OUT21/16478

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Dear Mr Way

Warragamba Dam Wall Raising (SSI-8441) –
Environmental Impact Statement (EIS)

I refer to your email of 28 September 2021 to the Department of Planning, Industry and Environment (DPIE) Water and the Natural Resources Access Regulator (NRAR) about the above matter.

The Warragamba Dam Wall Raising proposal includes raising the level of the central spillway crest by around 12 metres and the auxiliary spillway crest by around 14 metres above the existing full supply level for temporary storage of inflows.

The proponent will need to:

- demonstrate that they can obtain adequate entitlement to account for the project's expected water take and use; and
- provide further information regarding the impacts on surface and groundwater in accordance with the Secretary's environmental assessment requirements, including:
    - additional geomorphological impact assessment information,
    - an adaptive regime of monitoring, evaluation and reporting; and
    - additional evidence and analysis to support the proponent's position of low risk of groundwater impacts.

Please find our detailed advice, including specific recommendations (both prior to determination and post approval) in Attachment A and B, and background information regarding Surface Water impacts in Attachment C.

Any further referrals to DPIE Water and NRAR can be sent by email to water.assessments@dpie.nsw.gov.au or to the following coordinating officer within DPIE Water:

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Yours sincerely

Mitchell Isaacs
Chief Knowledge Officer
Department of Planning, Industry and Environment: Water
17 December 2021

Attachment A – Water Take/Use, Groundwater Impacts and Work Approval Modification

Detailed advice to DPIE Planning & Assessment regarding the Warragamba Dam Wall Raising (SSI-8441) – EIS

1. Water Take and Use

Recommendations – Prior to Determination

1.1 The Proponent should:

- Clarify where the water for construction (183 ML) will be sourced and confirm the strategy to obtain adequate entitlement.
- Confirm if any groundwater take is predicted, and if so provide an estimate of the water take and any licensing requirements.

Recommendations – Post approval

1.2 The proponent must ensure sufficient water entitlement is held in a water access licence/s to account for the maximum predicted take for each water source prior to take occurring.

Explanation

Water for construction

There is inconsistent information in the EIS regarding where the construction water requirements would be sourced which is either potable water supply or from the existing dam. For example:

- Chapter 5 Project Description (section 5.4.8.2) - states that water for construction will be sourced from the dam where possible and potable water will be used as required.
- Chapter 15 Flooding and Hydrology (section 15.5.6) - states water will be sourced from potable supply. It also states 183ML will be required for the duration of construction, at approximately 0.11 ML a day.

Taking water from the dam for construction would not currently be permitted as there is a condition MA2455-00020 on the special purpose access licence (SPAL) WAL 27431 (held by WaterNSW) which notes that water must be used for urban water supply purposes. NRAR notes that the Upper Nepean and Upstream Warragamba Water Source is over-allocated which means that the proponent may need to obtain water on the market, or seek an amendment to the conditions of the licence. NRAR notes that trades within the Management Zone are allowed, but not permitted into the Management Zone from another zone.

The *Access Licence Dealing Principles Order 2004* Part 3 Clause 17 (2) states that dealings under section 71T (Assignment of water allocations between access licences) of the *NSW Water Management Act 2000* are prohibited if they are a SPAL, except if it is a major utility who is allowed to trade water from a SPAL. Therefore, WaterNSW can transfer water from their WAL 27431 to another Zero Share WAL held by the construction company to account for this water take.

Groundwater take

The EIS (Appendix H1) mentions groundwater sources in the area and lists the number and amount of extraction by users in the area, but does not mention any potential use or interference from the proposed works.

The EIS (Chapter 15 - Flooding and Hydrology) states that the project will not impact on current groundwater extraction rates or current groundwater users. However, it mentions (Appendix H1) that impacts during construction may occur during or because of the following activities: '…water take (direct or passive) from surface and groundwater sources.'

