Appendix G BOOBOOK 2021. Dawson River Groundwater Dependent Ecosystem Assessment

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Report

Desktop assessment of presence of, and potential impact upon, Groundwater Dependent Ecosystems within the Dawson River Proposed action area, Santos Fairview Gas-field, GLNG Project Area.

Compiled by BOOBOOK for Santos

Revision	Date	Description	Author	Verifier	Approved
A	22/11/2021	Draft issued to client for review	R. Johnson, L. Hardwick	C. Eddie	C. Eddie
0	16/05/2022	Final report issued to client	M. Cunningham, L. Hardwick	C. Eddie	C. Eddie
1	01/02/2023	Revised report issued to client	M. Cunningham, L. Hardwick	C. Eddie	C. Eddie
2	02/02/2023	Revised report issued to client	M. Cunningham	-	C. Eddie

Contents

Executive Summary

BOOBOOK was engaged by Santos (the Client) to conduct a literature review and desktop assessment of the potential presence of groundwater dependent ecosystems (GDE) within and adjacent to a section of the Dawson River and associated watercourses, described as the proposed action area. The subsequent report was to provide additional information for use in assessment by the Commonwealth Department of Agriculture, Water and the Environment (DAWE), now known as the Department of Climate Change, Energy, the Environment and Energy (DCCEEW), of the Fairview Water Release Scheme (EPBC 2021/8914) with regard to impacts on groundwater dependent ecosystems (GDE). In accord with the requirements detailed in the DAWE request for additional information, this report will also provide a discussion of surface water and groundwater impacts to GDE and aquatic ecosystems within the proposed action area.

The proposed action is the release of up to 18 ML/day of treated desalinated produced water (desalinated water) to the Dawson River via a drainage feature, waterhole and outlet watercourse to the Dawson River. There is no proposed increase in the existing approved maximum daily release rate (18 ML/day) or total annual volume of 6,570 ML/year (limited by the State EA). Proposed releases of Gas Field Development (GFD) Project water will substitute Gladstone Liquefied Natural Gas (GLNG) Project water currently released, and other water management and beneficial use options such as irrigation will remain in place.

Water management and treatment prior to the proposed action will use existing water management and water treatment infrastructure at the Hub Compressor Station 04 (HCS04), including the reverse osmosis plant (ROP), water storage ponds and desalinated water release pipe from HCS04 to the drainage feature.

Initial release of treated water as part of the Dawson River Release Scheme (DRRS) began in July 2015 (frc environmental 2019a, Santos 2012). The water is piped from the ROP at HCS04 to the release point at the head of a stream order 1 drainage feature. Released water flows approximately 2.9 km along this drainage feature to a waterhole (the waterhole). Overflow from the waterhole flows 1.8 km along a watercourse to enter the Dawson River at a point approximately midway between Dawson's Bend and Baroondah (also known as Yebna) Crossing. Thus, the drainage feature, waterhole, watercourse and the Dawson River below the confluence with the watercourse to Baroondah Crossing form the receiving environment for the desalinated water release.

State and Commonwealth government mapping indicate the potential presence of GDE supported by up to four aquifer types; the presence and extent of these are mapped with confidence ranging from high to low. The largest input of groundwater is associated with the Precipice Sandstone, which provides bed and spring flows to the Dawson River.

GDE dependent on surface expression of groundwater (aquatic GDE) are present in the proposed action area, the most important being the riverine waterbody of the Dawson River. Springs are numerous upstream of the proposed action area that are supplied by Precipice Sandstone aquifer. Shallower alluvial aquifers may also contribute groundwater to the Dawson River and associated GDE. The waterhole may also receive water from shallow alluvial aquifer contained within the former buried river channel.

Terrestrial GDE, reliant on subsurface expression of groundwater, are either known or likely to be present. The extensive riparian community (RE 11.3.25) of the Dawson River, and its extensions on the banks of tributary streams represent the largest extent of this GDE. Terrestrial, treed ecosystems elsewhere are less confidently assigned to GDE. State mapping predicts a wider occurrence of the RE 11.3.2 than limited ground-truthing shows to be the case. Where this RE is known to be present, it is assigned to GDE. A less widespread RE on alluvium, RE 11.3.19, is similarly assigned. Limits to the accuracy of existing vegetation (RE) mapping and uncertainty over location of aquifers in turn limit the extent of areas that can be confidently assigned to terrestrial GDE. A preliminary mapping of this GDE has been provided.

Subterranean GDE are not predicted by government mapping, and their occurrence was not able to be documented. However, the Precipice Sandstone has features favourable to the existence of a stygofauna, and other aquifers may also be suitable. Additionally, the below-bed groundwater (hyporheic zone) of the Dawson River may support a stygofauna assemblage. Though this GDE seems likely to exist, no attempt to map it was undertaken.

Measured water depth data indicates desalinated water releases do not significantly alter water flow depths by more than 0.05 m in the Dawson River and 0.3 m in the waterhole, or water quality. Subsequent monitoring under the receiving environment monitoring program (REMP) has to date largely borne this out. Ecosystem health, as measured

by a series of measures of biotic indicators indicates that this water has not detrimentally impacted the aquatic environmental values of the receiving environment. Groundwater contamination via the Dawson River is unlikely due to an upward pressure gradient, which prevents surface water entering the aquifer from the river. The waterhole comprises a former river channel through alluvial deposits. It is likely that this substrate forms a shallow alluvial aquifer that reduces seasonal variability in the waterhole, with infiltration during wet periods and subsequent seepage during the dry season.

The downstream environment, including GDE, is not expected to be impacted by either the minimal hydrological changes, or release of contaminants into the catchment.

List of Abbreviations

BoM	Bureau of Meteorology
CSG	Coal seam gas
DAWE	Department of Agriculture, Water and Environment (Commonwealth)
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DES	Department of Environment and Sciences (Qld)
DRRS	Dawson River Release Scheme
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GDE	Groundwater dependent ecosystem
km	kilometre(s)
m	metre(s)
mAHD	metres above the Australian Height Datum (a measure of elevation)
mg/L	milligrams/litre
ML/d	megalitres per day
NC Act	*Nature Conservation Act 1992* (State)
RE	Regional Ecosystem(s)

1. Introduction and Scope

BOOBOOK was engaged by Santos (the Client) to conduct a literature review and desktop assessment of the presence of Groundwater Dependent Ecosystems (GDE) within a section of the Dawson River and associated watercourses, described as the proposed action area. The subsequent report was to provide additional information for use in assessment by the Commonwealth Department of Agriculture, Water and the Environment (DAWE), now known as the Department of Climate Change, Energy, the Environment and Energy (DCCEEW), of the Fairview Water Release Scheme (EPBC 2021/8914) with regard to potential impacts on GDE by the release of treated coal seam gas (CSG) produced water (desalinated water). In accord with the requirements detailed in the DAWE request for additional information, this report will provide a discussion of:

- The predicted and verified presence of GDE within the proposed action area;
- The potential occurrence of unverified GDE (i.e. those that are suspected to be present but lack conclusive field-based evidence in support of their presence);
- A preliminary assessment of potential impacts of the proposed action upon GDE in the proposed action area.

