Hunter Catchment Salinity Assessment

Final Report

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Cover photo: Goulburn River at Rosemount – Upstream of the Hunter River Junction. (Photo: M. Krogh.)

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Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian River Assessment System
EC	electrical conductivity
ENSO	El Niño–Southern Oscillation
EPA	NSW Environment Protection Authority
GAM	generalised additive model
HCR CMA	Hunter–Central River Catchment Management Authority
IPO	Interdecadal Pacific Oscillation
JI	Jaccard's Index
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
PC	protective concentration
PSS	pooled sample sets
RFR	relative family retention
SIGNAL	Stream Invertebrate Grade Number Average Level
SPEAR	SPEcies At Risk
SSD	species sensitivity distribution
SWC	State Water Corporation
TAD	total allowable discharge
WSP	water sharing plan

Summary

The Hunter River Salinity Trading Scheme (the Scheme) operates to minimise the impact of saline water discharges from industry on the Hunter River. It achieves this by allowing discharge of saline water only at times of high or flood flow in the Hunter River and uses a system of salinity credits to limit the amount of salt that can be discharged at any one time. The Scheme commenced as a pilot in 1995 and was formalised in 2002 when the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 (the Regulation) commenced.

In anticipation of the ten-year review of the Regulation, the NSW Environment Protection Authority (EPA) commissioned the Office of Environment and Heritage (OEH) to conduct a desktop study to evaluate the effectiveness of the Scheme based on available water quality and ecological health data.

There are a variety of potential sources of salinity in the Hunter River catchment including rainfall, atmospheric deposition, run-off and infiltration, weathering of geological strata, groundwater and a range of anthropogenic sources including the Scheme. The Hunter River valley is generally considered to be saline due to the marine origin of some of its Permian sediments. However, recent land-use activities in the catchment may have contributed to rising groundwater levels in some areas and an increase in the salinity load reaching many streams. Overlaid on the natural cycling of salts in the Hunter River catchment are anthropogenic sources – particularly mining, power generation and agriculture.

The Scheme restricts saline discharges from mining and power generation to times of high or flood flow. The Scheme's salinity targets apply only in the Hunter River between Glenbawn Dam and Singleton, and not within any of the tributaries.

The key findings of the current salinity assessment are:

- There was little evidence that groundwater levels or the electrical conductivity (EC) of groundwater have been rising in recent times. However, this conclusion is affected to some degree by limited temporal sampling and a bias to current monitoring bores being located in alluvial areas often well away from the areas of major mining operations.
- If future trends in groundwater level and conductivity are to be undertaken and related back to the impact of the Scheme (or mining and power generation), then a more comprehensive and representative groundwater monitoring program is required for the catchment.
- The major impact of the Regulation on EC levels is likely to have been the continued restriction of saline water discharges to periods of high and flood flows when the potential for dilution is at its greatest (as opposed to continuous or intermittent discharges regardless of flow conditions).
- The assessment of the overall effectiveness of the Scheme on surface water quality suggests that the Scheme has:
  - had little effect on flows and electrical conductivity levels in the Hunter River upstream of Denman
  - reduced electrical conductivity levels at (and immediately upstream of) Singleton and Greta, and
  - potentially reduced electrical conductivity levels at monitoring stations between Denman and Singleton.
- The available data suggests that throughout the catchment macroinvertebrate 'health' is on average good, but there are some areas where this is quite poor.

- Although salinity is one of several factors affecting stream macroinvertebrate communities in the Hunter River catchment, salinity appears to be a relatively important factor.
- The weight of scientific evidence suggests that current Scheme salinity targets should not be raised. Further scientific analysis and modelling would be required to support altering the Scheme salinity targets in the future, in order to better understand existing salinity impacts on ecosystem health in the Hunter River and its tributaries.
- On average over the life of the Scheme, participant discharges contributed approximately 10 per cent of the entire salt load of the Hunter River at Singleton. However, recent averages are in the order of 13–20 per cent of total annual salt load.
- On average over the life of the Scheme, participants have utilised approximately 25 per cent of the given opportunities to discharge [the 'total allowable discharge' (TAD)]. However, recent averages are in the order of 40–50 per cent of the TAD.
- Experimental studies are recommended in order to fully understand the environmental effects of the different components of saline water discharged to the Hunter River catchment (e.g. ionic composition, metals/metalloid contamination, etc.).
- The increasing discharge demand, salt load and TAD usage under the Scheme will need careful ongoing monitoring and assessment in order to assess the potential for future trends or changes to impact aquatic ecosystems and environmental values.
- Hunter River salt loads can also be affected by the major tributaries such as the Goulburn River and Wollombi Brook.
- The Goulburn River subcatchment contributes relatively high salinity water to the Hunter River and is not currently captured by the Scheme upstream of Kerrabee. Further strategic real-time monitoring of flow and salinity in the subcatchment is recommended, considering the likely expansion of mining and development of coal seam gas extraction. This monitoring is currently limited.
- The at times high EC levels in the Wollombi Brook at Warkworth in the mid to late 2000s (not related to flow) warrant further investigation.

1. Introduction

The Scheme is implemented under the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 (the Regulation). The central idea of the Scheme is to discharge salty water only when there is lots of low-salt, fresh water in the river (DEC 2006). This is when the river can best handle salt discharges because:

- large amounts of fresh water dilute the saltier discharge so the impact on the river is not as great, and
- through careful control, the mixture of river and discharge water can be kept fresh to meet water quality standards.

Monitoring points along the river are used to measure whether the river is in *low* flow, *high* flow or *flood* flow. When the river is in *low* flow, no discharges are allowed. When the river is in *high* flow, limited discharge is allowed, controlled by a system of salt credits. The amount of discharge allowed depends on the ambient salinity in the river which can change daily.

River salinity targets are established for three reference points in each of three River sectors (upper, middle and lower). Denman is the reference point for the upper sector; upstream of the Glennies Creek confluence for the middle sector; and Singleton for the lower sector. The total allowable discharge is calculated so that the salt concentration does not go above 900 EC in the middle and lower sectors of the river, or above 600 EC in the upper sector. When the river is in *flood*, unlimited discharges are allowed as long as the salt concentration does not go above 900 microsiemens per centimetre (µS/cm). Members of the scheme coordinate their discharges so this goal is achieved (DEC 2006). It is important to recognise that the salinity targets only apply to the Hunter River between Glenbawn Dam and Singleton and not within any of the tributaries. The targets also apply only during high or flood flow periods. As a result, the Scheme may actually have little influence over stream salinity levels for the majority of the time.

In anticipation of the review of the Regulation, the EPA commissioned the Office of Environment and Heritage (OEH) to conduct a desktop study to evaluate the effectiveness of the Scheme based on available water quality and ecological health data.

Three key questions were specifically asked to be addressed:

1. Has the Regulation impacted on aquatic ecosystems and associated environmental values since it commenced in 2002?
2. Does the Regulation have the potential to impact on aquatic ecosystems and associated environmental values in the future?
3. What other sources of salinity in the Hunter catchment could influence the operation of the scheme in the future?

This involved:

- collating research on the environmental impact of salt on Australian aquatic biota
- comparing pre-Scheme electrical conductivity and ecological health with post-Scheme conductivity and ecological health upstream of Singleton (and, if insufficient data, comparing existing information on the ecological impacts of salt with recorded conductivity levels)
- determining whether there is any trend in long-term background conductivity when the Scheme is not operating

- assessing existing trends and possible emerging sources and modelling their impact on the flow and conductivity levels in relation to Scheme thresholds and aquatic ecosystem values in the Hunter.

This aim of this report is to address these key questions as far as possible, based on available water quality, quantity and ecosystem health data for the Hunter River catchment.

2. Catchment overview

The Hunter River catchment drains an area of approximately 22,000 square kilometres on the central NSW coast. The valley comprises rugged mountain ranges in the north, undulating farmland in the central and western regions, and widespread fluvial/estuarine flatland coastal areas (PPK 1994). The river and some of its main tributaries have their source in the uplifted, deeply dissected and predominantly Tertiary basalt Mount Royal Ranges to the north of the valley. A large portion of the Hunter River flows are also contributed by its western tributary, the Goulburn River, which drains more than one third of the valley. Another major tributary, Wollombi Brook, joins the Hunter River from the south near Warkworth. The valley's central and southern regions consist of gently undulating topography associated with the more easily weathered Permian sediments. Areas immediately adjacent to the Hunter River are predominantly alluvial.

The Hunter River valley's stream sediments are strongly controlled by its underlying geology. Features such as major fault lines separate the Carboniferous rocks exposed along the northern areas of the valley from the central Permian-age coal measures and the Triassic sandstones in the south and south-east. Extensive folding and faulting of the Carboniferous rocks have resulted in the formation of steep country leading up to the Barrington Tops which is underlain by basalt. The Permian rocks have eroded to form the main corridor of the broad valley. Due to marine transgressions during their formation, some of these rocks are high in salt content, which has resulted in naturally high salinity levels in many of the central valley streams and drainages. Additionally, the valley is often prone to dryland salinity due to extensive clearing of the native vegetation and elevated or intersected saline groundwater tables.

The Hunter River and its tributaries, like most Australian coastal streams, have a highly variable flow. This variability is mainly influenced by the climatic regime; however anthropogenic factors have also altered the frequency, volume and seasonality of stream flows. The Hunter River's average annual discharge is approximately 180 gigalitres, including contributions from the Goulburn, Paterson and Williams rivers and Wollombi Brook, and the upper Hunter tributaries including the Pages and Isis rivers, and Middle, Dart, Stewarts, Moonan and Omadale brooks. The flows within the Hunter catchment are regulated through three major storages: Glenbawn, Glennies Creek and Lostock dams. The largest of these is Glenbawn Dam (completed 1958, enlarged 1987). It can hold 750 gigalitres with a reserve capacity of 120 gigalitres for flood mitigation and can release in excess of 7.5 gigalitres a day (plus whatever spills). Glennies Creek Dam (completed 1983) can hold 283 gigalitres and can release in excess of 4.6 gigalitres a day. Although these dams were constructed for water conservation and flood mitigation, they also affect the natural regime of smaller floods, but have limited impact on the larger floods. The dams' geomorphic effect of trapping coarse sediment causes 'sediment starvation' over an extended distance downstream and can result in bed lowering and channel expansion. The construction of Glenbawn and Glennies Creek dams has enabled significant increases in farming (i.e. wine grape, dairy, horse breeding) activities and the development of an important power generation industry (DLWC, 1996).

Water allocations in the Hunter River catchment are determined by water sharing plans (WSPs) which, following the introduction of the *Water Management Act 2000,* are being progressively developed for rivers and groundwater systems across NSW. These plans protect the health of the rivers, while also providing water users with greater certainty over future access to water and increased trading opportunities. The WSP for the Hunter area (DIPNR 2004) covers 39 water sources and 58 management zones (see Figure 1). The key rules in the WSP specify when licence holders can access water and how water can be traded.

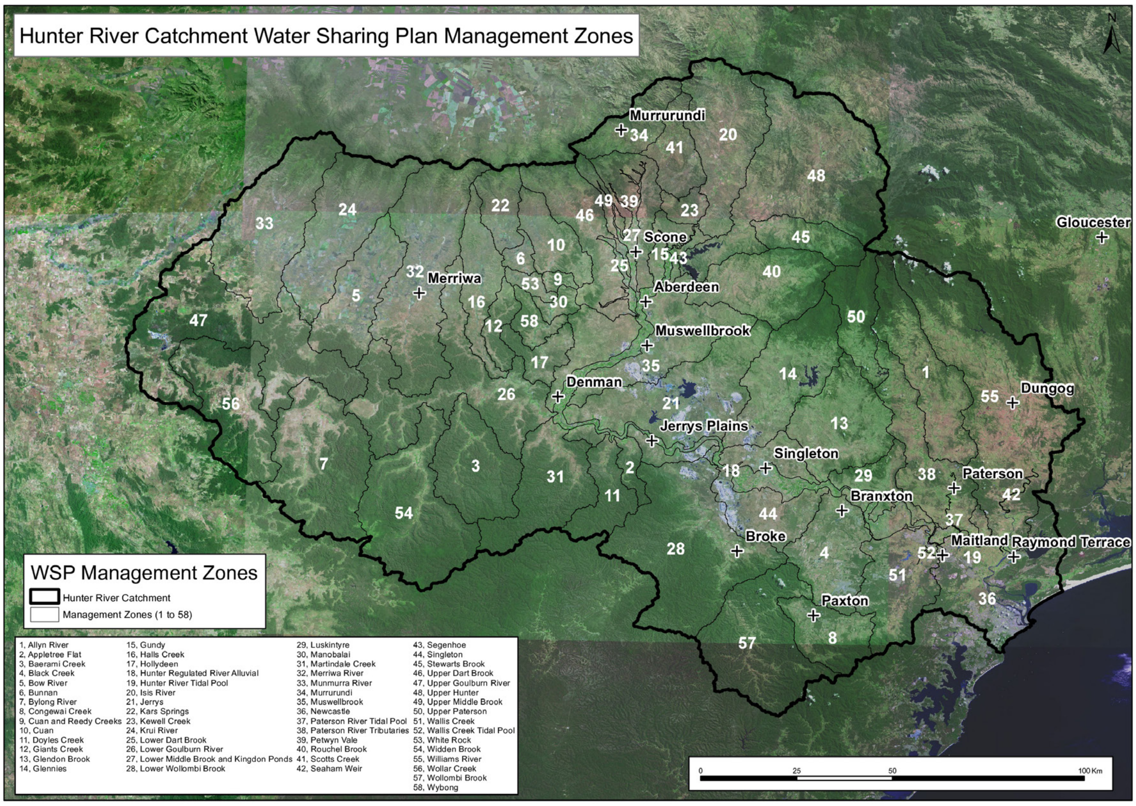

Figure 1: Water sharing plan management zones for the Hunter River catchment

Source: NSW Office of Water

Over the past decade, demand on water use in the Hunter Valley has shifted from predominantly agricultural to predominantly industrial activities. Today mines make up a relatively larger component of the WSP water allocations (over 30 per cent). Some mines use water collected from catchment run-off or dewatering on site for coal washing or dust suppression, and discharge anything unused due to either lack of infrastructure or lack of storage space. Water from catchment run-off is usually only fully utilised on site during dry years.

Since its earliest European settlement in the early 19th century, the Hunter River valley has provided a wide range of often competing land uses, exerting pressure on its natural resources. The Hunter River and its tributaries continue to support important activities including power generation, coal mining, heavy industry, agriculture and associated businesses, infrastructure and fisheries. The Hunter River valley remains the largest coal-producing region in NSW.

3. Sources of salinity in the Hunter catchment

There is a variety of potential sources of salinity in the Hunter River catchment including:

- rainfall
- atmospheric deposition
- run-off and infiltration
- weathering of geological strata
- groundwater, and
- anthropogenic sources (such as mining, power generation, agriculture, urban and peri-urban development, sewage treatment plants, etc.).

Evaporation/evapotranspiration can lead to concentration of salts within the catchment, particularly where widespread land clearing has occurred and where these areas are associated with either existing groundwater discharge zones or where groundwater levels may be rising due to land clearing and increased infiltration and recharge. Kellet *et al.* (1989) noted that during the severe drought conditions of August 1982, banks and low terraces in the lower reaches of almost every minor stream draining the lower Wittingham and Greta coal measures and marine sediments of the Maitland and Dalwood groups were coated by surface salt encrustations (*efflorescences*).

