Jumping Creek Deferred Area

Aquatic Ecology Impact Assessment

Prepared for
CIC Australia

16 October 2015

DOCUMENT TRACKING

Item	Detail
Project Name	Jumping Creek Deferred Area: Aquatic Ecology Impact Assessment
Project Number	15SGB_995
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Status	FINAL
Version Number	1
Last saved on	16 October 2015
Cover photo	View of study area from opposite bank of Queanbeyan River, 28/09/15, Ian Dixon

This report should be cited as 'Eco Logical Australia 2015. *Jumping Creek Deferred Area: Aquatic Ecology Impact Assessment*. Prepared for CIC Australia.

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from CIC Australia.

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Abbreviations

Abbreviation	Description
ARI	Average Recurrence Interval
DoE	Commonwealth Department of the Environment
DPI	NSW Department of Primary Industries
ELA	Eco Logical Australia Pty Ltd

Executive summary

This study aims to assess the potential impact of the proposed subdivision and subsequent residential development on the “Deferred Lands” within Jumping Creek Residential Estate. A review of threatened species databases and field inspection concluded there are no threatened aquatic species, populations or communities likely to occur in the waterways adjacent to the study area.

The condition of five reaches in the survey area ranged from degraded to good. Smaller tributaries were in the poorest condition, with severe slumping and channel incision. Mid-sized reaches were mostly impacted by dense infestations of Blackberries. The largest reach at Queanbeyan River is of better condition with a variety of habitats, but with a weedy riparian community.

Impacts to aquatic and riparian ecology (collectively termed riverine ecology), could occur if mitigation measures are not in place. Potential impacts (without mitigation) could include algal blooms, unstable changes to the aquatic food web, blockage of fish passage, loss of bed habitat, loss of bank habitat for platypus and other burrowing fauna, change of wetland bird habitat, loss of riparian vegetation, increased rubbish and accumulative catchment effects.

However, with mitigation measures in place, these potential impacts can be largely prevented or minimised. Recommended measures include maintaining the proposed bioretention ponds, minimise the use of concrete pipes, minimise exotic deciduous street trees, removal of weeds and restoration of riparian corridors, erosion and sediment controls, provision of fish passage, and installation of gross pollutant traps.

A water quality strategy prepared by Calibre Consulting (2015) demonstrates that the development would lead to a reduction in target loads of average annual pollutant exports (gross pollutants, suspended solids, phosphorus and nitrogen). Their report also shows there will be no impact on the 1 and 100 Average Recurrence Interval (ARI) storm event peak flows at the confluence of Jumping Creek and Queanbeyan River.

This Aquatic Ecology Assessment concludes that with mitigation measures in place there would be a *low risk to the environmental values* of Jumping Creek and Queanbeyan River.

1 Introduction

This report supplements an *Urban Capability Study* prepared by Calibre Consulting (2015) for the area within Jumping Creek Residential Estate which was deferred from rezoning in the Queanbeyan Local Environment Plan 2012. This portion of the site is shown on the zoning map as "Deferred Matter" (Deferred Area).

1.1 Description of works

The rezoning application is to demonstrate if development on the land is feasible with respect to slope, stormwater quantity, water quality and sediment control. A preliminary lot layout and stormwater design is shown in **Figure 1**. The design includes riparian corridors (measured from top of bank), roads, a creek crossing, stormwater schematic of dirty and clear water, bioretention basins and drainage outlet structures leading to Jumping Creek.

1.2 Study aims

The aim of this aquatic assessment is to gain an understanding of the biota and habitat occurring near the Deferred Area (the study site). With this understanding we aim to determine if any significant impacts will occur to threatened species, communities or populations from the proposed development; and if a further study/referral is required under the NSW *Fisheries Management Act 1994* (FM Act) or Commonwealth *Environmental Planning and Assessment Act 1979* (EPBC Act). General aquatic and riparian ecology (collectively riverine ecology) is addressed to ensure no more than minimal harm occurs from the proposal. The following tasks were undertaken to address these aims:

- A desktop review of existing literature, the site locality, and a review of known and likely species and habitats to occur.
- Field survey to inspect waterways and riparian zones to determine type and condition of habitat.
- Identification of potential impacts of the proposal on riverine ecology.
- Provide recommendations to mitigate potential impacts.

