

Keepit Dam Upgrade Environmental Assessment

Volume 1 - Main Report



Keepit Dam Upgrade

Environmental Assessment

Volume 1, Main Report

December 2007

State Water Corporation



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Statement of Validity

Submission of Environmental Assessment

Prepared under Part 3A of the *Environmental Planning and Assessment Act 1979*.

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In respect of Keepit Dam Upgrade

Concept Plan application

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Land on which the activity is to be carried out Keepit Dam is located on the Namoi River, between Gunnedah and Tamworth in north-west NSW. The three options for upgrading Keepit Dam encompass undertaking works between east of the subsidiary dam wall and north of the main dam wall.

Proposed development Construction and operation of a combination of additional spillways and dam wall raising, and other associated works to safely accommodate extreme flood events and earthquake events. Additionally, a set of measures to improve the environmental performance of the dam specifically in relation to the temperature of water releases and the ability of fish to migrate past the dam.

Environmental Assessment An Environmental Assessment is attached which addresses matters listed under Part 3A of the *Environmental Planning and Assessment Act 1979*.

Declaration I certify that I have prepared the contents of this Environmental Assessment and to the best of my knowledge:

- it contains all available information that is relevant to the environmental assessment of the proposed development to which this Environmental Assessment relates
- it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.

Signature

Name

Date

Greg Marshall
23 November 2007



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Technical Paper 3	Cultural heritage
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Glossary and abbreviations

Term or abbreviation	Definition
Abutment	Area where a dam wall meets the side of a valley.
Air space	The volume between a dam's full water supply level and the crest of the dam wall.
Alluvial	Deposited by river processes.
Alluvium	Sedimentary deposits from rivers.
Amphibian	A class of vertebrates that comprises the frogs, salamanders, and caecilians. Typically they lay eggs that hatch in water and the young go through a larval or tadpole stage, later metamorphosing into lung-breathing quadrupeds.
Anabranh	A branch of a river which leaves the main stream and enters it again further on.
Annual exceedance probability (AEP)	The likelihood of a flood being exceeded in any given year (for example, a flood with an AEP of 1 in 100 has a 1 in 100 chance of being exceeded in any given year, on average).
Aquatic	Existing or growing in water.
Arboreal mammals	Tree-dwelling mammals.
Australian height datum (AHD)	The standard reference level used to express the relative elevation of different features; a height given in metres AHD is essentially the height above sea level.
Backwater	An area inundated by water from a river but outside the general flow of the river.
Benefit cost ratio (BCR)	The ratio of the benefits derived from a project to the costs of constructing and operating the project.
Benthos	Organisms that live on the bottom of a water body.
Built form	The design characteristics of a built structure including its aesthetic relationship with the surrounding environment.
Catchment	The land surface area that drains into a reservoir or to a specific point in a river system.
CEMP	Construction environmental management plan.
Coffer dam	A temporary watertight enclosure that is pumped dry to expose the bottom of a body of water so that construction, as of piers, may be undertaken.
Confluence	A flowing together of two or more waterways.
Construction	The construction of all elements described in the Environmental Assessment other than survey, acquisitions, fencing, geotechnical investigations by drilling or excavation, minor utility adjustments, building/ road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing site compounds or other activities which would result in minimal environmental impact.
Dam	A structure across a river which impounds water.

Term or abbreviation	Definition
Dam safety upgrade	A key driver of the proposal which results from a requirement of the NSW Dams Safety Committee that the dam be upgraded to withstand extreme flood and earthquake events. The dam safety upgrade would generally involve raising of the main and subsidiary dam walls, strengthening of the main dam wall with post-tensioned steel cables, and the construction of additional spillways and saddle dams.
DECC	NSW Department of Conservation and Climate Change formerly the Department of Environment and Conservation (DEC).
Design flood	A flood where the levels at all points along the river have the same chance of occurrence; estimated using hydrologic and hydraulic computer models.
Design flood level (DFL)	The peak water level experienced at a particular location during a flood.
De-stratification	Vertical mixing within a lake or reservoir to totally or partially eliminate separate layers of temperature, plant, or animal life.
DEWR	Commonwealth Department of the Environment and Water Resources formerly the Department of the Environment and Heritage (DEH).
DIPNR	The former NSW Department of Infrastructure, Planning and Natural Resources (now separated into the Department of Planning and the Department of Natural Resources).
Director-General	The Director-General of the NSW Department of Planning.
DOP	NSW Department of Planning
DPI	NSW Department of Primary Industries
Environmental Assessment	<p>A formal description of a project that is subject to Part 3A of the NSW <i>Environmental Planning and Assessment Act 1979</i> and an assessment of its likely impact on the physical, social and economic environment.</p> <p>The Environmental Assessment is used as a vehicle to facilitate public comment and as the basis for analysing a project that requires planning approval under Part 3A of the NSW <i>Environmental Planning and Assessment Act 1979</i>.</p>
Environmental improvements	A set of measures which would improve the environmental performance of the operation of the existing dam. For this project, they include a reduction in cold water releases through the installation of a multi-level offtake and consideration of a means of providing fish passage past the main dam wall. Consideration of these measures is part of the proposal however their ultimate implementation is contingent on a range of ongoing feasibility investigations and availability of funding.
Environmentally sustainable development (ESD)	Development that uses, conserves and enhances the community's resources so that ecological processes, on which life depends, are maintained and quality of life for both present and future generations is increased.
Exotic	Not native or endemic

Term or abbreviation	Definition
Fish-lift	A mechanical device similar to a hopper that can transport migratory fish between the base of a dam wall and the water storage, thereby enabling fish passage over the dam. More simply, a fish-lift is much like an elevator for fish. A fish lift is a means of providing fish passage.
Fishlock	A device that assists the migration of fish over dams by filling a chamber with water that fish have entered at tailwater level. A fishlock is a means of providing fish passage.
Fish passage	Fish passage is the process by which fish move around within their environment, and relates particularly to movement past barriers in a stream.
Fishway	A channel, series of pools or a lift designed to allow fish to migrate upstream or downstream of an obstacle such as a weir or dam. A fishway is a means of providing fish passage.
Floodplain	That part of a river valley, adjacent to the river channel, over which a river flows in times of flood.
Flood-runner	A continuous channel across or down a floodplain that only carries flow during a flood.
Freeboard	The vertical height between the maximum flood level in a reservoir and the crest of a dam wall
Full supply level	The water level in a reservoir when it is at its full water supply storage capacity; it only rises above this level during floods and the excess water is discharged from the reservoir.
Gauging station	Location at which hydrological characteristics, including flow rate, velocity and depth, are measured and recorded.
Hydrograph	A graph showing the variation over time of water levels or flow.
IPART	Independent Pricing and Regulatory Tribunal.
In situ	In its original location.
Inundation	To flood, cover or overspread with water on normally dry land.
Invertebrates	Animals without a backbone.
Left-hand abutment	Area where a dam wall meets the left-hand side of a valley, while the observer is looking downstream.
Maximum design earthquake (MDE)	The earthquake that would generate the most critical ground movements from among those loadings to which the structure might be exposed.
Megalitre	One million litres
Multi-level offtake	An offtake structure within a dam that can take water from various depths within the storage, rather than just a single depth.
Net present value	The net difference between the present day value of future benefits and the present day value of future costs.
NSW Dams Safety Committee	A statutory body created under the Dams Safety Act 1978 which formulates measures and conducts monitoring to ensure the safety of dams in NSW.

Term or abbreviation	Definition
Operation	Operation of the proposal would occur when a storm larger than 1 chance in 2,400 each year occurs which would result in discharges of floodwaters through an auxiliary spillway(s). Alternatively, operation of the project may also refer to the use of the multi-level offtake or fish passage at the main dam wall.
OEMP	Operational environmental management plan.
Ogee weir	An overflow weir in which in cross-section the crest, downstream slope and bucket have an S or ogee form of curve.
Percentile	A data point that exceeds the same percentage of all other data within that dataset e.g. the 35 th percentile represents a data point that is greater than 35% of all other data within that dataset.
Potable water	Water of a quality suitable for human consumption.
Probable maximum flood (PMF)	A theoretical flood event that occurs as a result of probable maximum precipitation coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions. More simply, the PMF is the largest flood likely to occur in the catchment.
Probable maximum precipitation	The theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin More simply, probable maximum precipitation is the maximum rainfall statistically likely to occur.
Riparian, channel and environmental (RCE) score	A system for scoring the habitat quality of riparian bank structures based on the level of human disturbance and habitat characteristics.
Reduced level (RL)	Level relative to some datum.
Right-hand abutment	Area where the dam wall meets the right-hand side of a valley, while the observer is looking downstream.
Riparian habitats	Areas along the banks of a river or creek and their immediate environs inhabited by plants and animals.
Riverine	Of or pertaining to a river.
Scouring	Erosion of materials by the passage of water.
Spawning	The release of gametes or eggs by fish as part of their reproductive cycle.
Spillway	A channel to convey floodwater from a reservoir to a downstream watercourse in a controlled manner.
SEPP	State environmental planning policy
Storage	The water impounded upstream of a dam (i.e. Lake Keepit in the case of Keepit Dam).
Stratification	The separation of water in a water body into horizontal layers of different temperatures.
Surcharge	The operational practice of temporarily storing a portion of floodwaters between the full supply level and design flood level during a large flood.
Terrestrial	Existing or growing on the land.
'the proposal'	Comprises two fundamental elements; a dam safety upgrade and provision for environmental improvements.

Executive summary

Overview

This summary provides an overview of the Concept Plan and Environmental Assessment prepared to assess the environmental, economic and social effects of the proposed Keepit Dam Upgrade (the 'proposal'). The Concept Plan for the proposal is described in Chapter 4 of the Environmental Assessment. The Environmental Assessment has been prepared in accordance with the requirements of Part 3A of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979*.

Following extensive community consultation, the Environmental Assessment has considered three options for upgrading the safety of the dam and has identified the likely benefits and consequences of proceeding with the proposal (refer Chapters 5-9 of the Environmental Assessment). The performance of the three options was assessed across a range of social, environmental and economic criteria and compared relative to each criterion and to each other (refer Table 7.1 of the Environmental Assessment).

The Environmental Assessment has concluded that the benefits of the proposal substantially outweigh the risk of a catastrophic dam failure if the dam safety upgrade were not to proceed. While each of the dam safety options would have different local impacts if a large to extreme flood were to occur, these are indistinguishable in a regional context and in light of the catastrophic social and economic consequences which would accompany such a large flood, the relative environmental consequences of the dam safety options are considered acceptable.

State Water will consider the feedback from public exhibition of this Environmental Assessment and will respond to submissions in a Submissions Report. Following further consultation with key project stakeholders, if necessary, State Water will select a preferred dam safety option, which will be outlined in a Preferred Project Report.

A State Water Board meeting held in August 2007 resolved that:

"State Water will adopt the least cost environmentally acceptable option and will not be seeking funding to pursue a higher cost option. Based on the Draft Environmental Assessment, Option B1 is currently considered by State Water to be the least cost environmentally acceptable option".

Where is Keepit Dam and what is its function?

Keepit Dam is located between the townships of Gunnedah and Tamworth in the north-west of NSW (refer Figure S-1). The dam is situated on the Namoi River, 13 kilometres upstream of its confluence with the Peel River. The dam comprises a concrete gravity main wall, approximately 55 metres high, and an earthen subsidiary dam wall. The dam impounds a water storage body of approximately 425,000 megalitres, known as Lake Keepit. Water released from the dam is mainly used for irrigation purposes.

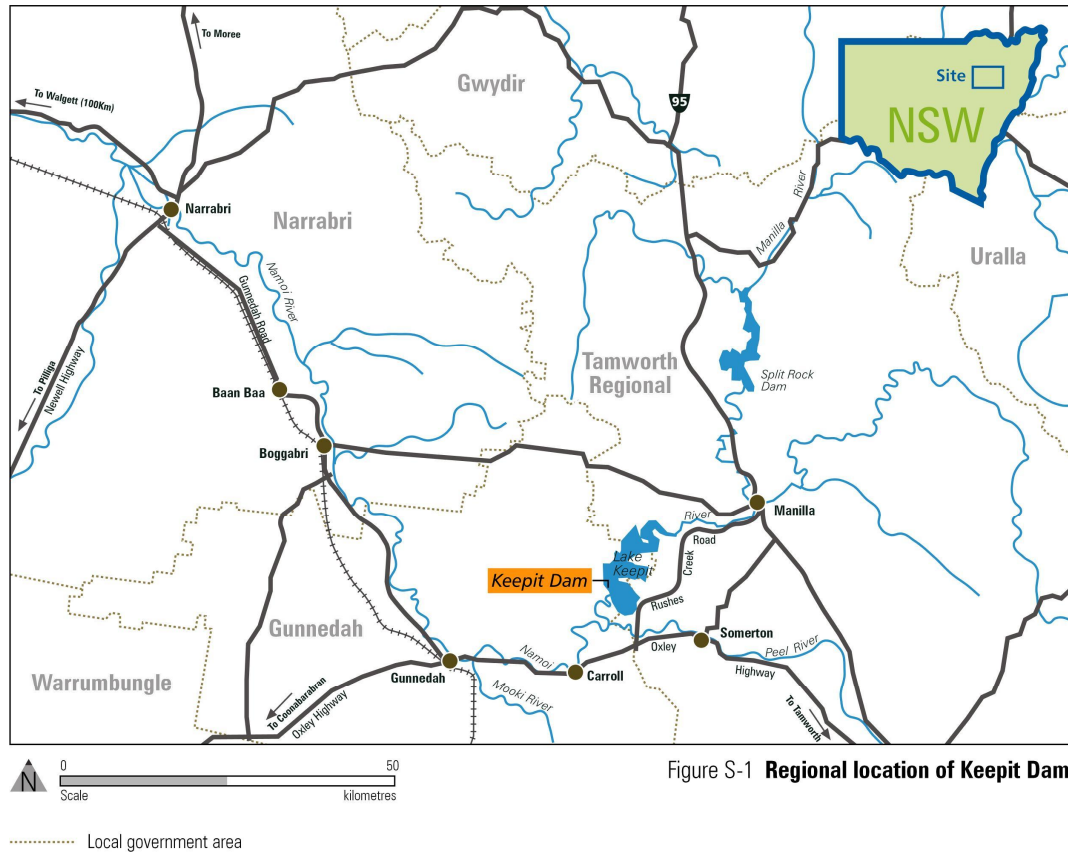


Figure S-1 Regional location of Keepit Dam

Why is an upgrade needed? (refer Chapter 3)

State Water Corporation (State Water) is the owner and operator of Keepit Dam and is responsible for ensuring that the dam meets the current safety requirements of the NSW Dams Safety Committee. While the existing dam is safe for day-to-day operations, flood estimation methods have improved and dam design standards have changed since it was originally constructed during the 1950's.

The NSW Dams Safety Committee requires that the dam be upgraded to be able to safely withstand extreme natural events, including the largest flood that could theoretically occur (known as the probable maximum flood or PMF) and earthquakes. Such extreme events have a very low likelihood of occurrence, although if they were to occur, the consequences would be catastrophic.

Prior to interim safety measures undertaken by State Water in 2003, it was predicted that there was a 1 chance in 2,800 each year that floodwaters could overtop the dam causing it to collapse. The interim measures implemented by State Water have reduced this risk to approximately 1 chance in 12,000 each year or less frequent.

The PMF in the Namoi River catchment is estimated to occur less frequently than 1 chance in 500,000 each year. Additional dam safety works are, therefore, required to further reduce the probability of dam collapse and achieve compliance with the requirements of the NSW Dams Safety Committee.

What would happen if the dam collapsed? (refer Chapter 3)

Prior to an unlikely collapse of the dam, the Namoi and Peel River catchments would already be experiencing very significant flooding. The enormous volume of water released during dam collapse and its speed of passage down the Namoi River valley would result in catastrophic social, environmental and economic consequences. It is estimated that these consequences would include approximately \$1.7 billion in direct damages and the risk of significant loss of human life.

What does the proposal comprise? (refer Chapters 4 and 8)

The key features of the three dam safety upgrade options are provided in Table S-1. All three options would involve raising of the main and subsidiary dam walls, strengthening of the main dam wall with post-tensioned steel cables, and the construction of additional spillways and saddle dams. No change to the full supply level of Lake Keepit is proposed. No change to the existing operation of the dam would occur unless a storm larger than a likelihood of occurrence of 1 chance in 2,400 each year occurred (refer Figure S-2).

A multi-level offtake (i.e. a mechanism for releasing water from various depths within Lake Keepit) is proposed to reduce the impact of cold water releases from the dam on the downstream riverine environment. Fish passage at the dam wall is also being considered as a requirement of the NSW Department of Primary Industries (Fisheries) under Section 218 of the *Fisheries Management Act 1994*.

Table S.1 Key features of the options

Option	Main and subsidiary dam wall raising	Proposed spillway locations	Spillway discharge locations	Saddle dam locations
Option B1	3.4 metres	<ul style="list-style-type: none"> ▪ right-hand abutment (220 metres) ▪ subsidiary dam wall (380 metres) 	Namoi and Peel Rivers	<ul style="list-style-type: none"> ▪ boat ramp ▪ sailing club ▪ caravan park
Option D2	4.6 metres	<ul style="list-style-type: none"> ▪ right-hand abutment 	Namoi River	<ul style="list-style-type: none"> ▪ caravan park

Option	Main and subsidiary dam wall raising	Proposed spillway locations	Spillway discharge locations	Saddle dam locations
		(220 metres)		
		<ul style="list-style-type: none"> ▪ sailing club and boat ramp (total 380 metres) 		
Option D3	5.5 metres	<ul style="list-style-type: none"> ▪ right-hand abutment (220 metres) ▪ sailing club and boat ramp (total 380 metres) 	Namoi River	<ul style="list-style-type: none"> ▪ caravan park

While these environmental improvement measures have been installed elsewhere in Australia, their adaptation to Keepit Dam requires innovative engineering design and, for fish passage, to suit specific fish migration needs. Concept designs have been developed as part of the proposal, however, further work needs to be conducted jointly with NSW Government agencies to determine whether these improvements would operate with the desired degree of effectiveness and are financially viable. If a decision is made to proceed with these improvements, the measures could be implemented separately from the dam safety upgrade with no detrimental effect on their performance.

The costs for implementing the dam safety upgrade are estimated to be between \$75 million and \$89 million (March 2007 estimates, depending on the option selected) and would be fully funded by the NSW Government. The multi-level offtake is estimated to cost an additional \$3.5 million. Fish passage is estimated to cost an additional \$21 million, depending on the concept adopted. The current determination of the Independent Pricing and Regulatory Tribunal (IPART) which oversees the regulation of the water industry, is that the multi-level offtake, if adopted, would be funded equally by the NSW Government and State Water's Namoi Valley customers. Funding arrangements for fish passage would be shared equally by State Water's Namoi Valley customers and the NSW Government as determined by IPART.

Subject to planning approval, the proposal would commence construction in 2008, with completion in approximately 2.5 years.

How would the proposal improve dam safety?

During large floods, the water level within Lake Keepit temporarily rises above its normal full supply level. Spillway gates in the main dam wall are opened to release this water, however, if the volume of incoming water is greater than can be released through the spillway gates, the dam could be overtopped by floodwaters, resulting in dam collapse.

Raising and strengthening the main dam wall and constructing additional saddle dams and spillways would enable the temporary storage of a greater portion of the incoming floodwaters. Implementation of additional spillways would increase the volume of water able to be released from the dam and the combination of both would prevent dam collapse.

Following implementation of the proposal, floods smaller than 1 chance in 2,400 each year would continue to be discharged through the dam's existing gated spillway in accordance with current operating procedures. The proposed additional spillways would only operate during floods larger than 1 chance in 2,400 each year. By contrast, the largest flood recorded in the Namoi River catchment was in 1955, which had an estimated likelihood of occurrence of 1 chance in 100 each year.

What options were considered? (refer Chapter 3)

The development and assessment of dam safety upgrade options was undertaken in a series of stages between 2002 and 2007. Details of the process adopted were outlined in the Project Application Report (Parsons Brinckerhoff 2006) and summarised in Figure S-3. A range of economic, engineering and environmental studies, including visual, ecology and heritage assessments, were conducted to provide information to assess the relative benefits and consequences of the options. Stakeholder and community feedback was also sought and integrated into the options development process (see below). The outcome of this process was a short-list of three dam safety upgrade options, which were developed from an initial list of over 70 feasible options. All the short-listed options comply with the requirements of the NSW Dams Safety Committee. The opportunity was also taken to consider environmental improvements as part of the dam safety upgrade. The improvements considered ways to address in-storage and downstream water quality issues including cold water releases, fish passage, and capturing additional floodwaters to create the ability to provide environmental flows to the Namoi River and potentially enhancing existing power generation capacity.

Capturing and releasing water for the purposes of creating environmental flows was considered at length during proposal development by a working group chaired by State Water and comprising NSW Government agencies, irrigators and a sub-group of the Community Reference Panel. While conceptual design investigations demonstrated a level of confidence that the proposal could be viable, the overarching 'value' of the proposal was difficult to demonstrate, particularly in the absence of experience in the administration and management of such schemes. Proceeding with the dam

safety upgrade would not preclude the ability to provide future environmental flows if desired.

How has the community been involved in the proposal? (refer Chapters 1 and 7)

Extensive efforts have been made to seek the opinions of a range of stakeholders on the environmental, social and economic performance of the options. The proposed dam safety upgrade options have been developed considering a wide range of values and opinions. More than 150 consultative meetings have been held and wider community consultation was also undertaken on a number of occasions.

Principal among these has been the Community Reference Panel established by State Water in May 2001. The Panel has guided the technical investigation of the options and acted as the primary advisory body to State Water. The Panel comprises representatives from relevant NSW Government agencies, local government, irrigators, land owners and local Indigenous groups. Nineteen meetings of the Panel have been held since its establishment which have included the options shortlisting processes and identification of a preferred option by the Panel.

Other consultation activities undertaken have included:

- distributing newsletters and fact sheets
- providing media releases to local newspapers
- displays at AgQuip annual field days in 2002, 2005 and 2006
- community and key stakeholder presentations
- land owner meetings
- formation of an Environmental Task Group to investigate selected topics
- meetings with representatives of key government departments
- a planning focus meeting with representatives of relevant government agencies
- conducting further consultation with key government agencies, local councils and the Community Reference Panel during the preparation of the Environmental Assessment.

Potentially affected land owners around the dam were advised of the proposal prior to lodging the Project Application Report in May 2006.

Further opportunity will be provided for the community and stakeholders to comment on the proposal during public exhibition of the Environmental Assessment.