In a study of the salt inputs into the Hunter Valley catchments, Creelman (1994) suggested that rainfall, ions released by rock weathering and mining were the major contributors to salinity in the Hunter Valley catchments. Kellet *et al.* (1989) found that input of groundwater from the Wittingham Coal Measures was also of special significance in terms of salinity contribution to the Hunter River catchment. Kellet *et al.* (1989) concluded that, of all the potential salt sources, geology was the dominant control in the chemistry of upper Hunter River valley groundwater and that high background salinity in groundwater of the Central Lowlands (Jerrys Plains and surrounds) was a natural phenomenon that would persist for the foreseeable future.

Overlaid on the natural cycling of salts in the Hunter River catchment, however, are anthropogenic sources; particularly mining, power generation and agriculture. These activities can either remove salts from the river system (e.g. via water extractions) or add them into the system (via licensed discharges and/or overland run-off). The multiplicity of salt sources and the highly variable spatial and temporal interaction of natural and anthropogenic sources make management of salinity in the Hunter River catchment a very complicated issue. This issue receives even greater focus when the catchment is affected by drought and when competition for sufficient water of suitable quality can become an area of conflict.

Rainfall and atmospheric deposition

The Hunter Valley has a varied climate, depending on elevation and proximity to the ocean. Coastal areas and the area around Barrington Tops receive the highest rainfall: over 1600 millimetres a year at Barrington Tops; and 1140 millimetres a year at Newcastle on the coast. Rainfall decreases with distance inland, with rainfall at Cassilis around 620 millimetres a year. The wettest months away from the coast tend to be December to January. Annual evaporations (> 1300 millimetres) also increase with rising temperatures, generally exceeding the rainfall rates in most parts of the valley. The highly variable nature of the climate in the Hunter Valley has caused both serious droughts and extensive floods (DWE 2009).

Rainfall water chemistry is controlled by a complex interaction of oceanic, mineralogical, geographical, biological and meteorological influences. A number of studies of rainwater chemistry have been undertaken in the Hunter River catchment (e.g. Avery 1984, Rothwell *et al.* 1987, Bridgman *et al.* 1988), although most earlier studies were focused more on acidic deposition and the potential contribution of air pollution sources rather than the salinity (and ionic constituents) of rainfall. The EPA (1994) published rainfall chemistry results for the Hunter River catchment over the period December 1988 to June 1991. These results indicated that the average salinity of rainfall falling in the Hunter catchment during this period was 16.3 microsiemens per centimetre (µS/cm), ranging from a minimum of 2.7 µS/cm at Singleton to a maximum of 89.2 µS/cm at Pokolbin. The major ionic constituents (by concentration) in the rainfall samples were sodium, chloride and sulphate.

Creelman (1994) calculated salt loads for rainfall in the Hunter River catchment based on salt levels [in milligrams per litre (mg/L)] and average annual rainfall. Creelman (1994) suggested that the average salt yield from rainfall was:

- 22 tonnes/km^2/year (range 12–30 tonnes/km^2/year) in coastal areas
- 14 tonnes/km^2/year (range 9–19 tonnes/km^2/year) in the lower Hunter Valley
- 8 tonnes/km^2/year (range 4–14 tonnes/km^2/year) in the mid Hunter Valley, and
- 6 tonnes/km^2/year (range 3–10 tonnes/km^2/year) in the upper Hunter Valley.

Collectively these results indicate there can be significant spatial variability in atmospheric deposition of salts across the Hunter River catchment, with salt loads generally decreasing with increasing distance from the coast.

Run-off and infiltration

Day (1986) provided a good general description of run-off and water transport processes in the Hunter River catchment. Once rainfall hits the Earth's surface it can infiltrate into the soil profile, flow off as overland flow (run-off) and/or be intercepted by soil or vegetation. Soil moisture taken up by vegetation can subsequently be lost as evapotranspiration, and rainfall intercepted by vegetation can be lost by evaporation. Water may flow through soils as unsaturated throughflow and re-emerge in tributary channels or collect in depressions in the landscape. It may then further infiltrate into bedrock fissures and flow downslope to the main stream channel responding to hydraulic gradients. Unsaturated soil may become saturated as precipitation increases and saturated areas may extend and contract along and beside tributary channels (Day 1986). Saturated throughflow moves under gravity within the lower valley sides and some of this water may move over the land surface and return to the stream channel. Water may also move from the saturated soil profile into groundwater aquifers which can themselves move into the drainage lines as baseflow drainage from saturated bedrock and soil (Day 1986). At each step in this process the water originating as rainfall can accumulate additional salts depending on the nature and characteristics of the soil, rock, aquifer, vegetation and stream channel involved.

European land-use changes within the Hunter River catchment date from the early 1800s when considerable vegetation was cleared along the major rivers (Day 1986). Later clearing for grazing and agriculture, particularly on the more fertile soils, and mining in areas where Permian coal seams outcrop or are close to the surface, have led to the current patchwork of land uses and vegetation cover across the Hunter River catchment. A map of current land use in the Hunter River catchment is included as

Figure 2[1]. The vegetation and land-use changes that have occurred since European settlement have in turn caused many changes to the natural run-off and infiltration processes in the catchment. Kellet *et al.* (1989) noted that some point sources of natural salt contamination existed prior to European settlement in the Central Lowlands or were contemporaneous with it, as evidenced by early geographic names with salinity connotations – such as Saltwater Creek. Kellet *et al.* (1989) also suggested that forest clearing had exacerbated degradation of the land by promoting salting under conditions of increased run-off, erosion and rising water tables in the Central Lowlands.

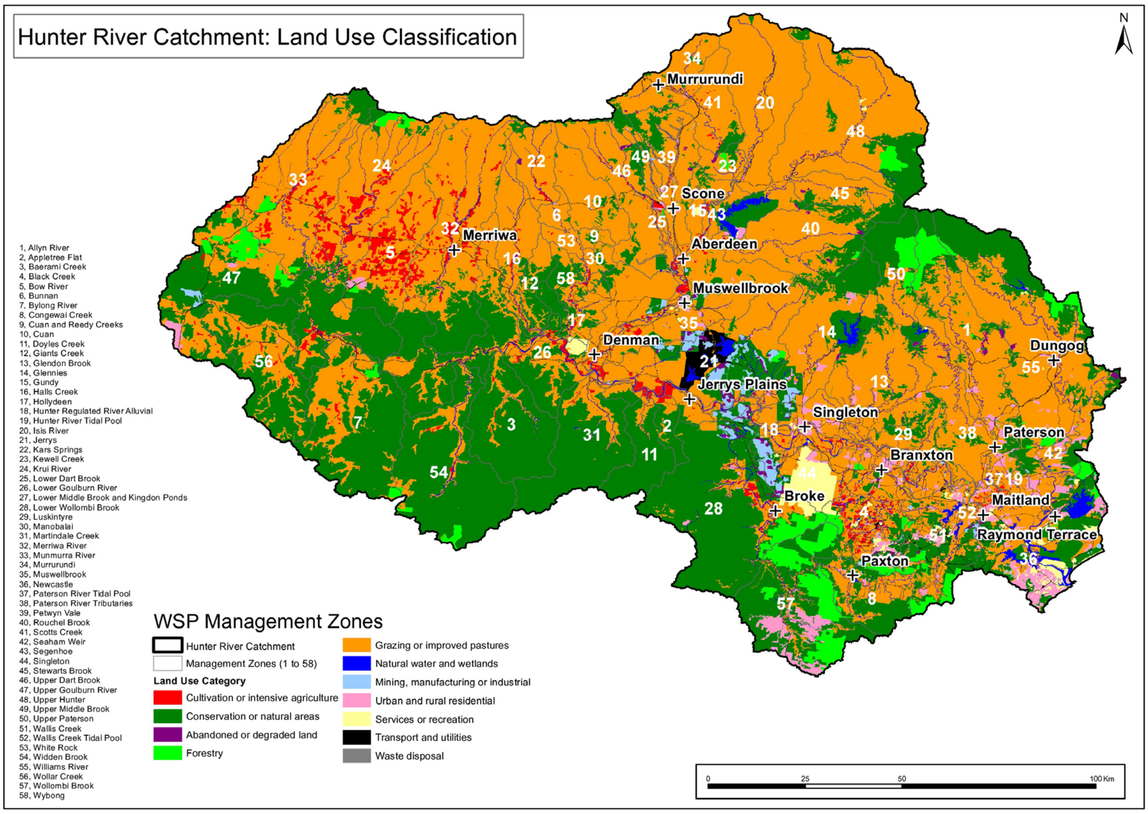

Figure 2: Land use categorised for the Hunter River catchment

Source: NSW Spatial Data Catalogue

Higher rainfall since the late 1940s has also been suggested as a cause for altering the geomorphology of the Hunter River and some of its major tributaries, with additional impacts on erosion, sedimentation and flow pathways (Day 1986, Erskine and Bell 1982, Erskine 1994). Significant changes in riverbed morphology continue to occur where the Hunter River has deepened in some areas, and changes to vegetation on river banks and within the riverbed have contributed to decreased flow velocities in other areas (NOW 2012). Rating table shifts at the gauging stations can also occur where the control is relatively unstable (e.g. sand) and there is a slow gradual shifting of that control. Floods in the 2011–12 period, mainly due to the flood in the Goulburn River in March 2012 (which affected the middle and lower sectors) and the flood in the Upper Hunter in November 2011, had an effect on rating tables (NOW 2012). Large changes were also noted at Singleton and downstream sites after flood flows in June

[1] Summary statistics for the percentage of land use categories in each water sharing plan subcatchment management zone are included in Table A1, Appendix A.

2011 (NOW 2012). There is a need to recognise that the Hunter River is itself a dynamic system.

Weathering of geological strata

The Hunter River valley occupies part of four major geological provinces of eastern Australia: the New England Geosyncline in the north-east; the Sydney Basin in the centre and south; the Great Artesian Basin in the north-west; and the East Australian Tertiary Volcanic Province in the north and west. (Galloway 1963). A map of the underlying geology of the Hunter River catchment is included as Figure 3[2].

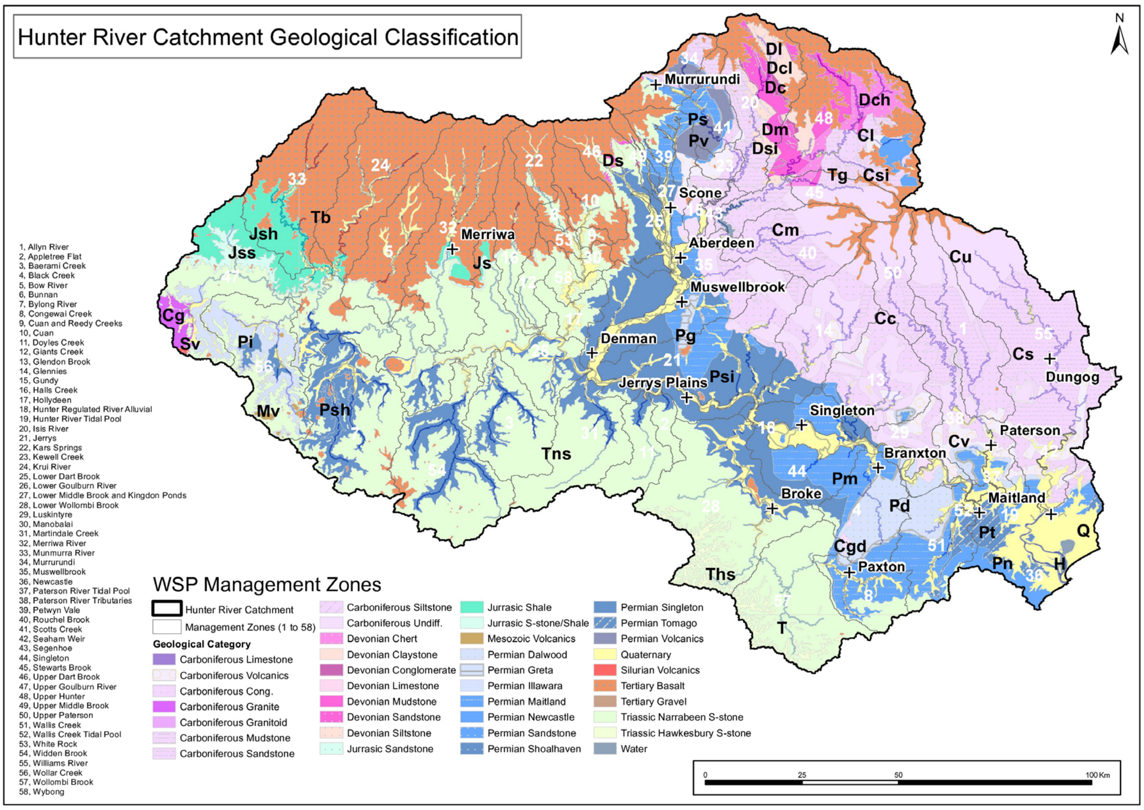

Figure 3: Geological classification of the Hunter River valley

Source: Geological Survey of NSW 1:250,000 Geological Maps

Kellet *et al.* (1989) described the geology of the Hunter River catchment as follows:

> *The Southern Mountains region consists of rugged Triassic sandstone mountains up to 1000 m and deeply incised valleys; soils are generally shallow because the Triassic sandstones are resistant to chemical weathering. At the junction of the Southern Mountains with the Central Lowlands, discontinuous sheets of quartzose sand fan out from the foothills for 1–2 km.*
>
> *To the west, the Central Goulburn valley region is similar to the Southern Mountains; it is underlain by Triassic sandstones and shales, and consists of irregular steep-sided hills and plateaus, and deeply incised rivers.*

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[2] Summary statistics for the percentage of various geological categories in each water sharing plan subcatchment management zone are included in Table A2, Appendix A.

The Merriwa Plateau region in the north-west consists of rolling to hilly terrain, developed as a planation surface on extensive Tertiary basalt flows. Lavas have partially filled pre-existing valleys, and post-volcanic streams have incised on either side of the flows, forming sub-parallel valleys that reflect the pre-basalt drainage. The degree of incision has been controlled by uplift, and by marked variations in relative sea level during the Cainozoic.

Resistant folded Devonian and Carboniferous lavas and sedimentary rocks form the Northeastern Mountains — rugged, dissected terrain, which diminishes in relief towards the Central Lowlands. This region is fringed to the north-east by the Liverpool and Mount Royal Ranges, and by the Barrington Tops, which comprise rugged basaltic terrain of small plateaus interspersed with narrow, steep-sided crests and valleys.

In contrast, the Central Lowlands have a gently undulating terrain developed on easily eroded Permian sedimentary rocks, on which deep soils have developed. The region is, therefore, important agriculturally, but is also important economically for its mineable coal deposits. Permian rocks occupy approximately one-fifth of the Hunter Valley and extend in a central belt from Newcastle to Murrurundi. Outlying occurrences are also found in the west where southern tributaries of the Goulburn River have stripped off overlying Triassic sandstone. (Galloway 1963)

The Hunter River itself and many of its tributaries are bounded by alluvial flats from 1–6 km wide. Cainozoic sediments occur as unconsolidated alluvial deposits of the Hunter River floodplain and, to a lesser extent, the alluvial terraces of the major tributary streams. These deposits are generally composed of basal gravels and boulders overlain by an upward-fining sequence of sands, silts, and clays with sporadic shoestring gravels. Secondary pedogenetic pore-filling of the Cainozoic sediments reduces porosity and becomes significant on the oldest (and highest) terraces.

Weathering of geological strata can liberate not only salts within the rock itself but also salt associated with old marine transgressions (often referred to as *connate* salt) that have remained stored within the geological profile. Some of the Permian coal measures are especially important in this context, in particular the Greta and Wittingham coal measures. These geological strata originally formed as peat swamps on alluvial fans close to the sea (Kellet *et al.* 1989). Within the Wittingham Coal Measures two brief marine transgressions are recorded by laminites of the Bulga and Denman formations (Kellet *et al.* 1989) and these are considered to be major sources of connate salts in the associated groundwater. The Wollombi Coal Measures show the least marine influence of the Permian deposits (Kellet *et al.* 1989).