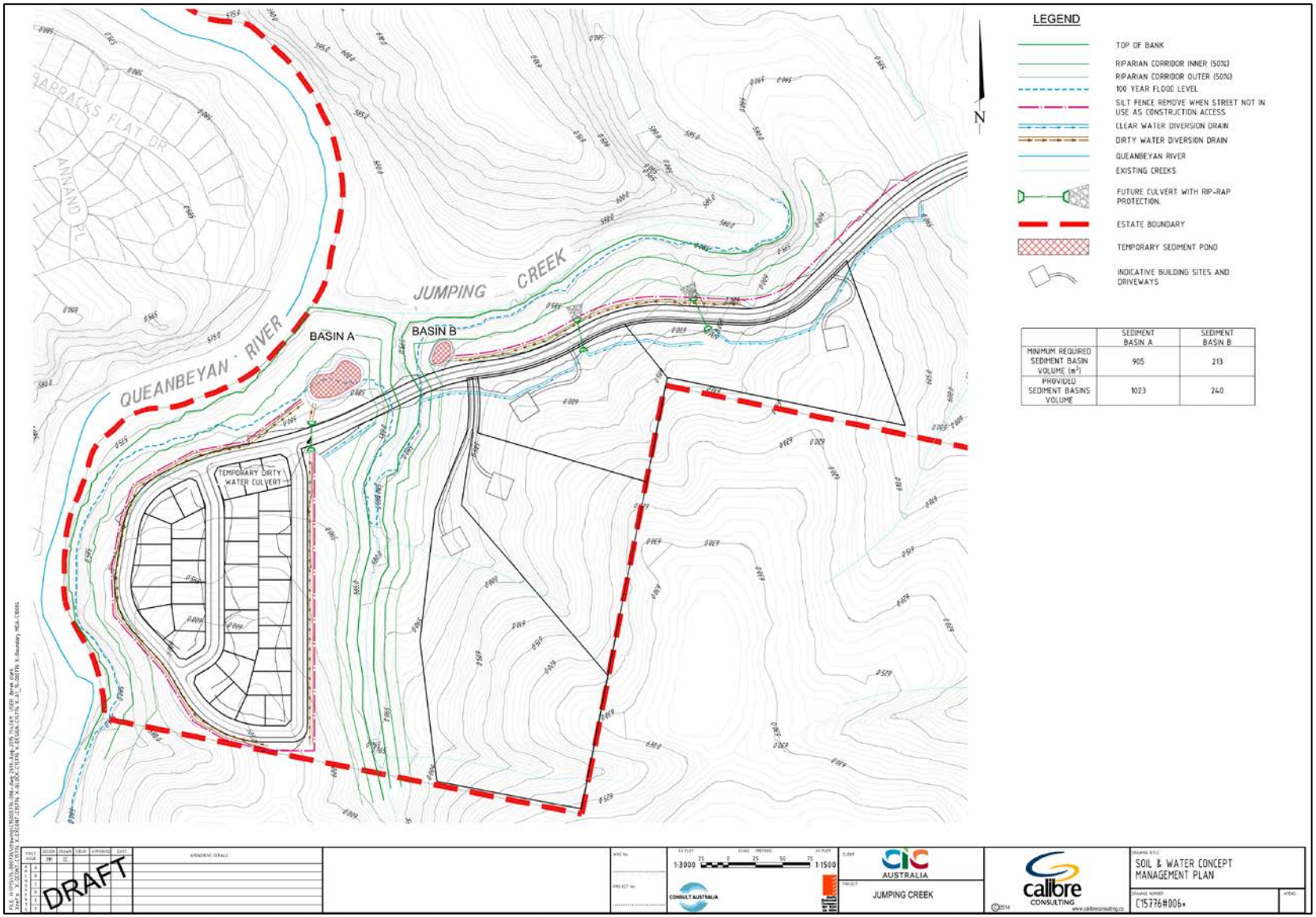

Figure 1: Proposed lot layout and stormwater (from Calibre Consulting 2015)

2 Methods

2.1 Desktop study

Available literature includes aerial photography, key fish habitat mapping by NSW Fisheries and studies by other consultants for this development. Online databases were accessed (25 September 2015) to determine likely threatened species, communities and populations within a 5 km radius of the study area:

- EPBC Act Protected Matters Search
- *Threatened Species Conservation Act 1995* (TSC Act) Threatened Species Search Tool (BioNet)
- FM Act listed protected and threatened species and populations, including species profiles, 'Primefact' publications and expected distribution maps
- NSW DPI threatened and protected species records viewer.
- Online Zoological Collections of Australian Museums (OZCAM)
- Other publications describing biota in the region (if relevant).

