Upper Condamine Alluvium

Central Condamine Alluvium
Groundwater Background Paper

July 2018
1 Introduction

This paper provides background information about the Central Condamine Alluvium (CCA) groundwater sustainable diversion limit (SDL) resource unit (GS64a) situated within the Queensland Water Plan (Condamine and Balonne) area. It provides context for the CCA, including location, climate, geology, hydrogeology, ecological profiles, uses and management practices, and supports the risk assessment report provided for the accreditation of the Queensland water plans under the Basin Plan 2012.

2 Location

The CCA is situated within the catchment of the Condamine River (Figure 1). It is bound by the aquifers of the Main Range Volcanics (MRV) that form the Upper Condamine Basalts (GS65) of the Great Dividing Range in the east, the Great Artesian Basin (GAB) in the east and west, the Upper Condamine Alluvium Tributaries (GS64b) in the east, north and west, and by metamorphics and intrusive geologies in the south. The entire CCA extends across the Southern Downs, the Toowoomba and the Western Downs regional councils and covers an area of approximately 4453 km².

Figure 1: The location of the Central Condamine Alluvium resource unit (GS64a).
3 Land use

Grazing and cropping (dryland agriculture) are the major land uses across the CCA (about 89 per cent of area), followed by irrigated agriculture (about 6 per cent), forestry plantations and residential uses (DNRM 2017b; Barron et al. 2011; DSITI 2016). All of these uses may access groundwater. In the CCA area irrigated and dryland agriculture are the dominant land uses followed by grazing and forestry, town and industrial uses (OGIA 2016b). Land use map is provided in Attachment A.

Minimal change in land used for grazing and cropping has occurred over the 14 year period from 1999 to 2013 (DSITI 2016). There is a small trend away from grazing, suggesting a minor decline in stock and domestic demand. Conversely mining land use is increasing and this may have implications for groundwater use in the south, central west and north-western parts of the CCA due to drawdown for operational purposes or due to dewatering and release into surface water (Holland et al. 2017). There is growth in the development of coal seam gas (CSG) in the Surat geological basin including under adjacent areas in the CCA under the central and western area of the aquifer (Sander et al. 2014, OGIA 2016b). Growth in CSG land use could have impacts on demand for groundwater through dewatering and water release. OGIA estimates CSG water losses to be 1160 ML per year, which is up to 2% of the volume extracted from the CCA for irrigation.

Irrigated cropping and intensive animal production has increased in the CCA area since the 1960s, which has significantly depleted the water resource. An admin hold was in place from 1970 restricting new entitlements and a moratorium on construction of new stock and domestic bores was in force from July 2008. This was removed in December 2014 when more stringent groundwater management rules were applied (refer to Sections 8 and 9 for management practices and effects).

4 Climate and rainfall

The climatic conditions in the CCA vary from subtropical in the western parts to temperate conditions in the eastern valleys. The CCA aquifers receive rainfall and subsurface inflows from the well-watered Great Dividing Range basalts and alluviums with annual rainfall averages ranging from 697 mm at Pittsworth on the south-eastern margins of the CCA to 602 mm at Dalby, in the central eastern CCA.

5 Geology and hydrogeology

5.1 Major formations

The CCA is composed of interlayered beds of riverine, floodplain and lakebed alluvial deposits of different ages sourced from basalts in the east and Jurassic sediments and older geological formations in the south and west (Dafny and Silburn 2013b; Huxley 1982). Deep sand and gravel beds which lie under clay strata under the surface sheetwash and other alluvium in the Condamine River valley provide storage for the aquifer water resource (OGIA 2016a).

The aquifer bearing beds are predominantly formed within extinct river and creek channels with deposits that have been weathered through extended periods of erosion, deposition, consolidation and concretion. The depth of alluvium ranges from less than 10 m in upstream headwater areas and along the floodplain edges to a maximum of 140 m through the deeper palaeochannel sections of the CCA. Sheetwash deposits of more poorly sorted clayey to silty sand and gravel surround the floodplain deposits and extend towards the alluvial valley margins. The division of the alluvial sediments into floodplain and sheetwash deposits is based upon differing depositional processes that have produced different landform and aquifer characteristics over the last 65 million years (OGIA 2016a). Most of the CCA lies on top of Walloon Coal Measures (WCM) with separation provided by a transitional zone of low hydraulic conductivity (high clay content) which developed over the last 145 million years after WCM formation.