Creelman (1994) provided a first estimate of salt release from the various rock units in the Hunter Valley (see Table 1). Salt releases from the Triassic rocks averaged 5 tonnes/km^2/year; the Carboniferous metavolcanics and glacial sediments averaged 4–5 tonnes/km^2/year; the Wollombi Coal Measures averaged 4–5 tonnes/km^2/year; the Greta Coal Measures averaged 30 tonnes/km^2/year; and the Wittingham Coal Measures averaged 40 tonnes/km^2/year.

Table 1: Salt release (tonnes/km^2/year) from the various rock units in the Hunter Valley (Figures in brackets indicate possible ranges)

Unit	Description	Included units	Salt release by erosion (tonnes/km^2/year)
CARB	Carboniferous volcanoclastic and glaciene sediments of the southern New England Fold Belt.	Carboniferous Rouchel and Gresford blocks.	5 (4–8)
GM	Interbedded coal seams and continental sediments of the Greta Coal Measures, marine sediments of the Maitland and Dalwood groups.	Greta Coal Measures, Mulbring Siltstone, Muree Sandstone, Branxton Formation, Gyarran Volcanics.	30 (25–80)
WI1	Upper Wittingham Coal Measures west of the Muswellbrook Anticline in the north, and near the 'Triassic' escarpment in the south.	Denman Formation, Jerrys Plains Subgroup.	40 (15–40)
WI2	Lower Wittingham Coal Measures east of the Muswellbrook Anticline in the north, and near the 'Triassic' escarpment in the south.	Archerfield Sandstone, Vane Subgroup, Saltwater Creek Formation.	40 (30–60)
WO	Interbedded coal seams and continental sediments of the Wollombi Coal Measures.	Wollombi Coal Measures.	5 (8–12)
TRIAS1	Lower Triassic conglomerate, sandstone, and shale of the Narrabeen Group.	Triassic Narrabeen Group. Mainly in the south of the Hunter and Goulburn valleys.	4 (8–10)
TRIAS2	Narrabeen Group overlain in places by Tertiary basalt in the north of the Goulburn/Hunter River confluence.	Triassic Narrabeen Group with Tertiary basalt flows, mainly to the north of the Goulburn Valley.	4 (8–10)
HFP1	Alluvium upstream of the Goulburn/Hunter confluence.	Recent alluvium, mainly coarser sediments.	Taken as 0
HFP2	Alluvium downstream of the Goulburn/Hunter confluence.	Recent alluvium, mainly finer sediments, but with coarser units at depth.	Taken as 0
Basalt	Tertiary basalts within the Hunter Valley.	All basalts, but excluding the plateau basalts of the Goulburn Valley.	2

Source: Creelman (1994).

Groundwater

Williamson (1958), Griffin (1960), Ringis (1964) and Kellet *et al.* (1989) have all discussed groundwater resources in various parts of the Hunter River catchment. Kellet *et al.* (1989) considered the Hunter River floodplain to be a regional groundwater sink for the Permo–Triassic fractured-rock aquifers; with bed underflow of the Hunter River representing a dividing streamline for groundwater flow, apart from a few important mixing zones. Contrasts in permeability and porosity between the alluvial and fractured-rock aquifers indicated that most groundwater in the upper Hunter River valley was stored in and transmitted through the floodplain sediments.

Several surface reservoirs in the catchment act as sources for groundwater recharge; although they can also impede lateral throughflow from upgradient groundwater stores, and in some areas create springs and artesian conditions (Kellet *et al.* 1989). The largest reservoirs are Glenbawn Dam, Glennies Creek Dam and Lake Liddell (148,000 megalitre capacity). Lake Liddell is filled with a mixture of water pumped from the

Hunter River, run-off, interflow, and groundwater from the 75 square kilometre upper catchment of Bayswater Creek. The upper Bayswater Creek catchment drains Maitland Group rocks on the eastern limb of the Muswellbrook Anticline (Kellet *et al.* 1989).

On a regional scale, groundwater of the fractured-rock aquifers constitutes only a minor proportion of storage and transmission, but the reserves are most important during times of low flow of the Hunter River and its tributaries (Kellet *et al.* 1989). Streams with identified groundwater interactions were often found to have very high salt loads. For example, the Saltwater Creek catchment was found to be releasing approximately 230 tonnes/km^2/year of salt, potentially as a result of groundwater–surface water connections due to the saltwater thrust which traverses Saltwater Creek (Creelman 1994). Groundwater in the Permian fractured-rock aquifers is also very important to the coal mining industry since it can form a large component of the mine water being discharged as part of the Scheme.

Alluvial aquifers are also important in the Hunter River catchment. Basal gravel and overlying sand of the floodplain alluvium of the Hunter River and its major tributaries are by far the most permeable aquifers in the study area (Kellet *et al.* 1989). In many places groundwater quality and yields are sufficient to permit intensive crop irrigation.

Kellet *et al.* (1989) divided groundwater of the upper Hunter River valley into eight hydrochemical provinces, characterised by groundwater of distinctive chemical composition, stored in and transmitted through particular rock and/or soil associations. This yielded information on the major ionic constituents of groundwater derived from differing geological and soil units (see Table 2). A more recent treatment of hydrogeology of the Hunter River catchment is given by Mackie (2009). Mackie (2009) gathered additional data on groundwater chemistry and noted considerable overlap in groundwater ionic composition for the hydrochemical provinces identified by Kellet *et al.* (1989). This led Mackie (2009) to develop a different generalised characterisation of groundwater in the Upper Hunter region (see Table 3). While differences exist in the general characterisations of groundwater hydrochemistry between Kellet *et al.* (1989) and Mackie (2009), they both indicate the importance to the Hunter River catchment of groundwater contributions to salinity of differing ionic composition.

Table 2: Groundwater hydro-chemical provinces of Kellet *et al.* 1989

Province name	Description	Dominant hydrochemical species
HFP1	Alluvium of the Hunter River floodplain between Glenbawn Dam (north east of Scone) and the Goulburn River confluence near Denman	Mg, Na, HCO_3, Cl
HFP2	Alluvium of the Hunter River floodplain between the Goulburn River confluence and Singleton	Na, Mg, HCO_3, Cl
TRIAS	Lower Triassic conglomerate, sandstone and shale of the Narrabeen Group, overlain in places by Tertiary basalt in the west and south-west of the area	Na, Mg, Cl
WO	Interbedded coal seams and continental sediments of the Wollombi Coal Measures	Na, Mg, Cl, HCO_3
WI1	Upper Wittingham Coal Measures west of the Muswellbrook Anticline (in northern areas), and near the Triassic escarpment (in southern areas)	Na, Cl, HCO_3
WI2	Lower Wittingham Coal Measures east of the Muswellbrook Anticline (in northern areas), and proximal to the Maitland Group rocks (in southern areas)	Na, Cl
GM	Interbedded coal seams and continental sediments of the Greta Coal Measures, and marine strata of the Maitland and Dalwood Groups	Na, Mg, Cl, SO_4
CARB	Carboniferous volcaniclastics and glacigene sediments of the New England Fold Belt in the north and north-east of the area	Na, Mg, Cl, HCO_3

Source: Mackie (2009)

Table 3: Groundwater hydro-chemical provinces of Mackie (2009)

Shallow alluvium associated with the Hunter River	Ca>Na>>Mg and HCO_3>Cl>>SO_4	Becoming increasingly Na-Cl type waters downstream from Muswellbrook
Shallow alluvium associated with Goulburn River	Na>Ca > Mg and Cl >HCO_3>SO_4	Primary salinity dominates near the confluence with Hunter River as a result of drainage across a large catchment.
Shallow alluvium associated with minor drainages	Ca-Na>Mg and HCO_3>Cl>>SO_4	Generally reflects localised conditions - HCO_3 contributions may derive from volcanics in some catchments
Wollombi Coal Measures	mixed dominance Ca-Na-Mg and HCO_3-Cl-SO_4	Older measures in the Bulga-Broke area may exhibit increased salinity with no dominant species.
Wittingham Coal Measures	mixed dominance Ca-Na-Mg and HCO_3-Cl-SO_4	Older measures may exhibit increased Cl-SO_4 salinity due to proximity to Maitland Group (marine and lower deltaic conditions).
Greta Coal Measures	Ca>Mg>Na and Cl>SO_4>HCO_3	Generally higher SO_4 and Cl due to proximity to Maitland Group (marine and lower deltaic conditions).
coal seam variation	Ca>Mg>Na and Cl>HCO_3>SO_4	Localised influence of cleat secondary mineralogy (eg. calcite, siderite) and CO_2-CH_4 leakage to observation bores
leakage from structural features (faults, bedding flexures etc.)	Ca>Na>Mg and Cl>HCO_3> SO_4	Influenced by secondary mineralisation within leakage pathways

Source: Mackie (2009)

Salt-affected areas

Kellet *et al.* (1989) provided the following summary of salinity affected areas and salt 'efflorescences' in the Hunter River valley:

> *Most salt efflorescences occur in the Wollombi Brook valley between Broke and Singleton. The Mulbring Siltstone, in particular, generates a large number of salt scalds and salt-affected streams. Salinisation of soils, streams and groundwater in the Central Lowlands is closely related to rock type, and the intensity of halite salting is greatest in provinces where groundwater has the strongest connate-marine signature. Some point sources of natural salt contamination existed before European settlement in the Central Lowlands or were contemporaneous with it, as evidenced by early geographic names with salinity connotations – such as Saltwater Creek. Forest clearing has undoubtedly exacerbated degradation of the land by promoting salting under conditions of increased run-off, erosion and rising water tables in the Central Lowlands.*
>
> *The second category of salt efflorescence in the upper Hunter River valley appears to be controlled in part by geological and geomorphological features. The efflorescences consist of small-scale salt scalds extending downstream from ephemeral springs along the nick point separating the upper and lower pediments on the north-eastern and southern sides of the Hunter River valley. Salt crusts in these areas comprise patchy impure films, 1 mm to 2 mm thick, which drape tunnelled dispersive clays. Most springs at the head of the salt scalds on the north-eastern side of the Hunter River valley – between Bowmans Creek and the headwaters of Bettys Creek – are roughly coincident with the Hunter Thrust Fault and probably represent saline water upwelling from the underlying Wittingham Coal Measures. However, similar springs on the western footslopes of Mount Surprise, and in the hills above Muscle and Grasstree Creeks occur in Carboniferous rocks at least 3 km from the Hunter Thrust Fault. Most salt scalds at the change of slope on the southern side of the valley between Alcheringa and Bulga seem to emanate from intermittent saline springs at the contact between the Wollombi and Wittingham Coal Measures. In August 1982, despite the drought, one of these springs was still flowing from the base of the Watts Sandstone (lowest member of the Wollombi Coal Measures) above Appletree Creek. Other salt scalds in this area appear to be related to springs and seepages at the contact between the basal fanglomerate of the Narrabeen Group and the underlying Wollombi Coal Measures.*

A current map of salinity affected areas in the Hunter River catchment is included in Figure 4[3], with black areas indicating known areas of land affected by dryland salinity. Areas of high salinity risk (dark orange/red areas in Figure 4) usually coincide with areas underlain by the Permian Coal Measures. Approximately 80 per cent of salinity in the Hunter catchment is attributed to diffuse sources (EPA 2001, ACARP 2004). A salinity audit completed in 2000 (DLWC 2000) predicted the salt load for the Hunter River at Singleton gauge to exceed 150,000 tonnes per year by 2010, almost 50 per cent of which was contributed by the upper sector.

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[3] Summary statistics for the percentage of salt-affected land and salinity risk in each water sharing plan subcatchment management zone are included in Table A3, Appendix A.

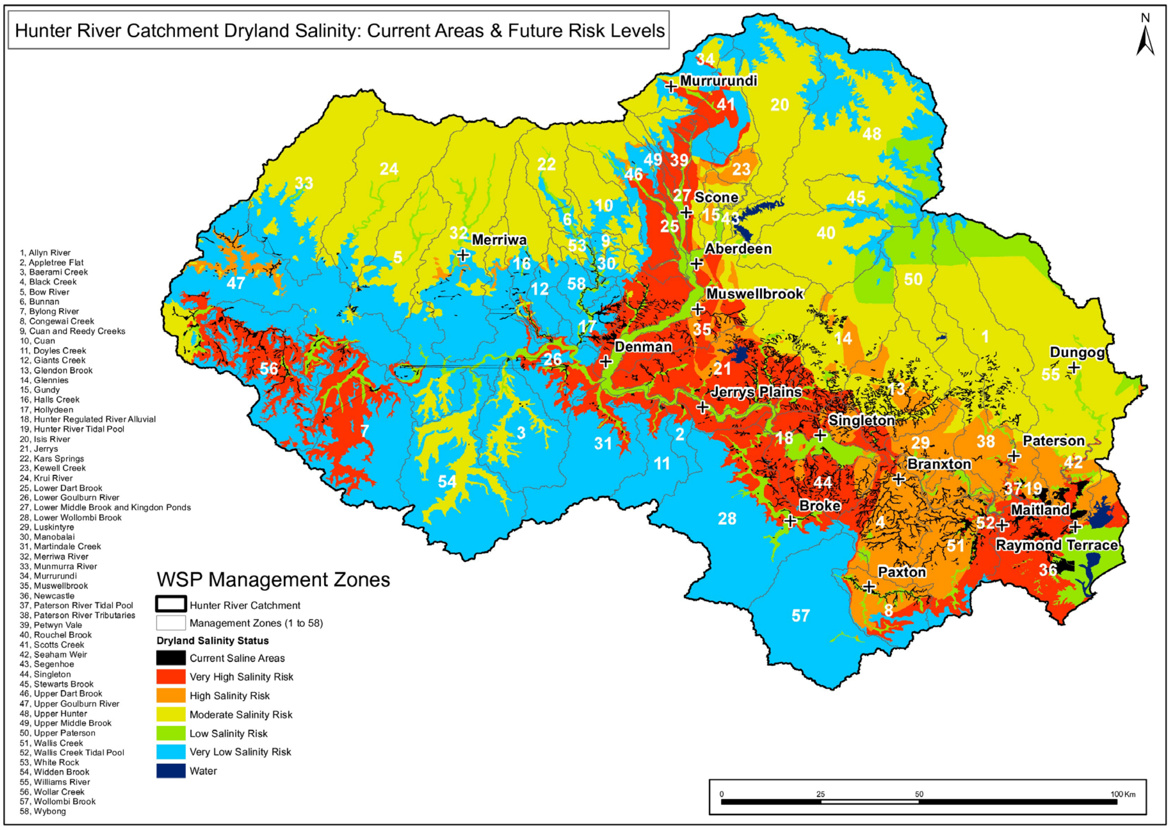

Figure 4: Areas of dryland salinity and salinity risk within the Hunter River catchment

Source: Hunter–Central Rivers CMA Salinity Hazard Map and OEH Known Salinity Areas Data Layer

Anthropogenic sources

A range of anthropogenic actions have the potential to influence salt concentrations and loads in the Hunter River catchment. The Hunter River valley is generally considered to be saline due to the marine origin of some of its Permian sediments, where ground water EC concentrations can reach ~7000 µS/cm. However, recent land-use activities in the catchment may have contributed to rising groundwater levels in some areas and an increase in the salinity load reaching streams (DLWC 2000 salinity audit). Diffuse sources from past land usage and known saline areas have been discussed above. While rises in river salinity in some locations may largely be attributable to natural processes (>75 per cent of current lower Hunter River salt levels have been attributed to natural processes; ACARP 2004), the remainder have been attributed to anthropogenic activities including 10 per cent current/former mining operations (ACARP 2004). Licensed discharges are a major potential source of salt in the catchment. These are distributed throughout the catchment and include licensed discharges from mines and power generators; licensed discharges from council and Hunter Water sewage treatment plants; and licensed discharges from manufacturing industries. It is important to note that not all of these discharges are captured under the Scheme, as the Scheme only applies to salt discharges in the Hunter River between Glenbawn Dam and Singleton. Discharges not covered by the Scheme are managed by individual environment protection licences. These latter discharges have not been considered in great detail for the current assessment, but they do have the potential to affect salinity levels in some areas of the catchment (e.g. the Goulburn River).

