Australian Government

BIOREGIONAL ASSESSMENTS

PROVIDING SCIENTIFIC WATER RESOURCE INFORMATION ASSOCIATED WITH COAL SEAM GAS AND LARGE COAL MINES

Description of the water-dependent asset register for the Clarence-Moreton bioregion

Product 1.3 from the Clarence-Moreton Bioregional Assessment

1 October 2015

A scientific collaboration between the Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a transparent and accessible programme of baseline assessments that increase the available science for decision making associated with coal seam gas and large coal mines. A bioregional assessment is a scientific analysis of the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources. This Programme draws on the best available scientific information and knowledge from many sources, including government, industry and regional communities, to produce bioregional assessments that are independent, scientifically robust, and relevant and meaningful at a regional scale.

The Programme is funded by the Australian Government Department of the Environment. The Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia are collaborating to undertake bioregional assessments. For more information, visit http://www.bioregionalassessments.gov.au.

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Cover photograph

Rainforest waterfall in Border Ranges National Park, NSW, 2008

Credit: Liese Coulter, CSIRO

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Introduction

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) was established to provide advice to the federal Minister for the Environment on potential water-related impacts of coal seam gas (CSG) and large coal mining developments.

Bioregional assessments (BAs) are one of the key mechanisms to assist the IESC in developing this advice so that it is based on best available science and independent expert knowledge. Importantly, technical products from BAs are also expected to be made available to the public, providing the opportunity for all other interested parties, including government regulators, industry, community and the general public, to draw from a single set of accessible information. A BA is a scientific analysis, providing a baseline level of information on the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of CSG and coal mining development on water resources.

The IESC has been involved in the development of *Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources* (the BA methodology; Barrett et al., 2013) and has endorsed it. The BA methodology specifies how BAs should be undertaken. Broadly, a BA comprises five components of activity, as illustrated in Figure 1. Each BA will be different, due in part to regional differences, but also in response to the availability of data, information and fit-for-purpose models. Where differences occur, these are recorded, judgments exercised on what can be achieved, and an explicit record is made of the confidence in the scientific advice produced from the BA.

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a collaboration between the Department of the Environment, the Bureau of Meteorology, CSIRO and Geoscience Australia. Other technical expertise, such as from state governments or universities, is also drawn on as required. For example, natural resource management groups and catchment management authorities identify assets that the community values by providing the list of water-dependent assets, a key input.

The Technical Programme, part of the Bioregional Assessment Programme, will undertake BAs for the following bioregions and subregions:

- the Galilee, Cooper, Pedirka and Arckaringa subregions, within the Lake Eyre Basin bioregion
- the Maranoa-Balonne-Condamine, Gwydir, Namoi and Central West subregions, within the Northern Inland Catchments bioregion
- the Clarence-Moreton bioregion
- the Hunter and Gloucester subregions, within the Northern Sydney Basin bioregion
- the Sydney Basin bioregion
- the Gippsland Basin bioregion.

Technical products (described in a later section) will progressively be delivered throughout the Programme.

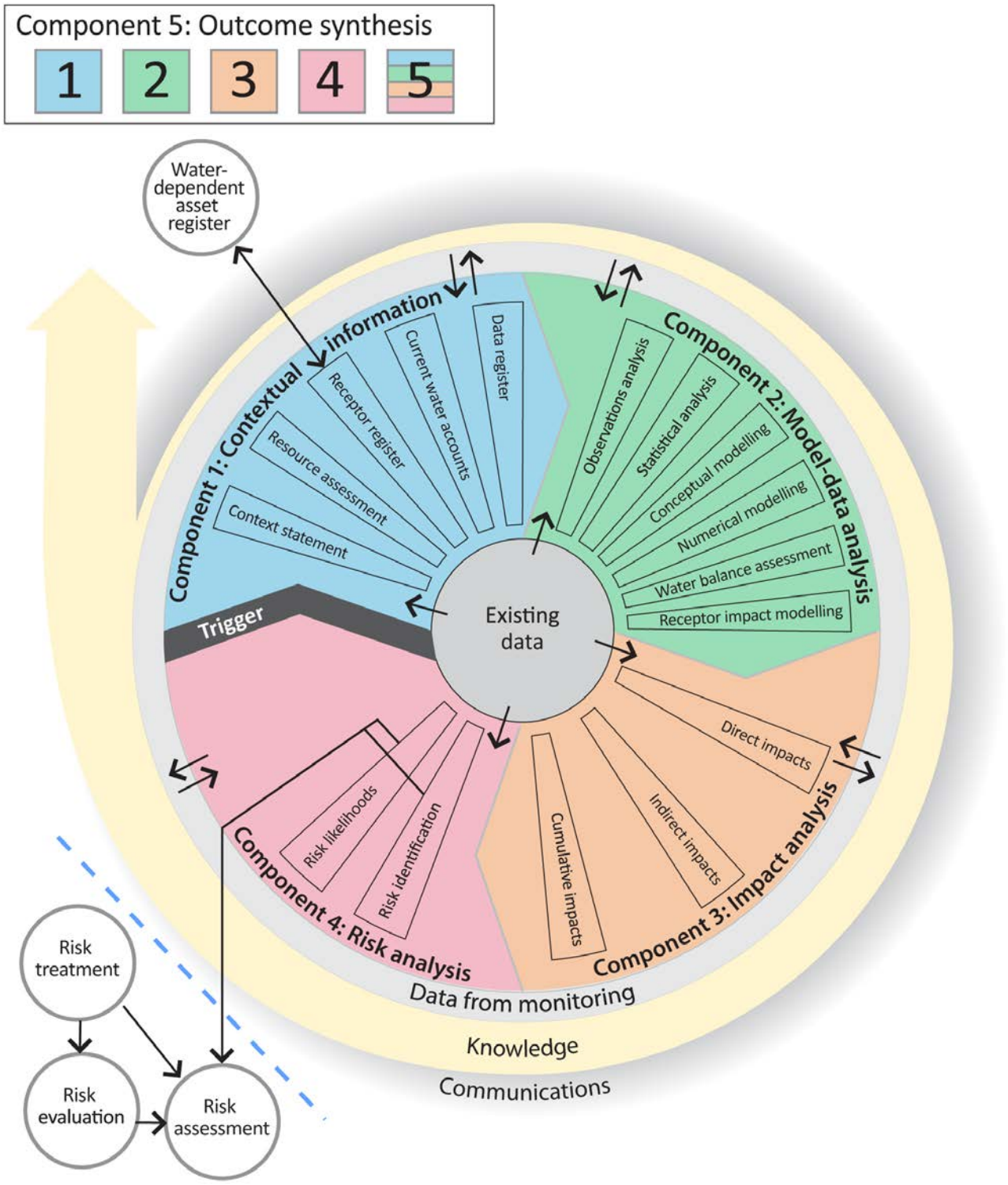

Figure 1 Schematic diagram of the bioregional assessment methodology

The methodology comprises five components, each delivering information into the bioregional assessment and building on prior components, thereby contributing to the accumulation of scientific knowledge. The small grey circles indicate activities external to the bioregional assessment. Risk identification and risk likelihoods are conducted within a bioregional assessment (as part of Component 4) and may contribute activities undertaken externally, such as risk evaluation, risk assessment and risk treatment. Source: Figure 1 in Barrett et al. (2013), © Commonwealth of Australia

Methodologies

For transparency and to ensure consistency across all BAs, submethodologies have been developed to supplement the key approaches outlined in the *Methodology for bioregional assessments of the impact of coal seam gas and coal mining development on water resources* (Barrett et al., 2013). This series of submethodologies aligns with technical products as presented in Table 1. The submethodologies are not intended to be 'recipe books' nor to provide step-by-step instructions; rather they provide an overview of the approach to be taken. In some instances, methods applied for a particular BA may need to differ from what is proposed in the submethodologies – in this case an explanation will be supplied. Overall, the submethodologies are intended to provide a rigorously defined foundation describing how BAs are undertaken.

Table 1 Methodologies and associated technical products listed in Table 2

Code	Proposed title	Summary of content	Associated technical product
M01	*Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources*	A high-level description of the scientific and intellectual basis for a consistent approach to all bioregional assessments	All
M02	*Compiling water-dependent assets*	Describes the approach for determining water-dependent assets	1.3 Description of the water-dependent asset register
M03	*Assigning receptors and impact variables to water-dependent assets*	Describes the approach for determining receptors associated with water-dependent assets	1.4 Description of the receptor register
M04	*Developing a coal resource development pathway*	Specifies the information that needs to be collected and reported in product 1.2 (i.e. known coal and coal seam gas resources as well as current and potential resource developments). Describes the process for determining the coal resource development pathway (reported in product 2.3)	1.2 Coal and coal seam gas resource assessment 2.3 Conceptual modelling
M05	*Developing the conceptual model for causal pathways*	Describes the development of the conceptual model for causal pathways, which summarises how the 'system' operates and articulates the links between coal resource developments and impacts on receptors	2.3 Conceptual modelling
M06	*Surface water modelling*	Describes the approach taken for surface water modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative.	2.6.1 Surface water numerical modelling
M07	*Groundwater modelling*	Describes the approach taken for groundwater modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative. It also considers surface water – groundwater interactions, as well as how the groundwater modelling is constrained by geology.	2.6.2 Groundwater numerical modelling

Code	Proposed title	Summary of content	Associated technical product
M08	*Receptor impact modelling*	Describes how to develop the receptor impact models that are required to assess the potential impacts from coal seam gas and large coal mining on receptors. Conceptual, semi-quantitative and quantitative numerical models are described.	2.7 Receptor impact modelling
M09	*Propagating uncertainty through models*	Describes the approach to sensitivity analysis and quantifying uncertainty in the modelled hydrological response to coal and coal seam gas development	2.3 Conceptual modelling 2.6.1 Surface water numerical modelling 2.6.2 Groundwater numerical modelling 2.7 Receptor impact modelling
M10	*Risk and cumulative impacts on receptors*	Describes the process to identify and analyse risk	3 Impact analysis 4 Risk analysis
M11	*Hazard identification*	Describes the process to identify potential water-related hazards from coal and coal seam gas development	2 Model-data analysis 3 Impact analysis 4 Risk analysis
M12	*Fracture propagation and chemical concentrations*	Describes the likely extent of both vertical and horizontal fractures due to hydraulic stimulation and the likely concentration of chemicals after production of coal seam gas	2 Model-data analysis 3 Impact analysis 4 Risk analysis

Each submethodology is available online at http://www.bioregionalassessments.gov.au. Submethodologies might be added in the future.

Technical products

The outputs of the BAs include a suite of technical products variously presenting information about the ecology, hydrology, hydrogeology and geology of a bioregion and the potential direct, indirect and cumulative impacts of CSG and coal mining developments on water resources, both above and below ground. Importantly, these technical products are available to the public, providing the opportunity for all interested parties, including community, industry and government regulators, to draw from a single set of accessible information when considering CSG and large coal mining developments in a particular area.

The information included in the technical products is specified in the BA methodology. Figure 2 shows the information flow within a BA. Table 2 lists the content provided in the technical products, with cross-references to the part of the BA methodology that specifies it. The red rectangles in both Figure 2 and Table 2 indicate the information included in this technical product.

This technical product is delivered as a report (PDF). Additional material is also provided, as specified by the BA methodology:

- all unencumbered data syntheses and databases
- unencumbered tools, model code, procedures, routines and algorithms
- unencumbered forcing, boundary condition, parameter and initial condition datasets
- the workflow, comprising a record of all decision points along the pathway towards completion of the BA, gaps in data and modelling capability, and provenance of data.

The PDF of this technical product, and the additional material, are available online at http://www.bioregionalassessments.gov.au.

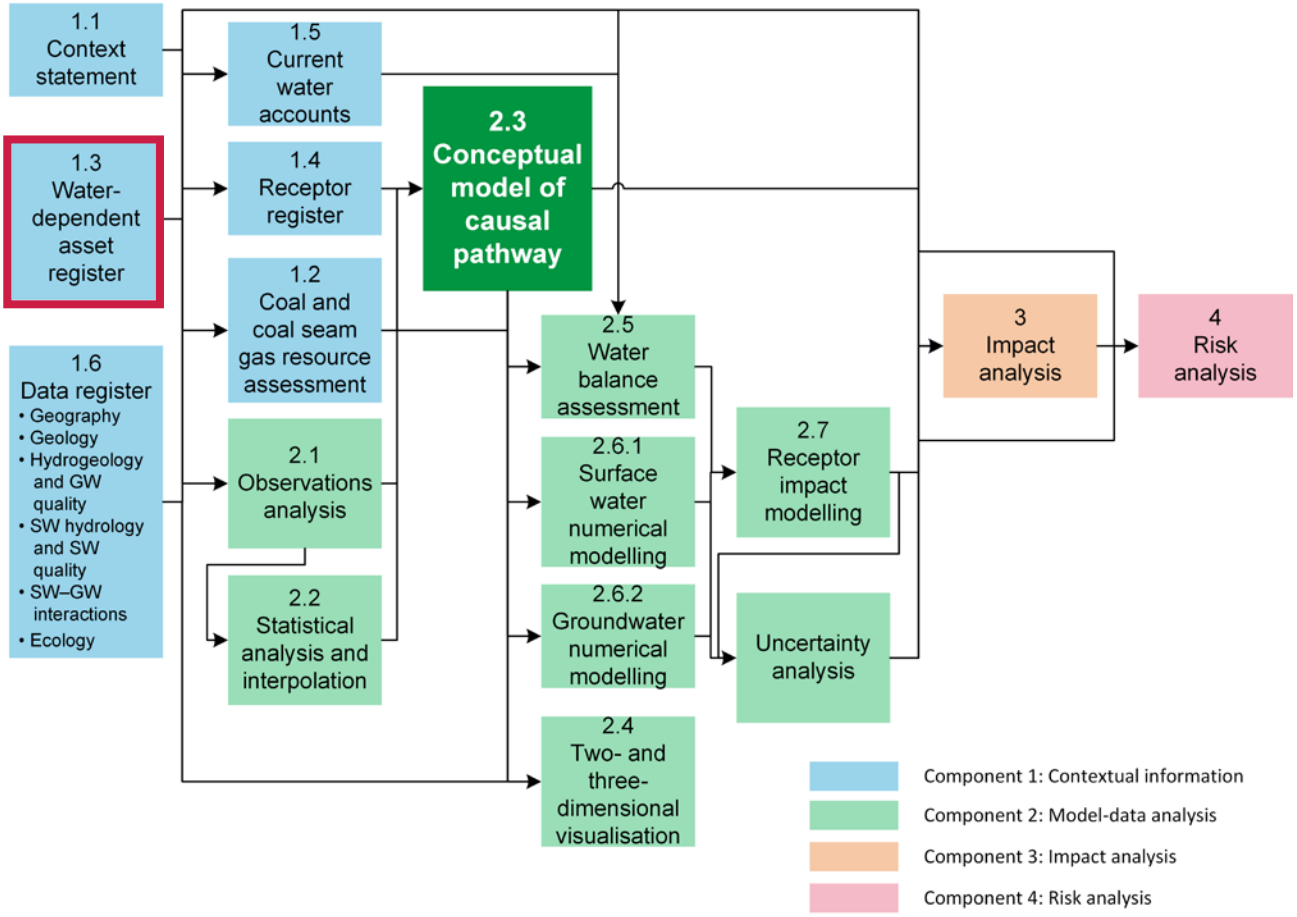

Figure 2 The simple decision tree indicates the flow of information through a bioregional assessment

The red rectangle indicates the information included in this technical product.

