Department of Climate Change, Energy, the Environment and Water

Our ref: OUT24/16906

Benjamin Cox
Planning and Assessment Group
NSW Department of Planning, Housing and Infrastructure

Email: ben.cox@planning.nsw.gov.au

30 October 2024

Subject: **Clarrie Hall Dam Raising (SSI-65020460) – Environmental Impact Statement**

Dear Benjamin Cox

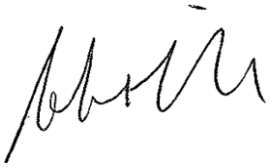
I refer to your request for advice sent on 25 September 2024 to the NSW Department of Climate Change, Energy, the Environment and Water- (DCCEEW) Water Group about the above matter.

Tweed Shire Council is proposing to raise the height of Clarrie Hall Dam by 8.5m and increase the water storage capacity from 16 gigalitres to 42.3 gigalitres. This proposal also includes a new spillway and raising of the intake tower, and supporting activities such as concrete batching, re-establishment of a quarry, road and utility infrastructure and workers accommodation.

NSW DCCEEW Water has reviewed the Environmental Impact Statement and has recommendations regarding water demands, water take and licensing, surface water and geomorphic impacts, monitoring and management. Please see **Attachment A** for more detail. **Attachment B** is provided to assist DPHI and the proponent with recommendation 2.1.

Should you have any further queries in relation to this submission please do not hesitate to contact DCCEEW Water Assessments at water.assessments@dpie.nsw.gov.au

Yours sincerely,



Rob Brownbill
Manager, Water Assessments, Knowledge Division
Department of Climate Change, Energy, the Environment and Water

Attachment A

Detailed advice regarding the Clarrie Hall Dam Raising (SSI-65020460) – EIS

1.0 Water take and licensing

1.1 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure request the proponent to:

- Quantify the annual maximum site water demands for operation of the proposed quarry and confirm the water supply sources.
- Quantify the maximum annual water take due to aquifer interference activities operation of the quarry.

Explanation

Water demands have been provided for dust suppression, concrete batching and the workers accommodation, however it is not clear if there are additional water demands for the proposed quarry and how these are to be met.

The EIS indicates there is potential groundwater interception for the quarry however the volume of water take has not been estimated or reported. There is also uncertainty as to whether there are other activities that may result in aquifer interception and resulting groundwater take. Quantification of maximum potential groundwater take per water year from all aquifer interference activities is required to understand the entitlement requirements and to determine potential impact assessment requirements under the NSW Aquifer Interference Policy (2012).

1.2 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure request the proponent to demonstrate sufficient water entitlement is held or can be acquired in the relevant water source/s to account for the predicted water take unless an exemption applies.

Explanation

The EIS makes references to obtaining a water access licence (WAL) to account for water take however no information is provided on the ability to obtain the necessary entitlement in the relevant water source. Further information is required to demonstrate this for all water sources where water take is predicted. Exemptions to the need for a WAL listed under Schedule 4 of the Water Management (General) Regulation 2018 may also be relevant and should be identified where they are to be used for the project.

1.3 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure request the proponent to identify and assess the impacts of construction and operation of all water supply works required for the project.

Explanation

The EIS has indicated there will be extraction points to meet the site water demands, however there is no detail to confirm the types of works required or the impacts of their construction and operation. These should be identified and assessed to ensure the exclusion from the requirement for a water supply work approval under the *Water Management Act 2000* as provided for in section 5.23 of the *Environmental Planning and Assessment Act 1979* can apply.

1.4 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure request the proponent to confirm if there will be impacts to existing water users due to the increase in inundation area from the proposed dam wall raising.

Explanation

The raising of the dam wall is predicted to significantly increase the upstream inundation area of the dam. It is unclear whether this will result in impacts to third party water supply works.

1.5 Recommendation – Post determination

The proponent is requested to contact the NSW DCCEEW Water Licensing and Approvals team at waterlicensing.servicedesk@dpie.nsw.gov.au to update currently held dam design specifications.