For information relating to the regional geological setting refer to Attachment B.

1 Data sourced from the Bureau of Meteorology monthly climate statistics (all years); www.bom.gov.au
5.2 Recharge and discharge

The aquifer is associated with the Condamine River and its tributaries. Rainfall infiltration, flood recharge and river leakage are the primary sources of water for the recharge of the CCA aquifer including leakage from the upslope UCAT aquifers.

Without the impact of over-extraction, the natural gravity driven gradient for groundwater flow in the CCA is from the southeast to northwest. Over-extraction of water has caused depressions in water levels in the Cecil Plains area and adjacent to and north-west of Dalby causing groundwater to flow into the depressions. Recharge to the CCA is complex. It is believed that the aquifer is mainly recharged from river and stream flow leakage (39 to 115 mm/year), including from weirs and other surface storages. Diffuse recharge by local infiltration and deep drainage including irrigation water is expected to be limited by the high clay content of sub-surface soils and resultant runoff to channels (OGIA 2016a).

Some recharge occurs from the bedrock including the underlying GAB system and other geological formations with water sourced from the adjacent Main Range Volcanics and outcrop areas along the eastern and south-eastern margins of the CCA. A significant upward gradient in groundwater levels from the GAB to the Condamine Alluvium in the central area has developed because of water extraction from the alluvium (OGIA 2016a).

Discharge is mostly through pumped extractions and downstream lateral flow, however due to extraction almost equalling rates of recharge it is likely that discharge from the CCA downstream is less than 700 ML/year (OGIA 2016a).

5.3 Water resource connections

The alluvium is hydraulically connected to the Main Range Volcanics which form the adjacent Upper Condamine Basalts SDL area in the east of this subcatchment, although the extent of the connection is unknown (refer to Attachment C). A recent study completed by the Office of Groundwater Impact Assessment (OGIA) concluded that the level of hydraulic connectivity between the Condamine Alluvium and the WCM is low due to the clay-dominated transition zone and mudstones that separate the CCA from the WCM (OGIA 2016a).

The CCA groundwater system is a self-contained, slow moving, partially confined aquifer. Exchanges with other water resource units are dominated by inflows, e.g. up to 1470 megalitre (ML) from the UCAT. Outflow from the CCA is estimated to be less than 700 ML to the lower Condamine.

Connections between aquifers include deep, lateral seepage and baseflows with the UCAT (GS64b), Upper Condamine Basalts (GS65) and the Condamine Fractured Rock (GS53) systems and the Great Artesian Basin (GAB). Most of the water is retained within the CCA with discharge governed by rates and quantities extracted (including releases due to mining and gas extraction) and annual rainfall conditions. There are no interstate connections or dependencies with other Groundwater Water Resource Plan areas. Sections 5.1 to 5.2 and Attachment C explore these connections in more detail.

Table 1 summarises connectivity status of groundwater in the CCA with other, adjacent water resources, particularly whether connection is significant or not.

**Table 1: Hydrologic connectivity between the CCA and other water resources**

<table>
<thead>
<tr>
<th>Connected resource units</th>
<th>Significant connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Condamine Alluvium (Tributaries) (GS64b)</td>
<td>Yes</td>
</tr>
<tr>
<td>Upper Condamine Basalts (GS65)</td>
<td>No</td>
</tr>
<tr>
<td>Condamine Fractured Rock (GS53)</td>
<td>No</td>
</tr>
<tr>
<td>Condamine-Ballone (SS26) (surface water)</td>
<td>Yes</td>
</tr>
<tr>
<td>Great Artesian Basin groundwater (not a basin plan resource unit)</td>
<td>No</td>
</tr>
</tbody>
</table>

* Two water resources are considered to have a significant hydrological connection to one another if both water from a resource is physically able to move to the other resource and activities in one resource may have a
material impact on the state or condition of the other. “No” status was assigned in case there was no evidence of significant, or high, connectivity between the resources based on hydrological studies or local, expert knowledge.