1.1. Site Description

The proposed action area consists of a stream order 1 drainage feature ("the drainage feature"), the entirety of a large, isolated ox-bow lake or billabong ("the waterhole") downstream, a stream order 2 watercourse ("the watercourse") that flows from the waterhole to the Dawson River, and the bed and banks of the Dawson River below this confluence to the Baroondah Crossing on the Injune-Taroom Road. In total, the proposed action area includes approximately 16.3 km of riparian and lacustrine features, comprising 2.9 km along the drainage feature, 3.5 km of waterhole, which extends east and west of the drainage feature, 1.8 km along the watercourse that flows from the eastern end of the waterhole, and 8.1 km along the Dawson River. These features carry releases of desalinated water, of varying volumes and duration, flowing from an outfall pipe at the head of the drainage feature, through to the Dawson River. Appendix A shows the location of the proposed action area.

The proposed action area is located approximately 55 km east-northeast of Injune, south central Queensland. It is located entirely within Subregion 24 (Carnarvon Ranges) of the Brigalow Belt bioregion (Sattler and Williams 1999) and is located in the mid- to upper reaches of the Dawson River, a major tributary of the Fitzroy drainage basin. The river here features a perennial, spring-fed flow derived from Hutton Creek, which enters the river about 14 km above the upstream limit of the proposed action area. This flow is greatly augmented in this upper section by numerous spring discharges in the river bed, banks and tributaries, associated with the incised Precipice Sandstone aquifer (specifically the lower Precipice sandstone). Within this section of the river the bed is largely confined within steeply sloping banks delineated by outcropping hills and rises, with only limited floodplain development. The area of the Dawson River within the proposed action area is underlain by the Evergreen Formation, including the Boxvale Sandstone and Westgrove Ironstone members, with no known springs, more subdued relief of rolling hills with some floodplain development.

Deep sandy to silty loam alluvium associated with the banks and channel of the Dawson River supports riparian open forest of Queensland Blue Gum (*Eucalyptus tereticornis*), River Oak (*Casuarina cunninghamiana*), Rough-barked Apple (*Angophora floribunda*) and Weeping Bottlebrush (*Melaleuca viminalis*). Where still present, the native vegetation of the floodplain is typically Poplar Box (*E. populnea*) woodland with areas of Carbeen (*Corymbia tessellaris*) and White Cypress Pine (*Callitris glaucophylla*) woodland on sandy levees.

Land use within the proposed action area includes CSG production activities on the properties "Fairview" and "Yebna", associated with the Fairview Gas Field. The upper part of the river, upstream of the proposed action area, is bordered to the north by Crown land, this being the Expedition Resources Reserve. Downstream from here, including most of the proposed action area, Yebna has an extensive double frontage on the river. Yebna is a pastoral (beef cattle) property with some areas of cropping, particularly around the waterhole. Extensive historical clearing of native vegetation has occurred on the property. The lower 1.5 km of the Dawson River within the proposed action area, immediately above Baroondah Crossing, is bounded by State Forest (SF) but this land has been largely cleared for pastoral purposes.

1.2. Details of the proposed action

The proposed action is the proposed release of up to 18 ML/day of desalinated produced water via a drainage feature, waterhole and outlet watercourse to the Dawson River. There will be no increase in the existing approved maximum

daily release rate (18 ML/day) or total annual volume of 6,570 ML/year (limited by the State EA). Proposed releases of Gas Field Development (GFD) Project water will substitute Gladstone Liquefied Natural Gas (GLNG) Project water currently released, and other water management and beneficial use options such as irrigation will remain in place. Initial release of desalinated water as part of the Dawson River Release Scheme (DRRS) began in July 2015 (frc environmental 2019a, Santos 2012).

Water management and treatment prior to the proposed action will use existing water management and water treatment infrastructure at Hub Compressor Station 04 (HCS04), including the reverse osmosis plant (ROP), water storage ponds and desalinated water release pipe from HCS04 to the drainage feature. The proposed action area is collectively the receiving environment for desalinated water from the release at the head of an ephemeral drainage feature, the waterhole, watercourse and Dawson River downstream to Baroondah Crossing on the Injune-Taroom Road.

The water is piped from a reverse osmosis water treatment facility (ROP2) to the release outfall at the head of the drainage feature. Released desalinated water flows approximately 2.9 km along the drainage feature to the waterhole. Overflow from the waterhole enters the watercourse, flowing 1.8 km to enter the Dawson River at a point approximately midway between Dawson's Bend and Baroondah Crossing (Appendix A).

Thus, the drainage feature, waterhole, watercourse and the Dawson River below their confluence form the receiving environment for the CSG treated produced water (desalinated water). Maximum designed output of treated water is 18 megalitres per day (ML/d) (Santos 2012) as limited by the existing Environmental Authority (EA) EPPG00928713. The frequency of desalinated water releases have varied between 87 days per year and 156 days per year between 2016 and 2022. Revised water management, prioritising more water use for beneficial uses such as irrigation, has recently been introduced, resulting in a reduction from 156 desalinated water release days in 2020 to 95 desalinated water release days in 2021.

2. Methods

The following assessment is based on both desktop review of project documentation, literature and other sources, and relevant State datasets; and first-hand experience of the proposed action area, derived from several projects undertaken by BOOBOOK on behalf of Santos.

Specific datasets interrogated included:

- Groundwater Dependent Ecosystems Atlas (BoM 2021);
- Remnant vegetation: Regional Ecosystems – biodiversity status (DES 2021a);
- Queensland Springs Database (Qld Herbarium 2021);
- Groundwater dependent ecosystems and potential aquifer mapping – Queensland (Queensland Government 2021a);
- *Queensland Subterranean Aquatic Fauna Database* (Queensland Government, 2021b).

GDE definitions follow the typology described in Richardson *et al.* (2011) and Wetland*Info* (DES 2021b).

The assessment was supplemented by field findings, analysis and insights from BOOBOOK projects (BOOBOOK 2020, 2021) within and adjacent to the proposed action area.