Table 2 Technical products delivered by the Clarence-Moreton Bioregional Assessment

For each subregion in the Clarence-Moreton Bioregional Assessment, technical products are delivered online at http://www.bioregionalassessments.gov.au, as indicated in the 'Type' column[a]. Other products – such as datasets, metadata, data visualisation and factsheets – are provided online.

Component	Product code	Title	Section in the BA methodology[b]	Type[a]
Component 1: Contextual information for the Clarence-Moreton bioregion	1.1	Context statement	2.5.1.1, 3.2	PDF, HTML
	1.2	Coal and coal seam gas resource assessment	2.5.1.2, 3.3	PDF, HTML
	1.3	Description of the water-dependent asset register	2.5.1.3, 3.4	PDF, HTML, register
	1.4	Description of the receptor register	2.5.1.4, 3.5	PDF, HTML, register
	1.5	Current water accounts and water quality	2.5.1.5	PDF, HTML
	1.6	Data register	2.5.1.6	Register
Component 2: Model-data analysis for the Clarence-Moreton bioregion	2.1-2.2	Observations analysis, statistical analysis and interpolation	2.5.2.1, 2.5.2.2	PDF, HTML
	2.3	Conceptual modelling	2.5.2.3, 4.3	PDF, HTML
	2.5	Water balance assessment	2.5.2.4	PDF, HTML
	2.6.1	Surface water numerical modelling	4.4	PDF, HTML
	2.6.2	Groundwater numerical modelling	4.4	PDF, HTML
	2.7	Receptor impact modelling	2.5.2.6, 4.5	Not produced
Component 3: Impact analysis for the Clarence-Moreton bioregion	3-4	Impact analysis	5.2.1	PDF, HTML
Component 4: Risk analysis for the Clarence-Moreton bioregion		Risk analysis	2.5.4, 5.3	
Component 5: Outcome synthesis for the Clarence-Moreton bioregion	5	Outcome synthesis	2.5.5	PDF, HTML

[a]The types of products are as follows:

- 'PDF' indicates a PDF document that is developed by the Clarence-Moreton Bioregional Assessment using the structure, standards, and look and feel specified by the programme.
- 'HTML' indicates the same content as in the PDF document, but delivered as webpages.
- 'Register' indicates controlled lists that are delivered using a variety of formats as appropriate.
- 'Not produced' indicates that the product was not developed. A webpage explains why and points to relevant submethodologies (Table 1).

About this technical product

The following notes are relevant only for this technical product.

- All reasonable efforts were made to provide all material under a Creative Commons Attribution 3.0 Australia Licence. The copyright owners of the following figures, however, did not grant permission to do so: Figure 4. It should be assumed that third parties are not entitled to use this material without permission from the copyright owner.
- All maps created as part of this BA for inclusion in this product used the Albers equal area projection with a central meridian of 151.0° East for the Clarence-Moreton bioregion and two standard parallels of –18.0° and –36.0°.
- Contact bioregionalassessments@bom.gov.au to access metadata (including copyright, attribution and licensing information) for all datasets cited or used to make figures in this product. At a later date, this information, as well as all unencumbered datasets, will be published online.
- The citation details of datasets are correct to the best of the knowledge of the Bioregional Assessment Programme at the publication date of this product. Readers should use the hyperlinks provided to access the most up-to-date information about these data; where there are discrepancies, the information provided online should be considered correct. The dates used to identify Bioregional Assessment Source Datasets are the dataset's published date. Where the published date is not available, the last updated date or created date is used. For Bioregional Assessment Derived Datasets, the created date is used.

References

Barrett DJ, Couch CA, Metcalfe DJ, Lytton L, Adhikary DP and Schmidt RK (2013) Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment. Department of the Environment, Australia. Viewed 8 October 2015, http://www.iesc.environment.gov.au/publications/methodology-bioregional-assessments-impacts-coal-seam-gas-and-coal-mining-development-water.

1.3 Description of the water-dependent asset register for the Clarence-Moreton bioregion

A water-dependent asset has a particular meaning for bioregional assessments; it is an asset potentially impacted by changes in groundwater and/or surface water due to coal or coal seam gas development. Some ecological assets solely depend on incident rainfall and will not be considered as water dependent if evidence does not support a linkage to groundwater or surface water.

This product describes water-dependent assets that have been identified in the bioregional assessment and are listed in the water-dependent asset register (available at http://data.bioregionalassessments.gov.au/product/CLM/CLM/1.3).

1.3.1 Methods

Summary

The water-dependent asset register is a list of water-dependent assets identified for use in the bioregional assessment (BA) of the Clarence-Moreton bioregion. This section details the specific application to the Clarence-Moreton bioregion of methods described in the companion submethodology M02 for compiling water-dependent assets (Mount et al., 2015), outlining how the register was compiled. Key concepts and terminology are also explained.

The methods covered include: the process of collecting different groups of assets and determining their water dependency, the development and compilation of the water-dependent asset register, and the determination of the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion.

The PAE of the Clarence-Moreton bioregion is defined by the boundary of the Clarence-Moreton Basin, a geological basin that contains coal resources of the Walloon Coal Measure (Rassam et al., 2014). The PAE boundary was influenced by the extent of the coal resources under consideration in the bioregion. The assets listed in the water-dependent asset register occur within this PAE.

1.3.1.1 Background and context

This product presents information about the water-dependent asset register developed for the Clarence-Moreton bioregion. The name of the dated snapshot of the asset register that this description refers to is 'Water-dependent asset register and asset list for the Clarence-Moreton bioregion on 19 August 2015' (available at Murray (2015)). The underlying dataset is Bioregional Assessment Programme (Dataset 1). Development of the register followed the methods and processes outlined in the companion submethodology M02 (as listed in Table 1) for compiling water-dependent assets (Mount et al., 2015); their specific application to the Clarence-Moreton bioregion is described in the following sections.

An *asset* is an entity having value to the community and, for BA purposes, is associated with a bioregion or subregion. Technically, an asset is a store of value and may be managed and/or used to maintain and/or produce further value. Each asset will have many values associated with it and they can be measured from a range of perspectives; for example, the values of a wetland can be measured from ecological, sociocultural and economic perspectives. A *bioregion* is a geographic land area within which coal seam gas (CSG) and/or coal mining developments are, or could, take place and for which BAs are conducted.

A *water-dependent asset* has a particular meaning for BAs; it is an asset potentially impacted, either positively or negatively, by changes in the groundwater and/or surface water regime due to coal resource development. Some assets are solely dependent on incident rainfall and will not be considered as water dependent if evidence does not support a linkage to groundwater or surface water.

The *water-dependent asset register* is a simple and authoritative listing of the assets within the *preliminary assessment extent* (PAE) that are potentially subject to water-related impacts. A PAE is the geographic area associated with a bioregion or subregion in which the potential water-related impact of coal resource development on assets is assessed. The compiling of the asset register is the first step to identifying and analysing potentially impacted assets, which is the goal of the overall BA.

The asset source data are compiled into an *asset database*, including the geographic location, which are designated as *elements* (individual spatial features – points, lines and polygons e.g. components of a larger system) and *assets* (combinations of one or more elements). During the compilation process, assets are classified into three groups: (i) ecological, (ii) economic and (iii) sociocultural. Many assets are obtained from state and national databases and an important group of assets is provided by natural resource management organisations (NRMs). The Office of Water Science liaised with Indigenous knowledge holders regarding Indigenous sociocultural water-dependent assets.

The asset database is then used to generate the water-dependent asset register. A preliminary version of the asset register is presented to experts and organisations with local knowledge at organised workshops. Feedback was sought about whether the asset register is complete and correct; appropriate amendments were then made. It is at this stage – when assets have been selected using the PAE and the amended water-dependent assets have been recorded in the database – that the water-dependent asset register is complete for the purposes of producing product 1.3. Note, however, that the addition of new assets to the asset database, or a review of the status of existing assets in the database will mean that the asset register may be updated. As this has implications for other BA components, any updates must be documented. The product 1.3 will not be updated or republished as part of BAs but an updated version of the asset register (derived from the asset database) may be published at the same time as other products, for example, those associated with Component 3: Impact analysis (Figure 1 and Figure 2).

Following development of the asset register, the connection of the registered assets to coal resource development is assessed using 'materiality' tests and, if potentially subject to water-related impacts, assigned *receptors* (after Barrett et al., 2013). A receptor is a point in the landscape where water-related impacts on assets are measured and/or estimated. The approach to assigning receptors to water-dependent assets is described in the companion submethodology M03 (as listed in Table 1).

1.3.1.2 Compiling assets and developing the water-dependent asset register

Assets were initially obtained from national and state governments. An expert workshop was held in Lismore, NSW on 12 December 2014 and in Brisbane (Queensland) on 19 January, 2015. Representatives from the three levels of government (e.g. water management officers), were invited to learn about the Bioregional Assessment process and see what type of assets had already been obtained. They were encouraged to provide feedback about the process and water-dependency decisions and provide links for missing data. Missing assets were obtained, if possible, and the asset register was updated.

1.3.1.2.1 Ecological assets

Ecological asset information for the Clarence-Moreton bioregion was acquired from a number of sources. Data were initially compiled via the BA-purpose-built Water Asset Information Tool (WAIT) database, which was populated by NRMs with contributions from those with expert local knowledge. Asset information for Queensland was provided by the South East Queensland NRM group. Asset information for NSW was provided by the former Northern Rivers Catchment Management Authority (CMA)[1]. Data were also combined with other national, state and regional authorities to complement the coverage of assets provided by the WAIT for the Clarence-Moreton bioregion.

Within the asset database, each surface water, groundwater and vegetation polygon, line or point was identified as an element. Elements were grouped by class and spatial location to create assets, which were assigned unique asset identifiers. For example, the ecological asset 'treed regional ecosystems and riverine wetlands on alluvia with near-permanent flow' (Asset identifier 16996), which comprises 2545 polygon elements, was classified as a groundwater-dependent ecosystem. The Clarence River estuary (Asset identifier 6714) has 250 elements and was classified as a surface water feature, in the 'lake, reservoir, lagoon or estuary' class. Acacia Creek (Asset identifier 15011) has three elements and was classified as a surface water feature in the 'river or stream reach, tributary, anabranch or bend' class. Table 3 lists the number of elements and resultant assets for each data source, along with the data custodians for the ecological assets in the Clarence-Moreton bioregion.

Table 3 Data sources for ecological assets in the Clarence-Moreton bioregion

Dataset[a]	Organisation	Dataset citation	Elements	Assets (asset list)
Collaborative Australian Protected Areas Database (CAPAD)	Department of the Environment	Australian Government Department of the Environment (Dataset 2)	125	125
Water Asset Information Tool (WAIT) database	Southeast Queensland and Northern Rivers Natural Resource Management (NRM) groups	Australian Government Department of the Environment (Dataset 3)	11,296	1,577
A directory of important wetlands in Australia (DIWA)	Department of the Environment	Australian Government Department of the Environment (Dataset 4)	557	16
Ramsar List of Wetlands of International Importance	Department of the Environment	Australian Government Department of the Environment (Dataset 5)	2	1
Threatened ecological communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)	Department of the Environment	Australian Government Department of the Environment (Dataset 6)	14,230	7

[1] From 1 January 2014, in NSW CMAs transitioned into local land services (LLS) regions. However, as this CMA operated within the NSW section of the Clarence-Moreton bioregion when it was defined in 2012, these data have continued to be used.