2. Groundwater Impacts

Recommendations – Prior to Determination

1.1 The Proponent should provide additional evidence to support the low risk of groundwater impacts that are implied in the EIS.

Explanation

The construction of the raised wall specifically is not expected to have a significant impact on groundwater at that locality. The temporary retention of very high runoff events raising the dam supply levels by 12 m for no more than 20 days is similarly not expected to cause significant impacts on groundwater. However, the groundwater related requirements specified in the project SEARs relating to potential groundwater impacts have not been fully addressed.

The EIS implies that there is low risk of groundwater impacts. However, it does not present hydrogeological baseline data and groundwater modelling or analytical assessment to allow DPIE-Water to conduct an assessment or comment on cumulative groundwater impact, and therefore lacks sufficient detail to give confidence that the project will have no more than minimal harm to groundwater sources.

The EIS does not mention upstream groundwater impacts, and does not consider any impacts further afield due to the potential propagation of groundwater pressures due to a reservoir level increase of 12 m. Downstream, the revised operation of the flood management zone (due to the retention of very high runoff events, and the likely reduction of floodplain recharge of the alluvial aquifer downstream), has not been analysed to determine the impact on groundwater availability and reliability for water uses and the environment. The Proponent states that the Project will not impact current groundwater extraction rates or current groundwater users, but this assertion relies on referencing existing literature and has not been tested by any modelling or analysis.

DPIE-Water notes that there are nearby underground developments such as the Metro railway stations at Western Sydney Airport and Aerotropolis, which are less than 15 Km to the east.

Further, despite extensive flood modelling indicating that there is a marginal decrease in flood level downstream (and the assertion that this will only marginally impact the recharge of the downstream alluvial aquifer), no technical based groundwater recharge analysis was presented to enable an assessment of this interpretation.

3. Work Approval Modification

Recommendations – Post Approval

3.1 Modification to the work approval 10CA117212 will be required so that it reflects the amended specifications for the project.

Explanation

The work approval for Warragamba Dam will have to be modified to include changed specifications such as:

- increased wall height of the dam by 14m;
- changes to crest length;
- additional temporary storage of up to 1,000GL during high rainfall events;
- increased retention times to a maximum of 14.8 days which is 10 days higher than the current retention time; and
- changed release strategy of 100GL a day until Full Supply Level is reached and up to 230GL a day for large flood events.

End Attachment A

Attachment B – Surface Water Impacts

Detailed advice to DPIE Planning & Assessment regarding the Warragamba Dam Wall Raising (SSI-8441) – EIS

1. Surface Water Recommendations

Geomorphology Impact Assessment

Recommendations – Prior to Determination

1.1 The applicant should provide a more detailed geomorphology assessment, particularly in relation to:

i. Hydraulic Effects - of altered regulated river discharges through both weir-controlled and uncontrolled river sections of the Hawkesbury-Nepean River.

ii. Erosion risk hotspot modelling - should be reviewed to

iii. Riparian Vegetation - Clarifying the impacts on riparian vegetation both up and downstream of the dam in terms of bank stability and vegetation losses due to changes in inundation and flow regimes.

iv. Sediment Deposition - The Hydrology and Soils reports should identify in detail the sources and stores of sediment in reaches which will be directly or indirectly affected by changes in water level (SEARs 20.4d).

Where these cannot be quantified, they should be identified and mapped corresponding to River Styles reaches. With this information, risk to instream features from changing erosion/deposition with fluctuating lake level can be more readily assessed.

v. Ancillary Features - The proponent needs to better define the 'ancillary features' (SEARs 20.4a) including "Natural processes within rivers…". This is not described in the main body of the EIS except for site specific descriptions included in the Geomorphic Assessment (Appendix N2).

vi. Impact Risk - Assess the likelihood of increased bank saturation leading to cantilever bank failure along weir controlled reaches of the Nepean River

1.2 Recommendation – Post Approval

2 The proponent should prepare a management strategy to mitigate impacts to those sections of rivers impacted by the project from within the emergency storage limit of Lake Burragorang and downstream to the effective tidal zone of the Hawkesbury-Nepean River.

