Augmentation of the WAIT database for the Border Rivers and Gwydir Catchments

Addition of local catchment and floodplain data

Prepared for
Border Rivers/Gwydir Catchment Management Authority

16 August 2013

DOCUMENT TRACKING

Item	Detail
Project Name	Augmentation of the WAIT database for the Border Rivers and Gwydir Catchments: Addition of local catchment and floodplain data
Project Number	13COFNRM-0003
Project Manager	Julian Wall 0401 421 161
Prepared by	Julian Wall
Reviewed by	Martin Stuart
Status	FINAL
Version Number	1
Last saved on	16 August 2013
Cover photos	NSW Office of Water 2012; MDBA (Arthur Mostead)

This report should be cited as 'Eco Logical Australia. 2013. *Augmentation of the WAIT database for the Border Rivers and Gwydir Catchments: Addition of local catchment and floodplain data*. Prepared for Border Rivers/Gwydir CMA.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Sally Croker, Border Rivers/Gwydir CMA.

Contents

List of figures

List of tables

Abbreviations

ABBREVIATION	DESCRIPTION
BRG	Border-Rivers Gwydir
CMA	Catchment Management Authority
CSG	Coal seam gas
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
DEM	Digital Elevation Model
Landsat 5 TM	Landsat 5 Thematic Mapping
WAIT	Commonwealth Water Asset Information Tool

1 Introduction

1.1 Background

An Independent Expert Scientific Committee on Coal Seam Gas and Coal Mining was established in 2011. The Committee will provide scientific advice to Governments in relation to coal seam gas (CSG) and coal mining proposals that are likely to have significant impacts on water resources. This will be facilitated by the undertaking of Bioregional Assessments in areas where CSG and/or large coal mining developments are underway or planned. The Bioregional Assessments will involve scientific analyses of the ecology, hydrology and geology of an area for the purpose of assessing the potential impacts and risks to natural water resources in the area arising from the direct and indirect impacts of CSG or large coal mining development.

The Bioregional Assessments are divided into Phases. Phase 1 involves data collation of water assets and analysis of their vulnerability to CSG and coal mining activities. Asset data are captured into the Water Asset Information Tool (WAIT) developed by the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC). The WAIT database (and an associated spatial geodatabase) for Phase 1 work was completed by ELA (2012a) for the Border Rivers-Gwydir Catchment Management Authority (BRG CMA).

A total of 1780 water assets from 27 spatial datasets were identified in the BRG catchment, comprising floodplains, groundwater aquifers, groundwater-dependent ecosystems, watercourses (streams and rivers), waterholes, wetlands and other assets (e.g. caves and waterfalls). The vulnerability of each water asset was determined using a matrix which cross-referenced their sensitivity to potential impacts arising from coal seam gas extraction and coal mining activities, with their inherent resilience (i.e. the level of disturbance an asset could experience without experiencing changes in its structure and function).

1.2 Project Purpose and Objectives

The purpose of this project was to augment the WAIT database for BRG by including two additional asset classes – local catchments and floodplains – and to determine the condition of each asset, and their vulnerability to CSG extraction and coal mining activities.

1.3 Structure of the Report

This report is separated into the following sections:

- Section 2 provides a description of the WAIT database
- Section 3 details the approach to derivation of local catchments, and assignment of condition and vulnerability ratings.
- Section 4 details the approach to derivation of active floodplains, and assignment of condition and vulnerability ratings.
- Section 5 lists recommendations for future work.

2 WAIT database

2.1 Context

The WAIT database was developed by DSEWPaC for Phase 1 of the Bioregional Assessments. It is designed to store various data about a catchment's water assets. It includes a module that allows a broad rating of vulnerability (high, moderate or low) to be entered in relation to the potential impact of major land use activities on flow pattern, habitat, water quality and water quantity.

For this project, vulnerability associated with coal mining and CSG extraction (but not other activities) were considered for the two new asset classes, local catchments and floodplains.

The following fields are included in the WAIT database:

General Fields

- Asset ID
- Asset Name
- NRM Region
- Description
- WaterBody_Type
- Coordinates
- Nearest_Town
- Mapsheet_100k_name
- Environmental Value
- National Water Quality Management Strategy (NWQMS) values
- Economic Value
- Social Cultural Value
- Hydrology
- Geology_geomorphology
- Other_Relevant_Details
- Management Authority
- Current_landuse
- Tenure
- Condition
- Is_map_available
- Is_GISdata_available
- Is_metadata_available
- File Identifier_in_ANZMetlitetool
- Dataset_resource_title_in_ANZMetlitetool
- References
- Known_knowledge_gaps
- Primary_contact_for_asset
- Legal_protection
- Notes

Vulnerability fields

- Activity
- Impact
- Existing/potential hazard
- Mitigation in place
- Effect

2.2 Populating WAIT

To enter additional data into the WAIT database, asset features were intersected with other spatial layers, then data were uploaded via Access lookups. This method was applied to populate several fields including: Coordinates, Nearest_Town, Mapsheet_100k_name, Geology_geomorphology, Current_ landuse, Tenure, Is_GISdata_available and Impact.

In some cases duplicate asset names occurred (e.g. local catchments named 'Sandy Creek'). Care was taken to identify these assets as individual features within both WAIT and the geodatabase.

3 Local Catchments

3.1 Definition

For the purpose of this study, a local catchment is defined as a geographical parcel of land circum-bounded by a elevated watershed (ridgeline), that drains into an area of no less than 1,000 ha, and terminates at either a confluence or a terminal wetland. Most local catchments are named according to the stream or river to which it contributes surface flow, although some are unnamed creeks. Some local catchments constitute drainage plains or warrumbools, and most of the rivers and larger streams are represented by more than one local catchment (in which case they are separated into unique reaches). In general terms, local catchments represented the contributing areas of streams or reaches that are 3^{rd} order and greater.

