

Advice to decision maker on coal seam gas project

IESC 2022-133: Fairview Water Release Scheme (EPBC 2021/8914) – Expansion

Requesting agency	The Australian Government Department of Agriculture, Water and the Environment [now - the Australian Government Department of Climate Change, Energy, the Environment and Water]
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The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. The advice is designed to ensure that decisions by regulators on coal seam gas or large coal mining developments are informed by the best available science.

The IESC was requested by the Australian Government Department of Agriculture, Water and the Environment (now the Australian Government Department of Climate Change, Energy, the Environment and Water) to provide advice on Santos Limited's Fairview Water Release Scheme in Queensland. This document provides the IESC's advice in response to the requesting agency's questions. These questions are directed at matters specific to the project to be considered during the requesting agency's assessment process. This advice draws upon the available assessment documentation, data and methodologies, together with the expert deliberations of the IESC, and is assessed against the IESC Information Guidelines (IESC, 2018).

Summary

The Fairview Water Release Scheme (the 'project') is in the Dawson River sub-catchment of the Fitzroy River, central Queensland, approximately 50 km east of Injune. It is co-located with Santos' coal seam gas (CSG) fields of Arcadia, Fairview, Scotia and Roma.

The project is a proposed expansion of the existing Dawson River Release Scheme (DRRS) for the management of produced CSG water. The DRRS currently releases reverse osmosis-treated produced

CSG water from the Gladstone Liquefied Natural Gas (GLNG) Project (EPBC 2008/4059). The proponent seeks approval to commence the release of reverse osmosis-treated produced water (up to 18 ML/day) derived from the Gas Field Development (GFD) Project (EPBC 2012/6615) using the DRRS water management system (treated releases). In addition, the proponent is seeking approval for the release of untreated produced water at times of higher (>100 ML/day) flow in the Dawson River (event-based untreated releases).

Much of the reach of the Dawson River where these releases are proposed is a near-permanent section fed by groundwater discharge, some of which comes from multiple vents of the Yebna 2/311 spring complex, part of a Threatened Ecological Community (TEC) listed by the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act). This river reach also provides important habitat for two species of EPBC Act-listed turtles as well as other aquatic plants and animals. The reach's riparian vegetation supports many terrestrial species, some of which are also EPBC Act-listed. Groundwater fauna (stygo fauna and hyporheos) are very likely in the saturated alluvial sediments of the river bed and banks but have not been sampled.

Releases of both treated and untreated produced CSG water from the GFD project are currently permitted under the Queensland Environmental Authority (EA) EPPG00928713. However, they are not currently permitted under the EPBC Act approval for the GFD project (EPBC 2012/6615). The Commonwealth conditions of approval for the GFD project specifically require that any release of produced CSG water (whether treated or not) be referred to the Minister for approval (see Condition 2A of the conditions of approval for EPBC 2012/6615).

Key potential impacts from this project are:

- Changes to water quality and flow regimes from the release of produced CSG water. Impacts could arise from both untreated produced water (up to approximately 52 event-based releases a year) and from regular releases of up to 18 ML/day of treated produced water.
 - Untreated water releases could contain contaminant concentrations sometimes substantially above the background water quality and water quality objectives (WQOs).
 - Approximately 12 km of the Dawson River, currently unimpacted by produced water releases, will be subjected to the release of untreated produced CSG water which may have major impacts on instream and riparian zone biota and ecological processes.
 - Water resources, including aquatic, terrestrial and subterranean groundwater-dependent ecosystems (GDEs) present at and downstream of the project site, may be impacted. This could include loss of habitat; exposure to chemical contaminants; changes to food resources; changes to water regimes; changes to nutrient cycling; and changes to erosion and sedimentation processes.
 - The EPBC Act-listed White-throated snapping turtle (critically endangered) and the Fitzroy River turtle (vulnerable) may be impacted, especially via direct and indirect exposure to contaminants.

The IESC considers that untreated produced CSG water should not be released into any surface waters, even during high flows, because of the risks of short- and long-term impacts of mixtures of chemical contaminants on downstream aquatic, riparian and shallow subterranean ecosystems. Downstream legacy impacts of some of these contaminants are unlikely to be resolved merely by dilution, especially as the releases of untreated water are projected to potentially continue until 2066.

The IESC has identified key areas in which additional work is required to address the key potential impacts, as detailed in this advice. These are summarised below.

