability;
- Identify threatened biota and their habitats that could potentially occur within the Forest and be affected by the project; and
- Predict the likely response of the natural environment to managed floods achieved through the project.

4.1.2 Existing Environment

The existing environment of the Forest and the likely response of the natural environment to the project were assessed with reference to a broad range of published literature and professional reports. The key resources reviewed included:

- GHD (2009a) *Draft Ecological Character Description for the NSW Central Murray State Forests;*
- GHD (2009b) *Environmental Impact Statement – Harvesting and associated roadwork operations in south-western NSW;*
- Forests NSW Ecological Objectives Report (FNSW, 2008a) and Ecological Analysis Report (FNSW, 2008b);
- Ecological Associates (2009) *Ecological Risk Assessment*;
- Webster (2008) *Ecological Values of Koondrook-Perricoota Forest*;
- Fish Passage Task Force (FPTF) (2009) *Draft Fish Passage considerations for Koondrook-Perricoota Forest*; and
- The Murray-Darling Basin Commission (MDBC) (2007) *Gunbower-Koondrook-Perricoota Forest Icon Forest Environmental Management Plan* and MDBC (2008) *The Living Murray Icon Forest Condition Report October 2008*.

4.1.3 Conservation Significance

To help identify threatened biota and their habitats that could occur within the Forest and be affected by the project the following resources were reviewed prior to the field investigations:

- Leslie (2002) *Ramsar Information Sheet for the NSW Central Murray State Forests*;
- NSW NPWS Wildlife Atlas database (June 2009– Data for the Cohuna, Moulamein and Mathoura 1:100,000 Map Sheets, queried within a 10km buffer around the Forest. The Murray CMA Sub region was searched for endangered ecological communities [EECs]);
- Atlas of Victorian Wildlife (June 2007 data, Area Searched of an irregular area bounded by the rectangle : Latitude: -35°34'54" to -36°06'40" Longitude: +144°03'38" to +144°38'35", 1896 surveys in

the search area, yielding 17067 records of 294 species. Data was queried to exclude records prior to 1989);

- Birds Australia's *The New Atlas of Australian Birds (*Barrett *et al*., 2003*)* and Birdata online database search tool;
- NSW Government's BioNet database of records from the collections of the Australian Museum, DECCW and NSW Department of Industry and Investment (DII, including NSW Fisheries); and
- EPBC online Protected Matters Database (online search, 11 August 2009, drawn polygon around the Forest, buffered at 10km).

4.1.4 Aquatic Ecology

No targeted aquatic ecology site surveys were performed for this assessment because of the following considerations:

- Floodplain Marshes and drainage lines throughout 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 Forest assessments; and
- GIS analysis and hydrological modelling has been conducted across the entire Forest 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 conducted by GHD terrestrial ecologists are considered to be adequate for the purposes of assessing potential impacts on aquatic ecosystems in this EA.

Key resources used in the desktop assessment of aquatic and wetland ecology include:

- Ecological Associates (2009), GHD (2009a,b), MDBC (2007, 2008) and FNSW (2008a,b) technical reports; and
- The Murray Wetlands Working Group *River Murray Wetland Database* (Green and Alexander, 2006), including mapping of wetlands in the Forest with commence-to-flow levels and discussion of wetland vegetation and the impacts of river regulation on wetlands.

4.2 Site Surveys

4.2.1 Overview

Two flora and fauna site surveys were performed by GHD ecologists: a preliminary survey and vegetation mapping exercise from 20-24 July 2009; and a targeted Spring survey from 8 to 18 September 2009. This staged approach allowed for the Spring survey effort and methodology to be designed around information collected in the initial survey.

Survey effort is presented on Figure 6 and summarised in Table 3. Survey methodology is described below.

Table 3 Ecological site surveys

Field Survey	Date	Purpose	Methodology
Preliminary survey and Inland Grey Box Woodland mapping	20-24 July 2009	Map extent of Grey Box woodland EECs. Survey for threatened species or their habitats. Preliminary flora and fauna surveys.	Vegetation mapping through ground-truthing of 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. Quantify direct impacts within the construction footprint for the project. Determine if threatened species or their habitats occur or are likely to occur within the Forest. Identify and describe sensitive receptors for operational (flooding) impacts. Map ecosystem type, conservation significance and likely response to flooding.	Habitat assessment; refinement of 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.

4.2.2 Terrestrial Flora Survey

The primary objectives of the survey were to:

- Map and describe the vegetation communities occurring within the study area and especially to map the extent of Inland Grey Box Woodland within the proposed inundation area;
- Compile a flora list of those species occurring within the Forest and identify any threatened species and EECs;
- Determine the condition, likely response to flooding and conservation significance of vegetation within the project disturbance footprint; and
- Assess the likely impacts of the proposed development and provide recommendations to assist in minimising adverse impacts on flora in the study area.

Vegetation Mapping

Available vegetation mapping for the Forest includes:

- Forests NSW Forest Quality mapping; and

- DECCW, Roff, A., Denholm, B. & Sivertsen, D. (unpub)., Draft *Broad Vegetation Type Mapping for the Murray Catchment Management Area*.

GHD combined these datasets with site survey notes to produce a composite, local scale vegetation map of the Forest. The approach is described below.

Forests NSW have comprehensively mapped forest types within the Forest at a high resolution, however according to 'site quality' classes rather than ecologically-based vegetation community classes. Forests NSW ascribes River Red Gum Forests a site quality category (SQ1, SQ2, SQ3 or Red Gum/Box) on this basis. SQ1 relates to the tallest, most well-watered and productive forests whereas SQ3 relates to shorter, drier stands of River Red Gum Woodland (Benson et al., 2006; Maunsell, 1992). Forests NSW site quality categories show a good general agreement with ecological systems for discriminating River Red Gum vegetation associations. This is because ecological systems discriminate on the basis of:

- Vegetation community structure, which is a function of productivity (Specht, 1981); and
- Understorey composition, which on the Murray River floodplain is related to geomorphic position and frequency of inundation with flood waters (Benson *et al.,* 2006; Roberts and Marston, 2000).

Inland Grey Box Woodlands were noted within the Forest by Ecological Associates (2009) and are significant to this assessment since they are a TSC Act-listed EEC. Inland Grey Box Woodlands have not been mapped as distinct from Black Box Woodland by Forests NSW. This is because Forests NSW vegetation mapping discriminates communities on the basis of productivity, not ecological characteristics. Neither Inland Grey Box nor Black Box are regarded as commercially harvestable timbers and so Forests NSW did not discriminate box woodlands in their site quality mapping.

Another limitation of the mapping for the environmental assessment is that all treeless areas have been mapped as 'Open Plain or Swamp' with no discrimination of wetland vegetation from terrestrial grasslands or cleared, degraded land. Further, the EARs for this project requested that vegetation communities in the Forest be mapped according to Benson (2006) vegetation communities, if possible. Therefore Forests NSW mapping is not entirely adequate for this assessment. Nonetheless, the available Forests NSW mapping is at a high resolution and was available as an editable GIS dataset and so this data was used as the basis of vegetation community mapping in this assessment.

The Roff *et. al*., (unpub) vegetation mapping classifies the Forest according to Benson (2006) vegetation types. However, it was performed using a remote sensing technique (pattern recognition), is at a relatively coarse (whole of catchment) scale and has undergone limited ground-truthing and verification (Roff, A., DECCW, pers. comm.).

Given the shortcomings of both available vegetation mapping systems for the purposes of this assessment, Forests NSW Forest Quality mapping was ground-truthed, edited and re-defined as Benson (2006) vegetation communities using the following procedure:

- A hand held 'Trimble' GPS with a colour screen was loaded with Forests NSW Forest Quality mapping and high resolution aerial photography of the Forest. Any required modifications to the mapping was made on large scale printed hard copies;
- Initial drive-through of the Forest to confirm the accuracy of the data with regards to the size and position of vegetation polygons, in general. This was confirmed as excellent, as vegetation ecotones consistently coincided with the boundaries of polygons;
- Systematic checking of 'box' polygons and discrimination as either Inland Grey Box or Black Box Woodland based on the presence of Inland Grey Box trees;

- Targeted survey for Inland Grey Box trees and marking as Inland Grey Box Woodland. This approach noted some patches of the community mapped as ‘Red gum/Box’ or ‘Red Gum SQ1 or SQ2’ where Inland Grey Box occurred alongside River Red Gum’;
- Detailed mapping of Inland Grey Box Woodland in the vicinity of proposed project infrastructure, including walking the boundaries of patches and capturing GPS points where required. Some regrowth stands of Inland Grey Box in areas mapped as ‘open plain or swamp’ were captured in this way;
- Ground-truthing and discrimination of ‘Open Plain or Swamp’ polygons into Floodplain Depression Marsh, derived grassland or herbland or River Red Gum regrowth;
- Desktop assessment of the likely relationship between River Red Gum Forest Quality classes and Benson (2006) vegetation communities, including cross-checking of DECCW and Forests NSW mapping;
- Re-attributing of River Red Gum site quality classes with targeted Benson (2006) vegetation communities to produce a uniform thematic; and
- Use of DECCW vegetation mapping, air photo interpretation and field notes to map areas not covered by FNSW site quality mapping.

All patches of vegetation with Inland Grey Box as a component of the canopy were mapped as Inland Grey Box Woodland (excluding isolated individual trees). This included extensive areas which also contained River Red Gum and less commonly Black Box. This approach was adopted because the Benson (2006) community ‘Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone’ (Comm ID 237 - Inland Grey Box Woodland) lists Inland Grey Box and River Red Gum as canopy species, whereas Red Gum Forest types (Comm. Ids 2, 5 and 7) list River Red Gum as the only canopy species. Detailed descriptions are provided in Table 7.

Flora survey

The timing of targeted flora surveys was determined based on observed conditions during the preliminary survey i.e. the growth stage of grasses and annual herbs. Survey effort included 25 20m x 20m quadrats positioned to help define native vegetation communities in the Forest but biased towards the proposed locations of project infrastructure. Survey effort was targeted using air photo interpretation, existing vegetation mapping and field habitat assessment. Additional random meander surveys were also performed through all areas of suitable habitat, noting any species not detected in other surveys as well as any threatened species. Random meander surveys were also used for habitats not readily sampled with quadrats, such as the banks of the Murray River and floodplain marshes.

All vascular plants (i.e. not mosses, lichens or fungi) observed were recorded on appropriate pro-forma field data sheets. Each species list was accompanied by a detailed biophysical description, including vegetation structure, soils, geology and geomorphology, habitat and fire and disturbance history.

Plant specimens that could not be identified quickly in the field were collected and subsequently identified using standard botanical texts and where required were compared with voucher specimens held in the National Herbarium of New South Wales Online Reference Collection. Structural vegetation communities were described according to classifications made by Specht (1970). Plant identifications were made according to nomenclature in Harden (1990, 1991, 1992, and 1993). Plant specimens which were difficult

to identify (either insufficient sample collected or buds/fruiting bodies were not available at the time of the survey) were submitted to the NSW National Herbarium for identification or identified to Genus level.

The BioBanking (2008) field data collection methodology was used to collect quantitative habitat attribute data. The BioBanking methodology is intended to provide a repeatable and consistent approach to measuring vegetation/habitat values and structural attributes of a representative area that can be offered as indicators of fauna and ecosystem function (Gibbons *et al*., 2008). Data collected include native species richness, native vegetation cover, length of fallen logs, numbers of hollow-bearing trees and exotic weed cover. Biobanking habitat attributes were compared with the DECCW (2009f) Vegetation Benchmarks Database. Benchmarks are quantitative measures that describe the range of variability in condition of vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement. Benchmarks are available for each Keith (2004) vegetation class in the Vegetation Benchmarks Database. Each vegetation class encompasses one to many vegetation types within each catchment management authority area.

The location of field survey quadrats and significant species, habitat and communities were captured with a handheld GPS unit. The locations of the vegetation survey quadrats are shown in Figure 6 and Figure 7.

4.2.3 Terrestrial Fauna Survey

The terrestrial fauna survey design was based on the likelihood of threatened species identified in the literature review occurring within the Forest and the initial habitat assessment. Methods included diurnal bird surveys, Anabat recording, active searches, nocturnal call playback, spotlighting, opportunistic observations and track and scat analysis. The scope and timing of targeted surveys was determined based on observed conditions during the preliminary survey and consultation with DECCW (Ewin, P., DECCW, pers. comm.). All observations were recorded on appropriate pro forma field data sheets.

The Spring Survey was split into two formal four-night sampling periods, 1x4 nights in the Koondrook SF in the vicinity of the proposed downstream infrastructure and 1x4 nights in the Perricoota SF in the vicinity of the proposed upstream infrastructure. Harp trapping, Anabat recordings and camera recordings were restricted to these two periods for logistical reasons, with survey effort stratified according to the locations of infrastructure and consideration of sample periods recommended in the DEC (2004) guidelines. Additional spotlighting, diurnal bird surveys and opportunistic fauna observations were made across the study area throughout the remainder of the total 11 days of the survey period.

Survey Conditions

Weather during the Targeted Survey generally featured warm to hot days with cool to cold nights.

Overall, 2.8 mm of rainfall was recorded during the last 24 hours of the preliminary survey period. No nocturnal work was performed on the rainy evening due to site access and health and safety constraints. There was standing water in drainage ditches and wetlands in the far southeast of the Forest, above Torrumbarry Weir, and frogs were actively calling in this portion of the Forest. The remainder of the Forest was dry and no frogs were heard. Weather conditions during the site survey were not ideal for the detection of all frog species likely to occur within the Forest.

Weather conditions would have been warm enough for the detection of diurnal reptiles potentially present in the Forest on at least half of the days spent on site. A moderate diversity and abundance of diurnal reptiles were observed. Evenings were too cool for the detection of nocturnal or crepuscular reptiles and none were observed.

Cold and or windy weather would have limited the effectiveness of harp trap surveys for some of the survey period. Bats were caught on five out of eight evenings sampled, which suggest that overall conditions were suitable.

Wind during dawn bird surveys was generally light to moderate and suitable for call recognition and seeing small birds.

There was nil to very minor light-spill from human sources within the Forest. Traffic through the Forest was very light, with less than ten vehicle movements per hour during daylight hours, to virtually nil at night. Conditions throughout the nocturnal surveys were suitable for the detection of small nocturnal fauna, nocturnal birds and larger mammals.

Table 4 Daily weather observations at Deniliquin during the survey period (BOM, 2009)

Date	Minimum temp (ºC)	Max temp (ºC)	Rainfall (mm)
Preliminary Survey			
20/7/09	8.2	19.4	0
21/7/09	5.8	20.8	0
22/7/09	6.9	17.6	0
23/7/09	3	13.1	1.2
24/7/09	-2.4	14.1	0
Targeted Survey			
8/9/09	5.5	17.4	0
9/9/09	3.6	17.6	0
10/9/09	1.4	17.7	0
11/9/09	3.9	25.9	0
12/9/09	13.1	33	0
13/9/09	14.4	23.8	0
14/9/09	1.5	17.8	0
15/9/09	2.5	20.5	0
16/9/09	5.1	24.7	0
17/9/09	12	19.4	0
18/9/09	4.1	20.7	2.8

Diurnal Bird Surveys

Diurnal bird surveys consisted of area searches through representative habitats on site. Searches were conducted at dawn, for at least 40 minutes over approximately 1 ha consistent with the DECCW guidelines (DEC, 2004). Bird surveys were conducted on a total of 13 mornings, in the vicinity of survey locations provided in Figure 6 and Figure 7. Generally two separate diurnal bird surveys were conducted at each of these locations. Opportunistic observations of bird species were recorded throughout the duration of all surveys on the site. Species were identified by visual observation and call. Counts of non-threatened species were not taken, due to the size of the site and because it was a one off survey. Threatened birds were documented along with numbers of individuals, behaviour, breeding activity and habitat type on pro forma data sheets and their location captured with a handheld GPS.

Trees were also scanned for nests, whitewash and roosts throughout the study area and the locations of habitat features and resources captured with a handheld GPS unit.

Active Herpetofauna Searches

Active searches for frogs and reptiles were performed focussing on wetlands and suitable substrate. Wetland areas were systematically searched and semi-aquatic vegetation was visually scanned. Shelter sites were carefully lifted and replaced, trunks and decorticating bark were scanned and visual scanning of vegetation for active and foraging specimens was undertaken. Frogs were identified by sight and by call.

No targeted call playback for frogs was considered necessary or appropriate, given the weather conditions, nature of the site and low likelihood of threatened frog species occurring.

Microchiropteran Bat Survey

Fixed Anabat recordings were undertaken as the primary method of sampling microchiropteran bats (micro bats) because of the size of the Forest, the generally open vegetation structure and because it permits identification of high-flying species. Four Anabats were left in place for at least one night per survey location over a total of eight nights. One unit failed to record on one evening. Overall 31 full nights of bat call recordings were taken, each from approximately half an hour before dusk until the following morning. Anabat units were directed at flyways, water bodies and potential roost trees. Recordings were sent to Ray Williams of Ecotone for identification. Calls were identified to species level where possible and were reported as ‘definite’, ‘probable’ or ‘possible’ depending on the confidence of the identification.

Harp trapping was conducted as a supplementary method, specifically targeting threatened species of micro bat not readily identified from Anabat recordings (e.g. Greater long-eared Bat, *Nyctophilus timoriensis*). Survey effort included two large (1.8 metre string) harp traps which were left in place for two nights at each survey location. Overall 16 trap-nights of survey effort was conducted.

Call Playback

Call playback was performed using broadcast speakers and targeted the Squirrel Glider (*Petaurus norfolcensis)*, Bush Stone-curlew (*Burhinus grallarius*) and Barking Owl (*Ninox connivens)*. Call playback included at least five minutes broadcasting and 10 minutes listening for each species per night plus additional listening and spotlighting at the beginning and end of the call playback period.

Spotlighting

Spotlighting surveys were performed over a total of 10 evenings and involved slowly-driven transects along haul roads for at least 2 hours per evening. This technique was considered the most appropriate for

detecting nocturnal mammals and birds given the large size of the site. Additional walked transects were conducted for one hour, over approximately one kilometre, targeting suitable habitat for frogs, small mammals and reptiles. Water bodies, floodplain marshes, woody debris, shedding-bark on tree trunks and other suitable substrate was systematically checked using a head lamp.