Dataset[a]	Organisation	Dataset citation	Elements	Assets (asset list)
Threatened species listed under the EPBC Act	Department of the Environment	Australian Government Department of the Environment (Dataset 7)	18,649	93
Birds Australia Important Bird Areas	Birds Australia	Birds Australia (Dataset 8)	4	4
Australian Hydrological Geospatial Fabric stream network	Bureau of Meteorology	Bureau of Meteorology, Water Division, Water Data Services (Dataset 9)	8,249	9
National Groundwater Information System (NGIS)	Bureau of Meteorology	Bureau of Meteorology (Dataset 10)	2,403	5
Queensland threatened species (minus EPBC-listed species)	Queensland Department of Natural Resources and Management (DNRM)	Department of Environment and Heritage Protection (Dataset 11)	36,390	93
QLD GDE_Surface_Areas_v01 QLD GDE_Surface_Lines_v01 QLD GDE_Terrestrial_Areas_v01	Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts (DSITIA)	DSITIA (Dataset 26)	78,450	79
Regional Ecosystem Description Database (REDD)	Queensland Herbarium	Queensland Herbarium, DSITIA (Dataset 25)	1,313	16
WetlandInfo	Queensland Department of Environment and Heritage Protection	Bioregional Assessment Programme (Dataset 24)	2,075	28
High Probability Groundwater Dependent Vegetation with High Ecological Value – Northern Rivers CMA	NSW DPI - Office of Water	NSW Department of Primary Industry (Office of Water) (Dataset 14)	112,010	73
Total			**285,753**	**2,126**

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

1.3.1.2.2 Economic assets

For a BA, water access entitlements are classed into economic elements and assets as either a basic water right (stock and domestic) or as a water access right and their associated water sources; and all the economic assets are considered as water dependent (Mount et al., 2015). An economic asset contains variable numbers of economic elements. An economic element is a combination of an entitlement and its associated work approvals that enable the element to have a specific location. Economic elements are grouped into assets based on water sources in the relevant water sharing plans (WSPs) or water management strategies.

The compiling of the economic asset database and maps for the Clarence-Moreton PAE included four main steps:

1. Source datasets are obtained from the state water agencies in NSW and Queensland.
2. Source datasets are processed by data coordinators at the Bureau of Meteorology (quality check, spatial coordinates added etc.) and the derived products are sent to the Environmental Resources Information Network (ERIN) within the Commonwealth Department of the Environment for inclusion in asset database with the other groups of assets.
3. ERIN compiles the processed data into 'elements' and 'assets' and produces the asset database. ERIN then provides the asset database to the Clarence-Moreton bioregion project team.
4. The Clarence-Moreton bioregion project team then summarises and visualises the economic assets.

Data associated with economic assets for Queensland and NSW were sourced from the Queensland Department of Natural Resources and Mines (Bureau of Meteorology, Dataset 15) and the NSW Office of Water respectively to determine economic assets (NSW Office of Water, Dataset 16) (Table 4). Data related to basic landholder rights in NSW were sourced online from the publicly available WSPs (NSW Department of Primary Industries, 2014). The collected data cover groundwater and surface water access entitlements, and their corresponding works locations.

In collating the economic elements, it was considered important to ensure no current or active water access entitlements were excluded to avoid underestimation of possible impacts, even where there was doubt about the current status of the entitlement as in 'sleeper' licences. For example, basic water rights (stock and domestic) do not have to be renewed on a regular basis thus leading to some uncertainty about their current use status. This meant that only surface water and groundwater access entitlements that are definitely 'abandoned', 'cancelled' or 'suspended' as of 20 November 2013 are excluded for BA purposes.

An economic element may be either a point, line or polygon spatial feature in the asset database and maps. When the location information associated with a water access entitlement was known, the economic element was represented by a point. Otherwise, an economic element was linked to its water source and described by a line or polygon depending on its associated water source. For example, a basic water access right that is held adjacent to a river usually does not have a specified location. However, it is recorded that a particular segment of the river is the water source for this water access right. Thus, the basic water access right will be linked to the associated river segment that is represented by a line or polygon, depending on its width.

Table 4 Data sources for economic assets in the Clarence-Moreton bioregion

Dataset[a]	Organisation	Dataset citation	Elements	Assets (asset list)
NSW groundwater and surface water points	NSW Office of Water and Bureau of Meteorology	NSW Office of Water (Dataset 15)	8053	149
NSW Groundwater Macro Plans	NSW Office of Water and Bureau of Meteorology	NSW Office of Water (Dataset 15)	7	7
NSW Regulated Rivers	NSW Office of Water and Bureau of Meteorology	NSW Office of Water (Dataset 15)	1	1
NSW Water Sharing Plans	NSW Office of Water and Bureau of Meteorology	NSW Office of Water (Dataset 15)	38	38
Queensland groundwater and surface water points	Queensland Department of National Resources and Mines/Bureau of Meteorology	Bureau of Meteorology (Dataset 16)	768	47
Total			**8867**	**242**

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

1.3.1.2.3 Sociocultural assets

Sociocultural data was sourced from the Australian Heritage Database (Australian Government Department of the Environment, Dataset 17, Dataset 18, Dataset 19, Dataset 20) (Table 5). Typically, sociocultural assets that are landscape water features were also included in the ecological asset classes.

Indigenous sites were included, where publicly listed in the Register of the National Estate (RNE). Meetings have been held with Indigenous knowledge holders in the Clarence-Moreton bioregion to gain further understanding of Indigenous cultural water-dependent assets.

Where possible and appropriate, and with the agreement of Indigenous knowledge holders, these additional Indigenous water-related values will be published in a separate report. Identified assets will be incorporated into an updated water-dependent asset register and/or incorporated into later technical products.

Table 5 Data sources in the Australian Heritage Database for sociocultural assets in the Clarence-Moreton bioregion

Dataset[a]	Organisation	Dataset citation	Elements	Assets (asset list)
World Heritage List (WHL)	Department of the Environment	Australian Government Department of the Environment (Dataset 17)	1	1
National Heritage List (NHL)	Department of the Environment	Australian Government Department of the Environment (Dataset 18)	3	3
Commonwealth Heritage List (CHL)	Department of the Environment	Australian Government Department of the Environment (Dataset 19)	12	12
Register of the National Estate (RNE)	Department of the Environment	Australian Government Department of the Environment (Dataset 20)	294	293
Total			**310**	**309**

[a]The asset database (Bioregional Assessment Programme, Dataset 1) is a collation of all these source datasets. Some assets may be captured in multiple databases. These replicates are retained in the asset register as boundaries may differ between databases.

1.3.1.3 Determining the preliminary assessment extent

The PAE is the geographic area associated with a bioregion or subregion in which the potential water-related impact of coal resource development on assets is assessed. Determining the PAE is the first step to identifying the potentially impacted assets. In the case of the Clarence-Moreton bioregion, the PAE was defined by the extent of the geological basin and the extent of the Walloon Coal Measures, the primary stratigraphic target for coal mining and CSG exploration in the Clarence-Moreton Basin. As described by Rassam et al. (2014), the Clarence-Moreton bioregion only includes the eastwards draining part of the Clarence-Moreton Basin. A detailed overview on the characteristics of the stratigraphic units and the geological framework of the Clarence-Moreton bioregion is given in products 1.1 and 1.2 of the Clarence-Moreton BA (Rassam et al., 2014; Raiber et al., 2014). The PAE boundary is conservative; it includes older sedimentary bedrock units of the Clarence-Moreton Basin (stratigraphically below the Walloon Coal Measures) up-gradient and typically more than 20 km away from any areas of coal seam gas exploration activities (Figure 3).

The PAE almost comprises the entire Clarence-Moreton bioregion (Figure 3 and Figure 5), with the exception being parts of the Brisbane river basin (Lockyer Valley) (Figure 3). Here, the Walloon Coal Measures are either absent or very thin (<50 to 100 m) and covered by more than 100 m of basalts, and this area is therefore not a coal seam gas exploration target. The older sedimentary bedrock units of the Clarence-Moreton Basin which are present in the Lockyer Valley are up-gradient from areas where coal seam gas exploration has occurred (Figure 3) and are therefore unlikely to be impacted by any CSG activities.

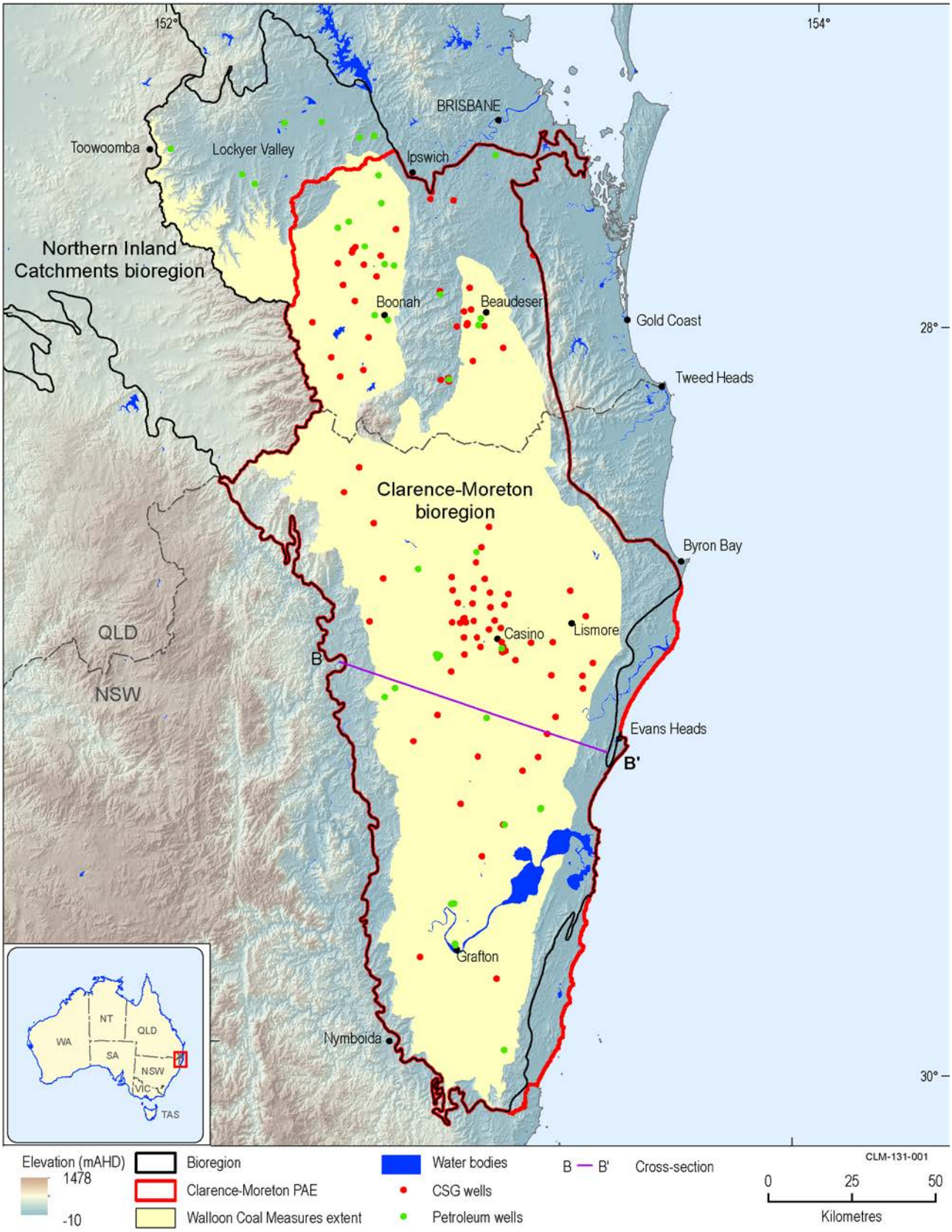

Figure 3 Extent of Walloon Coal Measures in the Clarence-Moreton bioregion, coal seam gas and petroleum exploration wells and spatial relationship to the preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 21, Dataset 22)

There is only a very limited understanding of the hydraulic connectivity between the basal Clarence-Moreton Basin aquifers and the basement aquifers, which underlie the Clarence-

Moreton Basin (Figure 4). However, the rocks that form the hydraulic basement to the Clarence-Moreton Basin sedimentary sequences are part of the New England Orogen (e.g. Texas Block, Coffs Harbour Block and Beenleigh Block), which is dominated by granitic plutons, igneous complexes or metasedimentary rocks (Rassam et al., 2014). These rock types are commonly considered to have characteristics of low-permeability and low-yielding aquifers or aquitards. In addition, these areas are up-gradient from the proposed areas of CSG development. Hence, there is unlikely to be any significant connectivity between rock sequences of the Clarence-Moreton Basin and the underlying basement rocks, and it is very unlikely that drawdown resulting from the depressurisation of the coal seams will have any influence on basement units outside the area of the Clarence-Moreton bioregion. Consequently, the basement rocks of the New England Orogen outside the Clarence-Moreton bioregion were not incorporated into the PAE.