- Direct toxicity assessment (DTA) of the untreated produced CSG water is needed to enable determination of 'safe' dilutions for proposed event-based releases (see Golding et al. 2022 for a method applied to produced water from shale gas extraction). The untreated produced CSG water toxicity arises not only from the individual contaminants but also from known and unknown constituents acting in combination, thus a whole-of-effluent toxicity approach is needed. This testing must also account for the likely greater toxicity in the initial flowback water given new CSG wells will be continuously added for several years.
- If release of untreated water is permitted, improved monitoring of water quality, including a DTA-based approach for event-based releases, is required.
- Further, this improved monitoring of water quality should occur during and until recession flows have returned to pre-event conditions.
- Mapping and impact assessment, together with collection of field data at a local scale (i.e., along the Dawson River and its riparian zone within and downstream of the project area) for aquatic, terrestrial and subterranean GDEs (e.g., stygofauna and hyporheos) is required, especially in alluvial sediments of the 12-km reach downstream of the proposed release point for untreated produced CSG water. Particular attention should also be paid to sampling the downstream section of the Dawson River where river water infiltrates into the banks and riverbed, providing potential flow paths into shallow alluvial aquifers. These data are needed to document the post-2015 baseline condition, to enable detection of potential impacts during operation, and to assess the effectiveness of proposed management and mitigation measures.
- A trigger action response plan (TARP) that implements timely action to prevent further impact when a WQO is exceeded should be developed.
- Further work is needed to understand potential accumulation of contaminants in bed and bank sediments, especially in the long term as a decadal legacy effect of untreated releases, and to determine whether this poses an impact pathway for EPBC Act-listed turtles, other aquatic biota and riparian vegetation.

Context

The Fairview Water Release Scheme (the 'project') is in the Dawson River sub-catchment of the Fitzroy River in central Queensland. The project is in an area of CSG production with other land uses including state forests, reserves, grazing and irrigated cropping.

The project area encompasses a reach of the Dawson River where flow is near-permanent due to groundwater discharge from the Precipice Sandstone. These conditions make the reach, which may be impacted by the proposed event-based releases (untreated produced water), important habitat and refugia for the two EPBC Act-listed turtles, the White-throated snapping turtle (*Elseya albagula*, listed as critically endangered), and the Fitzroy River turtle (*Rheodytes leukops*, listed as vulnerable), and other aquatic biota. Approximately 20 km of the Dawson River within the project area is considered to meet the description of critical habitat for the White-throated snapping turtle (AECOM 2022, p. 152). Both turtles are cloacal-respirers which may increase their likelihood of absorbing dissolved contaminants (AECOM 2022, p. 163).

The potentially impacted reach of the Dawson River also includes multiple watercourse springs (including at least five vents of the EPBC Act-listed TEC of the Yebna 2/311 spring complex) and appears to border a High Ecological Value area (HEVa2143) which has important implications for protection of its environmental values (noting that the proponent proposes to use 'slightly to moderately disturbed' WQOs whereas a HEV would require 99% aquatic ecosystem protection values). This section of the Dawson

River and associated saturated sediments are groundwater-dependent ecosystems (GDEs), including shallow aquifers associated with the saturated sediments of the river bed and banks (hyporheic and parafluvial zones). Subterranean fauna are predicted in these sediments (Boobook Ecological Consulting 2022a, p. 5) but have not been sampled. Some of the riparian and floodplain vegetation, including the TEC *Eucalyptus populnea* Woodland on Alluvial Plains, are also known to be GDEs (AECOM 2022, p. 129).

The releases of treated CSG water that have occurred as part of the DRRS have been to a headwater gully of a tributary of the Dawson River. These releases have resulted in an increase of approximately 1 m in the water level of the Waterhole (AECOM 2022, p. 77), an ox-bow lake between the treated water release point and the Dawson River and changed the Waterhole's water regime from intermittent to permanent.

The IESC notes that the geographic extent of the GLNG and GFD projects overlap, and it appears that these projects are differentiated based on timing only. That is, the first 2,650 CSG wells in the area are considered part of the GLNG project while subsequent wells (approximately an additional 6,100) will be part of the GFD project. The produced water from these projects will be mixed within the water-gathering and management systems and it will not be possible to differentiate between the different sources for the purposes of complying with approval conditions. Given the timing-based differentiation, as the project continues, the proportion of produced water derived from the GFD project will increase and eventually all produced water will likely be derived from the GFD project.

Response to questions

The IESC's advice in response to the requesting agency's specific questions is provided below.

Question 1: Noting the relevant water quality objectives, water management information and requirements associated with the Environmental Authority, can the Committee provide comment on likely scale and extent of potential downstream impacts to the waterhole and Dawson River water resources resulting from the proposed water releases?

1. The project includes two different proposed releases: the event-based release of untreated produced water directly to the Dawson River, and the release of reverse osmosis (RO)-treated produced water to the Dawson River via the Waterhole. The two planned releases will differ in the scale and extent of their potential impacts on the Waterhole and other Dawson River water resources.
 - a. The event-based releases of untreated produced water are likely to impact an approximately 12-km reach of the Dawson River that is not currently subject to any produced water releases. This reach is between the event-based release point and the monitoring location DRR1 (AECOM 2022, Figure 5.1, p. 70). Impacts are also likely downstream beyond DRR1, including areas where surface water enters bed and bank sediments (e.g., where the Dawson River changes from gaining to losing, see Paragraph 30).
 - b. The treated water releases will potentially impact the tributary, Waterhole and Dawson River downstream. The potentially impacted area extends from the desalinated water release point (blue dot in Figure 5.1, AECOM 2022, p. 70) to the confluence with the Dawson River just upstream of DRMP1 (AECOM 2022, Figure 5.1, p. 70) and downstream.