Fauna Habitat Assessment

An assessment of the quality of habitats present for native fauna was made across the entire site. Habitat quality was based on the level of breeding, nesting, feeding and roosting resources available. Indicative habitat criteria for targeted threatened species were identified prior to fieldwork. Criteria were based on information provided in TSC Act species profiles, field notebooks and the knowledge and experience of GHD field ecologists. This technique is important in assisting in the compilation of a comprehensive list of fauna that are predicted within the vicinity of the Forest, rather than relying solely on one off surveys that are subject to seasonal limitations and may only represent a snapshot of the species present.

The locations and quantitative descriptions of significant habitat features were captured with a handheld GPS unit and photographed where appropriate.

Habitat Tree Assessment

A quantitative survey of habitat trees was conducted throughout the Forest which included counts of hollow bearing trees, very large trees and standing dead trees (stags). Tree hollows are a critical habitat resource for many native fauna, including a number of threatened species known from the study area (DECCW, 2009b). Large trees and roosts provide important foraging resources and substrate roost sites and shelter in cracks, fissures and exfoliating bark.

The habitat tree survey involved the following components:

- Use of a Trimble GIS, loaded with an aerial photo and project infrastructure footprints to target survey effort. An approximately 50m survey buffer was captured around project infrastructure. The upstream cutting, return channel and the locations of all regulators were surveyed comprehensively. Approximately 300m x 50m transects were used to sample the downstream levee alignment due to its large size (approximately 42 km in length);
- Ground-based survey, involving a field ecologist systematically walking survey areas and capturing the locations of all habitat trees;
- Use of data capture forms on the GPS to record descriptive information for each habitat tree including: species, DBH, number of trunk hollows, number of branch hollows, number of hollows >20cm in diameter and additional notes about position, occupancy and likely significance;
- GIS-based plotting and counts of habitat trees; and
- Estimation of density across the Forest using the combined results of the habitat tree surveys and Biobanking plots.

The habitat tree survey was used to provide the following inputs to the impact assessment:

- Counts of habitat trees that fall within the footprints for fixed project infrastructure that were surveyed in detail;
- Estimates of the total numbers of habitat trees across the Forest as a guide to the significance of impacts associated with the removal of a proportion of the habitat tree resource; and

- A GIS shape file and database of habitat trees within the broader construction corridor, which was provided to the project team as a guide to minimising impacts through the detailed design and construction process.

SEPP 44 Assessment

A targeted search for signs of Koala activity (e.g. scats and scratches on trees) and listed Koala feed trees was conducted across the Forest as a guide to the assessment of the Forest using the methodology outlined in SEPP 44.

Habitat searches

Habitat searches were undertaken during the entire survey period while incidentally traversing the Forest. These included ground debris searches for scats and tracks, scanning of tree trunks for scratches, feed scars and white wash and continuous observation of burrows, dead animals or other traces.

Opportunistic Observations

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. Survey effort was concentrated on suitable areas of habitat throughout the course of the flora survey, for instance fallen timber was scanned for reptiles and trees and water bodies were scanned for roosting birds. Opportunistic fauna observations from a vehicle were found to be an effective survey technique given the size of the Forest (approximately 70 km by 30 km). Many individuals and species of native fauna were recorded whilst travelling to and from targeted survey Forests.

4.3 Conservation significance

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

- The TSC Act and FM Act for State significance; and
- The EPBC Act for National significance.

4.4 Impact Assessment

4.4.1 Approach

The scale and complexity of the project meant that it was not possible to survey every portion of the Forest in detail nor accurately quantify all impacts. By necessity construction impacts were estimated and extrapolated across broad areas and operational impacts were estimated according to indicative scenarios.

The approach adopted in this assessment included the following:

- Site surveys to describe the suite of native flora and fauna and their habitats which occur in the Forest;
- Detailed mapping of vegetation types, habitat resources and conservation significance using a combination of desktop assessment and site surveys;
- Quantification of habitat resources with reference to a standardised set of measurable habitat attributes. A modified form of the BioBanking (2008) field data collection methodology was used to collect quantitative habitat attribute data; and

- Habitat tree counts within the footprints of fixed infrastructure (e.g. the upstream channel and regulators).

4.4.2 Construction Impacts

GHD combined the results of field surveys and ecosystem mapping to undertake an assessment of the direct impacts associated with the proposed works. The impact assessment will specifically address:

- Potential impacts on TSC/FM and EPBC Act listed flora, fauna and ecological communities;
- Potential impacts on EPBC Act listed Matters of National Environmental Significance;
- Impacts on sensitive receptors such as wetlands, aquatic ecosystems or important habitat resources;
- The extent of clearing of native vegetation and habitat resources, calculated by overlaying the locations of project infrastructure on vegetation and habitat layers with GIS;
- Potential mortality, injury or displacement of native fauna; and
- Secondary impacts, such as soil or water degradation.

The impact assessment presented in this EIA is conservative, especially with regards to the estimated extent of vegetation clearing. This approach allows for minor changes in the position of infrastructure during detailed design. Conversely, detailed design may allow for the avoidance of impacts on native biota, such as by avoiding hollow bearing trees or by targeting disturbance within previously cleared areas.

4.4.3 Operational Impacts

Potential operational impacts were assessed through a detailed consideration of available databases, modelling and assessment reports identified in the desktop assessment. In contrast to the construction impacts assessment this section also required a detailed consideration of positive impacts. The operational impact assessment addressed the following key factors:

- Impacts of flooding on aquatic ecosystems, including potential for Blackwater events, changes to water quality, fish migration and spawning;
- Impacts of flooding on wetland ecosystems, including bird breeding activity, nutrient cycling, health and distribution of wetland plants and potential for acid sulphate soil generation;
- Impacts of flooding on the forest structural characteristics and the distribution and health of vegetation communities and species;
- Potential for negative effects on terrestrial vegetation through inundation of areas that would not have naturally flooded;
- Habitat fragmentation, edge effects, and loss of habitat due to clearing and the flooding area; and
- Potential for spread and dispersal of weeds or pest animals, such as Carp.

4.4.4 Assessment of Significance

Assessments of Significance were performed for threatened biota and their habitats identified within the Forest and likely to be affected by the project. Assessments were performed using the Part 3A criteria presented in the DEC/DPI (2005) guidelines.

GHD notes that the proponent has prepared a referral to the Commonwealth Minister for the Environment, Water, Heritage and the Arts (DEWHA) for the project. Nonetheless this assessment includes an assessment of significance of impacts on relevant Matters of National Environmental Significance (MNES) according to the DEWHA *Significant Impact Guidelines -Matters of National Environmental Significance* (DEH, 2006).

4.4.5 Part 3a 'Key Thresholds'

The conclusion of this EIA is an assessment of the Part 3A 'key thresholds' as outlined in the DEC/DPI (2005) guidelines and presented in Section 0. This includes the application of the 'improve or maintain' test to the project. This involves a summary of the expected ecological benefits of the project, potential impacts, measures to avoid or mitigate impacts and offsets required to compensate for unavoidable or residual impacts on native biota.

The approach adopted in this assessment is to compare the extent of vegetation and habitat clearing associated with the proposed construction against the likely ecological gains achieved through the proposed flood enhancement. Concluding statements summarise the net effects of the project on native biodiversity and demonstrate the expected net benefit of the project to the native biota of the Forest's wetland and aquatic ecosystems. Biodiversity offsets will be required to achieve an 'improve or maintain' outcome for native biota that will experience negative impacts but will not benefit directly from the proposed environmental watering. These potentially affected biota include the EEC Inland Grey Box Woodland. Therefore a biodiversity offsets strategy to accompany the project is discussed according to the principals outlined in the DECCW (2009e). *Principles for the use of biodiversity offsets in NSW*.

4.5 Staff Qualifications

Field surveys were undertaken by qualified GHD field ecologists. Staff qualifications and experience are presented in Table 5 below.

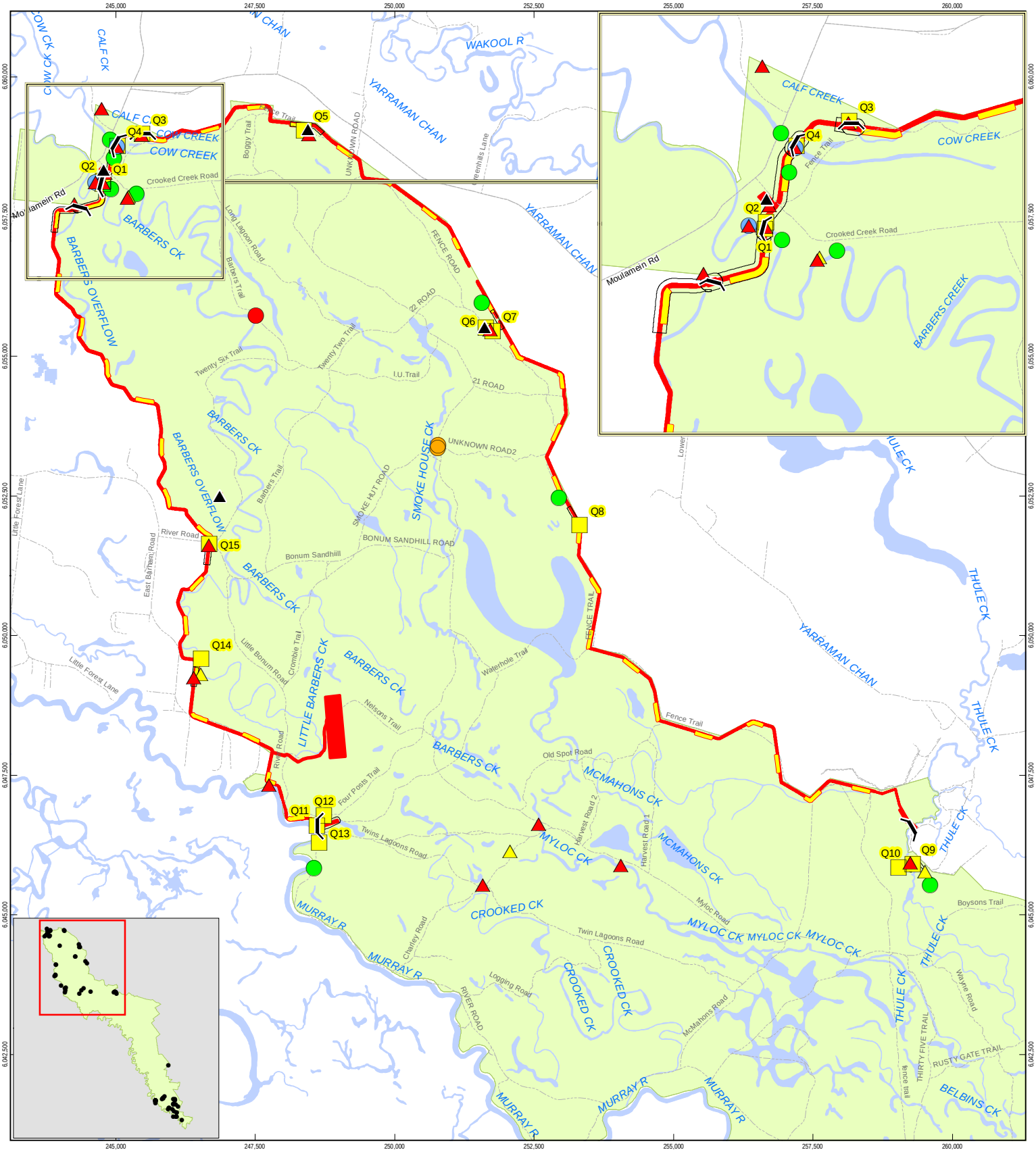
Table 5 GHD Ecology Personnel and Qualifications

Name	Position / Project Role	Qualifications	Relevant Experience
Ben Harrington	Ecologist / field surveys and reporting	Bachelor of Science, Masters of Science (Physical Geography), Macquarie University	7+ years
Brendan Ryan	Senior Zoologist / field surveys and technical review.	Bachelor of Science, Masters of Science (Environmental Science) Sydney University	11+ years
Tim Wills	Senior Botanist / field surveys and technical review.	Doctor of Philosophy - Botany, Monash University	10+ years
Skye Rivett	Ecologist / field surveys.	Bachelor of Applied Science (Social Ecology) - University of Western Sydney	8+ years
Richard Retallick	Senior Zoologist / field surveys	PhD (Zoology) – James Cook University	17+ years

Jennifer Hale	Wetland Ecologist / reporting, quality assurance and technical review (wetland and aquatic ecology).	BSc, Monash University MBa, La Trobe University	23+ years
Jayne Tipping	Principal Ecologist / quality assurance and technical review (terrestrial ecology).	BSc, MEnvLaw, Sydney University	16+ years

4.6 Survey limitations

It is possible that some species utilise the study area but were not detected during the survey period. These species are likely to include: flora species that flower after rainfall as well as annual, ephemeral or cryptic species; frogs which call at other times of year or after heavy rainfall; and reptiles which are only active in the hottest months. Some fauna species are also mobile and transient in their use of resources and it is likely that not all species (resident or transitory) were recorded during the survey period. The habitat assessment conducted for the Forest allows for identification of habitat resources for such species. As such, the survey was not designed to detect all species, rather to provide an overall assessment of the ecological values on site in order to predict potential impacts of the proposal.



Legend

- Turkey's nest dam
- Regulator
- Borrow pits
- Construction features
- trails/minor roads
- Major Roads
- Waterway
- Koondrook Perricoota Forest Site
- Hollow-bearing tree indicative survey area

Survey Effort

- Diurnal Bird Survey
- Anabat
- Harp trap
- Diurnal bird survey
- Call playback
- Motion sensing camera
- Vegetation quadrat

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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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

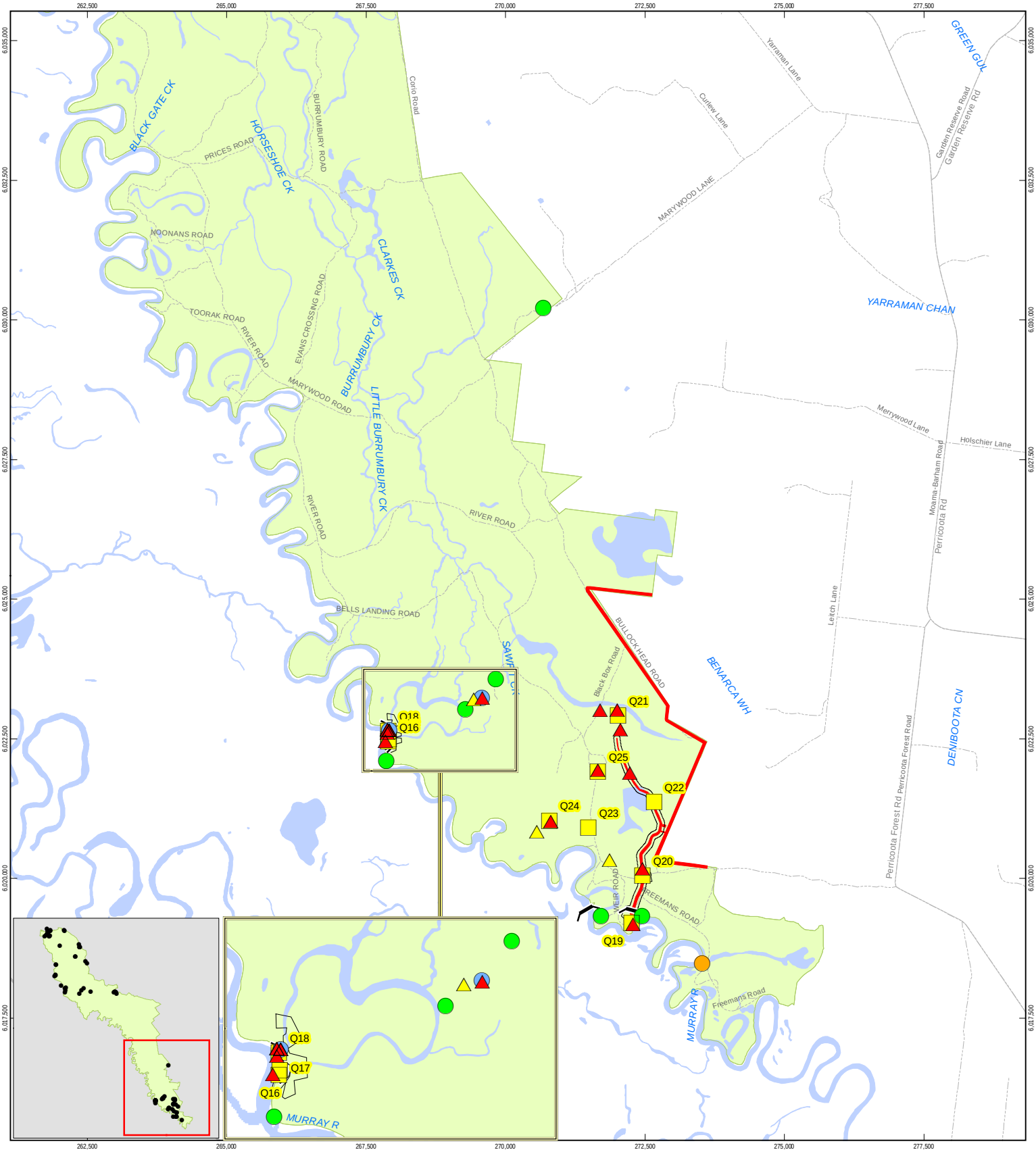
Job Number 21-18573
Revision C
Date 01 FEB 2010

Figure 6 - Survey effort downstream section

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z017_SurveyEffort_DownstreamSection.mxd

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

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



Legend

- River Road bridge
- Regulator
- Construction features
- trails/minor roads
- Major roads
- Waterway
- Koondrook Perricoota Forest Site
- Hollow-bearing tree indicative survey area

Survey effort

- Diurnal Bird Survey
- Anabat
- Harp trap
- Diurnal bird survey
- Call playback
- Motion sensing camera
- Vegetation quadrat

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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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	C
Date	01 FEB 2010

Figure 7 - Survey effort upstream section

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z017_SurveyEffort.mxd

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

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

5. Desktop Assessment Results

5.1 Objectives

The objective of the desktop assessment was to characterise the flora and fauna likely to be present within the Forest, in particular threatened species, populations and/or ecological communities. The desktop assessment also investigated the characteristics of the floodplain hydrological cycles of wetting and drying and how this is likely to impact on the presence of particular species over time. Brief reference to the results of the site surveys is also provided to provide an indication of changes in site condition over time.