What was the approach to the environmental assessment?

The environmental assessment was conducted by considering the construction and operational effects of the proposal separately. Specialist technical studies were conducted for each of the areas required by the Director-General of the NSW Department of Planning (refer Appendix A). These studies included the compilation of desktop information, field surveys of the affected areas and discussions with key regulatory agencies.

Assessing the operational effects of the dam safety upgrade resulting from large to extreme natural events (floods and earthquakes) is difficult given the magnitude of the events being considered and that such events occur unpredictably and very rarely. The approach adopted was to identify changes in the hydraulic effects of the options including the frequency of events, velocity of floodwaters and the duration and area of inundation and use these to predict the likely nature and scale of environmental impacts.

Computer flood modelling was undertaken for each of the dam safety upgrade options under probable maximum flood conditions. This represents the upper limit of predicted flood events and the 'worst case' scenario associated with the operation the dam. No changes to the downstream or upstream environments would occur for smaller floods than 1 chance in 2,400 each year. Therefore, no flood modelling for these events was undertaken.

The three dam safety upgrade options have different configurations and result in different construction and operational impacts. An assessment was conducted to examine the effects of each of the options individually and the full range of impacts which may result from the proposal should any of the options be implemented.

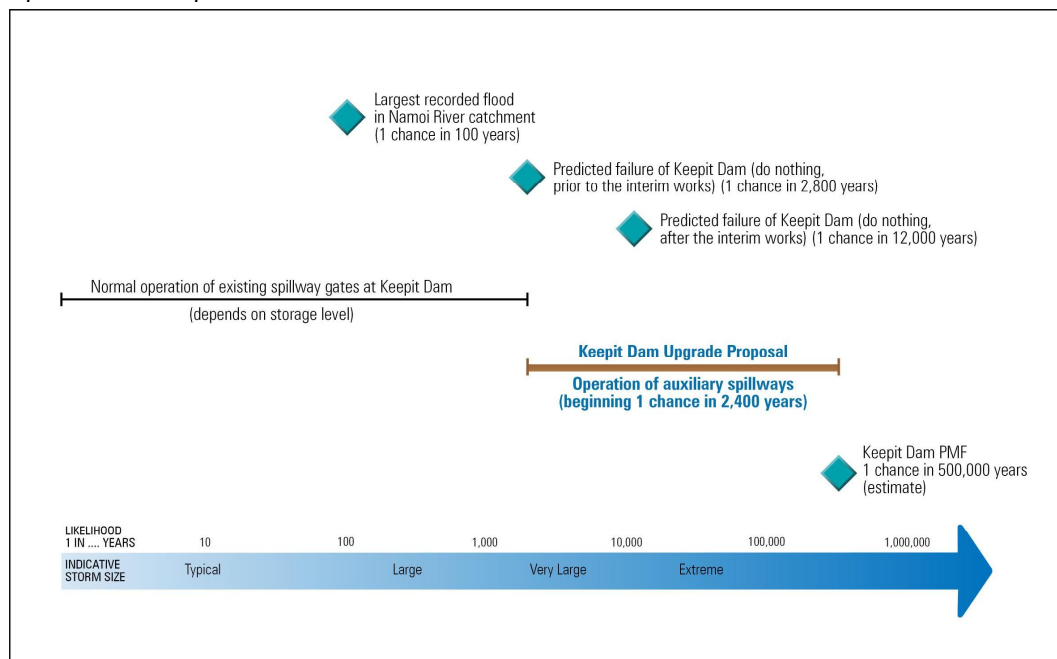


Figure S-2 Existing and proposed infrastructure operation

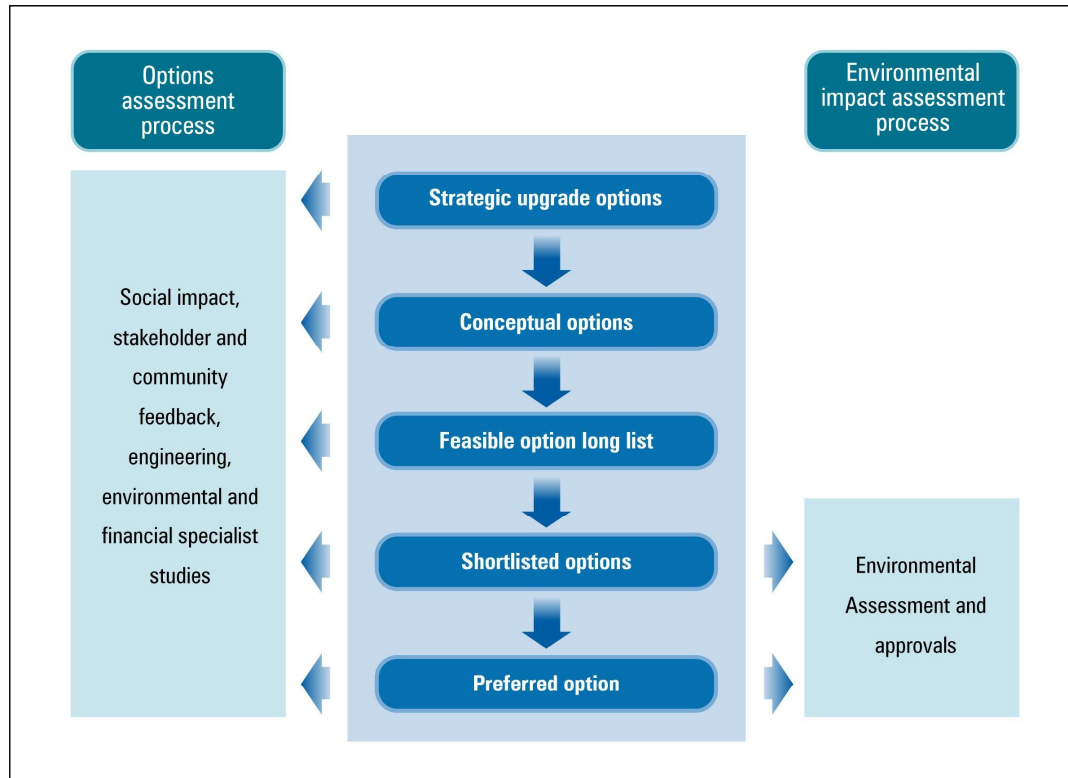


Figure S-3 **Relationship between options assessment and environmental assessment processes for Keepit Dam upgrade**

What are the potential environmental effects of the construction of the proposal? (refer Chapter 5)

The potential construction environmental impacts, which would occur if the proposal was implemented, are detailed in Chapter 5 of the Environmental Assessment. These would include terrestrial and aquatic ecology, heritage, visual and social issues. There are some specific differences in impact between the three dam safety upgrade options, associated with particular environmental issues. These issues would be manageable given the commitments to environmental protection and management made by State Water (refer Appendix D).

Terrestrial ecology

Vegetation clearing is required for all of the dam safety upgrade options: 41.0 hectares for Option B1 and 49.8 hectares for Option D2 and 49.3 hectares for Option D3. These areas includes a threatened ecological community – White Box Yellow Box Blakely's Red Gum Woodland. Clearing of 13.6 hectares of the community is for Option B1 and 18.0 and 17.6 hectares respectively for Options D2 and D3.

State Water has revised the sizing of the construction works areas to minimise the extent of clearing required, however, the environmental assessment concluded that the proposal is likely to have a significant impact on this community. A referral under the *Environment Protection and Biodiversity Conservation Act 1999* was submitted to the Commonwealth Department of Environment and Water Resources to seek approval for the necessary vegetation clearing.

State Water is committed to implementing a strategy to offset these impacts and has identified a package of offsets. The Department of Environment and Climate Change BioBanking Assessment Methodology would be used as a guideline for sizing an appropriate area of offset in combination with other measures proposed following any approval of the proposal. An approval from the Commonwealth Minister for the Environment and Water Resources concerning impacts to the threatened ecological community would also be required before the proposal could be implemented.

Aquatic ecology

Potential water quality impacts could occur as a result of sediment entering Lake Keepit or downstream areas during construction. Lake Keepit has previously been stocked with Murray Cod which is a Commonwealth-listed threatened species. The dam area also provides potential habitat for another Commonwealth-listed threatened species, the Namoi River Turtle. An assessment of significance for both species was conducted and concluded that impacts were unlikely based on the implementation of a comprehensive Soil and Water Quality Management Plan as proposed by State Water. As part of the plan, sediment and erosion controls would be routinely audited by a soil scientist during construction to ensure their effectiveness.

Non-Indigenous Heritage

All the options would require modifications to the main dam wall, which is listed on State Water's draft heritage register and which also meets the criteria for listing on the State Heritage Register. The potential impacts of the upgrade on the dam wall's heritage values would be reduced by designing the proposed modifications in harmony with the existing structure. Existing elements of the wall such as the gantry crane would be retained following completion of construction works.

The central spoil stockpile proposed for the construction of Options D2 and D3 would encroach on a historical school/scout hall that fulfils the criteria for local heritage listing. Management and mitigation measures would be implemented during construction to minimise the potential for disturbance to this item.

Indigenous Heritage

There is potential for the construction of Options D2 and D3 to affect an Aboriginal stone procurement source (i.e. a quarry). Further investigations would be conducted to determine the extent of the site and management measures to reduce the impacts.

Visual

The proposal would increase the visibility of infrastructure around the storage. The raised dam walls, additional spillways and saddle dams would be visible to users of Lake Keepit State Park and Lake Keepit and, to a lesser extent and depending on their location, local land owners and users of public roads. The visual impacts resulting from vegetation clearance would be mitigated by revegetating stockpile areas and other construction work areas.

Overall, Option B1 would have the least visual impacts of the three options and Option D3 would have the greatest visual impacts.

The ability to mitigate the visual impacts of the proposal is limited by the scale of the works and the inherent engineering function of the individual components. A Visual, Landscaping and Vegetation Management Plan would however be prepared in consultation with the local community and would address opportunities for revegetation and rehabilitation of areas as well as ensuring design elements integrate with the existing infrastructure.

Social

Construction of the proposal would result in disruptions to Lake Keepit State Park including temporary reductions in amenity and access. The State Park may suffer a loss of patronage during the construction period. However, it is possible that at least part of any impact may be offset by providing accommodation and supplies required by the construction workforce e.g. meals, recreation needs, and short-term accommodation.

State Water would develop a detailed master plan of Lake Keepit State Park for the preferred dam safety upgrade option in consultation with the Lake Keepit State Park Trust and local clubs. The relocation of some structures would be required outside the inundation area, subject to negotiations with the affected owners. The cost of the proposed relocation and management of associated impacts has been included in the option cost estimates.

The construction of Options D2 and D3 would cause greater disruption to Lake Keepit State Park operations than Option B1.

Other environmental issues

A number of other, more minor impacts may be generated during construction of the proposal. These include construction dust, noise and vibration, traffic and waste generation, erosion and sedimentation, and impacts on existing utilities and services.

State Water would manage these issues and other important aspects such as resource use and energy efficiency, ongoing consultation with affected residents and owners, potential property damage and public safety issues in accordance with the principles contained in its draft Statement of Commitments (refer Appendix D). A fundamental element of these commitments is the implementation of a comprehensive Construction

Environmental Management Plan which would include procedures and measures to reduce or avoid these and the other impacts identified in the Environmental Assessment. Independent supervision of the construction works would also be undertaken by an Environmental Management Representative reporting to the NSW Department of Planning. State Water would also establish a community liaison group to oversee any concerns relating to the works.

What are the potential environmental effects of the operation of the proposal? (refer Chapters 6 and 7)

A hydraulic analysis was undertaken to identify the operational effects of each of the three dam safety upgrade options. Details of the analysis are outlined in Section 6.2 of the Environmental Assessment. The key results, which are common to all dam safety upgrade options, are that:

- the depth of floodwaters during an extreme flood event would be reduced compared to the 'do nothing' scenario.
- the dam safety upgrade would have no effect on the environment for floods smaller than 1 chance in 2,400 each year on average. By contrast, the largest recorded flood in the Namoi River catchment occurred in 1955 and had an estimated likelihood of occurrence of 1 chance in 100 each year.
- the hydraulic effects of the dam safety upgrade during an extreme flood event are not observable beyond a point approximately 13 kilometres downstream of the main dam wall or at a point roughly coinciding with the confluence of the Namoi and Peel Rivers.
- downstream inundation would be more frequent than without the upgrade for a limited range of floods between 1 chance in 2,400 and 1 chance in 2,800 each year on average.
- the 'worst case' environmental impact would result from the probable maximum flood which has an estimated likelihood of occurrence of 1 chance in 500,000 each year. The effects of all other flood events would be less, although impacts for all storms larger than 1 change 10,000 each year would be severe.

The potential operational environmental impacts, which would occur only if a large to extreme flood event less frequent than 1:2,400 AEP occurred, are detailed in Sections 6.2-6.4 of the Environmental Assessment. These would include terrestrial and aquatic ecology, heritage, erosion, social and water supply security issues.

Downstream inundation

While the downstream operational impacts of the options are similar in general terms, they are different locally. Option B1 would discharge approximately 60% of flood flows to the Peel River while Options D2 and D3 would only discharge to the Namoi River consistent with the original design of the dam. Option B1 would result in erosion and sedimentation impacts to

the lower Peel valley during storms larger than 1 chance in 10,000 each year on average. High velocity discharges from the subsidiary dam spillway would result in the incision of a new channel between the spillway and the Peel River which could be several metres deep and hundreds of metres wide.

Terrestrial ecology

All the options would reduce the impact on the endangered plant species, *Hakea pulvinifera*, located in the Namoi River valley. Options D2 and D3 would provide a greater benefit to this population for floods between 1 chance in 2,400 each year and 1 chance in 10,000 each year. Option B1 would provide a greater benefit to this population than Options D2 and D3 for floods larger than 1 chance in 10,000 each year.

Discharges from the subsidiary dam spillway for Option B1 would result in additional impacts to the Peel River valley for floods smaller than 1 chance in 10,000 each year. A single individual of a threatened plant species located downstream of the subsidiary dam wall would be destroyed in the event of the operation of this spillway, however, a significance assessment concluded that this loss was not important to the survival of the species.

Aquatic ecology

All the options would reduce the extent of impacts in the Namoi River valley, with Option B1 providing a greater benefit than Options D2 and D3. For Option B1, discharges from the subsidiary dam spillway would result in additional impacts to the Peel River valley for floods smaller than 1 chance in 10,000 each year. Both riverine environments are highly degraded and in relatively poor condition.

Heritage

The proposal would result in reduced impacts to known and potential heritage sites in the Namoi River valley compared to the 'do nothing' scenario. The release of floodwaters from the subsidiary dam would exacerbate impacts to 15 known heritage sites in the Peel River valley for floods smaller than 1 chance in 10,000 each year.

Erosion and sedimentation

A storm of sufficient magnitude to cause operation of a second auxiliary spillway would mobilise a huge sediment load from the upstream catchment. The dam itself would act as a sink for a portion of this material including gravels, cobbles and boulders, vegetation and trees, although a large portion is also expected to pass through the dam and be deposited in downstream areas.

For Option B1, discharges from the subsidiary dam spillway into the Peel River valley would result in substantially greater local erosion due to the spillway's location on a highly erodible soil profile. Subsidiary dam spillway discharges would create a new channel between the spillway and the Peel

River over a distance of approximately 2.5 kilometres. The channel could be several metres deep and several hundred metres wide. The likelihood of this impact is very low and estimated to be 1 chance in 10,000 each year on average. In a regional context, the sediment arising from this spillway discharge would be minimal.

Social

All the options would avoid the social impacts that would result from catastrophic failure of the dam including the risk of significant loss of human life.

For Option B1, State Water would need to acquire some privately owned land immediately downstream of the subsidiary dam wall to enable the upgrade works to occur.

For Option B1, the operation of the subsidiary dam spillway in a flood larger than 1 chance in 10,000 each year would result in floodwater flow across Lake Keepit State Park, including an access road to the camping area, the golf course, a sewage treatment plant, and Keepit Dam Road (the main entry road into Keepit Dam). The affected infrastructure would require repair or replacement following operation of the subsidiary dam spillway. The operation of the subsidiary dam spillway would also affect an area of privately-owned land several hundred metres wide along a distance of approximately 2.5 kilometres between the spillway and the Peel River. The affected land is currently used for grazing/agriculture.

For Options D2 and D3, the operation of the sailing club and boat ramp spillways has the potential to damage sections of Lake Keepit State Park between the spillways and Namoi River. The damage would be limited to land degradation and some erosion.

Upstream inundation

The dam safety upgrade would result in a temporary increase in upstream inundation during storms larger than 1 chance in 5,000 each year for Option D3, 1 chance in 6,700 each year for Option D2, and 1 chance in 17,300 each year for Option B1. Upstream inundation would affect an area of land above the full supply level of the dam of between approximately 1,085 (for Option B1) and 1,795 hectares (Option D3). Land at a higher elevation would be inundated for a lesser period of time than that nearer to the full supply level of the dam. The maximum duration of temporary inundation ranges between 60 (Option B1) to 90 hours (Option D3).

Terrestrial ecology

The potentially affected upstream area includes some threatened ecological communities. The duration of upstream inundation is not expected to cause significant tree dieback, although grasses would be unlikely to survive. Ground-dwelling animals would have sufficient time to move to higher ground; however, some animals could be affected by being isolated or

possibly drowning, temporary loss of habitat, and increased exposure to predators due to temporary displacement. Option D3 would have the greatest impact and Option B1 the least impact.

Aquatic ecology

The increase in upstream inundation from all options would temporarily affect aquatic habitats by creating new aquatic habitats but at the same time reducing riverine habitats. Overall, no significant net effects are expected, however some redistribution of habitats would occur. Option D3 would have the greatest impact and Option B1 the least impact.

Non-Indigenous Heritage

One non-Indigenous heritage site already affected by inundation from the existing dam would be subject to longer periods of inundation, with Option D3 having the greatest impact and Option B1 the least impact.

Indigenous Heritage

Temporary upstream inundation resulting from Option D3 would affect one additional Indigenous heritage site. Three Indigenous heritage sites already affected by inundation from the dam would be subject to longer periods of inundation, with Option D3 having the greatest impact and Option B1 the least impact. The majority of the area to be impacted has a relatively low archaeological potential.

Social

The operation of the proposal would result in the temporary inundation of properties and infrastructure located on the foreshore of Lake Keepit during large to extreme flood events. Subject to detailed survey, the proposal would potentially result in temporary inundation of areas of the Manilla Ski Gardens Caravan Park, the Lake Keepit Sport and Recreation Centre, Lake Keepit State Park, and a number of privately-owned farming properties. The rise of floodwaters on these properties would allow sufficient time for evacuation (if necessary). The effects of inundation on particular facilities is not expected to be substantial, although there may be potential for wave action and settlement to occur. Option B1 would have less impact on upstream properties than Options D2 and D3.

Water supply security

Options B1 and D2 are designed so that the water released through the auxiliary spillways would include 30% and 15% respectively of the stored water within the dam. Therefore, there is a possibility that a storm larger than 1 chance in 2,400 each year that is immediately followed by a severe drought would potentially impact on the security of downstream water supplies.

State Water has investigated the likelihood of occurrence of a drought immediately following a large flood event using historical rainfall records. Based on these records, it is estimated that there is 1 chance in 3,000 each year that an impact to water supply security could occur. The supplementary water storage at Split Rock Dam upstream of Keepit Dam could also be used to avoid potential impact to water entitlements in the short term.

Environmental improvements

The multi-level offtake and fish passage concept designs currently being progressed by State Water represent concepts that have been successfully implemented on other dams in Australia. However, their adaptation to Keepit Dam requires innovative engineering design to suit specific fish migration needs

Preliminary modelling undertaken for the multi-level offtake demonstrates that the temperature of water released from the dam can attain the temperatures required for spawning by several native fish species including Murray Cod, Golden and Silver Perch and Catfish. However, the level of effectiveness varies with the water release demand. More detailed work needs to be undertaken to confirm the feasibility of the concept design and that the modelling assumptions being used address the majority of expected operating conditions. This work is ongoing and is being conducted in conjunction with the Department of Primary Industries (Fisheries).

The Environmental Assessment also includes a concept design for achieving fish passage at the main dam wall. Similar to the multi-level offtake, ongoing assessment of the concept is being undertaken jointly by State Water and the NSW Department of Primary Industries (Fisheries). An effect on the existing hydropower plant operation would result since the attraction flow for the fish passage would utilise water (estimated at 5% on average) that would otherwise be used to power the hydropower plant.

A final decision on the feasibility of the fish passage and multi-level offtake will be made by State Water and the Department of Primary Industries (Fisheries) prior to these components being implemented and subject to availability of funding.

Capital cost and economics

The capital cost of the options is presented in Section 4.6 as well as the results of an economic analysis. Option B1 is the cheapest of the three dam safety upgrade options by approximately 15%. Option B1 also has the lowest negative net present value. The ratio of benefits to costs for all options is similar.

What is the relative ranking of the dam safety upgrade options based on environmental, economic and social criteria? (refer Chapter 7)

The performance of each of the three dam safety upgrade options has been ranked against social, environmental and economic criteria in Table 7.1 of the Environmental Assessment.

At a regional scale, the social, environmental and economic benefits and consequences of the options are similar. However, differences between the options can be identified at a local scale in terms of the location and scale of impacts predicted and the likelihood of their occurrence.

The construction impacts of the proposal would occur at the time of development and are considered to be manageable given the commitments to environmental management processes and mitigation made in this Environmental Assessment by State Water.

The likelihood of the operational impacts occurring is much less likely and would only result if a large to extreme storm event were to occur. It is unknown when these impacts might occur, if at all, within the approximately 200-year lifetime of the dam. The size of such a large flood and its resulting social and economic damages is likely to render environmental issues a lower priority and, in this context, the environmental impacts of all the options are considered acceptable.

A meeting of the State Water Board held in August 2007 resolved that:

“State Water will adopt the least cost environmentally acceptable option and will not be seeking funding to pursue a higher cost option. Based on the Draft Environmental Assessment, Option B1 is currently considered by State Water to be the least cost environmentally acceptable option”.

How will a preferred option be selected? (refer Chapter 10)

State Water will consider all available project information but principally the information contained in this Environmental Assessment and the submissions received from the public and other project stakeholders arising from public exhibition, before making a decision on a preferred dam safety upgrade option. Depending on the submissions received and the outcome of further consultation if necessary, the preferred dam safety upgrade option may be one of the three options presented in this Environmental Assessment, or a combination of them.