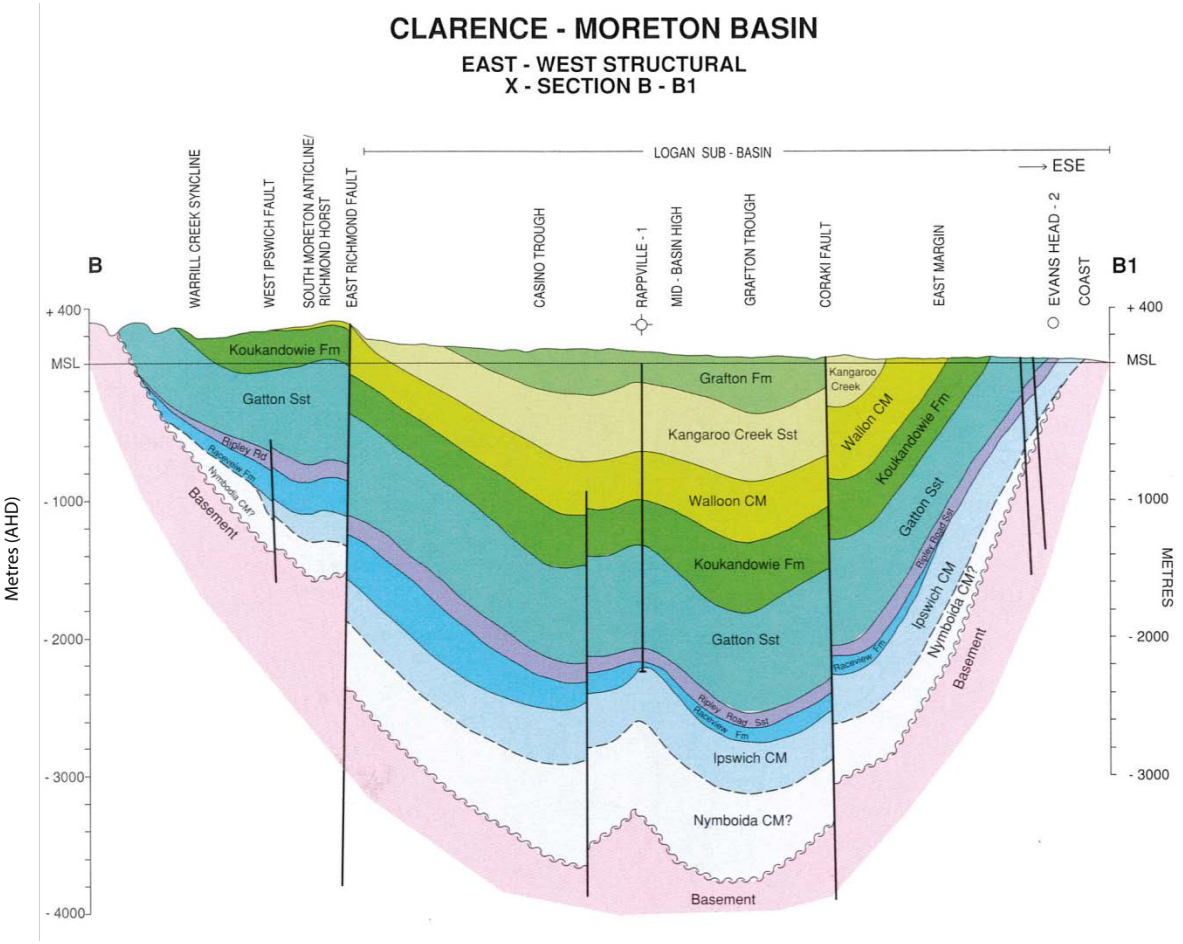

Figure 4 Cross-section of the Clarence-Moreton Basin in NSW. Vertical lines indicate faults. The orientation of the cross-section is shown on Figure 3

Source: Ingram and Robinson (1996). This figure is not covered by a Creative Commons Attribution licence. It has been reproduced with permission from NSW Trade and Investment.

Currently, the understanding on groundwater flow and surface water – groundwater interaction, especially in the NSW part of the Clarence-Moreton bioregion, is limited due to the lack of data for deeper formations and the complexity of the geology and hydrology.

The coastal areas at the eastern part of the Richmond and Clarence river basins outside the Clarence-Moreton bioregion boundary (Figure 3 and Figure 5) are included in the PAE, as any

changes of surface water quality or quantity may have impact on the water-dependent assets in these areas.

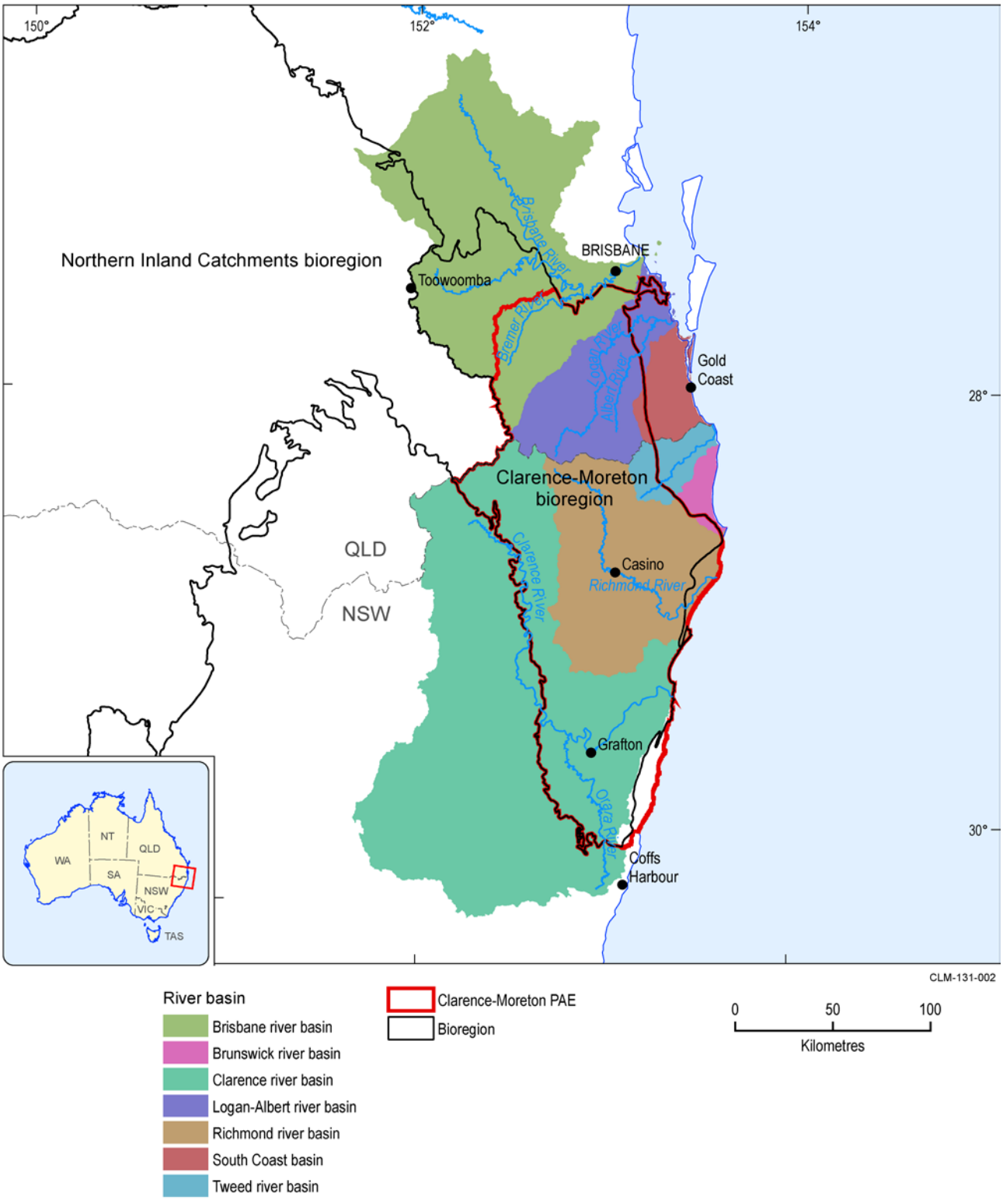

Figure 5 Location of the Clarence-Moreton bioregion and its associated river catchments showing the preliminary assessment extent (PAE) does not follow river basins

Data: Geoscience Australia (Dataset 23)

1.3.1.4 Assessing water dependence

Once the assets were compiled into the asset database and checked for inclusion in the PAE, they were assessed for water dependence. All assets in the asset list that may have been potentially impacted by changes in the groundwater or surface water regime due to coal resource development were identified. Although most of these assets were clearly water dependent (e.g. bores, rivers, wetlands), there were some that were less readily identifiable as 'water dependent'. Examples of these assets include species distributions that may use habitats associated with water dependency amongst other habitats that are not water dependent, or Indigenous assets that may be more difficult to access due to changes in the water regime.

All economic assets were assumed to be water dependent. Sociocultural assets were assessed by their vicinity to water features. That is, an intersection was run between the sociocultural assets and streams and groundwater-dependent ecosystems (GDEs). If a surface water feature or GDE intersected (i.e. overlaps at least some of the same geographic area) with the asset, it was considered to be water dependent.

The ecological assets were assessed through common knowledge (e.g. if the asset was a surface water feature, such as a river), literature searches and spatial intersections through Geographic Information Systems (GIS) software. All assets in the 'Surface water feature' and 'Groundwater feature (subsurface)' subgroups were assumed to be water dependent (Section 1.3.4).

The water dependency of threatened species assets were assessed through their habitats rather than the species per se. This was because the BAs consider the potential impact on an asset (or the habitat of an asset if it is a species distribution) as a result of groundwater or surface water changes due to coal resource development (Mount et al., 2015). In most cases, profiles from the NSW species profiles (NSW Environment and Heritage, 2013) were accessed for information on species' habitat. The information on the Species Profile and Threats Database (SPRAT) (Australian Government Department of the Environment, Dataset 7) and the Queensland Government's Wetland*Info* website (DEHP, 2014a) were also examined. The water dependence of the habitat for each species-related asset was ranked as being 'likely' if habitat features were consistent with demonstrated water dependency, 'possible' if habitat features were consistent with water dependency or 'unlikely' if habitat features were not consistent with demonstrated water dependency. Assets with 'habitat features consistent with demonstrated water dependency' were those with a clear and demonstrated link to aquatic ecosystems (e.g. aquatic species). Assets with 'habitat features consistent with water dependency' may have had some overlaps with habitats that were water dependent (e.g. habitat may have included riparian areas) so links were possible but difficult to prove. Assets listed with 'habitat features not consistent with water dependency' showed no water dependence in habitat requirements.

Only threatened species with modelled habitat data were included in the asset database. Therefore, a number of threatened species with known water dependency were not included, particularly the aquatic species. Negotiations have been underway to access models of these data from the relevant agencies. The data will be included in future products.

Water dependency of vegetation assets were assessed using the following rules:

- Riparian vegetation were assumed to be water dependent.
- Vegetation assets that intersected with local GDE data (NSW Department of Primary Industry (Office of Water), Dataset 14; DEHP, 2014b) and wetland data (NSW Office of Environment and Heritage 2001; DEHP, 2014c) were assumed to be water dependent.
- All vegetation assets in the 'Groundwater-dependent ecosystem' class (Section 1.3.2) with a known groundwater dependency derived from previous field work or a high potential for groundwater dependency were assumed to be groundwater dependent and attributed as 'likely'. Assets with a moderate potential for groundwater dependency were attributed as 'possible'.

All vegetation assets that intersected with drainage lines that have some surface groundwater dependency (GDE lines) were considered water dependent. A preliminary version of the asset data register was created, with associated decisions on water dependence. The preliminary version, with associated maps and data, was presented to experts and organisations with local knowledge for comment and feedback at two workshops: Lismore in December 2014 for the NSW assets and Brisbane in January 2015 for the Queensland assets. As a result, further assets were added to the asset register and assessed for water dependence accordingly.

The characteristics of the groups of water-dependent assets identified in the Clarence-Moreton bioregion, and the reasons for their inclusion or exclusion from the water-dependent asset register, are described in Section 1.3.2, Section 1.3.3 and Section 1.3.4.

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1.3.2 Ecological assets

Summary

The water-dependent asset register for the Clarence-Moreton bioregion contained 1520 ecological assets assessed from the 1616 in the asset list provided as of 19 August 2015. The asset register was divided into surface water features, subsurface groundwater features and vegetation. All surface water features were assumed to be water dependent. The asset list includes the potential spatial habitat distribution of 93 species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and 93 species listed under Queensland's *Nature Conservation Act 1992* (Nature Conservation Act). Four important bird areas (IBAs) and 170 lake, waterhole or wetland associated areas across the preliminary assessment extent (PAE) for the Clarence-Moreton bioregion were assessed. Seven threatened ecological communities within the PAE were also included in the asset list. There were also 157 groundwater-dependent ecosystems (GDEs) assessed for dependency on subsurface water or where the groundwater connected with surface water. Data knowledge gaps were identified, for example, when information was not available or species distributions were not modelled.

1.3.2.1 Description

The total number of ecological assets assessed for water dependency in the PAE of the Clarence-Moreton bioregion was 1616, including 1111 in the 'Surface water feature' subgroup and 505 in the 'Vegetation' subgroup (Table 6). All of the 1111 surface water features (consisting of six classes listed in Table 6) were assumed to be water dependent and were included in the water-dependent asset register. Of the 505 vegetation ecological assets, there were 157 classed as 'Groundwater-dependent ecosystem' of which all are water dependent.

Table 6 Summary of ecological assets within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion

Subgroup	Class	Not in water-dependent asset register	In water-dependent asset register	Total assets (asset list)
Surface water feature	River or stream reach, tributary, anabranch or bend	0	887	887
	Lake, reservoir, lagoon or estuary	0	39	39
	Waterhole, pool, rock pool or billabong	0	29	29
	Wetland, wetland complex or swamp	0	90	90
	Marsh, sedgeland, bog, spring or soak	0	12	12
	Floodplain	0	54	54
Vegetation	Groundwater-dependent ecosystem	0	157	157
	Habitat (potential species distribution)	96	242	338
	Riparian vegetation	0	10	10
Total		**96**	**1520**	**1616**

Data: Bioregional Assessment Programme (Dataset 1)