5.2 Flora

5.2.1 Flora species

River Red Gum (*Eucalyptus camaldulensis*) is the dominant over storey species in the Forest, occurring as a mono-specific canopy across the majority of the floodplain. Grey Box (*E. microcarpa*) and Black Box (*E. largiflorens*) occur on areas prone to floods of lower frequency and duration and form transitional woodlands with River Red Gum. Other over storey species, such as White Cypress Pine (*Callitris glaucophylla*) and Buloke (*Allocasuarina leuhmanii*) occur above the level of the floodplain on sand hills. The sub-canopy and shrub layers are sparse to absent. Silver Wattle (*Acacia dealbata*) may be locally common on the banks of the river but only occurs infrequently throughout the greater floodplain area. Dwarf Cherry (*Exocarpus strictus*) is locally abundant. On frequently flooded areas, native perennial sedges, such as Spike-rushes (*Eleocharis* spp.), *Carex* spp. and *Cyperus* spp., and rushes (*Juncus* spp., *Phragmites australis*) dominate the ground cover. On infrequently flooded areas, ground cover is dominated by exotic weeds, including annual grasses (*Avena* spp., *Bromus* spp., and *Vulpia* spp.) and herbs such as *Cotula* spp., Pattersons Curse (*Echium plantagineum*) and Fumitory (*Fumaria mularis*) (FNSW, 2008a; MDBC, 2007a).

Prior to the current assessment no detailed flora surveys had been conducted within Koondrook-Perricoota forest. Webster (2008) noted that a total of 39 plant species (36 native) were identified as present within the Forest from observations during fauna surveys or wetland monitoring (Vennel and Nias, 2005). Based on information collected for other River Red Gum forests within the central Murray Valley (e.g. Forestry Commission of NSW, 1985) this was considered to be only a very small portion of the flora diversity found within Koondrook-Perricoota (Webster, 2008).

The GHD (2009b) EIS included flora surveys of the Forest using a modified BioMetric methodology that sampled five 20m by 20m sub-plots at each of three survey locations. This assessment included diurnal bird surveys, nocturnal surveys and Anabat recordings in addition to vegetation and habitat quadrats. Results for surveys within the Koondrook and Perricoota State Forests are summarised in Table 7. No threatened plants were recorded.

Table 6 GHD (2009b) Flora Survey results for Koondrook and Perricoota State Forests

Location	Dominant tree species	Dominant shrub and ground species (* = exotic)	Threatened plant species	Total No. of plant species	Percentage of native species (%)	Average no. of native plant species per subplot	Average exotic plant % cover per subplot
North-west Koondrook S.F.	River Red Gum	*Xerochrysum bracteatum*	0	36	63.9	7.2	36.1
North-west Perricoota S.F.	River Red Gum, Black Box	*Muehlenbeckia florulenta* *Lolium rigidum**	0	45	71.1	9.4	48.9
East Perricoota S.F.	River Red Gum	*Echium plantagineum**, *Xerochrysum bracteatum*, *Fumaria mularis**	0	37	51.1	9	28.9

site surveys for the current assessment noted 154 flora species as described in Section 6.1.1.

5.2.2 Vegetation communities

Overview

The Forest supports the following broad vegetation types:

- River Red Gum Forests;
- River Red Gum Woodlands
- Black Box Woodlands;
- Inland Grey Box Woodlands;
- Floodplain Marshes;
- Sandhill Woodlands; and
- Derived grasslands and herblands.

Vegetation community structure and understorey composition in the Forest vary with flood regime, which in turn is a product of geomorphic setting. The driest portions of the floodplain support Black Box Woodland which grades into a River Red Gum Woodland at its wetter end, with a sparse, shrubby understorey and groundcover of grasses and herbs with increasing soil moisture. Better-watered locations support a taller River Red Gum Forest with an understorey of moisture-loving grasses, herbs and sedges. Small depressions within the Forest contain moist reed beds or rushlands beneath a canopy of River Red Gum (Benson *et. al.,* 2006; Roberts and Marston, 2000). Larger depressions such as billabongs, which are more frequently inundated, support treeless communities as too frequent or sustained flooding

precludes the recruitment of River Red Gum seedlings (Di Stefano, 2001). These treeless communities are collectively known as Floodplain Marshes and contain a variety of aquatic plants, semi-aquatic grasses and sedges. Species composition varies with depth, duration and frequency of inundation.

The general relationship between the distribution of vegetation associations, geomorphic setting and flood regime on the Murray River floodplain is shown on Figure 8. Additional native vegetation types occur with localised geomorphic features, such as Inland Grey Box woodlands on higher crests and levees and Sandhill Pine woodlands on source bordering dunes.

Riparian vegetation exerts a significant influence on fluvial geomorphology by affecting resistance to flow, bank strength, sediment storage, bed stability and stream morphology and is important for aquatic ecosystem function. Intact riparian vegetation is a valuable contributor to river health and may mediate ongoing detrimental impacts or help remediate degraded aquatic systems (Webb and Erskine, 2001).

River Red Gums provide important regulatory services in riparian environments including lowering saline water tables, stabilising river banks, reducing overbank flow velocities and maintaining depositional environments (CSIRO, 2008).

Table 6 presents the Benson (2006) vegetation types within the broad vegetation types of the Forest along with a summary of their structure and composition. The GHD (2009) site survey assessed the extent, species composition and distribution of these vegetation types within the Forest and this is summarised in Section 6.

Figure 8 Vegetation associations, geomorphic setting and flood regime

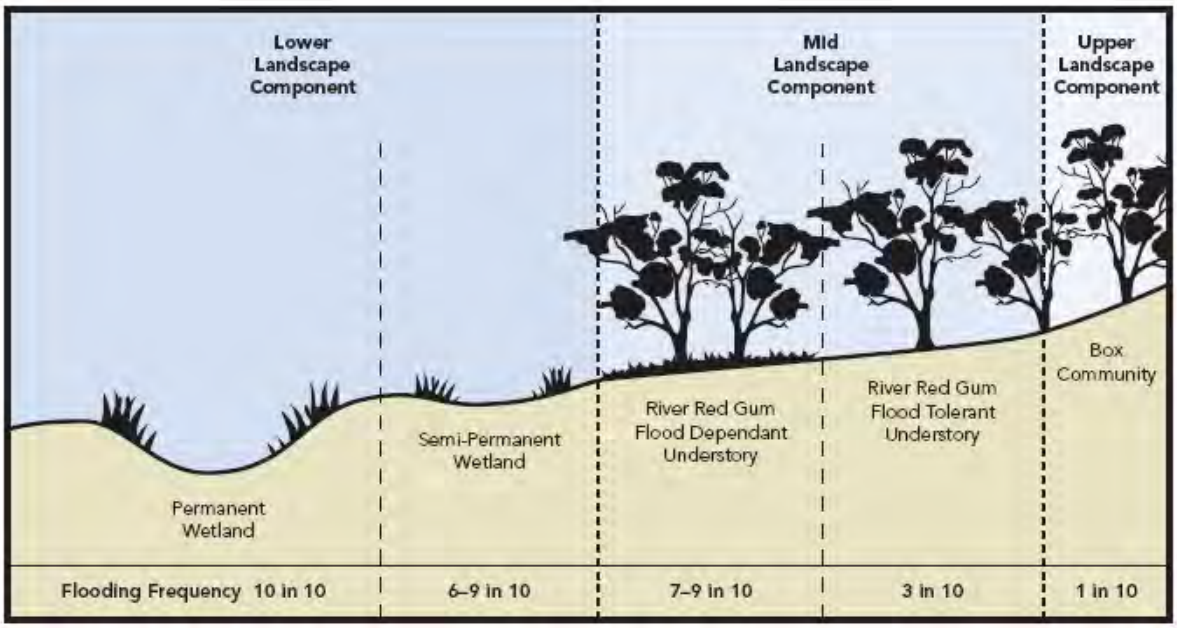


Table 7 Vegetation Types within the Forest

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
River Red Gum Forests						
Comm ID 2: River Red Gum-sedge dominated tall open forest in frequently flooded Forests of the semiarid warm climate zone	Vulnerable (RBG, 2009)	SQ1 Better developed stands with height >34m on frequently flooded areas or areas with shallow groundwater.	Very tall open forest dominated by River Red Gum that grow to over 30m high and sometimes exceed 45m. Shrubs are usually absent. The ground cover may be sparse and covered in litter or mid-dense to dense. It is dominated by sedges and rushes and occasional moisture tolerant grass species forbs and pond waterplants. Weed species may be common.	**Canopy** *Eucalyptus camaldulensis* subsp. *camaldulensis*. **Sub-canopy** *Acacia dealbata* (localised). **Shrub layer** absent. **Groundcover** *Eleocharis acuta-Centipeda cunninghamii-Ranunculus inundatus-Pseudoraphis spinescens*	Occurs on silty-loam-clay alluvial soils in frequently flooded Forests bordering river channels and in low-lying areas away from the river.	Inland Riverine Forests (Keith, 2004). Victoria[c]: EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest
Comm ID 5: River Red Gum herbaceous-grassy tall open forest of the inner floodplains of the lower NSW South West Slopes and Riverina Bioregions	Vulnerable (RBG, 2009)	SQ2 Intermediate levels of the floodplain. Canopy height 21-34m.	Very tall open forest dominated by River Red Gum with trees averaging about 25 m high and a canopy cover of about 40%. The shrub layer is sparse or absent with Acacias sometimes	**Canopy** *Eucalyptus camaldulensis* subsp. *camaldulensis*. **Sub-canopy** *Acacia dealbata* (sparse). **Shrub layer** absent. **Groundcover** *Paspalidium jubiflorum, Poa labillardierei* var.	Occurs on silty-sandy loam-clay soils on levees or other raised landform elements adjacent to rivers and wetlands.	Inland Riverine Forests (Keith, 2004). Victoria: EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest ()

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
			present. The ground cover may be mid-dense or dense and is dominated by grasses, sedges and rushes. Weed species may be common.	*labillardierei-Carex tereticaulis-Lachnagrostis filiformis-Hemarthria uncinata* var*. uncinata*		
Comm ID 7: River Red Gum – herbaceous tall open forest mainly in the Riverina Bioregion	Vulnerable (RBG, 2009))	SQ2	Tall open forest dominated by River Red Gum growing to average of 20 m with a canopy cover of about 40%. The shrub layer is sparse or absent with Acacias sometimes present. The ground contains a high leaf litter content with a mid-dense herbaceous cover dominated by grasses and forbs.	**Canopy** *Eucalyptus camaldulensis* subsp*. camaldulensis*. **Sub-canopy** *Acacia stenophylla* (sparse). **Shrub layer** absent. **Groundcover** *Austrodanthonia sp., Wahlenbergia fluminalis, Senecio quadradentatis, Ranunculus inundatus, Brachyscome basaltica, Pratia concolour,* and *Carex* spp*.*	Occurs on Alluvial loams and clays on flood plains along stream banks, levees and channels.	Inland Riverine Forests (Keith, 2004). Victoria: EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest
River Red Gum Woodlands						
Comm ID 9: River Red Gum - wallaby grass tall woodland on the outer River Red Gum zone in the semi-arid (warm) climate zone.	Endangered (Benson *et al.,* 2006)	SQ3 Poor stand development. Occurs as open woodland with canopy height <21m, or dense stands with	Tall woodland to about 18 m high dominated by River Red Gum. Shrub layer is generally absent. Ground cover may be mid-dense or sparse and is dominated by	**Canopy** *Eucalyptus camaldulensis* subsp*. camaldulensis*. **Sub-canopy** *absent*. **Shrub layer:** *Amyema miquelii* (sparse) **Groundcover** *Paspalidium jubiflorum, Austrodanthonia*	Occurs on grey and brown clay and loam soils on higher ground on the edge of the River Red Gum zone on floodplains.	Inland Riverine Forests (Keith, 2004). Victoria: part of EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
		lesser canopy height. Occupies margins of flood plain on fine clay soils.	native grasses. Rushes and sedges also common.	*caespitosa - Juncus flavidus - Carex inversa*		
Comm ID 10: River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone	Vulnerable (RBG, 2009)	Red Gum / Box Woodland	Tall to mid-high woodland averaging about 18 m high composed of a mixture of River Red Gum and Black Box. The understorey may contain dense to very sparse stands of Lignum with the occasional *Exocarpus strictus*. The ground layer is sparse and grassy.	**Canopy** *E. camaldulensis, E. largiflorens* **Sub-canopy** *Exocarpus strictus* **Shrub layer** *Muehlenbeckia florulenta* **Groundcover** *Paspalidium jubiflorum, Enteropogon acicularis, Cynodon dactylon, Austrodanthonia caespitosa*	River Red Gum / Black Box ccurs at the junction (ecotone) of River Red Gum and Black Box zones on the upper floodplains on grey to brown loam to medium clays.	Inland Riverine Forests (Keith, 2004). Victoria: part of EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest and/or EVC 106 Riverine Grassy.
Black Box Woodland						
Comm ID 13: Blackbox - Lignum woodland of the inner floodplains in the semi-arid (warm) climate zone	Vulnerable (Benson *et al.,* 2006)	Box woodland	Woodland, open forest or open woodland averaging about 15 m high dominated by a sparse to dense stands of *Muehlenbeckia florulenta* and *Chenopodium nitrariaceum*. The ground cover includes	**Canopy** *Eucalyptus largiflorens* occasional *E. camaldulensis* **Sub-canopy** *Acacia stenophylla* **Shrub layer** *Muehlenbeckia florulenta - Rhagodia spinescens* **Groundcover** *Einadia nutans subsp. nutans Paspalidium jubiflorum -*		ID 13 – Inland Floodplain Woodlands (Keith, 2004).

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
			low shrubs such as *Sclerolaena muricata* var. *muricata, Enchylaena tomentosa, Einadia nutan*s subsp. *nutans* and various saltbush species (*Atriplex* spp.).	*Sclerolaena muricata* var. *muricata - Austrodanthonia caespitose.*		
Inland Grey Box Woodland						
Comm ID 237 Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone.	EEC in NSW (TSC Act). Nominated as EEC Nationally (EPBC Act).	Red Gum / Box Woodland or Box Woodland	Tall to mid-high woodland averaging about 18 m high composed of a mixture of River Red Gum and Inland Grey Box and/or Black Box. The understorey may contain dense to very sparse stands of *Acacia dealbata, Muehlenbeckia florulenta* and *Exocarpus strictus*. The ground layer is sparse and grassy.	**Canopy** *E. microcarpa, E. camaldulensis* and *E. largiflorens* **Sub-canopy** *Acacia dealbata* **Shrub layer** *Muehlenbeckia florulenta* **Groundcover** *Paspalidium jubiflorum, Enteropogon acicularis, Cynodon dactylon, Austrodanthonia caespitosa*	Inland Grey Box occurs on higher points of the floodplain such as levees adjacent to major watercourses.	Inland Transition Woodlands (Keith, 2004). Victoria: part of EVC 255 Riverine Grassy Woodland/Riverine Sedgy Forest and/or EVC 106 Riverine Grassy.
Floodplain marshes						
Comm ID 12: Shallow marsh of regularly flooded	Least concern (Benson *et al.,* 2006)	Open plain or swamp.	Moist herbland, reedland or rushland containing a mix of	**Canopy** absent **Sub-canopy** absent **Shrub layer** Giant Rush	Occurs on silty clay loam soils in frequently inundated	Inland Floodplain Swamps (Keith, 2004).

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
depressions on floodplains mainly in the semi-arid (warm) climatic zone. Also comprises ID181 (Reedland) and ID182 (Rushland) near river channels or on the edges of lagoons or ox-bows. Grades into open water wetland (ID238) in billabongs			sedges, forbs, grasses and free floating or attached waterplants.	(*Juncus ingens*) locally abundant, also: dense aquatic grassland dominated by Common Reed *(Phragmites australis)* growing in shallower water to about 0.5 m deep; very tall, dense rushland dominated by Narrow-leaved Cumbungi (*Typha domingensis*) in water 1-2m deep. **Groundcover** *Eleocharis acuta - Pseudoraphis spinescens - Persicaria hydropiper - Lachnagrostis filiformis / Ludwigia peploides* subsp*. montevidensis - Myriophyllum crispatum*	low lying areas among stands of River Red Gum forest or Black Box forest and woodland. Reedland and Rushland on silty peat soils and silty clays in deeper oxbows and along margins of channels.	Victoria: possibly part of EVC74 Wetland Formation and/or EVC292 Red Gum Wetland.
Sandhill Woodlands						
Comm ID 19: Cypress Pine woodland of source-bordering dunes mainly on the Murray River floodplain	EEC in NSW (TSC Act).	Cypress	Mid-high woodland with trees up to 13 m high dominated by Callitris species. The shrub layer is often absent, sparse groundcover of native grasses.	**Canopy** *Callitris glaucophylla; Callitris gracilis* subsp*. murrayensis; Allocasuarina luehmannii.* **Shrubs** *Calytrix tetragona* **Groundcover**	Occurs on source bordering dunes on the Murray River floodplain. Soils are Earthy Sands composed of Aeolian sand and loam .	Riverine Sandhill Woodlands (Keith, 2004). Victoria: part of EVC 97 Pine Buloke Woodland

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
				Austrodanthonia caespitosa; Austrostipa scabra subsp*. scabra; Einadia nutans* subsp*. nutans; Oxalis perennans; Senecio quadridentatus; Crassula colorata* var*. colorata.*		
Derived Grassland and Herbland						
Comm ID 250: Derived tussock grasslands of the central western plains and lower slopes of NSW		Open plain or swamp.	Patchy to dense grassland or herbland.	**Canopy** absent **Sub-canopy** absent **Shrub layer**. *Muehlenbeckia florulenta - Rhagodia spinescens* **Groundcover** *Einadia nutans* subsp*. nutans, Sclerolaena muricata* var*. Austrodanthonia* spp. *, Austrostipa* spp*., Cotula* spp., *Vittadinia* spp., *Chamaesyce drummondii, Dichondra repens*	Occurs in a variety of settings and soil types across the Forest and is derived from clearing of native forest or woodland. Most extensive on sand dunes and higher portions of the floodplain near the margins of the State Forest.	n/a.

a = Forests NSW Forest Quality Classification

b = NSW Vegetation Classification – Western Plains

Vegetation Type [b]	Status	FNSW Forest Quality	Structure [b]	Species associations [b]	Soil and geomorphic position [b]	Other classifications
(Benson *et al.,* 2006) c =Victorian Ecological Vegetation Classes (EVCs) (DSE, 2008).						