4. Hunter River Salinity Trading Scheme operation and salt loads

As identified earlier, the Scheme is implemented under the Regulation. There are a total of 1000 salt discharge credits in the scheme with different licence holders having different numbers of credits. Licence holders can only discharge salt into a river block in proportion to the credits they hold – 1 credit allows a discharge of 0.1 per cent of the total allowed. Discharge credits can also be traded. Credit trading gives each licence holder the flexibility to increase or decrease their allowable discharge from time to time while limiting the combined amount of salt discharged across the valley (DEC 2006).

Participants in the scheme are licensed by the Environment Protection Authority (EPA). The environment protection licence defines the discharge points and the monitoring and reporting requirements. Any licence holder discharging outside the limits of the Scheme is violating their licence conditions, and penalties apply. The Regulation contains the Scheme rules and additional safety measures, such as discounting the value of credits if too many are traded into the one river sector.

The New South Wales Office of Water (NOW) currently operates monitoring, telemetry and modelling components of the Scheme under a service agreement with the EPA. NOW currently monitors flow and electrical conductivity (EC) in the Hunter River and its major tributaries through gauging stations at 21 locations across the catchment. Information collected from the gauging stations is transmitted through a telemetry system and used to model flow and conductivity at the three Scheme reference sites along the Hunter River. The EPA provides an online credit trading facility.

A predictive model run by the State Water Corporation (SWC) estimates the total allowable discharge (TAD) of salt to enable conductivity levels in the Hunter River to remain below set limits of 600 µS/cm in the upper, and 900 µS/cm in the middle and lower reference sectors of the river. The SWC, under an agreement with NOW, models river flow and salinity to determine saline water discharge opportunities and notify Scheme participants. When an approaching flow event is identified, the river operator models river flow and conductivity to predict TAD, timing of saline water discharges into the Hunter River and its tributaries. A River Register is then published as an authorising document to notify licence holders of the amount and timing of saline water discharges allowed, whereby each participant can calculate their share of the TAD and discharge accordingly. An important component of the scheme is its transparency; real-time flow and EC data are available on the NOW website for public viewing and scrutiny.

Salt loads

During the Pilot Salinity Trading Scheme, which operated from 1 January 1995 to 30 November 2002, the average annual discharge of salt by Scheme participants was 18,233 tonnes a year. The NSW Coastal Rivers Salinity Audit, in December 2000, estimated the average annual salt load for the Hunter River at Singleton as 149,500 tonnes a year (DLWC 2000). Saline wastewater discharges therefore contributed on average approximately 12 per cent of the entire annual salt load of the Hunter River at Singleton during the Pilot Scheme period.

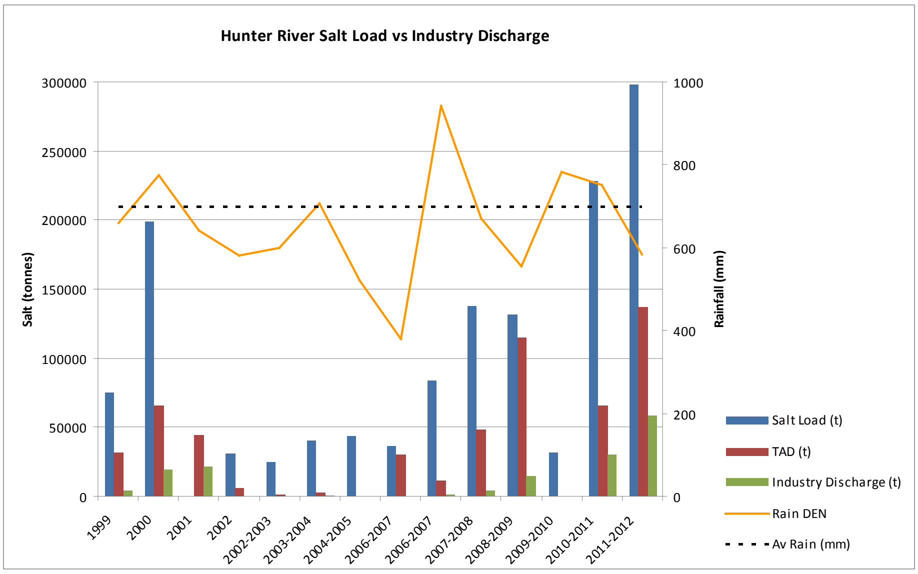

Figure 5: Total salt load carried by the Hunter River past Singleton gauge and allowable discharge opportunities and loads under various climatic conditions

Table 4: Salt discharge utilisation versus total allowable discharge(TAD) for the Hunter River at Singleton gauge (210001/210129)

Source: NSW Office of Water**Year**	**River salt load (tonnes)**	**TAD (tonnes)**	**Industry salt discharge (tonnes)**	**Rainfall at Denman (mm)**	**TAD utilised**
1999	75707	32152	4689	658.4	15%
2000	199652	66239	19693	773.9	30%
2001		44561	22337	640.4	50%
2002	31518	6204	217	580.9	3%
2002–2003	25404	1678	335	598.8	20%
2003–2004	40628	3412	891	706.4	26%
2004–2005	44149	351	170	520.6	48%
2005–2006	37186	30653	0	378.6	0%
2006–2007	83807	12027	1219	943	10%
2007–2008	137892	48585	4884	670.2	10%
2008–2009	131584	115669	14790	556	13%
2009–2010	31958	0	0	781.8	
2010–2011	228713	65940	30987	751.2	47%
2011–2012	298502	137543	59035	583.9	43%

Source: NSW Office of Water

Since the implementation of the Regulation in 2002, there has been a slight increase in the number of participants, and, on average, industry participants have utilised 25 per cent of the given opportunities (see Table 4). Over the past decade, the annual rainfall across the catchment ranged between 350 and 900 millimetres, providing Scheme participants with almost 250 allowable discharge events. During this time participants discharged approximately 112,500 tonnes of salt out of a total allowable discharge of 422,000 tonnes (26.7 per cent utilisation). Overall, a total of approximately 1.1 million tonnes of salt was carried by the Hunter River past the Singleton gauge (so the

Scheme contributed on average approximately 10 per cent of the total salt load). It is worth noting that this period also included one of the most significant drought periods on record, from 2002 to 2007 (See Figure 5). An increased frequency of rainfall events in recent times has led to increased utilisation rates – close to 50 per cent of the published TAD (Table 4).

Summary

The Scheme was an important response to catchment and river salinity levels. Under the Scheme, participants only discharge at higher flows to enable a greater dilution of the saline discharges to occur. On average, the Scheme contributed approximately 10 per cent of the total salt load at Singleton since 2002. However, in recent times significant salt loads (approximately 30,987 to 59,035 tonnes or 13.5 to 19.8 per cent of total annual salt load in the Hunter River at Singleton) have been discharged to the Hunter River and the value of salt credits is increasing. At the same time the utilization of the TAD has also increased (to 40–50 per cent). Additional demand for saline discharge is also coming from new or expanded mining operations. For example, as part of GlencoreXstrata's (Mangoola Coal Mine) bid to increase extraction from 10.5 million to 13.5 million tonnes of coal a year, the mine is applying to discharge 50 megalitres a day over set periods under the Scheme (EMM 2013; Newcastle Herald May 30, 2013). A number of other mine expansions with increased daily discharge volumes are also being proposed for various parts of the Hunter River catchment. It therefore appears there is currently an increasing demand. Although capped by the Regulation salinity targets and total credit allocation, this demand should continue to be monitored and assessed.

5. Groundwater and surface water – state and trend

Groundwater state and trend

The extensive dependence of users on the groundwater resources of the Hunter River catchment requires careful management. This includes ensuring equitable sharing of the resource between water users and protection of groundwater bores from intrusion of saline water from the underlying and enveloping hard rock aquifers associated with the Permian Coal Seams (DIPNR 2003).

Bore levels

Conaghan (1948), Williamson (1958), AGC (1967), Ainsworth (1994), DLWC (2001) and DIPNR (2003) have all reported on the groundwater resources within the Hunter River catchment. DIPNR (2003) analysed water table relationships with rainfall and stream flow finding a significant relationship between the upper catchment rainfall and the resulting bore groundwater levels. During drought, water table declines of around 5.5 metres have been recorded, which is similar to the declines reported by Williamson (1958) during the 1935–47 drought. This drop in water table had the effect of halving the aquifer throughflow and discharge volumes. Williamson (1958; see Table 5) summarised the groundwater resources in the alluvial sections of the Hunter River valley. This study was conducted during the Glenbawn Dam construction phase.

Table 5: Groundwater depth and water quality across the upper–middle Hunter catchment

Site/Reach name	Well depth (feet)	Well depth alluvium (feet)	Water quality
Hunter River at Glenbawn to Pages River confluence	20–48 [6.1–14.6 m]	60 [18.3 m]	Generally good with marginal poor-quality areas
Downstream of Glenbawn Dam to Aberdeen	36 [11 m]	20–60 [6.1–18.3 m]	Water becomes more suitable for irrigation further downstream of the dam
Kingdon Ponds and Dartbrook Creek systems	18–42 [5.5–12.8 m]	49 [14.9 m]	Generally satisfactory for irrigation with few marginal poor-quality areas
Kingdon Ponds and Dartbrook Creek confluence to Hunter River	10–40 [3–12.2 m]	50 [15.2 m]	Extensive areas of poor quality groundwater
Hunter–Dartbrook confluence to Muswellbrook	30–40 [9.1–12.2 m]	25–30 [7.6–9.1 m]	Groundwater salinity is above levels recommended for irrigation
Muswellbrook to U/S Denman	40–55 [12.2–16.8 m]	50–60 [15.2–18.3 m]	Poor groundwater quality for irrigation
Upstream of Denman to Goulburn River confluence	30–50 [9.1–15.2 m]	80 [24.4 m]	Groundwater salinity is above levels recommended for irrigation

Source: Adapted from Williamson (1958)

In the current assessment, historic groundwater levels from a number of reports (and bore surveys within the catchment) were collated and compared to recent data. Most bores with longer term data were found to be in the alluvial parts of the catchment and their levels generally fluctuated in concert with seasonal variability. Downstream of Glenbawn Dam, however, bores appear to have lost their strong connection with seasonal drivers and levels often remain relatively unchanged as they are currently being recharged by the regulated Hunter River flows. Figure 6 shows the long-term variation in groundwater levels in several bores located across the Hunter River catchment. Bore levels declined between 2003 and 2007 during the drought, but recovered during the 2007 catchment-wide rainfall events. This was followed by the 2010–2011 events when further recharge of groundwater aquifers occurred.

Williamson (1958) found groundwater levels around the tributaries fluctuated with seasonal conditions, while alluvial levels were sometimes reported to be lower than groundwater levels in areas further from the river. This latter result may be an effect of the base of the alluvium not being a flat surface, with groundwater being ‘trapped’ or ‘backed-up’ by bedrock highs leading to the impression of higher water tables away from the river. There is also the possibility that the river loses water in some sections (losing stream section), while in others it gains water (gaining stream section), particularly where there is active groundwater discharge into the alluvium. The detailed interaction between groundwater and surface water in many parts of the Hunter River catchment still requires further research.

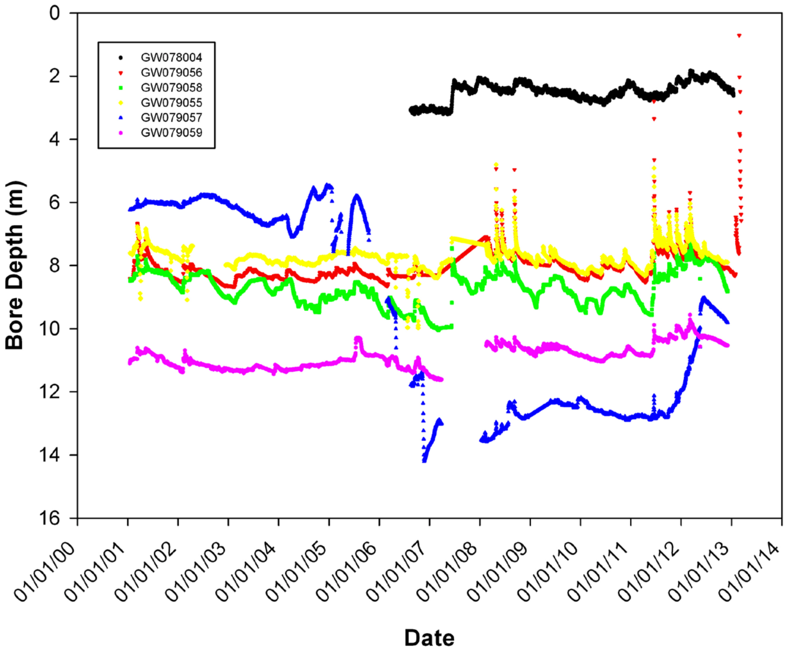

Figure 6: NOW groundwater monitoring bores across the Hunter catchment

Source: NSW Office of Water

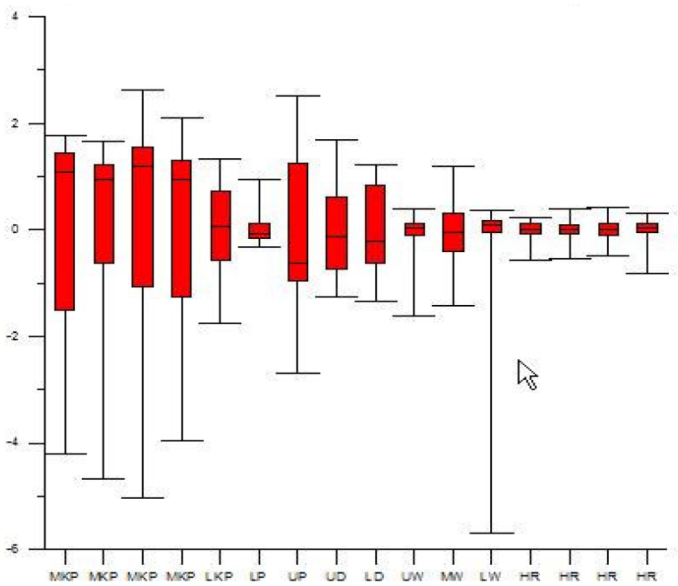

Figure 7: Water level fluctuations (in m) from the Hunter Valley alluvial monitoring bores in the Hunter River (HR); Upper Dart Brook (UD); Lower Dart Brook (LD); Mid Kingdon Ponds (MKP); Lower Kingdon Ponds (LKP); Lower Pages River (LP) Upper Pages River (UP); Mid Wybong Creek (MW); and Lower Wybong Creek (LW)

Source: J. Williams, NSW Office of Water

The impact of river regulation in the alluvial sections of the Hunter River (HR) can be seen in Figure 7, where most bore levels show relatively little variation as a result of the regular supply of river water for recharge. It also illustrates the higher variability in groundwater levels in bores across the unregulated streams such as the Upper and

Lower Dartbrook (UD, LD) and Kingdon Ponds (MKP) areas over the period of record. Earlier studies (e.g. DIPNR 2003) found bores in some Hunter River tributary catchments to have a stronger relationship with upper catchment rainfall rather than rainfall in surrounding areas. AGC (1967) actually suggested effective recharge of the complete system required a period of three wet years. The potential presence of severed hydraulic connections between creeks and water tables as a result of mining in some areas, however, could effectively require even longer periods of wet years for complete recharge to occur. Overall, when recent groundwater level changes are compared to those of historic records, similar patterns are evident. This is largely attributed to bores being either connected to the alluvial sections of the streams and recharging through regular stream flow or recharging during significant storm events when upper catchment surface run-off is greatest.