Explanation

Hydraulic Effects

Reach delineation (A.1.6 of Appendix N2 Geomorphology Technical Report) applies the NSW River Styles in a largely descriptive manner. The NSW River Styles database should be used as a geomorphic framework for delineating reaches, characterising sites, targeting more detailed investigation and defining the natural character and processes for each river section (SEARs 20.4a). The assessment of risk should include bank soil material vulnerability to extended inundation and subsequent slumping and changes in duration of flow-induced scour on vulnerable points along the Hawkesbury-Nepean River.

The geomorphology assessment of likelihood of bank scour and erosion indicates that some sections of the river length will have higher bank erosion risk but only considers this to limited 'hot spot' criteria against the current geomorphic condition of the Hawkesbury-Nepean River. Reach scale analysis should include vulnerable points such as exposed outside river bends, river segments denuded of vegetation or with inadequate or inappropriate vegetation cover and existing eroding sites.

The re-assessment of hydraulic effects must focus on potential bank scour and erosion within high risk sections of the storage and downstream sections of the Hawkesbury-Nepean River. This should include sections with deficient riparian vegetation and in-channel sections affected by historic and current sand and gravel extraction and sediment slugs in all reaches of prolonged inundation.

The Geomorphology Technical Assessment (Appendix N2) should clarify the extent of post approval geomorphic stability assessments for upstream river reaches and downstream of Warragamba Dam to the limit of effective scour potential. The scale of additional information should be at reach scale (~0.5-4.5km) and provide both existing and modified target river flow high scour potential sub-reach locations.

Erosion Risk Hotspot Modelling

Erosion risk hotspot modelling presented in the Geomorphology Technical Assessment (Appendix N2) does not provide sufficient resolution to identify risk relating to channel processes that may be used to design mitigation measures for flooding scour. The erosion risk hotspot modelling is set at too coarse a scale to allow an assessment of appropriate conditions for flood water release rules during operation of the temporary flood capture and release mechanism proposed. The ten field sites downstream of Warragamba Dam included in the Geomorphology Assessment (Appendix N2) are too limited to identify all relevant locations and flood scour processes to design detailed mitigation plans. Designing release flows to minimise or mitigate impacts will require a more detailed understanding of the processes by which erosion could occur post-development.

In locations where erosion is occurring or predicted to be high risk, channel cross sections and calculation of appropriate metrics (unit stream power, near bank velocity, bed mobilisation indices etc) would provide a useful framework for estimating and describing the change in flow characteristics, shear stress and probable bank failure modes and likelihood.

The review of the erosion risk hotspot modelling should consider whether the Sackville Ferry is the most suitable downstream location for assessment, as recommended in the Geomorphology Assessment Report (Appendix N2). As part of the erosion risk hotspot verification, a geomorphology walkover survey to monitor changes in channel geometry and excessive erosion should be included as part of WaterNSW Data Quality and Monitoring Improvement Program. Recommended frequency would be following construction and then on an annual routine basis. Field surveys or air photo analysis (in remote areas) to provide robust perspective of bank erosion within the catchment and target mitigation measures.

Riparian Vegetation

The ongoing reduction of native vegetation cover and protection to the banks of the Hawkesbury River between the Grose River junction to Sackville Ferry crossing is not assessed, but the assessment acknowledges heightened risk of bank failure and erosion due to extensive channel clearing, sand and gravel extraction and other disturbance. The geomorphology assessment acknowledges a complex interaction of processes in channel and bank materials may induce bank increased rates of erosion processes.

The project will remove 7.01 ha of riparian vegetation based on a 50 m riparian zone. Works on waterfront land include the clearing of vegetation from around the Warragamba River and in stream construction of Coffer Dams.