3. Discussion

3.1. Summary of Geomorphology and Hydrogeology of the proposed action area

Within the proposed action area the Dawson River is relatively narrow for much of its length, mostly confined by adjacent uplands (rises and low hills) formed on outcropping siltstones and sandstones of the Evergreen Formation (Forbes 1968), with limited development of a floodplain. The river channel contains mobile sand and gravel alluvium, interspersed with loose siltstone boulders and areas of solid outcropping bedrock (Santos 2012, AECOM 2016). Perennial flow upstream of and through the proposed action area is via groundwater discharge from the Precipice Sandstone aquifer that is incised and exposed by the Dawson River. This aquifer has a head of pressure some 20 m above the bed level, meaning that in this reach the Dawson River is a gaining stream. Numerous springs present on or near the banks of the river discharge into the Dawson River upstream of the proposed action area, but most inflow occurs from below the river bed level as baseflow. Similarities in water chemistry (8 major cations/anions) between

the river itself and an adjacent test bore in the Precipice Sandstone (AECOM 2016: Fig. 16) support the conclusion that the main source of baseflow water within the Dawson River in this upper perennial section and within the proposed action area downstream is from Precipice Sandstone groundwater. Downstream, in some reaches within the proposed action area, floodplains of clay loam extend landward from the silty sand to silty clay banks of the river.

The waterhole is an oxbow lake as a remnant of a former Dawson River channel and current floodplain, being confined on its southern and western sides by uplands. Some development of riparian vegetation is present, although native vegetation on the adjacent floodplain alluvium has been cleared for agricultural purposes. It is a semi-permanent waterbody, which dried out intermittently prior to desalinated water releases starting in 2015, with the water level dependent on prevailing rainfall over a season (and hence run-off from adjacent upslope areas) (Santos 2012).

The drainage feature, into which desalinated water is discharged, runs southward to the waterhole through a narrow valley in rolling hills. Here it is an order 1 stream, with ephemeral natural flows following rainfall and showing no development of riparian vegetation. An order 2 stream (the watercourse) carries overflow water 1.8 km from the waterhole to the Dawson River. This stream shows evidence of regular flows and development of a narrow fringe of riparian vegetation.

3.2. Potential for presence of GDE within the proposed action area

GDE can be classified into three broad types (Richardson *et al.* 2011, Doody *et al.* 2019):

- Type 1 - *Subterranean* - GDE include aquifer and cave (karst) ecosystems;
- Type 2 – *Aquatic* - GDE are those dependent on the surface expression of groundwater; and
- Type 3 - *Terrestrial* - GDE that are dependent on the subsurface presence and availability of groundwater.

Three aquifer types occurring within and immediately adjacent to the proposed action area, and potentially supporting GDE, are mapped with high to moderate confidence (Qld Govt 2021a). These include the permanent Precipice Sandstone, and Quaternary alluvial aquifers overlaying the Precipice Sandstone or sandstone ranges and having intermittent groundwater flows. A fourth aquifer type, permeable consolidated sedimentary rock aquifers with intermittent flow, is mapped with low confidence.

State mapping (Qld Govt 2021a) and the GDE Atlas (BoM 2021) indicate the presence of GDE in the proposed action area (Appendix B). These include aquatic GDE in riverine channels and associated springs with permanent flows supported by Precipice Sandstone groundwater; intermittently flowing riverine channels; and lacustrine and palustrine wetlands on alluvia overlying sandstones. These GDE have High to Moderate potential to occur (Qld Govt 2021a, BoM 2021). Terrestrial GDE in the form of treed regional ecosystems on alluvia are also mapped as present. This assessment is derived from Queensland Wetland mapping (Qld Govt 2021a) in which the State-mapped pre-clearing presence of regional ecosystems (RE) that may contain wetlands forms the predictive basis.

No subterranean GDE are indicated to be present in Queensland government mapping of the proposed action area and surrounds (Qld Govt 2021a).

3.3. Known or likely GDE within the proposed action area

3.3.1 Aquatic (Surface Expression) GDE

Within the proposed action area the most obvious aquatic feature is the Dawson River. Upstream of the proposed action area influx of groundwater from the Precipice Sandstone maintains and enhances perennial flow. The same aquifer delivers water into Hutton Creek, producing a spring-fed flow into the Dawson at their confluence (*ca*. 14 km above the upstream limit of the proposed action area within the Dawson River). For much of the time there is no surface flow in the Dawson River above the Hutton Creek confluence, being an ephemeral surface water fed system with occasional, well separated spring-fed waterholes.

The Dawson River for its entire length within the proposed action area supports a permanent, though variably flowing, freshwater riverine wetland GDE (DES 2021b). The topography, habitat values, flora and fauna of this reach of the river are well described (e.g. AECOM 2012, frc environmental 2019, BOOBOOK 2020). An inventory of 14 native fishes; 6 turtle species, including the Critically Endangered White-faced Snapping Turtle (*Elseya albagula*) and Vulnerable Fitzroy River Turtle (*Rheodytes leukops*); Platypus (*Ornithorhynchus anatinus*), Rakali (*Hydromys chrysogaster*); and a diverse aquatic macroinvertebrate community, is known to exist within this section of river.

A number of springs discharge into the river upstream of the proposed action area, either on the banks or at a relatively short distance away, where they connect via gullies. While the spring flows contribute to riverine GDE values, their conservation ranking is relatively low (Category 2: wetland vegetation without isolated populations) (Qld Herbarium 2021). These are Type 3 springs (Qld Govt 2017), in which development of wetland ecosystems is relatively limited. However, at one large spring (Spring 500-1: Qld Govt 2021a) where discharge volumes are large enough to maintain permanent pools, fish - Spangled Perch (*Leiopotherapon unicolor*) - and the turtle *Elseya albagula* have been observed (BOOBOOK 2021). Available mapping (BoM 2021, Qld Govt 2021a) underestimates the number of springs present: over 20 springs discharge into the Dawson River upstream of the proposed action area (this does not account for sub-surface inflows from the aquifer) (Santos 2012; BOOBOOK 2020a, 2021b).

The waterhole (see sections 1.1, 3.1) is a palustrine or lacustrine wetland, the volume of which appears dependent on local rainfall and run-off, with considerable reduction in area and depth during dry periods (Santos 2012, AECOM 2016). It nevertheless supports a well-documented wetland ecosystem with abundant aquatic macrophytes, crustacea and molluscs, fishes, turtles and waterbirds (Santos 2012, AECOM 2016, BOOBOOK 2021).

The waterhole may potentially be partly dependent on groundwater sourced from a Quaternary alluvial aquifer during dry periods, with recharge during the wet periods (Qld Govt 2021a). However, available hydrogeological (anion/cation) data suggest that this is largely rainwater fed and these data do not support significant connectivity or inflow of groundwater from the underlying Evergreen or Precipice sedimentary rock aquifers (Santos UWIR monitoring data). Therefore, the waterhole is not mapped as a surface expression GDE. The stream order 1 drainage feature that carries discharged water downslope from the pipeline outlet to the waterhole is also underlain by alluvium. BOOBOOK (2021) found that the drainage feature had no development of aquatic habitat except in the distal area where it meets the waterhole. Here, some pooling associated with minor channel formation occurred but this showed limited presence of hydrophytes or other habitat features. The watercourse that exits the waterhole to connect to the Dawson River is mapped as a Surface Expression GDE.

