6. Project description

This chapter describes the project and indicative construction method. It also outlines how the project would be operated in accordance with an Operating Plan developed within the framework of The Living Murray Initiative.

6.1 Project overview

The project involves construction and operation of infrastructure with the capacity to divert up to 6,000 ML/d from the Torrumbarry Weir pool into the Koondrook-Perricoota Forest to enhance flood flows to the site. The project has been specifically designed to provide the flexibility to operate within a range of flows to ensure that effective and measurable environmental outcomes are delivered across a broad range of available water.

The structures have been designed to create a major flood event; however they can also control small or medium flows of variable volume and duration. It is intended that large flood events would occur every three to four years and that smaller events would occur more frequently. The large flood events would be capable of inundating up to 52% of the forest, with about 41% (approximately 16,000 ha) of the forest inundated for a period of about 100 days to achieve the Icon Site Environmental Management Plan's (MDBC, 2006) interim objective of maintaining 30% of River Red Gum forest in healthy condition. The project would use the Forest's own unique series of waterways to target the natural distribution of vegetation communities within the forest for inundation during a watering event. The hydrological and hydraulic characteristics of the scheme are discussed further in Section 6.4.

The interim objective of 30% of River Red Gum forest in healthy condition is a spatial target to measure performance of the project. The spatial target was set at 30% as the extent of inundation is related to the spatial limits of potential environmental outcomes and ability of biodiversity and ecosystem functions to persist was considered to diminish significantly below this level (DWE 2008a).

The design is based on comprehensive hydraulic and flood modeling with consideration of environmental, heritage and triple-bottom-line benefits and impacts. The project has been designed to meet the operational, environmental, and risk management parameters outlined in Table 6-1.

Table 6-1 Design requirements

Operational	Environmental	Financial/risk management
◗ Enable a large flood event every 3 to 4 years for approximately 3 to 6 months, and smaller events more frequently ◗ Allow for variable diversion flows up to 6,000 ML/day. ◗ Control flow out of the forest to meet downstream system capacity. ◗ Protect downstream infrastructure and property from flood damage. ◗ Operational flexibility to enable use of opportunistic flows and adjust inflows, outflows and water balances for flooding events. ◗ Sound, functional and well engineered structures with 100 year design life. ◗ Simplistic structures with minimal infrastructure to stream flow operation.	◗ Achieve inundation requirements for high priority vegetation communities as per the draft ecological objectives. ◗ Return flows directly back to Murray River to maximise water savings. ◗ Minimise any impacts on flow distribution during natural flooding events. ◗ Minimise adverse environmental impacts.	◗ Provide effective combinations of structures that enable operational flexibility. ◗ Meet ecological and engineering objectives in a cost-effective fashion. ◗ Recognise and design with consideration of the potential for litigation issues related to changes to inundation.

6.2 Description of the project

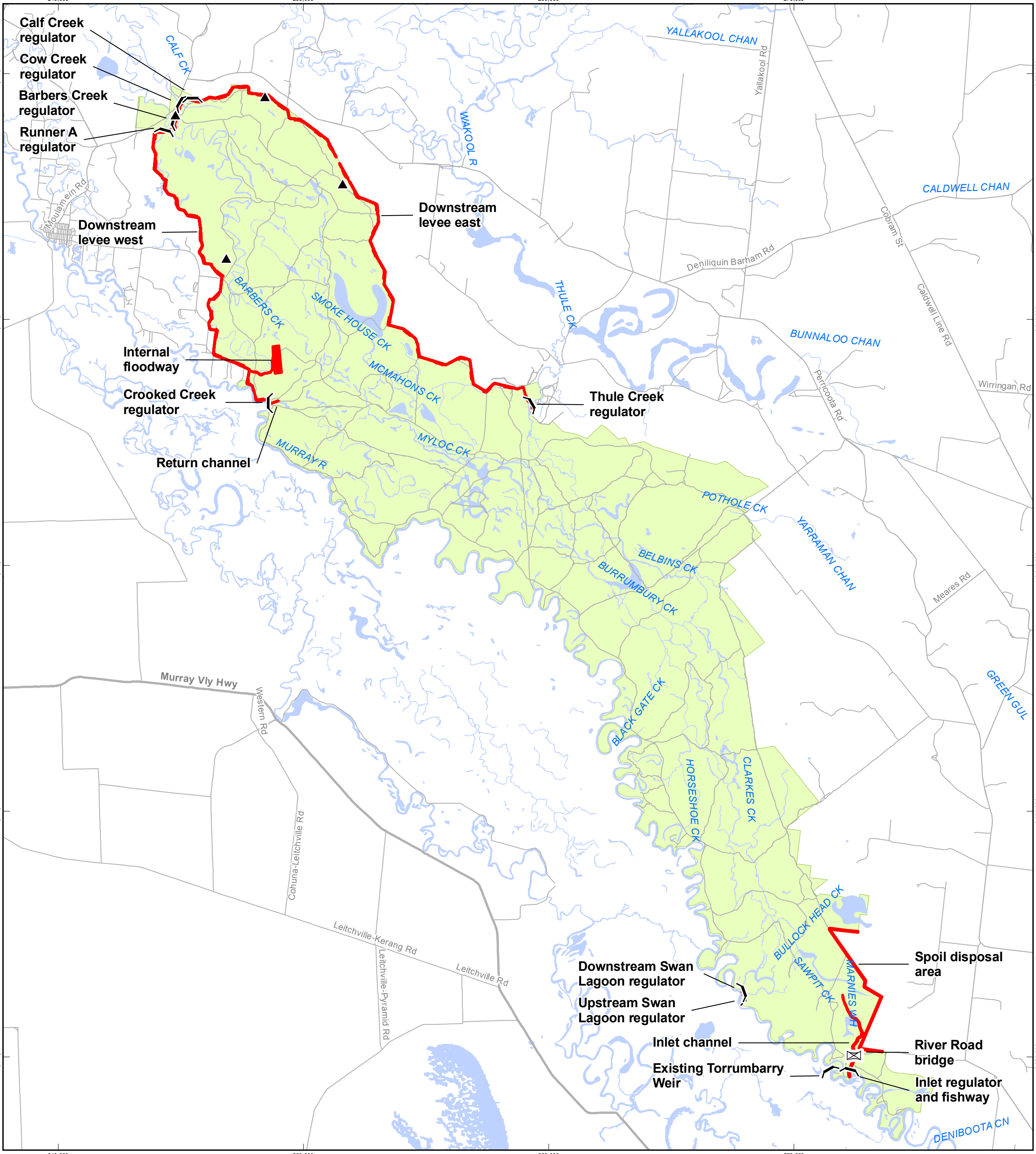
6.2.1 General

Structures that would form part of the project can be classified into the following broad categories:

- Upstream structures to divert water into the forest from Torrumbarry Weir pool. These structures include an inlet channel, inlet regulator and associated infrastructure, as well as regulators at Swan Lagoon to control flows re-entering the Murray River; and
- Downstream structures to control release of water from the forest and to maximise return flows back to the Murray River. These structures include a levee to retain water within the forest, floodway within the forest, as well as regulators and a return channel to discharge water to downstream waterways.

The location of these features is shown in Figure 6-1. Concept drawings for the main structures are provided in Appendix H.

The following sections describe the main structures. These structures would be progressively refined and optimised during detailed design and following engagement of a construction Contractor.



Legend

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

0 1 2 4
Kilometres

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

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Revision B
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Figure 6.1 Location of the main structures

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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: Dept of Commerce, Street Map- Navtec, Drawn: Cwilson, cwilson

6.2.2 Upstream structures

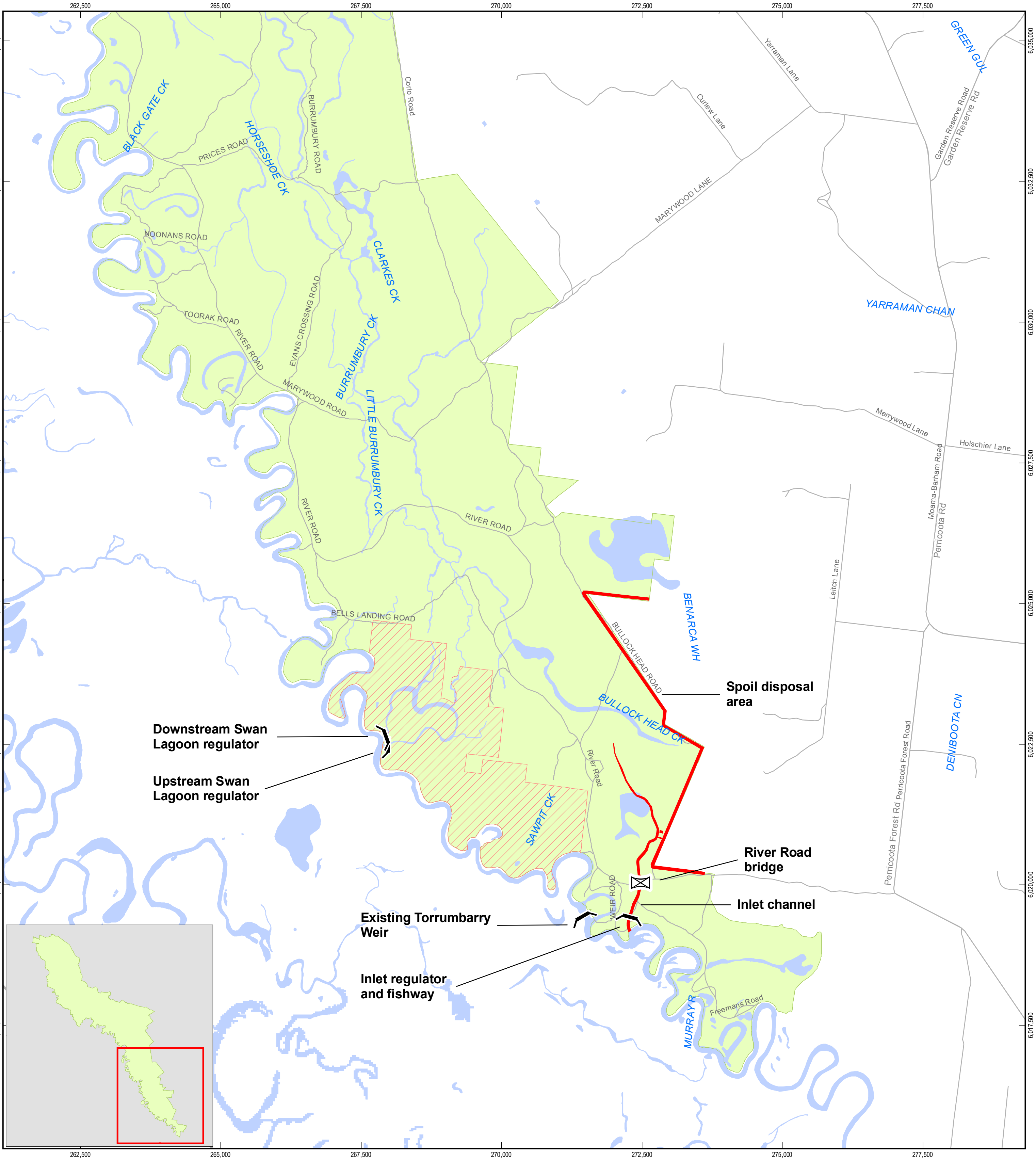
The structural works for the upstream portion of the project would primarily divert flows from the Torrumbarry Weir pool into the forest and prevent diversion flows short circuiting and returning to the Murray River once they reach Swan Lagoon. These structures have been designed to meet the following specific requirements:

- Capability to divert and control up to 6,000 ML/day from Torrumbarry Weir pool (RL 86.05 +/- 0.05);
- Contain diversion flow in the portion of the inlet channel between the Murray River and the inlet regulator;
- Distribute flow to the forest along the length of the cutting between the inlet regulator and the intersection with Bullock Head Creek such that in-channel flow at Bullock Head Creek is approximately 500 ML/day;
- Provide fish passage in and out of the forest and a freshwater turtle escape route in the vicinity of the inlet regulator; and
- The structures have been designed in accordance with relevant engineering and environmental standards and best practice for structures of this nature.

The upstream structures are depicted in Figure 6-2 and include:

- Inlet channel;
- Off-take regulator incorporating a dual fishway and turtle ramp;
- River Road bridge structure; and
- Swan Lagoon regulators.

Each structure is described in the following sections.



Legend

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

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Kilometres

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

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Figure 6.2 - Location of the upstream structures

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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

Inlet channel

The inlet channel would divert water from the Torrumbarry Weir pool on the Murray River to Bullock Head Creek. This is required to connect the Weir pool with the internal drainage system of the Forest. It would be approximately 3.8 km long (to the junction with the Bullock Head Creek on the downstream side) and would generally follow low points through the forest.

The channel would have side batters of 1V:2H and bed widths of 37 m (upstream: Ch 0 to Ch 900) to 10 m (downstream: Ch 900 to Ch 3800). The design is for a maximum velocity of 0.6 m/s. The depth of the channel varies from 2.8 m upstream to 1.2 m downstream, and construction would require excavation of approximately 250,000 m^3.

The channel would have a reverse slope to progressively displace flows out of the channel and onto the floodplain. This would enable flows to be contained in the upstream portion of the inlet channel, and for flows to be progressively spilled from the channel along the downstream sections. Table 6-2 summarises the flow velocities and floodplain intrusion levels for an event of 6,000 ML/day.

Table 6-2 Upstream channel characteristics

Percentage of flow contained within the channel	Theoretical average velocities
100% to Ch 900 (River Rd Bridge)	Channel (except at off-take regulator) 0.16 – 0.59 m/s
50% at Ch 1900	Left flood plain 0 – 0.3 m/s
30% at Ch 3300	Right flood plain 0 – 0.35 m/s
14% at Ch 4300 (within the natural channel at Bullock Head Creek)	

Inlet regulator

The main objectives considered during design of the inlet regulator were that it was required to:

- Provide 6,000 ML/day diversion capacity;
- Maximum velocity at the structure of 1.57 m/s;
- Provide diversion capacity at the specified variable pool range;
- Allow diversion and isolation of up to RL 86.55 (flood of record);
- Provide operational flexibility for effective ramp up and ramp down for diversion discharge hydrograph;
- Provide acceptable flow characteristics and structure profile for downstream fish passage, and
- Provide acceptable flow characteristics for upstream fish passage via fishways.

The inlet regulator would be constructed from reinforced concrete, with five tilting aluminium gates, approximately 3.4 m high by 3.6 m wide, combined with stop log capacity. The height of the gate top when closed would be RL 86.55 (flood of record). The gates would be manually operated by chain/cable fixed to winches mounted on a galvanised steel access bridge across the waterway. An artist's impression of the inlet regulator and associated fishway is provided in Figure 6-3.

The structure would have a sheet pile cut-off wall and a downstream erosion protection sheet pile wall. The floor of the main channel would be about 3 m below the existing surface levels. Downstream reinforced concrete training walls would channel discharge flows, and the channel invert would be protected against erosion by rock blankets.