2.0 Surface water impacts and management

2.1 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure requests the proponent to provide further explanation as to how environmental flows in lower Doon Doon Creek and the Tweed River will be managed to maintain flow and pool connectivity for all flow classes. Further information on the changes to the frequency and duration of flow metrics as described in Attachment B (Step 3(a) – Hydrological metrics analysis) should be provided for all modelled scenarios.

Explanation

The highest risk to the water source is an increase in zero flow periods with loss of pool connection and pool drawdown along Doon Doon Creek and into the Tweed River. This is evident in the coastal risk assessment for the Tweed catchment (DCCEEW 2021) which identifies a risk rating of High for zero flow periods where pumping may increase cease to flow triggers. Other flow classes are rated at low risk.

Increased evaporative losses from the expanded storage is predicted to have 0.5% reduction in end of system flows during typical water supply operations. This is likely to impact on cease to flow and extension to zero flow periods in Doon Doon Creek. Whether there will be a detectable low and minimum flow difference in the Tweed River depends on low flow releases from the dam.

The project is proposing to decrease the number of days the spillway operates from an average of 63% to 55%. The modelling also predicts a reduction in peak discharges and an increase in moderate to high discharges following an event as the water drains more slowly from the reservoir.

Further analysis of the frequency and duration of flow metrics will assist in understanding the changes for all flow classes within Doon Doon Creek and the Tweed River. The changes need to be reviewed against the requirements of the downstream environment eg. fish migration and water extraction, to identify ecological and water security impacts and to enable the development of adequate monitoring and management measures.

It is noted the majority of the flow analysis in the EIS is focussed on the gauge at Uki or Bray Park weir. As the catchment area at Uki is 275km2, and only 60km2 at Clarrie Hall dam, any comparison of changes caused by the dam at Uki are likely to be concealed by unaltered flows. Flow analysis at Clarrie Hall Dam is required to understand potential impacts to the flow regime.

2.2 Recommendation – Post approval

Department of Planning, Housing and Infrastructure requests the proponent to include a three-year monitoring program to ensure no impact on bass migration in Doon Doon Creek and downstream water sources following project completion. This is to include management and mitigation options for identified impacts eg. flow releases during fish migration.

Explanation

The project includes changes to the storage and release of water from Clarrie Hall Dam. The implementation of monitoring, management and mitigation is required to ensure impacts are consistent with predictions.

3.0 Geomorphic impacts and management

3.1 Recommendation – Prior to determination

Department of Planning, Housing and Infrastructure requests the proponent to provide further information on sediment transport and deposition to inform the design of geomorphologically effective flow releases. This is to include identifying sediment entrainment limits and the depositional characteristics of sediment structures downstream along Doon Doon Creek and the Tweed River.

Explanation

The geomorphology assessment (Annexure D) does not identify sediment entrainment limits or the distance or depositional characteristics of sediment structures downstream along either Doon Doon Creek or the Tweed River. Depositional features either as bedforms or bank/bar features record critical information on flow stage sediment transport and depositional relationships and the distance along which sediment fining occurs. These features present important evidence of flow attributes that should be applied to managed flow releases.

Sediment fractionation has not been addressed which further limits the assessment and results in a lack of proposed mitigation measures. Mitigation of the reduction in geomorphologically effective flows is necessary to perturb and renew bed materials and

induce sediment transport. Predicted reduction in bed perturbing flows in Doon Doon Creek is described in very general terms, due in part to the lack of sediment typing or transport rates through Doon Doon Creek into the Tweed River.

The assessment does not attempt to quantify the reach distances from the proposed dam for potential bed scour and downstream deposition changes in sediment regime. Instead, the surface water assessment makes a statement that existing gravel to cobble bed reaches will not be affected. The reduction in dam spill peak flows in Doon Doon Creek is likely to increase fine sediment gravel plugging in the bed of the watercourse. The downstream river sections likely to be affected by fine sediment plugging are located in Doon Doon Creek immediately above the junction with the Tweed River and in sections of the Tweed River above and within the tidal zone. This will have an impact on available habitat and bank form due to relocation of the deposition zone from benches to the stream bed.