River Red Gum Forests

The broad vegetation type 'River Red Gum Forests' is made up of a variety of River Red Gum (*Eucalyptus camaldulensis*) dominated forest and tall woodland communities on the floodplain of the Murray River and associated anabranch systems through the Forest. River Red Gum is a fast growing, highly competitive species in areas with sufficient soil moisture. It is the canopy dominant in all vegetation associations in which it occurs, and in many areas forms mono-specific communities. Co-occurring species include Silver Wattle (*Acacia dealbata*), Dwarf Cherry (*Exocarpus strictus*) as sub-canopy species, and Black Box and less commonly Grey Box, where River Red Gum forest intergrades with box woodlands (Benson *et. al.,* 2006).

No River Red Gum dominated vegetation communities are listed as Endangered Ecological Communities under Federal or NSW legislation. Nevertheless the Benson *et al.,* (2006) assessment and characterisation of NSW Western Plains vegetation communities and RBG (2009) update determined that River Red Gum communities were underrepresented in conservation reserves and classed them as 'vulnerable".

River Red Gum is physiologically dependant upon floodwaters to maintain sufficient soil moisture to sustain its metabolism, growth and reproduction. The extent, frequency, timing and duration of floods thus impose major limitations on the distribution (Roberts and Marston, 2000) species composition (Benson *et al.,* 2006) and silvicultural 'quality' of River Red Gum forests (Di Stefano, 2001).

River Red Gum produces abundant quantities of seed, which is released mostly during spring and summer. Greater seed fall in spring may have adaptive significance as under the natural flow regime floods would usually recede during this period (Dexter, 1978). Young plants appear over extensive areas after floods and can initially form dense stands of saplings, which gradually thin out as they grow. Maturing stands form forests of straight-trunked trees in areas with reliable floodwater (CSIRO, 2008_a; Cunningham *et al.,* 1981).

The structure of the River Red Gum Forests has changed due to river regulation, timber harvesting, other forest management and silvicultural activities and altered fire regimes. Forest management has changed the main vegetation community structure of the Red Gum Forests from tall woodland with widely spaced veteran trees to a forest with denser stands of younger trees. These changes are a combination of a number of factors, potentially including:

- Cessation of Aboriginal burning regimes which would have inhibited seedling regeneration (CSIRO, 2008a; Jurskis *et al*., 2003);
- Removal of veteran trees through timber harvesting and ringbarking which would have reduced competition with regenerating trees and changed the age structure of the forests (Mackay and Eastburn, 1990; Thompson, M. Forests NSW *pers*. *comm*.); and
- Cyclical harvesting, regeneration and thinning of forest compartments according to silvicultural practices designed to maximise stand condition, regeneration and the volume of merchantable timber (State Forests of NSW, 2000; Thompson, M. Forests NSW *pers*. *comm*.).

The majority of the River Red Gum Forests in the State Forests of the Riverina Plain comprise stands which regenerated in the 1870's when there were a series of major floods and rabbits were in low numbers (Mackay and Eastburn, 1990). These stands of Red Gums were actively thinned during the 20th Century (State Forests of NSW, 2000).

River regulation has dramatically changed the natural wetting and drying cycles of the Red Gum forests. The 'droughting' of Red Gums through this cycle has had significant negative impacts on the

health and vigour of the forests. The effect of drought and river regulation on forest health has probably been exacerbated by increasing basal area of trees (and therefore increasing transpiration) after European settlement; older trees are most affected (Jurskis *et al.,* 2005). Altered flood regimes, in combination with drought conditions over the period 2001-2008 mean that the Red Gum Forests of the Forest are in a generally poor condition at the time of this assessment (GHD, 2009a). The health of the River Red Gum Forests and other ecosystem components within the Forest is described further in Section 5.6.

River regulation, livestock grazing and altered fire regimes have also changed the understorey composition. Disturbance has opened up the understorey and flooding transmits weed propagules into the Forest, allowing the riparian understorey to be invaded by weeds such as Patterson's Curse (*Echium plantagineum*), exotic annual grasses, including *Avena* spp., *Bromus* spp., *Vulpia* spp., and Barley Grass (*Hordeum vulgare*).

River Red Gum Woodlands

River Red Gum woodland habitat generally consists of pure stands of River Red Gum on higher ground at the outer fringe of the forest and adjacent to the river bank, above deeper water tables. Infrequent flooding and depth to the water table over 6 metres generally determines the woodland structure. The lack of water restricts woodland tree development to a maximum of 21 metres and much smaller tree diameters than the River Red Gum forest and consequently the trees have less potential for hollow development. The Red Gum Woodland has a lower stocking than River Red Gum Forest with a more open canopy, except in areas of dense regeneration where growth becomes stagnated at an early age. Mistletoe and dead standing trees are common throughout River Red Gum woodland.

The understorey consists of herbaceous species such as grasses sedges and other annual herbs. Woody species such as Dwarf Cherry also occur and are locally abundant. As with the River Red Gum Forests, the understorey is dominated by exotic herbs and annual grasses in many areas. The woodland floor is scattered with coarse woody debris of varying size.

Some stands feature a mixed canopy of River Red Gum and Black Box. These areas are transitional between the two types of woodland, however are recognised as distinct vegetation communities by both FNSW site quality mapping systems and the Benson (2006) vegetation classification. Understorey structure and composition is similar to pure River Red Gum stands.

The River Red Gum Woodlands have developed through similar stages of forest management, hydrological changes and drying as described for the River Red Gum Forests above. They are generally in even poorer condition than the forests as they occur at the outer fringe of the forest, above deep water tables and have experienced less flood frequencies over recent decades compared to the River Red Gum Forests (MDBC, 2008).

Black Box Woodlands

Black Box Woodland is a woodland, open forest or open woodland averaging about 15 m high dominated by sparse to dense stands of Black Box. There is a locally dense shrub layer of Lignum (*Muehlenbeckia florulenta*) and Nitre Goosefoot (*Chenopodium nitrariaceum*). The ground cover includes low shrubs such as *Sclerolaena muricata* var. *muricata*, *Enchylaena tomentosa*, *Salsola kali, Einadia nutans* subsp. *nutans* and various saltbush species (*Atriplex* spp.). The understorey is sparse and includes the forb species *Cotula australis, Oxalis perennans* and *Pratia concolor* and native grasses Warrego Summer Grass (*Paspalidium jubiflorum*) and wallaby grasses (*Austrodanthonia* spp.). Exotic herbs and grasses are locally abundant and include the herbs *Cotula bipinnata, Erodium*

cicutarium and *Sisymbrium irio* and the grasses *Hordeum leporinum* and *Lolium perenne*. Occurs on clay or clay-loam, often gilgaied, soils on inner floodplains and on alluvial plains (Benson et al., 2006)

The structure and composition of the Black Box Woodlands in the Forest has been shaped by forest management. In recent decades FNSW has not harvested or conducted silvicultural activities within box woodlands in the Forest. Track construction and maintenance and grazing would continue to have an effect on these communites as part of ongoing FNSW operations within the Forest.

Black Box is less dependant on flood waters than River Red Gum and so these woodlands have been less severely affected by changes to the flood regime of the Forest and the severe drought over the last decade.

Inland Grey Box Woodlands

Inland Grey Box (*Eucalyptus microcarpa*)-dominated vegetation within the Forest is consistent with the Benson (2006) vegetation community 'Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone' (hereafter referred to as Inland Grey Box Woodland). It is a tall woodland with trees up to 20 m high dominated by Inland Grey Box, most often co-occurring with either River Red Gum or Black Box. Shrubs are absent or very sparse, and include Golden-dust Wattle (*Acacia acinacea*), Dwarf Cherry and Lignum. The ground cover may be dense or sparse depending on time since rain. It includes native perennial tussock grass species such as *Austrodanthonia caespitosa, Austrodanthonia laevis, Paspalidium jubiflorum* and *Chloris truncata*. The rush *Juncus flavidus* and the sedge *Carex inversa* are often present along with small chenopod sub-shrubs such as Berry Saltbush (*Atriplex semibaccata*) and Climbing Saltbush (*Einadia nutans* subsp*. nutans*). Forb species include *Sida corrugata* and *Oxalis perennans*. Inland Grey Box Woodland occurs on grey clays on slight rises on floodplains dominated by River Red Gum forests (Benson et al., 2006).

This community comprises a form of the NSW TSC Act listed EEC 'Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions' (DECCW, 2009b). Occurrences of the EEC within the Forest are not typical as the community generally occurs on lower slopes and flats on the western slopes and plains of NSW, associated with soils of Tertiary and Quaternary alluvial origin, largely corresponding with the Red Brown Earths (DECCW, 2009b). However, the DECCW (2009e) Scientific Committee determination notes that Inland Grey Box Woodland can grade into inland riverine forests of River Red Gum and Black Box along inland rivers and floodplains, which would include forms of the EEC in the Forest. This variant of the EEC is limited in extent and may have higher conservation significance than more widespread forms of the western slopes of NSW. The extent of this community in NSW is estimated at only 4000 ha (+/- 30 %) and there is less than 1% of this area formally protected in conservation reserves (Benson et al., 2006).

Inland Grey Box Woodland within the Forest would also qualify as the threatened ecological community currently nominated to be listed on the schedules of the EPBC Act. The DEWHA comments on the nomination note that the threatened ecological community includes the Benson (2006) community Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone' in NSW (DEWHA, 2009c).

Floodplain Marshes

Low-lying portions of the Forest feature a variety of treeless wetland types, including *Juncus* reed beds, *Phragmites* rushlands, moist grasslands, herb lands and semi-permanent marshes (Keith, 2007). These wetlands, referred to collectively as Floodplain marshes, are associated with a variety of

geomorphic settings including intermittent drainage lines, flood-runners, oxbow lagoons and floodplain depressions (Green and Alexander, 2006).

The extent and vegetation composition of these wetlands is dynamic, varying seasonally with flood cycles. A single wetland may support terrestrial herbs and grasses, aquatic herbs and macro algae or reed beds over a single flood cycle. Over longer time periods prolonged wetting or drying cycles may favour the dominance of a single vegetation type, such as the formation of Giant Rush (*Juncus ingens*) beds at the expense of grasses and herbs (McCarthy *et al.,* 2006) or a shift from Giant Rush to Common Reed (*Phragmites australis*) beds (Bowen, 2005). Accordingly these wetlands can not be readily separated into vegetation communities or mapped. The approach adopted in this assessment is to describe and map treeless wetlands in the Forest as the broad vegetation type 'Floodplain marshes', encompassing this temporal variation in hydrology and vegetation composition. Treeless wetlands have been mapped by the Murray Wetlands Working Group (Green and Alexander, 2006), however this data set includes wetlands in small effluent streams and depressions within areas mapped as River Red Gum vegetation communities. Therefore Floodplain Marshes are mapped separately to other vegetation communities in this assessment. Figures illustrating the Green and Alexander (2006) mapped Floodplain Marshes of the Forest are shown in Figure 12 and Figure 13.

Typical plant species of Floodplain Marshes include Giant Rush, Common Reed, Narrow-leaved Cumbungi (*Typha domingensis*), Ribbonweed (*Vallisneria americana*), Water-ribbons (*Triglochin procerum*), Nardoo (*Marsilea drummondii*) and Water Pepper (*Persicaria hydropiper*). These species occur in transitional patches based on their hydrological requirements. A typical succession from wet to increasingly dry environments is Water Ribbons - Giant Rush - Moira Grass - Common Reed. The majority of these species also occur as understorey components of the River Red Gum Forests. Some species such as Common Couch (*Cynodon dactylon*), Water Couch (*Paspalum distichum*), Nardoo and Common Spike Rush (*Eleocharis acuta*) are ubiquitous as a groundcover in forests, grass, reed and rush lands (Benson *et al.*, 2006).

Larger Floodplain Marshes within the Forest include Swan Lagoon, Long Lagoon and Smokehouse Lagoon. Swan Lagoon is an oxbow lagoon adjacent to the Murray River, which feeds Burrumbarry Creek and is the main natural source of water to the forests. Long Lagoon has historically supported large colonies of nesting Little Pied Cormorant (*Phalacrocorax melanoleucos*) (Disher, 2000 cited in Webster, 2008). There are a number of small, unnamed wetlands along Burrumbary Creek, Barber Creek and other effluent streams through the forests. Floodplain Marshes in the Forest have been subject to invasive growth of River Red Gum seedlings due to the protracted dry phase over the last decade.

There are not any very large or ecologically significant Floodplain Marshes in the Forest, nor are there any supporting large colonial nesting waterbird breeding aggregations as are known from other State Forests in the Central Murray (GHD, 2009a).

The most significant marsh in the locality is Pollack Swamp, which is within the Koondrook State Forest but outside the Koondrook-Perricoota Flood Enhancement project area. Pollack Swamp is located to the northwest of the Forest, downstream of the proposed Barbers Creek regulator. It is fed by Barbers Creek and also receives floodwaters from the Wakool River and managed flows via irrigation channels (MDBC, 2007_b; Vennel and Nias, 2005). During wet phases Pollack Swamp features open water and flooded grassland of Swamp Wallaby Grass (*Amphibromus* spp.), Giant Rush and Waterpepper. Pollack Swamp may be supplied with environmental water from a privately owned irrigation channel. It was last flooded via this mechanism in autumn 2009 and received top-up flows during Spring 2009. Water persisted within the Forest for four months, and covered an area of 118 ha, including the swamp

and lagoon. In large floods Pollack Swamp is flooded from the east via the Barbers, Cow and Calf Creek over flow system with water that has originally entered the Forest from Swan Lagoon (MWWG, 2005). It has historically supported an Egret (*Ardea* spp.) breeding colony, however the 2004 managed flood supported foraging waterfowl, but no breeding wetland birds (Vennel and Nias, 2005).

Sandhill Woodlands

The Forest contains a number of source-bordering dunes which would have historically supported Sandhill Woodlands dominated by either Cypress Pine (*Callitris* spp.) or Bulloke (*Allocasuarina luehmannii*). Extensive sandhills within the Forest include Bonum and Little Bonum Sandhills in the Kondrook State Forest and unnamed sandhills on the Belbin Forest road and in the former Toorangabby property. These geomorphic settings are extensively degraded by historical clearing and grazing and many now contain Derived Grassland and Herbland (discussed below). The most extensive intact stand assessed in the current survey contained White Cypress Pine (*Callitris glaucophylla*) typical of the Benson (2006) vegetation community 'Cypress Pine woodland of source-bordering dunes mainly on the Murray River floodplain'. This community qualifies as the TSC Act listed EEC 'Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions' (Sandhill Pine Woodland). Canopy, shrub layer and groundcover diversity and structure vary with the history of logging, grazing and soil erosion (DECCW, 2009b). Prior to European settlement, this community would probably have contained more shrubs and trees but these have disappeared through grazing by stock and rabbits. In most occurrences, the original understorey floristic composition has changed with the loss of palatable species and replacement of exotic grasses and forbs. Regeneration is apparently very slow given the results of fencing off of Sand Dune Pine Flora Reserve (Benson *et al.,* 2006). The Bonum Sandhill within the Forest has been fenced and managed for regeneration but exhibited very limited regrowth at the time of the GHD site surveys.

Sandhill Pine Woodland shares a number of species with the TSC Act EEC: *Allocasuarina luehmannii* Woodland in the Riverina and Murray-Darling Depression bioregions, which is also listed under the EPBC Act as 'Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions' (Buloke Woodland). These two ecological communities inhabit similar soils and landforms and have similar geographic distributions and may be distinguished on the basis of the relative abundance of their tree species and subtle differences in composition of their understorey. When assessed at the per-hectare scale, White Cypress Pine is the most abundant tree species in Sandhill Pine Woodland, whereas in Buloke Woodland Buloke is the most abundant tree species (DECCW, 2009b). Buloke is present in some sandhills within the Forest however most often in conjunction with Cypress Pine and as a few scattered trees. This makes the discrimination of these EECs in the Forest very difficult. There are no Sandhill Woodlands in the vicinity of the proposed construction footprint and they occur on higher ground that would not be affected by the proposed flooding of the Forest (refer Section 9). Therefore this broad vegetation type is unlikely to be affected by the project and so it was not considered necessary to survey or assess it in detail.

Derived Grassland and Herbland

The Forest contains treeless areas mapped as 'Open plain or Swamp' by FNSW. Some of these areas are Floodplain Marshes, where hydrology precludes the growth of trees, as described above. Floodplains of the Central Murray feature a variety of native grassland communities associated with frequently flooded geomorphic settings. Frequent or prolonged inundation of these areas prevents the encroachment of River Red Gums. Amongst these vegetation associations the Moira Grass Plains

have regional significance in the Central Murray (MDBC, 2007). They feature a moist, low mat grassland dominated by Moira Grass (*Pseudoraphis spinescens*). This community occurs on elevated rises and river banks on red to brown clay or loamy soils on the floodplains (Benson *et al.,* 2006). There are no extensive areas of these grasslands within the Forest (GHD, 2009a).

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'. Derived Grasslands and Herblands have very variable species composition and vegetation structure. Further description, on the basis of Site survey results, is provided in Section 6

5.3 Fauna

5.3.1 Fauna species

Overview

Webster (2008) summarises the results of a number of fauna surveys and monitoring projects undertaken for and by Forests NSW within Koondrook-Perricoota Forest. These studies have identified a total of 108 terrestrial vertebrate species within forest and woodland habitats in the Forest, including:

- Forest and woodland birds – 83 species;
- Mammals – 20 species;
- Frogs – 2 species; and
- Reptiles – 3 species.

Field surveys summarised by Webster (2008) were all conducted when the majority of the Forest was dry and did not directly sample the Murray River riparian zone nor any other waterbird habitats within the current survey area (Webster, R. Ecosurveys, pers. comm.). The fauna species list for the Forest would also include a number of wetland species as discussed below.