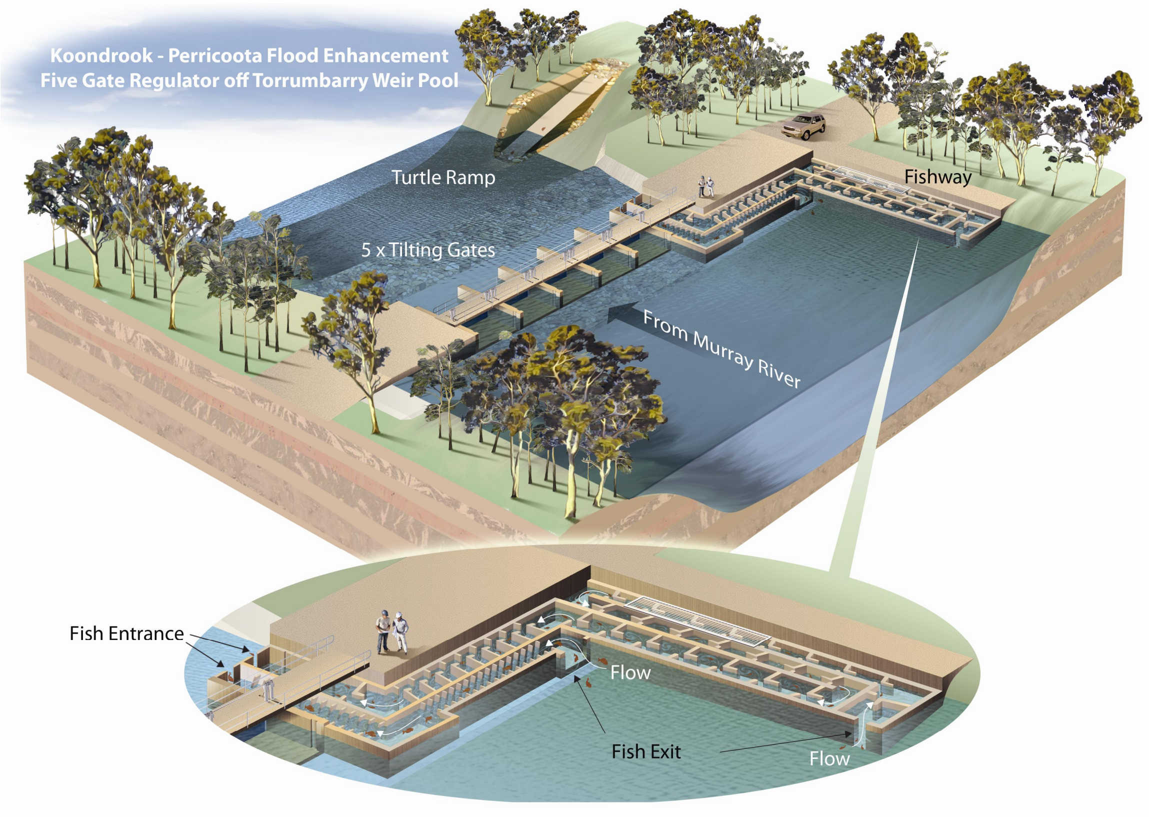


Figure 6-3 Artist's impression of the inlet regulator and fishway

(Image courtesy of NOW).

Dual fishway

A dual fishway would be provided on the inlet regulator to allow fish to leave the forest and enter the Murray River on the recession cycle of a flood event. It would consist of a denil fishway to accommodate the requirements of larger fish and a vertical slot fishway for smaller fish. As indicated in Section 6.4.5, the fishway designs have been developed in consultation with, and approved by, the Fish Passage Task Force.

The fishways consist of a reinforced concrete channel with graded inverts on the main runs and horizontal sections at each return. The denil channel is graded at 10% (1:10) and is fitted with denil baffles, while the vertical slot channel rises at approximately 4% (1:25) and has precast vertical slot baffles. The floor of the vertical slot channel would be covered with 200 mm rocks.

The vertical slot baffles are secured by chemical anchors fixing through stainless steel angles. Fishway trenches have grid flooring covers and handrails installed. Vertical lift gates, stoplogs, access stairways and miscellaneous hardware complete the fishway.

Turtle ramp

The ramp would be provided to enable safe passage for turtles around the inlet regulator and would be located approximately 20 m downstream of the regulator structure where there is lower turbulence and velocity. The ramp would be constructed of rock for erosion protection. Design features include:

- 1V: 8H ramp on downstream right-hand-side cutting bank; and
- Width of 3m.

River Road bridge

The inlet channel would cross River Road near the intersection of Freemans and River Roads, approximately 900 m downstream of the offtake point from the Murray River. A single lane, three span bridge present at this location would be replaced with an all weather, two lane bridge suitable for use by heavy vehicles, including timber trucks. The bridge structure would not obstruct fish and freshwater turtle passage along the channel.

The bridge would be constructed with cast-in-situ reinforced concrete piers and footings, precast prestressed girders and a composite cast-in-situ reinforced concrete deck. Design capability is for equivalent T44 loading to AS 5100 standards. This loading would cater for a heavy timber road train and withstand up to 147 tonnes of total vehicle load on the deck.

The bridge would have reinforced concrete footings supporting reinforced concrete piers and headstocks. The abutments would comprise reinforced concrete founded on fill and flanked by reinforced concrete retaining walls. The bridge would have three pairs of 1m deep “SuperTee” precast, prestressed concrete girders each approximately 20 m long, with cast-in-situ reinforced concrete deck, concrete parapets, and safety barriers.

The channel bed would be approximately 2.4 - 2.7 m below existing surface levels at this location. The footings for the bridge piers would be founded approximately 1 m below the channel bed.

Swan Lagoon regulators

Upstream and downstream gated regulators are proposed in adjacent gullies exiting the Swan Lagoon to the Murray River. These structures would control flows at this point during watering events. They would also allow fish to leave the forest during the recession sequence of a flood event and maintain acceptable waterway characteristics to minimise obstruction to natural flooding events.

There would be two regulators at Swan Lagoon, each with three vertical lift gates and sheet pile walls. The gates would be closed when water is passing through the inlet regulator, and would be operated when the water level in the forest falls to RL 83 to enable return flows to the Murray River during recession of the flood.

The vertical lift gate regulators would comprise a single sheet pile cut-off wall, projecting above the channel floor and forming the weir. The lagoon floor would be protected by a grout matt erosion protection layer. Water retention and release would be controlled by aluminium slide gates, operated by spindles mounted on a galvanised steel access bridge. Spindles would either be driven manually, or by use of a portable electric actuator with portable power source. An artist's impression of the Swan Lagoon regulators is provided in Figure 6-4.

Hydraulic modelling indicates that with Swan Lagoon blocked off, the water level would rise to approximately RL 84 at the site of the regulators during a watering event with the maximum diversion discharge of 6,000 ML/day. Therefore, each regulator would be constructed to a minimum level of RL 84, allowing 0.5 m freeboard for wave action and variation in the water surface.

Representatives from the Fish Passage Task Force advised that research into off-channel habitats of the Murray River indicates that large bodied native fish are likely to leave the floodplain and return to the main stem of the river when the flows start to recede, while small fish are expected to make these movements towards the end of receding flows. Subsequently smaller bodied fish are likely to remain in the remnant pools. The design of the Swan Lagoon structures has been targeted towards allowing safe fish passage for these smaller fish remaining in upstream water bodies back to the Murray River. Discharge velocity through the structures would be lower than the maximum design criteria of 10 m/s and there would be a minimum depth of 300 mm.

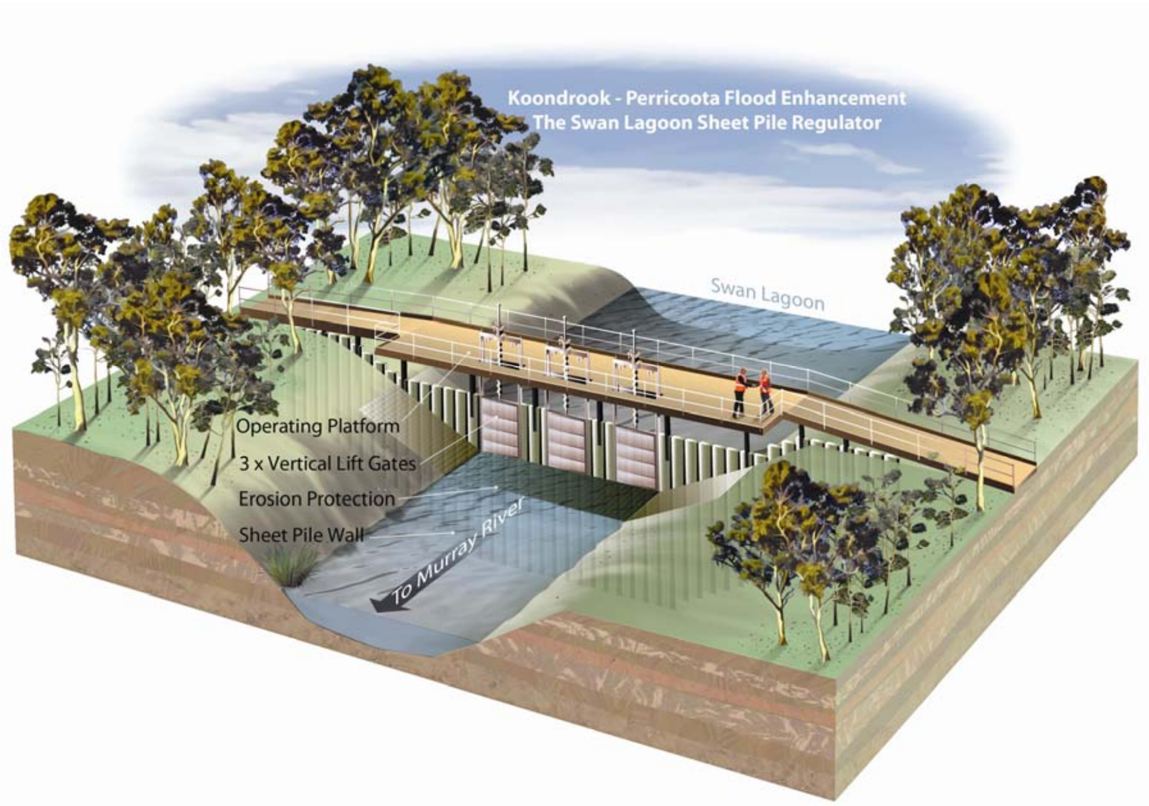


Figure 6-4   Artist's impression of the Swan Lagoon regulators

(Image courtesy of NOW).

Downstream structures

The downstream structures have been designed to meet the following requirements:

- Restrict surface flows into the downstream Barbers Creek system to within the system capacity of 250 ML/day during a managed watering event;
- Provide flood protection to downstream properties;
- Pass uncontrolled floods with minimum obstruction and allow native fish migration; and
- Create significant water savings by returning flows directly back to the Murray River.

Fishways are not proposed to be installed on the downstream regulators as part of this stage of the project. In discussions with the Fish Passage Task Force, agreement was reached that monitoring would be undertaken during the initial operating events to determine whether fish are attracted to flows discharged from the forest. This would determine the species, size, and number of fish associated with different sized events and different locations. The results of the monitoring would be reviewed by the proponent and the Fish Passage Task Force to determine whether the project should be modified to include a fishway, and if so, agree on an appropriate design. To accommodate this scenario, the regulator on Barbers Creek has been designed to enable it to be retrofitted with a fishway at a later date (refer to Section 4.2.3).

The downstream structures are depicted in Figure 6-5 and include:

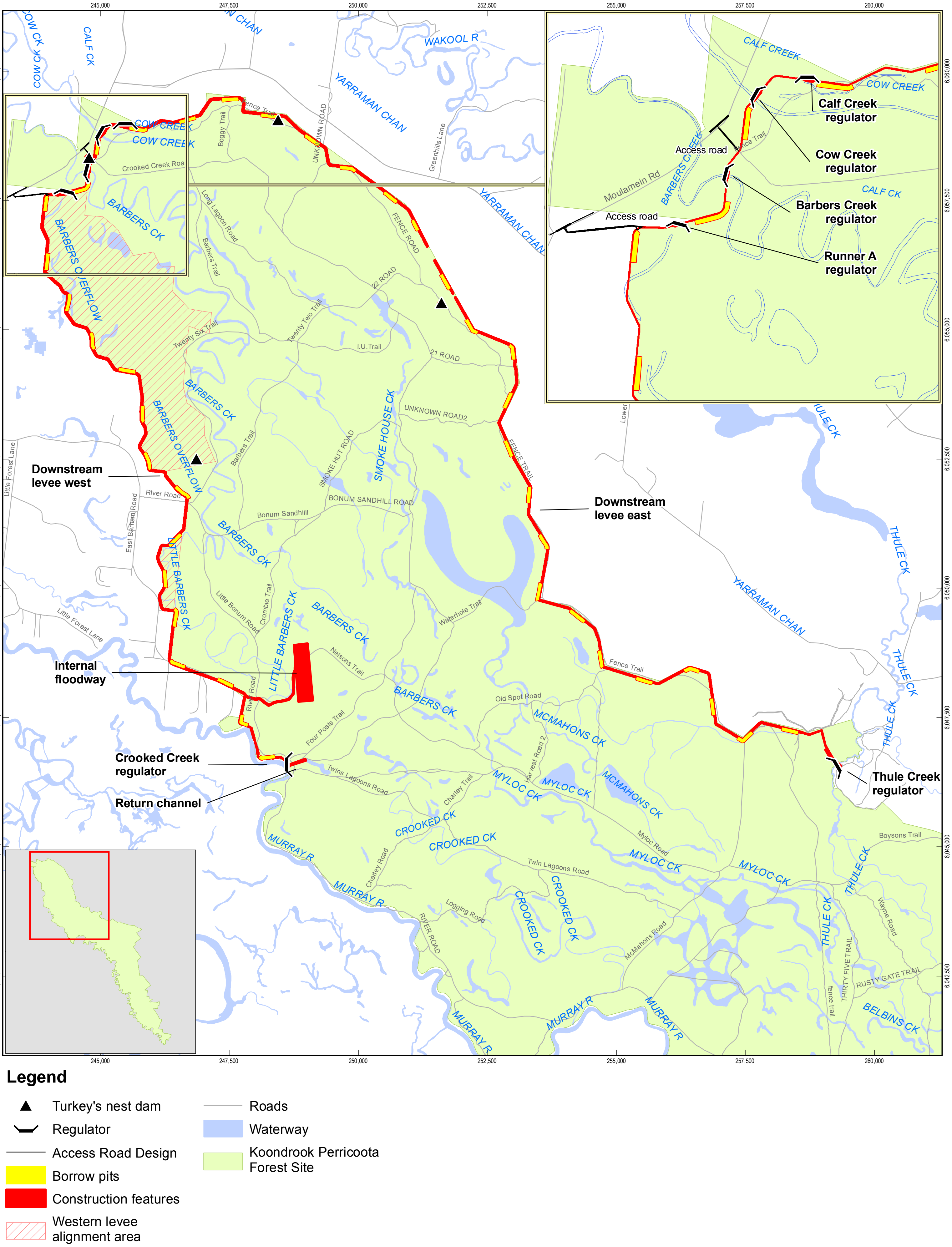
- Five stop log regulators at downstream main creeks/outflow points;
- Downstream levee;
- Return channel;
- Floodway; and
- Return channel regulator and Murray River junction drop-down structure.

Stop log regulators

Stop log regulators would be constructed on Runner A, Barbers Creek, Cow Creek, Calf Creek and Thule Creek to retain flows within the forest during a flooding event. The regulators would typically consist of an upstream sheet pile cut-off wall and a downstream scour control wall. Walls range from 9 m long sheets to 3 m long sheets, generally driven to approximately 1 m below creek bed level. Sheet pile cut-off walls would be capped with cast-in-situ concrete edge-beam and slab supporting the buttress walls and stop-logs. The anti-scour wall would be capped by the apron slab. Underlying the apron slabs is a sand and gravel drainage layer with weep holes.

The embankments either side of the regulators would feature reinforced concrete wing walls and abutment walls. Rock protection layers would be placed on both upstream and downstream sides of the structures.

The number of bays and waterway areas were designed to accommodate discharge of the 1956 flood of record to ensure the project is able to pass large flood events with minimal interference (DoC, 2008). The design also provides for low velocities for fish passage (up to 1 m/s maximum). The height of the structures is based on the design pool RL 78.5 and operating deck level requirements.