Several tributary gullies and creeks enter the Dawson River within the proposed action area, the most conspicuous of which is Boyd Creek, which discharges to the Dawson River 3.7 km downstream of the watercourse and Dawson River confluence, within the proposed action area. All are ephemeral streams. They are underlain by mapped alluvial aquifers or permeable consolidated sedimentary rock aquifers, and are mapped with moderate confidence as Surface Expression GDE (Qld Govt 2021a). As is the case for the waterhole and watercourse, GDE evidence is cited as 'expert opinion' and it would appear that no field validation (e.g. test bores) of GDE has been done. Surface Expression (Aquatic) GDE known or likely to be present within or adjacent to the proposed action area are mapped in Appendix C.

3.3.2 Terrestrial GDE

For its entire length within the proposed action area, the Dawson River supports a riverine wetland Terrestrial GDE (DES 2021b), this being the riparian community (RE 11.3.25) growing below the high banks of the river. While discharge from the Precipice Sandstone is identified as a major source of groundwater supporting the GDE, inputs of groundwater from alluvial aquifers may also be involved (Qld Govt 2021a). While this RE, growing on the valley bottom of a perennial stream, can also access stream water, it is known that some plants may preferentially draw on groundwater, particularly in gaining rivers, while others can use both sources (Styoecologia 2013). Thus, the RE in this location can be considered to be a GDE.

RE 11.3.25 here is represented by woodland to open forest of Queensland Blue Gum (*Eucalyptus tereticornis*), River Oak (*Casuarina cunninghamiana*), Rough-barked Apple (*Angophora floribunda*) and Weeping Bottlebrush (*Melaleuca viminalis*), the latter dominating on lower banks (BOOBOOK 2021). This RE has high fauna conservation value, being recognised for high fauna species richness, turtle breeding habitat and foraging and shelter habitat for Koala (*Phascolarctos cinereus*) (DES 2021c).

Extensive areas within and adjoining the proposed action area are mapped as supporting Terrestrial GDE (Qld Govt 2021a, BoM 2021). As discussed, this mapping is ultimately dependent on State mapping of RE: specifically, it is based on the mapped presence of RE 11.3.25 and 11.3.2 (as a mixed polygon), this extending to floodplain areas adjacent to the Dawson River but also including the slopes and floors of several smaller valleys containing tributary streams.

Ground-truthing of the RE in the proposed action area is presently limited but vegetation assessments by BOOBOOK (2020) in nearby areas of the Expedition Resource Reserve on the northern side of the river, and field observations elsewhere (e.g. BOOBOOK 2021) indicate that much of the mapped RE is other than shown in State mapping. In particular, RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains) is of much less extent than shown.

Nevertheless, this RE is confirmed as present in some areas. It may also have been historically of greater extent within and adjacent to the proposed action area than it is at present, as it was preferentially cleared for agricultural purposes, both within the proposed action area and across its wider distribution. RE 11.3.2 has a Biodiversity Status of Of Concern (*Nature Conservation Act 1992*) and is a component RE of the listed Poplar Box Grassy Woodland on Alluvial Plains Threatened Ecological Community (TEC) (*Environment Protection and Biodiversity Conservation Act 1999*). Poplar Box is a deep-rooted (phreatophyte) species likely to access shallow aquifer groundwater and thus form GDE on floodplains (Stygoecologia 2013).

Some State-mapped Terrestrial GDE is on land which recent aerial imagery shows to have been cleared – compare, for example, mapped GDE in Appendix B with areas shown in Appendix C

It should be noted that RE potentially underlain by permeable consolidated sedimentary rock aquifers with intermittent flow, are present on slopes of uplands and that this may include areas mapped by the State as GDE. For example, BOOBOOK (2020) mapped extensive areas on lower slopes within the Expedition Resources Reserve as RE 11.10.7, being *Eucalyptus crebra* woodland on coarse-grained sedimentary rocks. However, GDE related to this aquifer type were mapped with low confidence (Qld Govt 2021a).

Limited ground-truthing (BOOBOOK 2020) identified the presence of a further RE likely to represent a Terrestrial GDE, this being RE 11.3.19 (*Callitris glaucophylla*, *Corymbia* spp. and/or *Eucalyptus melanophloia* woodland on Cainozoic alluvial plains). This RE is located on sandy levees above the high banks of the Dawson River. It may at least periodically access groundwater from shallow alluvial aquifers and is likely to be a GDE.

Part of the eastern shore of the waterhole and the watercourse below the waterhole support a narrow fringe of vegetation equivalent to RE 11.3.25 (BOOBOOK 2020). Vegetation at these locations is potentially a Terrestrial GDE.

RE known or likely to represent Terrestrial GDE within or adjacent to the proposed action area are summarised in Table 1, and are mapped in Appendix C. Note that this is not a comprehensive inventory of GDE: it shows only those GDE that are known or have a high level of confidence in their presence, based on existing desktop and (partial) field assessments. Terrestrial GDE may be present in many other locations within the proposed action area.

Table 1: RE known or likely to be Terrestrial GDE in the Proposed action area.

RE	Short Description (REDD: DES 2021c)	Biodiversity Status (NC Act)	Status (EPBC Act)
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of Concern	TEC
11.3.19	*Callitris glaucophylla*, *Corymbia* spp. and/or *Eucalyptus melanophloia* woodland on Cainozoic alluvial plains	No Concern at Present	-
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Of Concern	-

3.3.3 Subterranean GDE

Though not known to be present, subterranean GDE are potentially present in aquifers and the hyporheic zone where discharging aquifer water enters the river channel below the bed. The Precipice Sandstone is known to be the major source of base flow in the upper perennial section of the Dawson River (Santos 2012, AECOM 2016). This is evidenced by similarities in water chemistry (section 3.1); and by the maintenance of pool depth by upwelling groundwater (e.g. BOOBOOK 2020, 2021).

A literature review and search of the Queensland Subterranean Aquatic Fauna database (Qld Govt 2021b) failed to find any evidence of investigation of the presence of stygofauna in the Precipice Sandstone. However, stygofauna are known to be present in a wide range of lithologies and environmental parameters (e.g. depth below ground, temperature, salinity, pH) in Queensland (Glanville *et al*. 2016). Despite this tolerance for a range of environments, taxon richness was positively correlated to lower depths to groundwater, lower salinity, mesic temperatures and neutral to slightly alkaline pH (Glanville *et al*. 2016). Taxonomic richness of eastern Australian stygofaunal assemblages is known to be highest in aquifers <10 m below ground, in the alluvium of large river tributaries and near phreatophytic trees (Hancock and Boulton 2008). Some or all of these characteristics are present in the alluvial aquifers present within the proposed action area and the upstream Precipice Sandstone aquifer, which influences water chemistry within the proposed action area. On this basis it seems likely that stygofaunal Subterranean GDE are present within the proposed action area. Subterranean GDE have not been mapped as part of this assessment.