3.2 Recommendation – Post approval

Department of Planning, Housing and Infrastructure requests the proponent to include a geomorphic monitoring and management plan that includes but is not limited to:

- Sediment trapping rates and sediment fraction so mitigation strategies are properly evaluated against actual sediment input rates and loading into Clarrie Hall Dam.
- The effects on channel form, depositional zones and changes in bed perturbation.

4.0 Groundwater impacts and monitoring

4.1 Recommendation – Post determination

Department of Planning, Housing and Infrastructure requests the proponent to prepare a groundwater monitoring and management plan that includes but is not limited to:

- Installation of a baseline groundwater monitoring bore network and ongoing monitoring.
- Groundwater user census
- Groundwater dependent ecosystem (GDE) survey and ongoing monitoring.
- Management and reporting

Explanation

There is limited groundwater data availability in regard to levels, water users and groundwater dependent ecosystems from the project area. Further data and continued monitoring are required to validate the conceptual model and hydrogeological dynamics and to verify the assessed impacts.

The installation of a baseline groundwater monitoring bore network prior to raising the dam level should be undertaken to aid the understanding of any changes in the surrounding aquifers. Several monitoring bores will be required to monitor groundwater levels at key sites, particularly in areas predicted to change due to the increases in dam water levels.

Additional information is also required on the status of nearby groundwater users to ensure their status is confirmed and impacts managed. Noting the two closest bores to the inundation area GW06539 and GW065508 are reported to be abandoned.

The groundwater assessment referred to previous records of springs located on the dam abutments however their current status is not known. A comprehensive survey for GDEs is recommended to confirm the status of GDEs in the area and to inform monitoring and management requirements. It is also noted that whilst there are currently no high priority GDEs listed in the study area from the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016, this may change in future as these plans are updated.

End Attachment A

Attachment B

Environmental considerations during water security project development

A guide to assist with shortlisting options

Purpose

This document provides advice about the assessment process, and information required, to prioritise water security activities ("options") based on potential environmental benefits or impacts. The Department of Planning, Industry and Environment - Water (DPIE Water) considers this information when reviewing proposed alterations to water management and infrastructure. All options must be evaluated and prioritised with a consistent approach that gives regard to potential impacts on river, wetland and floodplain ecosystems.

This document outlines a four-step process that DPIE Water uses to evaluate and prioritise options. The provision of information of this nature will assist in reducing further requests and hence, likely speeds up the process. Importantly, the process described below does not replace any legislative or formal assessment processes, such as environmental impact assessments or Basin Plan requirements. However, proponents will likely find that compiling this type of information will assist in preparing information for formal assessments and state significant projects.

Background

Water security activities may affect the quality, quantity and movement of water in ecosystems. Water Security activities include, but are not limited to:

- construction of, modification to, or removal of, dams, weirs, block banks, off-take regulators, and other regulating structures
- infrastructure that changes how water is extracted from or returned to river systems
- other activities that are likely to alter flow regimes.

Proposed water security projects must adhere to the *Water Management Act 2000*, the principal legislation for managing and sharing access to water resources in NSW. When assessing the environmental impacts of proposed projects, consideration is given to:

- the objects of the *Water Management Act 2000*, which include the protection, enhancement and restoration of water sources and their associated ecosystems (section 3(b))
- the water management principles of the *Water Management Act 2000* (section 5)
- the impact on downstream water sources and dependent ecosystems, and the relevant minimal harm test presented in the *Water Management Act 2000* (section 97)

Projects must also be consistent with the requirements and provisions of other relevant legislation, as well as relevant Water Sharing Plans (WSPs), Water Resource Plans, water management policies, Long-Term Water Plans and risk assessments. Any inconsistencies are to be adequately justified in the proposal documents.