2.2 Field survey methods

The site was visited on 28 September 2015, between 9 am and 4 pm by Ian Dixon (aquatic ecologist). The survey included a visual assessment of accessible areas along the Queanbeyan River, Jumping Creek, an unnamed tributary dissecting the site, and two of its tributaries (**Figure 2**). Several areas were inaccessible due to steep terrain (cliffs) and dense infestations of Blackberries. Alternative vantage points were sought to gain an understanding of inaccessible areas. The survey was limited to observations only, and no aquatic fauna sampling or water testing was performed. Each reach was described using key indicators of riparian and aquatic condition.

Figure 2: Survey reaches and photo points

3 Results

3.1 Creek condition assessment

Five reaches were surveyed in or surrounding the study site (**Figure 2**) with general descriptions of riparian and aquatic condition in **Table 1**. Representative site photos are presented **Appendix A**. Smaller tributaries were in the poorest condition, with severe slumping and channel incision. Mid-sized reaches where mostly impacted by dense infestations of Blackberries. The largest reach at Queanbeyan River is of better condition with a variety of habitats, but with a weedy riparian community.

Table 1: Condition of aquatic and riparian zones

Condition	Queanbeyan River	Jumping Creek	Unnamed Tributary of Jumping Creek	Tributary No 1	Tributary No 2
Strahler stream order	>4th order	>4th order	2nd order	1st order	1st order
Riparian: spatial integrity	Width reduced by up to 1/3 and/or some breaks in continuity.	Width reduced by up to 1/3 and/or some breaks in continuity.	About 50% of the native vegetation remains, either in strips or patches.	Only small patches of well-separated native vegetation remain.	Only small patches of well-separated native vegetation remain.
Riparian: nativeness	Exotic species present but not dominating any strata, 'high threat' species occasional.	One or more strata dominated by exotic species, 'high threat' species present.	One or more strata dominated by exotic species, 'high threat' species present.	Exotic species present but not dominating any strata, 'high threat' species rare.	Exotic species present but not dominating any strata, 'high threat' species rare.
Riparian: structural integrity	Cover within one stratum up to 50% lower or higher than reference.	Cover within one stratum up to 50% lower or higher than reference.	One stratum missing or extra, cover within remaining strata 50% lower or higher than reference.	More than one stratum completely altered from reference (lost or <10% remaining).	One stratum missing or extra, cover within remaining strata 50% lower or higher than reference.
Riparian: age structure	Reduced cover (75-50%) of dominant strata, and/or only two age classes present.	Reduced cover (75-50%) of dominant strata, and/or only two age classes present.	Reduced cover (<50%) of dominant strata, and only one age class present.	Reduced cover (<50%) of dominant strata, and only one age class present.	Reduced cover (<50%) of dominant strata, and only one age class present.
Riparian: debris	Quantities and cover of debris similar to reference.	Quantities and cover of debris similar to reference.	Debris only present in tree dominated portions.	Very small quantities of debris present.	Very small quantities of debris present.

Condition	Queanbeyan River	Jumping Creek	Unnamed Tributary of Jumping Creek	Tributary No 1	Tributary No 2
Aquatic: fish habitat classification (Fairfull 2013)	Class 1 (major fish habitat)	Class 1 (major fish habitat)	Class 4 (unlikely fish habitat)	Class 4 (unlikely fish habitat)	Class 4 (unlikely fish habitat)
Key Fish Habitat (DPI Fisheries)	Yes	Yes	No	No	No
Aquatic: dominant substrate type	Cobble	Cobble	Clay	Clay	Clay
Aquatic: subdominant substrate type	Sand	Sand (access limited)	Gravel	Gravel	Gravel
Aquatic: main habitat types	Mostly wide pool with three short riffles	Long narrow pools (riffles heard but access limited)	Ephemeral shallow pools, dry channel at time of survey	Eroded ephemeral drainage line	Eroded ephemeral drainage line
Aquatic: instream woody debris	Common	Occasional (access limited)	Occasional	Rare	Rare
Aquatic: macrophytes	Rarely occur	Rarely occur (access limited)	Absent	Absent	Absent
Overall condition	**Good** aquatic habitat condition due to size and habitat variety, but **moderate** riparian condition due to weeds.	**Moderate** aquatic habitat condition, but with **poor** riparian vegetation due to blackberry invasion	Mix of **degraded** condition due to erosion and blackberry invasion; and **moderate** condition where native riparian community occurs	**Degraded** condition due to severe erosion and lack of riparian vegetation	**Degraded** condition due to severe erosion and lack of riparian vegetation