Event-based releases of untreated produced water

2. The IESC considers that untreated produced CSG water should not be released into any surface waters, even during high flows, because of the risks of short- and long-term impacts of mixtures of chemical contaminants on downstream aquatic, riparian and shallow subterranean ecosystems.

Legacy impacts of some of these contaminants are unlikely to be resolved merely by dilution, especially as the releases of untreated water are projected to potentially continue until 2066.

3. For 12 km downstream of the proposed release point, the Dawson River has not been previously subject to releases of produced water. This reach provides aquatic, riparian and subterranean habitats for a range of biota including EPBC Act-listed turtles (see response to Question 2). It also includes GDEs such as groundwater-dependent riparian vegetation and watercourse springs, some of which are listed as a TEC ('The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' – GAB spring) (see response to Question 3).
4. The release of untreated produced water to this reach could result in a range of impacts on biota including impaired survival, growth, recruitment and reproduction. Impacts could arise through:
 - a. contact with contaminants, either directly via contact with contaminated water and/or sediments or indirectly (e.g., consuming contaminated plants or prey);
 - b. changes to habitat availability from altered flow regimes, altered and variable water levels and channel erosion and sedimentation; and/or
 - c. altered rates of ecosystem processes (e.g., instream nutrient cycling) mediated by microbial assemblages that have been impacted by contaminants.
5. An assessment of the scale and extent of the impacts requires further local-scale studies, using appropriate field data to provide baseline information on the current conditions (e.g., sediment and water quality, habitat types, aquatic and riparian biota, predominant ecological processes and their rates) including ecohydrological conceptual modelling to examine potential impact pathways and their materiality. These are discussed in more detail in Paragraphs 8, 15, 18b, 20-21, 23-28 and 30.
6. The proponent is relying on dilution of the untreated produced water to minimise impacts. However, without appropriate DTA, it is not possible to know whether the proposed dilution will be sufficient to prevent impacts associated with direct contact with the contaminant mixtures present in the untreated water releases. Previous studies have shown that for CSG produced water, dilutions of approximately 260:1 (Hydrobiology, 2018) can be needed whereas for shale gas produced water, 'safe' dilutions may be as high as 1140:1 (Golding et al., 2022). 'Safe' dilutions vary greatly depending on pre-release dilutions and local and operational conditions and should be determined for each produced water source (e.g., target formation, initial flowback and produced water).
7. If untreated releases are permitted, potential impacts should be monitored regularly. Monitoring should include:
 - a. a DTA-based approach to monitoring before and during releases such as described in Golding et al., (2022) to ensure 'safe' dilutions are being achieved;
 - b. continuous monitoring of electrical conductivity during untreated water releases within both the produced water management system and the Dawson River (upstream and downstream of the release locations) as an early warning of potential water quality issues; and
 - c. daily monitoring at the downstream extent of the mixing zone permitted under the Queensland EA, for metals and nutrients during releases, to confirm WQOs are being met. (As it is plausible that WQOs may be exceeded beyond the mixing zone, monitoring should include a site approximately 1 km downstream from the release point as part of a longitudinal series of sampling sites to detect any potential contamination gradient).
8. The IESC notes that insufficient information has been provided to characterise the current baseline condition of the reach of the Dawson River that may be impacted by the release of untreated water if

releases are permitted. Further information is needed on baseline water and sediment quality, flow regime, geomorphological and ecological conditions at additional sites within the reach. Baseline condition measurements for the 12-km reach downstream of the proposed release point must reflect current conditions, that is, conditions prior to exposure to any produced water releases given that this reach has not been previously subject to produced water releases. This information is needed to document existing conditions, allow detection of impacts through comparison with future monitoring data and guide development of a TARP to manage potential impacts.

9. The mixing zone modelling results for event-based releases show that water quality objectives cannot be achieved within the mixing zone as defined by the Queensland Government. Mixing is required to be complete within three stream widths from the release point or 300 m, whichever is smaller (AECOM 2016, p. 56). This would require WQOs to be met within 70 m of the event-based release point under high flows and 50 m for medium flows (AECOM 2016, pp. 56-57). Results of the modelling are summarised in Tables 25-27 and Figures 21-32 (AECOM 2016, pp. 58-72) and show that some WQOs may not be achieved until almost 1 km downstream. Alternative release scenarios, such as blending with produced water from wells that have not been hydraulically stimulated, although briefly discussed, require further consideration to ensure WQOs are met within the required distance downstream so that Matters of National Environmental Significance (MNES) are adequately protected.