Assessment process for shortlisting options

Described below is the process that DPIE Water undertakes to screen and shortlist options based on potential environmental benefits and impacts. Each step in the recommended process outlines the data that proponents will need to provide for options and expected outcomes (**Table 1**).

There are four steps in the environmental assessment of options, these are:

1. Screening options
2. Shortlisting options
3. Analysing shortlisted options
    a. Hydrological metrics analysis
    b. Analysis of infrastructure impacts (if applicable)
4. Choosing preferred options.

In each step, decisions should be documented and justified, clearly and transparently.

Table 1. Process for evaluating environmental benefits and impacts of options. Each step of the process produces specific outputs to standardise and facilitate the evaluation and prioritisation of options. The processes to generate these outputs have been outlined below.

Step	Action(s) by the proponent	Data / information requirements	Proposed outputs
1: Screening	Does the option have any **direct** influence on hydrology or ecology? **Yes** → Option proceeds through steps **No** → No further assessment as part of this process	Expected outcome(s) & objective(s) Comprehensive description of the option (e.g. location, type of infrastructure, construction timeline and operation protocols)	Three lists of options: 1. Options with impacts on hydrology & ecology 2. Options with impacts on ecology, but not hydrology 3. Options with no impacts on hydrology or ecology
2: Shortlisting	Conduct ecological impact assessment of remaining options: a) Consider likelihood of alteration of hydrology, and ecology b) Use expert opinion. Shortlist top options with greatest ecological benefit.	Hypothesised impact of each option, and justification (refer to Table 4 for definitions): • Major/extreme impact • Minor/moderate impact • No/little change • Minor/moderate improvement • Major/extreme improvement • Insufficient information to assess	List of top options with greatest benefit to environment.

Step	Action(s) by the proponent	Data / information requirements	Proposed outputs
3: Analysing	Categorise impacts, according to **Table 4** of option on flow metrics. Appendix B provides an example of the hydrological metric analysis and categorisation of impacts for an option.	**Hydrological metrics analysis**: Hydrology must be modelled if option is expected to impact quality or quantity of water (see **Figure 1** and **Table 2** for flow regime components). **Analysis of infrastructure impacts**: If the project recommends a structure that will impact quality or quantity of water, then address the assessment requirements under **Table 3**.	Comparison of hydrological and ecological impacts of options to baseline values. Impact categories for each option.
4: Choosing	Rank preferred options by considering hydrological modelling and ecological impact assessment.		Recommendation of preferred option(s) in order of preference.

Step 3(a) Hydrological metrics analysis

DPIE Water looks at a range of hydrological alteration metrics to determine whether key ecological values may be affected by water management. The flow metrics in **Table 2** are currently used for Water Sharing Plan risk assessments and Regional Water Strategy option assessments. They describe potential impacts of management activities on the magnitude, frequency, seasonal timing, predictability, duration and rate of change of flow conditions. We recommend that these flow metrics are included, and analysed for proposed infrastructure projects. This will allow DPIE Water to assess the relative merits of different options in the same context as our broader management framework.

To provide the hydrological metric analyses required by step 3(a), it is recommended that the following metrics are calculated at a number of hydrological gauge locations in the valley of interest (**Table 2**). Depending on the proposed project, more specific metrics may also be required. For example, if there are specific flow-based water sharing plan rules protecting an environmental asset at a location, then it will be important to analyse how proposed options affect the operation of these rules. A graphical representation of the different flow components is provided in **Figure 1**.