3.2 Semi-aquatic and riparian fauna

During the site inspection, four semi-aquatic fauna species were observed near the confluence of Jumping Creek and Queanbeyan River:

- one *Ornithorhynchus anatinus* (Platypus) observed swimming and entering a den on the northern bank of Jumping Creek (inside slumped bank from fallen tree);
- several *Limnodynastes dumerilii* (Eastern Banjo Frog) and *Crinia signifera* (Common Eastern Froglet) calls heard emitting from the inaccessible channel (steep rock walls/banks) along Jumping Creek;
- one *Intellagama lesueurii howitti* (Gippsland Water Dragon) on the eastern bank of Queanbeyan River.

Additionally, five wombat burrows and fresh scats occur along the bank and riparian corridor of the Queanbeyan River. No wetland birds were observed. Other species known to occur on site are detailed in ELA (2010).

4 Impact assessment

4.1 Potential impacts to riverine ecology

Without controls in place to mitigate impacts, urban development could trigger a range of impacts, from unseen water chemistry changes to broad-scale river degradation. The proposed subdivision, when developed, could contribute to the potential impacts listed in **Table 2**.

Table 2: General impacts to riverine ecology

Aquatic/riparian ecology impact	Potential cause of impact
Increased nutrients leading to algal blooms.	Increased or more constant nutrient inputs from urban catchment, such as pollutants, fertilisers, dog faeces, lawn clippings and leaves from exotic street trees; Increased water temperature of runoff from imperviousness surfaces, favouring algal growth. Increased pH due to water flowing through concrete pipes. This may disrupt high order zooplankton abundance that graze on phytoplankton.
Unstable change in populations of zooplankton, macroinvertebrates, planktivorous fish and picivourous fish leading to a shift or imbalance of the aquatic food web, including key invertebrate diet of platypus.	Altered physicochemical properties of the water runoff (see above) favouring an increase in food (algae and phytoplankton) and therefore increase in zooplankton and higher order predators. This 'bottom up' control may be unstable for mid-trophic fauna that respond to water conditions or increased food supply, but are then preyed upon by top predators. Increased leaf litter from exotic deciduous trees (street and garden trees) may reduce feeding opportunities for grazing macroinvertebrates and their fish predators. This is due to deciduous leaf fall being added seasonally and broken down in water over a relative short timeframe, whereas the harder leaves of Eucalypts and other native trees are gradually shed into the water year-round and take much longer to decompose. The rapid decomposition of exotic leaf litter can also cause severe declines in dissolved oxygen concentration, making the creek unsuitable for sensitive species.
Blockage to fish passage.	Although no instream barriers to fish passage are proposed, an increase in flash flows discharged from an impervious catchment may produce short term barriers to fish that are unable to swim through faster flowing sections of Jumping Creek. Sedimentation of shallow areas may also reduce longitudinal connectivity.
Loss of bank habitat for platypus, water rats, water dragons and other burrowing fauna (e.g. wombats).	Unintentional burrow destruction along banks from an increase human population attracted to water (e.g. fishing, swimming). Destabilisation of banks due to dense weeds preventing native tree recruitment. This reduces the number of deep rooted trees that bind the bank. An increase in the volume of runoff and intensity of flow that can cause bank scouring.
Change in wetland bird habitat.	An altered aquatic food web (see above) may impact the food source of

Aquatic/riparian ecology impact	Potential cause of impact
	piscivorous birds (wetland birds and raptors). Change in water quality, flows and increased rubbish may reduce foraging habitat and food source of filter feeders and shorebirds. An increase in domestic predator species, such as cats and dogs, could threaten or disrupt the waterbird and aquatic mammal communities.
Loss of riparian vegetation	Removal of small tributaries and unmapped drainage lines in the catchment for urban development. Weed invasion due to new vectors of seed dispersal (i.e. humans, cars, and discharge outlets) and an influx of urban garden plantings (potential environmental weeds).
Increase in solid in-stream rubbish	With an increase in human activity, discarded rubbish could get washed or deposited in the creek.
Accumulative effects on - Catchment water quality - Catchment food webs - Downstream weed invasion - Climate change (listed as a Key Threatening Process by NSW Fisheries)	Increased development leading to a change in water quality, water quantity, water velocity, weediness, air pollution and expansion of the urban heat island.