5.4 Transmissivity and specific yield

The Alluvium aquifer resource has lateral and vertical divisions due to intermediate clay layers that may impose semi-confined conditions over alluvium layers that are 20 to 80 m thick (Barnett and Muller 2008; SKM 1999). This layering causes variations in the transmission rates of water throughout the whole aquifer. The highest value of transmissivity occurs to the northwest of Dalby (2400 m²/day), east of Cecil Plains (1900 m²/day) and near Brookstead (1840 m²/day)² (Huxley 1982). The yields achievable under current conditions range from 4 to 10 per cent with the increase in clay content in the downstream direction causing a decrease in the specific yield³. Specific yield also decreases to the east (Barnett and Muller 2008; Huxley 1982; Dafny and Silburn 2013a, 2013b).

5.5 Groundwater quality

Water quality is generally suitable for most purposes of use, although there are areas where water quality is marginally suitable to unsuitable for stock, domestic and irrigation purposes (ANZECC 2000). Salinity is highest in the eastern part of the alluvial aquifer system, and increases down gradient and with depth in the aquifer although this is usually associated with the WCM underlying the alluvium (SKM 1999; OGIA 2016a; McNeil et al. 2017). Concentrations of salts can also develop at the alluvia edges as a result of evaporation and over-extraction may cause localised discharge of saline groundwater from strata associated with the WCM.

6 Groundwater dependent ecological assets

Groundwater dependent ecosystems (GDEs) in the CCA include natural springs, baseflows and groundwater dependent vegetation and fauna. Public mapping⁴ identifies ecosystems with GDE characteristics in the CCA area, although often the degree of connectivity to underlying aquifers has not been determined (the aquifer is now located below stream flows). Spring features may reliably indicate dependence on groundwater flows, however Purcell (2006) identified a limited extent to potential spring occurrence – focused on the southern and south-eastern limits of the CCA. Field survey only located one intercepting spring in lower Oakey Creek, spanning the influence of the UCAT and CCA systems (refer to the background paper for the UCAT groundwater system).

The DNRM risk assessment (2017a) has identified medium level risks to terrestrial vegetation and wetlands dependent on elevated groundwater levels. However, there are few GDEs in the area and active management is resulting in increased water levels.

7 Entitlements and use

The water resources of the CCA are managed under the Water Plan (Condamine and Balonne) 2004. A water license is required to access groundwater for purposes other than stock and domestic use within the groundwater management area. Works used to access the groundwater resource must be assessed by the department.

Table 2 summarises entitlements, use and sustainable diversion in 2012 and identifies the scale of the water use management challenge in the CCA (DNRM 2012; MDBA 2012). A recent water use

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² Estimates of transmissivity may be derived from conductivity statistics in national mapping <http://nationalmap.gov.au/> if aquifer cross-sectional depths are known. Note that hydraulic conductivity may exceed 30m/day in some areas.
³ Yield is the supply of water on demand or a measure of water available to bores across the depth of the aquifer; percentages represent the fraction of the volume across the depth of the aquifer that may be available for extraction.
audit by OGIA (2016a) in the CCA indicates that reductions are being achieved and that conditions are being monitored (Table 3).