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Kilometres

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

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Figure 6.5 - Location of downstream structures

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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

The regulators function by allowing concrete stop-logs to be added or removed from the bays to raise or lower the pool level. The stop-logs would be stored adjacent to the regulators and would be manoeuvred into place using a crane. When not in use, the stop logs would be stored in dedicated areas in the immediate vicinity of the regulators.

An artist impression of the stop-log regulator on Barbers Creek is provided in Figure 6-6.

Figure 6-6 Artist's impression of the stop-log regulator on Barbers Creek

(Image courtesy of NOW).

Downstream levee

The downstream levee has been designed to manage the extent of flooding within the Forest and also to enable water to circulate and be discharged directly to the Murray River via the return channel. The levee would contain the inundation pool to RL 78.5.

The levee would be approximately 42 km long and 4 m wide at the crest with 1V:2H batters. It would be up to 22 m wide and the width would vary depending on the height of the levee at different locations. The height would vary from zero to approximately 4 m above the floodplain, with an average height of 2.5 m and the maximum height achieved at the downstream regulators. The levee would be wider in the vicinity of the regulators to enable stop log structure storage and operational vehicle movement and turning.

The location of the downstream levee is shown in Figure 6-5 and was selected to maximise the area of forest that would be inundated, and minimise the area of private property affected and clearing of native vegetation required. The western portion of the levee would be located in the vicinity of an existing licensed levee that protects the town of Barham from floodwaters. This portion is located on land that has been acquired by Forests NSW for the project and would be added to the Koondrook State Forest. The eastern portion of the levee would be located in the immediate vicinity of the forest boundary.

The levee alignment identified in Figure 6-5 is based on the downstream perimeter of the pool maintained at RL 78.5. It represents locations where a levee would be constructed as well as higher points in the landscape where the natural elevation is above RL 78.5 and a levee is not required. A track would be located along the levee alignment to provide vehicular access to the downstream regulators during inundation events.

An artist's impression of the levee during an inundation event is provided in Figure 6-7.

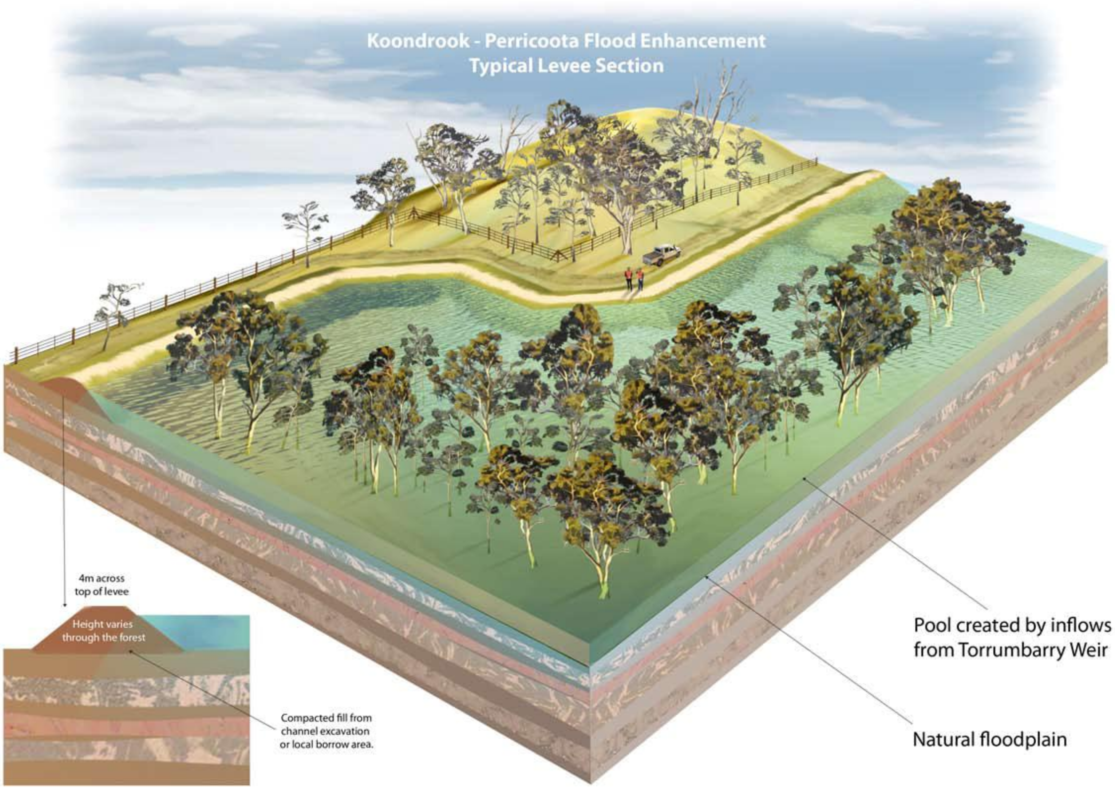


Figure 6-7 Artist's impression of the downstream levee during an inundation event

(Image courtesy of NOW).

Floodway

A floodway approximately 1 km long and 500 m wide would be constructed to the north of the return channel to convey flows to the Murray River via the Crooked Creek system. It would provide a mechanism to transfer water from the main downstream pool to the Crooked Creek system and is required because there is currently insufficient hydraulic capacity at this location.

The design discharge would be 2,000 ML/day with a maximum velocity of 0.15 m/s. The floodway would have a constant bed of RL 77.8 and construction would involve an average excavation depth of 0.5 m and removal of approximately 123,000 m^3.

Return channel

The return channel would be located at the shortest connection point between the Murray River and the upstream end of Crooked Creek. It has been sited as far downstream as possible to maximise water infiltration through the forest and has the following basic functions:

- Provide water savings via direct return of flow to the Murray River; and
- Provide of an overflow/spillway system to protect the safety of the downstream structures.

The channel would be approximately 350 m long and 20 m wide with an average depth of 1.5 m. Batters would be 1V:2H with a bed grade of 1V:2000H. Approximately 13,000 m^3 would be excavated to construct the channel.

The design maximum flow would be 1,850 ML/day with a flow velocity of 0.6 m/s. Discharges from the return channel would be controlled by a regulator as discussed below.

An artist's impression of the regulator on the return channel is shown in Figure 6-8.

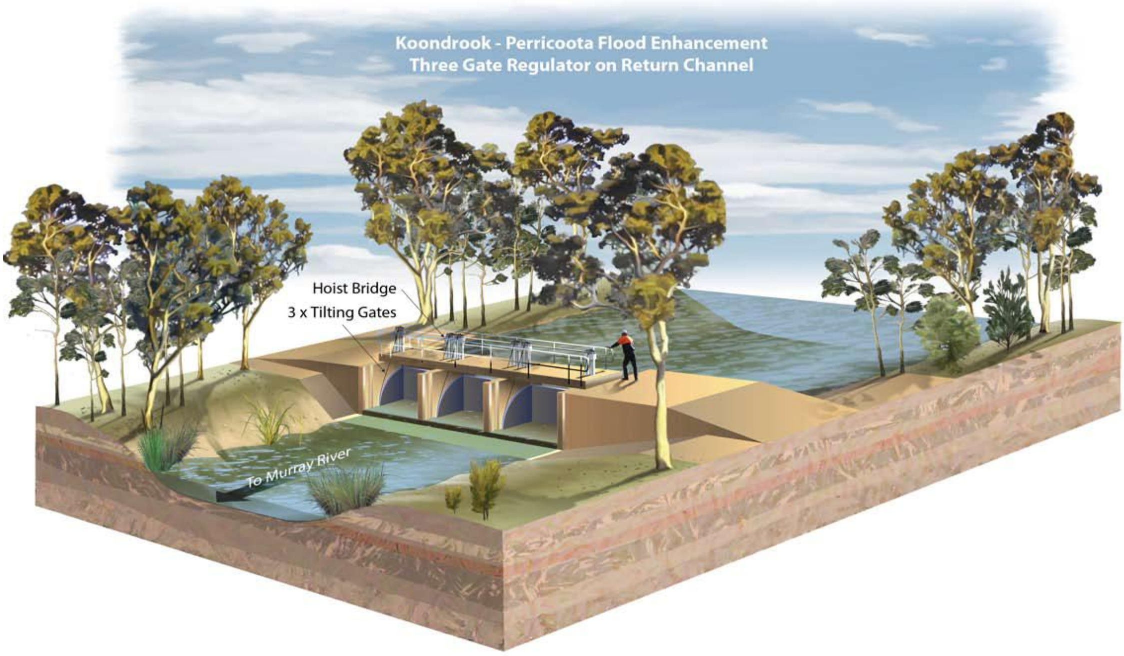


Figure 6-8 Artist's impression of a regulator on the return channel

(Image courtesy of NOW).

Return channel regulator

The return channel would be fitted with a regulator to control discharges to the Murray River. It would be a reinforced concrete structure similar to the inlet regulator and would have the ability to regulate flows up to 1,850 ML/day and contain the flood pool at RL 78.5. It has been designed to allow a high degree of operational flexibility to control flows returning to the Murray River.

The structure would have a sheet pile cut-off wall and a downstream erosion protection sheet pile wall. The regulator would be a tilting gate type, combined with stop-log capability. A reinforced concrete in-situ base slab and downstream apron slab encapsulate the heads of the sheet piling and support the buttress walls between the tilting gates. The buttress walls incorporate stop-log slots.

The gates would be manually operated by chain/cable fixed to winches mounted on a galvanised steel access bridge across the waterway.

There would be downstream reinforced concrete training walls to channel discharge flows, and the bed of the channel would be protected against erosion by rock blankets.

As the level of water in the Murray River would be several metres below the return channel bed, a drop down structure would be incorporated into the regulator design at the downstream end of the return channel to safely transfer return channel flow to the Murray River.

6.3 Construction

The following section describes an indicative construction method for the main components of the project described in Section 6.2 and is based on the Constructability Report prepared by MacMahon (2009). This report is based on the concept design and discusses:

- Construction methods and sequence of works;
- Environmental impacts during construction; and
- Construction risks and opportunities.

The construction method would be refined by the construction contractor during the detailed design phase of the project.

6.3.1 Construction footprint

This Environmental Assessment is based on indicative infrastructure locations presented in Figure 6-2 and Figure 6-5 and on the construction methods and sequence of works described in the Final Draft Constructability Report (MacMahon, 2009).

The magnitude and duration of impacts arising from the project would vary with the type of infrastructure as follows:

- Permanent impacts would be associated with:
  - Permanent removal of native vegetation and habitat at the locations of regulators;
  - Permanent modification of native vegetation habitat would occur along the downstream levee which would contain regenerating native understorey vegetation on the batter slopes, and the inlet channel, which would contain regenerating native understorey, including wetland herbs and grasses; and
- Temporary impacts. These would occur in locations where native vegetation and habitat would be removed to enable construction to proceed and would be allowed to regenerate naturally following completion of construction. These areas include the construction laydown areas, floodway, spoil disposal area, and borrow pits. Section 6.3.14 outlines rehabilitation that would occur following completion of substantial construction to restore affected areas to pre-existing conditions, where practicable, to assist regeneration.

The locations and detailed design of project infrastructure and construction methods would be defined by the construction contractor. Therefore, this Environmental Assessment is based on indicative footprints located within a construction corridor. Indicative temporary and permanent disturbance footprints for the infrastructure are summarised in Table 6-3.

While the contractor may refine the infrastructure, it is constrained to within metres of the indicative locations and would not extend beyond the temporary disturbance footprint. Although the location of construction compounds and associated facilities are yet to be confirmed, these features would be located in the temporary footprint outlined in Table 6-3. Access to construction sites along the alignment of the inlet channel and downstream levee, including associated infrastructure sites and construction compounds, would be provided from within the construction footprint. Turkey nest dams would also be sited in existing cleared areas where practicable.

As the temporary construction footprint would be influenced by the construction method, the contractor would be required to ensure that due diligence is exercised during planning and execution to identify and implement reasonable and feasible opportunities to avoid or otherwise minimise adverse impacts.

The construction footprint represents an estimated maximum area of surface disturbance and the contractor would implement measures to minimise the disturbance footprint by confining activities to existing cleared or disturbed areas where practicable. The total area required for the temporary construction footprint and permanent infrastructure footprint is unlikely to differ substantially from the estimates in Table 6-3.

The disturbance footprint includes an estimate of the area required for construction of access roads to those structures that are unable to be accessed either from the construction corridor or the existing forest road network. These sites include:

- Internal floodway –this is likely to be accessed from a track extending from the downstream levee alignment;
- Swan Lagoon regulators – this would be accessed from a track extending from the existing forest road network; and
- Spoil disposal site – this would be accessed from a track extending from the existing forest road network.

The location of these tracks would be determined by the contractor. Alignments for new tracks would be selected to minimise impacts, would traverse existing disturbed areas and would avoid endangered ecological communities where practicable.

Table 6-3 Construction corridors and footprints for infrastructure

Project Infrastructure	Temporary disturbance footprint (ha)	Permanent disturbance footprint (ha)
Haul roads (indicative)	2.7	0
Site facilities (indicative)	0.77	0
Upstream Structures		
Inlet channel and inlet regulator and fishways	14.39	14.39
Swan Lagoon regulators	0.15	0.15
Spoil disposal area	38.97	0
Downstream Structures		
Downstream levee alignment	69.55	69.55
Downstream stop log regulators	2.6	2.6
Internal floodway	29.94	0
Borrow pits	44.31	0
Return channel, return channel regulator and exit structure	1.06	1.06

Project Infrastructure	Temporary disturbance footprint (ha)	Permanent disturbance footprint (ha)
Turkey nest dams (four)	1.47	0
Total	**205.92**	**87.75**

6.3.2 Site preparation

Site preparation would involve activities such as removal of vegetation along the construction footprint and establishment of site compounds. The contractor would undertake clearing that is required to allow the project to be constructed and would implement strategies to minimise the area of vegetation cleared. A strategy would be developed to manage potential impacts on habitat trees and this would involve a pre-clearance survey for habitat trees prior to clearing in the affected locality.

All vegetation that is cleared would be removed from the site, apart from:

- Possible stockpiling of logs for a maximum of 3 months of timber beside construction areas.
- Stockpiling stumps on the former Toorangabby property for up to 12 months for reuse. Opportunities would be investigated to reuse stumps in restoration projects, such as re-snagging in the Murray River; and
- Relocating felled fauna-bearing trees in nearby forest.

Cleared vegetation would not be burnt within the forest as this would present a substantial bushfire risk.

Some vegetation would be mulched and reused on site to stabilise selected areas disturbed by construction.

The Construction Environmental Management Plan (CEMP) would detail measures to be implemented to minimise impacts associated with clearing and manage the cleared vegetation.

6.3.3 Concrete structures

Stop-log regulators

The following sequence may be implemented to construct the stop-log regulators:

- Earthworks to trim the land surface and excavate trenches to enable sheet piling to be driven to finished levels. Excavation would also be required for the base slab to allow construction of the reinforced concrete base slab and buttress walls;
- Construct concrete deck superstructure;
- Construct reinforced concrete wing walls and backfill approaches behind wing walls;
- Install road safety barriers on approaches and deck;
- Place rock erosion protection layer; and
- Clean-up and demobilise.

Gated regulators

Two types of gated regulators are required for the project. The inlet channel and Crooked Creek return channel would be fitted with tilting gate ("layflat") regulators combined with stop-logs. Vertical lift gate regulators would be fitted at Swan Lagoon.

Tilting gate regulators

The following sequence of activities may be adopted to construct the tilting gate regulators:

- Excavate channels to provide safe and efficient access, working space and laydown areas for permanent and temporary materials. Ensure there are sufficient working areas for cranes, concrete delivery trucks and concrete pumps;
- Construct concrete floor slabs, apron slabs, retaining walls, abutment walls, and training walls;
- Install and commission tilting gates and access bridge;
- Backfill behind abutments and construct ramps;
- Place rock protection layers; and
- Clean up and demobilise.