4.2 Aquatic threatened species

Threatened aquatic species listed under the FM Act and EPBC Act that have the potential to occur within a 5 km radius of the site are listed in **Appendix B**. The three fish species identified are stocked in Googong Reservoir approximately 6 km upstream, although the NSW Fisheries records viewer shows the nearest records as occurring in the Murrumbidgee River.

- **Murray Cod** is recorded by NSW Fisheries in the Murrumbidgee River (6 km downstream of the Molonglo River confluence). It is also stocked in Lake Burley Griffin (LBG) in the ACT and Googong Reservoir. Surveys in LBG indicate that natural recruitment may be present for Murray Cod but is not able to maintain the fish population, therefore, the only viable method of maintaining large bodied native predators and recreational target species is a continued stocking program (Beitzel et al. 2012). Unless individuals are displaced from Googong Reservoir, it is unlikely they utilise the waterways near the study area.
- **Macquarie Perch** is recorded by NSW Fisheries in the Murrumbidgee River (60 km upstream of the Molonglo River confluence). A breeding population in the Queanbeyan River upstream of the Googong Reservoir exists solely due to a translocation of individuals from the reservoir past a natural barrier (Lintermans 2006). The Googong Reservoir population is believed to be effectively extinct. Macquarie perch may occasionally become displaced downstream from the Queanbeyan River into Googong, but they do not form a population in the reservoir (Department of the Environment 2015). It is therefore unlikely that Macquarie Perch are downstream of Googong in the Queanbeyan River near the study site.

- **Silver Perch** is recorded by NSW Fisheries in the Murrumbidgee River (60 km downstream of the Molonglo River confluence). The fish is stocked in Googong Reservoir upstream of the study site. There are no contemporary records of it occurring in the Canberra region. There are occasional angler records of Silver Perch from the Queanbeyan River below Googong Reservoir but these fish are assumed to be stocked fish displaced downstream from the reservoir (ACT Government 2003). It is, therefore, unlikely that an important population occurs in the Queanbeyan River near the study site.

Given the known distribution of stocked and displaced threatened fish species described above, it is unlikely there is an important population utilising the waterways adjacent to or near the study site. Downstream of the site, barriers to fish passage (e.g. Queanbeyan city weir and Lake Burley Griffin) would prevent fish from migrating upstream from known habitats in the Murrumbidgee River. The stocked population in Googong Reservoir and any escapees downstream are disjunct from the 'naturalised' populations in the greater region. Therefore, an assessment of significance under the EP&A Act for threatened species listed under the FM Act is not required. Accordingly, the significant impact criteria test under the EPBC Act is also not required for these fish.

The Draft Flora and Fauna Assessment (ELA 2010) addresses terrestrial threatened species, including parts of the riparian corridors mapped as Box-Gum Woodland. This community comprises the endangered ecological community White Box, Yellow Box, Blakely's Red Gum Woodland which is listed as Endangered under the TSC Act and the White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grasslands (Box-Gum Woodland) which is listed as Critically Endangered under the EPBC Act.

4.3 Jumping Creek Deferred Area Urban Capability Study

The *Jumping Creek Deferred Area Urban Capability Study* by Calibre Consulting (2015) models the stormwater quantity and quality of the before and after development scenarios. The water quality strategy for the site was developed using MUSIC modelling, and demonstrates the performance of the proposed treatment in terms of reduction in average annual pollutant exports (gross pollutants, suspended solids, phosphorus and nitrogen). The report concludes that a proposed residential development in the currently zoned Deferred Area will have:

- No adverse effects on the environment, with the implementation of management measures. These management measures include the control of sediment runoff during both civil and housing construction phases; and the use of rainwater tanks, gross pollutant traps and bioretention basins for the treatment of stormwater runoff.
- No impact on the 1 and 100 Average Recurrence Interval (ARI) storm event peak flows at the confluence of Jumping Creek and Queanbeyan River.

Given the modelling results meet the acceptable standards for urban development, it is reasonable to assume the potential impacts to aquatic ecology (**Table 2**) are largely acceptable with the mitigation measures in place. It is beyond the scope of this study to calculate the accumulative impacts downstream in regards to additional urban development. However, localised impacts associated with the proposed development may be more noticeable or measurable. Such localised impacts could be attributed to:

- Scouring of banks opposite drainage lines entering Jumping Creek (i.e. from those collecting clear water runoff directed to discharge outlets; and overflow of basins).