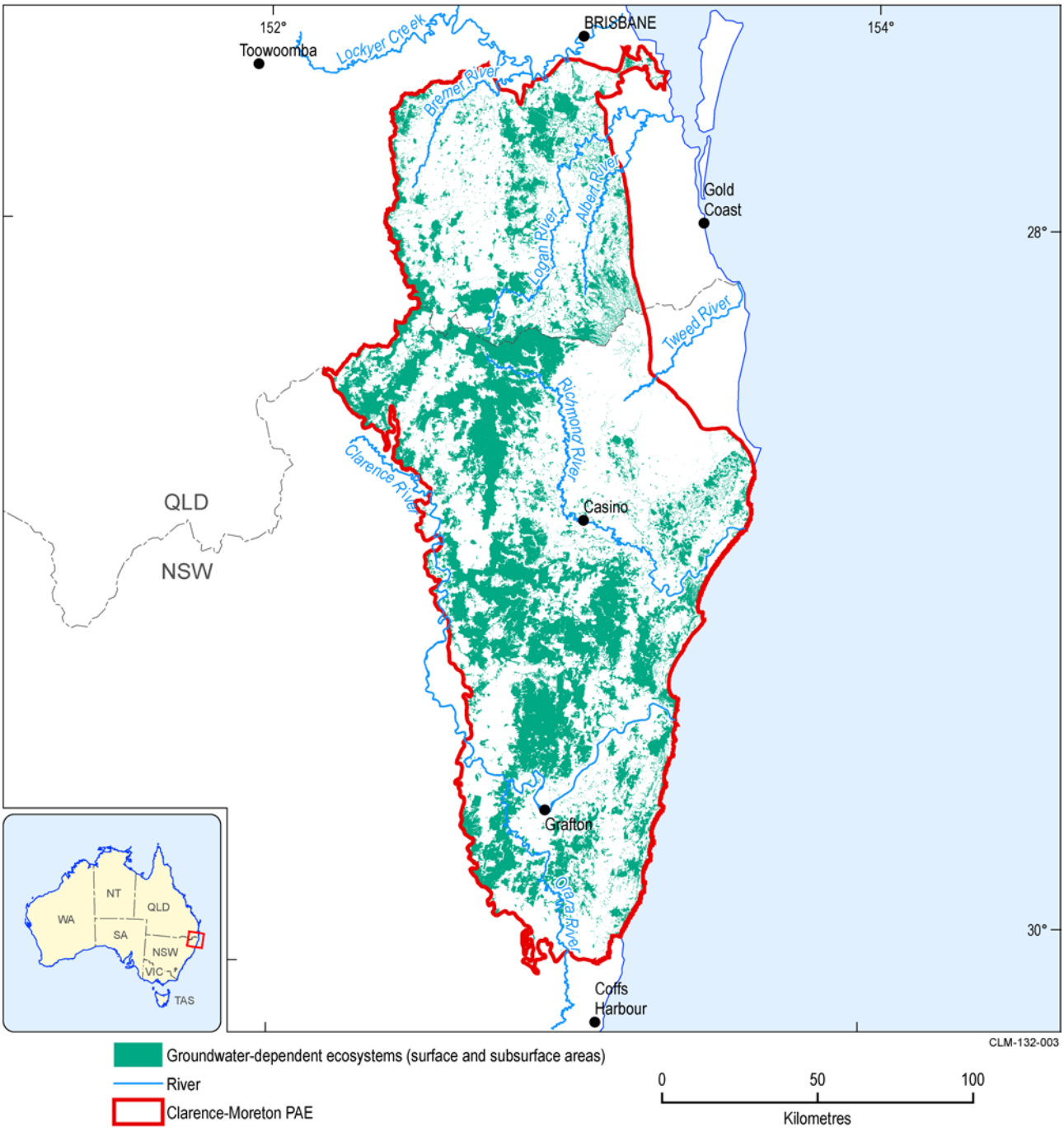

Figure 6 Groundwater-dependent ecosystems within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion

Data: Bioregional Assessment Programme (Dataset 1)

1.3.2.1.1 Surface water features

There were 1111 ecological assets associated with the 'Surface water features' subgroup in the PAE of the Clarence-Moreton bioregion (Table 6). These assets included: wetland, wetland complex or swamp; lake, reservoir, lagoon or estuary; marsh, sedgeland, bog spring or soak (Figure 7), rivers and streams (Figure 8). For the purposes of compiling the preliminary version of the asset register, all assets within this subgroup were assumed to be water dependent.

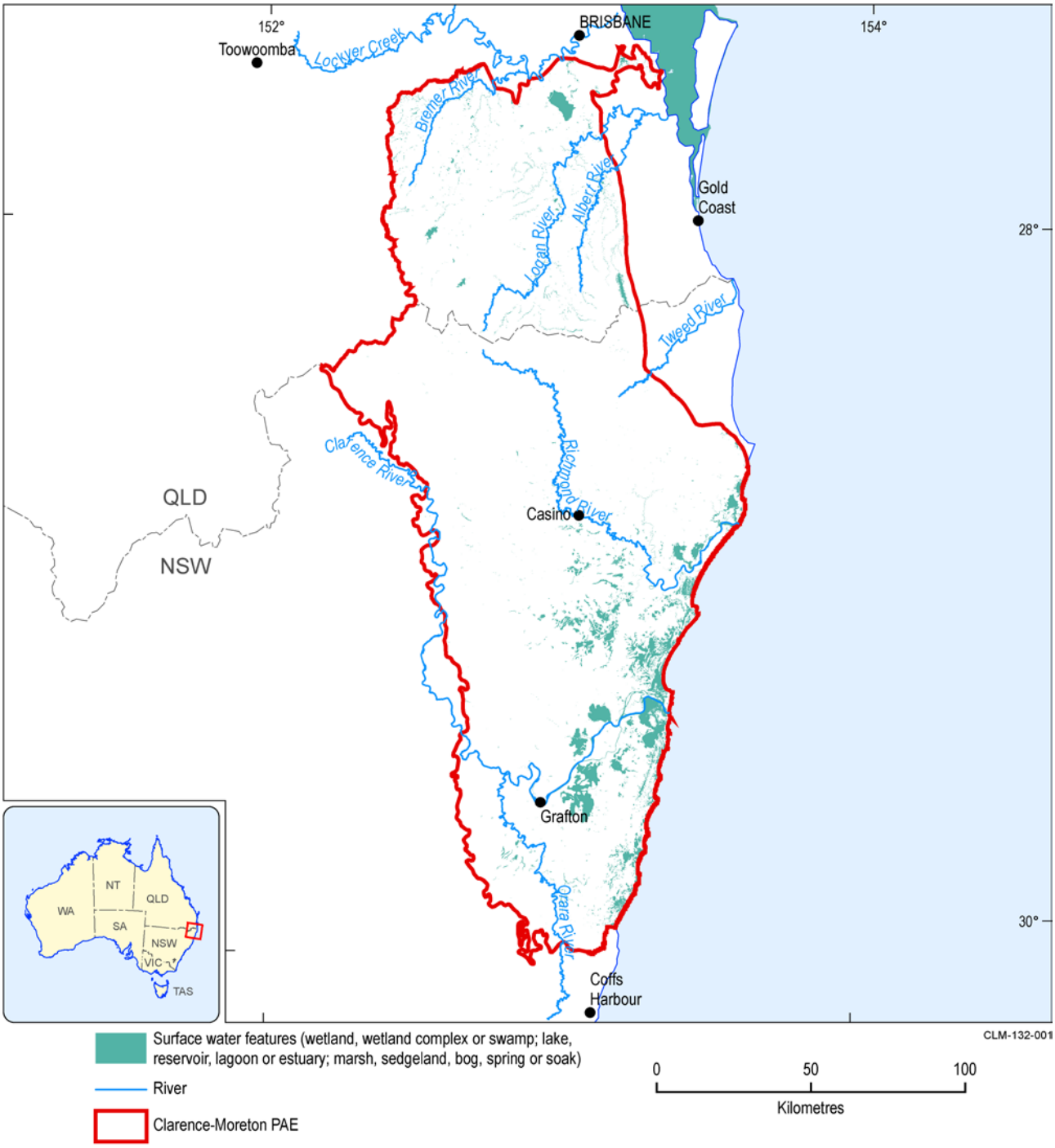

Figure 7 Surface water features and major rivers within the preliminary assessment extent (PAE) for the Clarence-Moreton bioregion

Data: Bioregional Assessment Programme (Dataset 1)

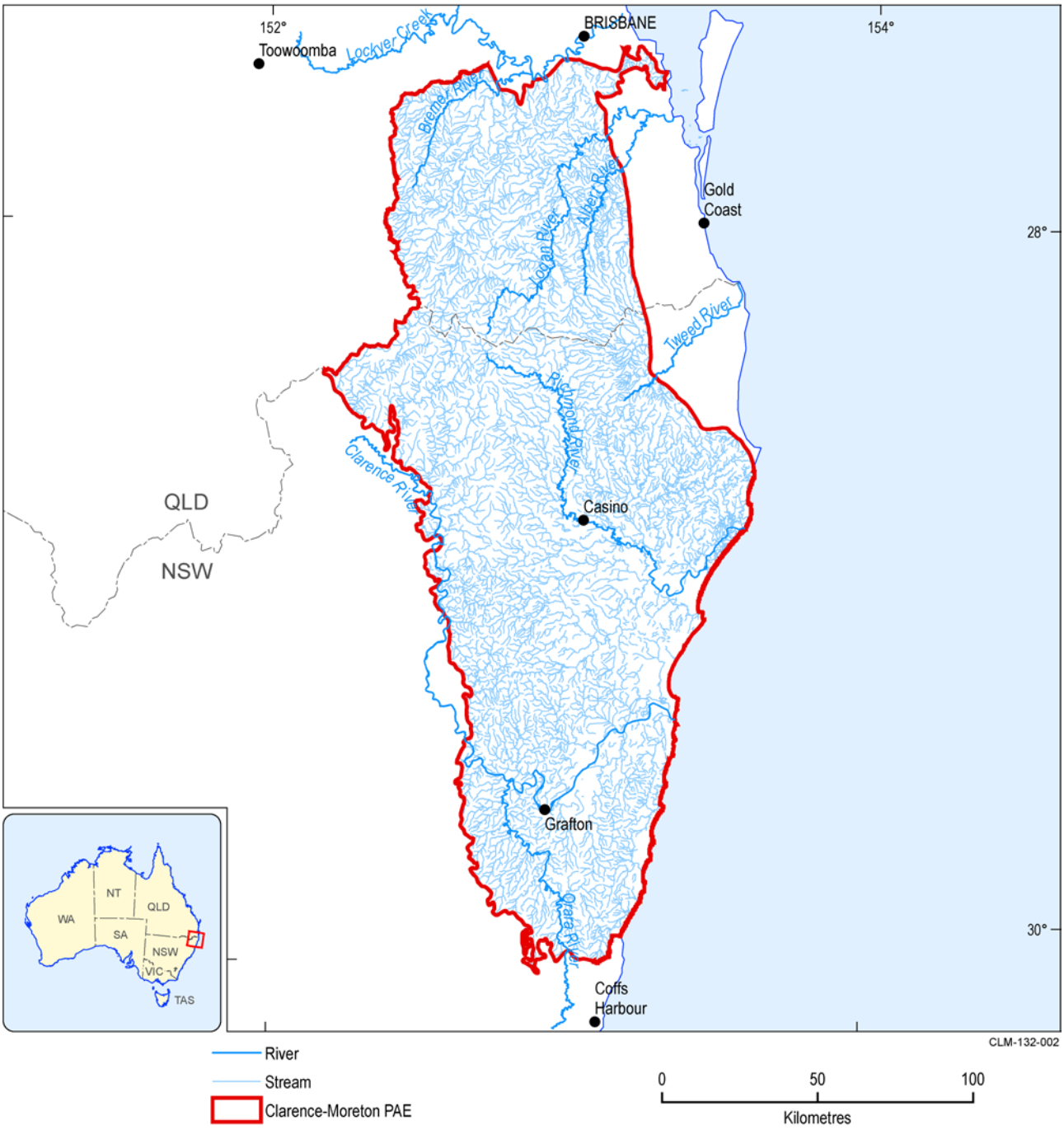

Figure 8 Stream network within the preliminary assessment extent (PAE) for the Clarence-Moreton bioregion

Data: Geoscience Australia (Dataset 3)

1.3.2.1.2 Groundwater features

Subsurface and surface (where groundwater rises to meet surface water) GDEs were present in the PAE of the Clarence-Moreton bioregion including groundwater-dependent vegetation. There were 157 groundwater-dependent ecosystem groundwater features assumed to be water dependent (Table 6). Water dependency for this class was determined by recent fine-scale (1:10,000) GDE mapping within the PAE (NSW Office of Water, 2014; DEHP, 2014). All of the fine-scale GDE data were considered water dependent,

Assessing GDEs was difficult due to the limited availability of data across the PAE. In the Clarence-Moreton Bioregional Assessment, a cautionary approach is applied and assets were included in the register if the asset intersected with the recent fine-scale GDE data from the Queensland and NSW state agencies (DEHP, 2014; NSW Office of Water, 2014).

1.3.2.1.3 Vegetation

The PAE of the Clarence-Moreton bioregion contained much of the South East Queensland Interim Biogeographic Regionalisation for Australia (IBRA) bioregion and consisted of five IBRA subregions: (i) Clarence Lowlands, (ii) Clarence Sandstones, (iii) Woodenbong, (iv) Scenic Rim and (v) Moreton Basin (SEWPaC, 2012) (for more details see Table 16 in companion product 1.1 for the Clarence-Moreton bioregion (Rassam et al., 2014)).

Seven threatened ecological communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were in the PAE of the Clarence-Moreton bioregion (Table 7). Six of these threatened ecological communities are included in the water-dependent asset register where the community represented is associated with a subsurface or surface groundwater-dependent ecosystem.

Table 7 Threatened ecological communities listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion

Community[a]	Status	Decision
Brigalow (*Acacia harpophylla* dominant and co-dominant)	Endangered	Community demonstrates water dependency, associated with subsurface groundwater-dependent ecosystems
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically endangered	Community demonstrates water dependency, occurs in moist soils that intersects with surface groundwater-dependent ecosystems
Lowland Subtropical Rainforest on Basalt Alluvium in NE NSW and SE Qld	Critically endangered	Community demonstrates water dependency, occurs in moist soils that intersects with surface groundwater-dependent ecosystems
Natural grasslands on basalt and fine textured alluvial plains of northern New South Wales and southern Queensland	Critically endangered	Not included in asset register as community does not demonstrate water dependency, associated with fine textured cracking clays and low tree canopy (<10%)
Semi-evergreen vine thickets of the Brigalow Belt (north and South) and Nandewar ranges	Endangered	Community demonstrates water dependency, associated with subsurface and surface groundwater-dependent ecosystems
Swamp Tea-tree (*Melaleuca irbyana*) Forest of South-east Queensland	Critically endangered	Community demonstrates water dependency, occurs in and around surface water bodies
White box-Yellow box-Blakely's red gum grassy woodland and derived native grassland	Critically endangered	Community demonstrates water dependency, associated with subsurface groundwater-dependent ecosystems

Data: Department of the Environment (Dataset 2)

[a]Typology and punctuation are given as they are used in the legislation.