Groundwater salinity levels

A map of the historic groundwater monitoring network across the Hunter catchment is illustrated in Figure 8. Conaghan (1948) sampled over 300 bores for conductivity and other chemical parameters around the upper parts of the Hunter River, lower Dartbrook and sections of the Pages River (e.g. Figure 9). Samples taken near the river flats often had lower conductivity levels than those taken from the slopes of the valley. These findings were supported by the studies of Ainsworth (1994) and DIPNR (2003). AGC (1967) and Williamson (1958) observed poor quality groundwater along marginal zones during and immediately after the onset of wet periods. This was suggested to be caused by groundwater storage and flow into the alluvium from the long piedmont slopes and was related to the presence of bicarbonate-rich, sulphate-poor and hard waters sourced from Tertiary basalts. In contrast, Ainsworth (1994) reported good quality water in bores tapping the alluvium where flows from the piedmont were negligible, resulting in lower EC levels. As identified earlier, EC in hard rock aquifers associated with the Hunter Coal Seams can at times be high, ranging between 4000–8000 µS/cm, but occasionally rises to over 26,000 µS/cm in some coal mines (DIPNR 2003). This is of particular importance for areas where these groundwater sources interact with surface streams.

NOW alluvial monitoring bores were analysed for changes in EC levels over time. At present only a handful of monitoring bores are operational, providing real-time or instantaneous data. For the current assessment, historic groundwater EC levels recorded across Kingdon Ponds and Dartbrook Creek systems were compared to those of recent bore EC results. Summary statistics for EC levels in various bores are displayed in Table 6 and the locations of bores are illustrated in Figures 9 and 10. Recent EC levels are suggestive of similar patterns and levels compared to those of historic (pre-Scheme) periods for bores near the confluence of Kingdon Ponds and Dartbrook Creek systems (Figure 11). EC levels appear to be correlated with river flow and rainfall, suggesting that alluvial bores in these areas are well-connected to river flows. Some caution needs to be exercised in this interpretation though, since some of these differences are based on single EC readings at different times. In addition, mining activities in and around this part of the catchment are limited and these results may not represent the parts of the catchment more heavily affected by mining.

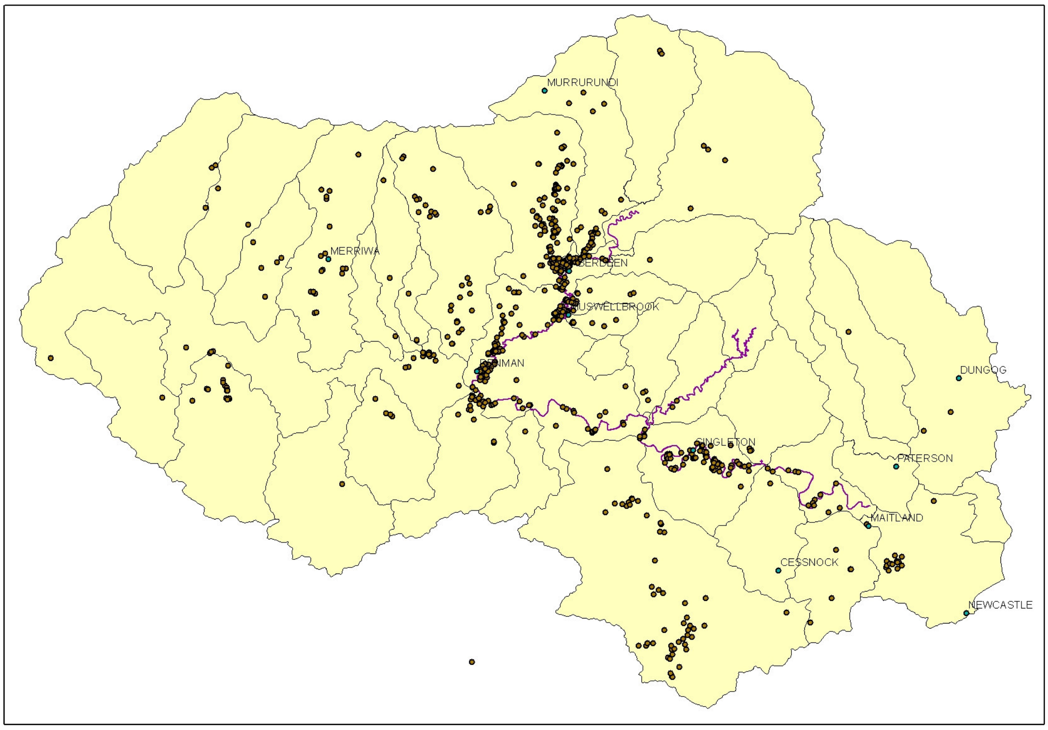

Figure 8: Historic groundwater monitoring network across the Hunter catchment

Source: NSW Office of Water

NOW monitoring bores were also analysed for areas around Singleton (end of Scheme sectors) as shown in Figure 10. Available data between the mid 1970s and 2004 were compared (see Figure 12) and the data again suggested patterns similar to monitoring bores in the upstream catchments, with EC fluctuations potentially exhibiting seasonal and river flow responses. EC levels showed a slight increase during drier conditions; however, again most of these assessments are based on limited temporal sampling. Bore EC levels in the alluvium around Singleton also appear to be affected by their connectivity to the river.

Distance from the river may also play a role in contributing to elevated EC levels in some areas. For example bores GW016053 and GW016054 sampled 6 and 1 times respectively between 1995 and 2005, produced EC readings twice as high as bores closer to the Hunter River. On the other hand, a single reading conducted in early 1995 for bore GW078357 (the furthest site in this reach) had EC similar to that of the alluvial section (see Figure 10). Further detailed assessment is required to fully understand the spatial variation in groundwater conductivity levels in these areas.

Groundwater summary

Since rising groundwater levels and/or EC can affect stream water quality (e.g. stream EC), any increase in groundwater level or EC could potentially have a confounding effect on the interpretation of Scheme effectiveness. Although there is access to a relatively good collection of historic groundwater EC data (e.g. Conaghan 1948, Williamson 1958, AGC 1967, Ainsworth 1994), recent monitoring is much more scattered and limited. There is also a bias towards recent monitoring bores being located in the alluvial areas of the catchment. This produces challenges in identifying trends over time and space, since many bores either have limited temporal replication of samples or are located in less-impacted areas of the catchment. Access to monitoring bores tapping into aquifers in close proximity to major development activities would be very useful, especially around open-cut mine pits with the potential to alter aquifer flow and recharge characteristics. From the groundwater monitoring data available for the current assessment, neither groundwater levels nor EC appeared to be rising in the Hunter River catchment in recent times (except perhaps in some very localised areas). While no obvious trends in groundwater level or EC were identified in the current assessment, if future trends in groundwater level and conductivity are to be undertaken and related back to the impact of the Scheme (or mining and power generation), then a more comprehensive and representative groundwater monitoring program is required for the catchment.

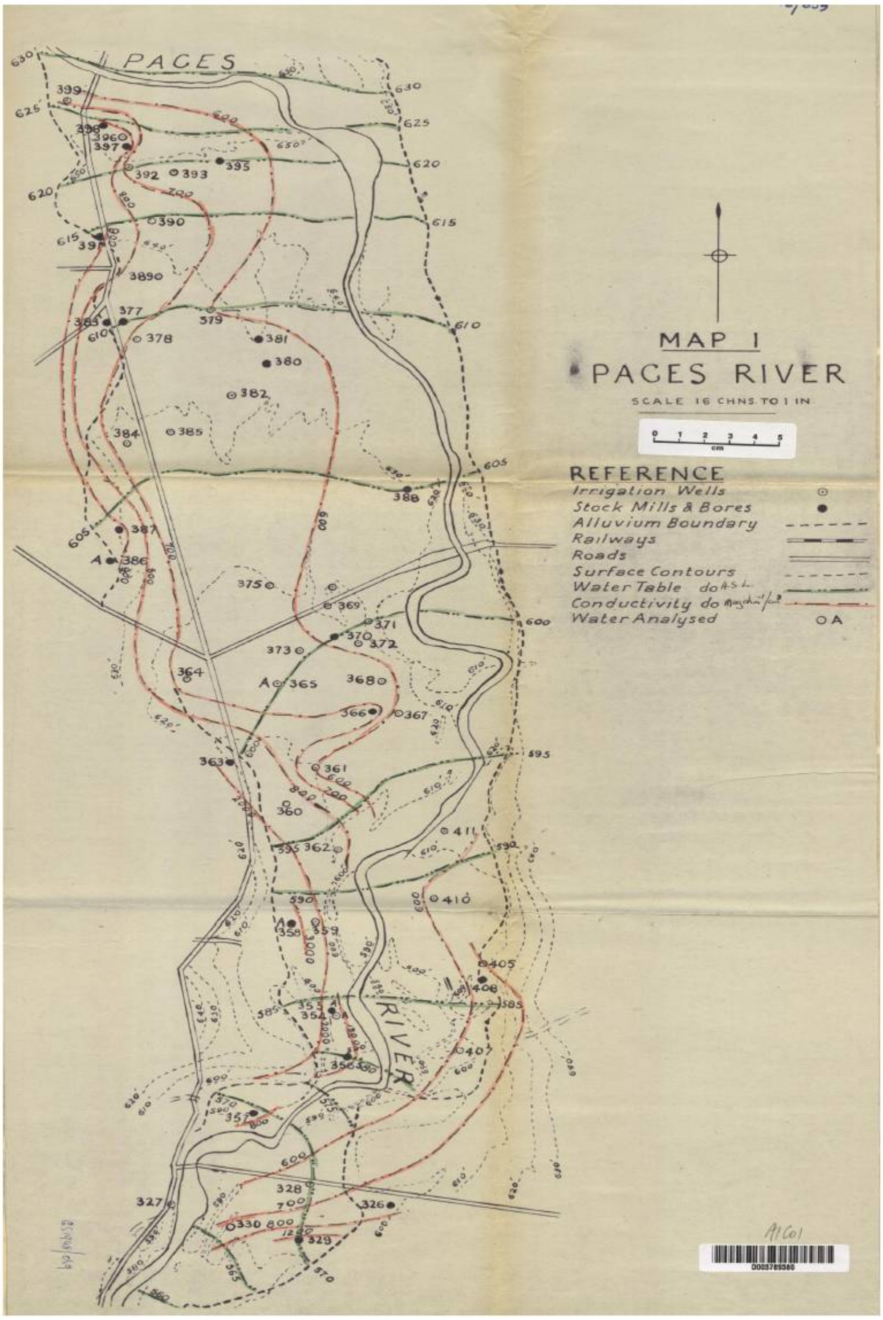

Figure 9: Upper Hunter groundwater conductivity level contours

Source: Conaghan (1948)

Table 6: Groundwater EC data recorded across the upper–middle Hunter catchment

Station No.	GW012695	GW012700	GW012705	GW012970	GW012976	GW012986	GW013322	GW013323	GW013324	GW013830
AVERAGE	1036	828	2877	2028	1817	1034	809	851	909	1370
80th percentile	1388	1042	3427	2770	2016	1330	1004	1083	1156	1700
20th percentile	706	530	2124	1200	1600	810	553	600	617	978
No. of samples	74	70	24	36	69	76	54	67	70	39
Sample year	1953-1988	1953-2004	1953-2008	1961-1976	1953-1986	1903-2004	1961-2004	1961-2004	1953-2000	1961-1975
Station No.	**GW014242**	**GW015096**	**GW015237**	**GW016050**	**GW018523**	**GW022309**	**GW024561**	**GW025646**	**GW025789**	**GW026200**
AVERAGE	1629	1287	1261	962	2165	2874	8301	2428	1133	2484
80th percentile	2032	1478	1754	1132	2588	3601	9449	3120	1272	2847
20th percentile	1064	1108	750	844	2019	2200	7150	1712	1039	2070
No. of samples	50	24	62	13	5	11	12	19	12	11
Sample year	1953-1981	1976-1986	1961-2004	1976-1999	1977-1985	2001-2004	2000-2007	1966-2008	2002-2008	2001-2008
Station No.	**GW026956**	**GW027107**	**GW027109**	**GW029267**	**GW033610**	**GW034015**	**GW034302**	**GW034303**	**GW037733**	**GW037796**
AVERAGE	909	1181	1368	1727	1312	865	960	1854	895	1625
80th percentile	1000	1750	1554	2000	1568	1030	1038	2300	998	1790
20th percentile	785	700	1184	1390	988	748	776	1204	788	1464
No. of samples	76	11	19	16	85	46	62	53	72	102
Sample year	1953-1988	1976-2003	1976-2002	1953-1973	1961-2002	1961-1988	1953-1988	1961-1988	1953-1988	1961-1986
Station No.	**GW038740**	**GW040498**	**GW040503**	**GW040552**	**GW040562**	**GW042899**	**GW042900**	**GW047070**	**GW049660**	**GW078396**
AVERAGE	3270	1183	988	1245	1667	3539	2399	1474	1907	2237
80th percentile	3800	1375	1104	1357	1875	4868	3161	1628	2055	2420
20th percentile	2480	960	850	962	1390	2356	1380	1339	1690	2130
No. of samples	11	46	59	58	61	24	35	23	10	11
Sample year	1993-2004	1964-1981	1953-1988	1961-1988	1961-1988	1977-1988	1977-2008	1978-1988	1979-2008	2001-2007
Station No.	**GW080941**	**GW080944**								
AVERAGE	3724	10630								
80th percentile	4274	11548								
20th percentile	3415	9951								
No. of samples	11	13								
Sample year	2005-2011	2005-2011								