GHD and Forests NSW site surveys conducted in October and November 2008 recorded a similar diversity of forest and woodland species (GHD, 2009b) as shown in Table 8 below.

Table 8 Diversity of fauna species previously recorded in the Koondrook and Perricoota State Forests (GHD, 2009b)

Location	# Survey plots	Total # recorded at each State Forest			
		Birds	Terrestrial Mammals	Microbats	Total
Koondrook SF	10	56	8	11	75
Perricoota SF	20	51	2	11	64

The current site surveys recorded a greater diversity of species, increasing the overall species list for the Forest as described in Section 6. This is probably because the current survey sampled wetland and riparian habitats and involved a single, relatively intense and extended period of survey effort at an appropriate time of year, rather than an actual change in the diversity of species present within the

Forest. There is insufficient survey data to draw any firm conclusions about trends in species diversity or population sizes.

Birds

Birds are an important component of the ecology of the Forest in terms of their number, diversity and conservation significance.

The Forest supports a diverse assemblage of native birds including:

- Woodland and forest birds, which forage and breed in River Red Gum Forests or Box Woodlands;
- Open country birds, which roost or nest in forests but forage in surrounding open woodlands, grasslands and shrublands;
- True water birds, which forage almost exclusively in wetlands and exhibit adaptive characteristics for a semi-aquatic existence (eg webbed feet); and
- Other wetland dependent birds, which are taxonomically aligned with terrestrial birds but which rely on wetlands for habitat (GHD, 2009a; Birds Australia, 2008).

Of these suites of species, woodland birds and wetland birds are often identified as having high conservation significance. Woodland habitats have been extensively cleared and contain a high proportion of threatened or declining bird species (Reid, 1999). Wetland habitats are limited in extent and vulnerable to degradation and support large numbers of threatened and/or migratory bird species recognised under Federal and International treaties and legislation.

The Reid (1999) report into *Threatened and Declining Birds in the NSW Sheep Wheat Belt* identified 20 bird species as declining and at risk. This suite of woodland bird species, known as 'declining woodland birds', are of conservation significance even though not all are listed as threatened species under the TSC Act or EPBC Act. The sheep-wheat belt of New South Wales covers the area west of the central tablelands to the Western Division boundary, including the Forest. Of the 20 bird species listed as declining, 15 have been recorded within the Forest (Webster, 2008), including three listed as Vulnerable on the TSC Act and a further two nominated for listing as Vulnerable (DECCW, 2009d). Declining woodland birds known from the Forest include:

- Hooded Robin (*Melanodryas cucullata)* – Vulnerable, TSC Act;
- Diamond Firetail (*Stagonopleura guttata*) – Vulnerable, TSC Act;
- Speckled Warbler (*Chthonicola sagittata*) - Vulnerable, TSC Act;
- White-browed Woodswallow (*Artamus superciliosus*) – nominated as Vulnerable, TSC Act;
- Varied Sittella (*Daphoenositta chrysoptera*) – nominated as Vulnerable, TSC Act;
- Emu (*Dromaius novae-hollandiae*);
- Painted Button-Quail (*Turnix varia*);
- Brown Treecreeper (*Climacteris picumnus*);
- Jacky Winter (*Microeca fascinans*);
- Red-capped Robin (*Petroica goodenovii*);
- White-browed Babbler (*Pomatostomus superciliosus*);
- Crested Shike-tit (*Falcunculus cristata*);
- Rufous Whistler (*Pachycephala rufiventris*);

- Restless Flycatcher (*Myiagra inquieta*); and
- Dusky Woodswallow (*A. cyanopterus*).

Of these species all but two were recorded in the Forest during the current surveys and the majority were frequently observed and widespread (refer Section 6).

MDBC Icon Site monitoring included summer and autumn 2008 surveys for bush birds, which identified the Black-chinned Honeyeater (*Melithreptus gularis*) in Inland Grey Box Woodland in Perricoota SF and in Black Box and River Red Gum communities in the Gunbower Forest (MDBC, 2008). This species was not recorded in the current surveys, however this was probably due to a seasonal absence of nectar resources. Webster (2008) noted that prior to the extended dry (2002-2008) period experienced in the Riverina this species was recorded only in taller, moister River Red Gum communities and that the species may have expanded its habitat into Box woodlands. The Forest would support a regular, seasonal population of the Black-chinned Honeyeater which would exploit nectar resources in a variety of Eucalyptus communities.

There are three records of the Barking Owl (*Ninox connivens*) in the Perricoota SF in the last five years (DECCW, 2009a). A Parker,e*t al*. (2007) survey of large forest owls in State Forests of south-western New South Wales sampled 28 Forests in Koondrook and Perricoota SFs. Two records of the Barking Owl were obtained in Perricoota SF (Parker *et al*., 2007). The species was not recorded in the current surveys, however the Forest contains suitable habitat resources for the species and is likely to support a local population.

The Bush Stone-curlew is known from remnant woodland in farmland adjoining the north western boundary of the Forest. Multiple birds have been heard calling (Tyers, H., pers. comm.) suggesting that at least one breeding pair of Bush Stone-curlews is resident in the local area. The species is known to frequent all habitat types present within the Forest (DEC, 2006) with the exception of Floodplain Marshes. The distribution and abundance of the species across the Forest is unclear, since the species was not recorded in site surveys nor in other recent surveys of the State Forests (GHD, 2009b; Webster, 2008). Feral predators exclude the species from many areas of physically suitable habitat (DEC, 2006). Based on the presence of suitable open forest and woodland habitat, with sparse, grassy understoreys and plentiful woody debris the majority of the Forest would comprise foraging and breeding habitat for the species and so for the purposes of this assessment it is assumed that a local population occurs.

The Central Murray contains one of three core Superb Parrot (*Polytellis swainsonii*) breeding populations in NSW (DECCW, 2009b) and there are known populations in other portions of the Ramsar Site (GHD, 2009a). The closest known breeding population is approximately 100 km upstream and to the east of the Forest in and around the Millewa and Gulpa Island State Forests (GHD, 2009b; Webster, 1988; DECCW, 2009b). There is no known breeding population of Superb Parrots in the Forest however there are a few reports of observations of foraging individuals, outside of the breeding season, in the far southeast of the Forest (Webster, R. Ecosurveys, pers. comm.). No such records appear in any formal reports or databases. These observations would be near the western limit of the distribution of the species (Webster, 1988; DECCW, 2009b) and so local populations would consist of individuals using foraging resources in the Forest on an occasional or opportunistic basis.

At least 68 species of wetland birds are known from the floodplains of the Central Murray region (GHD, 2009a). Guilds, typical species and general habitat associations of wetland birds known from the region are summarised in Table 9.There are extensive areas of waterbird habitat in the Barmah-Millewa group of State Forests, approximately 100 km upstream of the Forest and in the Gunbower SF

on the southern bank of the Murray River adjacent to the Forest (GHD, 2009a, MDBC, 2006). Not all of these species and habitat types are permanently present at the Forest. Numbers and diversity of wetland birds would vary seasonally, mainly in response to flood cycles. Annual Aerial Waterbird Surveys undertaken by MDBA have noted very few waterbirds in recent seasons: in November 2007, most shallow floodplain wetland habitat in the Gunbower-Koondrook- Perricoota system were dry and few waterbirds were present; and no waterbirds were recorded across the entire Icon Forest in Summer 2008, as all monitored wetland Forests were dry (MDBC, 2008). Wetland birds would occupy habitats along and immediately adjacent to the Murray River on a near-permanent basis. The riparian strip provides a near-continuous fauna movement corridor. In this context waterbird populations are likely to be maintained at a regional level and would occupy habitat within the Forest during flood events. This may potentially include breeding aggregations of wetland birds.

Threatened wetland birds known from the Central Murray region include the Painted Snipe (Australian subspecies) (*Rostratula benghalensis australis*), Australasian Bittern (*Botaurus poiciloptilus*) and Blue-billed Duck (*Oxyura australis*). There is potential habitat for all three species in the Forest and the Australasian Bittern has been previously recorded in the locality (DECCW, 2009a) and was observed in Gunbower SF, opposite the Forest, during the Site survey. The Forest supports a local population of White-bellied Sea-eagles (*Haliaetus leucogaster*) which is a listed migratory species (EPBC Act) and is endangered in Victoria (*Flora and Fauna Guarantee Act 1988*).

About 54 waterbird species have been recorded breeding in the Central Murray region, including 25 colonial nesting species (Leslie, 2001). The key determinants of the numbers of breeding birds and reproductive success are:

- The extent and availability of suitable habitat (provided by the River Red Gum Forests and Floodplain Marshes); and
- Flooding, which creates suitable nest sites and foraging areas and stimulates breeding (Chesterfield *et al.,* 1984; Maher, 1993 cited in Leslie, 2001).

In order to breed, waterbirds require appropriate Forests for their nests. Nesting requirements vary between groups of species. The critical habitat resources at the Forest include mature River Red Gums in the vicinity of open water and stands of Juncus or other emergent macrophytes in Floodplain Marshes (Briggs and Thornton, 1995; Barmah Millewa Forum, 2001).

Apart from Pollack Swamp, the waterbird nesting habitat in Koondrook-Perricoota forests is distributed across the floodplain as discreet intermittent wetlands as opposed to the larger, more permanent wetlands typical of Gunbower forest on the Victorian side of the Murray River. This has led to the generalisation that waterbirds breed in Gunbower and feed in Koondrook-Perricoota (FNSW, 2008b).

The significance of waterbird habitat in the Forest may have been underestimated in the past since the Forest features numerous floodplain marshes which have not been properly described in hydrological or ecological terms (Ecological Associates, 2009). Forests NSW personnel indicate that in the 20th century formerly open wetland areas, which would have been suitable waterbird rookeries, were colonised by River Red Gums, probably as a result of a reduction in flooding frequency and that these areas provided habitat over the long term for colonial nesting waterbirds, particularly those that build stick nests in trees (Ecological Associates, 2009).

Large colonies of Little Pied Cormorant (*Phalacrocorax melanoleucos*) have been recorded from Long Lagoon in Koondrook SF (Disher, 2000, cited in Webster, 2008.)

River Red Gum Forests support large numbers of migratory bird species as they provide wetland and forest foraging habitat in a relatively continuous riparian corridor. Thirteen migratory species listed under the international agreements JAMBA, CAMBA and ROKAMBA and/or listed on the schedules of the federal EPBC Act occur in the Central Murray region and approximately 30 species which are components of bird families recognised as migratory under the EPBC Act (GHD, 2009a). These listed migratory species may use habitat in the Forest during seasonal movements or when environmental conditions are suitable. The majority of wetland birds known from the Forest are at least partially migratory, and so populations fluctuate with breeding and/or exploitation of floods. Some species, such, as the threatened Blue-billed Duck, are nomadic within Australia and travel to take advantage of suitable feeding and breeding opportunities. Others, such as Ibis, Spoonbill and Egret species, occur as permanent resident populations whose numbers are swelled by migratory individuals during breeding events. Even resident, solitary nesting species such as Grey Teal, Coots and Moor Hens experience population eruptions as migratory sub-populations take advantage of favourable conditions (Kingsford, 2007).

Migratory bird species are MNES listed on the Schedules of the EPBC Act and are described in detail in Section 7.5.

Table 9 Wetland Birds of the Central Murray Region (Adapted from GHD, 2009a)

Wetland bird guild	Typical species	Feeding / habitat requirements (Pizzey and Knight, 1997)
True waterbirds		
Waterfowl (Anatidae)	Grey Teal (*Anas gracilis*); Pacific Black Duck (*Anas superciliosa*); Hardhead (*Aythya australis*)	Shallow or deeper open water foragers Vegetarian (e.g. Black Swan) or omnivorous with diet including algae, macrophyte leaves, seeds and invertebrates
Grebes (Podicipedidae)	Hoary-headed Grebe (*Poliocephalus poliocephalus*); Australasian Grebe (*Tachybaptus novaehollandiae*)	Deeper open waters feeding on fish and crustaceans
Pelican, Cormorants, Darter (Pelecanidae, Anhingidae, Phalacrocoracidae)	Australian Pelican (*Pelecanus conspicillatus*); Great Cormorant (*Phalacrocorax carbo*); Little Black Cormorant (*Phalacrocorax sulcirostris*); Darter (*Anhinga melanogaster*)	Deeper open waters feeding mainly on fish
Ibis, Spoonbills (Threskiornithidae)	Yellow-billed Spoonbill (*Platalea flavipes*); Australian White Ibis (*Threskiornis molucca*); Straw-necked Ibis (*Threskiornis spinicollis*)	Shallow water mudflats or wet grasslands, feeding mainly on animals (fish and invertebrates)
Egrets, Herons, Bitterns (Ardeidae) Cranes (Gruidae)	Great Egret (*Ardea alba*); White-faced Heron (*Egretta novaehollandiae*); Nankeen Night Heron (*Nycticorax caledonicus*)	Shallow water, bare mud and reedbeds, feeding on animals (large invertebrates, crustaceans, frogs and fish)
Crakes, Rails, Water Hens, Coots (Rallidae)	Australian Spotted Crake (*Porzana fluminea);* Purple Swamphen (*Porphyrio porphyrio*); Eurasian Coot (*Fulica atra) ;* Dusky Moorhen (*Gallinula tenebrosa*);	Eurasian Coot in open water; others in shallow water, within cover of dense emergent vegetation or wet grassland. Some species vegetarian, others mainly take invertebrates, some are omnivores

Wetland bird guild	Typical species	Feeding / habitat requirements (Pizzey and Knight, 1997)
Snipe (Rostratulidae, Scolopacidae)	Latham's Snipe (*Gallinago hardwickii*)	Shallow water, bare mud and reedbeds. Reliant on dense semi-aquatic vegetation cover. Feeding mainly on animals (invertebrates and some fish)
Shorebirds (Recurvirostridae, Charadriidae, Vanellidae)	Black-winged Stilt (*Himantopus himantopus*); Red-capped Plover (*Charadrius ruficapillus*); Black-fronted Dotterel (*Elseyornis melanops*); Masked Lapwing (*Vanellus miles*)	Shallow water, bare mud and salt marsh Feeding mainly on animals (invertebrates and some fish)
Gulls, Terns (Laridae)	Silver Gull (*Larus novaehollandiae*)	Terns, over open water feeding on fish; gulls, opportunistic feeders over a wide range of habitats.
Other wetland dependant birds		
Raptors (Accipitridae)	White-bellied Sea-Eagle (*Haliaeetus leucogaster*) Whistling Kite (*Haliastur sphenurus*)	Feed on fish, carrion and water birds within large home ranges centred on aquatic habitat
Songbirds (Sylviidae)	Australian Reed Warbler (*Acrocephalus australis*)	Feed on invertebrates and nest in dense reed beds
Kingfishers (Alcedinidae, Halcyonidae)	Azure Kingfisher (*Alcedo azurea)*	Feed on terrestrial and aquatic vertebrates and large invertebrates.

Mammals

Mammal populations in Red Gum Forests include terrestrial, arboreal, aerial and aquatic species though overall species diversity is low. Historical information indicates decline or extinction of medium-sized terrestrial mammals with a heavy dependence on understorey vegetation, as is typical of Western NSW. It is likely that destruction of understorey strata by sheep and cattle, as well as the introduction of exotic predators such as foxes and cats, has contributed to the decline of these species (Di Stefano, 2001). Yellow-footed Antechinus (*Antechinus flavipes*) were the only small, terrestrial native mammal captured in Elliot traps in a 2001 survey of River Red Gum Forests in the Central Murray (Mac Nally *et al*., 2001). Larger terrestrial mammal inhabiting the River Red Gum forests, such as the Eastern Grey Kangaroo (*Macropus giganteus*), appear to have been more resilient to these changes and numbers remain high (Di Stefano, 2001). The aquatic Water Rat (*Hydromys chrysogaster*)is likely to occur in the Murray River adjacent to the Forest and may occupy the Forest during inundation events.

GHD (2009b) surveys noted a moderate diversity of terrestrial and arboreal mammals within the Forest, including Yellow-footed Antechinus and the threatened Squirrel Glider. The other species observed were common and widespread native mammals and exotic pest species.

River Red Gum Forests of the Central Murray region support a relatively diverse assemblage of native micro bats. GHD (2009b) Anabat surveys recorded 10 species of microbat in the Koondrook and Perricoota SFs, including the threatened Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris).* A 1997 survey of River Red Gum forests of the Murray River noted high levels of other micro bat activity from 12 native species and recorded Large-footed Myotis (*Myotis macropus*) upstream of the Forest (Law and Anderson, 1999).

Reptiles

Webster (2008) reported a very limited diversity of native reptile species within the Forest, based on FNSW monitoring. This probably represents limited targeted survey effort, as the surveys in question predominantly targeted birds or tree health. The diversity of native reptiles in the Forest is likely to be considerably greater. 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). One regionally significant reptile species, the Carpet Python (*Milota spilota variegata),* which is listed as threatened in Victoria, is known from the Ramsar Site (Leslie, 2002 quoted in GHD, 2009a). No TSC/EPBC Act listed terrestrial reptiles are known from the locality or are known to occupy Murray River floodplain habitats (GHD, 2009a, DECCW, 2009a, 2009b; DEWHA, 2009a).

Frogs

There is a lack of published data relating to the frog populations of the Forest.

Based on previous records for the Central Murray the Forest is likely to support up to nine frog species potentially including Sloane's Froglet (*Crinia sloaneii)* which is listed as Vulnerable in NSW (GHD, 2009a; Leslie, 2002).

Periodic monitoring of frog populations has been conducted in the Barmah-Millewa Forest, upstream of the Forest (Ward, 2006). The 2005-06 monitoring assessed frog response to natural winter and spring flooding, augmented by the release of an Environmental Water Allocation to achieve a managed flood over spring and summer. Results from this monitoring included:

- Five of the nine frog species known from the forests bred during the managed flood with a sixth species very likely to have also bred though not confirmed;
- Many young-of-the year frogs were observed to be present in the wetlands showing that flood durations were sufficient for metamorphosis to be attained;
- Two species of frogs have not been observed in the Forest since first recorded in 2000 and there was no evidence of the threatened species Growling Grass Frog (*Litoria raniformis*), which has never been recorded in Barmah-Millewa Forest, despite broadly suitable habitat; and
- Frog activity and breeding attempts were greatest in well-vegetated ephemeral wetlands, consistent with previous monitoring results. These Forests were generally broad flat open wetlands that generally experience regular wet/dry regimes that tended to support a more diverse and abundant grassy/forb understorey. Deep, ponded and steep-sided wetlands generally supported less calling frogs (Ward, 2006).