3.2 Capture

3.2.1 Overview

The BRG catchment occupies an area of approximately 50,000 km^2 and includes two broad regions – the slopes and ranges of the Eastern Highlands and the alluvial floodplains of the Western Plains. For the more undulating Eastern Highlands, automated capture was undertaken using the digital elevation model (DEM), supported by manual on-screen refinement of linework as required.. For the relatively flat Western Plains, only manual digitising was used to delineate local catchments as the landscape is extensively flat with little change in elevation, and the DEM is much less reliable.

3.2.2 Automated analysis

Automated analysis utilised the 'Watershed Tool', a hydrological modelling extension available in the spatial analyst module of ESRI ArcMap. This tool derives watersheds (catchment boundaries) by analysing terrain datasets and their relation to a set of user specified points representing catchment sinks (stream outflow points). The following steps were used to run the Watershed Tool:

- A composite DEM was prepared for the region - most was covered by a 25m DEM (from Land and Property Information - LPI) and the remaining areas covered by a ~30m DEM from Geoscience Australia.
- All hydrological sinks in the DEM were filled.
- A flow direction raster was generated using the filled DEM.
- The flow direction layer was used to generate a flow accumulation layer.

- The flow accumulation layer was used as a guide for the placement of “pour points” which are the user specified locations representing the catchment outflow points. Pour points were manually placed at the confluence of drainage systems thought to be at least 1,000 ha, with reference to the flow accumulation layer and other supporting information including contours and hydrolines.
- Pour points were snapped to the flow accumulation raster (tolerance 50m) so that they could be input to the Watershed Tool with the flow direction raster.
- The raster output from the watershed tool was converted to a polygon shapefile and smoothed (using the Polynomial Approximation with Exponential Kernel - PAEK method and applying a tolerance of 500m).

3.2.3 Manual digitising

Manual digitising of local catchments was undertaken in ArcGIS with support of key spatial data including digital topographic map series, DEM, contours and hydrolines. Manual digitising required the operator to have a strong understanding of surface flow response (i.e. flow) to topography. In some flat areas in the western part of the catchment where 10 m contour lines were often separated by many kilometres, the DEM alone was used to separate local catchments. In these circumstances, the reliability of the watershed position is only as good as the apparent ‘ridge’ deciphered from the DEM.

For local catchments in the Eastern Highlands that were captured by the automated process described above, all polygons were visually checked against contours, hydrolines and other topographic map layers, and manually adjusted where necessary to ensure spatial accuracy against contours. In some cases, new catchments that satisfied the 1,000 ha+ area threshold were separated manually from the automated product, and excessively large catchments were divided into reaches, where possible. Finally, on completion of the layer, any local catchments found not meet the 1,000 ha threshold was merged into its neighbouring downstream catchment.

The southern boundaries of local catchments in the south of the BRG region were edge-matched with the northern boundaries of local catchments captured in the Namoi Catchment by ELA (2012b).

3.3 Description of final layer

A total of 894 local catchments were captured within the BRG catchment (Figure 1), including 606 named creeks (some larger creeks separated into reaches), 138 unnamed creeks, 65 river reaches, 45 gullies, 24 drainage plains and 16 other features. Local catchments were generally smaller in the eastern part of the catchment (minimum area = 1,000 ha for several features) and larger in the western part (largest area = 193,500 ha for Gingham Watercourse).

The 65 local catchments that delineate the reaches of prominent rivers in the BRG total 661,000 ha and include reaches of the Barwon, Beardy, Bluff, Boomi, Deepwater, Dumaresq, Gwydir, Horton, McIntryre, Mihi, Mole and Severn Rivers.