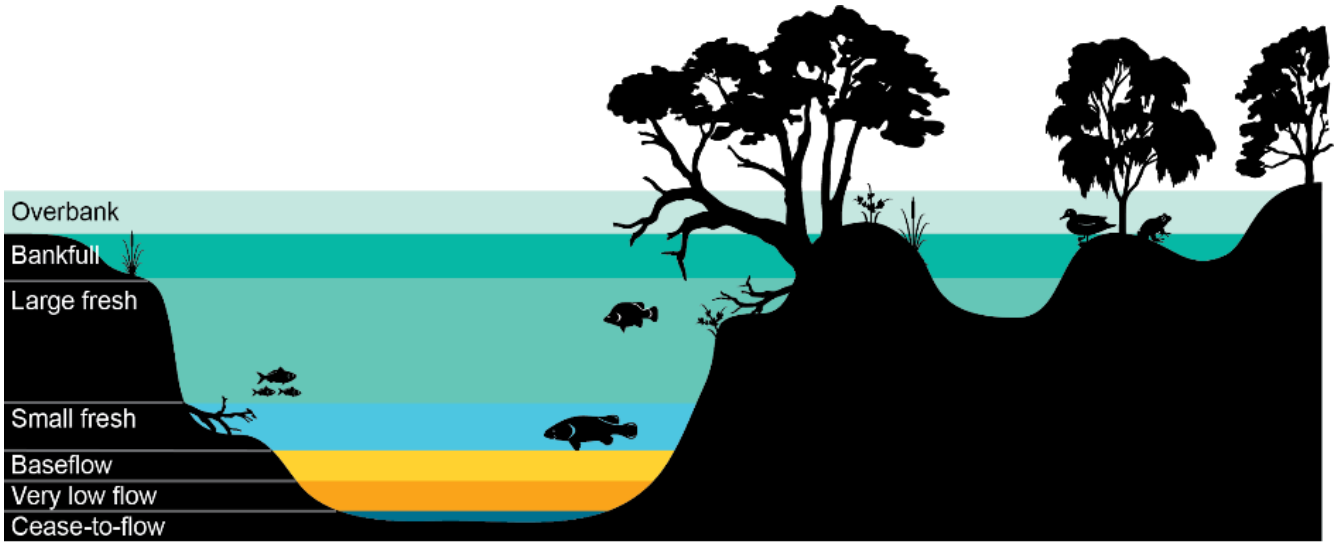


Figure 1. Conceptual model of flow regime components in a cross-section of a river (Source: Border Rivers Long Term Water Plan, 2018).

Table 2. Flow regime components, key features and statistics required for completion of step 3a. Appendix A provides detail on how to calculate the flow metrics listed below, and Appendix B provides an example of how this information can be used to prioritise options.

Flow component	Key features	Flow metric (for all modelled scenarios, including baseline)	Use of the flow metric in options analysis
Cease to flow (CtF) events for pools (Z)	Pools provide refugia for animals during low and no flow periods. Continued water extraction can lead to greater competition for resources, and changes to water quality. CtF events also inhibit flowing water habitats (e.g. riffles), which support specialist feeding groups of macroinvertebrates and fish.	Number of years with ≥ 1 CtF spell Average duration of CtF spells (number of days) Average number of cease-to-flow days per year Show high flow and low flow seasons	Percentage change from baseline CtF metrics, calculated for each option

Flow component	Key features	Flow metric (for all modelled scenarios, including baseline)	Use of the flow metric in options analysis
Base flows (BF)	Flows that are confined to low flow part of channel. Flow driven by groundwater aquifers and usually persistent even in absence of rain. Base flows protect longitudinal connectivity and provide flowing water habitats (e.g. riffles) to support and shelter specialist feeding groups of macroinvertebrates and fish. They also refresh water in pools, thereby maintaining water quality.	Flow rate (ML/d) for baseline 80th and 95th percentile discharge of daily flows Average number of days with flow above the baseline percentile per year Average duration of consecutive daily flows above the baseline percentile per year Show high flow and low flow seasons	Percentage change from baseline BF metrics, calculated for each option
Freshes (F) The default fresh is the 20th percentile flow	Larger flows that inundate the sides of banks, in-channel bars and benches. Often caused by rain leading to an increased flow and a pulsed flow down the system. Freshes support in-stream processes and biota similarly to bankfull and overbank flows.	Flow rate (ML/d) for baseline 20th percentile discharge of daily flows Number of years with ≥ 1 fresh Average number of days with flow above the baseline percentile per year Average duration of consecutive daily flows above the baseline percentile per year Show high flow and low flow seasons	Percentage change from baseline F metrics, calculated for each option