Table 2: Entitlement and water use statistics for the CCA

<table>
<thead>
<tr>
<th>Use or requirement</th>
<th>CCA entitlement or requirement (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total entitlement volume</td>
<td>86.06</td>
</tr>
<tr>
<td>Estimated stock and domestic use</td>
<td>6.0</td>
</tr>
<tr>
<td>Baseline diversion limit</td>
<td>81.4</td>
</tr>
<tr>
<td>Sustainable diversion level</td>
<td>46.0</td>
</tr>
<tr>
<td>Water to be recovered</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Table 3: Estimated use statistics for the CCA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Number of bores</th>
<th>Estimated use (ML/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring bores</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Water supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>1,052</td>
<td>64,251</td>
</tr>
<tr>
<td>Industrial</td>
<td>33</td>
<td>1,476</td>
</tr>
<tr>
<td>Stock and domestic</td>
<td>2,709</td>
<td>2,069</td>
</tr>
<tr>
<td>Town water supply</td>
<td>59</td>
<td>4,227</td>
</tr>
<tr>
<td>Total (supply and use)</td>
<td>3,853</td>
<td>69,953</td>
</tr>
</tbody>
</table>

8 Management arrangements

Groundwater in the CCA is managed primarily via water sharing rules under the Water Regulation 2016. The CCA groundwater management area (the GMA) defines the area of the alluvial aquifer (Figure D1 in Attachment D). It is divided into four sub-areas to better manage reliable access to the available water resource. Sub-areas 2 and 3 contain transitional zones across which variations in annual announcement are carried. This stems from a change in the number of subareas in 2012.

Rules for specific groundwater management areas are provided at <https://www.business.qld.gov.au/industries/mining-energy-water/water/sharing-rules> (DNRM 2016a). Table below summarises current management arrangements in the CCA.

<table>
<thead>
<tr>
<th>Management measure</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water plan</td>
<td>Water Plan (Condamine and Balonne) 2004</td>
</tr>
<tr>
<td>Moratorium</td>
<td>No</td>
</tr>
<tr>
<td>Declared subartesian area</td>
<td>No</td>
</tr>
<tr>
<td>Groundwater management area</td>
<td>Yes</td>
</tr>
<tr>
<td>Metering take</td>
<td>All active non-stock and domestic entitlements are metered</td>
</tr>
<tr>
<td>Water licences</td>
<td>Required for all purposes other than stock and domestic</td>
</tr>
<tr>
<td>Development permit for works</td>
<td>Required for all purposes</td>
</tr>
<tr>
<td>Water sharing rules</td>
<td>Yes</td>
</tr>
<tr>
<td>Announced entitlements</td>
<td>Yes</td>
</tr>
<tr>
<td>Carry over</td>
<td>Yes</td>
</tr>
<tr>
<td>Forward draw</td>
<td>No</td>
</tr>
<tr>
<td>Seasonal water assignment</td>
<td>Yes</td>
</tr>
<tr>
<td>Limitations on take</td>
<td>No</td>
</tr>
<tr>
<td>Pumping hours restrictions</td>
<td>No</td>
</tr>
</tbody>
</table>
Groundwater levels have been monitored in the CCA since the 1960s in private bores, wells and the departmental monitoring system. Monitoring of up to 250 bores in the CCA is undertaken by the Department of Natural Resources, Mines and Energy (DNRME) and agents as part of the state’s Groundwater Ambient Water Quality Network and Groundwater Level Network, to assist planning and management of groundwater resources\(^5\). Water quality and salinity sampling frequency varies from one to three years and water level measurement frequency varies between two and four times a year depending on location.

8.1 Proposed future management – new water plans in 2019

Draft new water plans and water management protocols for the Condamine and Balonne and the Border Rivers and Moonie catchments were released in April 2018. Due for finalisation in early 2019, these new statutory planning instruments include revised management arrangements for the QMDB.

Following the revision, enhanced water sharing rules will specify annual announcements arrangements to ensure consistency of the long term average extractions with the SDL under the Basin Plan (46GL).

It is anticipated that the Commonwealth water recovery program will likely recover enough entitlement to ‘bridge the gap’. However if recovery falls short, water entitlements will be reduced under a water planning process to a level equivalent to that sort by the Commonwealth water recovery process.

Other water sharing rule revisions will include changes to the accounting arrangements and the removal of the transitional zones introduced in 2012.