The preferred dam safety upgrade option will be identified in the Submissions Report (including a Preferred Project Report, if required).

What is the future decision-making process regarding the proposal? (refer Chapters 2 and 10)

This Environmental Assessment will be placed on public exhibition for a minimum period of 30 days. During the exhibition period, written submissions are invited from the public. Submissions can only be made during the public exhibition period. Submissions should be addressed to:

Keepit Dam Upgrade
Major Infrastructure Assessment
Department of Planning
GPO Box 39
SYDNEY NSW 2001

Following the exhibition period, State Water will review all submissions received by the Department of Planning (or summaries of those submissions where respondents have requested that their submissions not be sent to the proponent). In accordance with Section 75H(6)(a) of the *Environmental Planning and Assessment Act 1979*, the Director-General of the Department of Planning may require State Water to consider and respond to the issues raised by respondents in a Submissions Report.

State Water will submit to the Director-General a Preferred Project Report (including a Submissions Report, if required) that will include a preferred dam safety upgrade option. In accordance with Section 75H(7) of the *Environmental Planning and Assessment Act 1979*, the Director-General may require State Water to make the Preferred Project Report available to the public.

State Water will forward its Preferred Project Report (including a Submissions Report, if required) together with the final Statement of Commitments to the Department of Planning with a request for approval of the proposal.

The proposal will be assessed under Part 3A of the *Environmental Planning and Assessment Act 1979*. The Minister for Planning is the approval authority for all projects assessed under Part 3A of the Act. The Director-General of the Department of Planning will examine the Environmental Assessment, Preferred Project Report (including a Submissions Report, if required) and final Statement of Commitments and prepare an Assessment Report taking into account the views expressed by government agencies, local councils and the community in public submissions. Having reviewed the Director-General's Assessment Report, the Minister for Planning will decide whether to grant approval or refuse the Concept Plan under Section 75O of the *Environmental Planning and Assessment Act 1979*. Any approval granted by the NSW Minister for Planning may be subject to conditions that may, for example, include further environmental assessment. Under Section 75P(1)(c) of the *Environmental Planning and Assessment Act 1979*, the Minister for Planning may also determine that no further environmental assessment is required.

As a result of the proposed clearing of a Commonwealth-listed threatened ecological community during construction, the proposal will be assessed by the Commonwealth Minister for the Environment and Water Resources in relation to these matters. A request for approval from the Commonwealth Minister for the Environment and Water Resources would also be sought before the proposal could be implemented.

Conclusion

The proposed Keepit Dam Upgrade would meet the safety requirements of the NSW Dams Safety Committee for extreme consequence dams. No change to the full supply level of the dam is proposed and no change to the operation of the dam would occur for storms smaller than 1 chance in 2,400 each year on average.

The Environmental Assessment has investigated the issues associated with the proposal and concluded that:

- implementation of the proposal would result in a range of environmental and social benefits and impacts.
- the justification for the proposal is founded upon the avoidance of approximately \$1.7 billion of potential direct damages to downstream areas and significant loss of human life should a PMF occur. These benefits outweigh the predicted environmental impacts.
- construction impacts are likely to be manageable given the implementation of the mitigation measures proposed by State Water.
- the operational impacts would occur very rarely, if at all within the 200 year lifetime of the dam.
- Option B1 is considered to best meet the project objectives and is superior in relation to construction issues and finance and economics.
- the proposed multi-level offtake and fish passage are likely to result in benefits to the environment. However, these are subject to further studies of cost-effectiveness and their implementation would be subject to availability of funding.

State Water has discharged its obligations under the NSW and Commonwealth environmental legislation by assembling and evaluating options to resolve the safety of Keepit Dam and undertaking a comprehensive community and stakeholder consultation process. This has resulted in a multi-faceted proposal which is likely to substantially improve a number of impacts associated with the existing dam.

The Environmental Assessment has concluded that the environmental benefits of the proposal substantially outweigh the environmental impacts and therefore submit this proposal to upgrade Keepit Dam for approval by the relevant State and Commonwealth authorities.

1. Introduction

1.1 Background

On 25 January 2006, the New South Wales (NSW) Minister for Planning authorised the submission of a Concept Plan for a proposal to upgrade Keepit Dam in north-west NSW ('the proposal') pursuant to Section 75M(1) of Part 3A of the *Environmental Planning and Assessment Act 1979*. A Concept Plan outlines the scope, development options and staging of a project for which a proponent is applying for approval. The Concept Plan for the proposal is detailed in *Chapter 4* of this document, and includes a dam safety upgrade as well as environmental improvement measures. The remaining chapters of this document comprise the environmental assessment of the proposal.

The purpose of the proposal is to ensure Keepit Dam is able to withstand extreme natural events; specifically, very large to extreme floods or a severe earthquake. Such extreme events typically have a very low likelihood of occurrence; however, they may also result in devastating consequences.

While Keepit Dam is safe for day-to-day operations, a catastrophic failure of the dam during an extreme natural event would result in massive downstream inundation, with damages estimated in the order of \$1.7 billion and significant loss of human life.

The NSW Minister for Planning's authorisation came almost 4 years after the commencement of detailed technical investigations on the most appropriate means of upgrading Keepit Dam. During this period, the following interim safety works were implemented to reduce the risks of failure of the dam:

- conduct of a detailed risk assessment
- an upgrade of power supply and provision of backup power sources to improve the reliability of the existing spillway gate operations
- installation of spillway gate controls at site administration offices
- improvements to flood routing by modifying storage operational procedures
- installation of an early warning system to notify emergency services and downstream residents of instances when the integrity of the dam may be at risk
- lowering the height of the subsidiary dam wall by an average of 3.5 metres to allow it to function as a temporary auxiliary spillway.

As the owner and operator of the dam, the State Water Corporation (State Water or 'the proponent') is responsible for ensuring Keepit Dam complies with guidelines set by the Australian National Committee on Large Dams and enforced by the NSW Dams Safety Committee. The NSW Dams Safety Committee is a statutory corporation of the NSW Government created under the *Dam Safety Act 1978*. The committee has statutory functions under the Act to formulate measures to ensure the safety of dams.

The NSW Dams Safety Committee assigns consequence categories to dams in NSW according to the seriousness and magnitude of the adverse consequences of dam failure on the community's interests or the environment. In 1995, the NSW Dams Safety Committee classified Keepit Dam as an 'extreme consequence' dam, based on the estimated \$1.7 billion in direct damage and significant loss of life that would result if the dam failed. In accordance with the *Dam Safety Act 1978*, State Water is required to upgrade the safety of Keepit Dam to reduce the identified safety risks (refer *Section 3.3*).

The interim safety works already implemented have subsequently reduced the risk of failure of the main dam wall, from an annual exceedance probability (AEP) of approximately 1:2,800 to at least 1:12,000. (An AEP refers to the chance of a flood occurring in any one particular year. Larger floods have a lower chance of occurrence, and therefore a lower AEP, than smaller floods.) However, the dam still does not fully meet the safety requirements specified by the NSW Dams Safety Committee. The NSW Dams Safety Committee requires that extreme consequence dams are capable of withstanding a probable maximum flood (PMF) and a maximum design earthquake (MDE) without failing. A PMF is simply the largest flood that is theoretically possible to occur. An MDE is the largest earthquake that is likely to occur in a particular location.

Since 2001, State Water has analysed the performance of a range of potential dam safety upgrade options with inputs from relevant government agencies and the community (refer *Section 1.6.3*). A Community Reference Panel was set up by State Water in May 2001 and chaired by the Mayor of Gunnedah Shire Council. The Community Reference Panel has been the primary advisory body to State Water, having guided the direction of technical studies related to the options development and assessment (refer *Section 3.7*). Input has also been sought from the wider community at a number of key stages of the project.

This Environmental Assessment has been prepared by Parsons Brinckerhoff on behalf of State Water in accordance with the requirements of Part 3A of the NSW *Environmental Planning and Assessment Act 1979*. The Director-General of the NSW Department of Planning has determined the key issues that must be considered in this Environmental Assessment (see *Appendix A*). Other environmental issues not mentioned in this Environmental Assessment were assessed in the Project Application Report submitted to the Department of Planning in May 2006 (State Water 2006a), which concluded that they were unlikely to result in significant impacts on the environment and could be adequately managed through the implementation of standard mitigation measures. These and other precautions to mitigate the potential adverse effects of the proposal are contained in State Water's draft Statement of Commitments (refer *Chapter 9*).

At the completion of the options assessment process, three options for upgrading the safety of the dam remain. At the level of detail examined during the options assessment process, the options appeared to perform similarly, despite some obvious differences. State Water has therefore decided to examine each of these three dam safety options in more detail in this Environmental Assessment and to seek further feedback from project stakeholders before determining a preferred upgrade option. Only one of the three dam safety upgrade options would ultimately be implemented.

1.2 Location and key features of Keepit Dam

Keepit Dam is located between the townships of Gunnedah and Tamworth in the north-west of NSW, as shown in *Figure 1-1*. The dam is situated on the Namoi River, 13 kilometres upstream of its confluence with the Peel River.

The Namoi River flows into the Barwon and Darling Rivers and forms part of the Murray-Darling Basin.

Keepit Dam comprises a main dam wall and a subsidiary dam wall. The main dam wall (see *Photograph 1.1*) is a combined, concrete gravity structure with an earth and rock fill embankment. It has one gated spillway, consisting of six radial gates, each 14.9 metres wide and 11.3 metres high. Floodwaters discharged through the spillway flow directly into the Namoi River downstream of the dam. Other infrastructure at the main dam wall includes the gantry crane atop the wall, a valve house and hydroelectric power generating station.

The subsidiary dam wall (see *Photograph 1.2*) is an earth and rock fill embankment, located east of the main dam wall. The subsidiary dam wall was modified in 2003 to function as an auxiliary spillway. This was an interim measure undertaken to reduce the likelihood of failure of the main dam wall (refer *Section 1.1*), by providing a temporary increase in spillway capacity while a long-term solution to the dam safety concerns was developed and implemented.

The expected life of Keepit Dam is not more than approximately 200 years.

The key specifications of Keepit Dam are as follows:

Age	47 years (in 2007)
Storage capacity	425,000 megalitres
Length of main dam wall	533 metres
Maximum height of main dam wall	43 metres
Upstream catchment area	570,000 hectares
Length of subsidiary dam wall	914 metres
Maximum height of subsidiary dam wall	11 metres (prior to interim works)
Storage full supply level	329.6 metres AHD
Storage design flood level	333.5 metres AHD
Maximum spillway discharge	10,475 cubic metres per second
Flood handling capability (prior to/ after interim safety works being implemented)	1:2,800 / 1:12,000 AEP
Upstream area inundated at full supply level	4,370 hectares



Photograph 1.1 The existing main dam wall



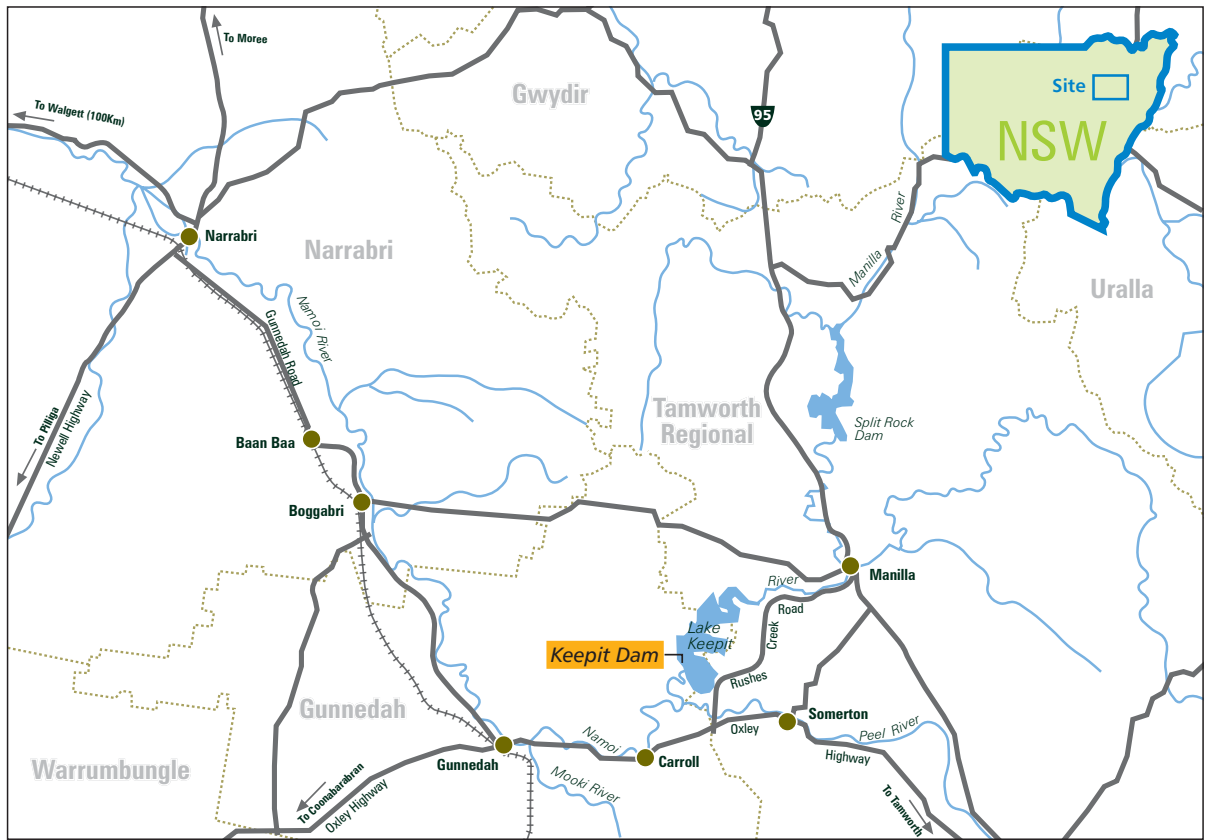
Photograph 1.2 The existing subsidiary dam wall

1.3 Role and importance of Keepit Dam

The main use of the water released from Keepit Dam is for irrigated agriculture in the Namoi Valley (approximately 97%), although other uses include town water supplies, stock and domestic uses, mining and riparian flows.

The Namoi valley has an area of approximately 42,000 square kilometres, stretching from Quirindi and Tamworth in the east to Wee Waa and Walgett in the west. Although irrigated agriculture covers just 1.5% of the area of the catchment, it contributes some 30% of total production. Major irrigated commodities in the Namoi valley are cotton, pastures for stock feed and cereals. Irrigated agricultural production in the Namoi valley was valued at approximately \$290 million in 2000/2001 (Namoi Catchment Management Authority 2006; NSW Irrigators' Council undated; Australian Bureau of Statistics 2001).

Keepit Dam and its surrounds also support a variety of other activities, including hydro-electric power generation, educational facilities and recreational uses, such as caravanning, boating, water skiing, fishing, gliding, camping, bushwalking and bird watching.



..... Local government area

Figure 1-1 Regional location of Keepit Dam

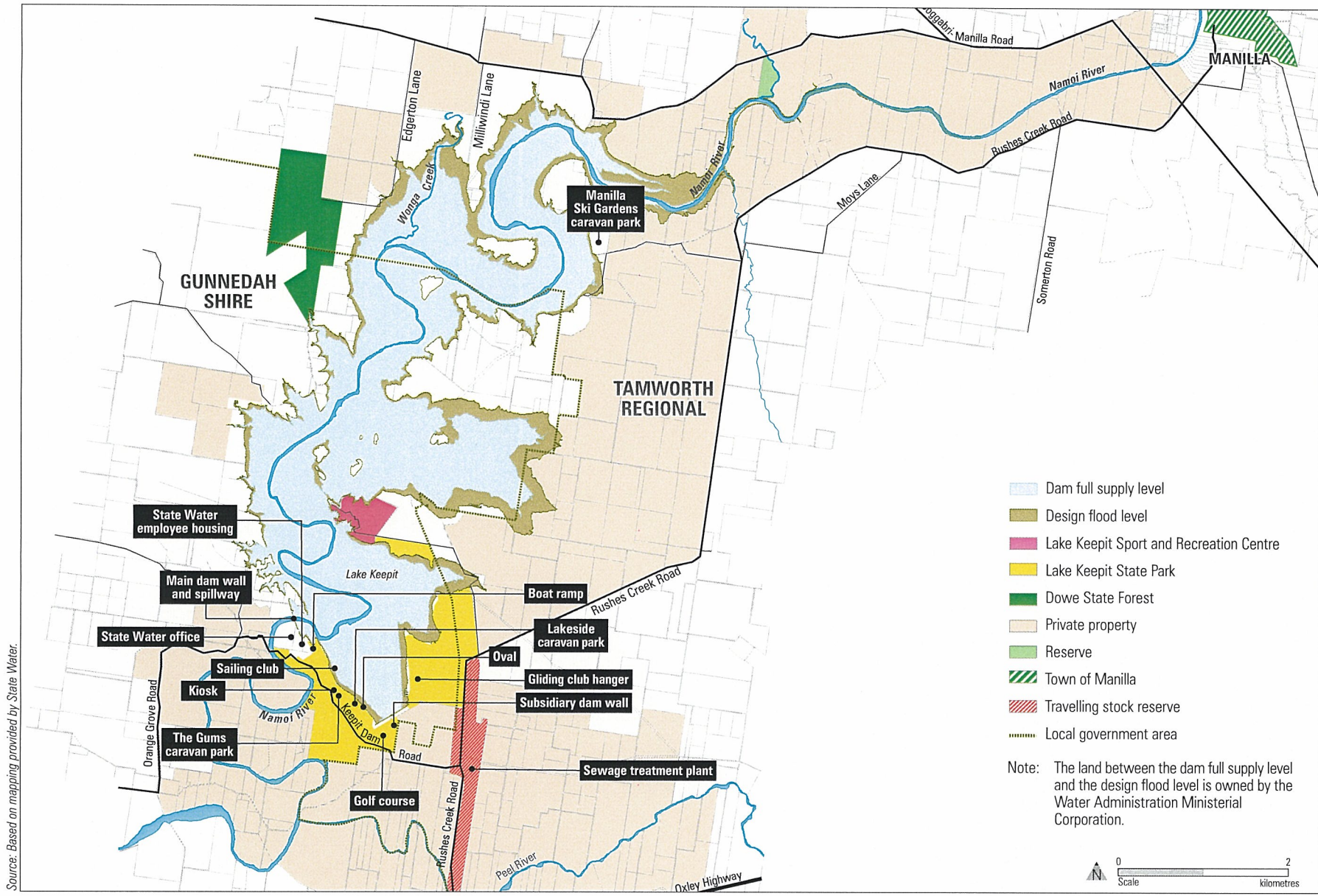
1.4 Surrounding land uses and ownership

Key land uses around the southern end of Lake Keepit are shown in *Figure 1-2* and include:

- A State Water administration office, workshop, depot and employee housing.
- Lake Keepit State Park, which includes a caravan park, five-hole golf course, two boat ramps, sailing and fishing clubs, gliding club, camping ground, kiosk, sewage treatment plant and other facilities. The sewage treatment plant is a package treatment unit housed within a shed. These facilities are generally located on the western side of Lake Keepit between the main and subsidiary dam walls, with the exception of the gliding club, camping ground and one of the boat ramps, which are located on the eastern side of the subsidiary dam wall.
- Lake Keepit Sport and Recreation Centre, which is located on the foreshore approximately 7 kilometres north-east of the main dam wall and includes cabins, a conference centre, a swimming pool and other recreational facilities.
- A further caravan park, the Manilla Ski Gardens, is located at the north-eastern end of Lake Keepit.

A large proportion of the foreshore area around Keepit Dam has been designated as a State Park (the Lake Keepit State Park). It is owned by the Water Administration Ministerial Corporation, which is a statutory body enacted under the Water Management Act 2000 and headed by the Minister for Water Utilities (formerly the Minister for Utilities). The Water Administration Ministerial Corporation has delegated management of these areas to the Department of Lands, which has subsequently established the Lake Keepit State Park Trust to manage the park on its behalf.

State Water was formed as a statutory, state-owned corporation on 1 July 2004. State Water owns 21 large dams and managed another 11 small dams on behalf of the Department of Lands. Additionally, State Water owns and manages more than 280 weirs and regulators in NSW. Various parcels of land comprising this infrastructure are being progressively transferred into the ownership of State Water from other Government bodies. At the time of writing, the land around the foreshore of Lake Keepit was owned by the Water Administration Ministerial Corporation.



Source: Based on mapping provided by State Water.

Figure 1-2 Keepit Dam features, land uses and property ownership

1.5 Overview of the proposal

The proposal is described in detail in Section 4 and comprises two fundamental elements: 1) a dam safety upgrade and 2) measures to improve the environmental performance of the dam's operation, known as 'environmental improvements'.

The three dam safety upgrade options examined in this Environmental Assessment involve a combination of raising the main and subsidiary dam walls, provision of additional saddle dams, strengthening the main dam wall and providing additional spillway capacity.

None of the options propose a change in the existing full supply level of the dam.

Raising and strengthening the existing dam walls and constructing additional saddle dams would:

- provide additional temporary storage of floodwaters during a very large to extreme flood event
- provide an increased capacity to discharge floodwaters in a controlled manner, thereby avoiding overtopping and failure of the main dam wall by floodwaters.

The dam safety upgrade options are summarised in *Figure 1-3*. In summary, they are:

- *Option B1*: raising the main and subsidiary dam walls by 3.4 metres and constructing two additional spillways (one at the right-hand abutment of the main dam wall and one at the subsidiary dam wall) and the installation of three saddle dams.
- *Option D2*: raising the main and subsidiary dam walls by 4.6 metres and constructing three additional spillways (one at the right-hand abutment of the main dam wall, one at the sailing club and one at the boat ramp) and the installation of one saddle dam.
- *Option D3*: raising the main and subsidiary dam walls by 5.5 metres and constructing three additional spillways (one at the right-hand abutment of the main dam wall, one at the sailing club and one at the boat ramp) and the installation of one saddle dam.

Only one of these three options would be implemented by State Water. A decision of which option is preferred considering environmental, social and economic issues will be determined following stakeholder feedback on this document (refer *Section 1.6.4*).