Flow component	Key features	Flow metric (for all modelled scenarios, including baseline)	Use of the flow metric in options analysis
Large and infrequent flows (BKF and OB)	Even larger flows occurring on an average recurrence interval (ARI) of greater than a year. Generate bankfull and overbank flows. Bankfull flows define and maintain channel dimensions (e.g. width, depth, slope, in-channel bars and benches). Overbank flows deliver water, sediment and dissolved matter (e.g. plant nutrients) to floodplains and wetlands, and provide temporary access to floodplain habitats for fish. Water returning from floodplains may increase channel productivity by transporting dissolved carbon, organic detritus, microorganisms and plankton. Both flows introduce disturbance to rivers, and trigger successional processes.	1.5-year annual recurrence interval (ARI) flow rate (ML/d) 2.5-year ARI flow rate (ML/d) 5-year ARI flow rate (ML/d) Show high flow and low flow seasons	Percentage change from baseline BKF and OB metrics, calculated for each option
Annual volume	Calculating these metrics provides a range of information on magnitude, frequency, seasonal timing, predictability, duration and rate of change of flow conditions that can be compared to the baseline conditions.	Median annual discharge (volume per year) Mean annual discharge (volume per year)	
Flow duration curves		Annual	
Variability of flows		Coefficient of variation daily flows (ML/d)	

Step 3(b) Analysis of infrastructure impacts

Expert opinion will be used to initially rank options and potentially exclude options with significant negative impacts. To progress infrastructure options with significant negative impacts, proponents will need to consider the following types of impacts, and perhaps consult with suitably qualified professionals:

1. assessment of impacts on surface and groundwater sources (both quantity and quality), related infrastructure, adjacent licenced water users, basic landholder rights
2. assessment of impacts on aquatic ecosystem assets and functions, fluvial geomorphology, riparian land, and groundwater dependent ecosystems
3. measures proposed to reduce and mitigate these impacts.

Preferred infrastructure options will also require a detailed assessment against the Secretary's Environmental Assessment Requirements (SEARs), as part of the State Significant Infrastructure process (see, example **Table 3**).

Table 3. Assessment requirements for projects recommending a structure. For projects proposing to construct, modify or remove infrastructure, the analysis in step 3 is expected to include, but is not necessarily limited to, the following information.

Category	Required information
Standard	Justify any inconsistencies arising from the project with: • Relevant legislation, i.e. Water Management Act 2000 • Relevant management policies & guidelines, i.e. SEARs • Water Sharing Plans (WSPs) • Water Resource Plan (WRP) • Relevant risk assessments • Long-term water plans for that area
Baseline information	A thorough description of baseline information for the local and downstream environments and any proposed inundated areas, including: • river channel form, relevant River Styles and alteration of channel form and geomorphic processes. This may include sediment transmission rates, storage and reworking, and in-channel sediment features, appropriate to the proposal • geomorphic features and energy transmission through the proposed infrastructure upper extent and downstream along the river • in-channel geomorphic features, and their persistence and resilience • associated downstream floodplain ecosystems and ecological assets that may be affected by altered flow • relationships between the channel and adjacent floodplains, including a description of the frequency and duration of overbank flows, sediment trapping and sediment features on the floodplain and any river levees • instream ecosystems, assets and functions, associated with all upstream and downstream river, that will see altered flow • water quality baseline data for the water resource likely to be impacted by the development • highly connected alluvial aquifers and their responses to river flows.
Objective/scope	The environmental assessment must consider and review existing hydrology, existing river operations, and alterations in river operations for the new weir, including: • the extent of the infrastructure and water level in adjacent wetlands and other water dependant environs • geomorphic criteria to inform measures to arrest and prevent deterioration of channel condition, address sediment starvation downstream of the dam(s), and promote geomorphic recovery in regulated rivers • catchment-scale water balance and projected alterations in water supply and demand management • means to provide adequate volumetric limits, timing, inundation, flow velocities and associated stream power or shear stress in channel and on adjacent floodplains • water quality objectives relating to weir operations, contingency and emergency measures to address poor water quality • water quality criteria of relevance to river operations and measures to manage water quality impacts, including cold water pollution, lowered dissolved oxygen and increased electrical conductivity or turbidity.