The asset register contains 120 Collaborative Australian Protected Area Database (CAPAD) areas that occur in the PAE. CAPAD areas include: national parks (e.g. Bungawalbin National Park), conservation reserves (e.g. Toonumbar State Conservation Area) and Indigenous Protected Areas (e.g. Bandahngan Aboriginal Area). These areas largely represent terrestrial nature reserves. If surface water features or GDEs are contained within the area, they are assumed to be water dependent.

There are 432 threatened species listed under the Queensland, NSW and Commonwealth legislations that are known to utilise the Clarence-Moreton bioregion. Many of these species are listed in Table 19 of companion product 1.1 for the Clarence-Moreton bioregion (Rassam et al., 2014). Species are assessed if their potential distributions are modelled by state government agencies (e.g. using MaxENT (Merow et al., 2013)). The PAE for the Clarence-Moreton bioregion includes the potential spatial habitat distribution of 186 species listed under the EPBC Act. This includes 139 plant, five invertebrate, seven frog, eight reptile, 14 bird and 12 mammal species. Note that the asset under consideration is the habitat of these species rather than the species per se, hence these assets are listed under the subgroup, vegetation. The habitats of 96 of the 186 species are considered water dependent for the following reasons:

- associated with drainage or soakage areas, wetland or permanent open water dependent
- associated with floodplain or riparian vegetation communities.

The remaining species are not considered to be water dependent because of ecological associations (they are associated with grassland, woodland, dry scrub, open forest, heathlands or rainforest vegetation communities, or rocky outcrops that are considered not water-dependent), upstream of potential coal seam gas (CSG) and coal mining developments, or it is a wide-spread migratory species that can move across regions. For some species there was insufficient habitat information to make a decision. Table 8 lists the rationale for inclusion in the water-dependent asset register for species' potential habitat within each functional group.

Table 8 Examples of species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion (based on a literature review of habitat requirements)

Functional group	Asset name[a]	Status	Decision
Birds	Australasian Bittern (*Botaurus poiciloptilus*)	Endangered	Included in asset register as habitat features consistent with water dependency, species is wetland dependent
	Marbled Balogia (*Baloghia marmorata*)	Endangered	Included in asset register as habitat features consistent with water dependency, associated subtropical rainforest, wet sclerophyll forest and notophyll vine forest
	Coxen's Fig-Parrot (*Cyclopsitta diophthalma coxeni*)	Endangered	Included in asset register as habitat features consistent with water dependency, gallery forest (along watercourses) appears to be important habitat
	Red Goshawk (*Erythrotriorchis radiatus*)	Vulnerable	Included in asset register as habitat features consistent with water dependency, associated with groundwater-dependent riparian trees
	Regent Honeyeater (*Anthochaera phrygia*)	Endangered	Included in asset register as habitat features consistent with water dependency, associated with groundwater-dependent riparian trees
	Black-breasted Button-quail (*Turnix melanogaster*)	Vulnerable	Not included in asset register as habitat features not consistent with demonstrated water dependency, primarily occurs in rainforests and forests
Frogs	Giant Barred Frog (*Mixophyes iteratus*)	Endangered	Included in asset register as habitat features consistent with water dependency, associated closely with stream habitats and tadpole is completely aquatic
	Fleay's Frog (*Mixophyes fleayi*)	Endangered	Included in asset register as habitat features consistent with water dependency, associated closely with stream habitats and tadpole is completely aquatic
Mammals	Hastings River Mouse, Koontoo (*Pseudomys oralis*)	Endangered	Included in asset register as habitat features consistent with water dependency, associated with sedges commonly found beside creeks and soakages
	Large-eared Pied Bat, Large Pied Bat (*Chalinolobus dwyeri*)	Vulnerable	Included in asset register as habitat features consistent with water dependency, associated with groundwater-dependent riparian trees
	Spot-tailed Quoll (*Dasyurus maculatus maculatus* (SE mainland population))	Endangered	Included in asset register as habitat features consistent with water dependency, associated with mature wet forest habitat and groundwater-dependent riparian trees
	Water Mouse, False Water Rat, Yirrkoo (*Xeromys myoides*)	Vulnerable	Included in asset register as habitat features consistent with demonstrated water dependency, inhabits mangroves, sedgelands and freshwater wetlands

Functional group	Asset name[a]	Status	Decision
	South-eastern Long-eared Bat (*Nyctophilus corbeni*)	Vulnerable	Included in asset register as habitat features consistent with water dependency, species roost in river red gums
Reptiles	Yakka Skink (*Egernia rugosa*)	Vulnerable	Included in asset register as habitat features consistent with water dependency, occurs in woodlands and open forests near river and creek flats
	Three-toed Snake-tooth Skink (*Coeranoscincus reticulatus*)	Vulnerable	Not included in asset register as habitat features not consistent with water dependency, this species occurs in a range of habitat types including rainforest and eucalypt forest
	Dunmall's Snake (*Furina dunmalli*)	Vulnerable	Not included in asset register as habitat features not consistent with water dependency, this species occurs in a range of habitat types, none of which are strictly water dependant
Fish	Oxleyan Pygmy Perch (*Nannoperca oxleyana*)	Endangered	Included in asset register as habitat features consistent with demonstrated water dependency, an entirely aquatic species
Invertebrates	Acrodipsas illidgei	Vulnerable	Included in asset register as habitat features consistent with demonstrated water dependency; this species occurs in mangrove forests
	Mitchell's Rainforest Snail (*Thersites mitchellae*)	Critically Endangered	Included in asset register as habitat features consistent with demonstrated water dependency; this species occurs in subtropical and swamp sclerophyll rainforest on alluvial soil
Plants	Three-leaved Bosistoa (*Bosistoa transversa*)	Vulnerable	Not included in asset register as habitat features not consistent with demonstrated water dependency, three-leaved Bosistoa grows in wet sclerophyll forest, dry sclerophyll forest and rainforest up to 300 m in altitude
	Swamp Stringybark (*Eucalyptus conglomerata*)	Endangered	Included in asset register as habitat features consistent with demonstrated water dependency, seasonally waterlogged areas consisting of poorly drained sandy soils
	bluegrass (*Dichanthium setosum*)	Vulnerable	Not included in asset register as habitat features not consistent with demonstrated water dependency, occurs on cracking soils (Blacksoil)
	Austral Toadflax, Toadflax (*Thesium australe*)	Vulnerable	Not included in asset register as habitat features not consistent with demonstrated water dependency, occurs in dry scrub and open forest

Data: Bioregional Assessment Programme (Dataset 1)

[a]Although examples of individual species are listed, bioregional assessments consider the potential impact to the habitat of species not individual species per se. Punctuation and typography appear as used in the asset database.

1.3.2.2 Gaps

Aside from the EPBC Act-listed threatened species, all threatened species listed in NSW's Threatened Species Conservation Act 1995 (TSC Act) and some threatened species in Queensland's Nature Conservation Act 1994 (Nature Conservation Act) were not included in the

water-dependent asset register for the Clarence-Moreton bioregion as there was insufficient spatial habitat modelling information available to confirm the presence of their habitats within the PAE of the Clarence-Moreton bioregion. Known threatened species absent from the water-dependent asset register are listed in Table 9. Negotiations are currently underway with the relevant state authorities to address these gaps. Modelled fish data for NSW will be supplied by the upcoming NSW Fish Community Status Final Report 2015 (Riches et al., In prep.). Missing data from NSW also include state forest boundaries, coastal floodplains, threatened migratory shorebird habitat and TSC Act-listed critical habitats. These data were not available at time of compiling the assets but will be included in future analysis within the Bioregional Assessments Programme.

Table 9 Known aquatic species with demonstrated water dependency without available modelled habitat data within the preliminary assessment extent (PAE)

These species will be included in the water-dependent register at a later date.

Functional group	Species	Status
Invertebrate (crayfish)	*Euastacus valentulus*	*Least concern*
	Euastacus sulcatus	Vulnerable
	Euastacus dalagarbe	Critically endangered
	Cherax leckii	Critically endangered
	Euastacus guruhgi	Critically endangered
	Euastacus jagabar	Critically endangered
	Euastacus mirangudjin	Critically endangered
	Euastacus girumulayn	Critically endangered
	Cherax cuspidatus	Least concern
	Euastacus gumar	Endangered
	Cherax quadricarinatus	NA
	Tenuibranchiurus sp.	NA
Fish	Eastern freshwater cod (*Maccullochella ikei*)	Endangered
	Purple-spotted Gudgeon (*Mogurnda adspersa*)	Endangered

Data: Coughran (2006); McCormack (2012); NSW's *Threatened Species Conservation Act 1995*; Queensland's *Nature Conservation Act 1994*
NA – not available

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1.3.3 Economic assets

Summary

The water-dependent asset register for the Clarence-Moreton bioregion has 752 economic water-dependent assets made up from 11,810 elements. There are 650 economic assets in the 'Surface water management zone or area' economic asset subgroup and 102 economic assets in the 'Groundwater management zone or area' subgroup. Each subgroup is composed of four classes that include surface water and groundwater features, surface water and groundwater infrastructure, basic water rights and water access rights. Overall, the distribution of economic assets in the Clarence-Moreton bioregion preliminary asset extent (PAE) shows a higher density towards major towns such as Casino, Lismore and Grafton.

1.3.3.1 Description

The economic water-dependent assets mainly consist of various water access rights and some water-associated infrastructure. Data are sourced from various national and state databases and then compiled into an assets database. The economic assets for the Clarence-Moreton bioregion are obtained by spatially filtering the assets database using the PAE boundary of the Clarence-Moreton bioregion. The analyses in this section are based on the assets database for the Clarence-Moreton PAE (Bioregional Assessment Programme, Dataset 1).

There are 752 economic water-dependent assets in the Clarence-Moreton PAE. The assets are categorised into a 'Surface water' subgroup and a 'Groundwater' subgroup (Table 10) (Mount et al., 2015) with each subgroup consisting of four classes. There are 650 economic assets in the 'Surface water management zone or area' economic asset subgroup and 102 economic assets in the 'Groundwater management zone or area' subgroup (Table 10). Every asset is comprised of a number of elements. An element may be either a point, a line or a polygon spatial feature. The distribution of each class is mapped in the following sections. According to the hydrological and hydrogeological characteristics of the Clarence-Moreton PAE and feedback obtained from relevant local experts in various organisations and councils, all of the 752 economic assets were included in the water-dependent asset register.

Table 10 Classification of the economic assets in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Subgroup	Class	Number of elements	Number of assets	In water-dependent asset register
Groundwater management zone or area (surface area)	A groundwater feature used for water supply	0	0	No
	Water supply and monitoring infrastructure	35	35	Yes
	Water access right	3266	28	Yes
	Basic water right (stock and domestic)	4739	39	Yes
Surface water management zone or area (surface area)	A surface water feature used for water supply	495	460	Yes
	Water supply and monitoring infrastructure	10	10	Yes
	Water access right	3029	98	Yes
	Basic water right (stock and domestic)	236	82	Yes
Total		**11810**	**752**	

Data: Bioregional Assessment Programme (Dataset 1)

1.3.3.1.1 Surface water features

There are 460 economic surface water assets classed as ‘A surface water feature used for water supply’. They are mostly in the NSW part of the Clarence-Moreton PAE (Figure 9) and comprise catchments and some national parks with the latter being mainly in the Queensland part of the Clarence-Moreton PAE. Access to water in these catchments is managed through water access entitlements. Ten dams and their declared catchments are classed as ‘Water supply and monitoring infrastructure’ and are all located in the northern part of the Clarence-Moreton PAE, with the exception of one asset about 30 km north of Grafton in NSW (Figure 10).

Water access entitlements are divided into two classes: basic water right and water access right (Mount et al., 2015) with both classes registered in the asset list (Table 10). The basic water right allows owners and land users to access water for domestic and stock purposes from rivers, estuaries and lake frontages without a licence. The water access right applies to all the other water usages such as irrigation, commercial, industrial, farming, mining etc. The distribution of these water access entitlements is shown in Figure 11 and Figure 12, respectively. Figure 11 shows a combination of points, lines and polygons spatial features. The points represent locations for water extraction from a surface water body. The lines represent regulated streams. The polygons depict the covered area of the water sharing plans. Figure 12 only contains point features indicating access locations from the surface water bodies.

1.3.3.1.2 Groundwater features

Although the companion submethodology M02 for compiling water-dependent assets (Mount et al., 2015) listed four classes for the economic groundwater assets, only three of them are present in the Clarence-Moreton PAE. The basic water right allows land owners and users to extract groundwater from aquifers within their land boundary without a licence, although the associated infrastructure still requires an approval. Similar to the economic surface water assets, the water access right includes all other licences for various groundwater usages. The distribution of the groundwater basic water rights in the Clarence-Moreton PAE is shown in Figure 13 and all are located in the NSW part of the Clarence-Moreton PAE. Although the Queensland part of the Clarence-Moreton PAE includes hundreds of functioning bores, there is no available information regarding their purposes and associated entitlements. In this study, they were categorised as groundwater bores with water access rights. Figure 14 demonstrates the distribution of the groundwater water access rights and the groundwater infrastructure in the Clarence-Moreton PAE. Similar to the surface water basic water right, most groundwater access entitlements appear around Casino, Lismore and Grafton in NSW. The groundwater infrastructure are made up of a number of borefields in the Queensland part of the Clarence-Moreton PAE.