Chapter 8 (Biodiversity – Upstream) of the EIS mentions that the riparian area surrounding the current dam is composed of mainly dry sclerophyll forest, areas of wet sclerophyll forest, dry rainforest, warm temperate rainforest, grassy woodlands and forested wetlands and mentions this is not typical riparian vegetation. This is due to this vegetation normally found on ridgetops as Lake Burragorang was created after the construction of Warragamba Dam.

Chapter 28 (Cumulative Impacts and Interactions) of the EIS indicates that there will be a change in vegetation condition and composition due to the impacts of repetitive increased temporary inundation.

The effects on riparian vegetation both upstream due to the vegetation composition as ridgetop species which will now be submerged during flood events and changes in flood inundation

extents and durations downstream are not quantified. Chapter 28 of the EIS also states there will be impacts such as loss and fragmentation of habitat, and potential impacts to flood dependent threatened species and vegetation communities downstream but there is no further information.

This suggests that riparian vegetation may be significantly impacted by the increased inundation due to the proposed works, but the effects are not stated in the EIS.

Sediment Deposition

The soil material assessment (Appendix N1 Soils and Contamination) has assessed sediment deposition a low risk along the Lake Burragorang foreshore as a result of temporary storage of floodwaters (Appendix N2 Geomorphology Assessment s 5.2.3). The report notes that the majority of sediment deposition will be at inlets to the storage with little likelihood of sediment deposits along the expanded foreshore zone.

The geomorphology assessment relies on single water quality parametric information to determine sediment transport within Lake Burragorang and downstream to the tidal interaction zone. The results of the simple sediment transport calculations do not produce reliable results, as any sediment fraction larger than silt cannot be incorporated into the calculated scores. As sand fraction slugs affect extensive sections of the Hawkesbury-Nepean River downstream of Penrith weir, modelled sand slug migration should be included in the modelling to account for any loss of weir surge capacity and channel characteristics from Penrith downstream to the junction of the Macdonald River.

As noted in s 5.3.3 of the Geomorphology Assessment, containment of higher flow events in channel is likely to reduce sediment deposition to floodplains. This will certainly cause greater accumulation of mobilised sediment from upstream to be deposited in-channel, extending or exacerbating existing slug affected reaches, increasing bed aggradation and potentially reducing channel capacity.

Sediment deposition features within the emergency flood storage zone of Lake Burragorang are given a general description, along with a short description of likely sediment deposition and subsequent erosion during and following large flood events. The analysis of likely sediment influx to storage is hampered by dry local conditions and lack of follow up analysis following the end of the most recent drought in February 2020.

Ancillary Features

The proponent needs to better define the ‘ancillary features’ (SEARs 20.4a) including “Natural processes within rivers…”. This is not described in the main body of the EIS except for site specific descriptions included in the Geomorphic Assessment (Appendix N2).

Impact Risk

Downstream impacts on river bank integrity and vegetation is regarded as having high likelihood if inundation duration is prolonged (Geomorphology assessment s 5.3.1). The likelihood of increased bank saturation leading to cantilever bank failure along weir controlled reaches of the Nepean River is not assessed. Existing risk of bank toe fretting due to boat wash and tree root mass exposure has been assessed in the geomorphology assessment.

Commitment to Mitigation

It is noted that none of the recommendations from the Geomorphology Technical Assessment (Appendix N2) were included in the EIS (EIS Ch 29 – Synthesis and recommended approval) as recommended conditions of approval, or conditional action.

The commitment to implement mitigation measures is crucial to ensure that the geomorphology issues are identified and then the impact risks associated with the project are effectively managed. This commitment must identify all likely impacts as outlined in the Hydrology and Flood assessment (Appendix H1) and Geomorphology Technical Assessment (Appendix N2), and would follow further assessment of channel scour potential and closer identification of erosion risk under a range of flows, including options for stored flood releases (as recommended above).