The Barmah-Millewa forests feature an equivalent suite of floodplain vegetation communities and habitats to the Forest, however have been less severely affected by reduced flood frequency over the last decade (GHD, 2009a). Nonetheless, these results suggest that a number of native frogs known from the region would persist in the Forest and are likely to breed in ephemeral wetlands during flood events. The prolonged dry period experienced by the Forest and the lack of understorey vegetation may influence the number of frog species responding to flooding and breeding success.

5.4 Aquatic Ecological Communities

5.4.1 Fish Species

There is a lack of published data relating to the fish populations of the Forest.

Based on NSW Fisheries records (BioNet database) the Central Murray region supports a total of 24 species of fish, of which 18 are native (GHD, 2009a).

Native fish of the Murray River main channel utilise anabranch and flood runner channels when they are available (Thoms *et al.,* 2000). Native fish move into off-stream areas on rising flows, and that they will make refuge movements into deeper waters during low flow periods. Water temperature and river flow rates appear to provide the environmental cues for these movements (Jones, 2006). Larval fish and spawn will also be carried into floodplain environments along with flooding flows.

Exotic species, especially Carp, are a large component of fish populations in the Murray River. Carp are consistently more abundant in offstream habitats compared with the Murray River (Jones, 2006).The Barmah-Millewa forest upstream of the Forest, has previously 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. 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).

Fish populations would migrate from the Murray River into intermittent aquatic habitats in the Forest during flood events. Processes of fish migration have not been studied within the Forest. An assessment of the relationships between wetland watering and fish production was undertaken in Gunbower Forest wetlands in autumn 2008 after environmental water was released for one month (MDBC, 2008). Up to six

fish species were recorded (five native) including Smelt (*Retropinna semoni*), Carp Gudgeon (*Hypseleotris* spp.), Un-specked Hardyhead (*Craterocephalus stercusmuscarum fulvus*) Murray- Darling Rainbowfish (*Melanotaenia fluviatilis*), Flat-headed Gudgeon (*Phylipnodon grandiceps*) and Goldfish (*Carassius auratus*) (MDBC, 2008).

The Central Murray region supports the one self-sustaining natural population of the FM Act listed Silver Perch in NSW. There is a breeding population of the species in the Murray River downstream of Yarrawonga Weir as well as several of its anabranches and tributaries including the Edward River. Large numbers of Silver Perch have been recorded moving upstream through the Torrumbarry fishway and other fishways in the area, (NSW DPI 2006). The Silver Perch would occur in the Murray River adjacent to the Forest and is likely to occupy the Forest during flood events.

The river reach between Yarrawonga and the Barmah Choke, approximately 50-100 km upstream of the Forest, contains critical habitat for the Trout Cod (*Maccullochella macquariensis*) listed as endangered on the FM/EPBC Acts. The species' natural range in the Murray River main stem is now restricted to this reach (ASFB, 2001). Therefore despite the presence of suitable habitat in the Murray River adjacent to the Forest, the Trout Cod is unlikely to occur. No other FM Act listed aquatic species are likely to occur within the Forest (refer Appendix C).

Additional EPBC Act listed species of fish known from the Murray Region, and noted as significant to the project by DEWHA (letter to NSW Technology and Administration of 21 October 2009) include the Murray Cod, Murray Hardyhead and Macquarie Perch. Of these three species only the Murray Cod is likely to occur in the Forest. The following section summarises advice provided by Mr Martin Mallen Cooper and presented in the NSW Technology and Administration letter to DEWHA of 10 November 2009 (DSTA, 2009) on the likely presence of Murray Cod, Murray Hardyhead and Macquarie Perch within the Forest:

- Murray Hardyhead is found in slightly to highly saline waters, mostly in ephemeral deflation basins with near-permanent lakes near Kerang and Mildura. Murray Hardyhead (*Craterocephalus fluviatilis*) has been recorded in receding floodwaters on the floodplain of the Millewa Forests (Ward, 2006). It has not been recorded within the Forest and is considered unlikely to occur in the future as the Forest contains only ephemeral wetland habitats, which have been dry for many years, that would not form saline lakes;
- Macquarie Perch were historically abundant along the Murray River as far downstream as Euston (Lock 15) downstream of the Forest in the 1940's (Mallen-Cooper and Brand 2007). They have been recorded using off-channel habitats in Barmah Forest, in the vicinity of the Forest, in the 1940's (Langtry 1950, in Cadwallader 1977). However, the Macquarie perch has not been recorded in the Murray River downstream of Yarrawonga Weir (i.e. well upstream of the Forest) since that time and are now restricted to upland habitats; and
- Murray Cod are common in the Murray River from Yarrawonga to Euston, encompassing the river near Koondrook-Perricoota Forest. Both adults and larvae are expected to enter the forest floodplain during the filling phase which would take water directly from the main river channel upstream of Torrumbarry Weir.

Murray Cod (*Maccullochella peeli peelii)* juveniles are relatively sedentary and are generally confined to the main channel of the Murray River, smaller channels and flooded anabranches (though not the floodplain). Within the channel they are occur almost exclusively in association with woody debris and so floodplain forests are an important provisioning resource for the species (Jones and Stuart, 2007).

Murray Cod juveniles and adults are likely to occupy larger flood runners within the Forest during flood events (FPTF, 2009).

5.4.2 Macroinvertebrates

Monitoring conducted after delivery of a managed flood in the Barmah-Millewa forest, upstream of the Forest, noted a high diversity and abundance of native macroinvertebrates utiliseing floodplain habitats. Ephemeral, well vegetated wetlands also accounted for most of the relatively high abundance and diversity of aquatic macroinvertebrate groups found, with the notable exception of *Paratya* Shrimp that was most abundant in snaggy permanent wetlands (Ward, 2006).

5.4.3 Physical Habitats

The Forest features an extensive and complex network of in stream habitats. They are all hydrologically connected to the Murray River and include recognised effluent streams, such as Burrumburry Creek, Barbers Creek, and Cow Creek and myriad of smaller, unnamed effluent streams and flood runners. These habitats were dry at the time of the site surveys and have been so since 2001. Some floodplain marshes contained water and currently support aquatic communities as described above.

The networks of smaller channels are important for transmitting floodwaters across the floodplain and inundating other habitat types. These habitats support aquatic and semi-aquatic plant species during and after flood events. They would play an important role maintaining propagules of these species during dry phases and then transmitting them onto the floodplain upon re-wetting. They also provide important foraging habitat, drought refuge and migratory pathways for fish and support aquatic communities of macroalgae, phytoplankton and macroinvertebrates. Monitoring of the 2005-06 flood of the Millewa Forests demonstrated clearly the link between floodplain inundation and the mass spawning and associated major recruitment of large bodied native fish species. (MDBC, 2007$_c$).

The condition and integrity of aquatic habitats within the Forest were not assessed in detail. A GHD (2009a) assessment ascribed ‘poor’ habitat ratings to Forests in Koondrook SF primarily because of weed invasion, bank erosion and poor bank vegetation cover. A Forest in Perricoota SF was rated as ‘fair’ and featured moderate bank stability and vegetation cover (GHD, 2009a). Both Forests featured large volumes of coarse woody debris which would contribute to aquatic habitat during flood events (GHD, 2009b).

Through the proposed inundation of the Forest aquatic habitats would be influenced by water quality and habitat condition of the Murray River. The Norris *et al.,* (2001) report “*Snapshot of the Murray- Darling Basin River Condition*” describes the condition of the Murray River through the reach that would contribute water to the Forest as follows:

- Hydrological condition was poor and characterised by unseasonal high flows and too infrequent peak flows and winter-sping flooding;
- Macroinvertebrate communities were in extremely poor condition, although the trend was improving. This condition was attributed to unseasonal high flows and reduction of available habitat through erosion of banks and in-channel benches.
- Fish communities were in very poor condition through alterations to the flow regime and loss of snags, with unseasonal flooding favouring carp breeding;
- Water quality was poor and declining with respect to nutrients, sediment and salinity; and

- Riverine habitat was in poor condition, with banks actively eroding and in-channel benches either lost or permanently inundated.

5.4.4 Aquatic Fauna Passage into the Forest

At present all inflow points to the Forest and effluent streams from the floodplain are unregulated. Nonetheless aquatic fauna passage into the Forest has been constrained in recent years by low Murray River flow. As described above, Murray River flows have not been high enough to fill drainage lines or overtop the bank for over 10 years.

The project would create a number of potential barriers to fish passage at the locations of the proposed regulators. The proposed operation of the project would facilitate movement of aquatic fauna by transferring water into the Forest and may also affect fish movement through downstream discharges. Based on the operation of similar regulators at Barmah-Millewa Forest both large bodied and small bodied native native and exotic fish (including adults, juveniles and eggs/larvae) are likely to enter into Bullock Head Creek and the floodplain via the intake channel and regulator (FPTF, 2009). The species predicted to enter the Forest by the FPTF (2009) are listed in Table 10.

Table 10 Fish Species Likely to Enter the Forest During Flood Events

Common name	Scientific name	FM Act Status	EPBC Act Status	Life stage
Large bodied fish				
Murray cod	*Maccullochella peelii peelii*		V	Adults Juveniles
Golden perch	*Macquaria ambigua*			Adults Juveniles
Silver perch	*Bidyanus bidyanus*	V		Adults Juveniles
Freshwater catfish	*Tandanus tandanus*	EP		Adults Juveniles
Small bodied fish (<100 mm)				
Crimson spotted rainbowfish	*Melanotaenia fluviatilis*			
Fly-specked hardyhead	*Craterocephalus fluviatilis*			
Australian smelt	*Retropinna semoni*			
Carp gudgeons	*Hypseleotris spp*			
Flat-headed gudgeon	*Phylipnodon grandiceps*			
Southern pigmy perch	*Nannoperca australis*			

Common name	Scientific name	FM Act Status	EPBC Act Status	Life stage
Introduced species				
Carp	*Cyprinus carpio*			
Goldfish	*Carasius auratus*			
Weatherloach	*Misgurnus anguillicaudatus*			
Redfin Perch	*Perca fluviatilis*			
Gambusia	*Gambusia holbrooki*			

Status: V – Vulnerable; EP – Endangered Population.

In addition to fish species, it is likely that invertebrates (such as smooth and spiny crayfish, turtles and freshwater shrimp) will enter Bullock Creek when the Forest is initially flooded (FPTF, 2009).

5.5 Floodplain Ecology

Cycles of wetting and drying are fundamental to floodplain ecosystems, affecting the physical, chemical and biological processes and functions. The duration, seasonality, frequency and intensity of wetting and drying will determine the type of biota that occurs on the floodplain and wetting and drying can provide important cues for flora and fauna in reproductive cycles. Of relevance to the current project are the general ecological processes that can be expected to occur during three distinct phases of the operation: filling; inundated state; and drying.

Filling

The arrival of floodwaters brings about the following physical and chemical changes within the floodplain (Boon 2006):

- Dry and aerated sediments quickly become waterlogged and devoid of oxygen;
- Mineralisation and release of nutrients and carbon from the sediments;
- Depending on the water quality of source water, velocity of flooding and sediment type, the floodwaters may be highly turbid (particularly in channels where velocity is greatest) and sediments may be deposited on the low relief floodplain surface.

Biological processes that occur upon wetting include (Boulton and Brock 1999):

- Microorganisms (bacteria and algae) process mineralised nutrients and a “boom” of productivity commences;
- Egg and seed banks hatch / germinate;
- Plant propagules are brought in with the floodwaters from upstream environments;
- Fish and invertebrates arrive on the floodplain with the floodwaters;
- Stimulation of aquatic plant growth;
- Stimulation of flowering in a number of species such as Lignum (Roberts and Marston 2000);

- The release of nutrients and subsequent “boom” in productivity act as cues to initiate breeding of waterbirds, frogs, fish and turtles.

Inundated state

When inundated the following ecological processes can be expected (Boulton and Brock 1999):

- Productivity boom may be maintained for some time (depending on conditions of light, temperature and nutrients released into the water column;
- Submerged aquatic plants grow and flower, while amphibious aquatic plants exist in their aquatic form;
- Aquatic invertebrates occur in both larval (aquatic stages as well as some emerging into mature aerial forms;
- Productivity boom provides important food resources for waterbirds, fish, frogs, turtles as well as insectivorous and nectivorous terrestrial species;
- Nesting of waterbirds in a variety of inundated habitats including inundated trees (e.g. Egrets, Ibis, Cormorants); shrubs (e.g. Coots, Swamphens); and sedges and rushes (e.g. Magpie Geese; Australasian Bittern);
- Frogs breeding in shallow water and inundated vegetation, tadpoles mature and grow;
- Turtles nesting on sandy island habitats, eggs hatch and juveniles feed and grow; and
- Fish breeding in inundated vegetation and woody debris; larval and juvenile forms within water column.

Drying

The recession of floodwaters and subsequent drying of the soil results in the following ecological processes (Boulton and Brock 1999):

- As waters recede nutrients and salts become concentrated in depressional wetlands as they dry by evaporation;
- Nutrients and organic carbon become stored in the sediment;
- Aquatic plants set seed to be stored dormant in the sediment for subsequent floods;
- Floodplain plants such as River Red Gum, Lignum and Black Box germinate and seedling emerge on the damp soil;
- Tadpoles mature and frogs migrate to nearby wet areas, some aestivate;
- Waterbirds fledge and disperse;
- Turtles migrate to nearby wet refuges, some aestivate;
- Fish return with receding waters to the river.

5.6 Floodplain Ecosystem Health

Floodplain ecosystems within the Forest are dependent on Murray River floodwater for their existence, as rainfall contribution to the soil water balance is not sufficient to sustain forest and wetland structure. Prior to river regulation, the floodplain experienced regular flooding periods, typically of 3-5 months duration, during winter and spring, every 1-2 years (FNSW, 2008a). The magnitude of these flood events

varies with geomorphology across the Murray River floodplain and is the primary determinant of vegetation composition and structure. Table 11 shows the inferred flood regimes associated with broad vegetation types and other ecological components of the Forest under natural conditions (i.e. pre-regulation of the Murray River).

Table 11 Inferred Natural Flood Regimes of Components of Floodplain Vegetation.

Component	Flood Frequency$_1$	Duration	Season
Floodplain Marshes	7-10 years in ten	7-10 months	Winter – mid Summer
River Red Gum Forest	4-9 years in ten	5 months	Winter - Spring
River Red Gum Woodland	3-5 years in ten	1-2 months	Spring
Black Box Woodland	1-3 years in ten	1-4 months	Winter - Spring

Adapted from Table 1 in MDBC (2007$_a$). which cites: Sharley and Huggan (1995), Ward (1991), Roberts and Marston (2000), Bren *et al.,* . (1988), Leitch (1989) and Dexter (1978) all cited in DSE and GBCMA (2005).

The health of vegetation types within the Forest is maintained by sufficiently frequent flooding. The distribution of vegetation communities across the floodplain is maintained by floods of appropriate duration to prevent faster growing or more drought tolerant species from increasing their distribution. River Red Gum seedlings can colonise extensive areas after floods. Prolonged inundation kills saplings, which is important for maintaining the distribution of treeless communities in the Forest (CSIRO, 2008$_a$; Cunningham *et al.,* 1981). Black Box seedlings are not able to persist where Forest flooding is greater than 2 months at a time (Heinrich, 1990), which helps to maintain the boundary between River Red Gum Woodlands and Black Box Woodlands.

Breeding of wetland birds in south-eastern Australia is stimulated by suitable flood conditions at appropriate times of year (Chesterfield *et al.,* 1984; Briggs, 1990; Scott, 1997). Breeding success of colonially nesting waterbirds, is also subject to a complex set of hydrological requirements as summarised in Table 12. A departure from these hydrological requirements during a flood event can lead to breeding failure and potentially abandonment of young. This is an important consideration in assessing potential operational impacts of the project as discussed in Section 9 .

Table 12 Hydrological requirements of colonially nesting waterbirds

Aspect of flood regime	Requirements
Seasonality	A flood pulse is required in September or October (or rarely November) to induce breeding. High stable water levels should continue for two months after the flood pulse with a gradual recession.
Water depth	Breeding is induced provided nest sites are sufficiently inundated. Rapid recession of floodwaters may result in breeding failure. A sudden change in water depth of 0.3 metres under nest sites or in foraging areas is likely to lead to nest abandonment
Magnitude	Floods must inundate both nesting and foraging areas Greatest success when river flows exceed 'broad area flow' capacities Small-scale breeding events may be triggered by regulated flooding of selected wetlands.
Duration	Flooding is required for up to 3.5 months after egg laying.

Aspect of flood regime	Requirements
	A period before this is also required for birds to prepare behaviourally, hormonally and nutritionally. Nest sites and foraging areas need to be inundated for at least 5 months.
Frequency	Flood events conducive to successful breeding must occur within the lifespan of a species (20-25 years in some species with mean wild survival of 8-10 years). Dry phases are necessary to allow nutrient accretion to support algae and macrophyte growth upon rewetting.
O'Connor (pers. comm.) and Leslie (2001) cited in DSE (2005). Also Webster (2003); Barmah Millewa Forum (2001); Briggs and Thornton (1999).	

Regulation of the Murray River effectively commenced with the construction of the Hume Dam in 1934, which dramatically reduced annual variation in flow and the magnitude of flood peaks. Construction of additional dams and weirs provided the capacity to store winter and spring river flows for release during summer and autumn to provide water for irrigation (Dexter *et al.,* 1986). This affected the seasonality of flows. Dams in the Murray-Darling system have the capacity to store 103% of annual runoff and 87% of divertible water extracted based on 1983–84 data (Kingsford, 2000). Accordingly, the present hydrology of the Murray River and of the Forest is markedly different to the pre-European regime. The impact of river regulation on the hydrology of the Murray Valley can be summarised as follows:

- Reduced variability of in-stream flow;
- Reduced flood frequency;
- Reduced flood extent;
- Reduced flood duration;
- An increase in summer and autumn stream flow; and
- A shift in the timing of flood peaks (fewer winter/spring floods and more summer floods) (MDBC, 2007_a, Di Stefano, 2001; Dexter *et al.,* 1986).