- Minor barriers to fish passage (water too fast for upstream travel) below discharge outlets on Jumping Creek during rain events. This may temporally prevent upstream movement of small bodied fish.
- Sedimentation of interstitial space of bed sediments due to unintended overland erosion during construction (i.e. dirty water entering clear water drains). This may reduce available habitat for macroinvertebrates and food resources for platypus.

These localised impacts are not unique in regards to an urban development. With maintained controls in place during construction to reduce erosion, and possibly bank stabilisation of vulnerable areas, these impacts can be minimised and would be limited to a small area.

The water quality strategy for the site prepared by Calibre Consulting (2015) demonstrates a reduction in target loads of average annual pollutant exports (gross pollutants, suspended solids, phosphorus and nitrogen). Those data presented are not in units or temporal scales comparative to ambient water quality goals (e.g. Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 – the ANZECC Guidelines), but target loads are an acceptable alternative to using trigger values (DEC 2006). Therefore, as the post-development modelling indicates exports will be below target loads, it is considered the development, with controls in place, would be a *low risk to the environmental values* of Jumping Creek and Queanbeyan River.

5 Recommendations

The following recommendations (**Table 3**) are designed to mitigate the potential impacts (**Section 4**) of the proposed development to riverine ecology.

Table 3: Recommendations to mitigate impacts

Aims	Mitigation recommendation
Minimise nutrient inputs to waterways. Maintain sustainable aquatic food web. Maintain aquatic habitat (dissolved oxygen, pH, physical etc.).	Maintain proposed bioretention basins in the long term. Where possible use open grass swales rather than concrete pipes to transfer stormwater. This will help water chemistry. Minimise exotic deciduous street tree planting. Preference is endemic native trees. Remove exotic riparian trees (Willows, Poplars), but leave roots intact for bank stability. Revegetate with native species. Leave fallen trees in the stream for fauna habitat.
Maintain existing fish passage.	Minimise sediment inputs during earthworks and construction with stringent erosion controls in place that are effective and maintained. Reduce sedimentation of waterways by stabilising steep land, erosion hot spots and exposed soil in the developed lands. Use appropriate controls (e.g. planting, mulch, jute matting, geotextile fabric, rock armour etc.) Reduce erosion at discharge channels towards Jumping Creek by installing scour protection and revegetation. The opposite bank of Jumping Creek may need reinforcing at each discharge point. Consider installing a small number (2 or 3) of scattered boulders instream to slow flash stormwater flows at points of discharge into Jumping Creek. This will create small eddies that provide resting stations for fish and other fauna swimming upstream during fast flows. Boulders should be sufficiency spaced to avoid creating debris dams or backed up water. Placement of these boulders should be supervised by a person with knowledge of fish passage requirements.
Protect riparian and bank habitat. Loss of bank habitat for platypus, water rats, water dragons and other burrowing fauna (e.g. wombats).	Provide controlled public access point/s to waterways (fishing, swimming etc) to reduce ad hoc tracks and destruction of bank habitat. Implement a Vegetation Management Plan (VMP) to reduce weeds and increase native trees, shrubs and groundcovers (see VMP item below). Check for wombat, water rat, and platypus burrows before using machinery on banks. If located, avoid digging or driving at these sites. . Plant dense shrubs along the upper bank of Jumping Creek near confluence with Queanbeyan River to screen urban use from local platypus population (one platypus and burrow observed here).
Restore and protect riparian vegetation.	Removal of vegetation along any drainage lines identified on the 1:25,000 scale topographic map should be discussed with DPI Water to identify required riparian corridor offsets. Offsets of riparian land should be applied to the unnamed tributary dissecting the site, Jumping Creek or Queanbeyan River.