Treated releases

10. The treated water releases have been occurring at a maximum rate of 13.5 ML/day since July 2015 (AECOM 2022, p. 77). The releases have raised the depth of water in the Waterhole (AECOM 2022, Figure 5.3, p. 77) so it is now permanently inundated to a depth of approximately 1 m. The Waterhole is likely to remain permanently inundated while regular releases from the project occur. Should releases under the project be 18 ML/day, water depth may remain higher for longer and spilling to the Dawson River could increase in frequency.
11. The IESC considers that increasing depth could favour further establishment and potential dominance of non-native invasive species using the Waterhole as a dry-season refuge. For example, increased spilling may allow invasive fish species such as goldfish (*Carassius auratus*) and mosquitofish (*Gambusia holbrooki*) that are already in the Waterhole to disperse repeatedly into the Dawson River. The proponent should assess the risk of the predicted changes to the Waterhole's water regime in facilitating the spread of invasive species in the Dawson River and propose suitable mitigation or remediation strategies if undesired changes occur.
12. Increased release rates could also affect erosion and bank stability upstream of the Waterhole and where the tributary enters the Waterhole. Although the proponent considers that the current armouring upstream of the Waterhole is sufficient to prevent this, monitoring data have not been provided to demonstrate that this is the case under current flow conditions. Thus, it is unclear whether the current armouring is sufficient or will be at releases of up to 18 ML/day.
13. Impacts to water quality of the Dawson River are also possible from treated water releases, with the greatest potential for impacts occurring when low river flows coincide with peak treated water releases (frc environmental 2021, pp. 15-16). The scale and extent of potential impacts are unclear with further information needed on:
 - a. the type of RO treatment used;
 - b. the chemical composition of the permeate and how it varies, including its ionic strength and how this is managed. Ionic matching of the treated release water to the receiving environment may be needed; and
 - c. the variability of background water quality at times of no releases.

14. The provided water quality summaries, show existing exceedances of WQOs for several analytes including suspended solids, aluminium, ammonia, boron, copper, nitrogen and zinc. The proponent has not discussed what the potential impacts of further increasing the concentrations and loads of these analytes may be, nor have they proposed management actions specifically to reduce the concentrations other than dilution which is not effective when WQOs are already exceeded.
15. Changes to stream levels in the Dawson River when treated water is released are stated to be small (approximately 0.30 m at Yebna Crossing, AECOM 2022, p. 73). Changes to daily release rates at the project site are less clear as this has been discussed for Utopia Downs some 60 km downstream (AECOM 2022, p. 82). Rapid and frequent rises and falls in water levels can impact streamside vegetation and bank stability, damage stream edge habitats, and affect stream edge groundwater seeps. To allow an assessment of the scale and extent of potential impacts of rapid fluctuations in water level and flow, further local-scale mapping of receiving waters (the Waterhole and the Dawson River) should be provided to identify habitats and biota that could be impacted by these changes so that the proponent can modify release strategies accordingly.

Chemicals

16. Released produced waters, both treated and untreated, will contain chemicals used in CSG operations (including chemicals used in hydraulic fracturing, drilling, water treatment) as well as geogenics that may adversely impact EPBC Act-listed turtles and other biota. The proponent has provided a Chemical Risk Assessment Framework (CRAF) assessing 34 chemicals that may be found in the produced water being managed by this project (Santos, 2022). The IESC notes several issues with the assessment as outlined below.
 - a. Drilling chemicals, potentially present in the produced water (e.g., barium), have not been identified or assessed in the chemicals risk assessment (CRA). Thus, the likely concentrations of these chemicals in the releases and their potential impact cannot be determined.
 - b. The CRA makes multiple assumptions about dilution of chemicals in produced water. The dilutions are not always clearly justified and initial concentrations that may be present in the untreated water to be released in the Dawson River are also unclear. Initial concentrations and assumed dilution factors should be clearly shown so that predicted concentrations relied upon in the assessment can be justified.
 - c. The CRA of Tier 2 and Tier 3 chemicals assumed a dilution of 50-fold for the untreated produced water releases and 5000-fold for the treated produced water releases for the calculation of Predicted Environmental Concentrations (PECs) (or EPCs as the proponent refers to these). If the PEC exceeded the Predicted No-Effect Concentration (PNEC), chemicals were then often excluded from further risk assessment on the basis that they lacked persistence (i.e., that they would dissociate or degrade in the water management system or the receiving environment). This has meant that some chemicals, for example, the surfactant cocamidopropylbetaine, which in the untreated releases is estimated to have a PNEC of 78 (well above the target level of 1) have not been adequately assessed. The proponent considers that cocamidopropylbetaine will readily biodegrade and has a short half-life of 15 days. Despite the relatively short half-life, 15 days is still a considerable time for a chemical to be present at potentially toxic levels. If dilutions are inadequate, this chemical may cause impacts to the aquatic ecosystem.
 - d. Tributyl Tetradecyl Phosphonium Chloride (TTPC) was identified by the proponent as a chemical of concern given the calculated risk ratio. TTPC is acutely toxic in aquatic environments; however, the proponent has concluded that since untreated releases will be infrequent, and TTPC is not expected to bioaccumulate, but rather will strongly absorb to soil and sediments, it will not be an unacceptable risk (AECOM 2022, p. 183). The assessment considered risk via ingestion in non-aquatic species only and did not fully consider the risk from TTPC through