All three dam safety upgrade options would:

- maintain the dam full supply level at its current level
- resolve the existing safety concerns and protect Keepit Dam from extreme floods and earthquakes, as required by the NSW Dams Safety Committee
- have no effect on existing dam operations or result in any different environmental impacts than currently occur until a flood larger than 1:2,400 AEP or more than twice the largest flood over the last 108 years occurs
- substantially reduce the likelihood of dam failure from an estimated frequency of 1:2,800 AEP to that of a PMF, which, although it cannot be directly converted to an AEP, is estimated to have an AEP of at least 1:500,000 and possibly less
- operate the existing gated spillway in the main dam wall for all floods smaller than 1:2,400 AEP, then operate the proposed right-hand abutment spillway; and subsequently, at approximately 1:10,000 AEP, operate the subsidiary dam wall and/or sailing club spillways; and subsequently at approximately 1:100,000 AEP, operate the boat ramp spillway as appropriate for each option
- result in temporary additional inundation of upstream areas during a very large to extreme flood, with a duration of inundation up to a maximum of 90 hours and less for most areas. (The actual level of additional inundation would be specific to each rainfall event and at most would be equal to the height of wall-raising proposed for each option)
- include a multi-level offtake to reduce cold water pollution on downstream areas, subject to confirmation of its cost-effectiveness and future Government approvals
- include a means of fish passage past the main dam wall, subject to further investigation of cost-effectiveness and future Government approvals.



Source: Aerial photograph supplied by State Water, 2006.



- New saddle dam
- New spillway
- Raise dam wall

Figure 1-3 Key features of the options

1.6 Approach to the Environmental Assessment

1.6.1 Approach to impact assessment

This Environmental Assessment considers the likelihood and significance of impacts arising from the construction and operation of the proposal.

If the proposal is approved by the NSW Minister for Planning (refer *Section 1.6.5*), the construction impacts identified in *Chapter 5* would occur.

However, unlike many other infrastructure proposals, the operational impacts of the proposal would not occur at the completion of construction and are unlikely to occur during the approximately 200-year life of the dam, if at all (refer *Chapter 6*). Operation of the first auxiliary spillway at the right-hand abutment would only occur if a flood of approximately 24 times the largest flood of record occurred. A flood event of this size is not known to have occurred before in Australia and its occurrence would be considered a natural disaster. Other auxiliary spillways would not commence operation until much larger floods occurred.

A detailed examination of the environmental impacts during such a large or extreme flood is not considered appropriate because of:

- the remote likelihood of the event occurring
- the widespread and catastrophic nature of social and economic damage if an event like this were to occur, likely relegating environmental issues to a lesser priority
- the inability to model the magnitude of hydraulic change which would accompany such extreme events
- the difficulty in assigning a quantum of damage to environmental issues related to the proposal base case or the proposed changes resulting from operational of the proposal.

Despite these difficulties, the hydraulic performance of the dam safety upgrade options, determined through computer simulation, has been used to gauge the level of environmental impact expected and a broader-scale impact assessment undertaken.

The operational impact assessment also focuses on the impacts likely to result from the PMF as this sets the upper limit or the 'worst case scenario' for the extent of damage likely to occur. Partly for the reasons outlined above, for storms smaller than the PMF, the environmental effects would be more difficult to identify and regardless, they would be reduced.

1.6.2 Identification of project baseline impact levels

The project application report (Parsons Brinckerhoff 2006a) identified the proposed baseline level of impact resulting from the existing dam infrastructure. It has since been clarified that for upstream inundation, the current design flood level of the dam is at RL 333.5 metres AHD (or 3.9 metres above full supply level). This represents the maximum water level around the dam that would have been envisaged when the dam was originally constructed. The project application report identified incorrectly that the upstream baseline impact level for the dam was the operating surcharge level at RL 330.8 metres AHD (or 1.2 metres above full supply level). The preamble to *Chapter 6* describes in more detail the dam operating procedures in relation to the surcharge level.

Regarding downstream conditions, the need for the dam safety upgrade is the impact which would result if the dam were to fail. Therefore, dam failure and the consequent environmental impact is considered the appropriate baseline for the environmental assessment.

1.6.3 Multiple dam safety upgrade options

As noted in *Section 1.1*, this Environmental Assessment considers three dam safety upgrade options as part of the Concept Plan, however only one of these would ultimately be implemented. The three options are considered in the same level of detail according to the requirements of the Director-General of the NSW Department of Planning (refer *Appendix A*).

Because of the different configuration and operating parameters of the three options, the assessment describes potential environmental effect for each issue. For example, a range of capital costs and net present values for the options is presented, for terrestrial biodiversity, a range of native vegetation clearing is described which addresses each and all of the options.

While the outcome of the future preferred option decision process is not yet known, the information contained within this document would support a preference for any of the options investigated (including a possible combination if required).

Section 10.3 outlines the anticipated future decision making process to determine the preferred dam safety upgrade option.

1.6.4 Ecologically sustainable development

State Water operates under the provisions of the *State Water Corporation Act 2004*. The Act establishes an objective for State Water to conduct its operations in compliance with the principles of ecologically sustainable development where they affect the environment.

The four principles of ecologically sustainable development are outlined in Schedule 2 of the Environmental Planning and Assessment Regulation 2000. In summary, the principles are:

- *the precautionary principle* — If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- *intergenerational equity* — The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.
- *conservation of biological diversity and ecological integrity* — The diversity of genes, species, populations and their communities, as well as the ecosystems and habitats they belong to, should be maintained or improved to ensure their survival.
- *improved valuation, pricing and incentive mechanisms* — Environmental factors should be included in the valuation of assets and services.

The approach to achieving ecologically sustainable development for this project encompasses two main aspects. The first is to enshrine in the project objectives (refer *Section 3.5*), the need to consider the environmental impacts of the proposal. The second is to ensure that at each stage of the project development or where key decisions are made, that environmental benefits and consequences are considered.

For this project, the appropriate objective is stated as "improve environmental outcomes". The Concept Plan for the proposal (refer *Section 4*) identifies specific elements designed to achieve this outcome. The parallel, detailed assessment of three dam safety options also provides an opportunity for project stakeholders to comment on the balance of environmental, economic and social benefits and impacts achieved by each option before a preferred option decision is made by State Water.

Section 10.2 details specifically how each of the above ecologically sustainable development principles were considered in the development of the proposal.

1.7 The process for considering the proposal

1.7.1 Role of the Environmental Assessment

The process undertaken in preparing this Environmental Assessment identified the elements of the environment that may be affected by the proposal and the significance of any effects at a local, regional, state and (as appropriate) national level. The Environmental Assessment also outlines measures that would be implemented to mitigate the adverse effects and enhance the benefits of the proposal. The baseline environmental conditions presented also provide a basis for future monitoring of the environmental performance of the proposal.

This Environmental Assessment will be the primary source of information on which an assessment of the benefits and impacts of the proposal will be made by State Water, the Department of Planning, other NSW Government agencies, the Commonwealth Department of the Environment and Water Resources (formerly the Department of the Environment and Heritage) and the community. It is, therefore, necessary that the document complies with all regulatory requirements and presents factual technical information.

The preparation of an Environmental Assessment is a statutory requirement of the NSW *Environmental Planning and Assessment Act 1979*. An Environmental Assessment and planning approval is required before a project can be implemented.

1.7.2 Statutory requirements

NSW Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* is the primary piece of legislation in NSW that requires proponents to conduct environmental impact assessments of activities prior to their undertaking. Various parts of the Act and the associated Environmental Planning and Assessment Regulation 2000 outline the requirements and the contents of an environmental impact assessment.

On 25 January 2006, the NSW Minister for Planning authorised the submission of a Concept Plan for the Keepit Dam Upgrade under Part 3A of the *Environmental Planning and Assessment Act 1979*. Section 75M(2) of the Act requires the Concept Plan to:

- outline the scope of the project and any development options
- set out any proposal for the staged implementation of the project
- contain any other matter required by the Director-General.

A Project Application Report and preliminary environmental assessment were submitted to the NSW Department of Planning in May 2006 (State Water 2006a). On the basis of the information contained in that document, the Director-General of the NSW Department of Planning, in conjunction with other government agencies, prepared a list of requirements to be addressed in the Environmental Assessment for the proposal. A copy of these requirements is contained in *Appendix A*. A checklist of where these matters are addressed and referenced in this document is provided in *Appendix B*.

Figure 1-5 provides an overview of the approvals process under the NSW *Environmental Planning and Assessment Act 1979*. The approvals process under this Act is also explained further in *Sections 1.6.4* and *1.6.5*.

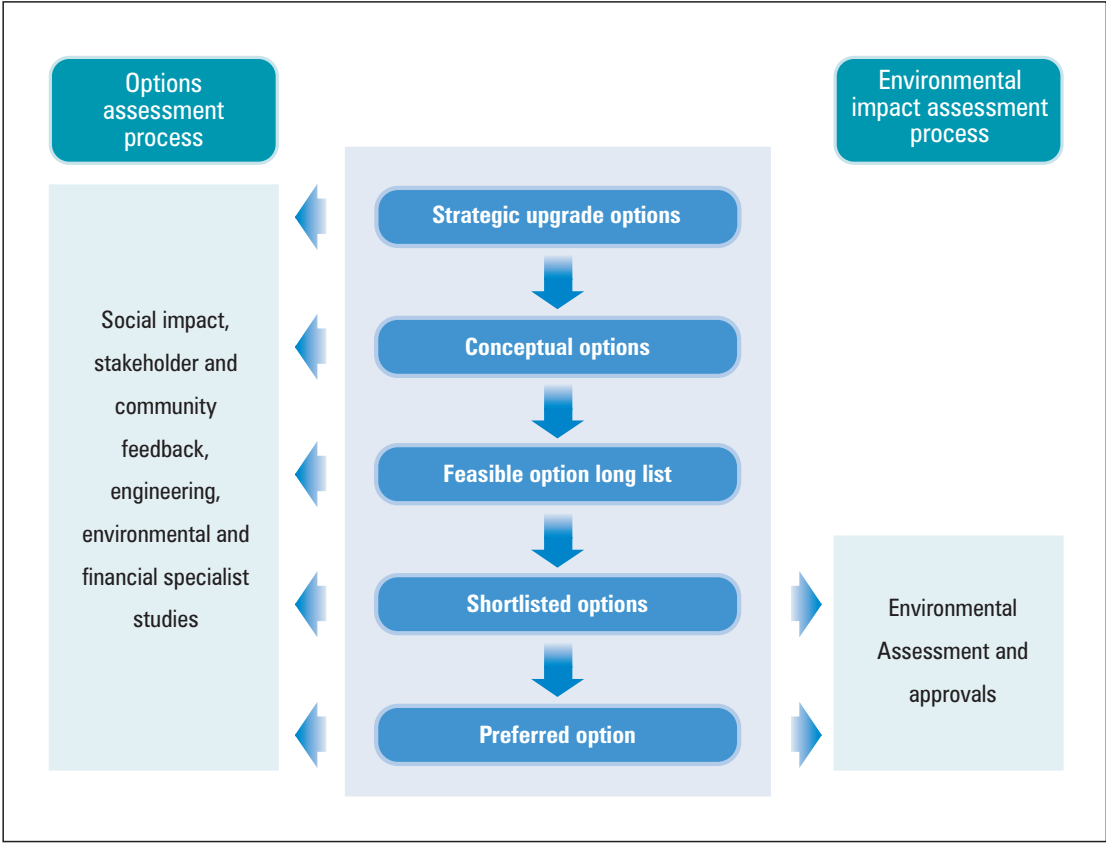


Figure 1-4 Relationship between options assessment and environmental assessment processes for Keepit upgrade

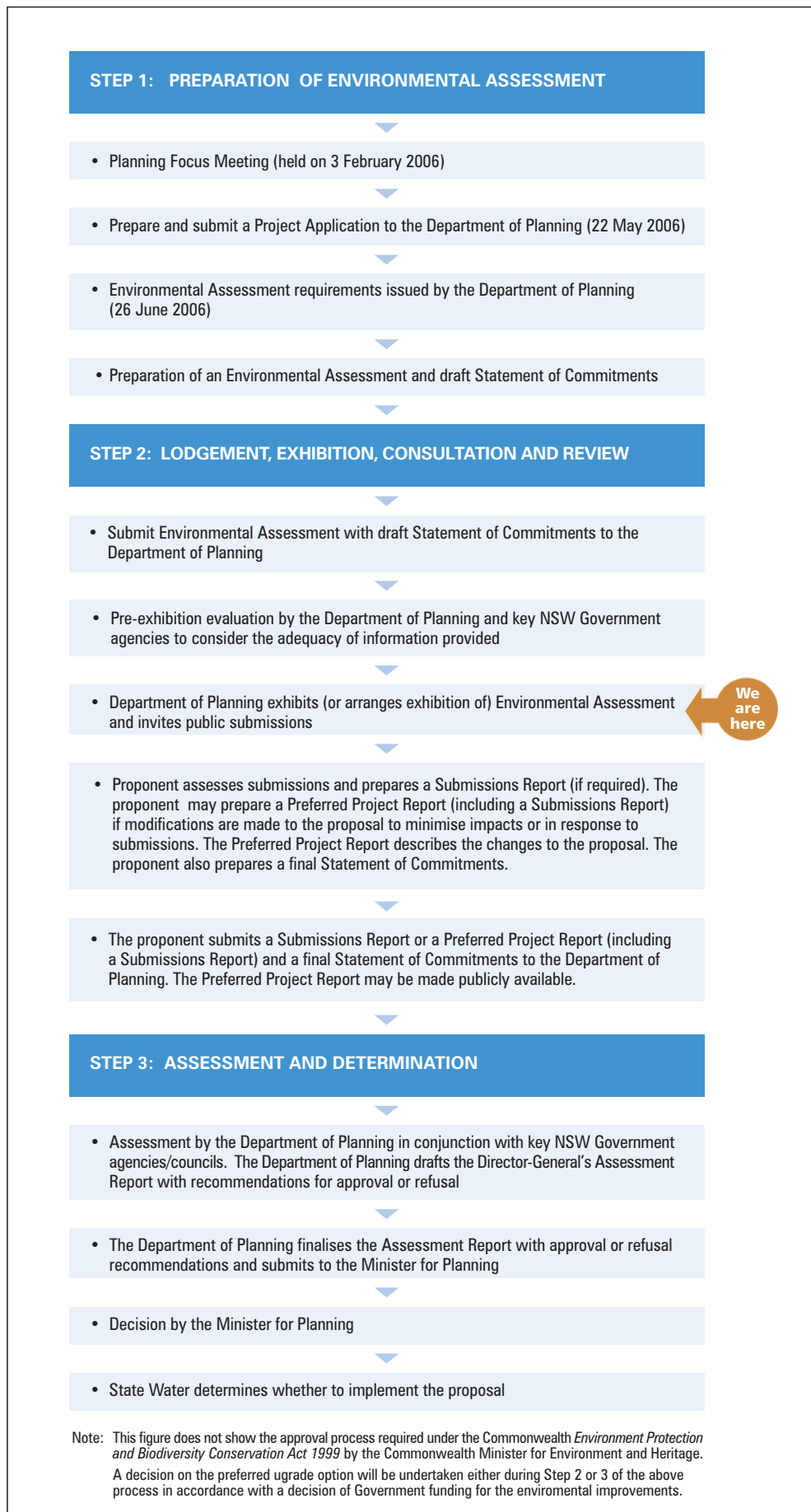


Figure 1-5 Approvals process under Part 3A of the *Environmental Planning and Assessment Act 1979*

Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The proposal is a 'controlled action' under Section 18 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, as the proposed construction works are likely to have a significant impact on an ecological community listed as nationally threatened under the Act. Approval for the proposal is also, therefore, required from the Commonwealth Minister for the Environment and Water Resources (formerly the Minister for Environment and Heritage).

A bilateral agreement exists between the Commonwealth of Australia and the State of New South Wales under Section 45 of the Environment Protection and Biodiversity Conservation Regulations 2000 relating to environmental impact assessment. Under the bilateral agreement, the preparation of an Environmental Assessment under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* is a recognised manner of environmental impact assessment.

The bilateral agreement also establishes the mechanism for the assessment requirements of the Commonwealth Department of the Environment and Water Resources to be incorporated into an environmental assessment under the relevant State environmental legislation. In accordance with the bilateral agreement, the Director-General of the NSW Department of Planning has incorporated these requirements into the environmental assessment requirements for the proposal by letter dated 20 March 2007 (refer *Appendix A*).

The proposal would therefore require approval from both the NSW Minister for Planning and from the Commonwealth Minister for the Environment and Water Resources before proceeding.

1.7.3 Community and stakeholder involvement

Details of the extensive community and stakeholder consultation undertaken since 2001 during the options development and assessment process for the proposal are provided in the Project Application Report (State Water 2006a). The principal advisory body to State Water throughout this process was the Community Reference Panel established in May 2001, with representatives from the following organisations and interest groups:

- Mayor of Gunnedah Shire Council (Chair)
- Namoi Water
- downstream land owners
- local community groups
- local Aboriginal community
- Lake Keepit State Park Trust
- Department of Natural Resources (formerly the Department of Industry, Planning and Natural Resources)

- Department of Primary Industries (formerly NSW Fisheries)
- Department of Environment and Climate Change (formerly the Department of Environment and Conservation)
- NSW Dams Safety Committee
- State Emergency Service
- State Water.

A number of newsletters and fact sheets describing the need and options for the proposal have also been produced and made available to the public at State Water's offices and website, NSW Government departmental regional offices, municipality offices, schools, and Lake Keepit State Park. Media releases have also been placed in local newspapers at key decision points in the options development and assessment process, with input invited. The following other community and stakeholder consultation has been conducted at 'AgQuip' Field Days held in Gunnedah:

- August 2002, 2003 and 2004: displays describing the project need, including dam safety and possible environmental improvements opportunities, interim works and potential long-term solutions.
- August 2005: displays describing four short-listed dam safety options (Options A3, B1, D2 and D3) and the proposed multi-level offtake.
- August 2006: displays describing the three short-listed dam safety options (Options B1, D2 and D3) and the potential environmental improvement options (multi-level offtake and fish lift).

Community consultation for the dam safety upgrade options and proposed environmental improvements was undertaken over a period of 3 months between June and August 2005. This included more than 20 community and key stakeholder presentations, nine land owner meetings and an environmental workshop comprising representatives of the Department of Natural Resources (formerly the Department of Infrastructure, Planning and Natural Resources (DIPNR)), the Department of Environment and Climate Change (formerly the Department of Environment and Conservation) and the Department of Primary Industries (Fisheries) (formerly NSW Fisheries). The contents of submissions received during this period of consultation are summarised in *Section 7.2*. Affected landowners were notified of this public exhibition process, and of the lodgement of the Project Application Report in May 2006.

A planning focus meeting was held on 3 February 2006 and was attended by representatives of relevant government agencies. Further consultation has since occurred with key government agencies, local councils and the Community Reference Panel during preparation of the Environmental Assessment, including:

- a meeting of the Community Reference Panel on 26 September 2006 to present the draft Environmental Assessment findings and proposed management and mitigation measures

- various meetings with the Department of Lands to discuss the impacts of the proposal on Lake Keepit State Park and proposed mitigation and management measures
- participation of the Tamworth and Red Chief Local Aboriginal Land Councils in cultural heritage field surveys
- participation of the Tamworth and Red Chief Local Aboriginal Land Councils and the Gunida Gunyah Community Development Employment Project in the preparation of the cultural heritage assessment of the proposal (refer *Technical Paper 3* in *Volume 2*)
- incorporation of advice from the Department of Environment and Climate Change (formerly the Department of Environment and Conservation), Department of Natural Resources and Department of Primary Industries (Agriculture) in an expert panel process convened to consider the relative erosion and sedimentation impacts of the options (February 2006)
- a meeting with the Commonwealth Department of the Environment and Water Resources (formerly Department of the Environment and Heritage) on 2 October 2006
- meetings with the Department of Planning on 23 November 2006 and 26 April 2007
- consultation with the Department of Environment and Climate Change (formerly the Department of Environment and Conservation) on heritage and ecology technical issues during January 2007
- various meetings with the Lake Keepit State Park Trust including the Department of Lands concerning the impacts of the proposal on Lake Keepit State Park.

1.7.4 Exhibition and public submissions

This Environmental Assessment will be placed on public exhibition for a minimum period of 30 days in accordance with Section 75H(3) of the *Environmental Planning and Assessment Act 1979*.

During the exhibition period, submissions are invited from the public. Submissions are voluntary and are invited from anyone interested in the proposal.

Submissions must be made in writing and may contain comments on any aspect of the proposal, the Environmental Assessment or the technical papers.

Submissions from the general public, interested groups, organisations and public authorities should be addressed to:

Keepit Dam Upgrade
Major Infrastructure Assessment
Department of Planning
GPO Box 39
SYDNEY NSW 2001

All submissions received by the Department of Planning will be regarded as public documents, and the information they contain may be published in subsequent assessment reports unless otherwise instructed in writing. The Department of Planning may send copies of the submissions received to the proponent and/or other interested parties. Any respondent that does not want a copy of their submission sent to the proponent or other interested parties, should state this clearly in their submission.

Each respondent will have free access to the information they have supplied themselves but not to any material supplied by others. A respondent may make a correction to their submission by sending the written correction to the same address as the original submission.

Section 75N of the *Environmental Planning and Assessment Act 1979* provides that the environmental assessment requirements for approval and public consultation apply, subject to the regulations, with respect to approval for the concept plan for a project in the same way as they apply with respect to approval to carry out a project. The key steps for the exhibition and assessment of concept plans are set out as follows.

Following the exhibition period, State Water will review all submissions received by the Department of Planning (or summaries of those submissions where respondents have requested that their submissions not be sent to the proponent). In accordance with Section 75H(6)(a) of the *Environmental Planning and Assessment Act 1979*, the Director-General of the Department of Planning may require State Water to consider and respond to the issues raised by respondents in a Submissions Report.

State Water intends to submit to the Director-General a Preferred Project Report (including a Submissions Report, if required) that would include a preferred option for the dam upgrade. Depending on the submissions received, the preferred option may be one of the three options presented in the Environmental Assessment or possibly a combination of two or all three of the options.

State Water may also submit a revised Statement of Commitments.

In accordance with Section 75H(7) of the *Environmental Planning and Assessment Act 1979*, the Director-General may require State Water to make the Preferred Project Report available to the public.

1.7.5 Determination

The process of 'determination' refers to the decision-making process by the NSW Department of Planning and the Minister for Planning following receipt of the Preferred Project Report or Submissions Report.

State Water will forward its Preferred Project Report (including a Submissions Report, if required) together with the final Statement of Commitments to the Department of Planning. State Water will only seek approval for the preferred option from the Minister for Planning.