Aims	Mitigation recommendation
	A Vegetation Management Plan (VMP) should be prepared for all riparian corridors accepted by DPI Water. The VMP should consider the full width of the riparian corridor and its functions including accommodating fully structured native vegetation. DPI Water lists criteria for preparing a VMP, including: • Vegetation species composition, planting layout and densities should be identified. The required mix of plant species relates to the actual community to be emulated and the size of the area or areas to be rehabilitated but mature vegetation communities are generally well structured, comprising trees, shrubs and groundcovers species. Planting densities should achieve quick vegetative cover and root mass to maximise bed and bank stability along the subject watercourse. • Costs associated with high density planting will be recovered through reduced maintenance costs for weeding or replacement planting in the maintenance period specified in the controlled activity approval (CAA). • Seed or plant sources should be identified. Where possible, native plants and seed sources of local provenance should be used. • Exotic vegetation should be avoided. The use of exotic species for temporary soil stabilisation is permitted provided they are sterile, non-invasive and easily eradicated when permanent vegetation is established. • Maintenance requirements should extend for a minimum of two years after the completion of works or until such time as a minimum 80 per cent survival rate of each species planted and a maximum 5 per cent weed cover for the treated riparian corridor controlled activity is achieved. • Project tasks, planting program, costing, monitoring and review (performance criteria) and reporting. See link below for further information: http://www.water.nsw.gov.au/__data/assets/pdf_file/0010/547219/licensing_approvals_controlled_activities_veg_mgt_plans.pdf
Prevent solid in-stream rubbish.	Install gross pollutant traps to intercept rubbish before it enters the waterways.

6 Conclusion

The proposed rezoning and subsequent development of the *Jumping Creek Deferred Area* will not impact aquatic species listed under the FM Act or EPBC Act, therefore, a Species Impact Statement or referral to the Commonwealth for aquatic species is not required. Riparian vegetation communities are discussed in the Draft Flora and Fauna Assessment (ELA 2010).

Potential impacts to the riverine ecology of Jumping Creek and Queanbeyan River can be mitigated via erosion controls during earthworks/construction, stormwater design, riparian vegetation management, street tree selection and habitat protection.

The water quality strategy for the site prepared by Calibre Consulting (2015) demonstrates a reduction in target loads of average annual pollutant exports (gross pollutants, suspended solids, phosphorus and nitrogen) and 1 and 100 ARI storm peak events. It is, therefore, considered the development, with controls in place, would be a *low risk to the environmental values* of Jumping Creek and Queanbeyan River.

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Appendix A Site photos

See **Figure 2** for location of photo points

Queanbeyan River

Jumping Creek


8


9


10


11

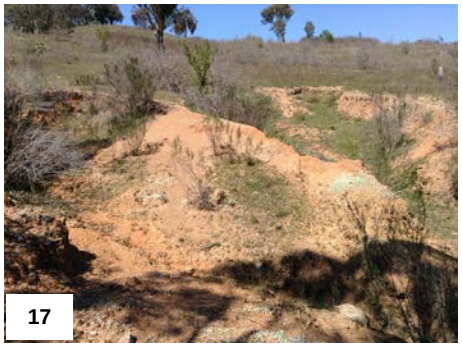
Unnamed Tributary of Jumping Creek


12


13

Tributary No 1

Tributary No 2



Unmapped drainage gullies

Appendix B Likelihood of occurrence table (fish)

Scientific Name	Common Name	FM Act	EPBC Act	Habitat Associations	Likelihood of Occurrence
Bidyanus bidyanus	Silver Perch	V	CE	Silver perch are a moderate to large freshwater fish native to the Murray-Darling river system. Silver perch seem to prefer fast-flowing, open waters, especially where there are rapids and races, however they will also inhabit warm, sluggish water with cover provided by large woody debris and reeds. Habitat is predominantly in lowland and slope waterways. Adults migrate upstream in spring and summer to spawn.	Unlikely an important population
Maccullochella peelii	Murray cod	-	V	Migrates wholly within freshwater (potamodromous). It utilises a diverse range of habitats from clear rocky streams, such as those found in the upper western slopes of NSW (including the ACT), to slow-flowing, turbid lowland rivers and billabongs.	Unlikely
Macquarie australasica	Macquarie Perch	E	E	Macquarie perch are found in the Murray-Darling Basin (particularly upstream reaches) of the Lachlan, Murrumbidgee and Murray rivers, and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments. Macquarie perch are found in both river and lake habitats, especially the upper reaches of rivers and their tributaries. Habitat for this species is bottom or mid-water in slow-flowing rivers with deep holes, typically in the upper reaches of forested catchments with intact riparian vegetation. Macquarie perch also do well in some upper catchment lakes. In some parts of its range, the species is reduced to taking refuge in small pools which persist in midland–upland areas through the drier summer periods.	Unlikely

CE = Critically Endangered; E = Endangered; V = Vulnerable

References from online species profiles (NSW DPI and DoE, 2015)

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