Natural hydrological requirements have not been met for the majority of the Murray River wetlands under post-regulation conditions. The most pronounced impact of river regulation on the Forest has been reduced flood frequency. Other wetlands and floodplain environments along the Murray River have also been degraded by floods that are too frequent, too long in duration or at the wrong time of year (MDBC, 2007a; MDBC, 2005).

Drought has been the overriding factor influencing hydrology during the past decade. This has exacerbated the long-term trend of reduced flooding of the Forest.

Altered water regime as a result of regulation of the Murray River has led to a decline in wetland function within the Forest. Examples of negative effects on floodplain biota include:

- Impacts on ecosystem function such as reduce carbon exchange from floodplain to river;
- Impacts on forest health such as less frequent regeneration and growth opportunities for River Red Gum; and
- Altered vegetation composition such as replacement of water dependent plants species with flood tolerant and terrestrial plant species (FNSW, 2008a).

Changes in current and natural flood regimes and the effect on components of the floodplain ecosystems are summarised in Table 13. The most pronounced impact on the Forest has been an overall reduction in the frequency of effective floods and a decline in the health of floodplain vegetation as a result.

Table 13 Comparison of Current and Natural Flood Regimes and Effects on Biological Components of the Floodplain.

Component	Flood Frequency	Duration / Magnitude	Effects
Floodplain Marshes	Less frequent than natural.	Longer duration than natural.	Outside tolerance range of community. Declining in extent in the Forest due to invasion by River Red Gum seedlings.
River Red Gum Forest	Less frequent than natural.	Shorter duration and less extensive than natural.	Outside tolerance in Forest (health and extent declining). Changing distribution and species composition.
River Red Gum Woodland	Less frequent than natural.	Shorter duration and less extensive than natural.	Outside tolerance range of community (health and extent declining).
Black Box Woodland	Less frequent than natural.	Data deficient[3]	Within tolerance range of community. Community extent may be expanding.
Colonial nesting waterbirds	Less frequent than natural.	Shorter and less extensive than natural.	The Forest has not featured waterbird breeding events of >1000 birds for >20 years (MDBC, 2007, Webster, R. pers. comm.)
Fish	Less frequent than natural.	Shorter and less extensive than natural.	Data deficient, however feeding and breeding opportunities on the floodplain would not have occurred for at least 9 years.

(MDBC, 2007_a; MDBC, 2008; Turner and Kathuria, 2008; DSE and GBCMA, 2005).

An 'effective' flood is one which ideally occurs in Spring to coincide with the reproductive periods of flood-dependant vascular plants and vertebrate fauna and in which the floodplain is inundated for at least 3 months to allow these biota to complete their reproductive cycle (FNSW, 2008b).The current frequency of effective floods within the Forest is considerably less than the inferred natural flood frequency and the minimum frequency that is considered to be adequate to maintain ecosystem function, as defined in the MDBC (2007) environmental management plan for the Icon Forest (the Icon Forest EMP). This shortfall in effective flood frequency is presented in Table 14. The acceptable minimum target for effective flood frequency for the Murray River system is considered, by an expert panel, to be half of natural (Leslie and Jacobs, 2003). Currently the flood frequency has been reduced to be only one third of the natural rate.

Table 14 Current effective flood frequencies in comparison with Icon Forest EMP and inferred natural flood frequencies for the Forest (FNSW, 2008b)

Component	Natural flood frequency (yrs in 10)	Icon Forest EMP flood frequency* (yrs in 10)	Current effective flood frequency (yrs in 10)
Floodplain Marshes	6-9	6-9	3
River Red Gum Forest	7-9	3-9	1
River Red Gum Woodland	4-5	1-4	1
Black Box Woodland	1	1-4	<1

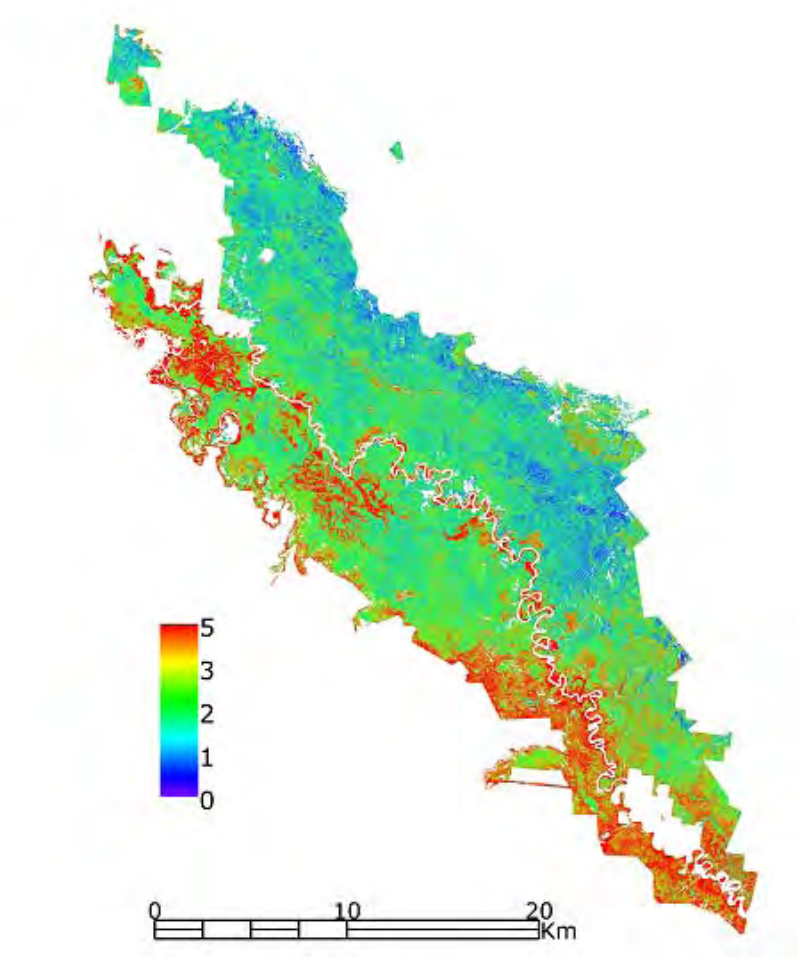
* the minimum effective flood frequency identified in the MDBC (2007) Icon Forest EMP "maintain healthy aspects of Icon Forest and to begin to address apparent declines in the health of other aspects".

Signs of severe stress have been evident in a large proportion of River Red Gums for several years, including dead and dying limbs, loss of leaf cover, and epicormic growth. There is evidence of tree death across large areas of the Forest. This includes large dominant trees, as well as areas of dense regrowth. Only isolated areas were reported to be in a relatively healthy condition (MDBC, 2008). The areas in the poorest condition are primarily in the Koondrook Forest at higher elevations, that is, along the high riverbank, and at the far margin of the forest. Recent observations of the forest canopy reveal some leaf growth following small rain events, but overall condition remains poor, and is continuing to decline (MDBC, 2008).

Remote sensing techniques employing satellite multi-spectral imagery were used to assess forest health condition across the Gunbower-Koondrook Perricoota Forests Icon Site based on a Spot 5 Image captured in 2006 and ground-truthing by qualitative estimation of forest health by FNSW staff through 2006-07. This study estimated that 56% of River Red Gums in the Icon Site were unhealthy as shown on Figure 9 (Turner and Kathuria, 2008). This image shows that the proportion of the forest in an unhealthy condition is far greater in the Koondrook and Perricoota Forests, north of the Murray River than the Icon Site as a whole. This reinforces the critical role of floodplain geomorphology and hydrology in forest health. The Forest has higher commence to flow levels to achieve floodplain inundation than the Victorian Gunbower Forest and have experiencing little or no flooding over the last decade.

The MDBC (2008) survey of wetlands in the GKP Icon Site found that all surveyed wetlands were dry and consequently, largely devoid of aquatic and mudflat flora and dominated by bare ground, litter and/or coarse woody debris. Floodplain Marshes and associated wetland and aquatic biota are adapted to periodic drying and are likely to be relatively resilient to the prolonged drying of the Forest.

Figure 9 Forest health in the Gunbower-Koondrook-Perricoota Forests Icon Forest (Turner and Kathuria, 2008).



Legend:

0 = Dead

1 = Near-dead with some epicormics present

2 = Unhealthy (<25% of original canopy)

3 = Stressed (25-50% of original canopy)

4 = Healthy (50-70% of original canopy), and

5 = Very Healthy (>70% of original canopy)

The poor health of River Red Gums is the most significant ecosystem health concern within the Forest. The decline of River Red Gums has the potential for secondary effects on other floodplain biota given that they are the basis of ecosystem productivity in the Forest providing the bulk of carbon and energy in the system as well as habitat for aquatic and terrestrial fauna (GHD, 2009a).

6. Site Survey Results

6.1 Flora

6.1.1 Flora species

A total of 25 20 x 20 metre flora quadrats and opportunistic observations during random meander surveys were used to compile a flora species list for the study area. A total of 147 plant species (86 native) were recorded during the field survey.

Species diversity is considerably higher than was recorded by GHD (2008b). This is probably because the current survey was conducted in September, after moderate rainfall whereas the GHD (2008b) survey was conducted in November after an extended dry period. 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 are listed as threatened under the TSC and/or EPBC Acts. Two Spear grasses (*Austrostipa* spp.) morphologically similar to threatened Spear grasses were forwarded to the Herbarium for identification. These samples were identified as *Austrostipa blackii* and *A. nodosa*, neither of which are threatened. 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 within the Forest.

The total plant species list recorded during the field survey is presented in Table 28.

6.1.2 Vegetation communities

Vegetation communities mapped within the study area are shown on Figure 10 and Figure 11 and described below. 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. Therefore the vegetation communities feature a variety of successional stages and condition classes.

Vegetation structure and habitat resources were measured in all vegetation quadrats using a modified Biobanking methodology. These results are presented in Table 29 with reference to DECCW (2009f) benchmarks for representative Keith (2004) vegetation classes.

River Red Gum Forest

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

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

Veg Comm. 5 and 7 occur across much of the floodplain throughout the Forest with 2 and 5 occurring along flood runners and the Murray River banks. On the Forest, this vegetation community features a

mono-specific canopy of River Red Gum, 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 areas areas remote from the Murray River, most likely owing to drought stress. Pockets of dense *E. camaldulensis* regeneration are scattered throughout the Forest, owing primarily to timber harvesting 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 *Exocarpus 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., *Cynondon 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.

Foliage projective cover of all vegetation strata was below or near the lower limit of DECCW (2009f) benchmark values for this vegetation class. This moderate to poor condition would be mainly attributable to the ongoing drought but would also reflect the effect of timber harvesting (GHD, 2009b), grazing and other disturbances within the Forest.

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

This vegetation community contains a relatively high number of hollow bearing trees (HBT) and stags compared with the DECCW (2009f) benchmark value of two per hectare: an average of 3 HBT were recorded per 20 x 50 m quadrat on the floodplain with this number increasing to around 3.6 along floodrunners and banks of the Murray River. A high number of stags is present throughout the Forest which appear to be a result of historic ringbarking practises.

The length of fallen timber and logs with a DBH greater than 10 cm present within each 20 x 50 m quadrat averaged 106 m but was up to 232 and 296 m in plots in that had been recently harvested. These amounts of fallen timber are considerable greater than the DECCW (2009f) benchmark of 56 m per quadrat.

A number of regulators as well as an extensive length of the proposed levy occur within this community.

River Red Gum Woodland

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

- Comm. ID 7: River Red Gum – herbaceous tall open forest mainly in the Riverina Bioregion.
- Comm. ID 8: River Red Gum – Warrego Grass – Couch Grass riparian tall woodland of the semi-arid (warm) climate zone.
- Comm. 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. Within 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 River Red Gum with influences of *Eucalyptus largiflorens* occurring in areas, 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 with occurrences of Weeping Pittosporum (*Pittosporum phylliraeoides*) occurring 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 to do with availability of light and hydrological factors.

These vegetation types contain a high number of hollow bearing trees (HBT) and stags per number of trees present reflecting generally old trees. However due to the more open nature of this community, the average number of HBT recorded per 20 x 50 m quadrat was slightly less than the River Red Gum Forest communities with an average of 2.25 HBT present. This is equivalent to the DECCW (2009f) benchmark value of 2 per plot.

The length of fallen timber and logs with a DBH greater than 10 cm present within each 20 x 50 m quadrat was relatively low with an average of 56.5 m. These tended to be larger logs of an older age, with greater habitat value.

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

Black Box Woodland

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

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

In the Forest, 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 (HBT) however the size of hollows present within this community where generally smaller than in River Red Gums. The average

number of HBT recorded per 20 x 50 m quadrat was 4.5, higher than eucalypt forests largely due to a higher density of mature trees per quadrat due to the nature of the community and its timber harvesting history.

Native overstorey cover was within the benchmark range for this vegetation class, probably reflecting the relatively greater tolerance of Black Box to drought when compared with River Red Gum. Foliage projective cover of grass and shrub strata was close to zero, which suggests poor site condition, despite the typically low DECCW (2009f) benchmark values for this vegetation class (9-13% grass cover and 5-10% shrub cover). This moderate to poor condition would be mainly attributable to the ongoing drought but is probably also due to grazing and other disturbances within the Forest. Foliage cover of other groundcovers, including herbs and chenopods, was in the lower range of benchmark values.

The length of fallen timber and logs with a DBH greater than 10 cm present within each 20 x 50 m quadrat was moderate to high, with an average of 113.5 m. These tended to be larger logs of an older age, with greater habitat value.

A considerable length of the proposed levy occurs within this community.

Inland Grey Box Woodland

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

- Comm. ID 237: Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone.

Within the Forest, this vegetation community is dominated by *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 this community's extent 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 Murray River edge. The condition and diversity of the ground layer varies across the study area, but generally comprises a range native and exotic annual and perrenial herbs including *Einadia nutans, Enchylaena tomentosa, Sclerolaena muricata, Rhodanthe corumbiflora, Crassula* spp., *Cotula* spp., *Carex sp., Brachyscome basltica*, and *Myosurus minimus*. Weed cover is usually low to moderate.

Inland Grey Box Woodland in the Forest is consistent with the TSC Act listed EEC Inland Grey Box Woodland (refer Section 7). This community is restricted to the Perricoota SF in the east of the 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.

As for Black Box woodlands native overstorey cover was within the benchmark range for this vegetation class, probably reflecting similarly greater tolerance of drought when compared with River Red Gum. Foliage projective cover of understorey strata was below DECCW (2009f) benchmark values for this vegetation class. This moderate to poor condition of understorey vegetation would be mainly attributable to the ongoing drought but is probably also due to grazing and other disturbances within the Forest.

This vegetation community contains a low number of hollow bearing trees (HBT) with an average number of 1 HBT recorded per 20 x 50 m which is below the benchmark of 3 per plot and is probably influenced by historic timber harvesting operations (GHD, 2009a).

The length of fallen timber and logs with a DBH greater than 10 cm present within each 20 x 50 m quadrat was low, with an average of 17.6 m, below the benchmark value of 33 m. This is probably due to the close proximity of this community to the entrance to the Forest and the Murray River and consequently the high number of people utilising this area for recreational activities.

The proposed intake channel and River Road bridge occur within this community.

Sandhill Pine Woodland

Within the Forest, this vegetation community 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 are devoid of over storey and only consist of a mixed ground layer with indicative species of this community present. The Cypress Pine is generally old growth with little to no signs of regeneration of this species. 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*), Pattersons Curse (*Echium plantagineum*), and Barley Grass (*Hordeum* sp.) with some Forests also containing Flannel Cudweed (*Actinobole uliginosum*), Midget Greenhood (*Pterostylis mutica*) and *Crassula* spp. in higher densities.

Native overstorey cover was within the benchmark range though foliage projective cover of understorey strata was below DECCW (2009f) benchmark values for this vegetation class. This moderate to poor condition of understorey vegetation would be attributable to the relatively intense history of clearing and grazing within the former Toorangabby property.

This vegetation community contains a low number of hollow bearing trees (HBT) with an average number of 1 HBT recorded per 20 x 50 m which is below the benchmark of 3 per plot and is probably influenced by historic timber harvesting operations (GHD, 2009a).

This vegetation community contains a low number of hollow-bearing trees (HBT) with an average number of 2 HBT recorded per 20 x 50 m, which is typical of White Cypress Pine and equivalent to the benchmark value. The hollows present are generally small, or occur within co-dominant Grey Box or River Red Gum trees.

The length of fallen timber and logs with a DBH greater than 10 cm present within each 20 x 50 m quadrat was high, with an average of 122.5 m, which is considerably greater than the benchmark value of 10 m per plot.

There are no Sandhill Woodlands in the vicinity of the proposed construction footprint and they occur on higher ground that would not be affected by the proposed flooding of the Forest (refer Section 9).

Floodplain Marshes

The majority of Floodplain Marshes within the Forest were dry during the Site 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 south east of the Perricoota SF 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 in 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 sand hills 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 Forest use. The current assessment did not attempt to systematically define and map all community sub-types in the Forest.

The Site 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 Sandhill's 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 intake regulator at the southern end of the Forest, 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 Sandhill's, 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*) dependant upon adjacent communities.

6.1.3 Noxious Weeds

The Forest contains six species declared as noxious weeds in Murray and Wakool LGAs as shown in Table 15 below.

Table 15 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 NW Act for a notifiable weed must be complied with'.

6.2 Fauna

6.2.1 Fauna species

At least 144 vertebrate fauna species were recorded within the Forest during the GHD 2009 site surveys and included:

- A high diversity (108 native species) of native birds, including four threatened species (Gilberts Whistler, the 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 site surveys and extended dry period preceding the Site survey.

The full list of fauna species recorded during site surveys is presented in Table 32 of Appendix A, along with their conservation status and the broad habitat types in which they were recorded.

A greater diversity of fauna species were recorded during the current site surveys than in previous studies summarised by Webster (2008), however the overall number of species in 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 within 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 cyaneu*s) were less common, and generally restricted to limited areas of the Forest 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 in 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*).