3.4. Impacts of the proposed action on GDE

The most frequently cited threat to GDE is the impacts of draw-down of water tables and aquifers (e.g. DES 2021b, Doody *et al*. 2019, Richardson *et al*. 2011). No abstraction of groundwater is contemplated in the proposed action. However, longer term draw-down of water tables is expected and groundwater modelling has been undertaken (AECOM 2016). A predicted impact on groundwater pressure in the Precipice Sandstone in the area is less than 1 m draw-down. This is not considered to significantly affect the groundwater pressure gradient such that the Dawson River would cease to be a gaining river at this point. Consequently, this impact is not discussed further.

The following discussion is focused on the potential threats identified in AECOM (2016: Table 16) where relevant to GDE. Though that document dealt specifically with the event-based release of CSG water, the threats identified are generally applicable to the variable semi-continuous release of desalinated water.

3.4.1 Surface water quality degradation

The discharge of desalinated water into the proposed action area (i.e. the Receiving Environment) is subject to the conditions of the Queensland Government Environmental Authority (EA) No. EPPG00928713, as revised and effective from 03 November 2022.

Conditions B15-B25 of the EA, which apply to the release of contaminants in coal seam gas water, are pertinent to the release of desalinated water. In particular, Table 4 – Contaminant Limits and Table 5 – Contaminant Limits for Protecting the Environmental Value (EV) of Drinking Water specify limits for a wide range of physico-chemical attributes, metals and metalloids, and other inorganic and organic contaminants. The limits used in the Tables are derived from the Dawson River Sub-basin Water Quality Objectives (DEHP 2011) and/or the ANZECC/ARMCANZ[1] Guidelines (2000a).

Under the conditions of EA No. EPPG00928713, the proponent is required to develop and conduct a receiving environment monitoring program (REMP) including monitoring of water quality. Summary results of REMP water quality monitoring from 2015 to 2021 for a range of parameters are shown in Table 2. Note that assessments were made at two sites on the river: site DRR1 is a control site located approximately 550 m upstream of the point of discharge into the river, above the proposed action area; and site DRMP1 is located 200 m downstream of the discharge point, within the proposed action area. Assessments were made biannually at times that should reflect differing river flow regimes, with high flows in the post-wet season and lowest flow in pre-wet season surveys.

Table 2: Water quality results for selected parameters 2015-2022, Dawson River (source: Santos GLNG REMP monitoring data).

			DRR1		DRMP1	
Parameter	**unit**	**Water Quality Objective (WQO) [a]**	**Data points**	**Median [b] or 95th Percentile [c] (minimum – maximum)**	**Data points**	**Median (Range)**
Dissolved oxygen [b]	mg/L	7.0 – 9.0	25	6.3 [b] (3.6 – 7.8)	58	7.1 (3.4 – 11.6)
Electrical conductivity [b]	µS/cm	370 (Base Flow) 210 (High Flow)	25	273 [b] (82 – 309)	58	275 (102 – 602)
pH [b]	unit	6.5-8.5	25	7.4 [b] (6.7 – 7.9)	56	7.4 (5.9 – 8.1)
Suspended solids [b]	mg/L	30	26	12 [b] (5 – 711)	25	12 (5 – 174)
Turbidity [b]	NTU	50	11	20 [b] (11 – 1,000)	10	17 (12 – 39)
Ammonia (as N) [c]	mg/L	0.02	26	0.10 [c] (0.01 – 0.15)	25	0.08 [c] (0.01 – 0.13)
Total Nitrogen [c]	mg/L	0.62	26	2.0 [c] (0.1 – 2.10)	25	1.7 [c] (0.1 – 1.8)
Boron (dissolved) [c]	mg/L	2.9	26	< 0.05 [d]	60	0.11 [c] (< 0.05 – 0.28)
Zinc (dissolved) [c]	mg/L	0.008	26	< 0.005 [d]	60	< 0.005 [d]

[a] from Environment Protection (Water) Policy 2009 Dawson River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130; [b] median measures are compared with objectives for physico-chemical parameters; [c] 95th percentile measures are compared with water

[1] Revised in 2018 to the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)

quality objectives for nutrients, toxicants and metals; [d] no detections or insufficient detections above limit of reporting to calculate median value.

Most measures of riverine water quality show substantial variation over time reflecting the dynamic flow regimes of this river system (Table 2). With the exception of nitrogen, median values of these parameters are generally within or close to the identified water quality objective ranges (Table 2). Median values exceeded guideline objectives for measures of nitrogen, either as ammonia or total nitrogen. Occasionally other measurements fall outside these guideline limits. Measurements of dissolved oxygen were regularly below the identified range, as were occasional measurements of pH. Outlier values of electrical conductivity and suspended solids exceeded the guideline range. However, all median values and variation in water quality measures are closely similar at the upstream control site (DRR1) to those measured downstream, below the discharge point (DRMP1), with no consistent differences between these sites.

It appears that riverine GDE water quality within the proposed action area, both upstream and downstream of the confluence of the waterhole-watercourse and Dawson River, is satisfactory following the discharge of desalinated water. This also implies that water quality thresholds are within limits for water travelling from the discharge point to the waterhole and thence to the river. Santos (2012) noted that cooling and oxygenation of discharged water was expected to occur as it travelled down the drainage feature to the waterhole.

Santos (2012) predicted that as discharged desalinated water flows to the waterhole would exceed natural inflow due to run-off, the water quality of the waterhole would, within approximately three months, be similar to that of the discharged water in terms of levels of nitrogen, salinity, total dissolved solids and boron. Summary water quality monitoring data from 2015 – 2022 for three sites within the waterhole, showed that median values for these parameters were generally within identified water quality objective ranges for the waterhole (AECOM 2022, Appendix D-2).

As with riverine water quality these values fluctuate considerably over time and some measures (dissolved oxygen, pH, suspended solids and total nitrogen) occasionally exceed the target range. However, contemporary studies of zooplankton, macroinvertebrate and fish assemblages, and crustacean carapace quality and breeding condition, all yielded results consistent with or better than baseline (pre-desalinated water release) values. Of note, the invertebrate considered most sensitive to boron, the microcrustacean *Ceriodaphnia cf dubia*, was recorded in the waterhole. Direct toxicology testing has shown this species to have a No Observable Effect Concentration for boron of 10.3 mg/L (an order of magnitude greater than the maximum level detected within the waterhole). frc environmental (2019) concluded that "…the release of desalinated produced water …has not likely impacted the aquatic environmental values of the receiving environment." Subsequent monitoring data has continued to support this conclusion.