The commitment should be specified as a condition of approval to the project, and involve relevant agencies, including agencies represented on the existing Hawkesbury-Nepean Technical Working Group (TWG).

Hydraulic Modelling

Recommendation – Post Approval

2.1 The proponent should update the hydraulic model to incorporate significant flood events to the ROBOR and TUFLOW models used to assess likely impacts in the river network.

Explanation

A flood model developed for the Hawkesbury Nepean Valley Regional Flood study was used within a catchment specific hydrology model for the project. This second model was used for a TUFLOW model to assess hydraulic characteristics and flood hydraulic hazard.

The flood mitigation protocols presented include immediate release of captured flood waters for events between 5% - 0.2% AEP and projections to indicative Maximum Probable Flood level based on the projected 0.0001% AEP flood event.

The EIS considers modelled scenarios for flood propagation along the Nepean-Hawkesbury River, with several backwater flood effects up South Creek, Eastern Creek and Cattai Creek. It is difficult to discern the likelihood of floods bypassing Warragamba Dam or floodwaters filling the Sackville Choke from the Colo and Macdonald Rivers prior to an opportunity for flood releases from Warragamba Dam under the flood inundation scenarios.

An updated hydraulic model should be developed to incorporate significant flood events (that occurred after the 1990 limit) to the ROBOR and TUFLOW models used to assess likely impacts in the river network.

This should include the February 2020 and March 2021 flood events and examine compartmentalisation between inflows to Warragamba and significant flows into the Hawkesbury-Nepean River downstream of the Warragamba/Nepean River junction, including the Grose, Colo and Macdonald Rivers.

Flood Management Framework and Plans

Recommendations – Post Approval

1.3 The detailed operational protocol should include a Flood Management Zone Drawdown Framework for releasing water from the Flood Management Zone (FMZ), which should include:

- **a.** A river management plan to identify sections along the Hawkesbury-Nepean River that require stabilisation measures.
- **b.** An annual report on the operation of the Flood Management Zone Drawdown Framework.
- **c.** A catchment erosion management plan.

Explanation

The EIS postpones consideration of floodwater management in the FMZ to a post-authorisation "detailed operational protocol" involving consultation with stakeholders (recommendation HF1 Appendix H1). This should include development of a Flood Management Zone Drawdown Framework. Flood and flow management present both the largest threat to downstream environments due to scour and erosion, and a significant opportunity (along with resilience-based rehabilitation) to minimise impacts through designed flow releases. These details are fundamental to assessing the impacts of the proposal and should be provided to enable full impact assessment (SEARs 2.2 & 3.1). Designed flow release details are specifically requested in SEARs 20.6.

Flood Management Zone Drawdown Framework

The Flood Management Zone Drawdown Framework should include guiding principles to assist in mitigating downstream impacts from FMZ. This framework should be developed in consultation with relevant NSW Government agencies and should include controlled ramping up and ramping down of FMZ release rates to minimise bank erosion issues. The Framework should include variations in dam release depending on the antecedent moisture, geomorphic condition and rotational slip failure risk of downstream river banks.

River Management Plan

The river management plan should include a monitoring and evaluation of the effectiveness of the flood water release protocols, any alteration in scour or bank failure risk and any alteration of bedform or need to enhance habitat availability in the Hawkesbury-Nepean River. The plan should include monitoring of infrastructure within the channel or below the top of bank of the Hawkesbury-Nepean River, active floodplain zones and any licensed drainage works into the river. This should particularly focus on river sections identified as having high fragility and/or high priority in the NSW River Styles database. Specific measures for such a plan should be developed in consultation with DPIE Water.

The mitigation actions should apply the detailed erosion risk assessment to design and apply erosion control works in river sections where prolonged flood drainage initiates scour and erosion. This should generally apply the revised erosion risk hot spot assessment tool and prioritisation measures consistent with the NSW River Styles classification and condition assessment project.