exposure to sediment due to a lack of available data. This exposure pathway is important given TTPC is expected to accumulate in the sediment. Given that TTPC is toxic and persistent, the proponent should investigate the effect of TTPC on sediment-dwelling biota (e.g., native bivalve species).

- e. A screening risk assessment of geogenics based on previous produced water maximum concentrations only considered a limited range of chemicals. The screening process identified that risk ratios for several geogenics were greater than the target value of 1, including aluminium (up to 1100), barium (870), arsenic (38) and chromium (16). The proponent has assumed that geogenics will be removed during RO treatment but given the untreated releases will not undergo RO treatment, dilution will be relied upon to manage geogenics in untreated releases. Substantial dilutions will be required to manage some of these geogenic chemicals, and this can be determined by using DTA.
- f. The chemical risk assessment has only considered individual chemicals, and management primarily through dilution for untreated produced water, similarly only considered individual chemicals. Interactive effects are not considered. DTA is needed to ensure that the potential impacts arising from the combination of chemicals (both known and unknown) present in produced water are adequately assessed and managed. Additionally, limited consideration of cumulative impacts has been undertaken as the proponent has not identified any chemicals being used as persistent, bioaccumulative and toxic. Further consideration is needed of potential cumulative impacts as some chemicals are toxic and may persist in sediments. Biota within the aquatic environment can be directly exposed to the sediments while foraging.

Management plan

- 17. The Receiving Environment Management Plan (REMP) is unclear on the sampling regime. It contains many qualifiers with statements such as “where a parameter records an exceedance within 2 hours of the release at site S1a then the parameter will also be monitored at all Dawson River sites twice in the following year, adhering to a pre-wet and post-wet schedule.” (frc environmental 2021, p. 45). This would correspond to sampling on the currently proposed, highly limited schedule so it is unclear how this is a timely response to an exceedance. The monitoring schedule in the REMP requires clarification to clearly commit to:
 - a. a spatially- and temporally-thorough monitoring schedule covering appropriate unimpacted (reference) and impact sites with sampling occurring at a frequency that will allow rapid detection of potential impacts;
 - b. monitoring that includes a DTA-based approach for untreated water releases (see Paragraph 7a); and
 - c. implementing a TARP that will allow early detection of impacts, and actions that will prevent further impacts from occurring.
- 18. While sediment sampling is undertaken, the purpose of this sampling is unclear as there appears to be no corrective actions to prevent further potential impacts if the proponent-defined ‘trigger values’ are exceeded. The sampling program is limited in spatial extent, has no sampling at unimpacted sites, and sampling only occurs twice-yearly.
 - a. The sediment sampling program needs to be continued for the life of the project and developed further to better understand the potential for contaminant accumulation in sediments:
 - i. in the Waterhole where sediment type (greater amounts of silt) may make it more likely (frc environmental 2021, p. 25) during backflushing at high flows;

- ii. within the event-based mixing zone where higher concentrations due to the release of untreated produced water will occur; and
 - iii. further downstream of the project area where contaminated surface water potentially infiltrates alluvial sediments.
- b. Further analysis of whether contaminants accumulate in the sediment and could enter the food chain providing a pathway to impacting water resources including EPBC-listed turtles (see response to Question 2) should also be provided, including consideration of how far downstream contaminated sediments could travel and whether there is lateral movement into the riparian zone.

Question 2: Can the Committee provide comment on likely scale and extent of potential impacts on the White-throated Snapping Turtle and Fitzroy River Turtle as a result of changes to hydrological regime and water quality associated with the proposed water releases?