3.4.2 Contamination of groundwater

A potential threat to GDE in the proposed action area is the transfer of contaminants to groundwater. Intermittent desalinated water discharges could impact on groundwater in the bed of the river (i.e. the hyporheic zone). The riverbed alluvial deposits will have similar chemical composition to the surface water due to intermixing with overlying channel water within the hyporheic zone. However, the data above (Table 2) indicate that release of desalinated water will not impact on water chemistry in the hyporheic zone.

The waterhole is mapped (Qld Govt 2021a) as a riverine wetland above a Quaternary alluvial aquifer overlying sandstone ranges (Evergreen Formation). However, available data suggest limited potential for leakage into the underlying sedimentary aquifers: the potentiometric surface for Precipice Sandstone groundwater is above the waterhole water level and the Evergreen formation is near impermeable with little or no capacity for infiltration.

3.4.3 Increased flows and impact on habitat, movement and life cycles of fauna

An increase in flow rate and water level rise within the Dawson River associated with anthropogenic inflows such as release of CSG water could potentially erode banks and increase inundation depth or duration, at least temporarily.

The Dawson River within the proposed action area experiences highly variable flows. Spring-fed low flows upstream of the proposed action area range from 15 ML/d at the end of the dry season to 18 ML/d during the wet season (Santos 2012), as measured at Baroondah (Yebna) Crossing, the downstream limit of the proposed action area. Low stream flows may persist for several years and are present for approximately 67% of the time (AECOM 2016). There is a high-flow season from November to March, driven by summer rainfall, though volumes are variable to a recorded maximum of 126,800 ML/d. The main river channel is capable of carrying a flow of 16,000 ML/d and floods of this size (i.e. that

fill the channel) occur every 2.33 years on average (Santos 2012, AECOM 2016). These floods are characterized by rapid water level rises and high current velocity. In summary, the Dawson River within the proposed action area is a perennial stream with variable flows, typically at low levels but periodically experiencing high-energy flood events.

Based on a series of assessments covering a range of flow levels from low to flood, frc environmental (2019) concluded that bank stability was moderate, with some unstable and eroding sections and areas of cattle disturbance to banks. Bed stability was low, with significant scouring and deposition of sand following very high flow events. These data indicate that the riverbank environment is reasonably resilient to flood-induced erosion events.

Measured water depth changes at Baroondah Crossing during desalinated water release events on baseflow levels showed that for a release of 18 ML/d (the maximum allowable daily release) the water level increases by approximately 0.05 m. Such a rise would still be contained below the first bench in the banks.

Measured water level data at Baroondah Crossing (S4) also shows that increases in water depth at S4 following the start of a desalinated water release occurs slowly, over a number of days as the upstream waterhole gradually fills and starts to spill. Initial water level increases in the Dawson River at S4 are not observable for between two to three days after the start of a desalinated water release, then water level at Baroondah Crossing slowly increases to the measured maximum of 0.05 m above pre-release baseflow levels over a duration of between nine to ten days. By comparison, water depth change response to rainfall events are rapid and occur within a day.

Measured effects on flow depth and rate of change in flow depth indicate that desalinated water releases are not likely to significantly alter the naturally variable stream hydraulics or hydrology when compared to natural variability in response to rainfall. No significant changes to the rate or extent of bank erosion, or to the extent and duration of waterlogging of riparian vegetation are expected or recorded in REMP data. Similarly, because changes are likely insignificant compared to those naturally occurring in this highly variable environment, it is unlikely that the life cycles (including breeding and movement) of aquatic fauna present within the riverine GDE will be affected.

As noted earlier, the waterhole was expected to experience increased inflow as a result of release of desalinated water (Santos 2012). Modelling predicted that, at discharges >6 ML/day, the waterhole would overflow almost continually (≥ 341 spill days per annum as measured by S4 gauging data). Recorded data from desalinated water releases between 2016 (the first full year of data) and 2021 at both 13.5 ML/day and 18 ML/day indicate the number of release days range between 87 days (2016) to 156 days (2020) with spill days from the waterhole, based on measured data at Baroondah Crossing being about the same; the waterhole continuing to spill for a short duration after a desalinated water release stops.

Examination of historical imagery shows that the waterhole, though it is a continuous waterbody when full or near-full, becomes dry or near-dry above the point where the drainage feature enters. Over the life of the proposed action, the waterhole will experience a regime of full or near-full conditions, reverting back to lower levels as discharge levels are reduced in the latter years of the Scheme (see section 1.2). frc environmental (2019) stated that the physical habitat features of the waterhole had improved due to higher water levels, and noted an increased submerged aquatic plant cover.

During July 2021, the upstream end of the waterhole was largely covered by submerged and emergent macrophyte beds, while downstream of the drainage feature ingress the lagoon was deeper, with macrophyte beds confined to the margins (BOOBOOK 2021). Numerous fish-eating birds (Australian Pelican, Great and Little Black Cormorants, Australasian Darter) were present on this part of the waterhole, indicating a population of forage fish was available. Prior to the start of the desalinated water discharge, at least intermittent connectivity with the Dawson River via the downstream watercourse was present during periods of heavy rainfall and during backflows from flooding in the river.

Modelling (Santos 2012) estimated the spill level at 249 m and the Dawson baseflow at 240.5 m. The spill point elevation measured by LiDAR elevation of 249.64 m above the Australian Height Datum (mAHD). Based on these elevations and available S4 gauging data, historical floods would have been sufficient for back-flow on three occasions since 2012. For much of the time, though, the watercourse would have been dry. Connectivity between the waterhole and the river has been augmented by the influx, and subsequent discharge, of desalinated water.

Modelling (Santos 2012) showed that the watercourse between the waterhole and Dawson River, when normally experiencing no flow during dry weather periods, would now have a flow at depths of 0.02-0.16 m, depending on discharge flow volumes (up to the maximum allowable daily discharge of 18 ML/day) and location within the watercourse. The modelled flow depth is consistent with observed flow depths at the spill point during REMP monitoring. These flows are unlikely to impact on existing Terrestrial GDE (a narrow riparian zone) by e.g. water-

logging, but may well facilitate the movement of aquatic fauna between the waterhole and the river: that is to say, connectivity between the river and the waterhole will be enhanced.

3.4.4 Downstream impacts on GDE

The release of water into the proposed action area will not significantly affect the naturally variable stream hydrology and hydraulics, with minimal to no impact on both baseflow and flood flows, such that downstream flow regimes will experience only minor modification. The release of desalinated water is also considered. The release of up to 6,570 ML per annum of desalinated water (based on releases at the maximum allowable daily level) is unlikely to adversely impact on downstream environmental values (Santos 2012).