The Director-General of the Department of Planning will examine the Environmental Assessment, Preferred Project Report (including a Submissions Report, if required) and final Statement of Commitments and prepare an Assessment Report taking into account the views expressed by government agencies, local councils and the community in public submissions. Having reviewed the Director-General's Assessment Report, the Minister for Planning will decide whether to grant approval or refuse the Concept Plan under Section 75O of the *Environmental Planning and Assessment Act 1979*. Any approval granted by the Minister for Planning may be subject to conditions that may, for example, include further environmental assessment. Under Section 75P(1)(c) of the *Environmental Planning and Assessment Act 1979*, the Minister for Planning may also determine that no further environmental assessment is required.

Assessment and approval of the proposal by the Commonwealth Minister for the Environment and Water Resources (formerly the Department of the Environment and Heritage) is also required before State Water can proceed with the proposal. Following a review of conditions attached to any approvals granted by the NSW and Commonwealth Government Ministers, State Water will determine whether or not to proceed with the proposal.

1.8 Structure of the Environmental Assessment

The Director-General of the Department of Planning has determined the key issues that must be considered in this Environmental Assessment. These are specified in *Appendix A*.

The analysis of these key issues including the outcomes of the community consultation, and the results of detailed technical studies are outlined in *Chapters 5* and *6* of this report. This analysis is supported by five technical papers (refer *Volume 2*), which provide detailed information on the existing conditions, survey techniques and assessment methodologies and the results of specialist environmental technical studies.

Volume 1 of the Environmental Assessment (this document) comprises the following Chapters:

- *Chapter 1: Introduction*
- *Chapter 2: Statutory planning and policy context* identifies and explains the legislation and policies relevant to the proposal.
- *Chapter 3: Proposal need and alternatives* identifies the role and function of Keepit Dam, the need for the upgrade and the alternatives considered.

- *Chapter 4: Concept Plan and Staging* describes the construction, operation and financial aspects of each element of the proposal and the intended timing of implementation for each element.
- *Chapter 5: Assessment of construction issues* summarises the potential environmental impacts associated with the construction of the proposal. Measures proposed to manage and mitigate these impacts are also presented.
- *Chapter 6: Assessment of operational issues* summarises the potential environmental benefits and impacts associated with the operation of the proposal. Measures proposed to manage and mitigate these impacts are also presented.
- *Chapter 7: Comparison of dam safety upgrade options* summarises the outcomes of the environmental assessment, and compares the performance of the dam safety options against the key issues identified in Chapters 5 and 6. It also identifies the option preferred by State Water and the Community Reference Panel based on investigations and consultation to date.
- *Chapter 8: Environmental improvements* describes the two measures proposed to improve the operational performance of the dam.
- *Chapter 9: Draft Statement of Commitments* summarises the key aspects of the more detailed draft Statement of Commitments presented in *Appendix D*.
- *Chapter 10: Justification and conclusion* presents a justification for the proposal and overall conclusions of the Environmental Assessment.
- *Appendix A: Environmental Assessment requirements* provides a copy of correspondence from the Director-General of the NSW Department of Planning, outlining the assessment requirements for this Environmental Assessment.
- *Appendix B: Checklist of Environmental Assessment requirements* provides a checklist identifying where these requirements have been addressed in the Environmental Assessment.
- *Appendix C: Checklist of Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000* provides a checklist identifying where the Environmental Assessment addresses the matters listed in Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000.
- *Appendix D Draft Statement of Commitments* contains the draft Statement of Commitment made by State Water to enhance the benefits and manage the adverse effects of the proposal.
- *Appendix E: Summary of erosion and sedimentation workshop discussion, 2005* provides a summary of proceedings from an expert panel assembled by State Water to review the relative erosion and sedimentation impacts of the dam safety upgrade options in local and regional context.

Volume 2 of the Environmental Assessment includes the following technical papers:

- *Technical Paper 1: Terrestrial ecology* provides a detailed assessment of the terrestrial ecological issues associated with the proposal.
- *Technical Paper 2: Aquatic ecology* provides a detailed assessment of the aquatic ecological issues associated with the proposal.
- *Technical Paper 3: Cultural heritage* provides a detailed assessment of the Indigenous and non-Indigenous heritage issues associated with the proposal.
- *Technical Paper 4: Visual assessment* provides a detailed assessment of the visual issues associated with the proposal.

2. Statutory planning and policy context

This Chapter discusses the applicable statutory and legislative requirements for the proposal.

2.1 Local environmental plans

Figure 1-2 shows the relevant local government areas in the vicinity of the proposal comprising the Gunnedah Shire and Tamworth Regional Local Government Areas.

2.1.1 Gunnedah Local Environmental Plan 1998

The *Gunnedah Local Environmental Plan 1998* is the principal environmental planning instrument guiding land use and development decisions in the Gunnedah Shire Local Government Area. The plan categorises land into land use zones and outlines the permissibility of particular types of development within each zone.

Land in the vicinity of the proposal is zoned *1(a) Rural (Agricultural Protection)*. Under the *Gunnedah Local Environmental Plan 1998*, public utility undertakings are permissible in the *1(a) Rural (Agricultural Protection)* zone without consent.

Public utility undertakings are defined in the *Gunnedah Local Environmental Plan 1998* as including undertakings for the supply of water carried on by any government department or under the authority of, or in pursuance of, any state Act. The proposal meets this definition of a public utility undertaking and the proposal is therefore permissible without consent in this land use zone.

2.1.2 Tamworth Regional Local Environmental Plan

The Tamworth Regional Local Government Area was formed in March 2004 as a result of an amalgamation of the former Barraba, Manilla, Nundle, Parry (part) and Tamworth Local Government Areas. No local environmental plan has yet been prepared for the Tamworth Regional Local Government Area. The relevant environmental planning instruments for land in the Tamworth Regional Local Government Area are, therefore, instruments of each of the former councils prior to their amalgamation.

Manilla Local Environmental Plan 1988

Land upstream of the dam in the former Manilla Local Government Area is zoned *1(a) (General Rural Zone)*. The objectives of the *1(a) (General Rural Zone)* are shown in *Table 2.1*.

Under the *Manilla Local Environmental Plan 1988*, public utility undertakings are permissible in the *1(a) (General Rural Zone)* with consent.

Public utility undertakings are defined in the *Manilla Local Environmental Plan 1988* as including undertakings for the supply of water carried on by any government department or under the authority of, or in pursuance of, any state Act. The proposal meets this definition of a public utility undertaking and is therefore permissible in this land use zone only with the consent of Council.

Parry Local Environmental Plan 1987

Land downstream of Keepit Dam in the former Parry Local Government Area is zoned *1(b) (General Agriculture Zone)*. The objectives of the *1(b) (General Agriculture Zone)* are shown in *Table 2.1*.

Under the *Parry Local Environmental Plan 1987*, public utility undertakings are permissible in the *1(b) (General Agriculture Zone)* with consent.

Public utility undertakings are defined in the *Parry Local Environmental Plan 1987* as including undertakings for the supply of water carried on by any government department or under the authority of, or in pursuance of, any state Act. The proposal meets this definition of a public utility undertaking and is therefore permissible in this land use zone only with the consent of Council.

2.1.3 Summary of permissibility

Table 2.1 provides a summary of the permissibility of the proposal. As shown in the table, the proposal is not a prohibited development in any of the relevant land use zones.

In the absence of any other legislation (refer *Section 2.3*), construction and operation of the proposal would only be permissible with the consent of Tamworth Regional Council in the former Manilla and Parry Local Government Areas.

Table 2.1 Summary of permissibility

Zone	Permissible	Prohibited
<i>Gunnedah Local Environmental Plan 1998</i>		
Zone: <i>1(a) Rural (Agricultural Protection)</i>	Without consent	No
<i>Manilla Local Environmental Plan 1988</i>		
Zone: <i>1(a) (General Rural Zone)</i>	With consent	No
<i>Parry Local Environmental Plan 1987</i>		
Zone: <i>1(b) (General Agriculture)</i>	With consent	No

2.2 Regional environmental plans

There are no regional environmental plans that apply to the area potentially affected by the proposal.

2.3 State environmental legislation

2.3.1 State environmental planning policies (SEPPs)

SEPP 4 - Development Without Consent and Miscellaneous Exempt and Complying Development

SEPP 4 aims to permit development for certain purposes by public authorities without the need to obtain development consent. It applies only where the carrying out of that development is not prohibited under other provisions of the *Environmental Planning and Assessment Act 1979*.

Clause 11 of the policy provides that:

Where, in the absence of this clause, development, being the construction of water storage dams, by or on behalf of a public authority may be carried out only with development consent being obtained therefore, that development may be carried out without that consent.

State Water is a NSW statutory, state-owned corporation constituted under the *State Water Corporation Act 2004*. It meets the definition of a public authority under the NSW *Environmental Planning and Assessment Act 1979*.

The action of SEPP 4, therefore, removes the need for State Water to obtain development consent from Tamworth Regional Council for the proposal as indicated in *Section 2.1*.

2.3.2 NSW Environmental Planning and Assessment Act 1979

As outlined in Section 1.6.2, State Water has an obligation under the NSW *Environmental Planning and Assessment Act 1979* to conduct an environmental assessment of its activities prior to their implementation. Through the action of SEPP 4, removing the need for consent under Part 4 of the NSW *Environmental Planning and Assessment Act 1979*, the environmental assessment would therefore be conducted under Part 5 of the Act.

State Water is the proponent of the proposal and is also a determining authority under Part 5 of the Act. State Water is of the opinion that the proposal may result in a significant impact on the environment and, would therefore require the preparation of an environmental impact statement under Part 5 of the Act.

The NSW Minister for Planning published a standing order in the NSW Government Gazette No. 96 on 29 July 2005 that declared the following major infrastructure development as development to which Part 3A of the Act would apply:

Development that is an activity for which the proponent (that is not a local council or county council) is also the determining authority and that, in the opinion of the proponent, would (but for this order) require an environmental impact statement to be obtained under Part 5.

Therefore, an Environmental Assessment under Part 3A of the Act is required.

Part 3A streamlines the approvals process and removes the requirement to obtain a number of authorisations in order to carry out an approved project. If a project is approved under Part 3A, it does not require other approvals that may have otherwise been needed (75U). These include certain permits, consents approvals under:

- the *Fisheries Management Act 1994*
- the *Heritage Act 1997*
- the *National Parks and Wildlife Act 1974*
- the *Native Vegetation Act 2003*
- the *Rural Fires Act 1997*
- the *Water Management Act 2000*.

Ongoing consultation with relevant agencies will however continue to be undertaken as necessary.

2.4 Commonwealth environmental legislation

2.4.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* is the principal Commonwealth environmental statute in Australia. Under Part 3 of the Act, an approval from the Commonwealth Minister for the Environment and Water Resources is required for:

- an action that is likely to have an effect on specified matters of 'national environmental significance', or
- an action that is carried out by a Commonwealth agency or in a 'Commonwealth area' and is likely to have a significant impact on the environment.

If a proposed action is considered to have the potential to affect the triggers identified above, the person proposing to take the action should refer the proposed action to the Minister for the Environment and Water Resources to determine whether an approval is required.

The terrestrial biodiversity assessment (refer *Section 5.1*, and *Technical Paper 1* in *Volume 2*) has identified that construction of the proposal is likely to have a significant impact on White Box Yellow Box Blakely's Red Gum Woodland, a matter of national environmental significance. The proposal was, therefore, referred to the Commonwealth Minister for the Environment and Water Resources on 8 December 2006.

On 21 December 2006, the Minister determined that the proposal is a 'controlled action' under the Act.

A bilateral agreement exists between the Commonwealth of Australia and the State of New South Wales under Section 45 of the Environment Protection and Biodiversity Conservation Regulations 2000 relating to environmental impact assessment. Under the bilateral agreement, the preparation of an Environmental Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* is a recognised manner of environmental impact assessment.

The bilateral agreement also establishes the mechanism for the assessment requirements of the Commonwealth Department of the Environment and Water Resources to be assessed under the relevant State environmental legislation. In accordance with the bilateral agreement, the Director-General of the NSW Department of Planning has incorporated these requirements into the environmental assessment requirements for the proposal by letter dated 20 March 2007. This includes a requirement to address the matters outlined in Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000. A checklist of these matters is provided in *Appendix C*.

Approvals from both the NSW Minister for Planning and the Commonwealth Minister for the Environment and Water Resources is required before the proposal can be implemented.

2.5 Other relevant legislation and approvals

Other relevant legislation and approvals that may be required for the proposal are summarised in *Table 2.3*.

Table 2.3 Summary of other applicable legislation and approvals

Provision	Requirement	Required action	Agency
<i>Protection of the Environment Operations Act 1997</i>			
Section 48	Environment Protection Licence for various construction activities	Apply for an Environment Protection Licence during construction	Department of Environment and Climate Change
<i>Water Act 1912</i>			
Section 10	Approval for extraction of water from a river or lake (if required)	Apply for approval if water is required to be sourced through direct extraction from surface waters	Department of Natural Resources
<i>Roads Act 1993</i>			
Section 138	Consent for activities involving modifications to or construction over/under a public road	Concurrence must be sought from road owner	Tamworth Regional and Gunnedah Shire Councils
<i>Crown Lands Act 1989</i>			
Section 34A	Ministerial approval to grant a 'relevant interest' over a crown reserve, if required	The Lake Keepit State Park is administered by the Department of Lands and consultation would be conducted to facilitate any approvals necessary	Department of Lands

Provision	Requirement	Required action	Agency
<i>Fisheries Management Act 1994</i>			
Section 218	Fishways to be provided in construction of dams or weirs	The NSW Department of Primary Industries has requested that State Water evaluates the level of risk to fish passage attributable to the dam and potential ameliorative measures, including a fish-lift at the dam, or a strategy, including a works program, to improve fish passage elsewhere in the catchment to achieve an equivalent outcome	Department of Primary Industries (Fisheries)
<i>National Parks and Wildlife Act 1974</i>			
Clause 8, Schedule 3	States that any reference to a state park shall be read as a reference to a national park	Consultation would be conducted with the Department of Environment and Climate Change to facilitate any approvals necessary	Department of Environment and Climate Change

2.5.1 Murray-Darling Basin Agreement

The Murray-Darling Basin extends across four states (South Australia, Victoria, NSW and Queensland) and also includes the entire area of the Australian Capital Territory. The Murray-Darling Basin Agreement was signed in 1992 by the Commonwealth, NSW, Victorian and South Australian Governments. The purpose of the Murray-Darling Basin Agreement is:

to promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of water, land and other environmental resources of the Murray-Darling Basin.

Schedule F of the Agreement establishes a 'cap' on the long-term diversion of water from designated river valleys within the Murray-Darling Basin beyond entitlements granted in 1992. The Namoi River is a designated river valley of the Murray-Darling Basin.

The proposed Keepit Dam Upgrade would have no effect on the Murray-Darling Basin cap since no change to the full supply level of the dam is proposed. The temporary capture, storage and release of water above the full supply level during an extreme flood event would take place over a period ranging between 60-90 hours and would therefore not result in a long-term change in the volume of water stored at the dam.

2.5.2 Water Management Act 2000

The *Water Management Act 2000* provides a framework for the sustainable and integrated management of NSW's water resources, with a focus on providing water for the environment. It considers the impact of surface and subsurface activities on water sources, their dependent ecosystems and other water users.

A primary function of the *Water Management Act 2000* is the ability to designate water sharing plans. These are statutory plans that regulate access to different water sources in either a catchment or groundwater management unit. The relevant water sharing plan for the Namoi River is the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003*, which took effect on 1 July 2004.

The Upper Namoi Regulated River Water Source is that between Split Rock Dam, near Barraba, downstream to Keepit Dam. The Lower Namoi Regulated River Water Source is that between Keepit Dam, downstream to the confluence of the Namoi and Barwon Rivers.

Section 6.4 of this report addresses the potential impacts of the proposal on water storage and water security.

2.6 Permissibility of the proposal and requirement to conduct an environmental impact assessment

The relevant Commonwealth, NSW and local environmental planning legislation have been reviewed in the preceding sections. This review has concluded that the proposal is not prohibited in any of the land use zones in which it is proposed and that, through the action of Clause 11 of SEPP 4, council consent is not required.

In accordance with Sections 111 and 112 of the *Environmental Planning and Assessment Act 1979*, State Water has a duty to consider the environmental impact of the proposal. Having considered that the proposal may have a significant impact on the environment, State Water would have needed, in the absence of other legislation, to prepare an environmental impact statement (EIS) for the proposal under Part 5 of the *Environmental Planning and Assessment Act 1979*. However, by virtue of Section 75B(1) of the *Environmental Planning and Assessment Act 1979*, an environmental assessment has been prepared under Part 3A of the Act. The requirements and process for preparing the Environmental Assessment are outlined in *Section 1.5*.

3. Proposal need and alternatives

This Chapter outlines the need for the proposal in the context of the dam safety requirements of the NSW Dams Safety Committee and current environmental conditions of the Namoi River (refer *Sections 3.1 to 3.4*). Alternatives to the proposal are discussed in *Section 3.6 and Chapter 8*. The objectives of the proposal are discussed in *Section 3.5*.

3.1 Requirements of the NSW Dams Safety Committee

The NSW Dams Safety Committee's flood capacity requirement for extreme consequence dams is the estimated PMF for that dam (NSW Dams Safety Committee 1992). The NSW Dams Safety Committee also requires that all extreme consequence dams can withstand a maximum design earthquake of less than 1:10,000 AEP, without an uncontrolled loss of storage due to partial or complete dam failure.

Both extreme floods and earthquakes have a very low likelihood of occurrence and it is impossible to predict the magnitude, location or timing of either event. However if such an event were to occur, the consequences would be devastating.

The need for the Keepit Dam Upgrade is driven by the catastrophic consequences if the dam were to fail as a result of an extreme natural event; specifically, floods or earthquakes. *Section 3.6.1* provides details of the anticipated magnitude of damage and loss of life which would occur if this eventuated.

3.2 Extreme event occurrence

Historical flooding and seismic data enables determination of historical maximum events and, to some extent, estimation of the magnitude of future events.

A total of 110 years of rainfall and historical flood data relevant to the Namoi River valley is available. The maximum recorded flood occurred in 1955, prior to the completion of Keepit Dam. This flood had an estimated frequency of occurrence of 1:100 AEP. The largest known storms in Australia have an estimated frequency of 1:1,000 AEP (*pers. comms.* Ross Hardie 2006).

Keepit Dam was designed in the 1940s and completed in 1961. Since then, earthquake, rainfall and runoff estimation methods have advanced and dam design practice has changed. As meteorologists have developed a better understanding of extreme rainfall events, they are now predicting rainfall of greater intensity than previously foreseen. Hydrologists have also developed improved methods for predicting the magnitude of floods resulting from extreme rainfall. As a result, current estimates of extreme floods are, in many cases, significantly higher than when dams were originally designed.

Several earthquakes of magnitude 7 on the Richter scale have occurred in Australia since European settlement. The 1989 Newcastle earthquake (magnitude 5.6) provided a reminder that large, damaging earthquakes can occur in NSW. Seismologists advise that, although Australia is often referred to as a relatively 'stable' continent, major earthquakes up to magnitude 7.5 can be expected to occur (NSW Dams Safety Committee 2000).

The PMF is the flood event that occurs as a result of probable maximum precipitation coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions. Probable maximum precipitation is the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin (NSW Dams Safety Committee 1998).

More simply, the PMF is the largest flood that could theoretically occur in a catchment. *Section 6.1* provides details on how the PMF for Keepit Dam was determined. Although the likelihood of a PMF cannot be directly determined, the chance of a PMF occurring within the Namoi River valley is estimated to be 1:500,000 each year and possibly less.

3.3 Identified dam safety risks

The NSW Dams Safety Committee has determined that the flood capacity and seismic capability of Keepit Dam are inadequate for large to extreme events. The following Sections further describe these risks to dam safety.

State Water's approach to addressing the inadequacies of Keepit Dam has been twofold, comprising:

- investigation and implementation of interim safety works to improve dam safety while a long-term solution was being investigated. The interim safety works were completed in 2003 and have reduced the risk of dam failure from approximately 1:2,800 AEP to at least 1:12,000 AEP.
- identification and assessment of options for upgrading Keepit Dam to meet the requirements of the NSW Dams Safety Committee. The options considered and the identification and assessment process were outlined in detail in Appendix C of the Project Application Report (State Water 2006a) and is summarised in *Sections 3.6 and 3.7*.

3.3.1 Inadequate flood capacity

Inadequate flood capacity refers to the situation where existing measures designed to protect a dam from collapse during very large to extreme rainfall events are considered inadequate by current standards. This situation is not unique to Keepit Dam or dams in NSW, but is a problem faced by dam owners worldwide.

The current mechanism protecting the integrity of Keepit Dam is a gated spillway at the main dam wall. The maximum floodwater discharge through the gates is approximately 10,475 cubic metres per second, which is approximately twice the flow rate of the maximum recorded flood.

As an indication of the magnitude of risk at Keepit Dam, the PMF estimate represents nearly four times the current capacity of the existing spillway, or approximately 40,646 cubic metres per second. The process used to estimate the PMF is described in *Section 6.1*.

3.3.2 Inadequate seismic capability

The gravity concrete and spillway sections of the main dam wall are considered unlikely to be able to maintain adequate stability during a maximum design earthquake. The only realistic solution is the installation of post-tensioned steel reinforcing cables. The additional reinforcement would also help maintain the dam wall integrity under extreme flood conditions.

3.3.3 Other risks

Another potential risk to dam safety is the reliability of the existing spillway gates. Factors influencing the reliability of the spillway gates include the mechanical lifting and control equipment and the reliability of electrical power supply and backup power sources. Both these issues have already been addressed at Keepit Dam over the past 6 years, with the provision of improved backup power and mechanical control facilities.

3.4 Environmental effects of river regulation

Dams and weirs are known to result in a number of undesirable operational environmental impacts. These include:

- pollution of downstream riverine environments by cold water released from the dam
- water quality issues associated with the potential release of sediments, algae and nutrients
- barriers to fish movement and passage past the dam
- reduction in downstream flows.

State Water's Environmental Management Plan (State Water 2006c) outlines a commitment to operate its assets in an environmentally responsible manner. The management of these issues are incorporated into the eleven objectives of the State Water Environmental Management Plan which forms the driver for the need to improve environmental performance.

An explanation of these issues as they relate to the existing conditions at Keepit Dam is provided in the following sections. Feasibility investigations and evaluation of options to remedy these impacts are discussed in *Section 3.6.2* and also in *Chapter 8*.

3.4.1 Cold water pollution

Research has shown that the water in most reservoirs over 10 metres deep stratifies into layers of varying temperature and density (Jones 2002). Thermal stratification is of concern because the temperature of released water is significant for downstream ecological health (Horwitz 1999).