19. The IESC considers that impacts to hydrological regimes and water quality in the Dawson River at the project area must be avoided because this reach of the river provides critical habitat (Boobook Ecological Consulting 2022b, p. 15) for the critically endangered White-throated snapping turtle and the vulnerable Fitzroy River turtle. Furthermore, populations of White-throated snapping turtles in the Dawson River are of substantial phylogeographic significance to conservation of the species in north-eastern Australia (e.g., Todd et al., 2013) and deserve particular protection. In the project area, turtle recruitment appears to be almost zero because of nest predation and trampling (Boobook Ecological Consulting 2022b, p. 21) which indicates that the local populations are already severely stressed. Additional stresses, even seemingly minor, to these two species from the project should be avoided and a precautionary approach is essential. Although recent research has provided new information about these species' ecology and conservation significance (e.g., Micheli-Campbell et al., 2017), specific knowledge of the requirements of turtle populations occupying the dryland waterholes of the Dawson River is very limited.
20. Project-specific impacts to EPBC Act-listed turtles in the Dawson River are possible via changes to water quality, flow regimes, habitat (e.g., through erosion and/or sedimentation reducing the occurrence or suitability of riffle habitat), and/or accumulation of contaminants in sediments or food (e.g., invertebrate prey, filamentous algae) ingested by the two turtle species. Potential impact pathways and their materiality should be portrayed using an ecohydrological conceptual model (ECM) to illustrate how changes to hydrological regimes and water quality associated with the proposed water releases may interact to affect the two species at different stages of their life cycle in the project area. This ECM should include a narrative for each pathway that specifies its uncertainty, justifies its inclusion with reliable evidence (e.g., site-specific data, relevant supporting literature) and describes appropriate mitigation options to reduce the risk of impacts on the two turtle species.
- a. Changes to water quality were discussed in the response to Question 1. These changes, especially those associated with untreated water releases, are particularly relevant to both species of EPBC Act-listed turtle because of their inferred high sensitivity to contaminants (AECOM 2022, pp. 162-164).
 - b. Given the significance of the Dawson River as habitat for the two EPBC Act-listed turtle species, further site-specific assessment of habitat requirements, including for foraging, nesting and dry-season refuge, should be undertaken at different hydrological phases to assess how hydraulic changes arising from the releases might reduce their survival, especially over the long term (decades). This assessment should focus on sections of the Dawson River and Waterhole where local-scale flow behaviour (e.g., within riffles) may be especially likely to be altered by the proposed releases.

- c. Further work is needed to understand the potential for contaminants to be present in the food resources of the two species of EPBC Act-listed turtles, and/or to accumulate in sediments. As the adults of the two species have different diets (Boobook Ecological Consulting 2022b, p. 10), assessment of the potential for bioaccumulation of contaminants in the food chain must include filamentous algae and aquatic invertebrates. Work needed on contaminant accumulation in sediments is discussed in Paragraph 18.
 - d. Assessing the vulnerability and sensitivity of hatchlings is particularly important because of their heavy reliance on cloacal respiration and greater potential susceptibility to contaminated water (AECOM 2022, p. 164). The proponent should provide more details about the risks of impacts to hatchlings from water contamination and altered habitat availability and describe mitigation measures to protect any hatchlings that survive nest trampling and egg predation.
21. Limited monitoring has been proposed for both water quality (as discussed in Paragraph 7) and ecological features and processes of the Dawson River to enable rapid detection of potential impacts.
- a. No plans (e.g., suitable TARPs) in response to potential impacts on the two EPBC Act-listed turtle species are provided to ensure that there are appropriate actions to prevent further impacts within a suitable timeframe.
 - b. Monitoring in the Waterhole is located mainly on the upstream side which is unlikely to provide favourable habitat for either turtle species; sampling locations (especially for aquatic macroinvertebrates) should include preferred foraging sites such as riffles and backwaters.
 - c. Additional ecological monitoring is needed closer to the event-based release location because the IESC considers that the risk of impacts to the two turtle species is greater from the untreated water releases.
22. The population of White-throated snapping turtles at the project site is isolated from downstream populations by substantial distance and waterway barriers. Should project-related impacts to the White-throated snapping turtle substantially reduce its population size and/or reproductive success, then there is a high chance that the population at the project site will become locally extinct as the downstream population will not be able to access and repopulate the area. The IESC is very concerned about the risks of this project, especially the potential long-term impacts of event-based releases of untreated produced water, on the persistence of this critically endangered species.

Question 3: Can the Committee provide comment on the likely scale and extent of impacts to downstream GDEs as a result of changes to hydrological regime and water quality associated with the proposed water releases?

23. Subterranean, aquatic and terrestrial GDEs are all present or highly likely at the project site and downstream of the proposed release points. However, their exact distribution and groundwater-dependence need to be ground-truthed and mapped at a local scale to enable a full assessment of potential impacts as a result of changes to the hydrological regime and water quality associated with the proposed water releases.
24. Subterranean GDEs (e.g., stygofauna, hyporheic fauna) are acknowledged as potentially present in aquifers and the hyporheic zone in the project area where discharging aquifer water enters the river channel (Boobook Ecological Consulting 2022a, p. 5). However, this GDE has not been sampled which prevents reliable assessment of potential impacts from, for example, inflows of contaminated water in zones into shallow alluvial aquifers. Baseline data are needed on stygofauna and hyporheic fauna, especially in alluvial sediments of the reach immediately downstream of the release point of untreated water and areas where infiltration may occur (e.g., parafluvial zones of unconfined channels, bed sediments where the Dawson River changes from gaining to losing). Field surveys and

sampling should follow the guidelines outlined in DSITI (2015) and Doody et al. (2019), focussing on shallow alluvial sediments along the bank and in the river bed, and including suitable unimpacted reference sites for comparison.