Source: NSW Office of Water

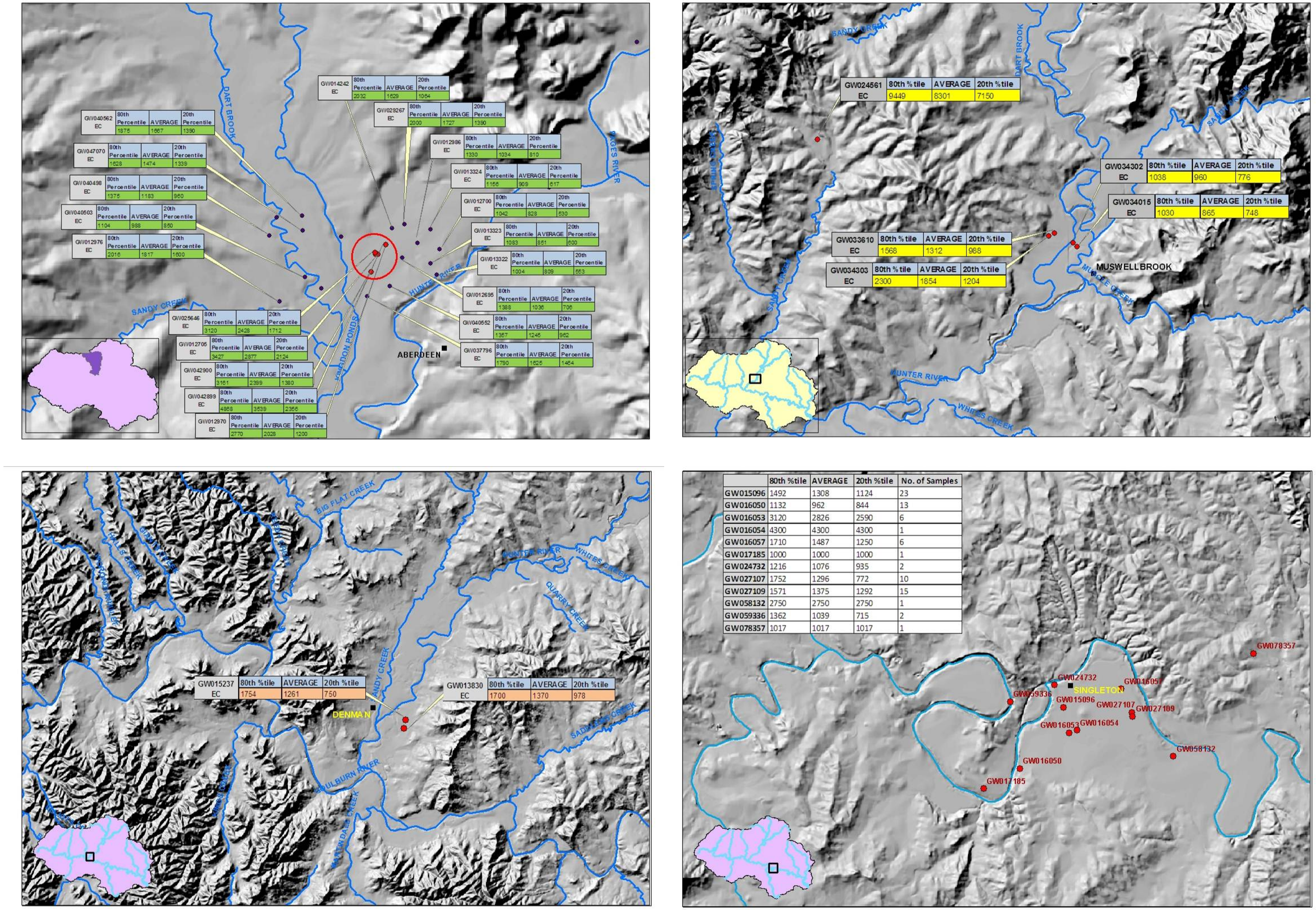

Figure 10. Location of bores and groundwater EC levels in the Hunter River catchment: near Aberdeen (top left); near Muswellbrook (top right); at the Goulburn River junction (bottom left) and near Singleton (bottom right)

Source: NSW Office of Water

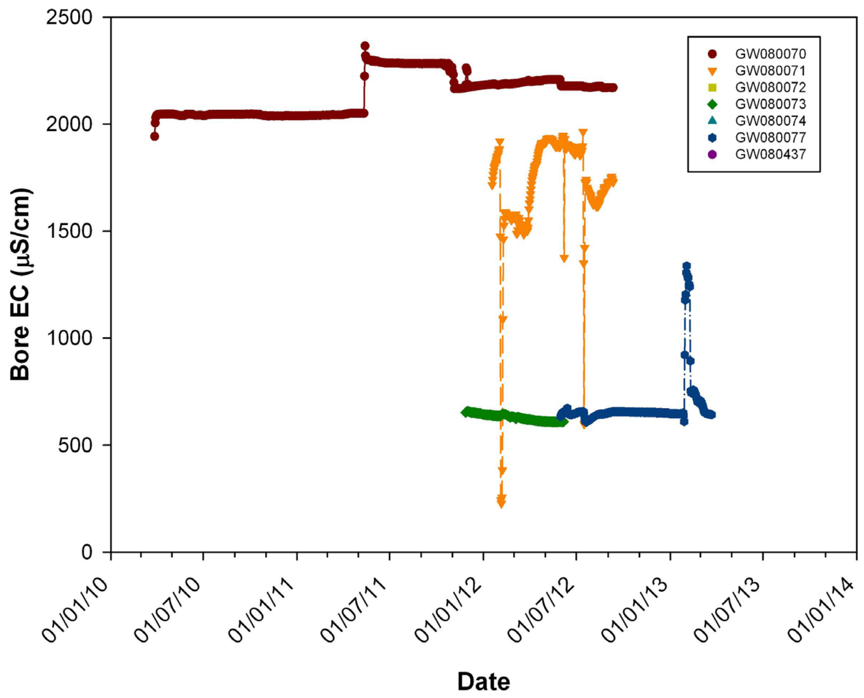

Figure 11: Recent continuous EC levels in bores in the Kingdon Ponds and Dartbrook catchments

Source: NSW Office of Water

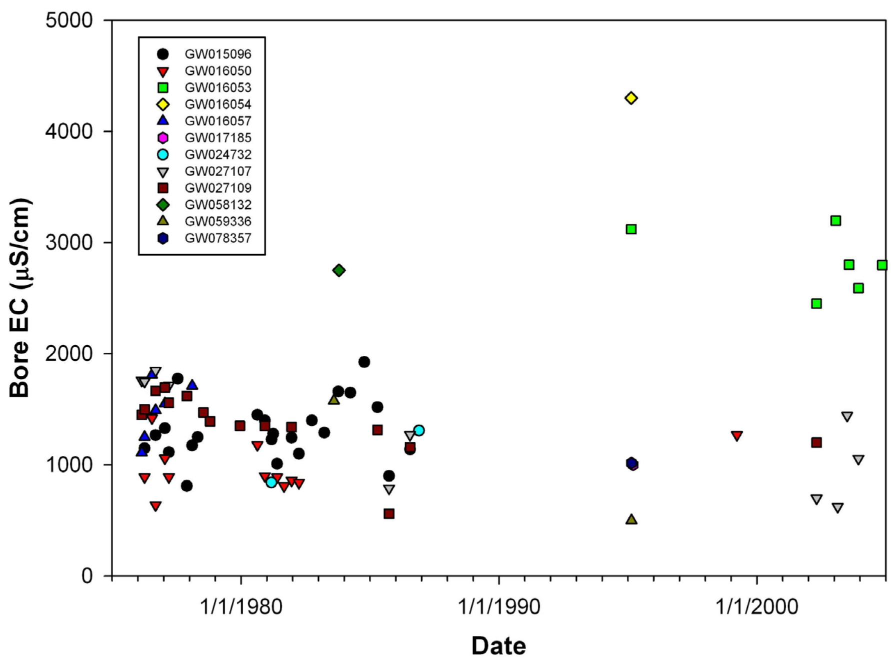

Figure 12: Historic and recent EC levels from groundwater bores near Singleton

Source: NSW Office of Water

Surface water state and trend

Water quality data were obtained from a wide variety of sources, including government agencies (e.g. NOW databases, OEH databases, Hunter Central Rivers Catchment Management Authority databases, local councils, Minerals Department reports, etc.); industry sources[4] (e.g. mining and manufacturers routine monitoring programs and/or environmental assessments) and a variety of research theses (e.g. Mackie 2009, Pritchard 2005, Jasonsmith 2010). These data were collated and used to calculate median conductivity data at monitoring locations throughout the catchment. Median water quality at individual sites is summarised in Table A4, Appendix A and illustrated in Figure 13. Colour coding has been based on the general criteria for the salinity of irrigation water in the Hunter Valley (Creelman 1994, Croft & Associates 1983; see Figure 13 for EC ranges) where: blue represents low salinity, green medium salinity, yellow high salinity, orange very high salinity; and red extreme salinity. Some caution needs to be applied in the interpretation of results where only a single grab sample is available at a site; these are identified in Table A4.

While this analysis provides some general indications of suitability of surface water for irrigation uses throughout the catchment, further site-specific assessment may need to be undertaken since the data come from varying time periods and do not necessarily capture the most recent changes which may have occurred in a local catchment.

Longitudinal variation – Hunter River

The range and variability of conductivity levels in the main stem of the Hunter River can be seen in a longitudinal boxplot of EC levels – from above Glenbawn Dam to downstream of Singleton (Figure 14). Increases in EC levels and variability are particularly noticeable in the Hunter River section between Denman and Glennies Creek. Flows from Glennies Creek appear to lead to both a decrease in the median conductivity levels and a decrease in the variation of EC levels. Higher variability in EC levels is seen again downstream of the Wollombi Brook junction.

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[4] For the current assessment, the EPA wrote to all companies and councils with an environment protection licence to discharge to the Hunter River catchment, requesting any ambient water quality and ecosystem health monitoring data. The contribution of the respondents to the current review is acknowledged and greatly appreciated.

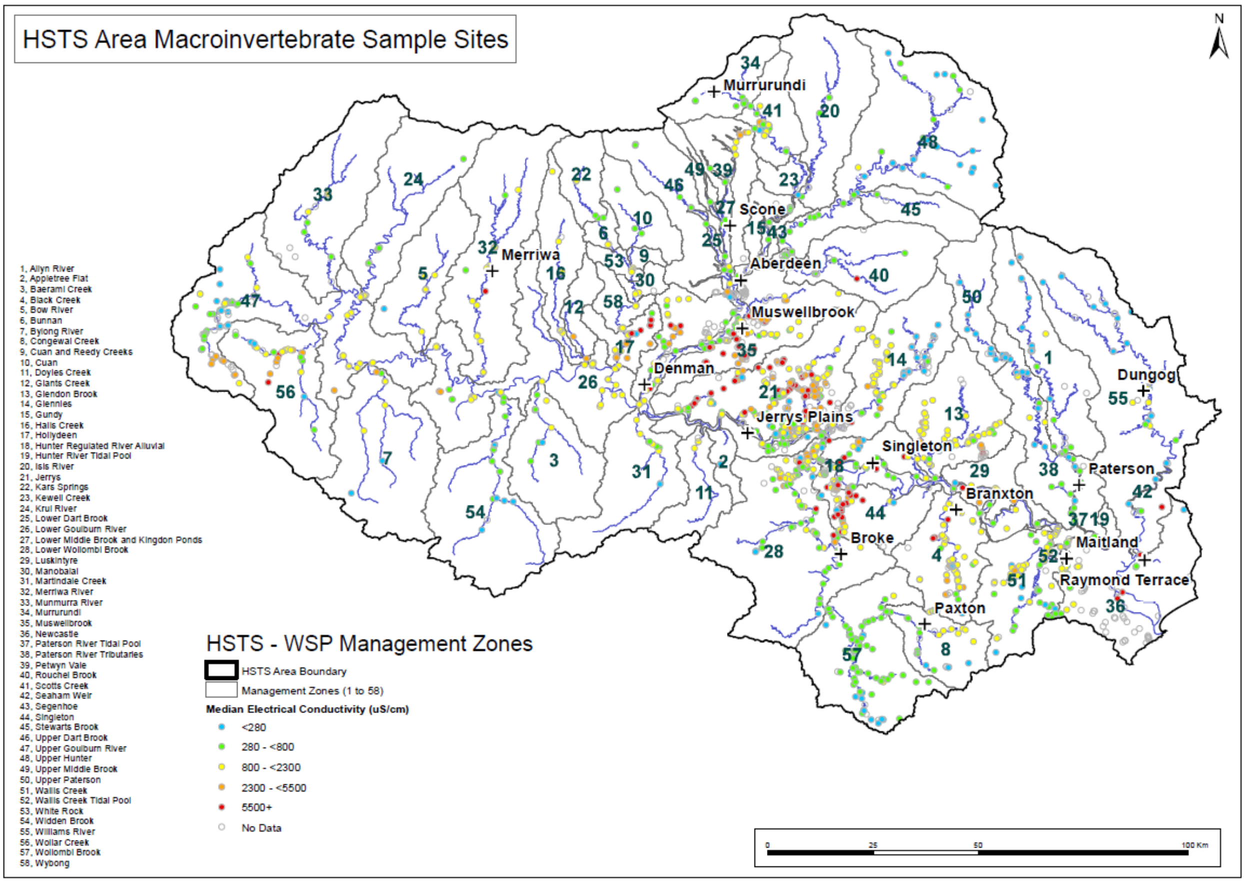

Figure 13. Surface water EC levels in the Hunter River catchment; colour coding based on Creelman (1994) and Croft & Associates (1983)

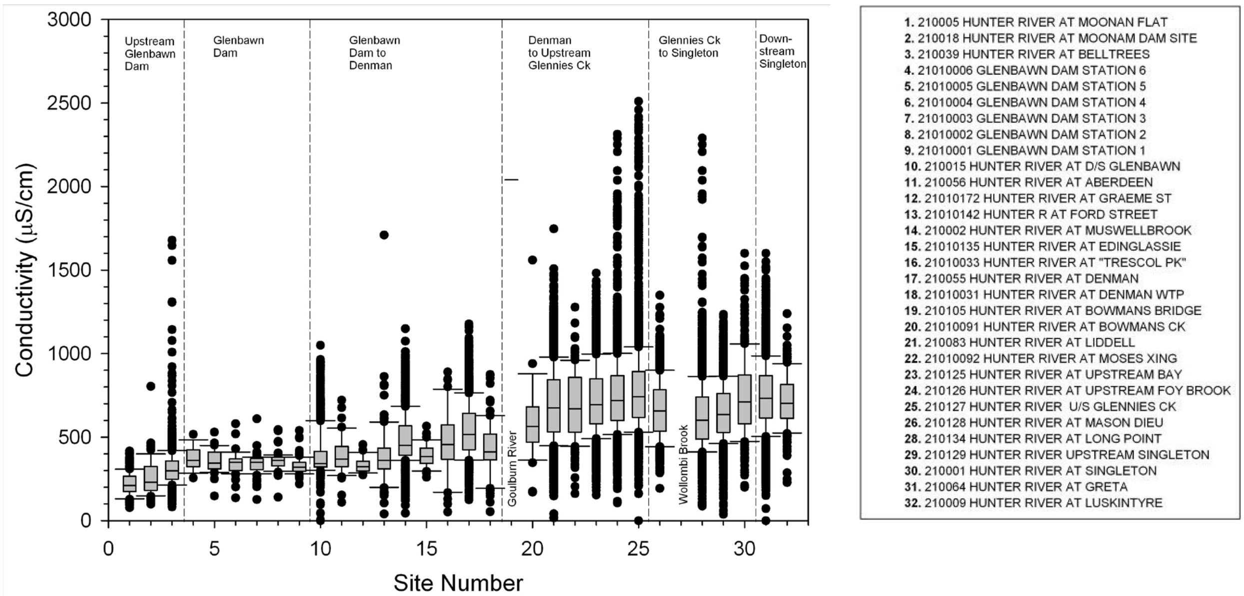

Figure 14. Boxplots of conductivity levels in the main stem of the Hunter River from above Glenbawn Dam to downstream of Singleton.

Single outliers at 210001, 210002, 210083 and 21010092 not illustrated.
Distance between sites not to scale.

Long-term trends in flow and electrical conductivity

Trends in hydrology and water quality in the Hunter River need to be interpreted in terms of both short-term climatic variations (e.g. significant rainfall events), longer term cycles [e.g. the El Niño–Southern Oscillation (ENSO) and Interdecadal Pacific Oscillation (IPO)] and human-induced changes (including the potential for climate change to impact in the future). Although the international scientific community has reached a consensus that global warming is unequivocal (IPCC 2007), the exact implications this has for rainfall and hydrology are far more uncertain, particularly at a regional scale in NSW. There have clearly been cyclic periods of higher and lower rainfall and flow within the Hunter River catchment and such trends are likely to continue even under a global warming scenario. In other catchments (e.g. Hawkesbury–Nepean River), some of these cyclical trends have been related directly to large-scale climatic patterns such as ENSO and IPO (for example, see DECC 2009). Since EC levels can be significantly affected by flow, assessments of changes and/or trends in EC usually also need to consider variation in flow.