Category	Required information
Surface and groundwater sources and their users	The environmental assessment must consider alterations in river hydrology for the new weir, including: • impact on other water users, including downstream delivery, infrastructure location, pool retention and pool connectivity • compatibility with the associated WSP, the associated Water Resource Plan (WRP) and any amendments that may be required to accommodate the new weir • Impact on delivery of Environmental Water including consideration of downstream connectivity.
Ecosystems	The environmental assessment requires an analysis of likely impact pathways and processes for the local, upstream and downstream environments, including: • modelled alterations to the hydrograph, and changes to baseline conditions expected due to operation of the weir. This analysis should include consideration of projected climate change effects. Hydrological modelling results for locations upstream and downstream of the weir should be made available • changes to geomorphic processes and associated impacts to habitat availability in-channel, on bank and in floodplains adjacent to, downstream and upstream of the weir. The likelihood of in-channel sediment accumulation at the weir leading to reduced out of channel sedimentation, and the potential for secondary incision should be assessed. The potential for loss of channel complexity should be addressed. Full channel cross section surveys are recommended to assess the potential changes • likely impact to floodplain ecosystems and ecological assets (including wetlands and ecological communities) associated with altered flow, both upstream and downstream • predicted water quality impacts arising from the operation of the weir, including assessment of changes to thermal stratification in the weir pool, and likely impacts on local flora and fauna, such as blue green algae and fish. A water quality monitoring program should be detailed, including algae monitoring and a management plan for releases to maintain/improve water quality and prevent fish kills • predicted impacts on licensed water users, including any impact to water quality and availability, and the potential for land salinisation adjacent to the extended weir pool • assessment of the likely impact on highly connected alluvial aquifers and modelled responses to river flows • the predicted change in aquatic habitat availability and type as a result of the weir should be quantified • the proposed fishway type should be detailed, and hydraulic modelling results provided, with reference made to the likelihood of fish passage by native species, particularly the identified threatened species/communities • tests of significance for identified threatened species and Endangered Ecological Communities, and platypus if relevant
Infrastructure operation	The environmental assessment must consider the consequences of weir operations on flow characteristics and any contingency arrangements that are required. This must include and identify: • measures to provide fish passage, through the construction, maintenance and operation of a fishway • measures to manage hydrologic connectivity along the regulated river and pool function and behaviour along the river below the weir

Category	Required information
	• measure to address altered rates of rise and fall and consequential impacts to bank form, sediment release and transport rates and bed perturbation • measures to maintain or enhance water quality and prevent water quality degradation within affected rivers, measures to maintain sediment transport relationships and lowered dissolved oxygen. Identify proposed water quality monitoring activities and methods.
Infrastructure construction	The environmental assessment must consider the proposed weir in the context of regional and catchment hydrologic character (which should be captured in the baseline information). This environmental assessment will consider: • changes to hydrologic behaviour upstream and downstream of the proposed weir • effects of construction and operation of the weir on longitudinal or lateral hydrologic connectivity • design criteria relating to flow hydrographs, release rules, any proposed translucency measures and other alteration of riverine hydrology, flow energy and sediment transport in the process of regulating a currently unregulated river • potential for erosion and sediment release in the river • Impacts on water quality • impacts on threatened and endangered species, including but not restricted to those known to occur in the location of the proposed weir.