Figure 9 Distribution of economic assets classed as surface water features in the surface water subgroup used for water supply in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

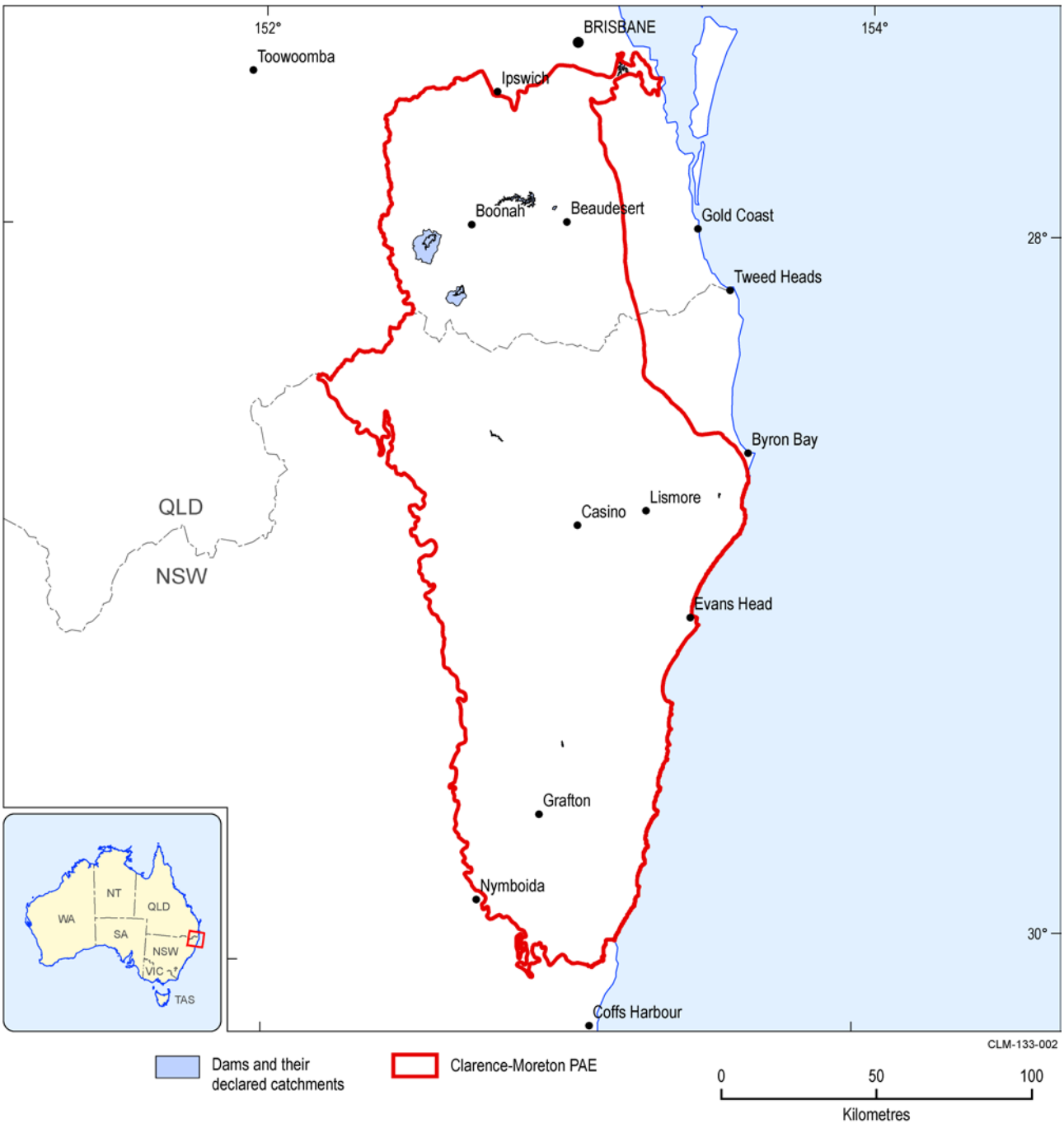

Figure 10 Distribution of surface water economic assets classed as water supply and monitoring infrastructure in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

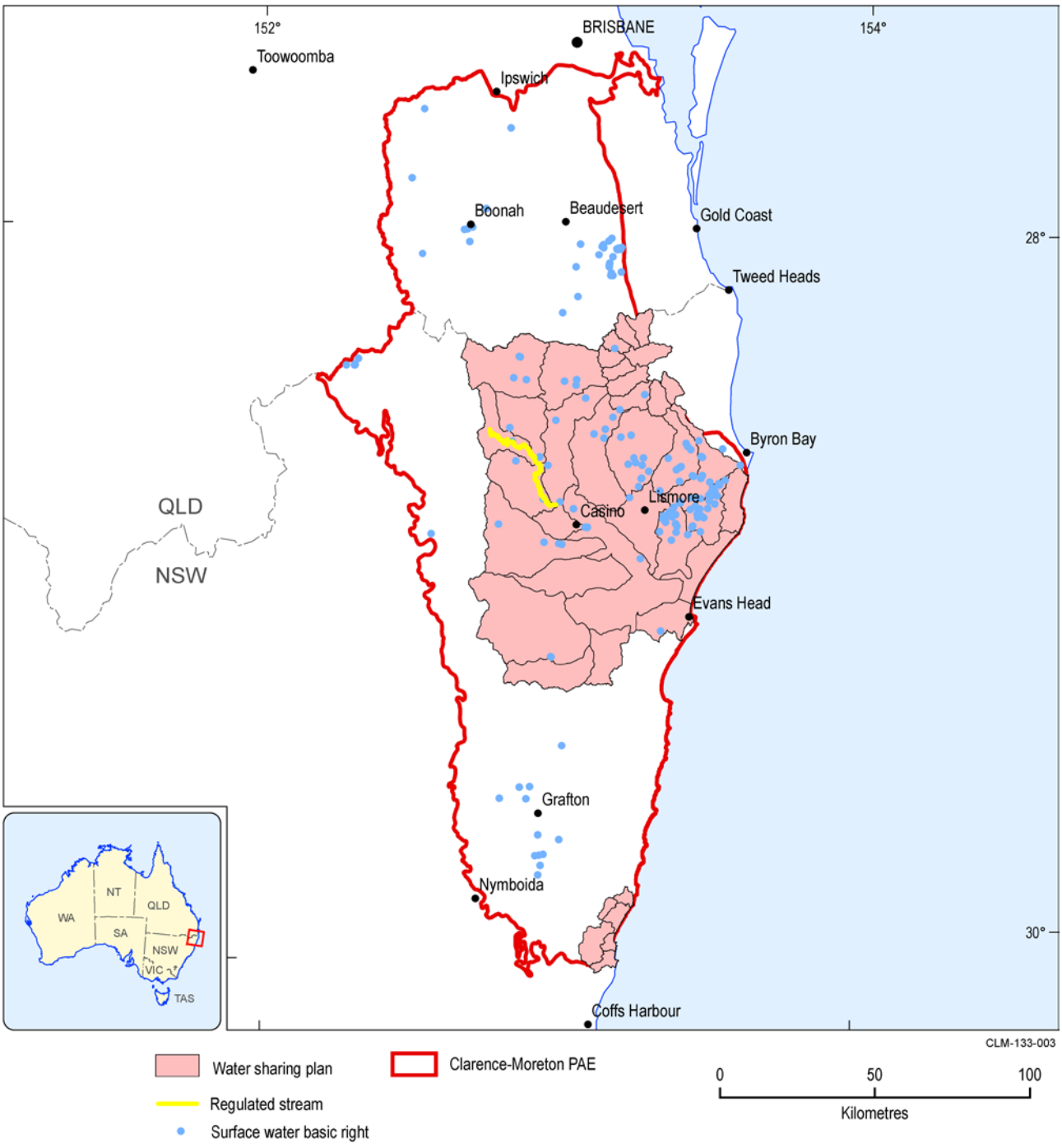

Figure 11 Distribution of surface water basic water rights in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

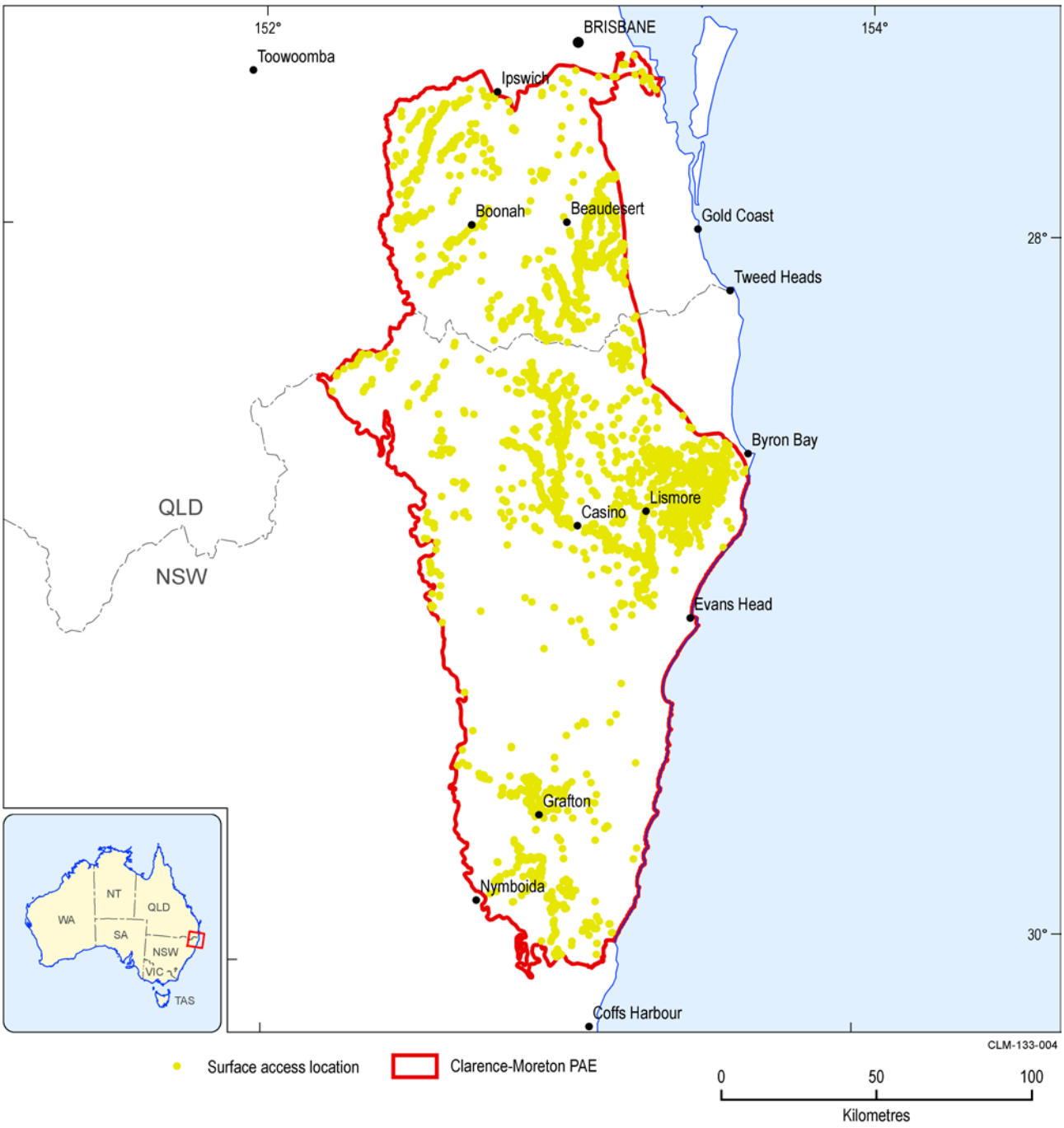

Figure 12 Distribution of surface water access rights in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

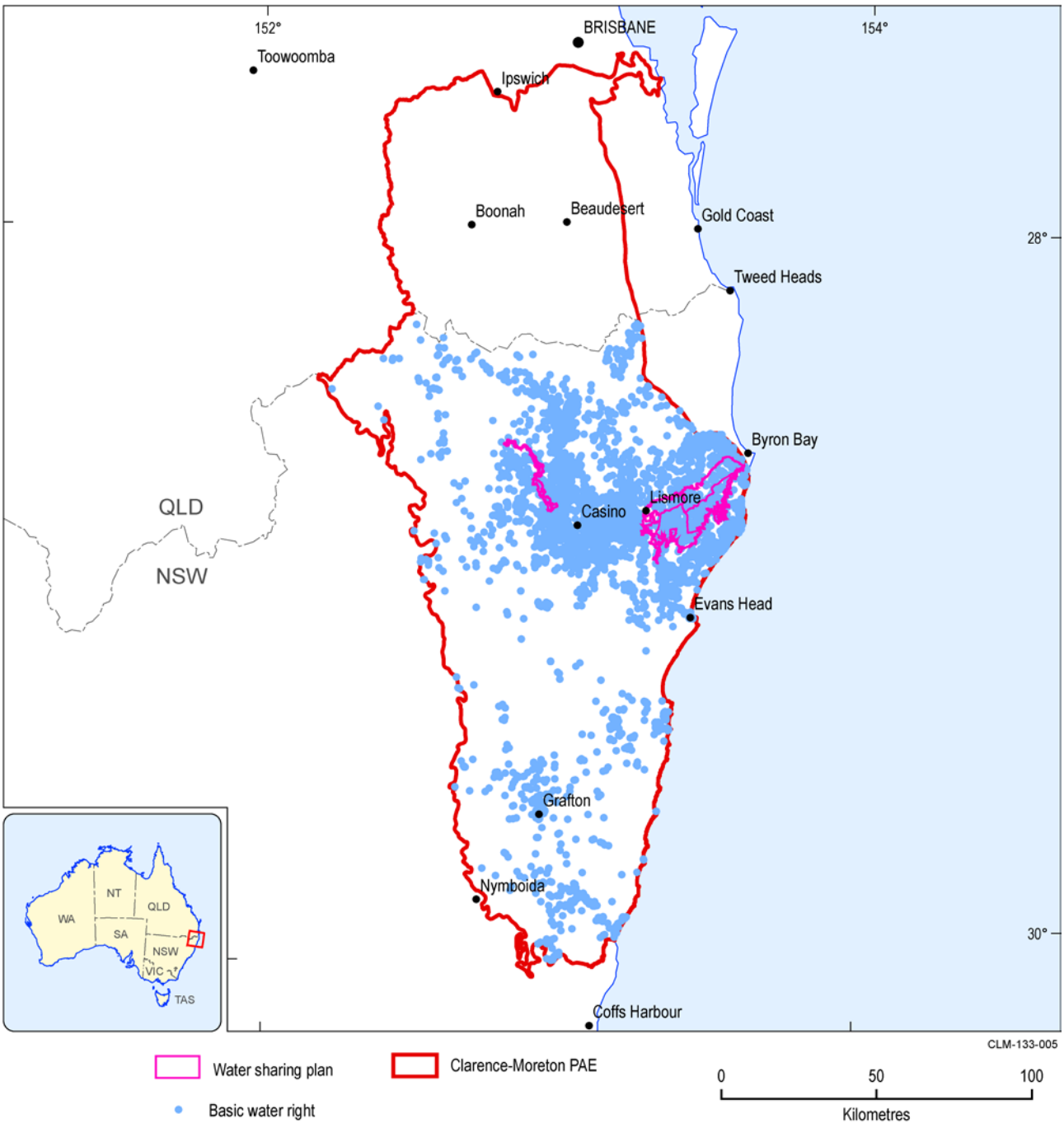

Figure 13 Distribution of the groundwater basic water rights in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