The potential impacts of cold water releases from dams include:

- a reduction in biological productivity
- a reduction in the diversity and number of native fish
- decreased native fish breeding
- an increase in feral fish breeding
- a shift in species distribution
- a reduction in primary contact recreation.

Keepit Dam has been identified as one of nine dams in NSW likely to cause severe cold water pollution (DIPNR 2004c). Cold water discharges from Keepit Dam currently reduce the natural temperature of water in the Namoi River for up to 100 kilometres downstream of the dam and affect potential fish spawning cues within a reach of approximately 40 kilometres downstream of the dam (Preece and Jones 2002).

While releases from Keepit Dam can be colder or warmer than ambient river temperatures, of particular concern are cold water releases that occur during spring and summer months, as these are key fish breeding periods. Spawning failure due to cold water releases from Keepit Dam is a likely contributing factor to the decline of native fish species in the Namoi catchment (Barlow *et al.* 2003).

Analysis of water quality data by Manly Hydraulics Laboratory (2003) found that Keepit Dam is causing increased winter temperatures, increased seasonal constancy (i.e. reduced temperature variation between seasons), and annual maximum water temperatures depressed by up to 5 degrees Celsius and delayed by up to three weeks. *Table 3.1* shows the desired spawning temperature of several species of native fish and the temperature deficit that currently exists downstream of Keepit Dam. Increasing the temperature of waters released from Keepit Dam would support the spawning of native fish species in downstream areas and potentially improve the effectiveness of installed fish passage infrastructure in the Namoi River.

Table 3.1 Temperature deficits downstream of Keepit Dam during fish breeding periods

Native fish species	Adopted minimum spawning temperature (degrees Celsius)	Start of fish breeding period		End of fish breeding period	
		Date	Temperature deficit (degrees Celsius)	Date	Temperature deficit (degrees Celsius)
Murray Cod	20	30 September	6	31 December	1
Silver Perch	23	30 September	8	31 January	2
Catfish	24	31 December	4	10 March	2
Golden Perch	23.5	31 October	7	31 March	2

Source: Manly Hydraulics Laboratory 2003, based on Preece and Jones 2002

3.4.2 Water quality

The quality of stored water at Keepit Dam is influenced by stratification, sedimentation and the presence of high nutrient levels, often arising from human activities in surrounding areas.

Stratification of a reservoir can result in a lack of dissolved oxygen, supersaturation with dissolved gases generation of hydrogen sulfide, and higher levels of manganese and iron. However, with some aeration provided by the release of water through the Keepit Dam hydroelectric power station, the most significant water quality issue for Keepit Dam is likely to be the impact on water temperature downstream of the dam.

Siltation occurs in all dams, as river flow is interrupted. Dams, in general, act as effective sediment traps inhibiting the transport of sediment downstream. This leads to an accumulation of sediment and associated nutrients within the reservoir.

Reducing the stratification of waters in the dam would allow for an improvement of release water temperatures and may also help reduce the currently low likelihood of algal blooms occurring in the future.

3.4.3 Barriers to fish movement

Dams introduce a physical barrier that restricts fish movement and threatens the survival and propagation of native fish populations (Horwitz 1999). The Namoi River's fish fauna is migratory, with some species migrating at the whole-valley scale and others migrating over smaller distances (Harris 2004).

The main dam wall of Keepit Dam creates a 55 metre high physical barrier to fish migration and is considered a likely factor contributing to the decline of fish species in the Namoi catchment (Barlow *et al.* 2003).

There are also other barriers to fish movement at downstream weirs at Mollee, Gunidgera and Weeta. Fish passage at these weirs have been installed but are currently ineffective. State Water, in conjunction with Namoi Catchment Management Authority and the Department of Primary Industries (Fisheries), are addressing these weirs as part of the overall Namoi River Fishway Strategy.

Until recently, fish passage past Keepit Dam was not under active consideration due to the high cost and time implications of the research required to resolve outstanding issues and the anticipated difficulty of achieving downstream passage. However, at the planning focus meeting held in February 2006, and at a subsequent workshop on 3 March 2006, the Department of Primary Industries (Fisheries) identified that more recent research and data on fish passage should be able to help resolve the outstanding issues at Keepit Dam.

In addition, the Department of Primary Industries formally advised, on 14 April 2006, that under Section 218 of the *Fisheries Management Act 1994*, State Water should evaluate the current impact that Keepit Dam has on fish

passage and investigate and assess the value of potential ameliorative measures as part of the Environmental Assessment for the proposal. The ameliorative measures may involve either construction of a fish-lift at the dam, or other measures to improve fish passage elsewhere in the catchment.

The Department of Primary Industries has conducted a number of investigations in relation to fish passage at Keepit Dam. These investigations include:

- assessment of the relevant literature (Barlow *et al.* 2003)
- a field visit to Keepit Dam
- consultation with senior staff from NSW Fisheries, State Water and the former DIPNR
- a review of the ecological and fisheries implications of the Keepit Dam Upgrade (Harris 2004).

Harris (2004) found that a fishway at Keepit Dam would provide major benefits in rehabilitating aquatic biodiversity and fisheries, and recommended development of a high-level fishway. A fishway is a channel, series of pools or a lift designed to allow fish to migrate upstream or downstream of an obstacle such as a weir or dam.

In addition to a high-level fishway at Keepit Dam, Harris (2004) also recommended a whole-of-system approach to fish passage in the Namoi catchment, involving rehabilitation of existing ineffective fishways and removal of unnecessary weirs. Specifically, Harris (2004) recommended a Namoi valley fish passage program that includes remodelling of the ineffective fishways at the Mollee, Gunidgera and Weeta weirs.

3.4.4 Reduction in downstream flows

The implementation of the existing Keepit Dam in 1961 has resulted in a number of significant changes in downstream flows. These changes can be summarised as 1) a reduced variability of natural flows and 2) reduced volumes of flow and particularly peak flows from smaller, more frequent floods. These changes are associated with the inherent role of the dam to provide flood mitigation for downstream areas.

The decline in flows from the natural (i.e. pre-dam) conditions in the Namoi River are believed to have had a profound effect on a number of related physical, chemical and environmental aspects including:

- channel instability and increased stream bank erosion
- reduced riparian vegetation
- decline of wetlands
- increased algal blooms
- increase in exotic fish species (Thoms 1998).

It is generally agreed that an improvement could be achieved if more frequent, smaller flood flows which mimic natural events could be facilitated through a program of dam water releases, specifically targeted to improve environmental outcomes.

3.5 Objectives of the proposal

The objectives of the proposal were determined through a workshop process involving State Water and the Community Reference Panel early in the genesis of the project in 2002. The objectives are to:

- improve dam safety
- reduce downstream inundation
- improve environmental outcomes
- support sustainable regional economic development.

The objective to improve dam safety is the fundamental driver of the proposal. The other objectives are desirable and opportunities that could potentially be realised in conjunction with improving dam safety.

Reducing downstream inundation was considered to support sustainable regional and social development if the proposed safety upgrade could also reduce disruption and damage caused by more frequent, minor floods.

Improving environmental outcomes emphasises the desire to identify longer term and positive contributions to the environment which could be addressed in conjunction with the dam safety upgrade. The principles of ecologically sustainable development could also be considered within this objective.

Supporting sustainable regional economic development was defined through a number of sub-objectives including:

- improving the efficiency and reliability of delivering water
- increasing the capacity of the existing hydro-electric power station
- minimising impacts on social and community infrastructure including issues such as heritage, visual, land use and infrastructure
- achieving the most economic solution i.e. least cost to achieve the project objectives
- enhancing the recreational quality of Lake Keepit.

These objectives were embedded in the options development and assessment methodology as well as the technical investigations and mitigation measures prepared for this Environmental Assessment.

Section 10.1 provides a justification of the proposal in relation to the achievement of these objectives.

3.6 Alternatives considered

3.6.1 Dam safety

At a strategic level, a number of alternatives were considered to address the safety concerns at Keepit Dam. While some of these alternatives would satisfy dam safety requirements, the social and economic impacts of the alternatives vary widely, requiring significant additional measures to reduce adverse effects.

Do nothing

In 2000, State Water commissioned a risk assessment of Keepit Dam (Department of Land and Water Conservation 2001). The objective of the report was to assess the consequences of dam failure in terms of loss of life, economic costs and the environment. The report indicated that dam failure (that is, dam collapse) would threaten life downstream, have severe impacts on property and the environment, and result in the loss of a vital water supply in the area. Dam collapse would potentially put more than 10,000 people at risk within the floodplain from upstream of Carroll to Wee Waa, and would involve significant loss of human life (in excess of 100 people). It would result in catastrophic downstream inundation, with direct damages and losses estimated to be in the order of \$1.7 billion. The irrigation industry, which is highly dependent on Keepit Dam and worth more than \$290 million per annum, and the whole regional economy, would be devastated.

State Water has a statutory obligation to make the dam safe in accordance with the requirements of the NSW Dams Safety Committee. The 'do nothing' alternative is, therefore, not an appropriate option, except as a baseline for impact assessment.

Adjusting full supply level

Adjusting the full supply level of the dam could take the form of either lowering or increasing the full supply level, as follows:

- *lowering the full supply level* — A reduction in the full supply level of the dam by approximately 11 metres could be achieved relatively easily by a change in operational rules that control discharges for the dam. However, this reduction would still be totally inadequate to protect the dam from extreme floods. A PMF would involve a total volume of floodwaters 8.5 times the capacity of Keepit Dam. Lowering the full supply level by itself is not, therefore, a feasible technical solution. Neither would the option be acceptable from a socio-economic perspective given the resultant inability to deliver the water required by the irrigation industry.
- *increasing the full supply level* — An increase in the full supply level of the dam by itself would not address the extreme event safety issues at Keepit Dam. Similar dam safety upgrade works to those required for the existing full supply level, would still be required to protect the dam from extreme floods and earthquakes. *Section 3.6.2* discusses in detail the investigations conducted into increasing the full supply level of the dam as part of the dam safety upgrade.

Adjusting the design flood level or providing additional spillway capacity

The design flood level is the maximum temporary water level in the dam that can be reached under flood conditions. The design flood level is 1.2 metres above the dam full supply level and corresponds to the maximum horizontal force for which the dam is designed to resist before the safety of the dam is compromised.

An estimated 12.5 metre raising of the main dam wall and design flood level would be required to achieve sufficient temporary storage of floodwaters, without the need to provide additional spillway capacity during a PMF. Alternatively, increasing spillway capacity from the existing six gated spillway (90 metres total width) to an equivalent 20 gated spillway (300 metres total width), with no increase in design flood level, would also safely pass a PMF. Both these alternatives would still require post-tensioning of the existing gravity sections of the main dam wall.

Both alternatives are extreme solutions, with costs well in excess of \$100 million. The options were not, therefore, considered further.

Removing responsibility

There are a number of available alternatives in this category that would reduce State Water's liability with respect to existing safety concerns. Alternatives include:

- transferring ownership
- decommissioning the dam (i.e. taking the dam out of service)
- removing Keepit Dam.

Keepit Dam is an indispensable asset, which serves a variety of essential needs in the Namoi valley. State Water is responsible for managing major rural water storages in NSW, and selling or managing Keepit Dam through a third party would not be consistent with its business plan. None of these alternatives would, therefore, be appropriate for consideration by State Water.

Other alternatives

While structurally there is only one realistic way to protect the main concrete gravity and spillway wall from the maximum design earthquake event — post-tensioning — there are numerous alternatives that can be considered to protect the dam against very large to extreme floods.

The traditional alternatives for flood protection have been discussed above. However, a number of other alternatives exist, which are included here to demonstrate that the widest possible range of possibilities has been considered. These alternatives generally involve a series of measures remote from the dam wall, either upstream or downstream of Keepit Dam such as:

- morning glory spillway or tunnel spillway
- upstream storages or controls within Lake Keepit

- improved upstream gauging techniques
- downstream solutions.

The above options were not considered more than conceptually, because of feasibility issues and their excessive costs compared to the other upgrade solutions.

Outcome

Increasing a dam's design flood level or increasing its spillway capacity (or a combination of both these measures) is the most commonly adopted approach to achieve extreme event safety objectives. Accordingly, various combinations of design flood level raising and smaller additional spillway capacities were considered the most realistic alternatives for achieving the required safety upgrade at Keepit Dam.

3.6.2 Environmental improvements

In 2004, State Water arranged a series of technical groups and value management workshops with key environmental agencies to assist with investigations of proposed environmental improvements at Keepit Dam. The investigations focused on:

- fish passage at the dam wall
- enhancing environmental flows in the Namoi River through improvements to outlet capacity and potentially increased impoundment of water specifically for this purpose
- in combination with the above, better aligning the temperature and quality of water discharged from the dam with natural river waters.

Conclusive data on most of these issues was not available, owing to either the nature of some of the devices required, or a lack of background data on which to base assumptions or draw conclusions about the effectiveness of existing management methods.

Most literature on the benefits of fish passage in dam environments hails from overseas, with limited information available in Australia regarding its success or otherwise. Similarly, the benefits of providing variable environmental flows from the dam into a highly degraded ecosystem are the subject of much debate.

State Water used the outcomes of the various investigations, technical groups and value management workshops to help determine which environmental improvements should be included as part of the proposal. The following sections provide a summary of the outcomes of the individual initiatives.

Fish passage

As identified in *Section 3.4.3*, the Department of Primary Industries (Fisheries) has requested State Water investigate the current impact of Keepit Dam on fish passage. Concept designs for fish passage have therefore been developed and are incorporated as part of the proposal. The investigations have considered various means of providing fish passage and have involved collaborative interaction with the Department at a number of important

junctions. The investigations conducted and the evaluation of the various concepts investigated is outlined in *Section 8.2* as well as the proposed investigations following exhibition of this Environmental Assessment. Should the concept design of the fish passage not be considered feasible, State Water will continue to implement the Namoi River Fishway Strategy in conjunction with the Department and the Namoi Catchment Management Authority.

Progressing with the dam safety upgrade would not preclude the installation or operation of fish passage at a later date.

Enhancing environmental flows and renewable energy generation

Keepit Dam currently provides environmental flows to the Namoi River in the order of 10-20 megalitres per day, however investigations indicated that much larger flowrates of up to 8,000 megalitres per day (double the capacity of the existing dam outlets) would be required to achieve downstream environmental improvements in key sensitive areas. Such releases, if they could be provided, would provide flows into important flood-runner and anabranch habitats in the Bugilbone region, resulting in improvements to approximately 1,000 kilometres of flood-runner habitat, habitat for threatened and non-threatened native species, and improved nutrient cycling and flush events, triggering fish migration and breeding events.

A key aspect investigated therefore was the ability to increase the capacity of the two existing dam outlets. The works typically required tunnelling through the main dam wall or its abutments. Engineering studies indicated that such works were relatively expensive as well as posing risks to the integrity of the main dam wall.

A subsequent option considered was for the capture and storage of an additional 100 gegalitres of water (or 24% increased capacity) in an enlarged dam for later release as environmental flows. This would require a 2.1 metre increase in dam wall raising, in addition to the wall raising proposed as part of the dam safety upgrade. This additional wall raising together with modifications to the existing spillway gates, would cost between \$13 million and \$16 million (depending on which option was selected) if undertaken in conjunction with the proposal or at least \$21 million if undertaken separately. A similar outcome could be achieved by buying back 36 gegalitres of water from irrigators. This would cost at least \$36 million and unless voluntary, would result in substantial socio-economic impacts in the region.

Realising the full anticipated benefits of providing environmental flows would require improvements in land management techniques in the target areas which would have major cost and long-term management implications for State Water and require co-ordination with other NSW Government agencies.

The investigations conducted by State Water demonstrate that increasing the full supply level was likely to result in net environmental benefits, however a number of outstanding issues still need to be resolved including:

- ensuring the long-term security of additional water captured for environmental purposes
- resolving implications on the Namoi River Water Sharing Plan and Murray-Darling Basin cap

- management responsibilities and priority within the context of State Water's overall asset portfolio
- development of effective release management procedures
- responsibilities for monitoring and performance evaluation
- confirmation of overall value for money of the proposal
- a viable funding source
- evaluation of potential liabilities.

A value management workshop convened by State Water in December 2004 and including representatives from key environmental agencies, considered the proposal but highlighted the agencies' concerns that the environmental value, potential impacts and management processes had not been sufficiently demonstrated. Additionally, the concept was not considered to be consistent with current environmental policies. Therefore, the proposal does not include the ability to enhance environmental flows, however, the design of the proposal does not preclude future implementation of the concept if desired.

An opportunity to enhance the generation of renewable energy from the existing hydroelectric power station at the dam was also investigated through consultation with the operator of the station, Eraring Energy. A capacity enhancement of the existing station would be relatively costly however and the only other way to enhance generating capacity would be by increased discharges from the dam.

Improved water quality

Changing the temperature differential within a storage the size of Lake Keepit, both between the water layers and more uniformly across the Lake, was found to be very difficult and expensive. The inclusion of destratification measures, such as an impeller system or air entrainment to circulate the stored water were investigated but not considered feasible due to the associated high costs.

A more cost-effective approach is the incorporation of a means of selective withdrawal of water from the dam which can be chosen based on temperature. A means of selective withdrawal, known as a multi-level offtake, has been incorporated into the proposal and is discussed further in *Section 8.1*.

An expert workshop was convened in May 2003 by State Water to consider the issues associated with sedimentation and water quality in Keepit Dam. The outcome of the workshop was that sedimentation is not a significant issue for Keepit Dam and it is likely having negligible impact on storage capacity. Although there is a build-up of nutrients in the storage leading to potential algal blooms in summer months, there are no feasible options in terms of in-storage sediment management at this stage to ameliorate the issue. Instead, procedures to combat potential outbreaks of algae would be included in the design of the multi-level offtake.

3.7 Development and assessment of dam safety options

The development and assessment of options for the dam safety upgrade was described in detail in Appendix C of the Project Application Report (State Water 2006a). This Section provides a summary of the process adopted. Assessment and evaluation of the environmental improvements was undertaken in parallel with the dam safety options and is described in *Chapter 8*.

The development and assessment of dam safety upgrade options was undertaken in a series of stages between 2001 and 2007 (refer *Figure 3-1*). This provided a clear decision trail, while taking account of the wide range of values and opinions presented by members of the Community Reference Panel and other project stakeholders. Some of the considerations raised in consultation, which contributed to the extended duration of the study, included:

- the large number of spillway options and variations possible at a number of locations around the dam, each of which required initial assessment to verify its achievement of the safety criterion
- the wide range of issues and potential solutions requiring assessment, which, in some cases, included further studies with data collection and computer modelling to provide sufficient information for the decision-making process
- the complexity and inter-relationship of many of the issues, requiring a wide variety of inputs and necessary reconciliation of sometimes competing objectives
- the need to consider both the local and regional effects of the proposal and the decision to adopt a 'whole of system' approach to the effects of the works and potential environmental improvement options
- the need for a comprehensive, open and transparent consultation process, taking account of all stakeholder views, with particular emphasis on community involvement
- the need for an integrated development, assessment and evaluation process, requiring simultaneous consideration of many different issues, refinement of the options, and the development of additional or modified options to address the implications of the specialist studies conducted.

Extensive effort was made to seek the opinions of a range of stakeholders and the community on the options' performance. This was based on inputs from a variety of technical specialists to support the options assessment and development process. More than 150 consultative meetings were held over some 4 years.

The outcome of the process was an initial short-list of four dam safety options and the multi-level offtake. All the dam safety options were developed to achieve full compliance with the requirements of the NSW Dams Safety Committee, therefore, safety performance was not an issue that differentiated between the options and was not relevant to the selection of the short-list.

After consideration of the studies conducted and feedback from stakeholder consultation and potential funding limitations, the State Water Corporation Board removed one of the short-listed options (Option A3) because of its significant additional cost, which was not considered commensurate with a net increase in environmental benefits.

As indicated in *Section 3.4.3*, subsequent to the planning focus meeting held on 3 February 2006, the Department of Primary Industries (fisheries) formally requested State Water to investigate the impact of Keepit Dam on fish passage and assess the value of ameliorative measures as part of the Environmental Assessment. Further discussion of the options considered and the status of these investigations is provided in *Section 8.2*.

The remaining three short-listed dam safety options (Options B1, D2 and D3), the multi-level offtake and fish passage, are incorporated into the Concept Plan for the Keepit Dam Upgrade presented in *Chapter 4*.

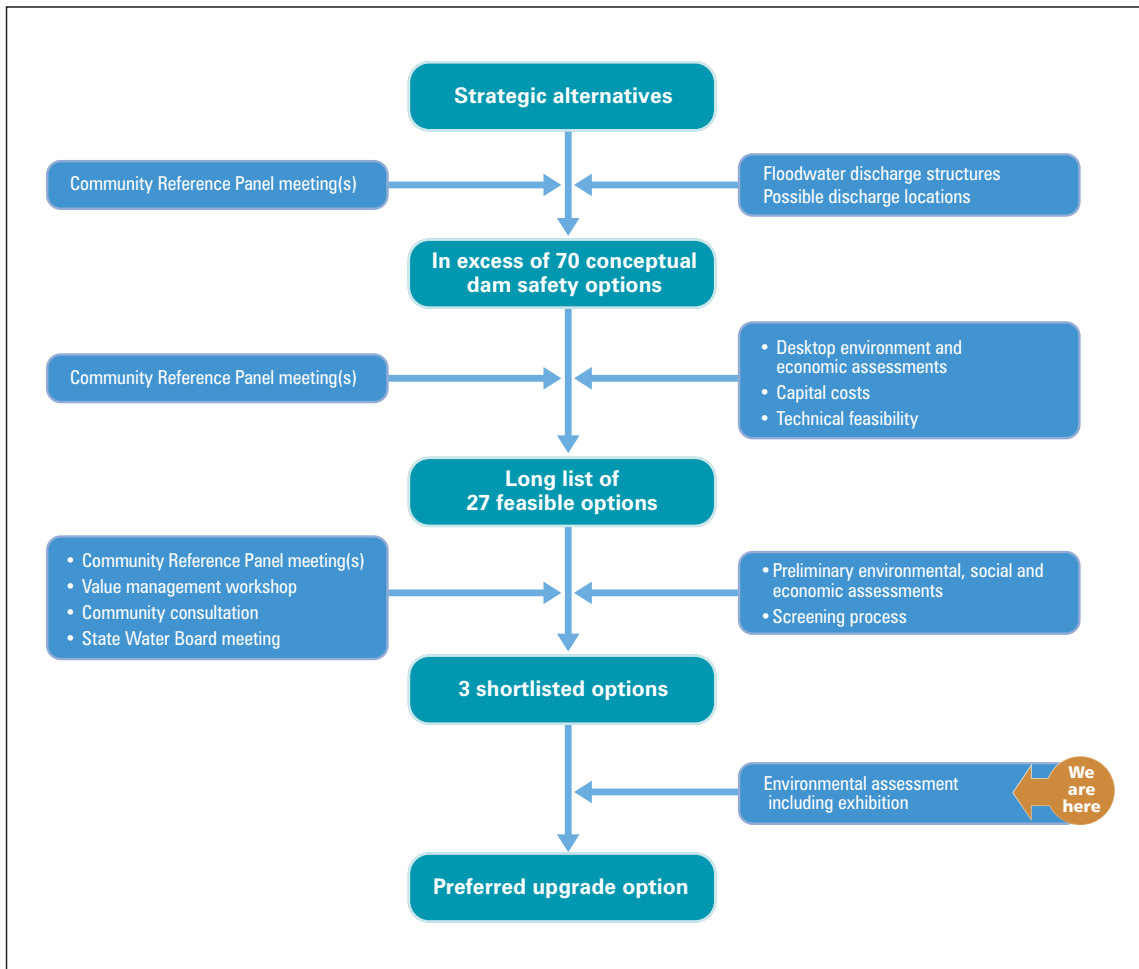


Figure 3-1 Overview of the dam safety options identification and environmental assessment processes

4. Concept Plan and staging

This Chapter contains the Concept Plan for the proposal. The Concept Plan describes the key features of the proposal, including the three dam safety upgrade options and the environmental improvements. *Chapters 5 and 6* describe the potential benefits and impacts that would result from construction and operation of the dam safety upgrade options. *The environmental* improvements are described in more detail in *Chapter 8*.