Vertical lift gate regulators

The following sequence of activities may be adopted to construct the vertical lift gate regulators:

- Trim banks and floor of channel to required profile;
- Drive sheet piling;
- Install access bridge;
- Install slide gates and spindles; and
- Install "grout matt" erosion protection.

Fishways

The following sequence of activities may be adopted to construct the fishways:

- Excavation and ground preparation, including removal and replacement of any unsuitable foundation materials. Install sheet pile coffer dam at return channel. Dewater coffer dam and excavate to the required depth to encounter sound foundation material;
- Starting at the lowest levels, construct floors to the required lines and grades. Supporting walls for multiple cells would be constructed progressively to enable higher level floors to be constructed. When all floors have been poured, freestanding walls would be constructed;
- Deck grating and other cast-in metalwork would be installed progressively;
- Install precast baffles/ denil baffles and place rocks in channel floors;
- Install all miscellaneous metalwork and other items; and
- Remove sheet pile coffer dam at return channel.

River Road bridge

The following sequence of activities may be adopted to construct the bridge over River Road:

- Excavation to form the channel profile under and beside the bridge. This would be sufficient to allow working space and laydown areas within the channel. Excavated material would be used to construct the River Road bridge approach ramps and also to create ramps into the channel for access for concrete trucks, cranes and jinkers transporting girders;
- Construct footings, piers and abutments;
- Install precast girders and construct in-situ bridge deck, parapets, and wing walls;
- Install traffic barrier railing and rock batter protection;
- Final trimming and shaping of River Road and all earthworks batters; and
- Clean up and move demobilise.

6.3.4 Earthwork structures

The earthworks structures include the inlet channel, downstream levee, Crooked Creek return channel, internal floodway, and access road to the Swan Lagoon regulator. These are predominantly constructed within the forest, with some areas of the downstream levee on land that has been acquired for the project. The forest is a moderately wooded area, with a mixture of merchantable trees (River Red Gums), timber suitable for firewood, and non-commercial timber, including tree stumps. Sites for trench excavation and levee embankment construction would be cleared of all vegetation, including removal of tree stumps. The floodway would be substantially cleared to allow efficient earthworks operations. Borrow pits for embankment material would also be cleared prior to excavation.

Typically, earthworks that occur less than about 2.5 km from the disposal site (fill or spoil area) would be carried out using scrapers. Hauls of between approximately 2.5 km and 5 – 8 km are most suited to off-highway dump trucks, either articulated or rigid. Hauls beyond 8 km are most economically undertaken using highway-type trucks. The type of machine to be used would be determined by the contractor.

Materials to be used in the embankment would be pre-conditioned in the borrow pits to achieve optimum mixing and moisture distribution for use in levee construction.

Water for conditioning and dust suppression would be obtained from turkey's nest dams constructed at discrete locations around the levee and near the inlet channel. The water would be distributed by water carts mounted on scrapers, articulated dump trucks or rigid dump trucks. Water would be sourced from bores, the Murray River or irrigation canals, depending on availability of licences and price, and pumped into the dams.

Material is likely to be compacted using padfoot rollers (e.g. Cat 825), and batters, haul roads and other finished surfaces would be trimmed using graders. Fuelling and workshop facilities are likely to be established at a convenient location near the levee, with another facility near the upstream channel.

Inlet channel

Topsoil would be removed from the channel footprint and stockpiled for reuse on the spoil disposal site and channel batters. Excavation for bridge construction and the regulator is likely to be completed in advance of bulk excavation of the channel.

Excavation would commence at a location near the spoil disposal site to minimise unnecessary disturbance of the natural surface for haul roads. Excavation would then move progressively away from this location, in both upstream and downstream directions, using the excavated channel as the haul and return roads. Temporary ramps would be constructed to allow scrapers to enter and exit the channel.

Excavation of the inlet channel would generate about 250,000m^3 of spoil that would be stored adjacent to an existing levee near the upstream boundary of the forest. Figure 6-2 shows an indicative storage location for the spoil that is between the existing levee and the boundary of the forest. The final location for spoil storage would be determined during detailed design and would be placed so that it is equal to or below the top of the levee to minimise potential impacts on the hydrology of the floodplain in this area.

Temporary ramps would also be required at the regulator to allow scrapers to bypass the regulator during and after construction. At the completion of excavation, all ramps would be removed and batters would be trimmed to the required profile.

A “plug” about 20m long would remain between the Murray River and excavated channel. Once the channel and upstream regulator are complete, the regulator would be closed and the channel would be flooded by pumping from the Murray River. This would enable the regulator to be commissioned and ensure no leakage, and would also equalise the pressure on both sides of the plug. The plug would be excavated using a hydraulic excavator digging underwater and the excavated material would be hauled to the spoil disposal site. The channel upstream of the regulator would remain inundated unless the water level upstream of Torrumbarry Weir drops.

The profile of the underwater excavation would be controlled and verified using sonar or GPS equipment linked to the excavator. Sedimentation of the Torrumbarry Weir storage area may be prevented by options such as installation of a silt curtain secured around the mouth of the channel opening.

Downstream levee construction

Topsoil would be stripped and stockpiled adjacent to the alignment for later replacement on the levee batters and final surface of the borrow pits.

Earthworks are likely to be carried out by two separate earthworks fleets operating concurrently. Works would commence near Barbers Creek, with embankment construction progressing both north and south away from this central point. The central servicing workshop and construction depot would be established at this location. Gaps would be left in the levee at the regulator sites until the structures are completed, at which time the structures would be backfilled and the embankment tied in and completed.

Approximately 800,000 m^3 of fill would be required to construct the levee (refer to Table 6-4), the majority of which would be sourced from borrow pits in the vicinity of the levee alignment. It is anticipated that approximately 40 borrow pits would be required and these would be spaced intermittently along the alignment. At least 10 m separation of the borrow area from the levee would be required and where possible, a 4 m wide corridor either side of the levee would be established to allow for maintenance. Indicative borrow pit locations are shown on Figure 6-5 and are based on the assumption that they would be spaced approximately 1 km apart. Borrow pits are unlikely to be required in all locations shown in Figure 6-5 and the actual locations would be determined by the contractor during construction planning following detailed consideration of the volume of material required at individual locations.

Borrow pits are likely to be more closely spaced, or larger, near the higher sections of the levee. Each borrow pit would be approximately 25 m wide, 250 m long and 2.5 m deep to yield approximately 15,000 m^3 of material. Batter slopes of 3:1 would allow for safe movement by personnel and vehicles around the pits, and entry and exit ramps would allow scrapers and other vehicles to gain ingress and egress.

While most of the fill material is expected to be sourced from borrow pits adjacent to the levee alignment, other potential sources include excavated soils from construction of the return channel and internal floodway.

Table 6-4 Downstream levee earthworks summary

Item	Approximate solid volume (m^3)
Total downstream levee requirement	800,000
Potential available material from borrow sources:	
Return channel excavation	13,000
Floodway excavation	123,000
Other structures - foundation excavations	10,000
Approximate balance from borrow pits along the alignment	654,000

Borrow pits would be deep ripped and water added at pre-determined rates, based on in-situ moisture contents and optimum moisture contents to ensure it is suitable for levee construction. This process is referred to as ‘conditioning’. The borrow material would be scarified, ploughed or tyned to achieve reasonably uniform moisture throughout the mass of soil. This conditioning process would most likely be carried out as a nightshift operation to reduce congestion in the borrow pit, maximise efficiency, increase plant utilisation and minimise water losses through evaporation.

Stockpiled topsoil would be placed on the surface of the borrow pits following completion of excavation. The borrow pits would retain water after forest flooding and would regenerate naturally.

Floodway

It is likely that all trees would be removed from the floodway prior to excavation commencing to allow the works to proceed as efficiently as possible. It may be possible to leave a small number of selected trees, such as habitat trees, without having an undue impact on operational efficiency.

Excavation would generally be shallow cuts from an undulating surface and would generate about 123,000m^3 of material that would be transported to use in construction of the downstream levee.

6.3.5 Construction water supply

Water demand for construction works is likely to be in the order of 3 – 4 ML/day for up to 8 months, which equates to about some 700 – 750 ML in total. It would be used to condition soil materials and suppress dust on the haul roads, and river water or ground water would be suitable.

Advice from NOW and State Water indicates that a licence would be required to source the water from bores, pump it from the Murray River or divert it from irrigation channels.

To ensure no disruption to construction progress, a minimum of three days water supply would be provided at each storage location i.e. 10-12 ML. Dams would be constructed as turkey's nest dams (half in and half out of the ground), with nominal depth of approximately 4m. Each dam would be about 55m x 55m and would remain in place following completion of construction. The dams would be located in existing cleared areas and possible locations are indicated on Figure 6-5.

Approximately 3,000 – 5,000 litres of potable water would be used by the project each day. Storage tanks of 2,000 – 5,000 litres capacity, depending on the numbers of workforce personnel working at each site, would be located at each site compound. These tanks would be filled by road-registered water carts purchasing water from the Barham town water supply using licensed contractors.

6.3.6 Construction access

Local roads

Worksites would be accessed via public roads, and this would include traffic movements required to mobilise and demobilise site sheds, construction plant and equipment, and deliver construction materials.

The main access point for the downstream work sites would be at the main workshop facility that is likely to be established within the forest in the vicinity of Barbers Creek/Cow Creek. A safe exit/entry point would be established off Moulamein Road and this would involve providing appropriate warning signage to motorists travelling along Moulamein Road. Access for construction plant and materials, and workforce personnel for the internal floodway, Thule Creek regulator and Swan Lagoon regulators would utilise Moulamein Road, Barham Road, Perricoota Road and Thule Road before accessing roads within the forest. The entry point for the upstream works is likely to be from Moama, via Perricoota Road, Perricoota Forest Road and Nineteen Mile Road, before joining River Road within the Forest.

Haulage of earthworks materials would be restricted to roads within the forest.

Anticipated traffic movements (each way) on each of these routes are shown in Table 6-5.

Table 6-5 Anticipated construction traffic movements

Activity	Moulamein Rd, Barbers Creek		Moulamein Rd, Perricoota Rd, Thule Rd		Perricoota Rd, Perricoota Forest Rd and Nineteen Mile Rd	
	Construction period – Month 2 - 9		Construction period – Month 3 - 6		Construction Period – Month 3 – 9	
	Max Daily	Total	Max Daily	Total	Max Daily	Total
Light vehicles (cars, utes)	50	8,000	5	500	20	1,300
Heavy haulage (Permit loads)	25	800	3	20	5	200
Construction materials	35	1,500	6	200	6	800

Haul roads

Haulage of earthworks materials would be restricted to roads within the Forest. Ideally, haul roads and haul distances would be as short as possible to minimise cycle times. Short access ramps onto the levee and a series of off-ramps and return roads to the borrow pits would be designed to minimise impact on the forest. One-direction haul roads would be a minimum 8m wide, while two-way haul roads should be at least 12m wide.

A haul and return road 12m wide between the return channel and the nearest section of the levee would be required. It is probable that the excavated channel would be utilised as a haul and return road for part of the cycle distance.

The floodway would be about 4 - 5 km from the nearest section of the downstream levee. Material excavated from the floodway would be transported to the downstream levee for reuse via a 2-way, 12m wide haul road.

Minor access roads to the sites of all structures would also be required. Access to sites along the inlet channel and downstream levee would be provided from within the construction footprint for these structures and the forest road network. As such, new access tracks would not be required for these structures.

Access to the spoil disposal area, Swan Lagoon regulators, and internal floodway would be provided from new access tracks extending from the existing forest road network. Where possible, these access roads would follow established forest roads and short branch lines would be constructed to the actual sites. These access routes would need to be suitable for construction plant, including concrete trucks. The access track to the location of the new bridge on River Road would be of a higher standard to provide access for an 80 tonne all-terrain crane and a number of trucks and jinkers hauling bridge girders.

Where practical, new access roads would be constructed in accordance with Forests NSW existing procedures for roads and fire trails in State forests. These procedures are detailed in *Forest Practices Code Part 4, Forest Roads and Fire Trails* (February 1999). The contractor would also implement strategies to minimise impacts associated construction and operation of new access tracks, including avoiding, or otherwise minimising impacts on threatened species, endangered ecological communities and areas of indigenous heritage significance.

6.3.7 Construction timing and hours

It is anticipated that construction would occur over a period of about 9 months, commencing in October 2010 and finishing in June 2011.

Crews would work on the project six days per week during the following general construction hours:

- Monday – Saturday – 7 am – 6.30 pm; and
- No work on Sunday or public holidays.

There may be occasions where work occurs outside these hours. For example, it is likely that soil conditioning in the borrow pits may be undertaken during evening and night time periods to reduce the amount of construction activity in the borrow pits and reduce evaporation of water used in the conditioning process.

It is anticipated that there would be a weekend shutdown once a month.

6.3.8 Construction sequencing

To complete construction within nine months, the contractor may utilise multiple specialist teams and multiple sites. Careful planning and programming would be required to minimise downtime, re-establish specialist operations such as piling crews, and maximise re-use of temporary materials such as formwork.

An independent earthworks operation for site preparation for the regulators is likely to progress from site to site, completing initial works before moving on. The sheet piling operation would then follow closely behind. Formwork shutters would be used on a number of sites in succession.

Levee construction would be continuous through most of the construction period and is not dependent on any of the structures.

6.3.9 Construction workforce

For the main project elements, it is estimated that a construction workforce of approximately 92 people would be required on site at one time. To complete the project within the nine month period, the following personnel are likely to be required:

- Plant operators approximately 40
- Skilled workers and tradesmen approximately 20
- Construction labourers approximately 10
- Supervisors, engineers and administrators approximately 12
- Specialist subcontractors approximately 10

Experience with other similar projects in this region suggests that the majority of plant operators and skilled and semi-skilled labour could be sourced from the regional workforce. Supervision, engineering and management personnel would be drawn from the contractor's pool of permanent employees and would reside in the region for the period of the works.

Those employed locally would not require temporary accommodation. The contractor's staff would be housed in rented accommodation, caravan parks and "board and lodging" style facilities, depending on location and duration of their stay on-site. It is expected that local accommodation for some 10 – 20 personnel may be required. Project workforce and staff may require caravan park style accommodation, hotel lodging and rented housing.

6.3.10 Construction compounds

Project office

Due to the geographical extent of the project, the absence of any dominant construction area and the lack of services close to the work fronts, the main project office is likely be located in an industrial/commercial site in Koondrook or Barham. This site would comprise the contractor's administration and project management centre, a materials storage depot, and training and induction facilities.

Satellite construction sites

Satellite construction sites would be established at each of the main work sites i.e. downstream regulators, Thule Creek regulator, return channel regulator, inlet channel and structures, Swan Lagoon and internal floodway. Temporary facilities would be located at some sites according to the construction sequence.

Satellite facilities for concrete structures would consist of office facilities, workforce amenities, first-aid facilities and a materials laydown area, within a compound of approximately 30 m x 20 m. The compounds would be accessible by trucks, for delivery of water, fuel etc and construction materials. Parking for 6 – 10 cars would also be required.

Major earthwork site compounds

Compounds and servicing facilities would be required for the major earthworks sites at the downstream levee and inlet channel. These facilities would be established near the "centre-of-mass" for the levee earthworks and near the disposal area for the inlet channel. Earthworks locations would require mobile workshops and servicing areas, mobile fuel storage and dispensing facilities, and plant parking areas. Both sites would be self contained, with portable generators, potable water storage, waste water collection, first-aid facilities and effective communications, possibly satellite telephone and data transmission.