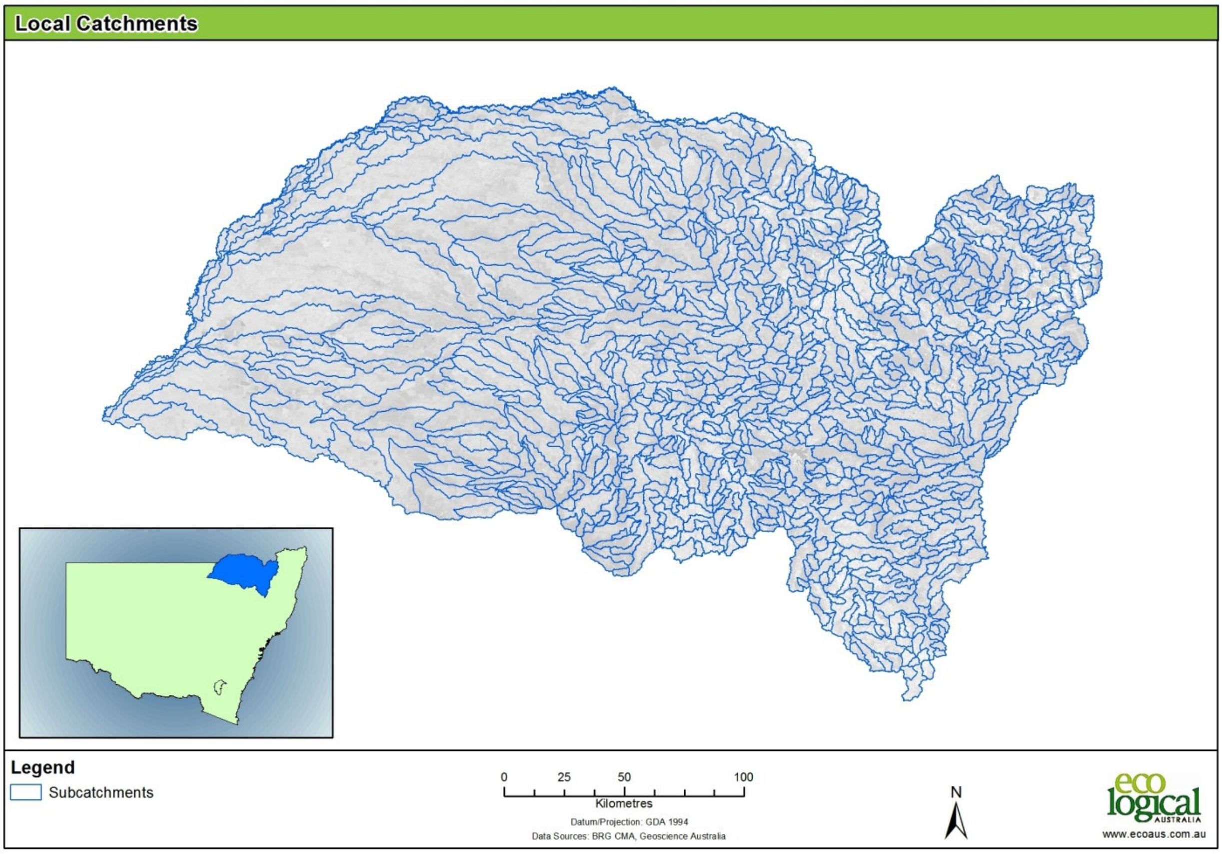

Figure 1. Local catchments within BRG

3.4 Assignment of vulnerability

3.4.1 Background

Vulnerability is a function of an asset's *sensitivity* and its *resilience*. Sensitivity is the degree to which an asset is affected by 'pressures' (in this case activities associated with coal mining and CSG extraction), and resilience is the amount of change a system can undergo (i.e. its capacity to absorb disturbance), and remain within the same regime that essentially retains the same function, structure and feedbacks (Walker and Salt 2006). Determining an asset's capacity to absorb change or disturbance without moving to a new state often involves identifying thresholds (i.e. 'tipping points' from one stable state to another). Thresholds are typically related to core structural and functional elements of ecosystems, such as wetting-drying periods in wetlands, lateral and longitudinal connectivity in rivers, and carbon exchange between floodplains and rivers.

3.4.2 Method

A rating for vulnerability was derived from a matrix that cross-references levels of asset sensitivity to levels of asset resilience (Table 1). The lower the sensitivity and higher the resilience of an asset to the effects of coal or CSG extraction, the lower its vulnerability.

To achieve the comparison in Table 1, sensitivity and resilience levels were generated for each local catchment using a set of rules and conditions relevant to each asset class. These are outlined in Appendix I.

Table 1. Asset vulnerability as a function of asset sensitivity and asset resilience.

	Resilience		
Sensitivity	High	Medium	Low
High	*Medium*	*High*	*High*
Medium	*Low*	*Medium*	*High*
Low	*Low*	*Low*	*Medium*

Once all data were compiled, a final review was conducted in which vulnerabilities were revised downwards if part or all of the asset occurred outside the mapped extent of the potential coal or CSG gas resource, as depicted in Table 2. A map of coal resource potential in the BRG catchment is provided in Figure 3.

Table 2. Revised vulnerability scores based on coal potential

Location of Local Catchment	**Change to Vulnerability Status**
Part or all within OCM/LWM areas	No change
All outside OCM/LWM areas	Moderate → Low; High → Low
Part or all within areas of high or moderate CSG potential	No change
None within areas of high or moderate CSG potential, but part within area of low CSG potential	Moderate → Low; High → Moderate
All within areas no CSG potential	Moderate → Low; High → Low

3.4.3 Results

Results of sensitivity, resilience and vulnerability analysis in the context of potential CSG extraction are shown in Table 3. After reducing the vulnerability rating for local catchments that occur outside the region of CSG-potential, the total number of high and medium vulnerability catchments within the BRG catchment is relatively low: 5% for flow pattern; 12% for habitat; 19% for water quantity; and 16% for water quality.

As the WAIT asset data are linked to a geodatabase via unique identifier, it is possible to display sensitivity, resilience and vulnerability spatially. Figure 2 shows an example for the habitat value of local catchments. Note the low vulnerability of catchments in the eastern part of BRG that has no CSG potential.

Table 3. Number of local catchments by sensitivity, resilience and vulnerability class (CSG extraction)

	Sensitivity			Resilience			Vulnerability*		
Effect	High	Medium	Low	High	Medium	Low	High	Medium	Low
Flow pattern	27	460	397	124	211	560	15	32	847
Habitat	33	396	465	332	293	269	45	64	785
Water Quantity	no data			324	277	293	92	82	720
Water Quality	126	587	181	203	376	315	111	35	748

* values based on sensitivity-resilience pairing (Table 1) and location of local catchment in relation to CSG potential (Table 2)

Table 4. Area (km^2) of local catchments by sensitivity, resilience and vulnerability class (CSG extraction)

	Sensitivity			Resilience			Vulnerability*		
Effect	High	Medium	Low	High	Medium	Low	High	Medium	Low
Flow pattern	547	15,595	34,698	8,789	31,728	10,323	459	2,332	48,049
Habitat	1,790	14,934	34,117	15,675	17,113	18,053	3,796	10,896	36,148
Water Quantity	no data			16,692	12,237	21,912	8,989	10,486	31,365
Water Quality	9,253	36,212	5,375	6,542	26,057	18,242	7,962	2,620	40,258