25. Field surveys are also needed to determine if the critically endangered Boggomoss snail (*Adclarkia dawsonensis*), which occurs at the downstream GAB spring Boggomoss Spring and within riparian areas, is present at the project site. Aquatic snails can be highly susceptible to impacts from contaminated water and are good ecotoxicological bioindicators (review in Chen et al., 2021).
26. Aquatic GDEs within and downstream of the project area may be impacted through several mechanisms outlined below. The expected scale and extent of impacts to these GDEs varies and is dependent on their distribution, water source and vulnerability to change.
 - a. GDEs supported wholly or partly by shallow aquifers, including colluvial and alluvial aquifers underlying the Dawson River and the Waterhole, may be impacted.
 - i. Impacts are most likely in the hyporheic zone where localised infiltration of surface water occurs and can transport contaminants into these shallow systems.
 - ii. Impacts can also arise from changes to the hydrological regime such as transient changes to hydraulic gradients that may be induced by elevated surface water levels from water releases.
 - iii. In the hyporheic zone, changes to hydraulic gradients can alter subsurface redox conditions and affect biogeochemical processes such as nutrient cycling in these GDEs (review in Boulton et al., 2010). These GDEs are particularly poorly characterised in the provided assessment yet are potentially vulnerable to sustained changes to the hydrological regime and water quality, especially where river water infiltrates shallow aquifers.
 - b. It is recommended that the proponent map these GDEs in the project area and assess their potential vulnerability to altered water regimes and water quality resulting from the proposed releases (see Paragraph 23). This is especially relevant if the predicted cumulative drawdown reduces hydraulic gradients and discharges within the project area. The Underground Water Impact Report (OGIA, 2021) predicts cumulative long-term impacts on groundwater levels for the Precipice Sandstone at springs adjacent to the proposed action area of up to 0.7 m within 38-39 years (AECOM 2022, Table 4.16, p. 67). The proponent asserts that this drawdown is 'not sufficient to alter vertical groundwater gradients within the proposed action area' (AECOM 2022, p. 67) yet presents no supporting evidence. Even if hydraulic gradients driving surface water-groundwater interactions in the project area are weakened rather than reversed, there are likely to be implications for surrounding groundwater resources and the river's baseflow.
 - c. Riverbank seeps at the project site, other than GAB springs, may be impacted by both types of water releases depending on their location. The seeps are likely reliant on the alluvial aquifers and could be exposed to contaminants. This can occur directly from the releases, or potentially could also arise as high flows recede and contaminated water discharges from the alluvial sediments. It is possible that contaminated water from the untreated releases may be temporarily stored within the alluvial aquifers as bank storage. When the surface water level recedes, this stored water is released back into the surface water system possibly resulting in a second pulse of contaminants that could impact downstream GDEs and aquatic biota. A vulnerability assessment should be done for each seep, and its water quality and biota should be monitored as part of the REMP to confirm the proponent's predictions that no significant impacts will occur from the project.

- d. The IESC agrees with the proponent that most GDEs supported by deeper aquifers such as the Precipice Sandstone are unlikely to be impacted by the proposed water releases, especially where there are no feasible pathways for movement of contaminants into the groundwater.

27. Terrestrial GDEs occur in the project area and include the TEC '*Eucalyptus populnea* Woodland on Alluvial Plains' (AECOM 2022, p. 129). It is not clear whether contaminants from untreated releases may be transported laterally into the riparian zone during high flows and, over time, infiltrate into the shallow groundwater used by groundwater-dependent vegetation. If this pathway is feasible (see Paragraph 18b), the proponent should ground-truth likely sites in the project area and assess the distribution and groundwater-dependence of terrestrial GDEs in potentially affected locations. These may be useful monitoring sites for assessing long-term (decadal) legacy effects of contaminants from untreated releases on downstream terrestrial GDEs. The health of these GDEs should be monitored in vulnerable locations as part of the REMP, especially for potential long-term impacts of deposited contaminants.

Question 4: Can the Committee provide comment on likely scale and extent of potential impacts to surrounding groundwater resources resulting from the proposed water releases through interactions between surface water and groundwater resources?

28. The proponent's assessment that impacts from produced water releases will have a limited impact on regional groundwater is based on the maintenance of groundwater pressures above the base of the Dawson River (i.e., gaining conditions occurring within the Dawson River prevent recharge of the regional aquifer). From the information provided, it is not possible to determine the current and future likelihood of hydraulic gradient weakening or reversal. Further work to support their assessment is needed that considers:

- a. whether predicted drawdown (noting that uncertainty in drawdown predictions can be up to one order of magnitude) from CSG operations in the area could result in any reaches of the Dawson River potentially impacted by produced water releases from the project becoming losing reaches which may facilitate aquifer recharge with contaminated water (see Paragraph 26b); and
- b. if a decrease in gaining conditions (e.g., not a full reversal to losing conditions) could occur and cause impacts in the hyporheic zone (e.g., altered rates or types of biogeochemical processes) or affect spring discharge.