The two main earthworks compounds would each have nominal 50,000 L fuel storage and dispensing equipment. Dimensions of the storage tanks would be approximately 2.75 m wide, 11.60 m long and 4.0 m high. The workshop would consist of two 12 m x 3 m shipping containers joined by an arched awning structure. There would be a concrete floor with appropriate drainage and structures to trap all contaminated runoff.

In addition to the plant servicing and repair facilities, the earthworks compounds would include workforce amenities, including site offices, meal rooms, ablutions, generators, water storage etc. The required area would be approximately 100 m x 50 m at each location and would be enclosed by security fencing.

Mobile site facilities

Mobile amenities and facilities would be provided for plant operators and others at the earthwork locations. These may be caravan-style facilities which can be relocated every two to three weeks as the work front advances. These facilities are likely to be established on the embankment or in the borrow pits.

Access to all construction compounds would follow existing forest roadways wherever possible.

6.3.11 Materials

Waste management

Based upon an assumed consumption rate for potable water of 50 L/person/day, the total potable water consumption through the various satellite compounds would be approximately 1 ML over the duration of the construction period which equates to about 15 kL per week. Waste water would be collected in holding tanks and disposed of periodically by licensed contractors at licensed premises. Domestic waste would be collected and stored in closed-top waste bins and collected weekly by licensed contractors, with disposal at the local council waste disposal centre.

Construction waste would consist of non-putrescible materials including timber, steel and concrete. It is estimated that 5-10 tonnes of such material would be generated. Waste oil generated from servicing plant would be collected and recycled by licensed oil recycling operators. It is estimated that up to 15,000 litres of waste oil would be recycled.

All waste generated by the project would be managed in accordance with DECC's Waste Classification Guideline (2008).

Material storage

As indicated in Section 6.3.10, materials such as fuels and oils would be stored at the major earthwork site compounds within the Forest. The contractor would operate within the requirements of the *Occupational Health and Safety Act 2000* and AS 1940-2004 *"The storage and handling of flammable and combustible liquids"* when storing, transporting, handling, using or dealing with spills of dangerous goods and or agricultural chemicals.

All materials would be transported, used and stored in accordance with the relevant Australian Standard, Material Safety Data Sheets, and the Australian Dangerous Goods Code. In the event of any inconsistencies between these, the most stringent criteria would be applied.

Chemical or fuel spills can have potential impacts on the environment and a range of control mechanisms would be applied to ensure these impacts are minimised. This would involve implementing relevant measures detailed in Forests NSW's *Chemicals Manual* (2006) (including Forests NSW HAZMAT procedure) that requires:

- Relevant staff being adequately trained and equipped;
- Storage and handling facilities meeting legislative requirements;

- Mobile fuel tanks not being located within, or within 10 metres of the boundary of a filter strip;
- Transportation and storage of fuel, and the refuelling of equipment is to be carried out in a manner which prevents the pollution of waters by fuel spills;
- All servicing and repair of equipment is to be carried out in a manner which prevents the pollution of surface and ground waters;
- Waste stored for removal is to be removed within seven days after completion works; and
- Emergency response procedures being available to respond to chemical or hazard materials incidents, and notify the relevant authority.

Material source

A local supplier operates a series of concrete batch plants and quarries capable of servicing all parts of the project. The concrete supplier has knowledge of and experience in supplying concrete to meet tight engineering specifications and has delivered product to many of the local Murray River construction projects. Rock and other quarry products may be sourced from local quarries from the same supplier.

Prestressed, precast concrete members, such as bridge girders and planks, would be sourced from manufacturers outside the region. Other precast concrete products, including stop logs, may be cast locally or brought in from outside the region.

Specialised materials such as vertical lift and swing gates would be sourced from outside the region. Fabricated metalwork may be manufactured by local sub-contractors or external suppliers.

Generally, decisions about procurement and use of local suppliers and subcontractors would be made by the contractor predominantly based on safety, quality and commercial merits. The contractor would also consider the opportunity to develop effective working relations with the local community.

Approximate quantities of materials required include:

- Reinforced concrete 6,000 m^3
- Precast concrete 1,700 m^3
- Sheet piling 500 tonnes
- Steelwork (other) 100 tonnes
- Aluminium gates 17 tonnes
- Rock protection 1,500 m^3

6.3.12 Construction equipment

An indicative list of construction equipment/plant that would be used during construction is provided in Table 6-6.

Table 6-6 Indicative construction equipment

Task	Indicative construction equipment	
Clearing and Topsoil stripping	Cat D9 dozers Cat 623 scrapers	Cat 16 grader
Bulk earthworks	Cat 631 scraper D10 dozer Cat 14 graders	50 kL water cart Cat 825 compactor 18 tonne vibrating padfoot rollers
Conditioning	Cat D10 dozer 50 kL water cart	Dozer drawn plough
Channel excavation	Cat 631 scraper D10 dozer Cat 14 graders *Or (dependant on methodology):*	Cat 345 excavator B-Double side tippers Cat 16 grader 50 kL water cart
Structures site preparation	Cat 623 scrapers Cat 14 graders	Cat 345 excavator Misc support plant
Installation of structures	25 tonne rough-terrain crane	

6.3.13 Access to the Forest during construction

Access to the Forest would need to be carefully managed during construction to minimise the potential for conflicts between construction activities and other Forest users, including Forests NSW staff, its contractors, as well as the general public. This issue needs to be managed to:

- Meet legislative and legal occupational health and safety (OH&S) and public safety responsibilities;
- Minimise interruption to construction; and
- Accommodate forest uses during the construction phase.

The contractor would be responsible for the construction site and be required to implement appropriate OH&S procedures. However, the Forest is also used by a range of stakeholders in accordance with the *Forestry Act 1916* and an agreement would need to be reached between the contractor and Forest NSW (as the manager of the Forest) regarding arrangements to provide stakeholders with access for purposes such as:

- Forests NSW activities including timber harvesting and associated operations including road maintenance, feral pest control, forest health monitoring, research, fire suppression and management;
- Lessees and Permit holders – Grazing Permits (eight permits), Water Facility Permits (five permits), Apiarist Permits (18 permits), Firewood Permits (estimate many hundreds of

permits), Research (unknown number of permits), Special Purpose Permits (unknown number of permits);

- Traditional Owners and Indigenous community - Site identification and rehabilitation, repatriation ceremonies, other cultural and traditional activities;
- Recreational hunters (Game Council NSW) - Recreational hunting of feral animals; and
- Other recreational users – Variety of recreational pursuits. Organised events such as Southern 80 and Barrie Beehag ski races (February and November).

While final details regarding access arrangement would be negotiated with the contractor, it is envisaged that Forests NSW operations such as harvesting and haulage would continue. These activities are able to be planned and scheduled to cause minimum disruption to the construction program. Commercial permit and lease holders would be required to apply to Forests NSW for written permission to access the Forest. Evidence of this permission would be required to be carried on site and would include induction information.

There is an existing mandatory annual No Hunting Period from November to Easter. This exclusion period for recreational hunting would be extended to cover the entire duration of the construction phase.

The Forest would be accessible by indigenous people, recreational users and firewood permit holders for one weekend per month during the “shutdown weekend” of the construction period. During this time, the contractor would implement the following measures to manage safety issues:

- Provide signs and maps at the four main forest entrances stating procedures, protocols and indicating the position of the restricted areas;
- Erect temporary barriers and “No entry, authorized person only” signs at all roads and intersections leading to the restricted areas;
- Manage all access to the restricted areas; and
- Advance public notices to be placed in the media indicating the dates other forest users would be permitted to enter the Forest together with a map indicating the restricted areas.

To facilitate access for recreational events such as ski races, consultation with event organisers would be undertaken by the proponent to ensure minimal disruption to both the construction activities and the event.

6.3.14 Rehabilitation

Following completion of construction, the worksites would be rehabilitated and returned to the pre-existing condition where practicable. This would involve activities such as but not limited to:

- Placing stockpiled topsoil over the batters of the downstream levee and borrow pits;
- Rehabilitating areas such as worksites that may have been compacted by construction activities;
- Removal of soils that may have been contaminated by spills from construction equipment;
- Removing all plant and machinery, including associated waste materials;

- Removing site fencing and signage; and
- Stabilising the landforms.

Disturbed areas would be allowed to regenerate naturally and the passage of floodwaters would deposit sediment and seeds that would assist this process.

6.4 Operation

The project has been specifically designed to provide the flexibility to operate within a range of flows to ensure that effective and measurable environmental outcomes are delivered across a broad range of available water. The structures have been designed to create a major flood event; however they can also control small or medium flows of variable volume and duration. It is intended that large flood events would occur every three to four years and that smaller events would occur more frequently. The large flood events would be capable of inundating of up to 52%, with a maximum maintainable extent of 41% of the Forest (approximately 16,000 ha) for a period of about 100 days. The extent and duration of flood events would achieve the Icon Site Environmental Management Plan's (MDBC, 2006) interim objective of maintaining 30% of River Red Gum forest in healthy condition. The flooding would result in numerous ecological benefits such as improved ecosystem health, and conditions favourable for bird and fish breeding events.

The project would be operated in a regulated river system that is operated for multiple outcomes and there are a range of risks and trade-offs that need to be considered. The design has been developed to manage these risks by enabling highly flexible operations to provide the opportunity to implement adaptive management principles in response to factors such as:

- Differing water availability and river conditions;
- Risk management requirements; and
- Targeting specific environmental outcomes that may be required from time-to-time to achieve long term objectives.

The natural flow regime at the site 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 River 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 facilitate bird breeding; and
- Very large, infrequent flood events to occasionally inundate fringing Black Box communities.

While predictive models provide some guidance, the exact ecological outcomes arising from operation of the project would be unknown until they have been operated in real time, under a range of antecedent conditions. Flexible operation and the ability to capitalise on a variety of flow events is therefore an important element of structure design.

6.4.1 Role of the Operating Plan

The overarching objective for the project is to maintain and restore a mosaic of healthy floodplain communities. To achieve this, operations would be in accordance with an Operating Plan (NSW Public Works, 2009) developed specifically for the project. The purpose of the Operating Plan is to provide a framework for the operation of the structures to meet key ecological objectives within the broader context of The Living Murray Initiative and Scheme's governance.

The Operating Plan would not prescribe particular watering events, however it would provide an effective platform for operational decision making based on knowledge development and a strong understanding of what the project aims to achieve.

The exact nature of future unregulated and regulated river flows, and the quantum of environmental water available for the project, is dependent on seasonal conditions and rostering undertaken as part of The Living Murray Initiative for the Icon sites. The management sequence needs to be flexible to allow for uncontrolled flooding events, entirely managed events, or a combination of uncontrolled and managed events (referred to as 'hybrid events'), depending on water availability and climatic conditions. In line with adaptive management principles, it is important to be able to alter the operation of the structures, both during events and from one operation to the next, in order to react to the ecological response observed. The ability to plan for, and respond to, varying ecological objectives would be a key function of the Operating Plan.

The following section provides a summary of the main elements of the Operating Plan (NSW Office of Public Works, 2009) which is included in Appendix B. This plan is preliminary and will be finalised in consultation with relevant agencies prior to commencement of operations.

Operating context

The Operating Plan summarises the overall operating context of the project within the framework of The Living Murray. This includes the Business Plan, Environmental Watering Plan, Icons Site EMPs, Annual Environmental Watering Plan, and Outcomes Evaluation Framework which are summarised in Section 5.2.

Water availability

As the project would source water from a regulated system, it would not alter allocations to other licensees in the system. The water would be sourced from a range of entitlements that are able to be used for environmental watering purposes. It is yet to be determined whether water discharged by the project would remain as environmental water or would become available for consumptive use. This is a broader issue would be resolved as part of the overall Living Murray Initiative, not as part of this project.

The Operating Plan details factors that influence the availability of water for the project, including:

- **Regulated flows, water that is subject to an entitlement, and unregulated flows**. Water can be sourced from different types of entitlements that have different reliability definitions.

These entitlements can be accessed at varying times because they have different triggers describing when and under what conditions they become available. Different entitlement types that could potentially be used at the site include any entitlement that is deemed available for use in an environmental watering context. This is complex, in that within the regulated water category alone there are the following available entitlement types: NSW General Security, NSW High Security, NSW Supplementary, Victorian High Reliability Water Share, and South Australian Water Entitlement.

There are various account managers including the Living Murray (MDBA) water manager, the Commonwealth Water Manager, the States' water managers and potentially, individuals who may deem it appropriate to plan for their entitlements to be used in the Forest for environmental watering purposes.

Additionally, both NSW and Victoria have sovereign access to their own Unregulated Flows – flows that are surplus to other requirements as described in the NSW Water Sharing Plans, in the Victorian Bulk Entitlements and in the Murray Darling Basin Agreement.

- **Commonwealth water**. The Commonwealth Environmental Water Holder manages the water entitlements that the Commonwealth is currently acquiring through the Restoring the Balance in the Basin program, and the Sustainable Water Use and Infrastructure program. The amount of water available for use depends on the volumes acquired and seasonal water allocations.
- **NSW environmental water**. The main tool used for managing NSW's water resources are Water Sharing Plans. These set out the rules for sharing water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. The environmental rules in the water sharing plans are designed to limit extractions so that the major share of water is protected, and replicate natural flow patterns or events to provide water when and where it would best meet environmental needs. The Water Sharing Plan for the NSW Murray - Lower Darling Regulated Rivers Water Sources has planned water that is to be provided to the Barmah Millewa Forest allocation. There can be up to 500 GL of this (half contributed from NSW and half contributed from Victoria). This water is not to be used for other purposes than to water the Barmah Millewa Forests. It also has Adaptive Environmental Allocations which can total 32,027 ML in any one year. This water is potentially available for use within Living Murray Icons Sites.
- **Unregulated flows**. Unregulated flows are normally declared by the Murray-Darling Basin Authority when high flows are forecast to occur that are in excess of that required to meet South Australia's entitlement flow and cannot be captured and re-regulated in Murray System storages. This declaration triggers processes to permit use of the unregulated flows for purposes and under rules that vary between jurisdictions.
- **The Living Murray water**. The Living Murray has implemented a range of water recovery measures. The Living Murray water would include a range of different water entitlements with different use provisions and reliability. The amount of water available for use would vary from year to year with changes in water availability. In relatively 'wet' years there would be much more than 500 GL available, whilst in relatively 'dry' years there may be much less than 500 GL. Based on historical climate conditions, the average would be about 500 GL per annum.

The portfolio would also include ‘regulated’ water that can be ‘called’ from storages, and water that is ‘unregulated’ and that is available in some higher flow situations (consequently it cannot be ‘called’ from storages – this water is sometimes referred to as non-callable).

Some of the water would be able to be carried over from one year to the next, which then means the water is in the account at the start of the new water year. This would potentially mean that in low inflow years some sites can gain access to The Living Murray water at the start of the water year on the 1st of July.

Governance

The project would be operated by the MDBA as it would be a component of the overall River Murray system. MDBA River Operations staff would oversee and coordinate water delivery, and would issue instructions relating to regulator settings and flow releases in the same manner as the MDBA operates other works within the system.

MDBA would receive advice from an Operations Committee that would include:

- Jurisdictional representatives, including the persons actually involved in day-to-day management of the structures (including Goulburn-Murray Water staff at Torrumbarry Weir);
- Operations Manager (State Water);
- The Environmental Manager (Forests NSW); and
- Other members (Murray CMA and Victorian representatives) as required.

The Operations Committee would meet weekly, or as required, to provide feedback on how the operation was going and to plan ahead for the following week. Between these meetings, River Murray Operations would make operational decisions required to implement the watering plan in the best possible way taking into consideration the other water requirements along the river system.