Following public exhibition of this report and comments by the community and other stakeholders, one dam safety option and the environmental improvements, collectively known as the preferred option, would be proposed for implementation. None of the dam safety options have any effect on the ability to implement the environmental improvements, either at the same time, or at any time subsequently. Also, none of the options propose to increase the full supply level of the dam or change its operation, except during very large or extreme flood events.

4.1 Description of dam safety upgrade options

4.1.1 Option B1

The key components of Option B1 are:

- raising the main and subsidiary dam walls by 3.4 metres, including post-tensioning of the main dam wall
- constructing a 220 metre release-plugged spillway at the right-hand abutment of the main dam wall
- constructing a 380 metre release-plugged spillway at the subsidiary dam wall
- constructing three saddle dams (one each at the boat ramp, sailing club and caravan park) to match the raised height of the main and subsidiary dam walls.

The key components of Option B1 are shown in *Figure 4-1*.

The two proposed spillways would have a total width of 600 metres and would comprise seven release plugs, with sill levels 3.0 metres below the full supply level of the dam.

4.1.2 Option D2

The key components of Option D2 are:

- raising the main and subsidiary dam walls by 4.6 metres, including post-tensioning of the main dam wall

- constructing a 220 metre release-plugged spillway at the right-hand abutment of the main dam wall
- constructing 380 metres of release-plugged spillways at the boat ramp and sailing club or at the sailing club location
- constructing a saddle dam at the caravan park to match the raised height of the main and subsidiary dam walls
- constructing a saddle dam at the boat ramp to match the height of the raised dam wall if the full 380 metres of spillway is implemented at the sailing club location.

The key components of Option D2 are shown in *Figure 4-2*.

The three proposed spillways would have a total width of 600 metres and would comprise seven release plugs, with sill levels 1.3 metres below the full supply level of the dam.

4.1.3 Option D3

The key components of Option D3 are:

- raising the main and subsidiary dam walls by 5.5 metres, including post-tensioning of the main dam wall
- constructing a 220 metre release plugged spillway at the right-hand abutment of the main dam wall
- constructing 380 metres of release-plugged spillways at the boat ramp and sailing club or at the sailing club location
- constructing a saddle dam at the caravan park to match the raised height of the main and subsidiary dam walls
- constructing a saddle dam at the boat ramp to match the height of the raised dam wall if the full 380 metres of spillway is implemented at the sailing club location.

The key components of Option D3 are shown in *Figure 4-3*.

The three proposed spillways would have a total width of 600 metres and would comprise seven release plugs, with sill levels 0.3 metres above the full supply level of the dam.

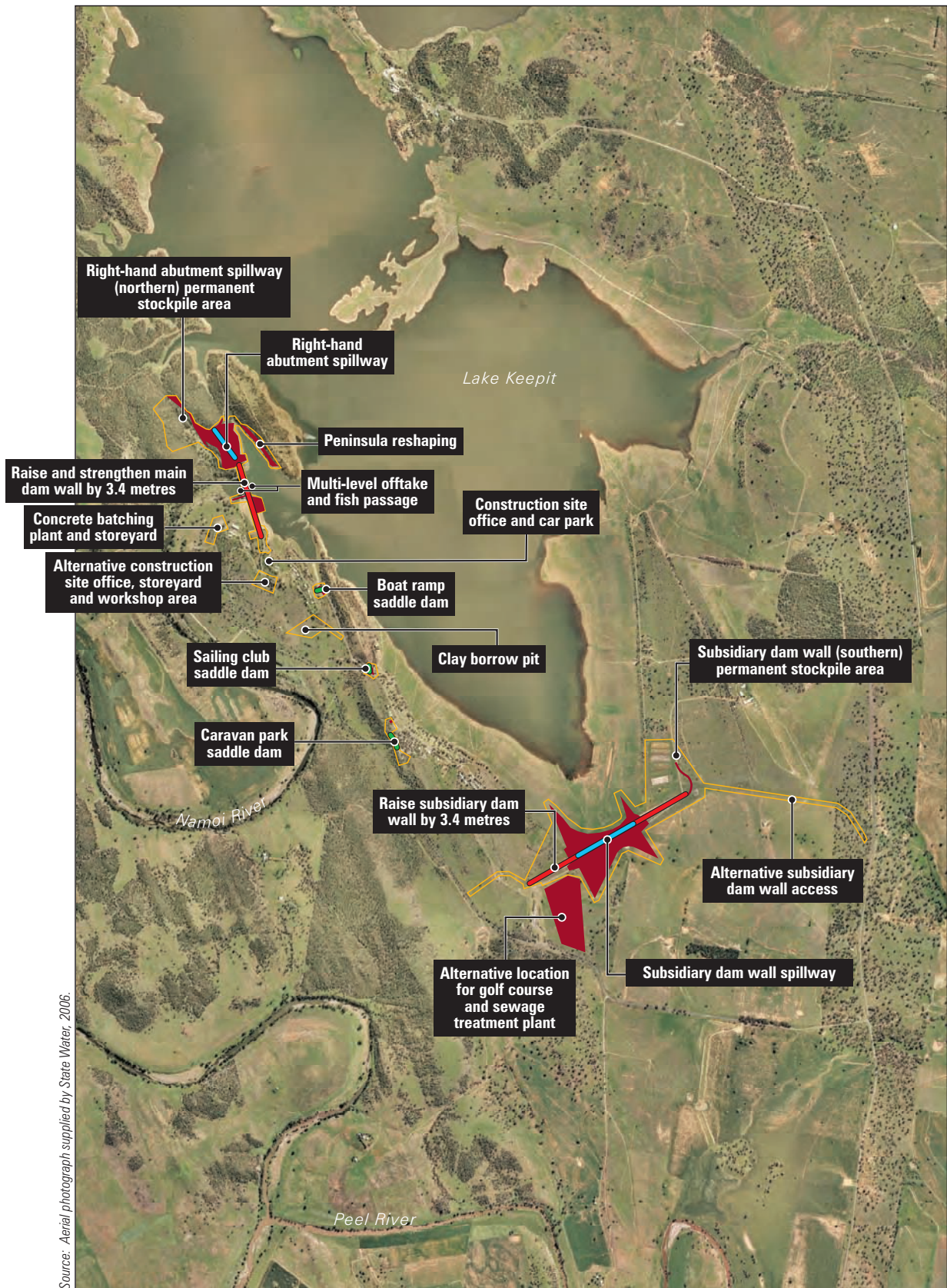
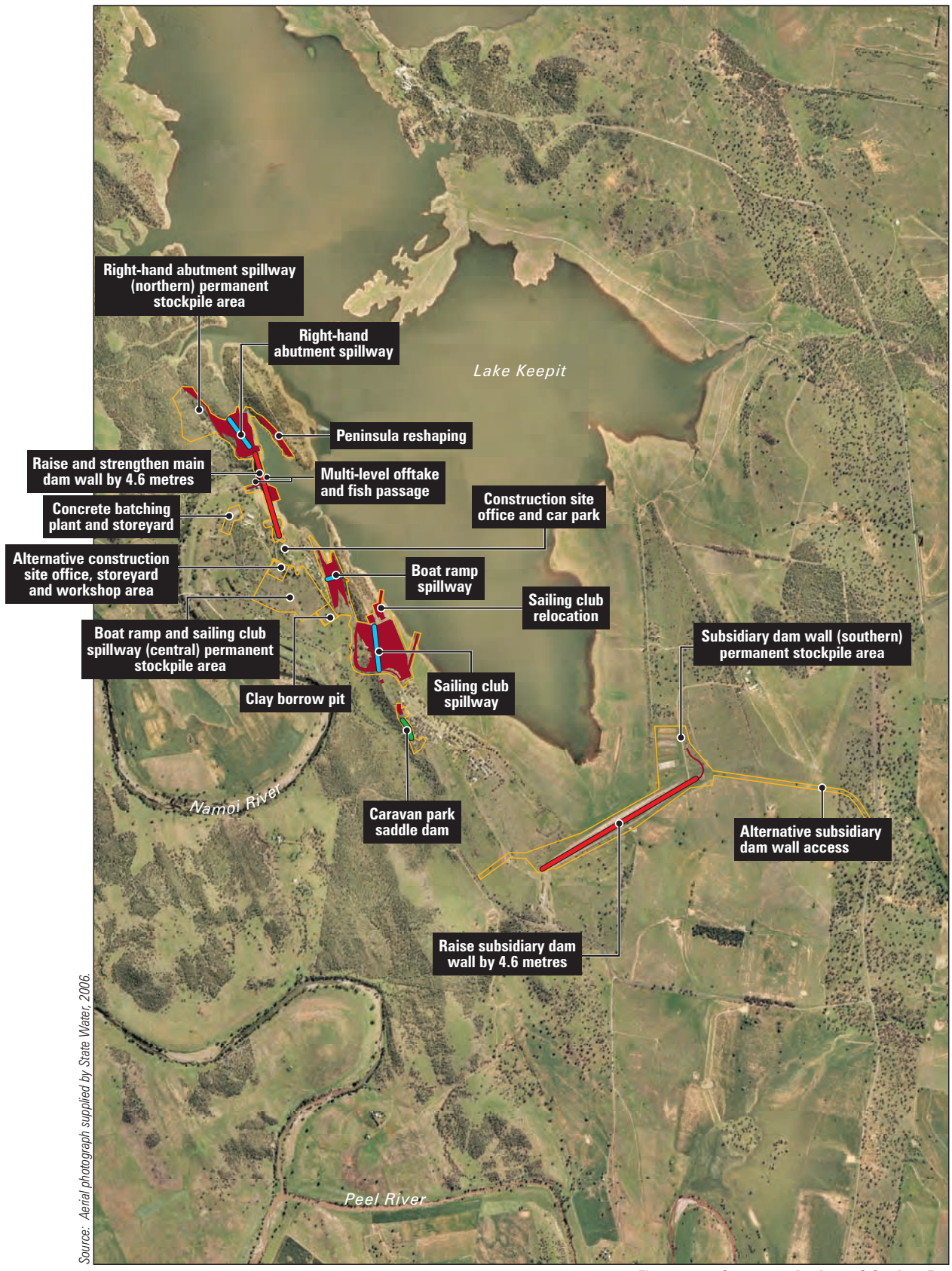


Figure 4-1 Concept design of Option B1



- New saddle dam
- New spillway
- Raise dam wall
- Construction work area
- Areas affected by construction (e.g. stockpile area, construction vehicle access)

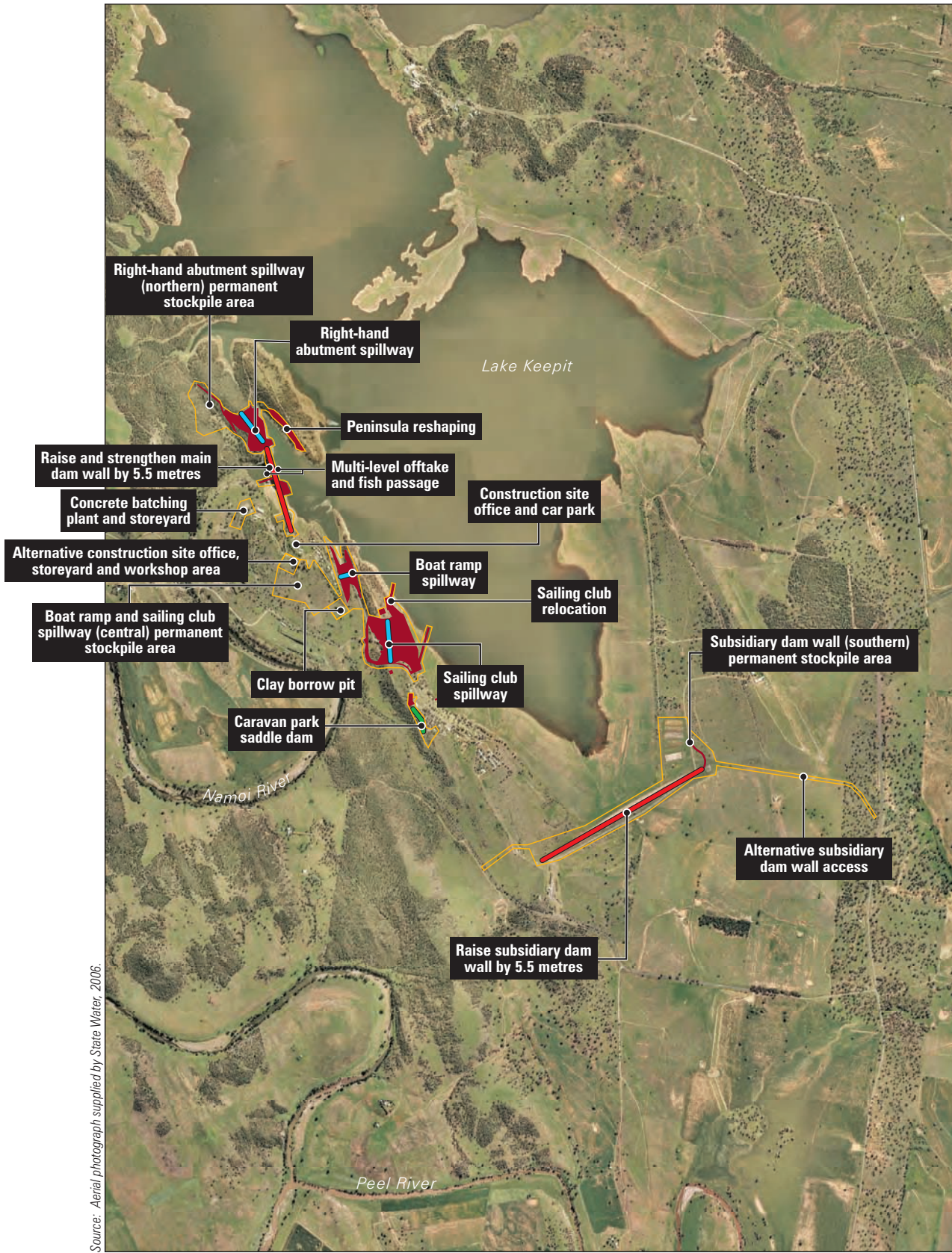


Source: Aerial photograph supplied by State Water, 2006.



Figure 4-2 Concept design of Option D2

- New saddle dam
- New spillway
- Raise dam wall
- Construction work area
- Areas affected by construction (e.g. stockpile area, construction vehicle access)



Source: Aerial photograph supplied by State Water, 2006.



Figure 4-3 Concept design of Option D3

- New saddle dam
- New spillway
- Raise dam wall
- Construction work area
- Areas affected by construction (e.g. stockpile area, construction vehicle access)

4.2 Description of the environmental improvements

The proposed Keepit Dam Upgrade also includes works to improve the environmental performance of the dam. These environmental improvements are subject to further investigations to confirm their cost-effectiveness and the availability of funding. However, they would be able to be developed irrespective of which dam safety upgrade option is implemented. They comprise a:

- multi-level offtake
- fishway.

The options considered and their likely performance are described in more detail in *Chapter 8*. *Figure 4-4* shows the key components and construction footprints.

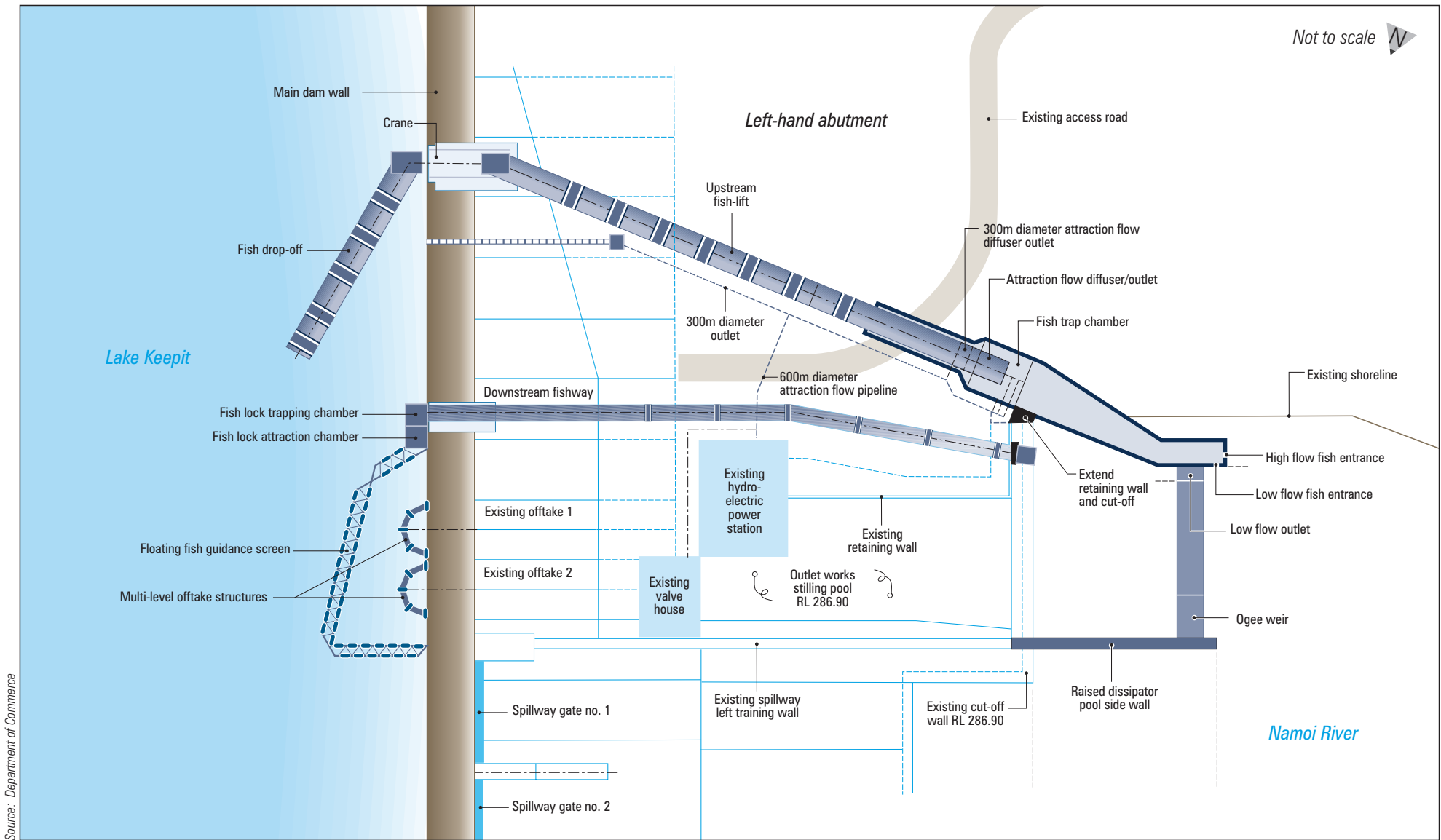
4.3 Operation of the dam safety upgrade options

The dam safety upgrade would not alter the existing operational procedures at Keepit Dam for flood events with a frequency of occurrence of approximately 1:2,400 AEP or more frequent. When outflow from the dam reaches that of a flood with a frequency of occurrence of 1:2,400 AEP (or less frequent), the first release plugs in the proposed auxiliary spillway at the right-hand abutment would start to operate. If the rate of floodwater inflow to Keepit Dam continues to exceed the outflow, further release plugs and auxiliary spillways would operate.

For Option B1, the release plugs in the proposed subsidiary dam spillway would start to operate at a flood frequency of approximately 1:10,000 AEP.

For Options D2 and D3, the proposed spillway at the sailing club would start to operate at a flood frequency of approximately 1:10,000 AEP. The proposed spillway at the boat ramp would start to operate at a flood frequency of approximately 1:100,000 AEP.

For all the options, specific emergency management procedures would be developed for occupants of Lake Keepit State Park, Lake Keepit Sport and Recreation Centre and the Manilla Ski Gardens Caravan Park. For Option B1 only, special emergency management procedures would be developed to include lower Peel River land owners.



Source: Department of Commerce

- Existing dam infrastructure
- Works associated with environmental improvements

Figure 4-4 Key components of the environmental improvements

4.4 Design and construction of key dam safety upgrade components

4.4.1 Main dam wall raising

The three dam safety upgrade options require the height of the main dam wall to be raised by 3.4 metres, 4.6 metres and 5.5 metres for Options B1, D2 and D3 respectively using reinforced concrete.

The proposed design flood levels for all the options would adequately accommodate a PMF. The top of the dam walls would provide at least 600 millimetres freeboard for waves and any potential coincidental surcharge actions.

Raising the height of the main dam wall would require the following construction activities:

- raising the bridge piers and deck to the required height
- raising (and refurbishing, as required) the existing gantry crane
- raising the spillway gate lifting gear
- installing steel post-tensioning in the main dam wall
- crest raising by placing additional rock fill on the downstream side of the left-hand abutment.

Rock fill for the main dam wall raising would be obtained from either on-site or off-site sources.