Following the hydrological metric analysis and analysis of infrastructure impacts (if applicable) in step 3, the categories listed in Table 4 should be assigned to options. Options and/or scenarios can be ranked and prioritised by comparing relative changes across the indicators.

The categories identified here are arbitrary to enable comparison and ranking of options. Indeed, in some situations there may be more appropriate categories that represent particular thresholds or ecologically significant components. These categories could be identified for a particular project with descriptions and/or justifications of the categories.

Table 4. Impact categories for differentiating ecological impacts and benefits. These categories are arbitrary to allow comparison between options.

Impact Category	Total percentage of relative change across indicators
Extreme impact	More than 30% change in a negative direction
Major impact	Between 21% and 30% in a negative direction
Moderate impact	Between 11% and 20% change in a negative direction
Minor impact	Between 4 and 10% change in a negative direction
Little change	Between 1 and 3% change in a negative direction
No change	0%, rounded to nearest percentage point
Little change	Between 1% and 3% change in a positive direction
Minor impact	Between 4% and 10% change in a positive direction
Moderate impact	Between 11% and 20% change in a positive direction
Major impact	Between 21% and 30% change in a positive direction
Extreme impact	More than 30% change in a positive direction

Appendix A

Definitions and methods for calculating and analysing flow metrics

Defining a baseline: Baseline flow data represents the flow conditions before options are considered. DPIE Water uses either modelled natural flow sequences (i.e. without development) or long-term historical flow data as baselines to assess the relative hydrological effects of different options. We recommend using modelled natural flow where possible, however historical data is sufficient.

Defining low flow and high flow seasons: The low flow season is defined as 5 consecutive months with lowest median monthly flow. The high flow season is defined as 5 consecutive months with highest median monthly flow. We recommend that analyses are conducted for both the low and high flow seasons.

Deriving the partial series for estimating Average Recurrence Interval (ARI) flows:

- for peak flows of events use the daily total flow (**not** an instantaneous maximum within a day)
- use an independence of events of 30 days between events
- base partial series on selecting 2 events per year on average (i.e. if using 130 year sequence select the top 260 events)
- can use interpolation to estimate the ARI flow in the partial series as a short cut, rather than fitting a curve

Appendix B

Table B1. Example of the analysis required by step 3. Below, flow metrics from the proposed project (i.e. Scenario 1) are compared to the baseline values. The percentage change in the metric caused by the project determines in the category of impact.

Flow metric	Base case at gauge	Scenario 1 at gauge	Percentage change	Impact category
Low Flow Season - 80th percentile	11.53	4.31	-62.6	Extreme impact
High Flow Season - 80th percentile	15.26	4.31	-71.8	Extreme impact
Low Flow Season - Number of years with zero flow events	2	2	0	No change
Low Flow Season - Number of zero flow events per year	0.04	0.04	0	No change
Low Flow Season - Average duration of zero flow events	11.50	11.50	0	No change
High Flow Season - Number of years with zero flow events	0	0	0	No change
High Flow Season - Number of zero flow events per year	0	0	0	No change
High Flow Season - Average duration of zero flow events	0	0	0	No change
Low Flow Season - Number of years with freshes	40	34	-15	Moderate impact
Low Flow Season - Number of freshes per year	2.43	1.33	-45.1	Extreme impact
Low Flow Season - Average duration of freshes	10.04	8	-20.4	Major impact
High Flow Season - Number of years with freshes	46	46	0	No change
High Flow Season - Number of freshes per year	3.19	2.24	-29.7	Major impact
High Flow Season - Average duration of freshes	9.74	8.25	-15.1	Moderate impact
Average recurrence interval flow of 1.5 years	7638	7447	-2.5	Little change
Average recurrence interval flow of 2.5 years	10472	10284	-1.8	Little change
Average recurrence interval flow of 5 years	15269	15078	-1.3	Little change
Median annual	100365	100111	-0.25	Little change
Mean annual	130545	120500	-7.7	Minor impact

End of Attachment B