One member of the Operations Committee would be responsible for stakeholder management during the event. This would specifically involve liaising with downstream landholders, informing the wider community and managing media releases.

The Environmental Manager (Forests NSW) would be responsible for environmental monitoring, reporting and advice to River Murray Operations. A freshwater fish ecologist would report to the Environmental Manager and be responsible for providing advice on risks and opportunities relating to spawning events and fish passage. The Operations Manager (State Water) would manage operation and maintenance of all structures within the scheme, utilising staff from Goulburn-Murray Water and Wakool Shire Council to operate the scheme on a day-to-day basis.

Watering principles

The Operations Committee would base decisions to initiate and manage watering events on a set of watering principles to be defined in the Operating Plan.

Watering principles - initiation

The decision to initiate watering would consider the constraints of the operating environment. This would involve consideration of:

- Water availability and water requirements which are the foundations for the decision to initiate a watering event.
- River levels in the system that is monitored on a daily basis by MDBA, including at locations immediately upstream and downstream of Torrumbarry Weir.
- Clear ecological targets which would be defined before initiating a watering event.
- Watering events would aim to maximise net environmental benefits.
- Early watering during cooler months (winter and early spring) would be favoured over summer watering. As discussed in Section 9, there is a greater risk of blackwater events during flood events over summer as water temperatures are higher. Watering during cooler months would reduce the risk of these events occurring. Depending on the water requirements at the site, water made available during summer may be rejected in favour of autumn watering.
- Large watering events would not commence beyond October to reduce the risk of blackwater events.
- Overbank flows would be favoured as a cue for initiating watering.
- Unregulated water would be used when beneficial.
- Autumn watering would be considered if environmental water is not made available until late in the season.

The decision to water would also take into account a variety of relevant parameters including:

- Antecedent soil moisture – This would impact on infiltration rates and affect the rate of spread of flood waters, time to fill the pool, and required water volume.
- Landscape factors – Particularly relevant to waterbird needs, the presence or recent history of waterbird breeding in Gunbower Forest, Barmah-Millewa, and other locations in the Murray Darling Basin may influence the targeted ecological objective.
- Season – Watering during cooler months is preferred as it would be more consistent with the natural flow regime.
- Climate – Watering during widespread drought would be avoided except to maintain critical processes and drought refuges.
- Modelled natural flow – Flow that would have occurred at the site if there were no river regulation provides a clue for appropriate timing of events.
- Community needs and expectations – Watering planning would take account of the impact on the local community in terms of forest use and off-site impacts.

Watering principles - management

The management of a watering event would be based on the following principles:

- The initial ecological target would be pursued for as long as practicable.
- Modelled natural hydrographs would be used as a guide during the management of an event.
- Where beneficial, managed watering would prolong or enhance overbank flow.

- Downstream regulators would only be used to the extent needed to achieve the required objectives.
- Watering operations would aim to minimise impacts to third party property.
- The need to protect the integrity of the project infrastructure such as regulators and levees overrides the need to meet environmental targets.
- Inflows through Swan Lagoon would be favoured over equivalent inflows through the inlet channel.

6.4.2 Operating mechanisms

Gated structures

Gated structures (off-take regulator, Swan Lagoon regulators, return channel regulator) are likely to be controlled with portable actuators, however a study is currently being carried out to investigate the options of:

- Permanent electric operation with or without remote (original);
- Mobile generators connected to distribution panel; or
- Portable actuators with portable power packs.

Access to the structures could be either via land or boat, and the downstream pool levels would be monitored by an automatic data logger.

Stop log regulators

The stop log regulators are likely to be controlled via a truck mounted mobile crane. This would be able to drive to each stop log regulator via a track along the crest of the levee.

6.4.3 Management of flow regimes

As indicated in Section 6.4.1, there is no single way to operate the project and operating strategies would target the long-term achievement of the environmental objectives. These strategies would respond to water availability, watering history, requirements of the Forest, risks and engineering constraints.

Diversion of a range of flows is possible, ranging from as little as 2,000 ML/day, up to a design capacity of 6,000 ML/day. Large events would be delivered every three to four years, with smaller floods occurring more frequently. Duration of diversion would be variable and would depend on the required ecological outcomes. Operation is expected to coincide with natural high flow events.

As the structures can be operated in a variety of ways, they can be used to target specific environmental outcomes. It is likely that different events would target different outcomes, and planning for future watering events would give careful consideration to the environmental outcomes of previous events.

The project would be operated using adaptive management techniques, where knowledge from previous events would be incorporated into the decision making process, both during individual events, and from event to event. Operation would be fine-tuned as improvements to the practical operation of the structures are made, and as ecological responses are monitored and evaluated. The first operations are likely to be conservative to test understanding and management of risks. Larger events are likely to occur as outcomes of initial events are observed and confidence grows. Appropriately designed and implemented monitoring programs would be detailed in the Operating Plan and would be required to ensure this adaptive management approach is effective.

Hydrologic conditions

With reference to hydrologic conditions in the River Murray downstream of Torrumbarry Weir, the operation of the project could occur in one of three general ways:

- For flow events <18,000 ML/day, water can be delivered to the Forest through the inlet channel. Flows below this threshold are unable to naturally enter the Forest (refer to Section 9);
- For flow events >18,000 ML/day, water can enter the Forest through natural watercourses/effluents such as Swan Lagoon (refer to Section 9). These flows could potentially be supplemented with water delivered through the inlet channel. As this scenario would involve a combination of natural flows and managed flows, it is referred to as a hybrid event;
- There would also be larger flood events when flow is greater than about 35,000 ML/day downstream of Torrumbarry Weir. Flows of this magnitude exceed the channel capacity of sections of the Murray River and result in widespread flooding within the Forest (refer to Section 9). During these events, the project would not be operated and the regulators would be fully open to minimise impediments to flood passage.

Table 6-7 summarises the relationship between the river flow and the percentage of the forest that would be inundated.

Table 6-7 Relationship between river flow and inflows to Koondrook-Perricoota Forest (DWE, 2008a)

River flow	Inflow to forest	Inundated area	
ML/day	**ML/day**	**ha**	**% of total area of the Forest**
15,000	0	-	-
20,000	300	500	2
25,000	1,500	3,520	11
30,000	3,800	10,300	33
35,000	6,500	25,000	80

Operational constraints

The main operational constraints of the project are:

- Inlet regulator and channel: The top of regulator gates closed would have RL 86.55 (flood of record) and diversion capacity of flows between 2,000 ML/day and 6,000 ML/day with a maximum velocity at structure of 1.57 m/s. The inlet channel is designed for a maximum velocity of 0.6 m/s.
- Swan Lagoon: Discharge velocity would be lower than the maximum design velocity of 10 m/s and would have a minimum depth of 300 mm. Waterway areas of 60% at RL 84 (top of sheet piling) and 80% at top of banks RL 85 (approximately).
- Return regulator and channel: Ability to regulate return flows of up to 1,850 ML/day and contain the downstream pool to RL 78.5. Flows can be returned to the invert level of the return channel regulator, (77.3 m AHD).
- Downstream levee and regulators: The downstream levee would contain a maximum design pool at RL 78.5. Under some circumstances, the release rate to Barbers Creek may be managed to minimise flooding risks to downstream landholders.

Desired watering regime

The primary objective of the project is to deliver a flood regime that restores and maintains an adequate, representative area of River Red Gum forest, particularly that part that supports flood dependent understorey communities. An effective flood is considered to endure for at least 100 days, and an acceptable regime is considered one that delivers flood water at greater than half the natural frequency, during the late winter/spring period (Leslie and Jacobs, 2003).

A water regime that would achieve the project's management goal would ensure that a significant proportion of the Forest and a variety of ecosystems would be retained within the forest. This watering regime is summarised in Table 6-8.

Table 6-8 Desired water regime for vegetation classes

Vegetation class	Frequency	Duration	Timing
Wetland vegetation	6-9 years in 10	2-8 months	August – December
Waterbird breeding	6-9 years in 10	5-8 months	September – February
Fish	6-9 years in 10	2-4 months	August – November
River Red Gum forest	3-9 years in 10	4 months	August – November
Waterbird breeding	3 years in 10	5 to 8 months	September – February
River Red Gum Woodland	1-4 years in 10	1-4 months	August – November
Black Box	6-9 years in 10	1-4 months	September, October
Grey box, sandhills	Nil		

Source: MDBC, 2006

An initial assessment of the flooding required to achieve the individual objectives at Koondrook-Perricoota Forest is shown in Table 6-8. As there are no permanent wetlands in the Forest, there are no resident native fish and it is assumed that achieving the other objectives would provide suitable habitat conditions for native fish. Actions such as provision of fish passage and management of pest species would contribute to positive outcomes for native fish (MDBA, 2009).

Whilst the watering required to achieve the individual objectives differs, there is clear overlap in those requirements. The operating strategies would need to integrate those requirements, as well as the requirements for Gunbower Forest and the Icon site as a whole (MDBA, 2009).

There is a number of different ways implement this water regime and one possible 10 year sequence of operations for both Koondrook-Perricoota Forest and Gunbower Forest is shown in Figure 6-9 (MDBA 2009).

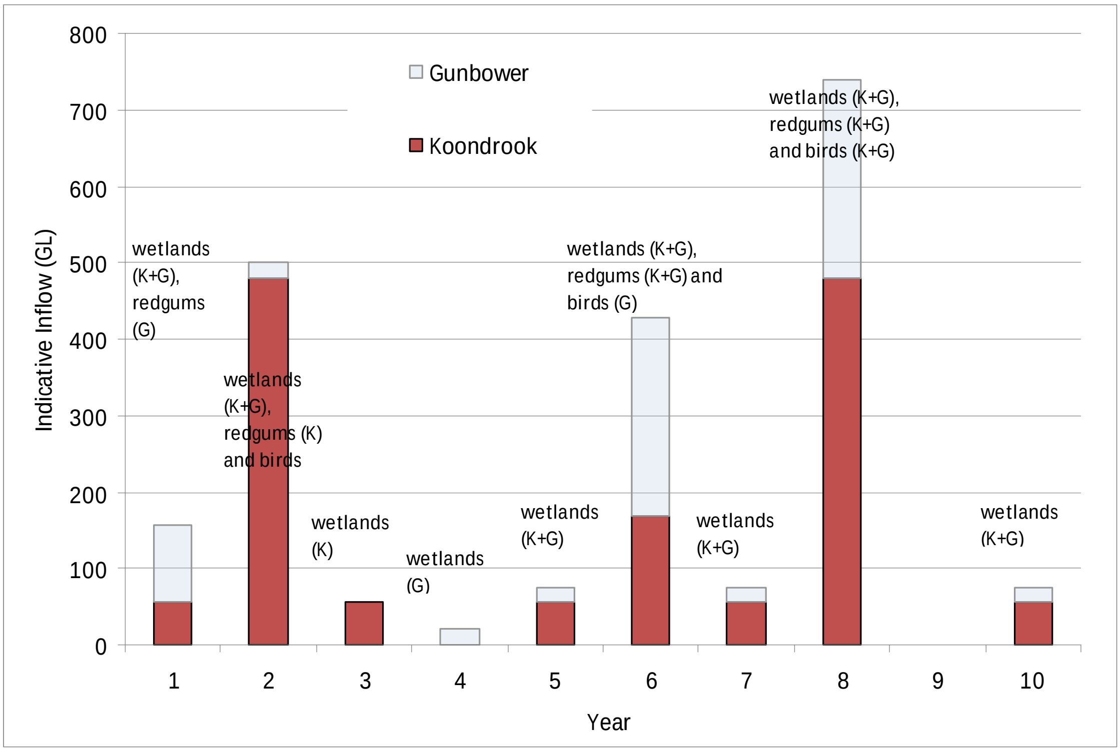


Figure 6-9 Potential 10 year operating strategy for Gunbower-Koondrook-Perricoota Forest Icon Site

6.4.4 Possible operating sequence

A hydraulic model has been developed for the project to assist in identifying water use, predicting flood coverage and determining environmental benefit to be gained from the flooding. For large flood events, the project requires initial inflows of 6,000 ML/day, which are then reduced to flows of 3,400 ML/day after 50 days. This would result in the diversion of 466 GL into the Forest and an estimated 222 GL returned directly to the Murray River.

It is predicted that a total cycle of flooding and recession for a large event would occur over approximately 235 days and that the maximum maintained extent of inundation would occur for approximately 100 days of the cycle (refer to Table 6-9). It would take approximately 110 days for the water to recede out of the Forest.

The duration of the inundation event is likely to provide suitable conditions for most floodplain species to reproduce. The timing of the event would be dependent on the availability of environmental water, however it is likely to operate on the back of high flows in the Murray River. Flooding would extend into summer and provide for the most optimum response from species across the floodplain.

One possible scenario to manage the maximum design event of 6,000 ML/d initial diversion is summarised in Table 6-9 and the associated hydrograph is presented in Figure 6-10. As discussed in Sections 1.6 and 6.4.1, there are numerous possible operating scenarios and it is not feasible to assess them all within this Environmental Assessment. This Environmental Assessment is based on the possible operating scenario outlined in Table 6-9 and all events would be managed in accordance with the Operating Plan and associated adaptive management principles.

The Environmental Assessment is based on this scenario as it would result in the maximum area and duration of inundation able to be maintained by the project.

As discussed in Section 9.2, this possible scenario would be broadly equivalent to a flood under existing conditions with a return interval greater greater than 1 in 5 years. It would be between the following two events:

- 1991 which had flows downstream of Torrumbarry Weir of about 43,000 ML/day, an inundation area of about 7,800 ha, and a return interval greater than 1 in 2 years; and
- 1993 which had flows downstream of Torrumbarry Weir of about 60,000 ML/day, an inundation area of about 23,600 ha, and a return interval of about than 1 in 10 years

Table 6-9 Operating sequence

Phase	Action	Structure arrangement
Phase 1 Initiation	◗ Open inlet regulator over period of about 5 days to 6,000 ML/day diversion capacity	◗ Swan Lagoon structures closed ◗ Return channel regulator fully open ◗ Downstream stop log regulator structures closed except for one bay at one structure
Phase 2 Filling	◗ Maintain inlet regulator discharge at 6,000 ML/day ◗ Fill downstream forest section to near the design operating level of RL 78.5 ◗ Takes about 45 days ◗ Flows back to Murray River via the return channel commence when the downstream pool reaches RL 77.32 ◗ Reaches maximum return flow of 1,850 ML/day at Pool RL 78.5	◗ Stop logs placed in downstream stop log regulator bay as pool level rises to maintain 250 ML/day discharge (if not in place already).
Phase 3 Main watering	◗ Raise gates at off-take regulator to reduce flow to 3,320 ML/day ◗ Design pool operating level RL 78.5 maintained ◗ Diversion flow of 3,320 ML/day maintained for 55 days to achieve 100 day watering event (in conjunction with Phase 2) ◗ Flows back to Murray River via return channel continue at 1,850 ML/day ◗ Flows into Barbers Creek system continue at 250 ML/day	
Phase 4 Off-take closure	◗ Off-take regulator gradually shut down over a 10 day period ◗ Flows ramped up and down (if required) to facilitate fish exit ◗ Flows back to the Murray River via return channel reduce as pool level drops	◗ Gradually remove stop logs from one downstream structure bay to maintain 250 ML/day flow
Phase 5 Downstream pool dewatering	◗ Pool emptying takes about 110 days ◗ Flows back to Murray River via return channel cease when pool level reaches RL 77.32	◗ Continue to remove stop logs from downstream structure bay to empty pool ◗ Stop log removal is initially slow; gains momentum as pool level drops ◗ All stop logs to be stripped and stored at all downstream structures