* values based on sensitivity-resilience pairing (Table 1) and location of local catchment in relation to CSG potential (Table 2)

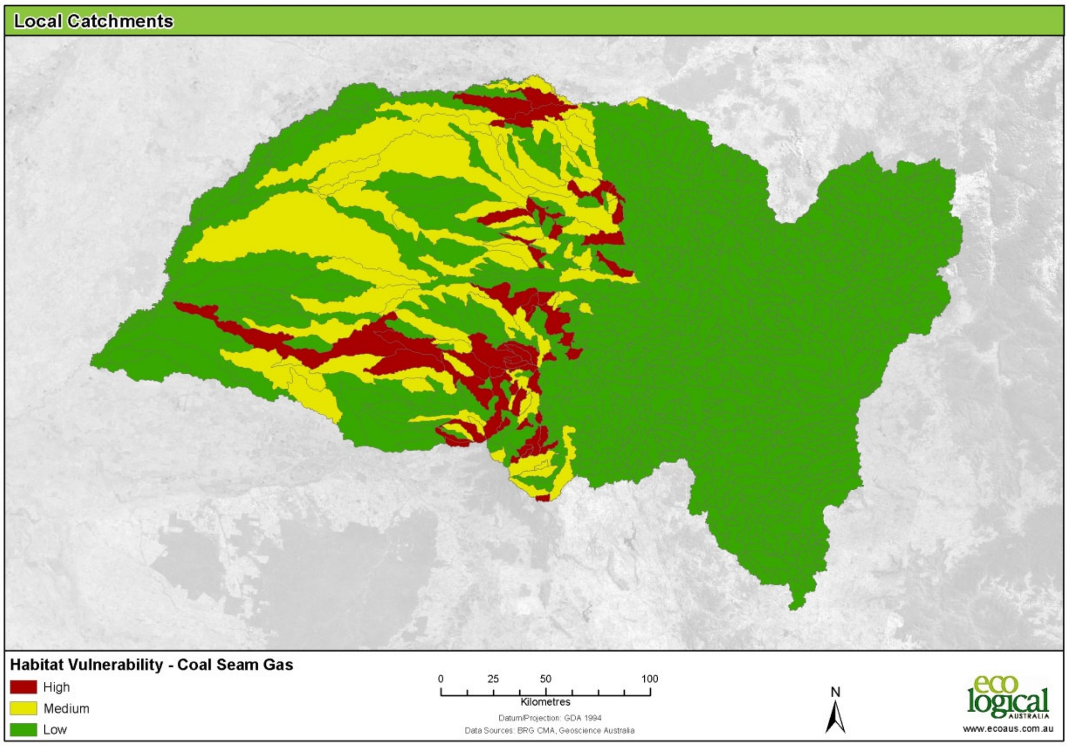

Figure 2. Vulnerability of potential CSG extraction to habitat value of local catchments in BRG

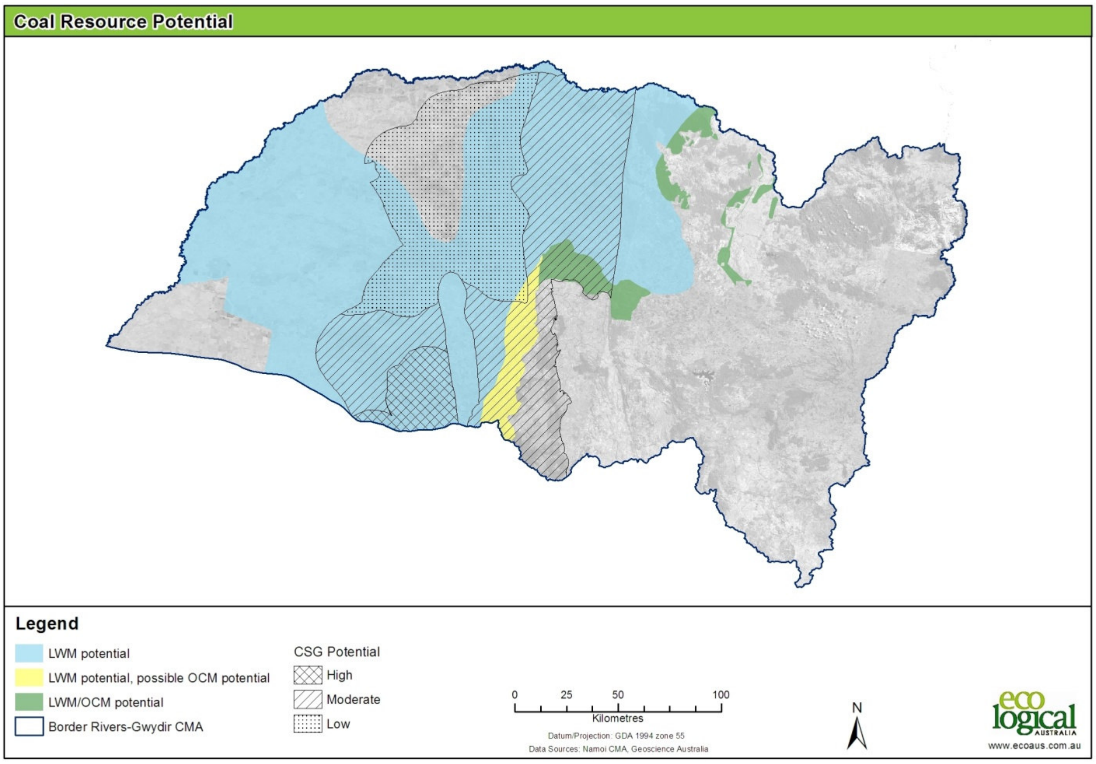

Figure 3. Coal resource potential in the BRG catchment

4 Floodplains

4.1 Definition

For the purpose of this of this study a floodplain is defined as a low-lying parcel of land adjacent to a drainage line that is subject to natural inundation. Variations in flow frequency, duration and depth create complex spatial variations of floodplain extent during different flood events therefore it should not be assumed that all floodplain areas are inundated during every flood event. Rather floodplain limits should be regarded more as indicative opposed to a firm definition, as they illustrate an envelope of potentially flooded areas across multiple flood events.