9 Overall status

A water table depression has expanded considerably since 1966 and a depletion zone has developed within the central part of the CCA, which has progressively expanded to incorporate almost all of the CCA Subareas 2 and 3. The falling water levels in the departmental monitoring bores indicate the historical maximum groundwater entitlement of 86 GL/y exceeds rates of recharge and is not sustainable (DNRM 2012). When compared with water levels recorded in the 1960s, the depletion zone exhibits water level reductions of up to 35 m in the most highly impacted areas.

Due to the practices and levels of extraction applied in the CCA, aquifer levels fell until 2009, irrespective of rainfall (OGIA 2016a). A long-term policy of gradually increased restrictions on permitted take began in 1994, peaking at 50/70 per cent in the water year starting 2010. This has resulted in reductions in the rate of decline and a trend toward a new aquifer equilibrium level. This is demonstrated by transects of groundwater monitoring levels in each sub area that indicates that the regional groundwater trend in water levels has stabilised following previous declines (DNRM 2015; Dafny 2014).

Nonetheless, the trend to what appears to be a more regionally stable water level needs to continue to be monitored, in order to understand how these management arrangements (and potential future water recovery programs) influence the longer-term water levels and the aquifer sustainability.

10 References


Climate change impact on groundwater resources in Australia, Waterlines report, National Water Commission, Canberra.


DNRM (Department of Natural Resources and Mines) 2017a. Condamine and Balonne. Water Plan: Risk assessment for the condition and continued availability of water resources of the water plan area (Draft). The State of Queensland.


Attachment A: Land use

Figure A: Condamine and Balonne land use (DSITI 2016).
Attachment B: Regional geological setting

The geology of the Condamine and Balonne catchment is predominantly jurassic to quaternary in age (i.e. 205 million to the present time). The geology of the Condamine catchment (shown in Figure B1 and B2) is composed of four main regional geological formations:

- The MRV basaltic formations to the east and north
- The alluvial deposits of the UCAA including the CCA, Condamine tributary alluviums and the Chinchilla Sands (as part of the Lower Condamine Alluvium)
- The sedimentary deposits of the Great Artesian Basin (GAB) which include sediments above the GAB and the sediments comprising the GAB, including the Kumbarilla Beds, Walloon Coal Measure and Marburg Sandstone underlying and to the west of the Condamine
- The metamorphics and intrusives of the Texas Beds and Granites to the south.

![Figure B1: Regional themes of geological formations of the Condamine catchment.](image)

Table B provides a detailed description of the age and composition of the geological formations relevant to the Condamine catchment, with geological unit names (and colours) linked to the areas in Figure B1.
Table B: Condamine catchment detailed analysis of the age and composition of geological formations (SKM, 1999; Geoscience Australia, 1980).