Annual Report

The annual report should include storage volume capacity and proportional capacity, flood release protocols when used, volumetric release rates and duration of downstream in the Flood Management Zone downstream. It should also include monitoring of riverine condition, areas of incipient or active scour and erosion and provide details of any mitigation, remediation or rehabilitation works conducted along the Warragamba and Hawkesbury-Nepean River and tributaries affected by extended backwater flooding due to flood water release from Warragamba Dam.

Catchment Erosion Management Plan

The catchment erosion management plan should be prepared in consultation with relevant NSW Government agencies in relation to erosion risk within the Flood Management Zone for inflows zones to the storage and foreshore of Lake Burragorang. The plan should include identification and arrangements for bank erosion control at impacted sites on the Coxs, Kedumba, Nattai and Wollondilly Rivers within the Drinking Water Catchment area and within deposition zones along the Flood Management Zone and storage foreshores.

Mitigation and Monitoring

Recommendations – Post Approval

1.4 The applicant should develop a specific Trigger Action Response Plan (TARP), which should:

- Address key river processes that may be affected by the partial regulation of the Hawkesbury-Nepean River.
- Address alteration of shear stress and bank saturation due to extension of high flows in the Hawkesbury-Nepean River during flood water releases from Warragamba Dam.
- Incorporate recommended actions from the Geomorphology Technical Report, including monitoring and audit of altered flows on banks and bed of the Hawkesbury-Nepean River and mitigation measures should alteration of channel hydraulics and bank saturation lead to scour or bank failure (also see Recommendation 1.5 below)
- Include performance review and reporting the effectiveness of monitoring arrangements and mitigation measures employed on river reaches affected by altered flows as a consequence of any flood storage release mechanisms.

Explanation

To address any remaining uncertainty over potential and actual impacts arising from the project, an adaptive regime of monitoring, evaluation and reporting should be undertaken. Monitoring of the geomorphic condition of the Hawkesbury-Nepean River should be a required outcome of any approved enhanced flood mitigation project and the recommendations and mitigation measures identified in Appendix L of the Geomorphology Assessment Report (Appendix N2 of the EIS) should be incorporated into any approval.

Interpretation of geomorphic processes that are important for forming and maintaining present river character and condition (geomorphic values) are not described in detail, particularly relevant for 'upstream impacts' and 'downstream impacts' sections (SEARS 20.4a). The proponent should interpret these processes and use this to identify any reaches that may be close to a threshold of change (e.g. change in River Style or condition) and where that change could be triggered by change in flow regime (project operations).

1.5 DPIE-Water recommends that all mitigation measures (MM) within the Geomorphology Technical Assessment (Appendix N2) classed under Geomorphic stability program (that is, MM48-52) and Hydrology (that is, MM56, 57, 63, 65, 66) should be adopted as minimum operational actions should the project be approved.

In particular, the following Mitigation Measures identified in the Geomorphology Technical Assessment are critical impact management actions:

- MM48 - Audit and investigation of riverbanks (e.g. materials, riparian vegetation, existing patterns of erosion and the vulnerability to future erosion caused by the project) should be carried out to determine specific capital works requirements to mitigate the projects effects. Focus of the investigation should initially be on high risk reaches, but also investigate potential localised risk sites in medium risk reaches.
- MM49 – survey bank erosion protection structures, including weirs to determine capital works or other measures required to mitigate project effects.
- MM51 - Bank erosion control at identified locations within 'High' rated reaches.
- MM52 - Bank stabilisation work in vulnerable areas in reaches ranked as at Medium risk.

These measures should be designed in consultation with the relevant NSW Government agency and should incorporate land and/or boat survey to monitor changes in channel geometry and excessive erosion as part of the WaterNSW Data Quality and Monitoring Improvement Program (as per MM5 and MM33).

Explanation

As operation of the flood mitigation mechanisms will alter channel processes to an as yet unspecified degree, the applicant should make a commitment to implement appropriate measures to implement improved river management techniques and improve river resilience and potential for geomorphic recovery.