4.2 Capture

4.2.1 Overview

Automated capture of floodplains was undertaken within the CSG footprint (hatching in Figure 3) using density slicing of the mid-infrared band 5 across a multi-temporal series of Landsat 5 TM (thematic mapper) images from periods of high flow. Where possible, the composite layer of inundated areas identified in the density slice were used to inform the manual digitising of the floodplains. Various other key spatial data and existing floodplain mapping were used to inform mapping. Delineating floodplains in areas within the relatively flat Western Plains that did not coincide with existing floodplain mapping relied heavily on operators understanding surface flow across extensively flat land with little change in elevation. Due to the highly variable flow patterns during individual flood events, where no existing floodplain data existed, the precautionary principle was applied and maximum possible floodplain extent was captured.

4.2.2 Automated analysis

Hydrographs for the BRG Catchment were obtained and used to identify a range of large flood events from 2009 – 2013. Available Landsat imagery was obtained for the two major flow peaks, being 14 November 2011 and 27 November 2011. A density slice technique was applied to the single-band monochrome imagery (Landsat 5 TM), whereby greyscale values (0-255) were converted into a series of intervals, or slices, and different colours assigned to each slice. All slices below the upper wetness index threshold of 56 were classified as areas of inundation. These layers were then merged to create a composite floodplain layer.

The density slice classification gave a reasonable estimate of inundation pixels but tended to include more pixels that were obviously not floodplain areas (e.g. shaded hillsides, croplands). On the other hand, lowering the threshold, reduced the capture of known inundated areas. As a result of inaccuracies within the layer, the automated floodplain capture was used only as an indication of possible floodplain throughout the manual digitising process.

4.2.3 Manual digitising

Manual digitising of the floodplains was undertaken in ArcGIS with support of key spatial data including DEM, hydrolines, contours, digital topographic map series and ADS40 imagery; as well as a range of existing floodplain layers that included Gwydir floodplain mapping (Cameron McNamara Pty Ltd 1980) and an Inundation Frequency Map of Gwydir Wetlands 1988-2009 (Thomas *et al* 2011). Where possible these layers were combined to inform the operator of surface flow response (i.e. flow) to topography during periods of high flow. However, the eastern part of the catchment extended beyond the footprint of the existing floodplain layers, so the reliability of the floodplain delineation was only as good at the apparent topography deciphered from the DEM.

The inundation map (Thomas *et al.* 2011) only covered a small area in the western part of the catchment, while the Gwydir floodplain mapping had known inaccuracies and over-compensations. Every reasonable effort has been made to ensure accuracy of the floodplain delineation, however in the flat areas of the catchment where precise information on flood limits was not available, the precautionary principle was applied, and areas classified as low risk of inundation were included as outer floodplains.

4.2.4 Nomenclature

Individual floodplain units were named after the major contributing watercourse from which floodwaters are received. These included the Boomi, Gwydir, Horton, McIntyre and Mihi rivers, Croppa, Gil Gil, Moonin, Ottleys, Thalaba, Tycannah and Whalan creeks, and Gingham Watercourse. Delineation was carried out by intersecting the final floodplain layer with the local catchment layer, where it coincided with the CSG footprint. Where more than 1 unit occurred within a valley, sequential numbers were assigned from upstream.

4.3 Description of final layer

A total of 40 floodplain units (assets) covering 840,700 ha in total were captured within areas of CSG potential in the BRG Catchment (Figure 4). Floodplains were generally smaller in the eastern part of the catchment (minimum area = 2 ha for Gwydir River floodplain 2) and larger in the western part (largest area = 279 300 ha for Gil Gil Creek floodplain).

