SUBMISSION TO SNOWY 2.0 PROJECT

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Preamble

This document is in response to the call for submissions on the Snowy 2.0 Main Works Environmental Impact Statement (EIS) as submitted to the NSW Department of Planning, Industry and Environment. This submission explicitly does not address concerns on the construction phases of the project. Rather it speaks to our collective scientific opinion that insufficient attention is paid to the operational risks of the proposed scheme.

Setting of the project

The project as proposed would involve underground excavation and tunnelling works between Lake Tantangara and Lake Talbingo, allowing pumping of water to Tantangara at times of lower energy costs/needs and generation from returning water to Talbingo via turbines.

Once operational, the project would provide a connection between the two lakes via the tailrace, potentially allowing pathogens and biota to move between the two catchments. These two water bodies currently differ substantively in their native biodiversity and the presence of invasive species and pathogens.

The operation of the system will result in changes in the timing and amount of water in the two lakes, potential rapid drawdown or increase in lake levels, and changes in the way in which the outlet rivers are managed.

	Lake Tantangara	**Lake Talbingo**
Catchment	Murrumbidgee	Tumut
Important native fish species present		
Macquarie perch (*Macquaria australasica*)[1]	Present	Absent
Stocky galaxias (*Galaxias tantangara*)[2]	Present	Absent
Potential new galaxias spp.[3]	Present	Absent
Potential invasive species		
Redfin Perch (*Perca fluviatilis*)[4]	Absent	Present
Climbing galaxias (*Galaxias brevipinnis*)[5]	Absent	Present
Potential pathogens		
Epizootic Haematopoietic Necrosis Virus (EHNV)[6]	Absent	Present

1. Native, listed as endangered under NSW and Commonwealth legislation. IUCN Red listed.
2. Native, critically endangered and limited to 4km of Tantangara Creek.
3. Native, potential new species identified in the upper- and mid-Murrumbidgee (Raadik, 2018)
4. Invasive, Class 1 noxious fish in NSW
5. Invasive in the Murray Darling Basin, native to Snowy River system
6. Native. Highly contagious and lethal to Macquarie perch, carried by Redfin perch.

Summary of risks

Risk	Risk id	Outcome	Consequences
1. Invasion of Tantangara by redfin perch	1.1	Predation on native fish species in Murrumbidgee catchment	Potential extinctions of endemic galaxias. Potential local extinction of Macquarie perch
	1.2	Competition with native fish species	Potential extinctions of endemic galaxias. Potential local extinction of Macquarie perch
	1.3	Introduction and maintenance of EHNV	Potential local extinction of Macquarie perch
2. Invasion of Tantangara by climbing galaxias	2.1	Predation on native fish species in Murrumbidgee catchment	Potential extinctions of endemic galaxias.
	2.2	Competition with native fish species	Potential extinctions of endemic galaxias.
3. Altered flow regimes in rivers	3.1	Disruption of native fish population's resources	Potential local extinction of Macquarie perch
	3.2	Disruption of native fish population's breeding cues	Potential local extinction of Macquarie perch
	3.3	Altered algal species composition and productivity	Risk of nuisance algal blooms Risk of invasive algal species
	3.4	Impacts on geomorphology of rivers	Unknown impacts on fish breeding habitat
4. Interception of tributary flows	4.1	Potential for reduced flows in Tantangara Creek or increased frequency of drying	Potential extinctions of endemic galaxias. Potential changes in food supply for endemic galaxias.

These risks are described and assessed in more detail in the following sections. For each of the identified risks we have as a group determined the residual risk after the proposed mitigation. These risks are identified as unknown/low/moderate or high.

We have additional concern about a lack of detail in many areas of the EIS, and this has been exacerbated by difficulties and delays in obtaining copies of the scientific reports prepared for the Aquatic Ecology Assessment (Appendix M.2). The information contained in these reports is critical for the evaluation of the proposal, and as outlined in the sections below is needed for an assessment of risk.

Finally, some key documents do not appear to have been generated. A "Weed, Pest and Pathogen Management Plan" is proposed (Table 6.11, EIS Main Report Part 2), but no detail is provided. Given the high risk associated with transfer of species, there needs to be detailed information on barriers, monitoring, maintenance and responses to incursions in order to make an informed assessment of risk.