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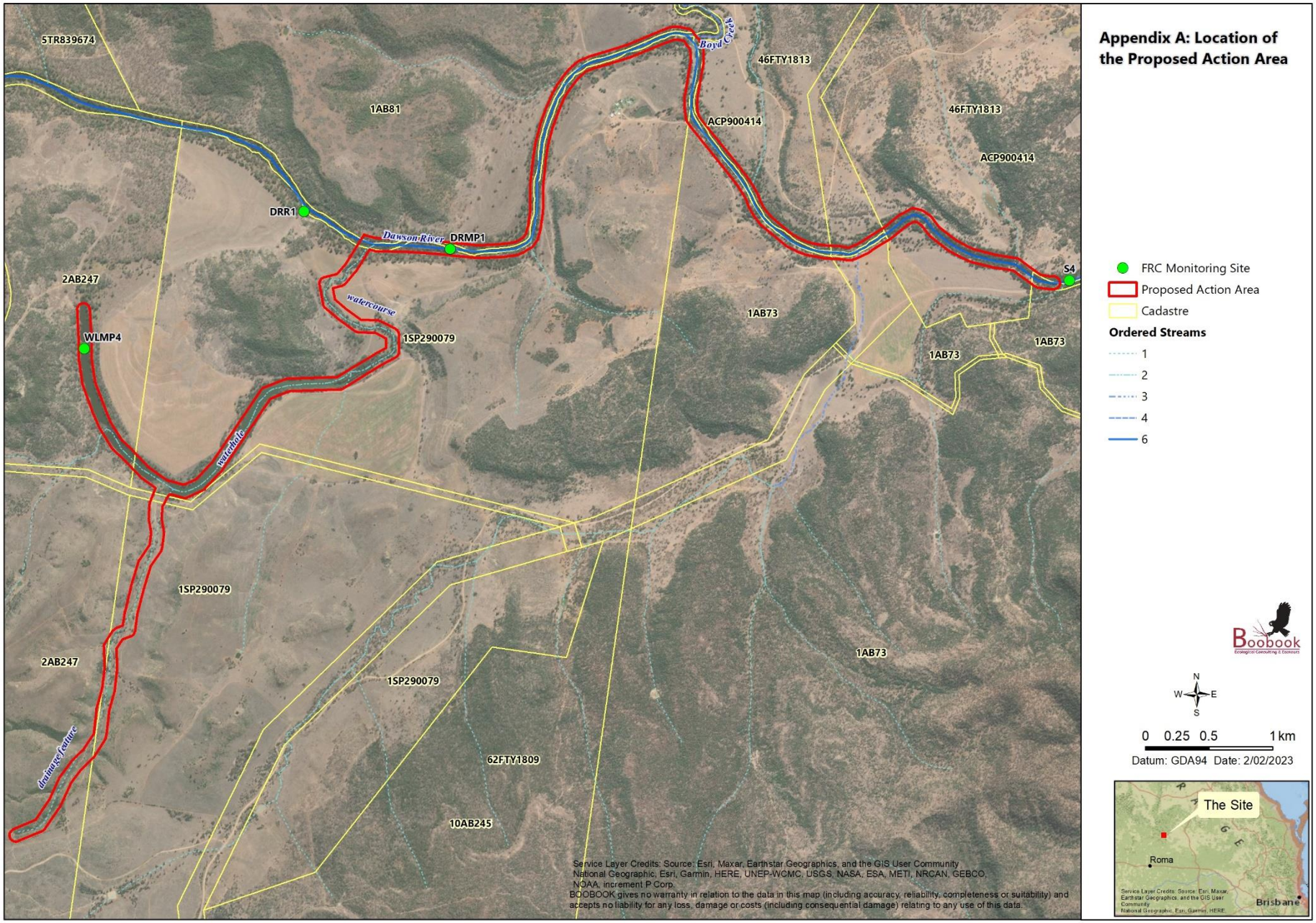
Appendix A. Location of the proposed action area.


Appendix A: Location of the Proposed Action Area
5TR839674
1AB81
46FTY1813
ACP900414
46FTY1813
ACP900414
Boyd Creek
DRR1
Dawson River
DRMP1
S4
2AB247
watercourse
1AB73
WLMP4
1SP290079
1AB73
1AB73
waterhole
1SP290079
2AB247
1AB73
1SP290079
drainage feature
62FTY1809
10AB245
FRC Monitoring Site
Proposed Action Area
Cadastre
Ordered Streams
1
2
3
4
6
Boobook
N
W
E
S
0 0.25 0.5 1 km
Datum: GDA94 Date: 2/02/2023
The Site
Roma
Brisbane
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
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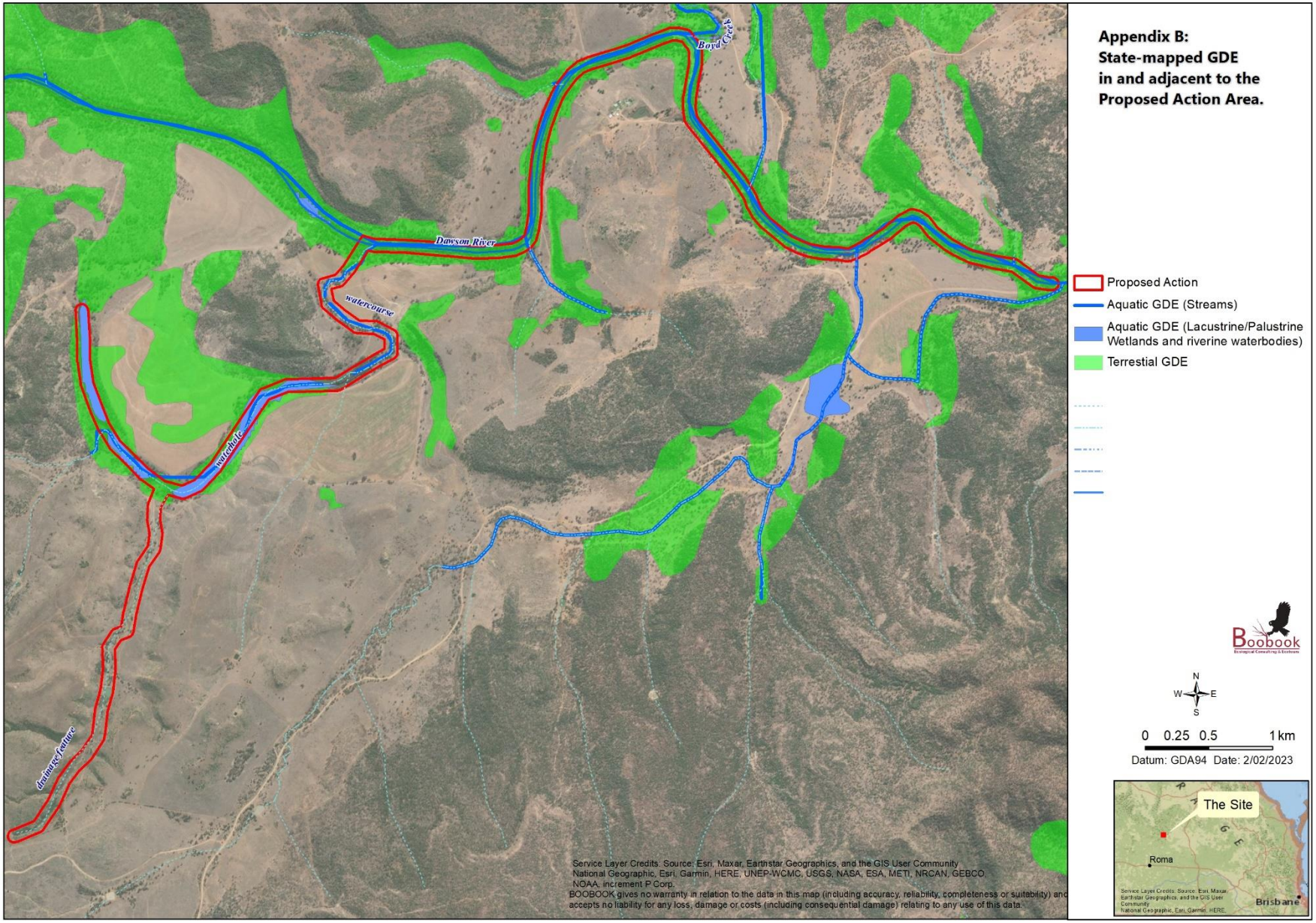
Appendix B. State-mapped GDE in and adjacent to the proposed action area