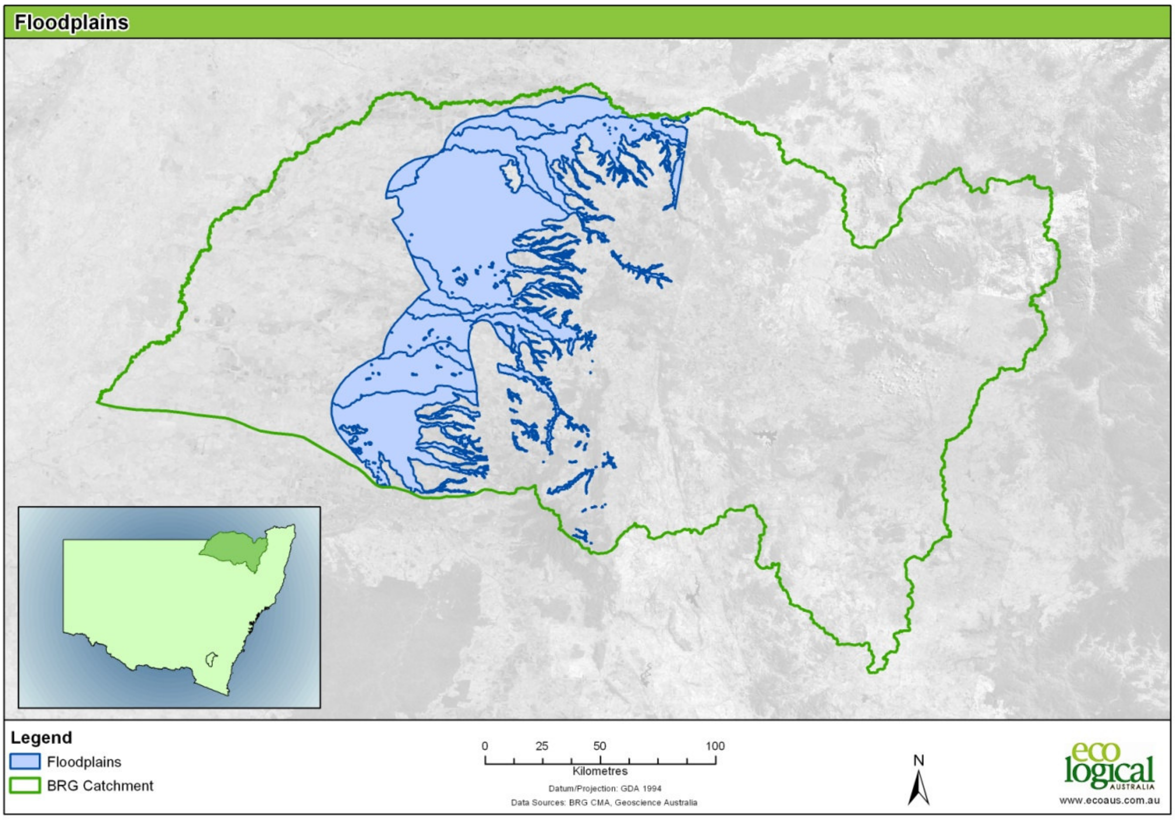

Figure 4. Floodplains within the BRG Catchment (areas of CSG potential only)

4.4 Assignment of vulnerability

4.4.1 Background

Refer to Section 3.4.1 above.

4.4.2 Method

A rating for vulnerability was derived from the sensitivity-resilience matrix shown Table 1, where sensitivity and resilience were established using the rule-set in Appendix I. Absence of key hydrological data such as median flows and level of water allocation were not available for this analysis.

Once all data were compiled, a final review was conducted in which vulnerabilities were revised downwards if part of the asset occurred outside the mapped extent of the low-potential CSG gas resource, as depicted in Table 5.

Table 5. Revised vulnerability scores based on coal potential

Location of Floodplain	Change to Vulnerability Status
Part or all within areas of high or moderate CSG potential	No change
None within areas of high or moderate CSG potential, but part within area of low CSG potential	Moderate → Low; High → Moderate

4.4.3 Results

Results of the vulnerability assessment for floodplains is shown in Table 6 and Table 7. The majority of floodplain is considered to be high vulnerability for habitat, while the majority of floodplain is considered to be low to medium vulnerability for flow pattern, water quantity and water quality.

The level of confidence associated with sensitivity, resilience and vulnerability classes for flow pattern water quantity and water quality is considered to be poor given the absence of key hydrological and land use data for this study. Habitat estimates are more reliable however, as they account for native vegetation attributes that play a key role in floodplain function.

Figure 5 shows an example for the water quality value of floodplain units.

Table 6. Number of floodplain units by sensitivity, resilience and vulnerability class (CSG extraction)

	Sensitivity			Resilience			Vulnerability*		
Effect	High	Medium	Low	High	Medium	Low	High	Medium	Low
Flow pattern	18	8	14	1	15	24	19	15	6
Habitat	5	15	20	20	7	13	11	9	20
Water Quantity	no data			25	6	9	25	6	9
Water Quality	1	17	22	3	25	12	3	21`	16

* values based on sensitivity-resilience pairing (Table 1) and location of floodplain in relation to CSG potential (Table 2)

Table 7. Area (km^2) of floodplain units by sensitivity, resilience and vulnerability class (CSG extraction)

	Sensitivity			Resilience			Vulnerability*		
Effect	High	Medium	Low	High	Medium	Low	High	Medium	Low
Flow pattern	35	69	8,303	0	2,121	6,281	37	6,313	2,058
Habitat	1	8,283	123	2,891	5,272	244	5,261	254	2,892
Water Quantity	no data			2,483	3,311	2,613	2,483	3,311	2,613
Water Quality	0	3,111	5,296	0	4,616	3,791	17	6,467	1,923

* values based on sensitivity-resilience pairing (Table 1) and location of floodplain in relation to CSG potential (Table 2)