Raising the height of the main dam wall is anticipated to occur over a period of approximately 12 months.

Post-tensioning of the main dam wall would be sufficient to cater for any proposed future expansion of the dam.

4.4.2 Right-hand abutment spillway

All the options would require construction of an additional 220 metre-wide spillway at the right-hand abutment of the main dam wall. The spillway would comprise a reinforced concreted sill, aprons and walls, grouted cut-off and earthen release plugs.

The sill and crest levels of the release plugs at the right-hand abutment spillway vary between the options. The sill level of the release plugs for Options B1 and D2 are lower than for Option D3 and below the full supply level, meaning a temporary loss of storage during a very large to extreme flood event until the release plugs are replaced. The crest levels of the release plugs progressively increase with each option to ensure a progressive release of water as floods intensify.

Following activation of a release plug at the right-hand abutment, floodwaters would travel approximately 150 metres through the spillway and partly along a rock channel into a plunge pool at the base of the existing spillway gates.

Drilling, blasting and bulk excavation of rock at the right-hand abutment would be required to create the additional spillway and rock channel. Construction machinery would include drilling equipment, bulldozers, excavators, scrapers and off-site haul trucks. The works would begin from the downstream side of the main dam wall and would progress towards the storage in order to limit potential impacts on in-storage water quality. Erosion and sediment control measures would be implemented before the substantial commencement of construction.

A public car park, road access across the main dam wall via Keepit Dam Road, and access out to the adjacent peninsula would be unavailable during construction of the right-hand abutment spillway. The affected road is used infrequently and an alternative route is available via Orange Grove Road for through-traffic. Access across the main dam wall via Keepit Dam Road and to the car park and peninsula would be restored at the end of construction to at least the same standard as the existing facilities and in accordance with discussions with the road owner.

Construction of the right-hand abutment spillway is anticipated to occur over a period of approximately six to nine months.

4.4.3 Peninsula reshaping

For all options, the peninsula inside the dam storage, immediately in front of the proposed right-hand abutment, would require reshaping to increase the hydraulic capacity of the proposed auxiliary spillway.

The western edge of the peninsula would be reshaped by drilling and blasting, followed by excavation. Silt curtains would be set up within the storage across the entrance to the peninsula to limit the effects on in-storage water quality.

If possible, the peninsula reshaping works would occur concurrently with the right-hand abutment spillway works. However, it may not be possible for these works to coincide if storage levels are high.

Construction machinery would be similar to that required for the right-hand abutment spillway (refer *Section 4.4.2*).

4.4.4 Sailing club and boat ramp spillways

For Options D2 and D3, additional spillways are proposed at the locations of the existing sailing club and public boat ramp or at the Sailing Club on the western side of the subsidiary dam wall. These spillways would have a combined width of approximately 380 metres. The spillways would comprise reinforced concreted sills, aprons and walls, grouted cut-off and earthen release plugs.

The sill and crest levels of the release plugs at the sailing club and boat ramp spillways would vary between Options D2 and D3. The sill level of the release plugs for Option D3 would be slightly above the full supply level. The sill level of the release plugs for Option D2 would be lower than the full supply level, meaning a temporary 15% loss of storage during a very large to extreme flood event, until the release plugs are replaced. For both options, the crest levels of the release plugs would progressively increase to ensure a progressive release of water as floods intensify.

Drilling and blasting and bulk excavation of rock would be required to create the additional spillways. Construction machinery would be similar to that required for the right-hand abutment spillway (refer *Section 4.4.2*).

The existing boat ramp would need to be relocated as part of the construction works, as would the sailing club, subject to finalising the location of the spillway relative to the existing sailing club building. New 'like for like' or modified facilities would be provided as agreed in negotiations with the relevant parties. The access road to the existing sailing club and boat ramp would also need to be relocated and would be finalised during detailed design.

During operation of the sailing club spillway, or both the sailing club and boat ramp spillways, floodwaters would flow approximately 200 to 400 metres across Lake Keepit State Park and Keepit Dam Road before merging with the Namoi River, approximately 2 kilometres downstream of the main dam wall.

During the proposed construction works, it may be necessary to temporarily close part or all of Lake Keepit State Park to enable the construction works to occur. State Water would program the construction works to minimise the impacts to the park.

4.4.5 Subsidiary dam spillway

For Option B1, an approximately 380-metre wide spillway would be installed at the subsidiary dam wall. The centre section of the existing earthen wall would be removed and a concrete spillway constructed. The spillway would comprise a reinforced concreted sill, aprons and walls, and grouted cut-off and earthen release plugs.

Construction of the subsidiary dam spillway would require a combination of scrapers, bulldozers, off-site haul trucks and excavators. Due to the poor ground conditions, more extensive grouting and concrete works would be required than at the other spillway locations to prevent failure of the spillway under very large flood flows.

The sill level of all the release plugs for Option B1 would be lower than Options D2 and D3, and well below the full supply level. This would result in a temporary 30% loss of storage during very large to extreme floods until the release plugs are replaced. The crest levels of the release plugs would progressively increase to ensure progressive release of water as floods intensify.

Operation of the subsidiary dam spillway would result in floodwater flow across Lake Keepit State Park, including an access road to the camping area, the golf course, a sewage treatment plant, and the main entry road into Keepit Dam. This infrastructure would require replacement following operation of the subsidiary dam spillway. Floodwaters would exit Lake Keepit State Park and then flow approximately 2 to 2.5 kilometres across highly erodible grazing land before discharging into the Peel River.

Construction of the subsidiary dam spillway is anticipated to occur over a period of approximately six to nine months.

4.4.6 Release plugs

Earthen release plugs are a feature common to dams around the world. As an example, they were installed during construction of the auxiliary spillway at Warragamba Dam in the 1990s. Release plugs can be installed in new or existing spillways. Each release plug comprises a non-permeable downstream sloping clay core supported by selected gravel fill. Under normal circumstances, release plugs act just like a dam wall and retain water upstream. When a release plug is overtopped during a flood event, the plug is designed to erode at a relatively rapid, but reasonably predicably rate. As the supporting gravel fill is eroded, the clay core collapses and the plug washes away. Reinforced concrete foundations or 'sills' and side walls ensure that the design volume and flow rate of water is released, and the shape and integrity of the spillway remains intact. Multiple release plugs may make up a spillway and each can be designed to activate individually, progressively increasing in number as the size of the flood increases.

A release plug may take up to six months to be replaced following its release, and replacement can only occur after floodwaters have stopped flowing through the spillway. A typical detail of an earthen release plug is shown in *Figure 4-5*.

An alternative to an earthen release plug is a release gate. The operational principles of release gates are similar to release plugs; however, they are made of either concrete, steel or both, and tip and roll away, rather than erode. Release gates can also be made to smaller widths and much finer differentials in crest levels than release plugs. As a result, release gates are much more flexible than release plugs and are considered more efficient and reliable. They also potentially require less maintenance. However, release gates are normally more expensive to build than release plugs.

Concept designs have been developed assuming earthen release plugs only. However, the choice between release plugs and release gates would be made during detailed design and tendering phase of the proposal.

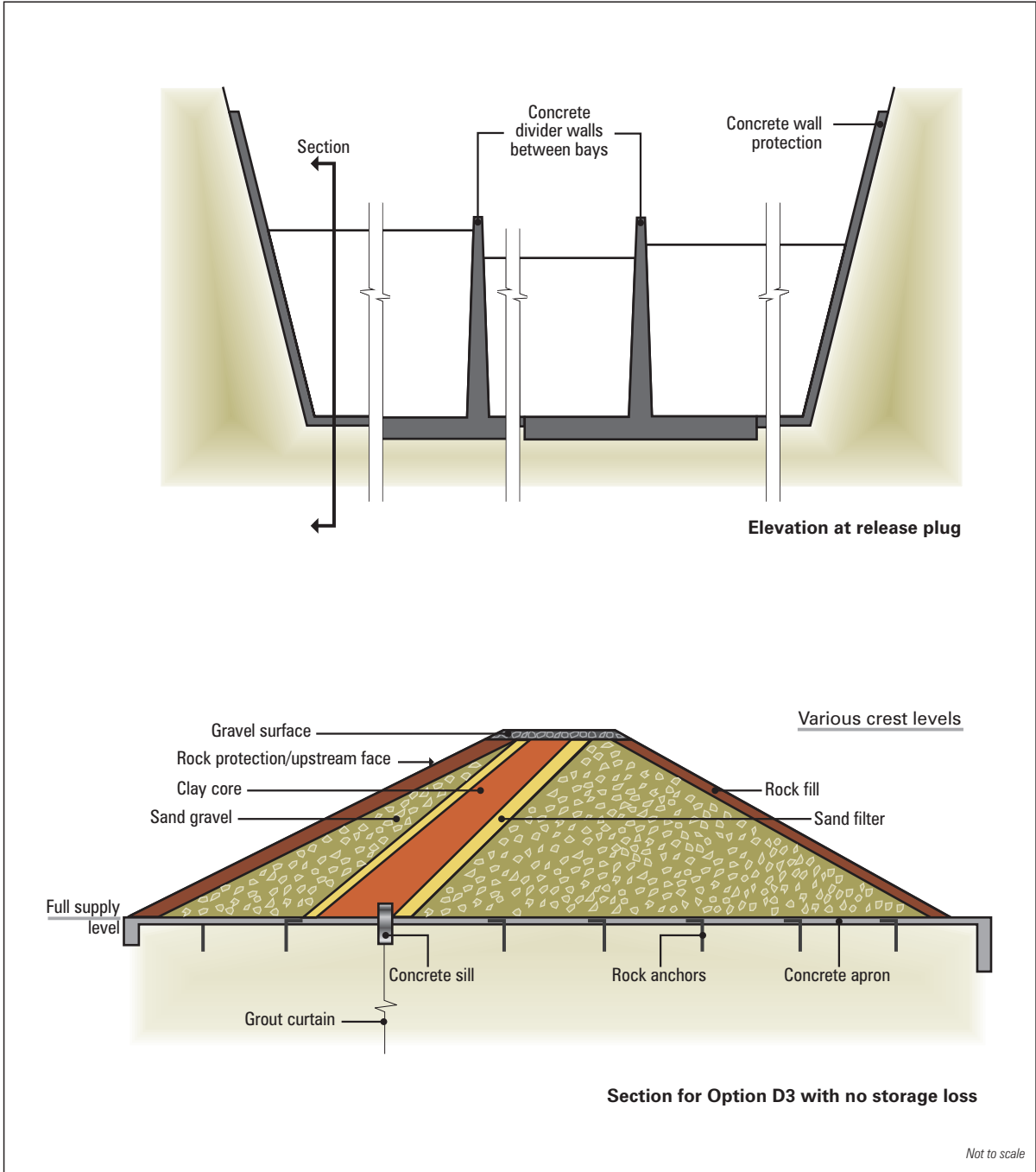


Figure 4-5 Typical detail of an earthen release plug

4.4.7 Subsidiary dam wall raising and saddle dams

Subsidiary dam wall raising

All options would require raising the height of the subsidiary dam wall, by 3.4 metres for Option B1 (either side of a centrally located spillway), 4.6 metres for Option D2, and 5.5 metres for Option D3. The construction works would involve raising the clay core and supporting gravel zones using bulldozers, scrapers, off-road haul trucks and compaction equipment. The access road to the camping area and glider club would require relocation.

Material for the clay core of the subsidiary dam wall would be sourced from either existing stockpiled material located on the north-eastern side of the subsidiary dam wall, or an on-site clay borrow pit located near the proposed sailing club spillway (refer *Figures 4-1 to 4-3*). Gravel fill would be sourced from existing spoil stockpiles and crushed rock from excavation of the right-hand abutment or sailing club spillways.

Rock armour would also be placed on the upstream face of the subsidiary dam wall and sourced from either on-site or off-site.

Saddle dams

For all options, construction of an earthen saddle dam is proposed at the rear of The Gums Caravan Park to match the height of the raised main dam wall. Option B1 would require a further two saddle dams at the sailing club and boat ramp.

Saddle dam construction would comprise bulk earthworks using bulldozers, scrapers, off-road haul trucks and compaction equipment. The saddle dams would be constructed using crushed fill sourced from the spillway excavations and clay from an on-site borrow pit. Rock armour would also be added to the upstream faces of the saddle dams.

Construction of the saddle dam at The Gums Caravan Park would require relocation of up to eight caravans, an amenities block and associated services for Option B1. Taller saddle dams associated with Options D2 and D3 would require relocation of up to 15 caravans as well as the amenities block and associated services. Various permanent fixtures attached to the caravans are unlikely to be salvageable however the caravans themselves would be moved to a location to be agreed with the Lake Keepit State Park Trust and in consultation with caravan owners, but possibly to the south-west of The Gums Caravan Park.

4.4.8 Ancillary facilities

Concrete batching and crushing plant

A concrete batching and crushing plant is expected to be required on-site during construction of the dam safety upgrade. The plant is proposed to be located immediately downstream of the left-hand abutment near the existing State Water works depot (refer *Figures 4-1 to 4-3*). Following any planning approval granted for the project, a license to operate the plant would be required from DECC (formerly known as DEC).

Clay borrow pit

Clay is required for construction of the release plugs and saddle dams. Clay is proposed to be sourced from an on-site clay borrow pit, most likely located at the proposed sailing club spillway (refer *Figures 4-1 to 4-3*). The location of the clay borrow pit would be subject to detailed site investigations following appointment of a construction contractor. Should the investigation find insufficient material of suitable quality, clay would need to be obtained from off-site sources.

4.4.9 Spoil disposal

The balance of earthworks is anticipated to be approximately 400,000 cubic metres of spoil excess. Excess spoil would be placed in the following stockpiles (refer *Figures 4-1 to 4-3*):

- *northern stockpile* — north-west of the main dam wall (for spoil from the peninsula reshaping and right-hand abutment spillway, all options)
- *central stockpile* — to the west of the State Water employee housing (for spoil from the boat ramp and sailing club spillways, Options D2 and D3 only)
- *southern stockpile* — to the east of the subsidiary dam wall (for spoil from the subsidiary dam spillway, Option B1 only).

Both on-site and off-site alternative spoil disposal sites were investigated for the emplacement of excess spoil (State Water 2006b). Spoil disposal sites were selected after considering their performance against a range of desirable attributes, including:

- being located on land managed by State Water
- being previously used as construction work areas at the time of the original construction of Keepit Dam
- as a result of previous works, containing regrowth vegetation that is mostly in poor condition
- minimising the haulage distance and thereby reduce consequent impacts (e.g. traffic safety, dust, noise, etc.)
- minimising the interaction with other upgrade aspects (e.g. avoid the need to cross the dam wall for works at the right-hand abutment)
- minimising the capital cost of construction works.

4.4.10 Environmental improvements

The construction footprint of the environmental improvements falls within that of the dam safety works and would occur mainly at the main dam wall as shown in *Figure 4-4*.

The multi-level offtake structure would be constructed from pre-cast, reinforced concrete sections requiring minimal works within the storage. The installation works would involve a crane, which would lower the segments into position within the storage. Divers would help position the structures on the dam floor and undertake bolting and welding of the structure to the existing water intake structures. Some rock-armouring at the upstream face of the dam wall would be removed and replaced to enable these operations to be completed.

Construction of the fishway would be undertaken within a coffer dam constructed within the Namoi River downstream of the dam within 50 metres of the hydropower station. An additional site on the other side of the dam wall may also be required, depending upon the final configuration of the fish-lift. Piling and in-situ concreting works would be undertaken within the coffer dam to minimise impacts on water quality. The piling would be undertaken from the shore. Concrete training walls and the fish intake/offload structures would also be constructed within the river. The remaining fish-lift structures would either be cast in-situ above the river, or pre-cast and lowered into place by crane.

Standard water quality and erosion control measures would be applied during construction of the environmental improvements to minimise any potential environmental effects. The works would last for approximately 2–3 months.

While these types of environmental improvement measures have been installed elsewhere in Australia, their adaptation to Keepit dam requires innovative engineering design. Preliminary performance modelling of the concept designs incorporated as part of the proposal (refer *Chapter 8*) indicates a level of confidence that they can achieve their objectives, however further work needs to be conducted, jointly with NSW Government agencies, to ensure that they achieve the desired degree of effectiveness and are financially viable. If these studies are successful and subject to funding being available, these components would be implemented.

4.4.11 Construction workforce and timing

The maximum and average number of construction workers would be approximately 70 and 30 respectively. The overall duration of construction is expected to be approximately 2.5 years.

The construction contractor would be responsible for any decisions made in relation to providing accommodation for construction workers. However, it is anticipated that the construction workforce would stay in Gunnedah and at the caravan park at Lake Keepit State Park. It is also possible that other townships (including Tamworth) and facilities in the vicinity of Keepit Dam may also be used to provide accommodation for construction workers.

The existing kiosk at Lake Keepit State Park is also anticipated to be a major source of food and drinks and other incidental supplies for workers during the construction period.

4.5 Land acquisition and other compensatory arrangements

For Option B1, State Water would need to acquire some privately owned land immediately downstream of the subsidiary dam wall to enable the upgrade works to occur.

Some privately-owned land (farming properties) upstream of Keepit Dam not currently affected by the operation of the dam would be affected during floods larger than 1:5,000 AEP. Option D3 would affect the largest area and Option B1 the smallest area (refer *Table 6.2*).

Additionally, Option B1 would affect Lake Keepit State Park sewage treatment plant and golf course, a section of Keepit Dam Road within the State Park, and privately-owned land between the subsidiary dam spillway and the Peel River currently used for grazing/agriculture during floods larger than approximately 1:10,000 AEP. Options D2 and D3 would also affect sections of Keepit Dam Road within the State Park downstream of the sailing club and boat ramp spillways during floods larger than approximately 1:10,000 AEP and 1:100,000 AEP respectively. None of these areas are currently affected by the operation of the dam.

State Water, where liable, would compensate land owners in accordance with Commitments 39.3 and 39.4 provided in the draft Statement of Commitments (refer *Appendix D*). State Water has discussed this approach to compensation with the various land owners and facilities managers potentially affected by operation of the proposal. Where a residential property is unduly affected by operation of the proposal, State Water would consider negotiating with the land owner to provide appropriate mitigation such as a flood easement, including providing compensation in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*.

4.6 Capital cost and funding

4.6.1 Capital cost

The estimated capital costs of the three dam safety upgrade options and the environmental improvements are shown in *Table 4.1*. The capital costs include estimates for compensation and relocating and reinstating facilities as required during construction of the respective options. It is not possible to realistically determine costs that might be incurred as a result of very large to extreme events during operation of the proposal.

Table 4.1 Estimated capital costs of upgrade options

Option	Estimated capital cost (March 2007) (\$ million)
Dam safety options	
Option B1	75.0
Option D2	87.0
Option D3	89.0

Option	Estimated capital cost (November 2007) (\$million)
Environmental improvements	
Multi-level offtake	3.5
Fish passage at Keepit Dam ¹	21.0

Notes

¹ Based on a draft concept design report (Department of Commerce, 2007)

4.6.2 Funding procedures

The Independent Pricing and Regulatory Tribunal (IPART) regulates the maximum charges that government utilities may apply in providing monopoly services to various industries. IPART regulates the charges that State Water apply for the delivery of bulk water in NSW.

Under current IPART pricing determinations, the dam safety component of the Keepit Dam Upgrade would be fully funded by the NSW Government while the multi-level offtake and fish way would be funded on a 50:50 basis by the NSW Government and State Water's Namoi Valley customers as determined by IPART.

4.6.3 Economic assessment

A financial and economic analysis has been prepared in accordance with NSW Treasury Guidelines to investigate the relative merit of investment in the dam safety upgrade options proposed for Keepit Dam (Hassall & Associates 2007).

The analysis assessed the performance of the options for the PMF event relative to the 'do nothing' base case. As discussed briefly in *Section 3.2.3* and in detail in *Section 6.1*, the frequency of the PMF event may be in the order of 1:500,000 or lower and was a significant factor in the analysis.

The analysis was undertaken for an assumed period of 25 years.

The following factors were included as costs resulting from dam failure:

- infrastructure, buildings and commerce, including public, commercial and residential buildings, utilities, vehicles, emergency provision (e.g. temporary accommodation)
- social effects, including loss of life, tourism and recreational impacts
- agricultural losses in the year of failure and subsequent years.

The following factors were included as costs of implementing each dam safety upgrade option:

- capital, operating and maintenance costs
- reinstatement costs of any spillway structures (e.g. release plugs)

- costs of reprovion of any infrastructure, buildings and commerce potentially affected by inundation associated with the proposed dam wall raising.

The overarching benefit of upgrading dam safety is the social benefit, or alternatively, the social cost of dam failure avoided by implementation of the dam safety upgrade.

The results of the economic analysis are summarised in *Table 4.2*.

Table 4.2 Economic comparison of dam safety options

Option	Capital cost	Present value of costs	Present value of benefits	Net present value	Ratio of benefits to costs
	(\$ million)	(\$ million)	(\$ million)	(\$ million)	
Option B1	75.0	72.3	17.8	-54.2	0.25
Option D2	87.0	83.1	19.7	-63.0	0.24
Option D3	89.0	84.4	20.1	-64.0	0.24

Source: Hassall and Associates 2007

Notes: Figures rounded to nearest one hundred thousand

A negative net present value indicates there would be no return on investment.

A ratio of benefit to costs of less than 1.0 indicates the option is not economically efficient.

For all the options, the project costs are predicted to exceed the project benefits. While substantial social benefits accrue from the dam safety upgrade options, these are tempered by the relatively high capital costs of the options and the extremely low likelihood of occurrence of the PMF. Therefore, a ratio of benefits to costs of the order shown in *Table 4.2* was not an unexpected result as the works are proposed in response to an event that has a low frequency of occurrence, but if it occurred, would be associated with catastrophic regional damage and significant loss of life. As also discussed in *Chapter 2*, the need to upgrade the dam to safely pass a PMF is not based on economic efficiency, but on compliance with regulatory requirements.

The ratios of benefits to costs shown in *Table 4.2* indicate that there is little economic difference between the three options. Option B1 has a capital cost that is approximately 15% lower than Options D2 and D3.

4.7 Staging

While it is possible and more cost effective for the dam safety upgrade and environmental improvements to be implemented at the same time, given the ongoing feasibility investigations and future decisions required concerning these, it is likely that these components would be implemented separately and at a later date. The scope of work to implement the environmental improvements is much smaller than the dam safety upgrade and centred on the main dam wall. Progressing with the dam safety upgrade would not preclude the installation or operation of the identified environmental improvements at a later date.