Boyd Creek
Dawson River
watercourse
waterhole
drainage feature
Appendix B:
State-mapped GDE
in and adjacent to the
Proposed Action Area.
Proposed Action
Aquatic GDE (Streams)
Aquatic GDE (Lacustrine/Palustrine Wetlands and riverine waterbodies)
Terrestial GDE
Boobook
N
W
E
S
0 0.25 0.5 1 km
Datum: GDA94 Date: 2/02/2023
The Site
Roma
Brisbane
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
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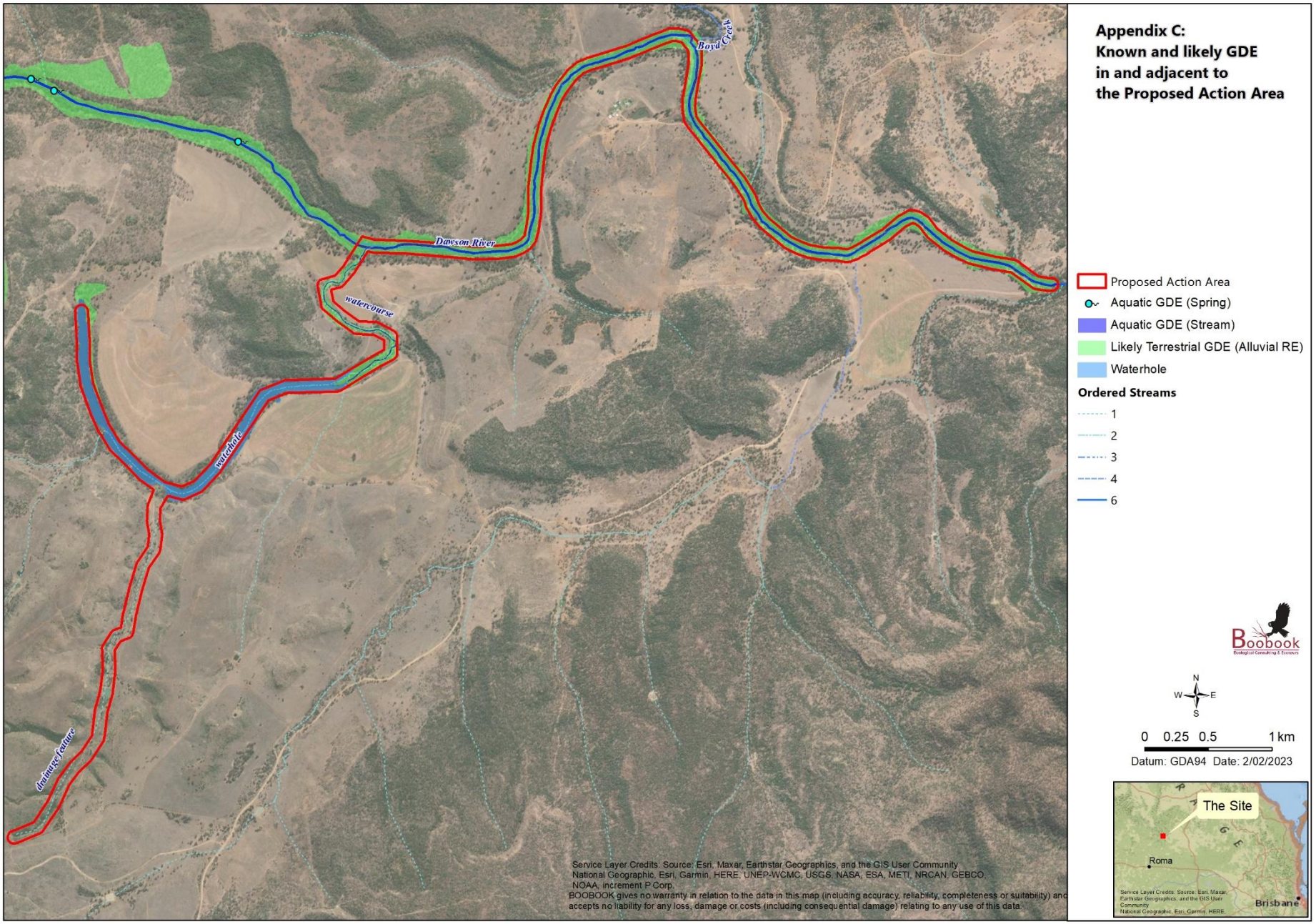
Appendix C. Known and likely GDE in and adjacent to the proposed action area


Boyd Creek
Dawson River
watercourse
waterhole
drainage feature
Appendix C:
Known and likely GDE
in and adjacent to
the Proposed Action Area
Proposed Action Area
Aquatic GDE (Spring)
Aquatic GDE (Stream)
Likely Terrestrial GDE (Alluvial RE)
Waterhole
Ordered Streams
1
2
3
4
6
Boobook
Ecological Consulting & Ecotours
N
W
E
S
0 0.25 0.5 1 km
Datum: GDA94 Date: 2/02/2023
The Site
Roma
Brisbane
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
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