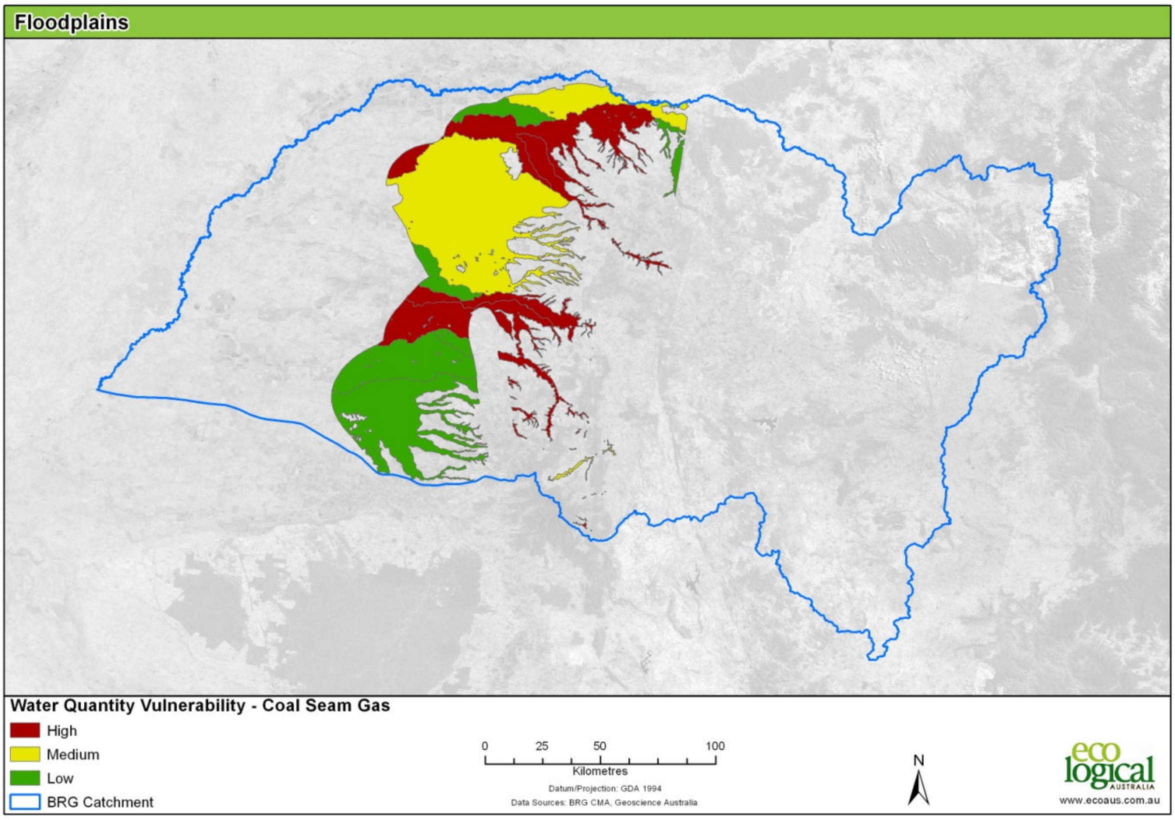

Figure 5. Vulnerability of potential CSG extraction to water quantity value of floodplains in BRG

5 Discussion

Given the tight timeline for the project and the lack of water flow information available for the local catchment and floodplain assets, a number of assumptions were necessary to complete and implement the vulnerability framework:

- As a rule the vulnerability asset framework is supported by generic rather than specific understanding of catchment floodplain assets in the Border Rivers-Gwydir catchment
- Vulnerability ratings are relative, not absolute
- The number and type of values used to assign asset sensitivity and resilience were limited by the availability of existing spatial data to describe the target asset. It is acknowledged that there are likely several important descriptors for qualifying water asset responses to pressure from coal seam gas extraction and coal mining, but if they were not available in a compatible spatial format they could not be used in the assessment
- In completing the vulnerability framework it was also assumed that the more degraded an asset's current condition, the less sensitive it would be to further impacts. Conversely, it was assumed the assets in the best current condition were most resilient to change
- It was assumed that where pressure from coal seam gas extraction and coal mining did not involve total physical loss of the asset, the pressure would never equate to a total change in condition of the asset; that there would always be some component of the current structure and function retained.

Consistent with recommendations provided in ELA (2012a), it is suggested that assignment of a condition class for each asset (where condition is an indicator of resilience and sensitivity, and thus vulnerability) be improved by factoring other metrics such as landscape connectivity, contiguity of vegetation that links riparian assets across catchments and floodplains, and 'naturalness' of flood regimes. This would in turn improve the reliability of the vulnerability categories incorporated in this revised version of the WAIT database for the BRG CMA.

References

Cameron McNamara Pty Ltd. 1980. *Gwydir Valley Floodplain Atlas,* Prepared for the Water Resource Commission.

Eco Logical Australia. 2012a. *Bioregional Assessment of the Border Rivers and Gwydir Catchments Phase 1.* Prepared for the Border Rivers and Gwydir Catchment Management Committee.

Eco Logical Australia. 2012b. *Assessing the cumulative risk of mining scenarios on bioregional assets in the Namoi Catchment: Development and trial of an interactive GIS tool.* Prepared for Namoi Catchment Management Authority'

Thomas, R.F., Lu, Y., Cox, S.J and Hunter, S.J. 2011. Inundation Frequency Map of the Gwydir Floodplain 1988-2009 Version 1.0. NSW Wetland Recovery Program, Department of Environment, Climate Change and Water, Sydney

Walker, B., and Salt, D. 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press, Washington DC.

Appendix I. Rules used to assign levels of ‘sensitivity’ and ‘resilience’ to each local catchment and floodplain asset.

Outline

This Appendix outlines the rules used to assign a sensitivity and resilience level, and thus a vulnerability rating (high, medium or low) to each asset for each effect.

Algorithms

Land Use Index = [0 * intensive + 0.5 * semi-intensive + 1.0 * non-intensive]/catchment area (ha)

Where

intensive (ha) = area of intensive agriculture, including cropping, vineyards, horticulture, industry/urban etc

semi-intensive (ha) = area of semi intensive agriculture, mainly grazing on modified (improved) land; and

non-intensive (ha) = area of non-intensive agriculture, including grazing native pastures and woodlands, native forestry etc

EEC index = [(1 X EEC1) + (0.75 * EEC2) + (0.5* EEC3) + (0.25*EEC4) + (0 * EEC5)]/catchment area (ha)