KOONDROOK-PERRICOOTA FOREST FLOOD ENHANCEMENT
OFF-TAKE FLOW HYDROGRAPHS - 6000ML/d INITIAL DIVERSION FLOW

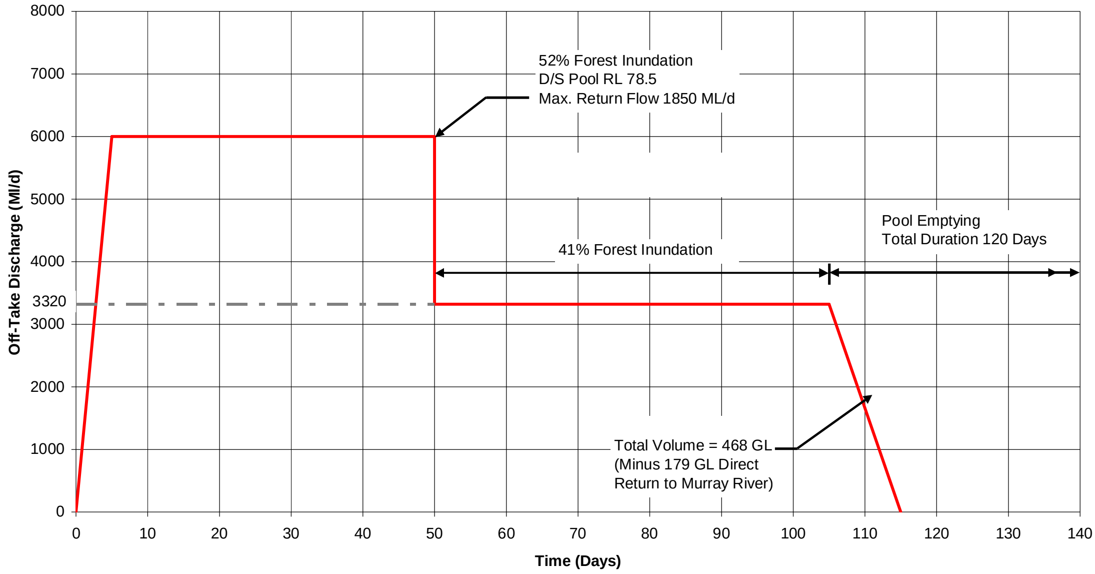


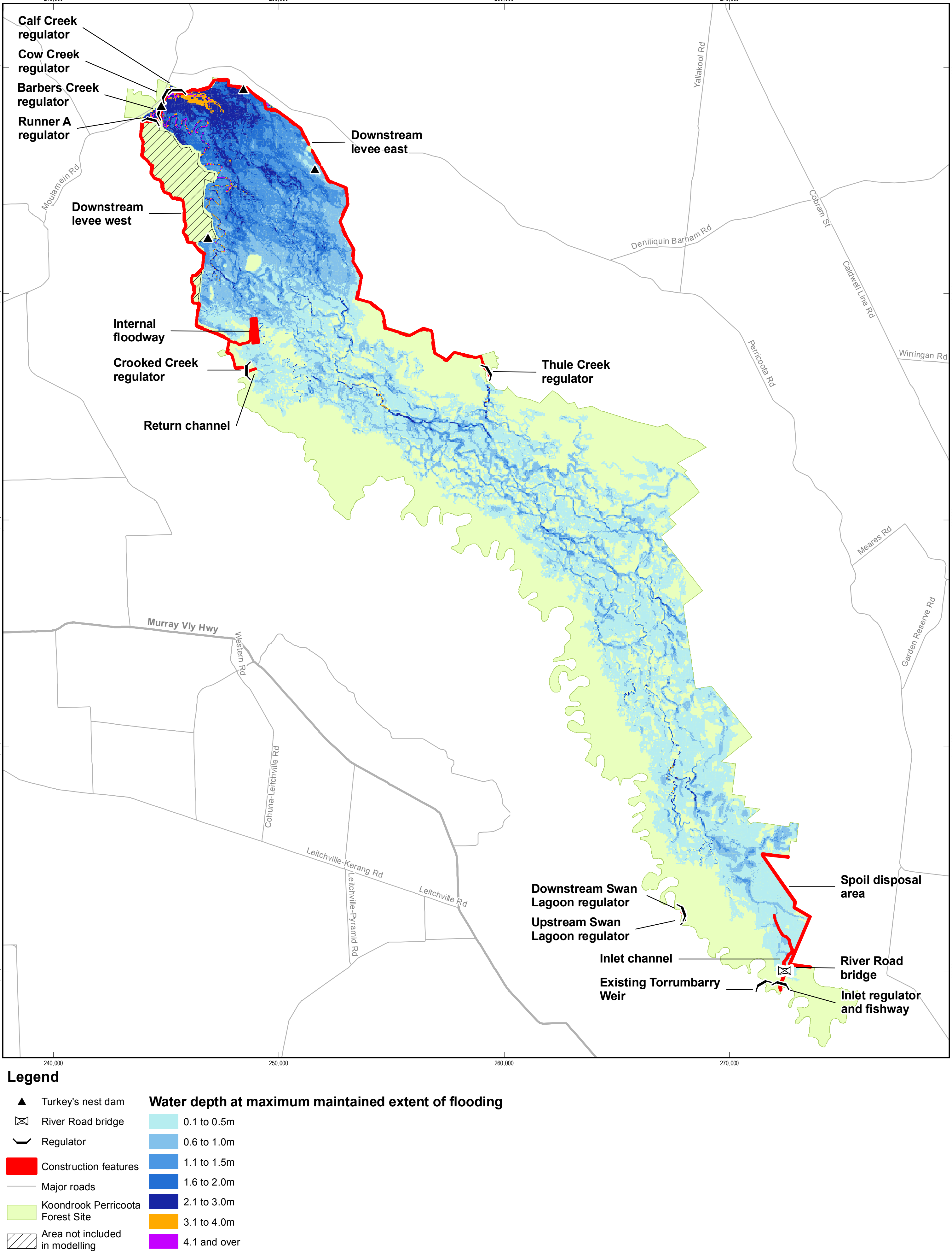
Figure 6-10 Flow hydrograph for operating sequence for an entirely managed event

Table 6-10 summarises water that would be used during this possible operational scenario and indicates that of the 466 GL required, 222 GL would be returned to the Murray River via the return channel and Barbers Creek system. This water would be sourced from environmental water accounts and it is yet to be determined whether it would be available for consumptive use following discharge from the Forest. This issue applies to watering events at all Icon Sites and would be resolved prior to commencement of operation as part of The Living Murray Initiative. The maximum extent of inundation is shown in

Figure 6-11.

Table 6-10 Estimated volumes for a typical flooding event (6,000 ML/day initial diversion)

Description	Estimated volume (GL)
Total diversion inflow from Torrumbarry Weir pool	466
Total estimated water usage via infiltration and evapotranspiration	225
Return flow to Murray River via Barbers Creek/ Wakool River system (including transmission losses)	47
Return flow direct to Murray River from the return channel (including losses between Barham and the Wakool River junction)	175
Total return flow to the Murray River per event	222



1:150,000 (at A3)
0 1 2 4
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water
Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	A
Date	10 DEC 2009

Figure 6.11 Maximum maintained extent of flooding

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z039_MaximumMaintainedExtentOfFlooding.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: Dept of Commerce, Street Map- Navtec, Drawn: Cwilson

Figure 6-12 summarises the area and duration various vegetation communities within the Forest site would be inundated by this event. As discussed in Section 6.4.3, a flood regime that involves large scale events such as this scenario every three or four years, and more frequent smaller events, would achieve the project ecological objective which is to implement a water regime to a representative area of the Forest that has, or historically supported, a water dependent understorey.

It would also achieve the interim ecological objectives for the Koondrook-Perricoota component of the Icon site which are to maintain and restore a mosaic of healthy floodplain communities:

- 30% of River Red Gum forest in healthy condition;
- Successful breeding of thousands of colonial waterbirds in at least three years in ten.

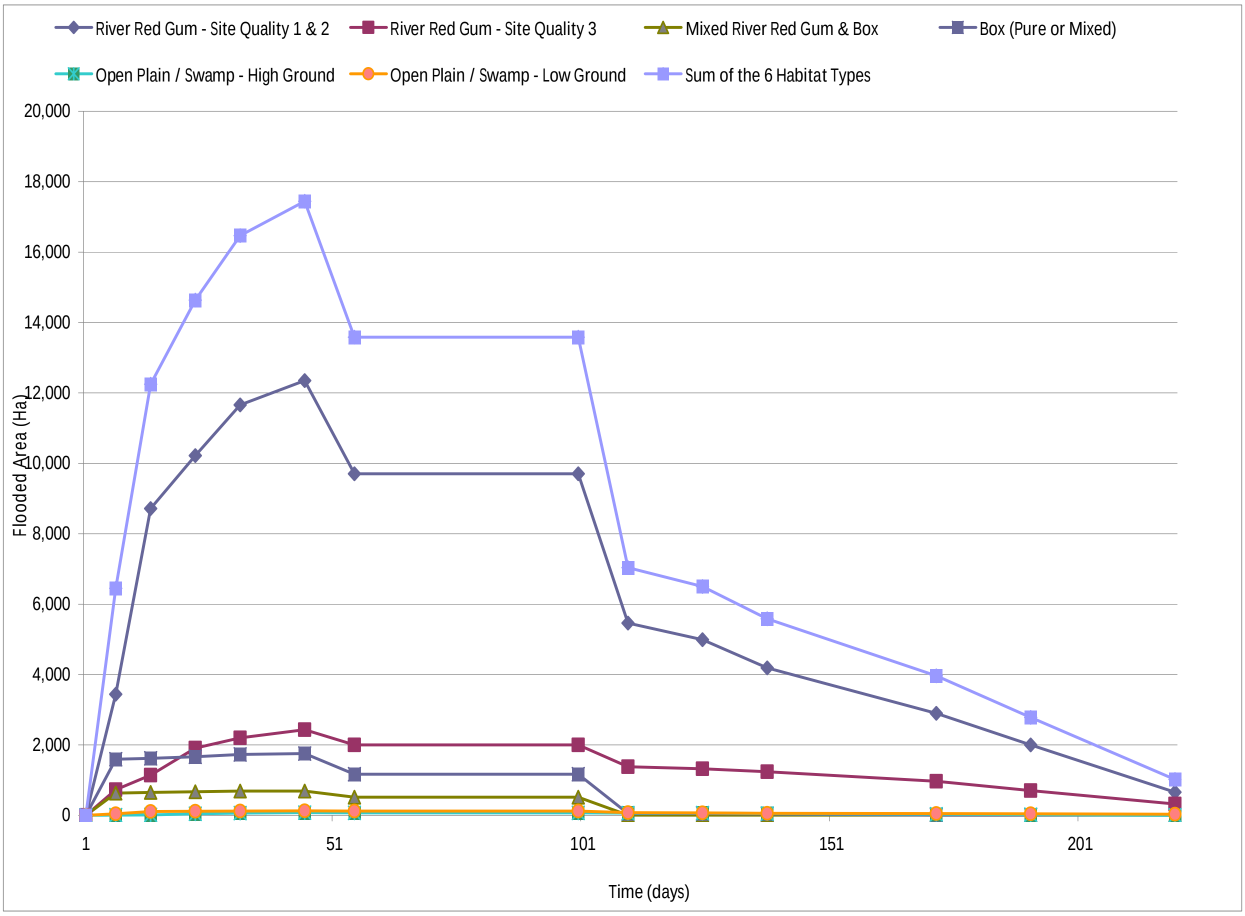


Figure 6-12 Inundation area by time (6,000 ML/day initial diversion)

Other possible operational scenarios

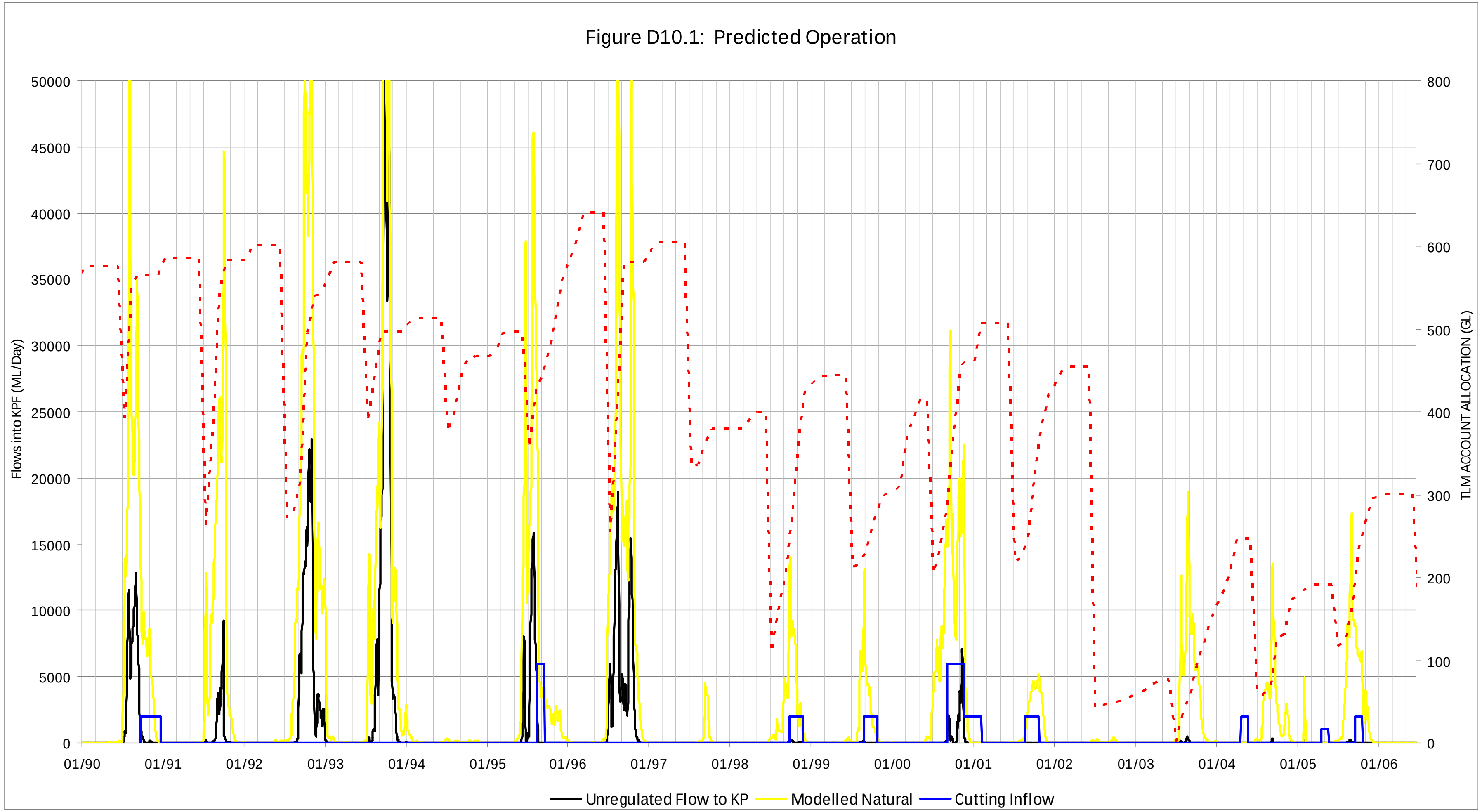
As detailed in Section D10 of the Preliminary Operating Plan (Appendix B), modelling was undertaken to determine how the project could have been operated between 1990 and 2005 based on watering principles and water available through the Living Murray account and natural inflows. The period 1990 – 2005 was selected as it includes both relatively wet and relatively dry periods.

Table 6-11 and provides a summary of whether the project would achieve the intended ecological objectives in each of the years between 1990 and 2005. Figure 6-13 summarises the flows into the Forest and the volume of water in The Living Murray account over this period.