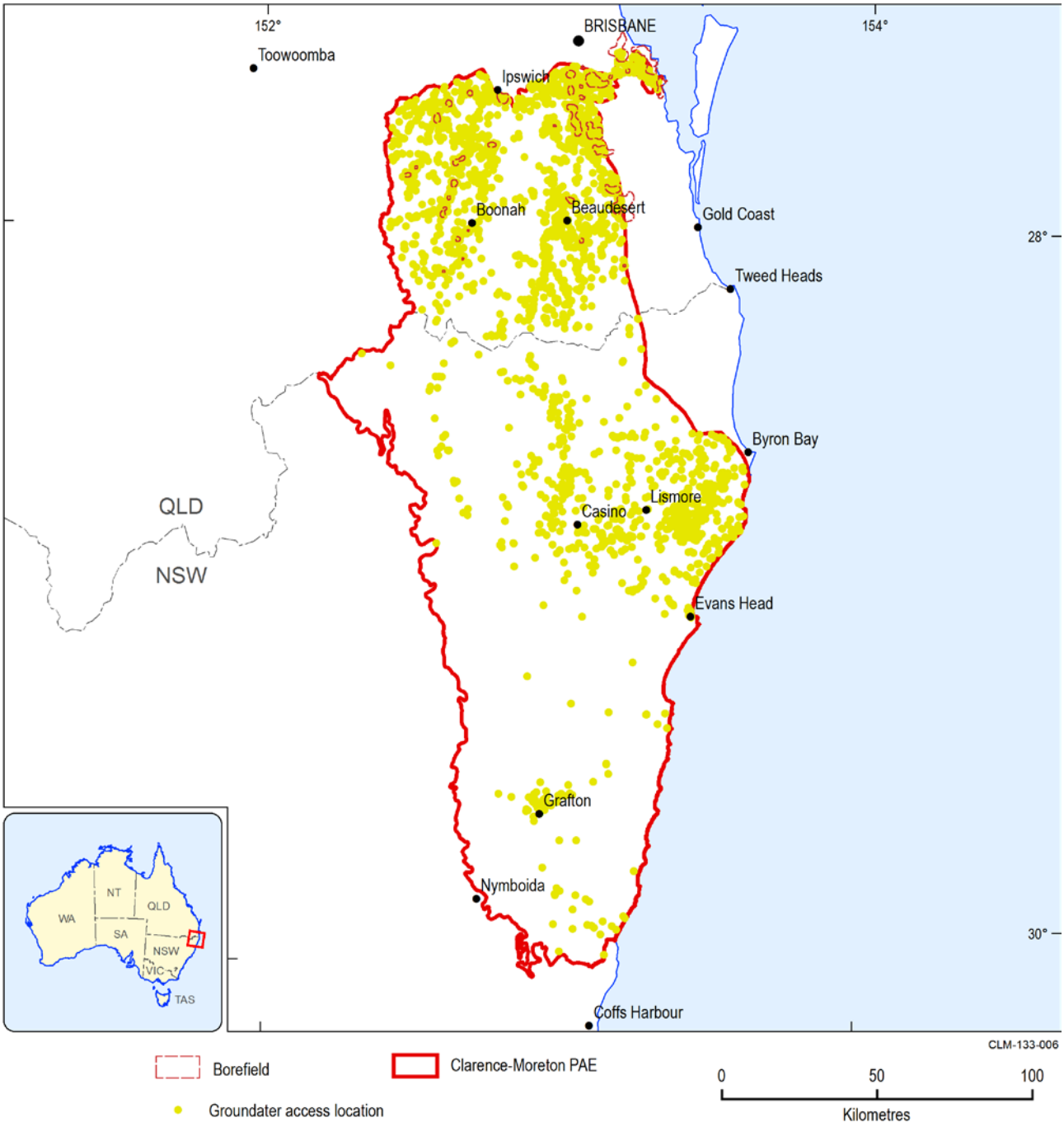

Figure 14 Distribution of the groundwater water access rights and groundwater infrastructure in the Clarence-Moreton bioregion preliminary assessment extent (PAE)

Data: Bioregional Assessment Programme (Dataset 1)
There are notable differences in the quantity of the data between the two states in the map as the State agencies involved supplied different data sources.

1.3.3.2 Gaps

Some water access entitlements in the Richmond river basin do not include specific information regarding their location. Thus, all the types of licences have been aggregated to the corresponding water source location – the Richmond river basin (Figure 11). Most basic water rights have an entitlement of 'null' or zero. The water access right class also has some elements with zero or 'null' entitlements. Although there are hundreds of functioning bores in the Queensland part of

Clarence-Moreton PAE in accordance with the state groundwater database, their purposes and associated licences are not recorded.

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1.3.4 Sociocultural assets

Summary

There were 309 sociocultural assets within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion as of 19 August 2015. A total of 160 of these sociocultural assets were assessed as water dependent and included in the asset register. These comprised 15 heritage, 35 Indigenous and 110 recreational sites. Most heritage sites were not consistent with water dependency but most of the Indigenous and recreational sites were considered water dependent.

1.3.4.1 Description

Sociocultural assets were sourced from the Australian Heritage Database (Department of Environment, 2014; Australian Government Department of the Environment, Dataset 2, Dataset 3, Dataset 4, Dataset 5) and were classified into heritage, Indigenous and recreational sites (Table 11). The areas of some sites overlapped. For example, some of the Indigenous sites were also listed as recreational sites (e.g. Tucki Tucki Bora Ground and Tucki Tucki Nature Reserve). Figure 15 displays the sociocultural assets in the PAE of the Clarence-Moreton bioregion.

The sociocultural assets were assessed for water dependence using a cautionary approach. Hence, when water dependency was unclear (assessed as 'unsure' or 'possible'), the asset was kept in the asset register. Some sociocultural sites were relatively straightforward to assess their water dependence, such as recreational sites having surface water features (e.g. Cunningham's Gap National Park).

Most heritage sites were not considered water dependent as they were listed historical buildings. While other 1.3 reports from different bioregions (e.g. (O'Grady et al., 2015; Mitchell et al., 2015)) included historical buildings that are situated in the maximum flood extent, this was not possible for the Clarence-Moreton bioregion as the available floodplain extent in the PAE did not overlap in area with any historical buildings. In this case, any historical buildings within close vicinity (less than 100 m) of a surface water feature were also checked using available high resolution imagery to see where the asset was situated and if physical barriers, such as hills, surrounded the asset to impede any overbank flows. If not, the asset was included in the register. The 15 heritage sites that were considered water dependent were large areas of natural environment containing surface water features or groundwater-dependent vegetation (e.g. military training areas, such as Canungra Land Warfare Centre) or were on a floodplain (e.g. Archerfield Airport). There was one World Heritage Site, the Gondwana Rainforests of Australia World Heritage Areas, which was considered water dependent as surface water features were prominent in these areas.

There were 47 Indigenous sites to be assessed. Preliminary assessment of water dependence for Indigenous sites was conducted by considering: (i) the purpose of the site and (ii) the proximity to water (within 300 m). Indigenous ceremonial sites, such as Bora rings (e.g. Casino Bora Ground), were considered water dependent as they are often positioned close to water for access while camping during ceremonies (Bowdler, 2000). Other Indigenous sites, such as axe grinding sites and

shelters, were not considered water dependent unless they were near surface water or contained groundwater-dependent vegetation.

The recreational areas were mainly national parks, reserves and environmental parks. The assets were determined to be water dependent if they contained surface water features or groundwater-dependent ecosystems.

Table 11 Classification of sociocultural sites in the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion

Subgroup	Class	Not in water-dependent asset register	In water-dependent asset register	Total assets (asset list)
Cultural	Heritage site	125	15	140
Cultural	Indigenous site	12	35	47
Social	Recreation site	12	110	122
Total		**149**	**160**	**309**

Data: Bioregional Assessment Programme (Dataset 1

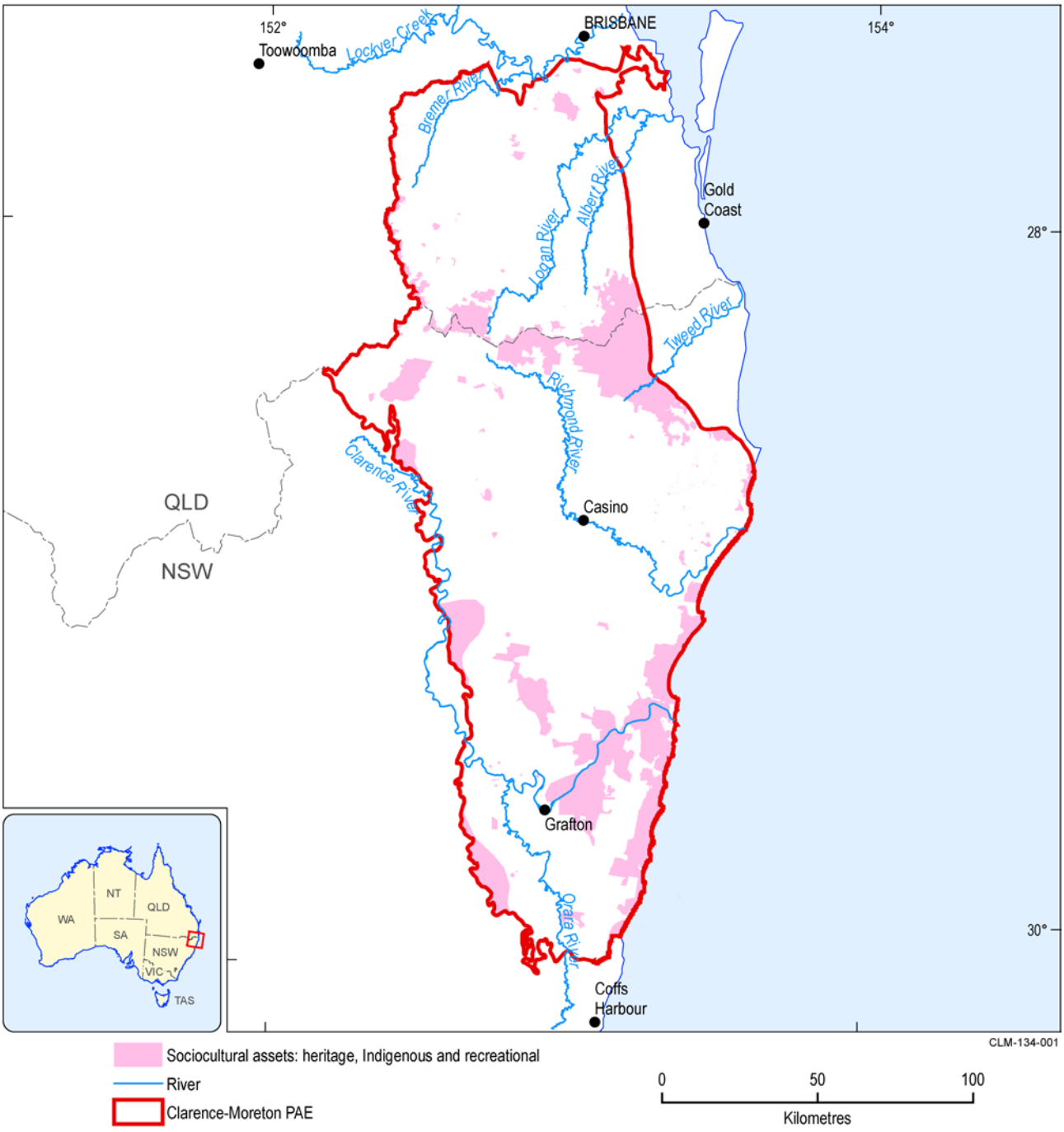

Figure 15 Sociocultural assets within the preliminary assessment extent (PAE) of the Clarence-Moreton bioregion

Data: Bioregional Assessment Programme (Dataset 1)

1.3.4.2 Gaps

Currently there were no knowledge gaps identified in the data for the purpose of the Bioregional Assessment. However if sociocultural sites were not listed in the Commonwealth-listed heritage databases, they were not included in the asset register. Meetings have been held with Indigenous knowledge holders in the Clarence-Moreton bioregion to gain further understanding of Indigenous cultural water-dependent assets. Where possible and appropriate, and with the agreement of Indigenous knowledge holders, these additional Indigenous water-related values will be published in a separate report. Identified assets will be incorporated into an updated water-dependent asset register and/or incorporated into later technical products.

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Datasets

Dataset 1 Bioregional Assessment Programme (2014) Asset database for the Clarence-Moreton bioregion on 19 August 2015. Bioregional Assessment Derived Dataset. Viewed 19 August 2015, http://data.bioregionalassessments.gov.au/dataset/e265e9cf-b3a3-474c-850b-db4616389a24.

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Dataset 3 Australian Government Department of the Environment (2014) National Heritage List Spatial Database (NHL) (v2.1). Bioregional Assessment Source Dataset. Viewed 13 April 2015, http://data.bioregionalassessments.gov.au/dataset/26daa8d7-a90e-47f3-982b-0df362414e65.

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