The Geomorphology Technical Assessment states that detailed investigations should be undertaken to ascertain actual impacts caused by operation of Warragamba Dam for enhanced flood mitigation. These studies should focus on specific areas that may be susceptible to bank erosion and/or riverbed profile changes. Mitigation design cannot be undertaken without conducting detailed investigation to identify susceptibility, vulnerability, moderate to high erosion risk and consequential impacts caused by existing and modified operations of Warragamba Dam.

Appendix L of the Geomorphology Assessment Report (Appendix N2) includes sixty four detailed mitigation measures outlined for consideration as part of approval to the Warragamba Dam expansion project. A number are noted as 'out of scope' for this proposal. However, many are suitable for river management and rehabilitation. Although the mitigation measures proposed are extensive to upstream and downstream of the project site, these are relevant to achieve the objectives of the *Water Management Act 2000* and the NSW State Water Strategy 2021.

The mitigation measures for existing or future flood risks or design management options for the Nepean/Hawkesbury River should be incorporated. This includes review of sediment accumulation at maximum flood storage level, erosion risk of deposited sediment and bank toe erosion on weir controlled reaches (MM49 of Appendix N2 Geomorphology Technical Report). This includes investigations and any mitigation works to reduce and/or minimise wave displacement, bank fretting or cantilever failure for existing alluvial or deposition zones along NSW owned weirs along the Hawkesbury-Nepean River.

This project offers a good opportunity to develop a whole of river action strategy between the applicant and relevant planning, regulatory and operational agencies involved in water planning and decision making and land managers and regulatory agencies in the Hawkesbury Nepean catchment. The focus of this strategy should conform to the objectives of the NSW River Styles program and incorporate measures to identify and address current and potential erosion, degradation and abnormal sedimentation processes along the Hawkesbury-Nepean River (see Fryirs 2015, Hancock in prep). This strategy should include the Flood Management Framework and plans referred to in recommendation 1.3 and adopt the recommended minimum action measures identified above and consider the potential for mitigation measures: MM14, MM19, MM21, MM45, MM46, MM58, MM59, and MM64.

1.6 The applicant must ensure river flow gauges are maintained and report on flood sources, water level and discharges into Warragamba Dam and on tributaries that drain into the Hawkesbury-Nepean River.

Explanation

Maintaining flow gauges for flood inputs and sources into the Hawkesbury-Nepean River is essential to understand likely changes in flood transmission and backwater flooding effects from different tributaries to the river. The impact of flood transmission on channel features, sensitivity and vulnerability require on-going monitoring of flood flows to ascertain the relationship between instantaneous shear stress and duration of floods and the impact that has on channel form.

The gauging network is essential to assess compartmentalisation of flow inputs to the Hawkesbury-Nepean River and reporting on the effects of design flood water releases from Warragamba Dam into the Warragamba and Hawkesbury-Nepean Rivers.

End Attachment B

1. Surface water impacts: background information

The geomorphological assessment largely relies on desktop assessment to determine downstream impacts that are likely to occur as a result of expansion of Warragamba Dam. A limited number of field sites were used to extrapolate riverine conditions and likely risk to riverine condition for the entire river. Fluvial geomorphology is described in relatively broad terms for the Hawkesbury-Nepean River through the hydrology and flood assessment (Appendix H1, H2) and Geomorphology assessment (Appendix N2).

The geomorphology assessment includes site and sediment storage descriptions based on limited field assessment with some indicative figures on bank cohesiveness. These descriptions relate to 17 sites on or upstream of the Warragamba Dam foreshore and 10 sites along the Warragamba, Nepean and Hawkesbury Rivers downstream to Wilberforce. The erosion potential assessment relies on a low resolution, broad scale assessment of potential bank scour relying on a one dimension hydraulic model. Although this may provide some useful information, it should not be relied upon for detailed planning or assigning acceptable limits to volumetric releases from Warragamba Dam.