Table 6-11 Indicative operation of the project between 1990 - 2005

Year	**Scheme operation**	**Intended objective achieved**		
		Wetlands	**Bird breeding**	**River Red Gum**
1990	Extend natural inflows for bird breeding	Yes	Yes	Yes
1991	Natural event waters wetlands, some River Red Gum watering	Yes	No	Yes
1992	Natural event waters all	Yes	Yes	Yes
1993	Natural event waters all	Yes	Yes	Yes
1994	Do nothing, dry year	No	No	No
1995	Fill gap, extend to complete River Red Gum	Yes	No	Yes
1996	Fill gap for bird breeding	Yes	Yes	Yes
1997	Do nothing, dry year	No	No	No
1998	Water wetlands	Yes	No	No
1999	Water wetlands	Yes	No	No
2000	Fill gap and extend natural inflows for bird breeding	Yes	Yes	Yes
2001	Water wetlands	Yes	No	No
2002	Do nothing, dry year	No	No	No
2003	Late autumn small wetland watering	Yes	No	No
2004	Late autumn small wetland watering	Yes	No	No
2005	Small wetland watering	Yes	No	No
Total		13	5	7
%		81% of years	31% of years	44% of years

Figure 6-13 Predicted operation between 1990 – 2005 (NSW Public Works, 2009)



Indicative use of unregulated flows

As indicated in Section 6.4.1, unregulated flows are one possible source of water for the project. Table 6-12 indicates that there were unregulated flows at Torrumbarry Weir on 26 occasions between 1980 and 2008. Of these, all but four unregulated flow events commenced in winter or spring which is consistent with the intention outlined in the Operating Plan to initiate large managed events during these seasons. Many of these events had average daily flows greater than 18,000 ML/day which is sufficient to enter the Forest at Swan Lagoon.

Subject to availability, unregulated flows would be used to maximise environmental benefits. This is not expected to impact on consumptive uses as unregulated flows are declared after consumptive demands have been met.

Table 6-12 Summary of unregulated flows between 1980 - 2008

Day	Season	Average Daily Unregulated Flow at Torrumbarry Weir (ML/day)	Duration (days)
1/08/1980	Winter	9974	61
1/06/1981	Winter	27231	183
1/06/1983	Winter	21014	153
1/08/1984	Winter	20131	92
1/08/1985	Winter	15743	61
1/07/1986	Winter	26542	153
1/06/1987	Winter	15389	122
1/06/1988	Winter	18020	122
1/12/1988	Summer	6873	31
1/04/1989	Autumn extending through to Winter/Spring	22180	244
1/05/1990	Autumn extending through to Winter/Spring	20710	214
1/08/1991	Winter	25439	92
1/05/1992	Autumn	4553	31
1/07/1992	Winter	27089	215
1/04/1993	Autumn extending through Winter/Spring	22701	275
1/06/1994	Winter	3462	92
1/06/1995	Winter	20041	183
1/06/1996	Winter	29943	183
1/08/1998	Winter	7350	92
1/08/1999	Winter	8673	61
1/07/2000	Winter	18805	153

Day	Season	Average Daily Unregulated Flow at Torrumbarry Weir (ML/day)	Duration (days)
1/08/2003	Winter	13227	61
1/09/2004	Spring	11439	30
1/08/2005	Winter	9084	122
1/08/2007	Winter	3154	31
1/09/2008	Spring	2366	30

6.4.5 Fish passage

Specific design considerations that have been included at each structure to minimise impacts on fish passage are outlined below. These designs have been developed in consultation with the FPTF.

Although no special provisions have been made specifically for Macquarie Perch there have been measures to accommodate passage in and out of the floodplain and mitigate loss of native fish that have a similar bodysize, including Murray Cod.

For Murray Cod, once on the floodplain it would be important to ensure that adult fish and larval fish that have grown to fingerling size (50 mm long) can freely return to the river, and water quality is maintained to minimise fish kills.

Inlet Regulator

The inlet regulator is a key site for fish passage for the scheme and a number of design features have been incorporated to minimise impacts to aquatic species. These include:

- High level of operational flexibility;
- Overshot gates;
- Denil fishway for large bodied fish;
- Vertical slot fishway for small bodied fish; and
- Turtle ramp.

High operational flexibility of the regulator including flow rates

The structure has been designed to have high operational flexibility for to enable diversion discharges to be ramped up and ramped down. It also has acceptable flow characteristics, structure profile and control for upstream fish passage (Department of Commerce 2008).

To enable fish movement, the upstream regulator was designed to pass medium and large-bodied fish as flows start to recede, when the tailwater remains relatively high and the head difference varies from 0.4 m to 1.3 m. It can also pass small-bodied fish at the end of receding flows, when the tailwater is lower and the head difference varies from 1.3 m to 2.3 m.

Overshot gates

Overshot gates have been selected on the regulator to minimise fish mortality. It has been identified that undershot gates can cause fish mortality (Baumgartner et al 2006).

Denil fishway

The fishway has been designed with a diversion flow rate between 900 ML/day and 6,000 ML/day to suit the larger fish. The Denil fishway is designed to operate for the upper half of the receding hydrograph (i.e. when flows at the inlet regulator are starting to recede and water levels on the floodplain start to recede). This is the part of the flood cycle when large fish are most likely to start moving from the floodplain back into the Murray River and is referred to as upstream fish passage.

It is anticipated that the Murray Cod, a nationally threatened fish, would use the Denil fishway. To specifically pass large adult Murray Cod, the fishway has been designed with a 40 cm width.

As the Denil fishway would not operate in the lower half of the receding hydrograph, there is the risk that large fish may not be able to pass through the structure. A fish rescue plan would be initiated for Murray Cod, and when there are large numbers of native fish that have accumulated. This would involve capturing fish downstream of the inlet regulator and transfer them to the Murray River.

Vertical slot fishway

The vertical slot fishway would be a separate fishway that provides passage for small-bodied fish (e.g. 20-100 mm long), including juvenile Murray Cod. The fishway has small pools, low water velocities and low turbulence to cater for the swimming ability of small fish. The fishway would operate during the lower half of the receding hydrograph and has been designed with a diversion flow rate of up to 1,100 ML/day.

Freshwater turtle ramp

Representatives of the FPTF advised that a 1 Vertical: 8 Horizontal ramp is required to allow fresh water turtles to escape from the inlet channel and relocate to the Murray River. The ramp has been located downstream of the inlet regulator in a low turbulence and low velocity zone (Department of Commerce 2008). The ramp would avoid the use of large cobbles so that turtles do not become trapped between the gaps.

Fish monitoring

Fish monitoring at the intake regulator would be undertaken when it is in operation to establish the species of native and exotic fish entering the Forest to assist in developing a fish movement model. The monitoring would also assist to establish adaptive management strategies for carp that enter the Forest.

Carp trap

A carp trap would be constructed at the inlet regulator to capture adult carp as they leave the floodplain.

Inlet channel

The inlet channel was designed to provide favourable habitat for native fish. Trees would be strategically placed within the channel to act as snags that create local resting zones with low velocities. The channel would have flow velocities suitable for native fish.

Swan Lagoon regulators

The Swan Lagoon regulators would be capable of allowing mainly small fish to safely leave the Forest at the tail end of the recession phase. This would cater for the anticipated movement of small bodied fish from the shallow areas to the deeper and longer lasting water pools at Swan Lagoon as the water levels in the Forest recede (Department of Commerce 2008).

Based on advice from the FPTF representatives, the Swan Lagoon regulators have been designed to accommodate the passage requirements of smaller fish. The discharge would be lower than the maximum design velocity of 10 m/s and the minimum operating depth would be 300 mm. Erosion protection would be provided on the upstream and downstream sides of structures to minimise fish injury.

The central overshot gate segments on each Swan Lagoon structure would initially be operated to the fully open position to minimise mortality to small fish. When the gates are in the process of being opened it is possible that some fish mortality may occur. To minimise this impact, a combination gate has been designed in the middle of the structure to allow initial overshot flows and the establishment of a tailwater pool on the Murray River side of the structure.

Injury to fish would also be minimised by taking into consideration the timing of releases in regards to the water level in the Murray River.

Return regulator

FPTF representatives (Dr Mallen-Cooper and Dr Baumgartner (NSW Industry & Investment)) attended a meeting held on 30 July 2009 with the MDBA and the NSW Public Works. They advised that an upstream fish passage structure to allow fish to move from the Murray River into the forest was not required on the return regulator. The reason for this is that the flows being released from the regulator (up to 1,850 ML/day) would be at a rate that would not result in significant attraction of fish into the forest due to the higher flow generally occurring within the Murray River.

The design of the regulator is being developed to ensure safe passage of fish in a downstream direction (i.e. fish moving from the forest to the Murray River). This includes avoidance of design features that could cause injury to fish, such as baffle blocks, sharp rocks etc. The regulator would control velocities of water released back to the River so that the flow characteristics are amenable for downstream fish passage.

Downstream regulators

Barbers Creek regulator has been designed to be suitable for downstream fish passage during the recession phase of the flood cycle. An overshot gate and a downstream dissipater would provide downstream passage of fish back to the river.

The design flow rate release of 250 ML/day to the Barbers Creek system during a managed event is unlikely to be substantial enough to attract fish into the Forest. Based on the proposed low flow release, the FPTF representatives advised that there is no requirement at this stage to provide upstream fish passage on the structure. The Barbers Creek regulator is being designed to allow for a fish lock to be retrofitted if it is found to be required in the future.

The other downstream stop log regulators do not require fish passage structures as it is not proposed to release flows via the other regulators during a managed event.

Barber Creek block banks

Bywashes would be constructed around the block banks along the Barbers Creek system. The bywashes would be proportioned to accommodate the 250 ML/day design flow into the downstream system. At a meeting held on 26 October 2009, Dr Baumgartner advised that upstream fish passage is not a requirement at each block bank site due to the low design flow. The concept design for the bywashes has been developed in consultation with the FPTF and is included in Appendix G.

Timing of operations of the project

In addition to design of the structures, other factors to be considered relating to fish passage are the timing and the way in which the flood event is managed. Important timing issues for fish passage include:

- Where possible, replicating the timing of natural flow regimes (peak flows in October/November), variability and pulsing;
- Provision of a continuous and variable water supply to optimise water quality during a managed inundation event;
- Sufficient time during flooding recession phase to allow fish to move from the floodplain to the river; and
- Controlling summer carp recruitment by ceasing flooding in late December/January

6.5 Ongoing management of the Koondrook-Perricoota Forest

6.5.1 Management of the Forest

The Forest would be managed in accordance with the Interim Gunbower-Koondrook-Perricoota Forest Icon Site Environmental Management Plan (MDBC, 2007b). It is important to note that the scope of this Environmental Assessment does not include the ongoing management of the Forest, aside from water management. Ongoing management of the Forest would continue in accordance with the Riverina ESFM, including activities such as timber harvesting that are permitted under the *Forestry Act 1916*.

The ESFM plan covers the management, in terms of the *Forestry Act 1916*, of native forests and plantations within Forests NSW managed lands to fulfil the requirements of Clause 5 of the *Forestry Regulation 2004* (Forests NSW, 2008b).

Forests NSW is committed to promoting transparency and continual improvement of forest management. The ESFM Plan plays an integral role in the ISO 14001 certified Forests NSW Environmental Management System, in achieving a systematic and accountable approach to measuring, monitoring and managing performance related to ecological sustainability. Forests NSW's success in promoting sustainability through transparency and continual improvement is formally recognised through independent third party certification under the Australian Forestry Certification Scheme's Australian Forestry Standard, and internationally by the Programme for the Endorsement of Forest Certification schemes (Riverina ESFM, 2008a).

Forest management zoning

Forest Management Zoning (FMZ) is a land classification system which maps the way Forests NSW intends to manage forest areas across the entire estate. The FMZ system is based on nationally agreed reserve criteria and clearly differentiates between those areas of State forests which are specifically set aside for conservation and those areas that are available for other activities including timber harvesting (State Forests NSW (e) 1999). Forests NSW has defined eight FMZ categories. The FMZ definitions in Table 6-13 are sourced from *Forests NSW Managing our forests sustainably: Forest Management Zoning in NSW State Forests*.

Table 6-13 Forests NSW forest management zoning categories

Zone	Details
Zone 1 - Special Protection	Set aside to maximise the protection of very high natural and cultural conservation values. This includes flora reserves established under Section 25A of the *Forestry Act, 1916*, that can only be revoked by an Act of Parliament.
Zone 2 - Special Management	These areas receive specific management and protection of natural and cultural conservation values, where it is not possible or practicable to include them in Zone 1.
Zone 3a - Harvesting Exclusion Zone 3b - Special Prescription	Areas are nominated for management for conservation of identified values and/ or forest ecosystems and their natural processes, whilst also facilitating other management and production activities.
Zone 4 - General Management	This Zone allows for management of native forests for timber production, utilising the full range of silvicultural options, as appropriate. A range of prescriptions operate to protect specific values (for example clean water, cultural heritage and special habitat elements). In this zone, timber harvesting would not occur on areas such as those lacking commercial resource, those excluded by general prescriptions, or those unavailable due to specific research, inventory or adaptive management requirements.
Zone 5 – Hardwood Plantations	Management of hardwood plantations to maximise sustainable timber production
Zone 6 – Softwood Plantations	Management of softwood plantations to maximise sustainable timber production
Zone 7 – Non Forestry Use	Management of cleared (non-forested) areas
Zone 8 – Areas for further assessment	Interim zoning of areas where further field investigation is required to determine final FMZ. Management of these areas is undertaken as per Zone 3a requirements until such a time as a FMZ category is assigned

The majority of the Forest would be managed as FMZ 4 – General Management. An offset area has been identified and would be managed in accordance with the requirements of FMZ 3A – Harvesting Exclusion (refer to Section 6.5.2).

FMZ 4 allows for management of native forests for timber production, utilising the full range of silvicultural options, as appropriate. A range of prescriptions operate to protect specific values (for example clean water, cultural heritage and special habitat elements). In this zone, timber harvesting does not occur on areas such as those lacking commercial resource, those excluded by general prescriptions, or those unavailable due to specific research, inventory or adaptive management requirements (Forests NSW, 2008c).

6.5.2 Management of the offset area

In accordance with the requirements of Part 3A of the EP&A Act, the project includes a strategy to offset residual ecological impacts. The offset strategy was developed by the project team in consultation with DECCW and focuses on offsetting the area of Inland Grey Box Woodland that would be permanently cleared during the construction phase. This community is listed as an endangered ecological community under the TSC Act and as it is not dependent on flooding for its survival it would not benefit from operation of the project.

The strategy does not include an offset for the River Red Gum community that would be permanently cleared for the project as it was agreed with DECCW that the project has been specifically designed to deliver substantial benefits to large areas of these communities.

The offset strategy involves setting aside approximately 93.5 ha of Inland Grey Box Woodland on the former Toorangabby property as an offset for clearing this community during construction. DECCW agreed that this parcel of land would be managed in accordance with the Forest Management Zoning 3A – Harvest Exclusion, and the principles of the Riverina ESFM. . Harvesting is excluded within zone 3A, however other management activities, including but not limited to grazing, are permitted.

Sustainable grazing would occur under Forest NSW's grazing strategy to manage fine fuel loads to reduce wildfire hazard. Forests NSW considers this to be the most practical fuel reduction method available in River Red Gum forests as prescribed burns would be likely to have a negative effect on this species.

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

Pest and weed management would also occur in accordance with the Riverina ESFM.

The Toorangabby property was purchased specifically for the project and has a history of agricultural use and timber harvesting. This parcel of land has been added to Forests NSW's estate and been managed in accordance with Forests NSW procedures since being purchased.

Further details of the offset strategy are provided in Section 8.8.4.