SECTION 1: RISKS ARISING FROM INVASION OF TANTANGARA BY REDFIN PERCH

Risk	Risk id	Outcome	Consequences
1. Invasion of Tantangara by redfin perch	1.1	Predation on native fish species in Murrumbidgee catchment	Potential extinctions of endemic galaxias. Potential local extinction of Macquarie perch
	1.2	Competition with native fish species	Potential extinctions of endemic galaxias. Potential local extinction of Macquarie perch
	1.3	Introduction and maintenance of EHNV	Potential local extinction of Macquarie perch
Proposed mitigation		Barrier against pest fish passage – Tantangara Creek Barriers on outlet to Tantangara	
Residual risk		High. Very high risk of redfin perch introduction over time.	
Suggested mitigation		1.A Additional study of the potential mid Murrumbidgee galaxias distribution and threats 1.B Additional study of the potential additional upper Murrumbidgee galaxias distribution and threats 1.C Further assessment of an inlet screen for pest fish at Talbingo.	

Background. Environmental investigations for the project and previous study have identified native endemic galaxiids at multiple sites on the Murrumbidgee River and Tantangara Creek. It has been proposed that these represent two species (Raadik 2018), the stocky galaxiid, known from a small 4km reach on Tantangara Creek, a potential additional undescribed species from the upper Murrumbidgee and an undescribed species from the mid Murrumbidgee (Section 5.2.5 Watercourses, Annexure B, Appendix M.2 Aquatic Ecology Assessment and The impact assessment assumes "…that there are two undescribed and potentially narrow-range species; one in the Upper Murrumbidgee River and one in the Mid Murrumbidgee River".

Macquarie perch are present in the Murrumbidgee River system and form a breeding population in Tantangara. This species is in significant decline in across its former range and is considered threatened in NSW and under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Macquarie perch are highly susceptible (100% mortality in 4 days) to the native EHNV virus.

Risk. Redfin perch are excellent competitors for resources and as adults are piscivorous (fish feeding). The species has been associated with population declines of numerous small-bodied fish globally and in Australia (e.g. Fletcher et al. 1986; Moore et al. 2007). An incursion of redfin perch would be likely to result in the extirpation of the small-bodied galaxiid species in the catchment.

Redfin perch are competitors with Macquarie perch for food and predate on Macquarie perch larvae. Redfin are also a reservoir for EHNV virus, maintaining the virus in the ecosystem and passing it to other, more susceptible species like Macquarie perch. An incursion of redfin perch would be likely to result in the local extinction of Macquarie perch.

Mitigation. Table 7-3 in Appendix M.2 outlines the control risks from fish transfer between reservoirs, including the creation of a pest fish barrier on Tantangara Creek upstream of the Alpine Creek Firetrail. This barrier is poorly described and is inadequate to protect the potential undescribed galaxiid species, or potential habitat for stocky galaxiid reintroductions. While there is further discussion of mitigating risks to the stocky galaxiid, there is inadequate information provided on the other putative species, which are grouped with stocky galaxiids as 'Mountain galaxias' in Table 6-2 of Annexure B and are not included in Table 7-4 in Appendix M.2.

It is our informed opinion that inlet screens are the most likely technique to prevent invasion of pest fish into Tantangara. A number of screens were apparently considered for the project including flat-panel wedge-wire screens, drum screens and submerged water intake, fish-friendly screens (Section 7.2.3.2 Preventing Fish Movements, Appendix M.2) (THA,2019). Given the THA (2019) report is not publicly available, it is not clear the basis for inlet screens not being incorporated into the final design, other than considerations of cost. Given the high risk of fish invasion, potential for ecological harm and high ongoing costs to control invasive species if they were to establish in Tantangara, there is a need for a well-articulated and transparent cost-benefit analysis of inlet screens.