Long-term data for the analysis of flow and EC were primarily taken from the NOW gauging station database (Hydstra) and the NOW water quality database (KWiQM). Few other sites have the same length time series of continuous (or near continuous) flow and EC readings at an individual site. However, most continuous (or near-continuous) EC records exist only since about 1993 when the EC meters were progressively installed at the gauging stations. Where appropriate surface water quality data from grab samples existed at the gauging station site, pre-dating the installation of continuous EC meters, these were added to the continuous (or near-continuous) EC records. In doing so it is assumed that there are no systematic differences in EC measurements based on grab samples or EC meters[5]. Where there were multiple EC readings on the same day, the median for these records was calculated and used in subsequent analyses.

Since the establishment of the Scheme extended over approximately a decade before the formal gazettal of the Scheme, the data were split into three time periods as surrogates for *before* Scheme operation[6] (1970s and 1980s), *during the initial stages* of the Scheme (1990s) and *after commencement* of the Scheme (2000s to present). These periods were then compared using empirical distribution functions[7] (analogous to Flow and EC exceedance curves) to see if there were any clear differences between periods in terms of the distribution of flows or EC levels. Most sites show a clear relationship between flow and EC, with EC generally decreasing as flows increased. This is presented graphically for important monitoring sites in Appendix B. These EC–flow relationships were used to underpin the management of Scheme discharges so they occurred during periods of high river flow when the opportunity for dilution was at its greatest. Summary statistics for long-term sites in the Hunter River main stem and other important stream/river sites are also included in Appendix B. In addition, empirical distribution functions for EC and flow at these sites are presented graphically in Appendix B. To some extent, the conclusions from the analysis of flow and EC may be affected by the varying length and consistency of data records at individual sites in the different periods, and where limited data occurs in any period this is identified below.

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[5] A number of 0 or negative values for conductivity were identified in the continuous EC data which may indicate a problem with the meter at the time of record.

[6] Increased water quality monitoring appears to coincide with the establishment of the *Clean Waters Act 1970*, and few water quality records for the Hunter River catchment extend further back than the early 1970s.

[7] The ecdf function in R Version 2.8.0 (see The R Foundation for Statistical Computing 2013) was used to compare empirical distribution functions over time.

Hunter River monitoring stations

Results of comparisons for the Hunter River monitoring stations suggest the following:

- Limited sampling at Belltrees (210039), upstream of Glenbawn Dam, during the 1970s to 1990s makes comparisons between periods difficult, but at this point there appears to be little difference in the distribution of conductivity levels over time at this site.
- Temporal variability in flow and EC levels downstream of Glenbawn Dam (210015) are noticeable, with flows in the 2000s generally being higher than in the 1970s & 1980s or 1990s. However, the distribution of EC levels does not appear to have changed markedly between the 1990s and 2000s.
- Limited EC data is available for the Hunter River at Aberdeen (210056). Flows appear to be relatively similar between the 1990s and 2000s, although some higher flows were recorded during the 1990s and increased medium flows were recorded in the 2000s, potentially as a result of river regulation. Continuous EC records were only available from March 1998, but the distribution of EC records suggests higher EC for the period monitored in the 1990s compared to those recorded in the 2000s.
- The distribution of flow and EC records for the Hunter River at Muswellbrook Bridge (210002) over the various time periods show relatively little change in either flow or EC. Median EC over the period 1970 to 2013 was 451.1 µS/cm.
- The distribution of flow and EC records for the Hunter River at Denman (210055) over the various time periods show relatively little change. Slightly higher flows were recorded in the 1970s, however the distribution of EC levels was similar for all periods. Median EC over the period 1970 to 2013 was 515.5 µS/cm.
- The distribution of flow and EC records for the Hunter River at Liddell (210083) suggests higher flows in the 1970s & 1980s compared to the 1990s and 2000s. The distribution of EC levels was similar for most periods; however, there appeared to be some higher EC levels in the 1970s & 1980s and EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level for longer periods than at Denman. These higher EC levels were usually associated with lower flow in the river. Median EC over the period 1970 to 2013 was 675.7 µS/cm.
- The distribution of flow and EC records for the Hunter River upstream of Bayswater Creek (210125) suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was similar, but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median EC over the period 1990 to 2013 was 698 µS/cm.
- The distribution of flow and EC records for the Hunter River upstream of Foy Brook (210126) suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was also similar but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median EC over the period 1990 to 2013 was 719 µS/cm.
- The distribution of flow and EC records for the Hunter River upstream of Glennies Creek (210127) suggests similar flows in the 1990s and 2000s, but comparatively more high flows in the 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was also similar but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median EC over the period 1990 to 2013 was 741.4 µS/cm.

- The distribution of flow and EC records for the Hunter River at Maison Dieu (210128) suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was also similar, but EC levels were only recorded between July 1993 and November 2000, making inter-decadal comparisons less meaningful. At times EC levels exceeded the 900 µS/cm level.
- The distribution of flow and EC records for the Hunter River at Long Point (210134) suggests higher flows in the 2000s compared to the 1990s. No flow or EC data were available at this site for the 1970s & 1980s. In contrast, EC levels in the 2000s were generally lower than in the 1990s. Fewer EC levels exceeded the 900 µS/cm level than at sites further upstream, potentially as a result of diluting flows from Glennies Creek. Median EC over the period 1990 to 2013 was 719 µS/cm.
- The distribution of flow and EC records for the Hunter River upstream of Singleton (210129) suggests higher small to medium flows in the 1990s compared to the 2000s, but more high flows in the 2000s period. If data from the Singleton gauge (210001) are included, then flows were even higher (median = 371 megalitres a day) in the 1970s & 1980s. EC levels in the 2000s were generally lower than in the 1990s and much lower than EC levels measured at Singleton (210001) in the 1970s & 1980s. Fewer EC levels exceeded 900 µS/cm over the period 1990 to 2013. Median EC over the period 1990 to 2013 was 639.9 µS/cm, much lower than the median EC level of 831 µS/cm recorded at Singleton (210001) in the 1970s & 1980s.
- The distribution of flow and EC records for the Hunter River at Greta (210064) suggests higher flows in the 1970s & 1980s but similar flows in the 1990s and 2000s. EC levels in the 2000s were generally lower than in the 1990s and much lower than EC levels in the 1970s & 1980s. EC levels exceeded the 900 µS/cm more frequently over the period 1990 to 2013 at Greta than at Singleton. Median EC over the period 1990 to 2013 was 731.9 µS/cm, much lower than the median EC level of 979 µS/cm recorded during the 1970s & 1980s.

Goulburn River monitoring stations

Results of comparisons for the Goulburn River monitoring stations suggest the following:

- Limited sampling of the Goulburn River at Coggan (210006) during the 1970s to 2000s makes comparisons between periods difficult. At this point there appears to be no trend in conductivity levels at this site but further analysis is warranted as more EC data are collected over time. Median EC level over the period of record was 1007 µS/cm.
- The distribution of flow and EC records for the Goulburn River at Kerrabee (210016) suggests higher flows in the 1990s compared to other periods. Very few EC records were available for the 1990s, but the EC levels in the 2000s were similar to EC levels in the 1970s & 1980s, but with some higher EC records overall in the 2000s. EC levels frequently exceeded 1000 µS/cm but there appears to be a declining trend since the mid-2000s. Cyclical patterns were also evident in the data and these require further assessment. Median EC over the period 1970 to 2013 was 1070.4 µS/cm.
- The distribution of flow and EC records for the Goulburn River at Sandy Hollow (210031) suggests higher flows in the 1970s & 1980s compared to more recent periods. EC records for the 1970s & 1980s and 1990s were higher than EC records in the 2000s. EC levels frequently exceeded 1000 µS/cm and again there appears to be a declining trend since the 1990s. Some relatively high EC levels (2500 to 3000 µS/cm) have been recorded in recent times. Cyclical patterns were also

evident in the data for the Goulburn River at Sandy Hollow, but not as pronounced as at Kerrabee. These patterns require further assessment. Median EC over the period 1970 to 2013 was 837.5 µS/cm.

Wollombi Brook monitoring stations

Results of comparisons for the Wollombi Brook monitoring stations suggest the following:

- Flow and EC records for Wollombi Brook at Bulga (210028) suggest higher flows in the 1970s & 1980s compared to the 2000s. Limited flow data were available for the 1990s. EC records for the 1970s & 1980s and 1990s were slightly lower than EC levels in the 2000s but this may be affected to some degree by sample size differences. EC levels exceeded 1000 µS/cm on some occasions and there appears to be a declining trend since the early 2000s. The median EC level over the period 1970 to 2013 was 674 µS/cm.
- Flow and EC records for Wollombi Brook at Warkworth (210004) suggest higher flows in the 1970s & 1980s compared to the 1990s and 2000s. EC records for the 1970s & 1980s and 1990s were obviously lower than EC levels in the 2000s. EC levels exceeded 1000 µS/cm for most of the 2000s with some very high EC levels (approaching 10,000 µS/cm) recorded. The EC–flow relationship demonstrates that EC concentrations were often not well-correlated with flow. This is clearly different to the patterns of EC and flow upstream at Bulga. Overall, the EC data implies impacts either from saline groundwater moving into Wollombi Brook or from mining. Further assessment is necessary to fully understand the underlying mechanisms yielding high EC levels in Wollombi Brook at Warkworth. Median EC over the period 1970 to 2013 was 740.5 µS/cm, however, the median EC level during the 2000s was 891.1 µS/cm.

Glennies Creek monitoring stations

Results of comparisons for the Glennies Creek monitoring stations suggest the following:

- Flow and EC records for Carrow Brook at Carrowbrook (210114), upstream of Glennies Creek Dam (constructed in 1983), suggest flows were similar in all periods. Limited EC data were available for the 1970s & 1980s. EC records for the 1990s and 2000s were similar. EC levels are low and have not exceeded 600 µS/cm. Median EC over the period 1970 to 2013 was 175.8 µS/cm.
- Glennies Creek at the Rocks No. 2 (210044) is downstream of Glennies Creek Dam. Flow and EC records for 210044 suggest higher flows in the 1990s and 2000s compared to the 1970s & 1980s. EC records for the 1970s & 1980s were limited but indicate higher EC levels (median = 427.5 µS/cm) than EC levels in the 1990s and 2000s (median = 263–265 µS/cm). EC levels now rarely exceed 600 µS/cm.
- Flow and EC records for Glennies Creek at Middle Falbrook (210044) suggest higher flows in the 1990s and 2000s compared to the 1970s & 1980s. EC records for the 1970s & 1980s were limited but appear to have been much higher than EC levels in either the 1990s or 2000s. Higher EC levels occurred in the 2000s compared to the 1990s, but EC levels rarely exceed 900 µS/cm. Median EC over the period 1970 to 2013 was 361.4 µS/cm.

Other monitoring stations

Results of comparisons for other monitoring stations suggest the following:

- Flow and EC records for Wybong Creek at Wybong (210040) suggest flows were similar in all periods. Limited EC data were available for the 1970s & 1980s but it appears that EC levels in the 2000s have been significantly higher (median = 1728.1 µS/cm) than in either the 1990s or 1970s & 1980s. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought conditions. Further assessment of EC levels are required for Wybong Creek. Median EC over the period 1970 to 2013 was 1578.8 µS/cm.
- Flow and EC records for Merriwa River upstream of Vallances Creek (210066) suggest flows were much lower in the 2000s compared to either the 1970s & 1980s or the 1990s. Limited EC data were available for the 1970s & 1980s or 1990s, but it appears that EC levels in the 2000s have been significantly higher (median = 1598.2 µS/cm) than in earlier periods. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought conditions. However, since that time EC levels have declined significantly. Further assessment of EC levels is required for the Merriwa River. Median EC over the period 1970 to 2013 was 1590 µS/cm.
- Flow and EC records for Foy Brook downstream of Bowmans Creek Bridge (210130) suggest flows were similar in the 1990s and 2000s. No flow data were available for the 1970s & 1980s. Limited EC data were available for the 1970s & 1980s, but EC levels were higher in the 1990s compared to the 2000s. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought conditions. However, since that time EC levels have declined significantly, although there is a clear outlier (~ 6000 µS/cm) and a gap in the EC record. Further assessment of EC levels is required for Foy Brook. Median EC over the period 1970 to 2013 was 1297.3 µS/cm.
- Flow and EC records for Bayswater Creek (210110) suggest flows were similar in the 1990s and 2000s. No flow data were available for the 1970s & 1980s. Overall flows are low (median = 0.24 megalitres a day). No EC data were available for the 1970s & 1980s, but EC levels were higher in the 2000s compared to the 1990s. EC levels have remained relatively consistent over the past two decades (median = 3118.9 µS/cm), however maximum levels can at times be high (approaching 5000 µS/cm). While a flow concentration relationship exists for Bayswater Creek it appears also to be influenced by discharges at relatively higher flow rates. Further more detailed assessment of EC levels is required for Bayswater Creek.
- The distribution of flow and EC records for Black Creek at Rothbury (210089) suggests higher flows in the 2000s compared to the 1970s & 1980s and 1990s. EC records for the 1970s & 1980s were limited but appear to have been much higher than EC levels in either the 1990s or 2000s. Higher EC levels occurred in the 2000s compared to the 1990s and EC levels often exceed 900 µS/cm. Median EC over the period 1970 to 2013 was 1360.5 µS/cm.

Generalised additive modelling of electrical conductivity

As stated earlier, assessment of trends in water quality need to take into account changes in rainfall, flow and other important environmental variables. A generalised additive model (GAM) was developed to model water quality in the Hunter River using the water quantity and quality data taken from the NOW databases. The modelling approach taken is similar to that used by DECC for the Hawkesbury–Nepean River (DECC 2009). The predictor variables used in these models were flow at the gauging station/water quality sampling site, flow on the day before sampling, seasonal terms and time[8] (consecutive number of days since 1/1/1970). In these analyses, the stochastic effects of rainfall were assumed to be captured through their effects on flow and were not modelled directly.

GAMs were fitted to the data using the *mgcv* package (Wood 2006) in R Version-2.8.0 (see The R Foundation for Statistical Computing 2013). GAMs:

- can provide flexibility in statistical modelling
- do not assume linearity of dependent variables (unless you define them to be linear)
- provide a less subjective choice of appropriate form of relationship between predictor and independent variables, and
- can be implemented in several ways in the R statistical package (DECC 2009).

Due to time constraints, GAM modelling of EC levels was only undertaken for the Hunter River at Muswellbrook (Station 210002) and Hunter River upstream of Singleton (Station 2100129; with the addition of EC levels from Station 210001 prior to 1993 when the continuous EC meter was installed at 210129). Flows, lagged flows and seasonal components were all found to be significant (see Appendix C). The resulting non-linear time trend in EC levels for the Hunter River at Muswellbrook and Singleton is illustrated in Figure 15.

The GAM non-linear time trend analysis supports the conclusions from the assessment of the distribution of flow and EC levels above:

- There is evidence of cyclical temporal trends in EC levels in the Hunter River at Muswellbrook, but EC levels do not appear to be either increasing or decreasing over time.
- There is evidence of cyclical temporal trends in EC levels in the Hunter River at Singleton, and EC levels appear to have declined over the more recent time periods.

To some extent these trend conclusions have been affected in the past by periods when EC levels were not recorded (e.g. the mid to late 1980s) or where sampling was inconsistent, yielding higher levels of uncertainty at these times. It is expected that as further continuous (or near-continuous) flow and EC levels are measured, these models can be further refined to confirm if future trends or changes in EC levels occur.