<table>
<thead>
<tr>
<th>Map Code</th>
<th>Period / Epoch</th>
<th>Age</th>
<th>Formal unit name</th>
<th>Rock type</th>
<th>Thickness range (m)</th>
<th>Depositional environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jurassic-Quaternary</td>
<td>200-1.8 million years ago</td>
<td>-</td>
<td>Laterite, silcrete.</td>
<td>Variable</td>
<td>Diagenetic alteration.</td>
</tr>
<tr>
<td></td>
<td>Quaternary (Pleistocene to Holocene)</td>
<td>1.8 million years ago - present</td>
<td>Includes Condamine River and Tributary Alluvium</td>
<td>Quartzose sandy alluvium, black and dark red-brown calcareous clay soil; vertebrate fossils.</td>
<td>0-140</td>
<td>Fluvial, colluvial, channel, overbank and sheetwash deposits.</td>
</tr>
<tr>
<td></td>
<td>Tertiary to Quaternary (Pliocene-Pleistocene)</td>
<td>5-0.01 million years ago</td>
<td>Includes Chinchilla Sands</td>
<td>Poorly consolidated sandstone, mudstone, conglomerate.</td>
<td>0-100</td>
<td>Fluvial labile sand grading into granule conglomerate and sandy clay, some pebbles.</td>
</tr>
<tr>
<td></td>
<td>Tertiary (Upper Oligocene to Lower Miocene)</td>
<td>55-1.8 million years ago</td>
<td>Main Range Volcanics</td>
<td>Alkali-olivine basalt, minor tuff, sandstone, agglomerate, shale, dolomite (Tmt = trachyte).</td>
<td>0-200</td>
<td>Mafic volcanics.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trachyte, rhyolite, syenite, micromonzonite, granophyre.</td>
<td></td>
<td>Felsic volcanics.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dolerite, gabbro, teschenite, basalt.</td>
<td></td>
<td>Mafic volcanics.</td>
</tr>
<tr>
<td></td>
<td>Early Cretaceous-Mid-Jurassic</td>
<td>145-100 million years ago</td>
<td>GAB-Kumbarilla Beds</td>
<td>Fine to coarse, lithic and calcareous to quartzose sandstone, generally cross-bedded but poorly bedded in places; laminated to massive, comparatively well bedded siltstone and mudstone. Some conglomerate.</td>
<td>0-200</td>
<td>Terrestrial.</td>
</tr>
<tr>
<td></td>
<td>Middle to Upper Jurassic</td>
<td>170-145 million years ago</td>
<td>GAB-Walloon Coal Measures</td>
<td>Thin-bedded, claystone, shale, siltstone, lithic and sublithic to feldspathic arenites, coal seams and partings; minor limestone.</td>
<td>0-400</td>
<td>Lacustrine, deltaic and meandering fluvial.</td>
</tr>
<tr>
<td></td>
<td>Lower Jurassic</td>
<td>200-170 million years ago</td>
<td>GAB-Marburg Formation</td>
<td>Lithofeldspathic labile and sublabile sandstone, siltstone, shale, minor coal, ferruginous olivine marker. Some pebbly quartzose sandstone at base.</td>
<td>0-300</td>
<td>Lacustrine, deltaic and braided fluvial.</td>
</tr>
<tr>
<td></td>
<td>Devonian-Carboniferous</td>
<td>359-313 million years ago</td>
<td>Texas Beds</td>
<td>Greywacke, mudstone, slate, asper, chert, conglomerate, limestone, acid to intermediate volcanics.</td>
<td>Unknown</td>
<td>Greywacke, conglomerate, siltstone, mudstone, slate, local phyllite, chert, basalt limestone and rare tuff; low grade regionally metamorphosed, variably deformed.</td>
</tr>
</tbody>
</table>
Figure B2: High resolution mapping of overlaying geological units (Dafny and Silburn 2013b).
Attachment C: Regional hydrogeological setting

The Central and Upper Condamine sub-catchment hydrogeology is complex with varying connectivity between water stores contained within the major geological formations (Figure C1 and C2). Some general patterns of hydrogeological storages and connections are:

- Hydrologic connections between the alluvium, the basalts and the GAB intake beds in the east of the sub-catchment (CSIRO, 2008)
- Leakage from the MRV into the UCAT and CCA, generally following topographic contours
- Leakage from the MRV and Chinchilla Sands and direct infiltration through outcropping Kumbarilla Beds and WCM into the GAB
- Groundwater flow through the GAB generally following a slope to the west and southwest towards the Surat Basin
- Flows from the GAB into the central areas of the CCA due to reductions in the level and pressure in the Alluvium aquifer
- Groundwater flow through the upper alluvium, generally following the direction of surface water flow
- Groundwater flows into the CCA and CCA streams from UCAT groundwater leakage.

Figure C1: GAB intake beds (Red) in the Upper Condamine catchment. The green area of the Condamine represents the alluvium and sediments accumulated over the last 65 million years (Cainozoic aquifer), yellow is Cretaceous shale and the hatched area is the Great Artesian Basin (modified from Herczeg, 2008). Arrows represent direction of water movement.
Figure C2: Schematic representation of the CCA hydrogeological setting (OGIA 2016a), including gas and water wells that are separated by the WCM transition layer (Lacustrine formation in the Upper Jurassic period). The evergreen formation represents the GAB geological formation.
Attachment D: CCA groundwater management area

Figure D1: Distribution of all the CCA groundwater management area