SECTION 2: RISKS ARISING FROM INVASION OF TANTANGARA BY CLIMBING GALAXIAS

Risk	Risk id	Outcome	Consequences
2. Invasion of Tantangara by climbing galaxias	2.1	Predation on native fish species in Murrumbidgee catchment	Potential extinctions of endemic galaxias.
	2.2	Competition with native fish species	Potential extinctions of endemic galaxias.
Proposed mitigation		Barrier against pest fish passage – Tantangara Creek Barriers on outlet to Tantangara	
Residual risk		High. Very high risk of climbing galaxias introduction over time.	
Suggested mitigation		1.A Additional study of the potential mid Murrumbidgee galaxias distribution and threats 1.B Additional study of the potential additional upper Murrumbidgee galaxias distribution and threats 1.C Further assessment of an inlet screen for pest fish at Talbingo. 2.A Detailed further assessment of feasibility of a fish barrier on Tantangara Creek.	

Background. As outlined in Section 1, and in Section 5.2.5 Watercourses, Annexure B, Appendix M.2 of the Aquatic Ecology Assessment, it is considered that there are undescribed and potentially narrow-range species in the Upper Murrumbidgee and in the Mid Murrumbidgee in addition to the stocky galaxias in Tantangara Creek.

Risk. Climbing galaxias are native to Australia but did not naturally occur in the Murray River before they invaded from the Snowy River via the Snowy Power Scheme. The species has been implicated in the decline of small-bodied galaxiid fishes through competition for food and predation on juveniles (e.g. McDowall and Allibone 1994; Waters et al. 2002). Climbing galaxias, as the name suggests, are exceptional climbers and can move upstream against very powerful flows, across wet vegetation and up vertical concrete surfaces (e.g. Waters et al. 2002; Green 2008). An incursion of climbing galaxias would likely result in the extirpation of small-bodied galaxiid species in the catchment.

Mitigation. Table 7-3 in Appendix M.2 outlines the control risks from fish transfer between reservoirs, including the creation of a pest fish barrier on Tantangara Creek upstream of the Alpine Creek Firetrail. This barrier is poorly described but the location is indicated as being "located in a zone in which very few individuals due to the extensive areas of bedrock and fast flows (Raadik 2019)" - Section 6.4.2 Impacts on Aquatic Habitats and Biota, Appendix M.2. Such an area would not provide any natural barrier to climbing galaxias passage and we are unaware of any successful artificial barrier design. Climbing galaxias have been observed to move over a 20m shear concrete dam wall (Thompson, pers. obs. and McDowall and Allibone 1994). There is also no indication of ongoing monitoring of the effectiveness of the barrier, although it is stated that there is "A very small residual likelihood … associated with the requirement for ongoing successful operation and maintenance of these barriers..." (Section 7.2.3.6 Mitigation Measures and Residual Risks, Appendix M.2). It is our informed opinion that there is no barrier design which is likely to be adequate to prevent movement of climbing galaxias into Tantangara Creek.

The proposed barrier on Tantangara Creek, even if it were to be effective would be inadequate to protect the potential undescribed galaxiid species and would limit stocky galaxiids only to their current very small range. As such it would make impossible any future translocations within this catchment to protect the stock galaxias from localised events which may result in its extinction (e.g. loss of flows due to drought or interception, see Section 4). While there is further discussion of mitigating risks to the stocky galaxiid, there is inadequate information provided on the other putative species, which are grouped with stocky galaxiids as 'Mountain galaxias' in Table 6-2 of Annexure B and are not included in Table 7-4 in Appendix M.2.

As detailed in Section 1, it is our informed opinion that inlet screens are the most likely technique to prevent invasion of pest fish into Tantangara. Given the high risk of fish invasion, potential for ecological harm and high ongoing costs to control invasive species if they were to establish in Tantangara, there is a need for a well-articulated and transparent cost-benefit analysis of inlet screens. With respect to a barrier on Tantangara Creek, if this proceeds, we propose two barriers, one in the lower reaches and a second at the site proposed. This would provide a buffer zone in the event of barrier failure and potential habitat for establishing populations of the stocky galaxiid.