29. Direct impacts from the water releases to the regional groundwater system, the Precipice Sandstone, are unlikely. This is because the pressure head in the Precipice Sandstone in the area close to the proposed untreated release point is above the level of the Dawson River streambed making substantial recharge of the Precipice Sandstone aquifer by contaminated water unlikely. In times of high surface water flows, some recharge to the stream bed and banks will occur, but this recharge is unlikely to infiltrate into the Precipice Sandstone aquifer. Additionally, this localised recharge and storage is typically temporary and is expected to discharge back to the downstream surface water system as water levels recede. The effects will most likely occur in the alluvial sediment overlying the Precipice Sandstone aquifer. See Paragraph 26c for discussion of potential impacts arising from this process.

30. Shallow groundwater systems at the project site may be impacted by the releases of treated and untreated water. The scale and extent of the impacts are likely to be localised; however, the importance and significance of the impacts is unclear from the information provided. For example, treated water releases, especially at low flows, are very likely to alter hyporheic water chemistry (assuming hyporheic water is chemically different from the released water) because of advective exchange in the river bed in places where groundwater inputs are weak or absent, and this will potentially occur for a considerable distance downstream if the releases continue for years to decades. Assessing the scale and extent of these potential impacts depends on mapping these areas

and their vertical hydraulic gradients at various flows and then inferring the likelihood that impacts to groundwater resources may arise from contamination and, to a lesser degree and in much more localised areas, changes and even reversals in surface water-groundwater exchange. Impacts to GDEs supported by shallow groundwater systems are discussed in the response to Question 3.

Date of advice	30 July 2022
Source documentation provided to the IESC for the formulation of this advice	AECOM 2022. <i>Santos Fairview Water Release Scheme. Preliminary Documentation. 01-Jun-2022. Dawson River Release Approvals. Revision A.</i> Prepared by AECOM Australia Pty Ltd. Job No.: 60667740
References cited within the IESC's advice	<p>AECOM 2016. <i>Dawson River Event Release Technical Impact Assessment Report.</i> Prepared by AECOM Services Pty Ltd. Job No.: 60452094/42627587. (Appendix A – Dawson River Event Release Report, Produced Water Releases – Fairview Referral).</p> <p>Boobook Ecological Consulting 2022a. <i>Dawson River Groundwater Dependent Ecosystem Assessment.</i> Compiled by Boobook for Santos. Revision 1. (Appendix G - Boobook 2021. Dawson River Groundwater Dependent Ecosystem Assessment).</p> <p>Boobook Ecological Consulting 2022b. <i>Dawson River proposed action area habitat survey and impact assessment for White-throated Snapping Turtle and Fitzroy River Turtle.</i> Compiled by Boobook for Santos. Revision 1. (Appendix H - Boobook 2021. Habitat survey and impact assessment for White-throated snapping turtle and Fitzroy River turtle, Fairview Water Release Scheme PD, Revision A).</p> <p>Boulton AJ, Datry T, Kasahara T, Mutz M and Stanford JA 2010. Ecology and management of the hyporheic zone: stream-groundwater interactions of running waters and their floodplains. <i>Journal of the North American Benthological Society</i> 29: 26-40.</p> <p>Chen Z, Eaton B and Davies J 2021. The appropriateness of using aquatic snails as bioindicators of toxicity for oil sands process-affected water. <i>Pollutants</i> 1: 10-17. https://doi.org/10.3390/pollutants1010002.</p> <p>DSITI (Department of Science, Information Technology and Innovation) 2015. <i>Guideline for the environmental assessment of subterranean aquatic fauna: sampling methods and survey considerations.</i> Department of Environment, Science, Information Technology and Innovation [Online]. Available: Environmental Assessment of Subterranean Aquatic Fauna - Dataset - Publications Queensland Government Accessed 28/7/2022.</p> <p>frc environmental 2021. <i>Santos Ltd Dawson River watercourse releases. Receiving environment monitoring program.</i> Prepared for Santos Ltd. Edition 210208ii_REMP. (Appendix J - Dawson River water course release receiving environment monitoring program, Fairview Water Release Scheme PD, Revision A).</p> <p>Golding LA, Kumar A, Adams MS, Binet MT, Gregg A, King J, McKnight KS, Nidumolu B, Spadaro DA and Kirby JK 2022. The influence of salinity on the chronic toxicity of shale gas flowback wastewater to freshwater organisms. <i>Journal of Hazardous Materials</i> 428:128219.</p> <p>Hydrobiology 2018. <i>Ecotoxicology of coal seam gas hydraulic fracturing fluids. Joint Industry Report. V1-0 Final March 2018.</i></p>

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