When compared with previous surveys the current site surveys are likely to have detected the majority of terrestrial bird species likely to occur within the Forest. Additional species in the Forest are likely to include cryptic species, migratory species and threatened species with limited population sizes and or distributions in the study area. Additional threatened species which may occur are discussed in Section 7.

Wetland Birds

A moderate diversity (22 species) of wetland birds were recorded within 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 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 all dry and did not support any wetland birds during the site 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 site 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 FNSW 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 (up to 30 individuals observed during a 2 hour driven spotlighting transect). Common Ringtail Possums appeared to be locally abundant in the southeast corner of Perricoota SF. The distribution of ringtails may be linked to greater vegetation structural diversity through the presence of dense Dwarf Cherry understorey in this area, or possibly due to the presence of Inland Grey Box.

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 terrestrial or arboreal mammal species in addition to those recorded during the Site survey.

Microbats

A total of 15 species of microbat were recorded in the Forest, through harp traps or Anabat recordings with varying confidence levels.

Eight species of microbat were recorded from the Forest 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 a high chance of occurring in 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) nor the locality (DECCW, 2009a). Further, FNSW 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 Site 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 in 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 in 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 within 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 within the Forest, however in small numbers or in restricted areas. Overall there was a low abundance of frogs and limited calling activity, probably attributable to the relatively cool weather during the site surveys and extended dry period preceding the site 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).

6.2.2 Fauna habitats

Habitat assessments were conducted across the entire study area in order 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 7.

The habitat assessment also included a quantitative survey of habitat features and resources. Fauna habitat resources of 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 in 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 in 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 with 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 in the Forest, which are discussed in greater detail below.

Eucalyptus spp. within 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 within the Forest, including the River Red Gum forests and Floodplain Marshes. The majority of these wetland habitats were dry during the site 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 as described in Section 4.1.

There were some Floodplain Marshes containing water in the south east of the Perricoota SF 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 project infrastructure and are unlikely to be directly affected by the project.

Habitat Trees

Habitat trees assessed in this report include hollow bearing trees (HBTs), stags, nest trees and roost Forests. These resources may be significant for threatened species in the locality (DECCW, 2009b). Tree hollows are important for native fauna as diurnal or nocturnal shelter Forests, for rearing young, for feeding, for thermoregulation, and to facilitate ranging behaviour and dispersal. An estimated 15% of all terrestrial vertebrate fauna in Australia are dependent upon tree hollows and for many of these species the relationship is obligate i.e. no other habitat resource represents an adequate substitute (Gibbons and Lindenmayer, 2002).

HBTs 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 HBTs close to suitable foraging habitat are a critical resource for the Squirrel Glider (DECCW, 2009b).

The Superb Parrot is a significant hollow-dependant species in the region since the Central Murray contains one of three core breeding populations in NSW (DECCW, 2009b). This breeding population is reliant on suitable breeding hollows in appropriately sited, large mature River Red Gums (Webster, 1988). The closest known breeding population is approximately 100 km upstream and to the east of the Forest (GHD, 2009b; Webster, 1988; DECCW, 2009b) and there are only a few reports of observations of foraging individuals, outside of the breeding season, from the Forest (Webster, R. Ecosurveys, pers. comm.). Therefore HBTs are not an important habitat resource for the Superb Parrot in the Forest.

Habitat trees are an element of eucalypt forest structure which may be substantially modified by timber harvesting over longer time periods (Gibbons and Lindenmayer, 1997). Timber harvesting operations conducted in Australian forests may result in a overall reduction in the number of hollow-bearing trees and changes in the spatial arrangement of hollow-bearing trees, including from a random to a clumped distribution (Gibbons and Lindenmayer, 1997).

Common and widespread HBT-dependant fauna such as Brush-tailed Possums, Galahs, Little Corellas and Sulphur-crested Cockatoos were abundant during surveys conducted for the present assessment and do not appear to be disadvantaged by ongoing timber harvesting. Less abundant and aggressive species are likely to be less successful and may suffer from competition with these species if the tree-hollow resource is reduced. It is not clear whether historical timber harvesting of the Forest has reduced the diversity or population sizes of other hollow-dependant fauna. Adequate provision of hollow-bearing trees is a complex issue and must consider longer time scales. Sustainable conservation of habitat trees must account for senescence, storm or bushfire damage to existing habitat trees and recruitment of future habitat trees from younger age classes (Gibbons and Lindermayer, 2004). FNSW timber harvesting of the Forest includes prescriptions for the retention of habitat trees and recruitment trees (GHD, 2009b). No empirical study has been conducted in River Red Gum forests to determine occupancy rates of hollow-bearing trees (Leslie, *unpub*.).

The quantitative habitat tree survey conducted during the site 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 4.1 habitat trees per hectare 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. Variation in numbers of HBTs between vegetation types is summarised in Section 6.1.2. This inherent variation must be considered when assessing the estimates of habitat tree numbers and densities provided above. The site 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 within the Forest. Table 15 provides a breakdown of habitat tree counts and densities in the various sampling locations, including a general description of the survey area as a guide to the likely reasons for this variation. Note that the survey area included a buffer around the infrastructure footprints.

Table 16 Habitat Tree Survey Results

Survey Area (technique)	Feature	Survey Area Extent (ha)	Habitat tree count	Density per ha	Description
Downstream Levee (sampled)	Downstream Levee	41	152	3.7	A range of vegetation types. Typically close to the margins of the forest and relatively intensely disturbed. Includes sections of cleared land and immature regrowth.
Downstream Stop Log Regulators (comprehensive counts)	Downstream Stop Log Regulators	10	79	8.3	Tall, productive River Red Gum Forest dominated by very large mature trees.
Inlet Channel, Regulator and River Road Bridge (comprehensive counts)	Inlet Channel, Regulator and River Road Bridge	56	189	3.4	Includes tall River Red Gum Forest and Inland Grey Box Woodland with a number of large mature trees. Also features treeless areas associated with access tracks, historical disturbance and floodplain depressions.
Return Channel (comprehensive counts)	Return Channel	6	15	2.5	Relatively immature River Red Gum regrowth. Also features a cleared stock yard.
Swan Lagoon Regulators (comprehensive counts)	Swan Lagoon Regulators	3	21	8.1	Tall, productive River Red Gum Forest dominated by very large mature trees.
Supplementary survey areas	Indicative survey areas	13	76	5.9	A range of intact and partially disturbed vegetation types.
Total survey area		**128**	**532**	**4.1**	

As can be seen from Table 15 the greatest densities of habitat trees are associated with the vicinity of the regulators. This is because regulators coincide with drainage lines which 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.

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

- Provision of diurnal roost Forests 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 site 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 contains zero 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 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

Fallen woody debris is a natural component of native vegetation communities and provides an important habitat resource for native fauna, including vertebrates, invertebrates and micro-organisms. For example, MacNally *et al.,* (2002) estimated that more than 40 tonnes of fallen timber per hectare is required to maintain the populations of some vertebrate species such as the Yellow-Footed Antechinus (*Antechinus flavipes*). Woody debris on the floodplain also provides an important habitat component for aquatic fauna, providing shelter, foraging and breeding substrates and territory markers for many fish and aquatic invertebrates. Many native fish are dependant on habitats with dense accumulations of woody debris, including threatened species in the Riverina, such as Trout Cod and Silver Perch, and its removal from the floodplain can reduce the reproductive success of these species.

The coarse woody debris resource in commercial forests is made up of both natural fallen timber and residue from timber harvesting operations. Timber harvesting and silvicultural thinning generate large volumes of woody debris, such that immediately after harvesting the forest contains considerably greater volumes of woody debris than under natural circumstances. The condition for retention of coarse woody debris in a commercial residue harvesting plan is to salvage as much of this material as is economic whilst retaining naturally fallen wooden debris for habitat. The aim of these operations is to remove all

merchantable sawlog residues (as against natural fallen timber). The management prescriptions for both timber harvesting operations provide for the retention and protection of woody debris. If the density and nature of woody debris is not representative of a natural forest then on-ground residue from logging is retained. Densities are estimated with reference to photo standards. In addition, harvesting operations must be undertaken in a manner so as to minimise disturbance to harvest debris and naturally fallen woody debris existing prior to the current operation.

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 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 >20, 000 ha of additional floodplain habitats similar to those in 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 contemporary, managed 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 SF, other State Forests and River Red Gum Forests on private land. Native vegetation cover to the east, south west 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 all 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.

SEPP 44 Assessment

SEPP 44 – Koala Habitat Protection does not apply to this assessment as discussed in Section 3. Nonetheless, the Koala is known from the study area (DECCW, 2009a), is listed in the EARs 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’ which is defined as ‘an area of native vegetation where the trees of the types listed in Schedule 2 of SEPP 44 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component’. River Red Gum is a Schedule 2 feed tree species and comprises well over 15% of the total number of trees in both the upper and lower strata of the tree component of vegetation of the Forest. River Red Gum comprises close to 100 % of the tree component in River Red Gum Forest types, which are the most extensive vegetation types in the Forest. In addition, box woodlands in the Forest are dominated by Black Box and Inland Grey Box, which 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 SF 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. Original populations of the Koala in the study area were hunted to extinction for their pelts during the late 1800’s and early 1900’s (M. Thompson, Forests NSW pers. comm). The current populations are a result of a number of introductions of Koalas, primarily from islands where the populations had become too large and therefore unsustainable (i.e. Kangaroo and French Islands were the main source populations, G. Miller 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 on 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 within 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 included in Section 7 and Appendix C.

6.3 Threatening Processes

A ‘key threatening process’ is defined under the TSC Act as ‘a threatening process specified in Schedule 3’ of the Act. Schedule 6 of the Fisheries Management Act, 1994, also outlines a range of KTPs. 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’.

There is direct evidence of the following key threatening processes (KTPs) currently operating within the Forest:

- Invasion of native plant communities by exotic perennial grasses**;**
- Competition and grazing by the feral European Rabbit ;
- Predation by the European Red Fox;
- Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*);
- Competition by feral honeybees; and
- Herbivory and environmental degradation caused by feral deer.

The following processes are currently operating within the Forest or have operated previously, given the modified landscapes and vegetation communities present in the Forest:

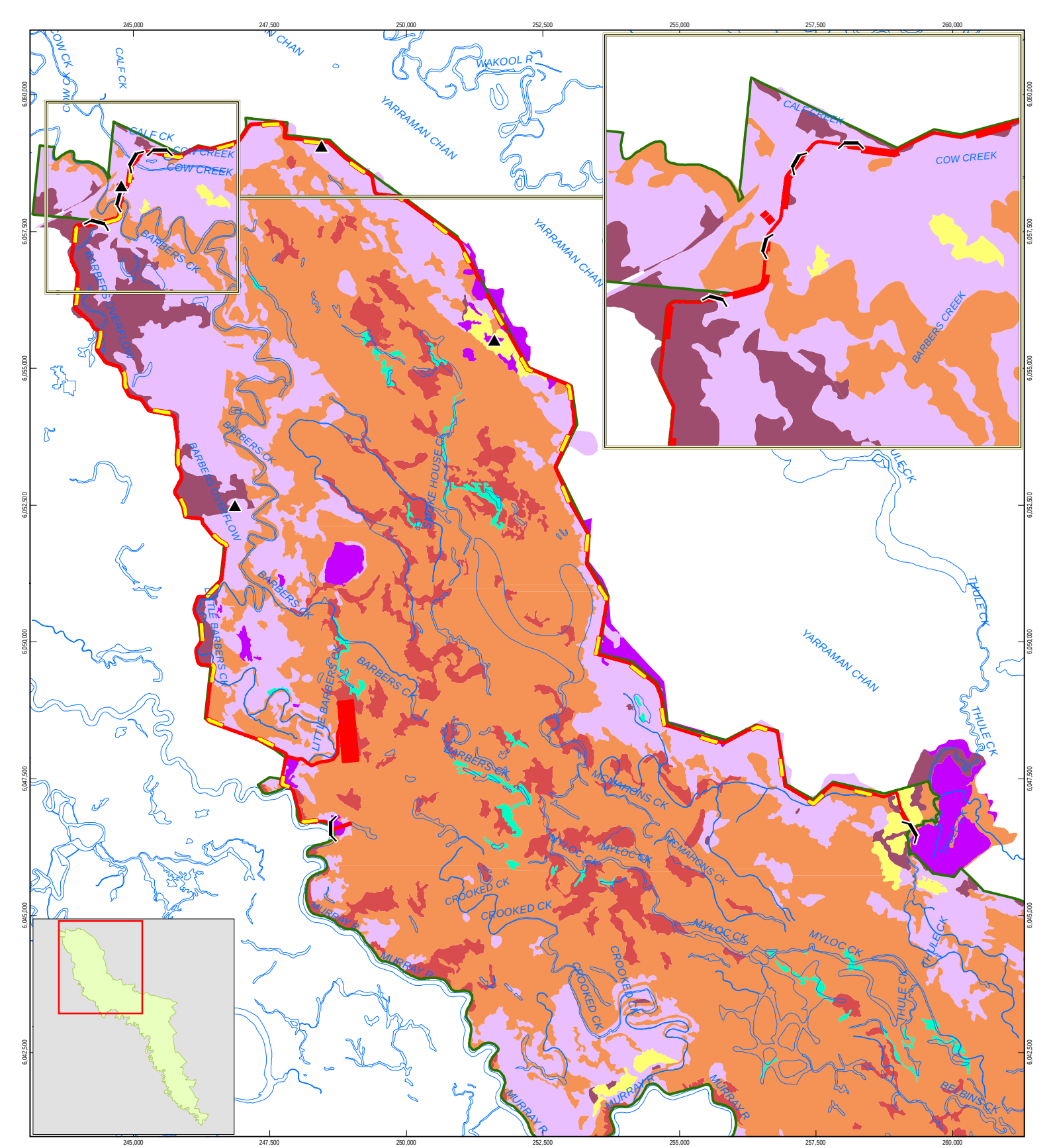
- Clearing of native vegetation;
- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands
- Invasion of native plant communities by exotic perennial grasses;

- Loss of Hollow-bearing Trees; and
- Removal of dead wood and dead trees.

The project will directly contribute to the operation of three KTPs:

- Clearing of native vegetation;
- Loss of Hollow-bearing Trees; and
- Removal of dead wood and dead trees.

The extent and severity of the operation of these processes is described in Section 10.



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

N

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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	C
Date	11 FEB 2010

Figure 10 - Vegetation - downstream section

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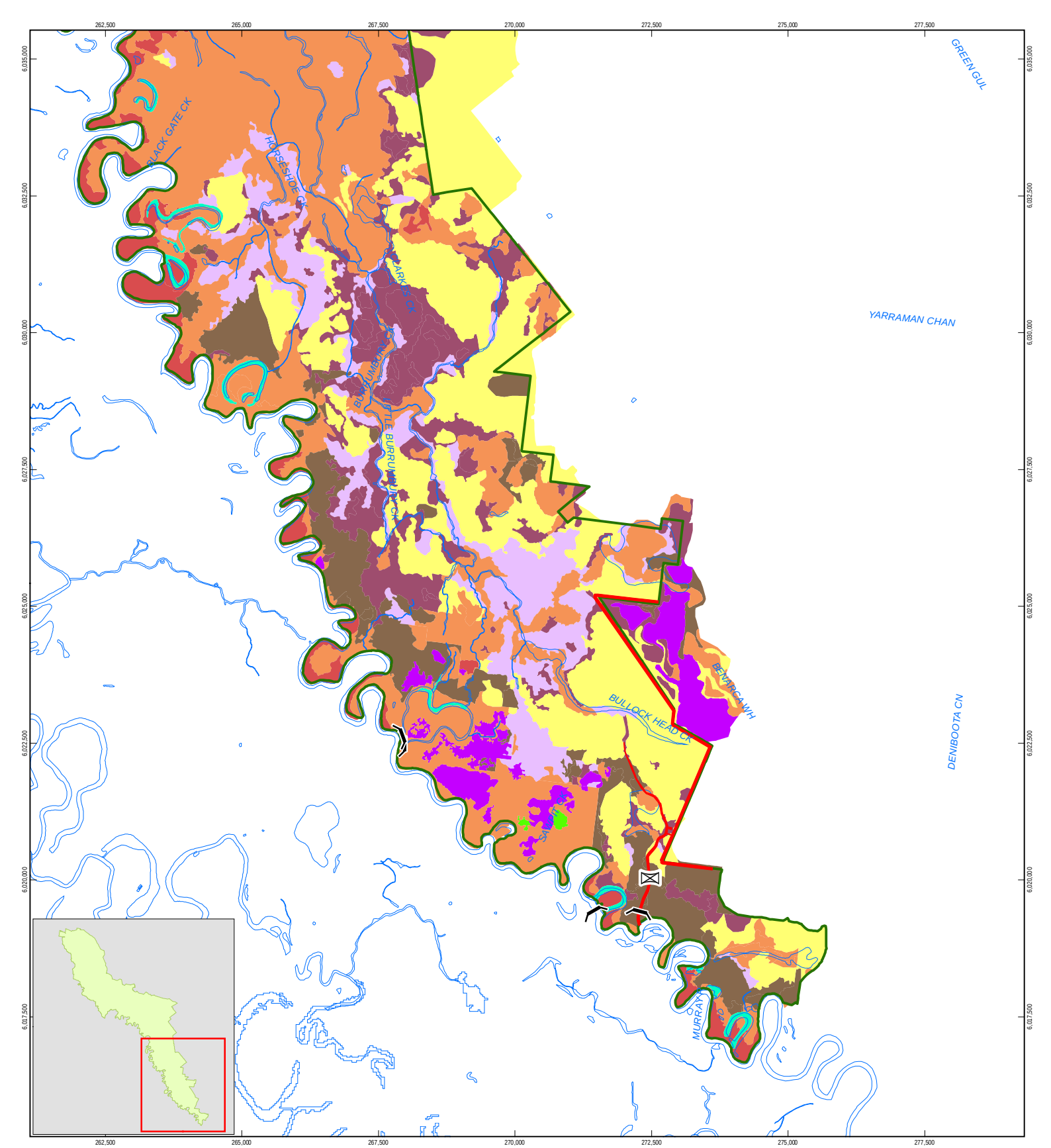
Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

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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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	C
Date	11 FEB 2010

Figure 11 - Vegetation - upstream 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

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