SECTION 3: RISKS ARISING FROM ALTERED FLOW REGIMES IN RIVERS

Risk	Risk id	Outcome	Consequences
3. Altered flow regimes in rivers	3.1	Disruption of native fish population's resources	Potential local extinction of Macquarie perch
	3.2	Disruption of native fish population's breeding cues	Potential local extinction of Macquarie perch
	3.3	Altered algal species composition and productivity	Risk of nuisance algal blooms Risk of invasive algal species
	3.4	Impacts on geomorphology of rivers	Unknown impacts on fish breeding habitat
Proposed mitigation		None indicated	
Residual risk		Unknown	
Suggested mitigation		1.A Additional study of the potential mid Murrumbidgee galaxias distribution and threats 1.B Additional study of the potential additional upper Murrumbidgee galaxias distribution and threats 3.A Development of operating flow guidelines for affected rivers	

Background. Environmental flow allocations are in place for the Murrumbidgee River and Tumut Rivers, in addition to rules around spilling of the impoundments. These flows are in place to protect downstream ecosystem values including native fish feeding and breeding habitat. As outlined in Section 1, the Murrumbidgee catchment contains populations of Macquarie Perch and potentially an undescribed species of small-bodied galaxiid.

Risk. There are unknown effects of the operation of Snowy 2.0 on the flow regimes of the rivers and the frequency of spilling of the impoundments. Hydrological drivers are critical to maintaining patterns of geomorphology (bed form, channel form and sediment characteristics) which underpin the provision of fish feeding and breeding habitat. In addition, timing and magnitude of flows are important cues for fish breeding. Altered flow regimes, particularly in rivers affected by hydro-electric development, have been implicated in the establishment of nuisance algal species including *Didymosphenia geminate* which has invaded similar habitats in NZ with significant ecological and economic cost (Kilroy and Unwin, 2011).

Mitigation. There is no information provided in the EIS on what operating flow rules may be applied when the project is operational, or the impacts they may have on environmental flows.

It is our informed opinion that there is a need for a detailed assessment and consultation on operating flow rules for the project which include likely impacts and which address relationships to current environmental flow allocations.

SECTION 4: RISKS ARISING FROM FLOW INTERCEPTION OF GROUNDWATER TO TANTANGARA CREEK

Risk	**Risk id**	**Outcome**	**Consequences**
4. Interception of tributary flows	4.1	Potential for reduced flows in Tantangara Creek or increased frequency of drying	Potential extinctions of endemic galaxias. Potential changes in food supply for endemic galaxias.
Proposed mitigation		None proposed	
Residual risk		Unknown but potentially high	
Suggested mitigation		1.B Additional study of the potential additional upper Murrumbidgee galaxias distribution and threats 2.A Detailed further assessment of feasibility of a fish barrier on Tantangara Creek. 4.A Detailed assessment of groundwater dependency of stocky galaxias habitat	

Background. As outlined in Section 1, and in Section 5.2.5 Watercourses, Annexure B, Appendix M.2 of the Aquatic Ecology Assessment the stocky galaxias occupies a short section of Tantangara Creek, living in shallow water habitat which is at risk of drying.

Risk. Appendix J.1 models groundwater impacts of project construction on headwater streams, and predicts loss of a significant portion of baseflow and increases in numbers of no-flow days. Annexure B, Appendix J.4 suggests that there is uncertainty around the actual impacts as " … fracture flow is not uniform and local scale and overall tunnel groundwater inflow will only be known once the project commences…" The risk is identified that "Should the hydraulic conductivity of the rock be higher than modelled (ie there are more fractures encountered than anticipated), then impacts to creeks at the surface may be larger than estimated." (Modelling Report, Annexure B, Appendix J.4)

It is not clear that groundwater flows to upper Tantangara Creek will be maintained. This would be expected to have profound impacts on stocky galaxias habitat, with the potential to cause extinction. There is inadequate information provided to assess risk to the other putative galaxiid species, which are grouped with stocky galaxiids as 'Mountain galaxias' in Table 6-2 of Annexure B and are not included in Table 7-4 in Appendix M.2.

Mitigation. There is no mitigation proposed in the EIS for this risk.

The proposed barrier on Tantangara Creek would limit stocky galaxiids to their current very small range without the potential for translocations to other suitable catchments. With respect to a barrier on Tantangara Creek, if this proceeds we propose two barriers, one in the lower reaches and a second at the site proposed. This would provide a buffer zone in the event of barrier failure and potential habitat for establishing populations of the stocky galaxiid. Stocky galaxias requires additional populations to be established to increase resilience of the species to localised population decline - and the headwater streams in the Tantangara catchment are prime candidates for establishing additional populations.

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