Sediment deposition features within the emergency flood storage zone of Lake Burragorang are given a general description, along with a short description of likely sediment deposition and subsequent erosion during and following large flood events. The analysis of likely sediment influx to storage is hampered by dry local conditions and lack of follow up analysis following the end of the most recent drought in February 2020. Further, the erosion risk description set out in Appendix N2 for the upstream to storage area does not sufficiently explain the energy regimes that currently exist and may alter under different climate change realisations.

The geomorphology assessment relies on single water quality parametric information to determine sediment transport within Lake Burragorang and downstream to the tidal interaction zone. The results of the simple sediment transport calculations do not produce reliable results, as any sediment fraction larger than silt cannot be incorporated into the calculated scores. As sand fraction slugs affect extensive sections of the Hawkesbury-Nepean River downstream of Penrith weir (Lampert 2013, Hancock in prep), modelled sand slug migration should be included in the modelling to account for any loss of weir surge capacity and channel characteristics from Penrith downstream to the junction of the Macdonald River.

The Geomorphology report does not provide adequate detail on the types or potential locations of likely scour and erosion. The fluvial geomorphology assessment should focus on finer scale potential zones and locations where specific erosion processes may become active. This includes breakout and re-entry points to the Hawkesbury floodplain, transitional inundation areas and high shear stress zones on outside bends, tributary junctions and areas with ineffective riparian vegetation cover. This should also include potential cantilever or rotational bank failure zones along weir controlled river reaches that dominate the Nepean River upstream of Penrith.

The Geomorphology report (s 5.3.1) states that ‘Existing (without project) patterns of susceptibility to erosion in the Hawkesbury-Nepean River are likely to continue into the future, with some potential changes in erosion rates…the rate of bank erosion is likely to increase for the ‘With Project’ scenario in the Penrith and Windsor-Sackville (upstream Sackville Ferry) areas of the Hawkesbury-Nepean River. At Penrith, this is probably by virtue of a much more sustained period of flow associated with the FMZ discharge, exerting a greater degree of force onto the banks…

Land clearing and/or extraction of sand and gravel from the riverbed has been extensive in the Penrith and Windsor-Sackville (upstream Sackville Ferry) areas. These sections of the river bank typically have little or no riparian vegetation and often have steep slopes. The 1 in 20 year flows have a combination of high stream power and intermediate duration, resulting in higher bank erosion.’

DPIE – Water concurs with this descriptive assessment. However, modelling of inundation and erosion should serve to support interpretation of causes of adjustment within the channel and scour

potential along the river banks. Without this analysis, effective mitigation recommendations cannot be made.

The Geomorphology report in s 5.3.2 notes the movement of existing large sand slugs in the Hawkesbury-Nepean River below Penrith weir is likely under both 'Existing' and 'With Project' scenarios. This is likely to force greater accumulation of sand size material into the reaches between the Grose River junction at Yarramundi downstream to Sackville. As noted elsewhere, large volumes of sand are being transported from the Macdonald and Colo Rivers into the tidal reaches of the Hawkesbury River (Lampert 2013, Rustomji 2019, Hancock 2021).

As noted in s 5.3.3, containment of higher flow events in channel is likely to reduce sediment deposition to floodplains. This will certainly cause greater accumulation of mobilised sediment from upstream to be deposited in-channel, extending or exacerbating existing slug affected reaches, increasing bed aggradation and potentially reducing channel capacity.

As uncertainty remains over potential and actual impacts arising from the project, an adaptive regime of monitoring, evaluation and reporting should be undertaken. Monitoring of the geomorphic condition of the Hawkesbury-Nepean River should be a required outcome of any approved enhanced flood mitigation project and the recommendations and mitigation measures identified in Appendix L of the Geomorphology Assessment Report (Appendix N2 of the EIS) should be incorporated into any approval.

References

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End Attachment C