Where

EEC1 (ha) = vegetation types that have >75% EEC candidacy

EEC2 (ha) = vegetation types that have 50 – 75% EEC candidacy

EEC3 (ha) = vegetation types that have 25 – 50% EEC candidacy

EEC4 (ha) = vegetation types that have 5 – 25% EEC candidacy

EEC5 (ha) = vegetation types that have < 5% EEC candidacy

Asset class = Local catchments

Effect = flow pattern

Sensitivity

Sensitivity = high if stream density ≥ 4.0 km per 100 ha (1 km^2) of catchment

Sensitivity = medium if stream density 2.0 – 4.0 km per 100 ha (1 km^2) of catchment

Sensitivity = low if stream density < 2.0 km per 100 ha (1 km^2) of catchment

Resilience

Resilience = high if land use is non-intensive (land use index ≥ 0.700)

Resilience = medium if land use is semi-intensive (land use index 0.300 – 0.700)

Resilience = low if land use is intensive (land use index < 0.300) or local catchments are largely impacted by major storages (i.e. upstream)

Resilience is reduced by a factor of one (e.g. from High to Medium) when local catchments are moderately impacted by major storages (i.e. storage upstream but significant flow from other catchments occurs).

Effect = habitat

Sensitivity

Sensitivity = high where EEC index ≥ 0.500 or number of vegetation types ≥ 10

Sensitivity = low where EEC index = < 0.250 and number of vegetation types < 7

Otherwise sensitivity = medium

Resilience

Resilience measured based on historical level of clearing in catchment, and proximity to the 30%, 70% and 100% clearing thresholds (specified in Namoi CAP).

Resilience = high where % vegetation cleared = 0 – 10%, 30 – 50%, 70 – 80% (at least 20% from any threshold)

Resilience = medium where % vegetation cleared = 10 – 20%, 50 – 60%, 80 – 90% (at least 10% from any threshold)

Resilience = low where % vegetation cleared = 20 – 30%, 60 – 70%, 90 – 100% (within 10% of a threshold)

Effect = water quantity

Sensitivity

Sensitivity could not be calculated as flow and water entitlement data were not available.

Resilience

Resilience = high if Max RCI hydrological stress index > 0.999

Resilience = medium if Max RCI hydrological stress index = 0.947 – 0.999

Resilience = low if Max RCI hydrological stress index < 0.947

Effect = water quality

Sensitivity

Sensitivity = high if majority of land use is high intensity (land use index ≤ 0.300)

Sensitivity = medium if majority of land use is semi-intensive (land use index = 0.300 – 0.700)

Sensitivity = low if majority of land use is low intensity (land use index > 0.700)

Resilience

Resilience = high if ≥ 70% of riparian areas (100m buffer of drainage) are comprised of native vegetation

Resilience = medium if 30 - 70% of riparian areas (100m buffer of drainage) are comprised of native vegetation

Resilience = low if < 30% of riparian areas (100m buffer of drainage) are comprised of native vegetation

Asset class = Floodplains

Effect = flow pattern

Sensitivity

Sensitivity = high if stream density ≥ 4.0 km per 100 ha (1 km^2) of catchment

Sensitivity = medium if stream density 2.0 – 4.0 km per 100 ha (1 km^2) of catchment

Sensitivity = low if stream density < 2.0 km per 100 ha (1 km^2) of catchment

Resilience

Resilience = high if land use is non-intensive (land use index ≥ 0.700)

Resilience = medium if land use is semi-intensive (land use index 0.300 – 0.700)

Resilience = low if land use is intensive (land use index < 0.300)

Resilience is reduced by a factor of one (e.g. from High to Medium) when local catchments are moderately impacted by major storages (i.e. storage upstream but significant flow from other catchments occurs).

Effect = habitat

Sensitivity

Sensitivity = high where EEC index ≥ 0.500 or number of vegetation types ≥ 10

Sensitivity = low where EEC index = < 0.250 and number of vegetation types < 7

Otherwise sensitivity = medium

Resilience

Resilience measured based on historical level of clearing in catchment, and proximity to the 30%, 70% and 100% clearing thresholds.

Resilience = high where % vegetation cleared = 0 – 10%, 30 – 50%, 70 – 80% (at least 20% from any threshold)

Resilience = medium where % vegetation cleared = 10 – 20%, 50 – 60%, 80 – 90% (at least 10% from any threshold)

Resilience = low where % vegetation cleared = 20 – 30%, 60 – 70%, 90 – 100% (within 10% of a threshold)

Effect = water quantity

Sensitivity

Sensitivity could not be calculated as flow and water entitlement data were not available.

Resilience

Resilience = high if Max RCI hydrological stress index > 0.999

Resilience = medium if Max RCI hydrological stress index = 0.947 – 0.999

Resilience = low if Max RCI hydrological stress index < 0.947

Effect = water quality

Sensitivity

Sensitivity = high if majority of land use is high intensity (land use index ≤ 0.300)

Sensitivity = medium if majority of land use is semi-intensive (land use index = 0.300 – 0.700)

Sensitivity = low if majority of land use is low intensity (land use index > 0.700)

Resilience

Resilience = high if ≥ 70% of riparian areas (100m buffer of drainage) are comprised of native vegetation

Resilience = medium if 30 - 70% of riparian areas (100m buffer of drainage) are comprised of native vegetation

Resilience = low if < 30% of riparian areas (100m buffer of drainage) are comprised of native vegetation

HEAD OFFICE
Suite 4, Level 1
2-4 Merton Street
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

SYDNEY
Level 6
299 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9264 0717

ST GEORGES BASIN
8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

CANBERRA
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

COFFS HARBOUR
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1230
F 02 6372 9230

PERTH
Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 08 9322 1358

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 4268 4361

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1220
F 02 4322 2897

DARWIN
16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601

BRISBANE
PO Box 1422
Fortitude Valley QLD 4006
T 07 3503 7193

1300 646 131
www.ecoaus.com.au