Surface water summary

Given that a specific experimental design for testing the impact of the Scheme was not developed at the time, assessment of the effectiveness of the Scheme has relied upon the partitioning of available data into three major time periods: *before* Scheme operation (1970s and 1980s), *during the initial stages* of the Scheme (1990s) and *after formal commencement* of the Scheme (2000s to present). Provided these periods are adequate surrogates for the various stages of the Scheme operation and that natural EC sources have remained relatively constant between periods, then the data suggests that the Scheme has:

- had little effect on flows and EC levels in the Hunter River upstream of Denman over the three time periods
- improved EC levels at (and immediately upstream of) Singleton and Greta, particularly when comparing EC levels in the 2000s with EC levels in the 1970s and 1980s. This is despite lower flows occurring in the 1990s and 2000s, and

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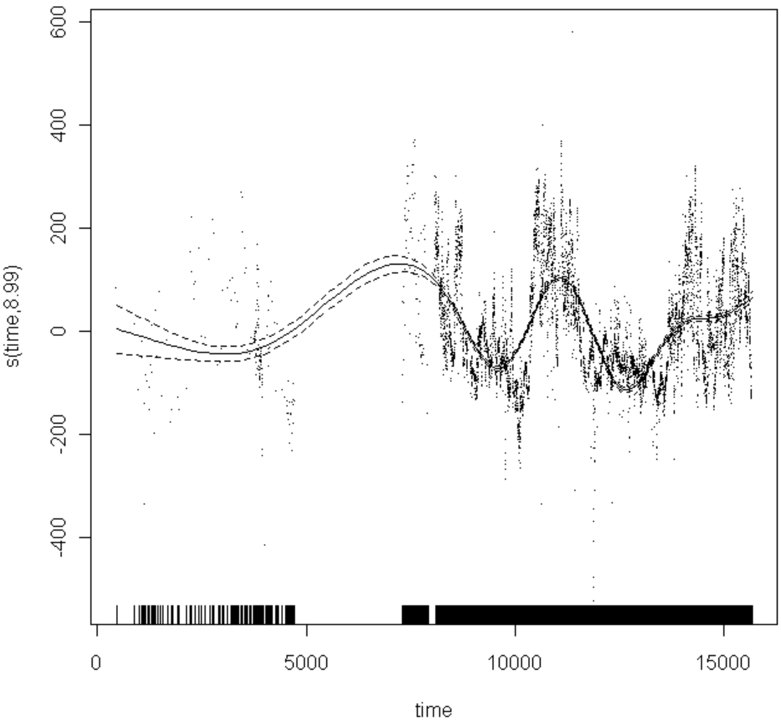
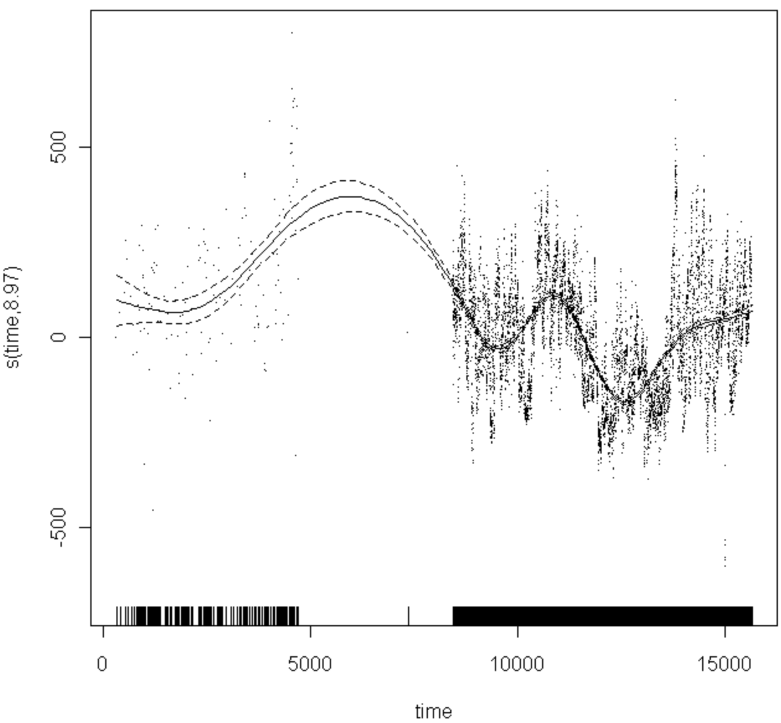
[8] Time was taken to be an increasing series from 1 on a start date of 1/1/1970 up to a maximum on the latest record for that site (e.g. 15,758 for 21/2/2013).

- potentially improved EC levels at monitoring stations between Denman and Singleton, although limited if any EC data were available at these latter stations during the 1970s & 1980s to clarify pre-existing EC levels prior to the Scheme commencing (in ‘pilot’ or ‘full’ implementation). The 1990s appear to have similar flows to the 2000s at these monitoring stations, but the EC levels are usually lower in the 2000s (see Appendix B).

These putative trends are supported by the GAM assessment which found evidence of cyclical temporal trends in EC levels in the Hunter River at both Muswellbrook and Singleton but little evidence that EC levels had either increased or decreased at Muswellbrook, and that EC levels had declined at Singleton over the most recent time period.



210002 Hunter River at Muswellbrook



210001 Hunter River at Singleton

Figure 15: Non-linear generalised additive model (GAM) time trend in EC levels in the Hunter River at Muswellbrook (above) and Singleton (below)

Values on the y-axis represent partial residuals (see Wood 2006);
Time = 1 on the x-axis corresponds to 1/1/1970; Time = 15,000 is 25/1/2011.
(EC data from Stations 210001 and 2100129 were combined and medians calculated where more than one record occurred on the same day.)

Since the Scheme only applies to discharges at times of high or flood flow, if discharges under the Scheme were increasing conductivity levels in the Hunter River at these times, then such an increase would be reflected in the EC-flow relationships, with higher flows leading to higher EC levels. Such a pattern was not evident in the Hunter River monitoring sites (see Appendix B).

While salinity targets do not apply to the Hunter River tributaries, high salinity waters in the tributaries can still affect Scheme discharge opportunites within the Hunter River. Most tributary monitoring sites also showed a decreasing relationship between EC and flow (see Appendix B). An exception to this last generalisation was Wollombi Brook at Warkworth, where the EC–flow relationship demonstrates that EC concentrations were often not well-correlated with flow (as would normally be expected and appeared to be the case for most other monitoring stations, including the upstream Wollombi Brook site at Bulga). Overall, the flow and EC data at Wollombi Brook at Warkworth implies impacts either from saline groundwater and/or mining. Further assessment is necessary to fully understand the underlying mechanisms which yielded the high EC levels at Warkworth, but these relatively high levels have the potential to reduce the opportunities of the Scheme by increasing the EC contributed by Wollombi Brook waters where they join the Hunter River. Fortunately the very high EC levels of the mid to late 2000s have now declined, but still need ongoing monitoring.

Most other monitoring stations throughout the catchment also showed little evidence of increasing EC levels over time, except potentially during the 2000 to 2007 drought. The interaction of rainfall, flow and groundwater contribution can often be complex and requires further assessment in these areas to fully understand the effects of drought on surface water EC levels in these areas of the Hunter River catchment.

While not exhibiting major trends in EC at the stations investigated (apart from during drought conditions), the Goulburn River can also contribute relatively high salinity water (median EC levels often greater than 800–1000 µS/cm) to the Hunter River. Goulburn River salt loads are highly variable and dependant on subcatchment source. Natural salt inputs from the Wollar, Wybong and Merriwa subcatchments are significant and the total salt load from the Goulburn River can at times be greater than the salt load measured in the Hunter River at Denman (Table 7). While the Goulburn River upstream of Kerrabee is not captured by the Scheme, it can exert an influence on Scheme discharge capacity and opportunity downstream of its confluence with the Hunter River. At present, salinity levels in the Goulburn River downstream of Sandy Hollow cannot be regularly assessed until Jerrys Plain, which is approximately 60 river kilometers (half-day travel time) from Sandy Hollow. In addition, three mines (Ulan, Wilpinjong and Moolarben) currently have discharge licences in the Upper Goulburn River catchment and further mining is proposed for the Bylong Valley. There is currently limited monitoring in the upper Goulburn River catchment[9]. With the likely expansion of mining and coal seam gas extraction in the Upper Goulburn River catchment and the lack of real-time monitoring in the both the upper and lower sections of the Goulburn River catchment, strategic real–time monitoring of flow and salinity in other areas of the Goulburn River catchment is recommended.

[9] The NOW Ulan gauge was discontinued some time ago; however monitoring is a requirement for the Ulan, Wilpinjong and Moolarben discharges.

Table 7. Total salt load from the Goulburn River at Sandy Hollow (210031) and the Hunter River at Denman (210055)

Year	Salt load – Goulburn River at Sandy Hollow (tonnes)	Salt load – Hunter River at Denman (tonnes)	Ratio of salt load Goulburn/Hunter
2007–08	34,100	65,900	52%
2008–09	24,200	72,400	34%
2009–10	11,800	24,100	49%
2010–11	93,200	71, 000	130%

Source: NSW Office of Water

Lastly, the above assessment has focused primarily on EC levels but it is known that the ionic composition of saline groundwater and mine/power generation water can often be very different to what naturally occurs in the surface waters of the catchment. Insufficient time was available to fully analyse the differences in ionic composition of surface water, groundwater and mine water throughout the Hunter River catchment. However, such analysis is warranted given the recent literature on ecotoxic effects of some mine waters and the implication of the potential role of differing ionic and metal/metalloid constituents (e.g. Farag and Harper 2012, OEH 2012, Cardno Ecology Lab Pty Ltd 2010). This aspect is discussed further in the Ecosystem Health Section below.

6. Ecosystem health in the Hunter catchment

Aquatic ecology in the Hunter catchment is affected by natural flows, flow regulation and modification, water quality, changes due to catchment disturbance and run-off, the discharge of treated (or untreated) effluent and land use. The most well-developed and widespread of the available biological indicators of stream 'health' in NSW are macroinvertebrates collected by the methods of either Chessman (1995) or Turak *et al.* (2000, 2004). Macroinvertebrates are commonly used throughout the world to assess the environmental health of a river, stream, creek or wetland because they are sensitive to changes in water quality and flow regimes and allow detection of environmental impacts for some time after the event has occurred. They are easily collected, abundant, diverse, readily seen with the naked eye and the knowledge of taxonomy is advanced and well-documented.

The widely accepted and supported AUSRIVAS (Australian River Assessment System) methodology utilises site-specific predictions of the macroinvertebrate assemblage expected to be present at a site in the absence of environmental stressors. The expected assemblages of macroinvertebrates from sites with similar physical and chemical characteristics (characteristics that are not influenced by human activities, e.g. altitude) are compared to the macroinvertebrate assemblage observed during sampling. The ratio of observed to expected macroinvertebrates can vary from zero, when none of the expected macroinvertebrates are collected at a site, to one or greater, when all or more of the expected macroinvertebrates are collected. The observed over expected ratios (scores) are placed in bands thus permitting an assessment of the environmental health of the river for that site. Computer models calculate a band for each site based on the physical and chemical properties of the site, the time of collection (spring or autumn), the habitat (edge or riffle) and the macroinvertebrate families collected (Table 8 and Table 9).

Since the purpose of the Scheme is to control industrial discharges of saline water and ensure they are only released at times of high or flood flows when there is adequate dilution, the Scheme itself provides limited ability to control the more general impacts of high salinity waters on aquatic health. Nevertheless, an assessment of the impacts of saline waters on macroinvertebrates is necessary to provide the context for addressing questions of whether the Regulation has impacted aquatic ecosystems and associated environmental values since it commenced, or its potential to impact on aquatic ecosystems and associated environmental values in the future.

Macroinvertebrate assessment

Chessman (1997a,b) conducted the first extensive survey of macroinvertebrates in the Hunter River catchment. He found most of the Hunter River valley sites were rated as poor or very poor. Several sites were in a fair category and only a few sites were rated as good or excellent, and these were mostly upstream sites around the edges of the catchment (Chessman 1997a).

Macroinvertebrate monitoring is also a major component of the NSW Monitoring, Evaluation and Reporting (MER) Strategy and OEH has collected data on macroinvertebrates in the Hunter River catchment as part of MER (or earlier programs) for the past two decades. Data from Chessman (1997a) and OEH were combined with macroinvertebrate data from the Hunter–Central Rivers CMA (HCR CMA) to assess the current state of macroinvertebrates in the Hunter River catchment. Chessman calculated Stream Invertebrate Grade Number Average Level (SIGNAL) scores for 48 sites and OEH has calculated AUSRIVAS scores for 316 samples in the Hunter River catchment. The majority of HCR CMA samples (9 sites) come from the Goorangoola Creek catchment and AUSRIVAS scores were calculated for these sites as well for the current assessment. It is highly likely that there are other macroinvertebrate monitoring sites which have not been captured in this summary and further work is required to provide a comprehensive summary of all macroinvertebrate sampling that has taken place in the Hunter River catchment.

Of the 173 unique sites identified as having been sampled for macroinvertebrates over the past decade, over half (56.6 per cent) were found to be in *similar to reference* (band A) or *richer than reference* (band X) condition (see Table 10). Forty seven sites (27.2 per cent) were found to be in a significantly impaired (band B) condition. Eight sites (4.6 per cent) were found to be in a *severely impaired* (band C) condition and one site (0.5 per cent) in an *extremely impaired* (band D) condition. Nineteen sites were outside the experience of the model (OEM) or had insufficient data to calculate an AUSRIVAS score. A further 42 sites only had a SIGNAL score calculated (see Chessman 1997a, b). This indicates that the macroinvertebrate ‘health’ throughout the catchment is on average good, but there are some areas that are poor in terms of macroinvertebrate health. A relatively high number of samples (n = 9) in the Hunter Regulated River Alluvial Zone were found to be in a significantly impaired (band B) condition.

Table 8: AUSRIVAS bands for spring – edge habitat

Band Label	SIGNAL O/E50 (upper limit)	AUSRIVAS O/E50 (upper limit)	Band Name	Band Description
Band X	Infinity	Infinity	More biologically diverse than reference sites.	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	1.09	1.16	Reference condition.	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	0.87	0.83	Significantly impaired.	Fewer families than expected. Potential impact either on water quality or habitat quality or both resulting in loss of taxa.
Band C	0.65	0.51	Severely impaired.	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	0.43	0.19	Extremely impaired.	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Source: DECC (2009)

Table 9: AUSRIVAS bands for spring – riffle habitat

Band Label	SIGNAL O/E50 (upper limit)	AUSRIVAS O/E50 (upper limit)	Band Name	Band Description
Band X	Infinity	Infinity	More biologically diverse than reference sites.	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	1.06	1.18	Reference condition.	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	0.93	0.8	Significantly impaired.	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band C	0.80	0.43	Severely impaired.	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	0.67	0.06	Extremely impaired.	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Source: DECC (2009)

The spatial distributions of monitoring sites within a subcatchment are illustrated in Figure 16 and further details for individual sites are available in Appendix D. Colour coding has been applied to Figure 16 to identify sites considered to be in good to very good condition (blue and green), fair condition or disturbed condition (yellow) and poor to very poor or severely to extremely impaired condition (red and pink). Sampling sites are often clustered rather than being distributed evenly throughout the WSP catchments and some WSP catchments have no record of macroinvertebrate sampling. Since the majority of sites have not been selected randomly, and the sample size for some subcatchments is relatively small, inference from the percentages above to the entire Hunter River catchment still need to be treated with caution.

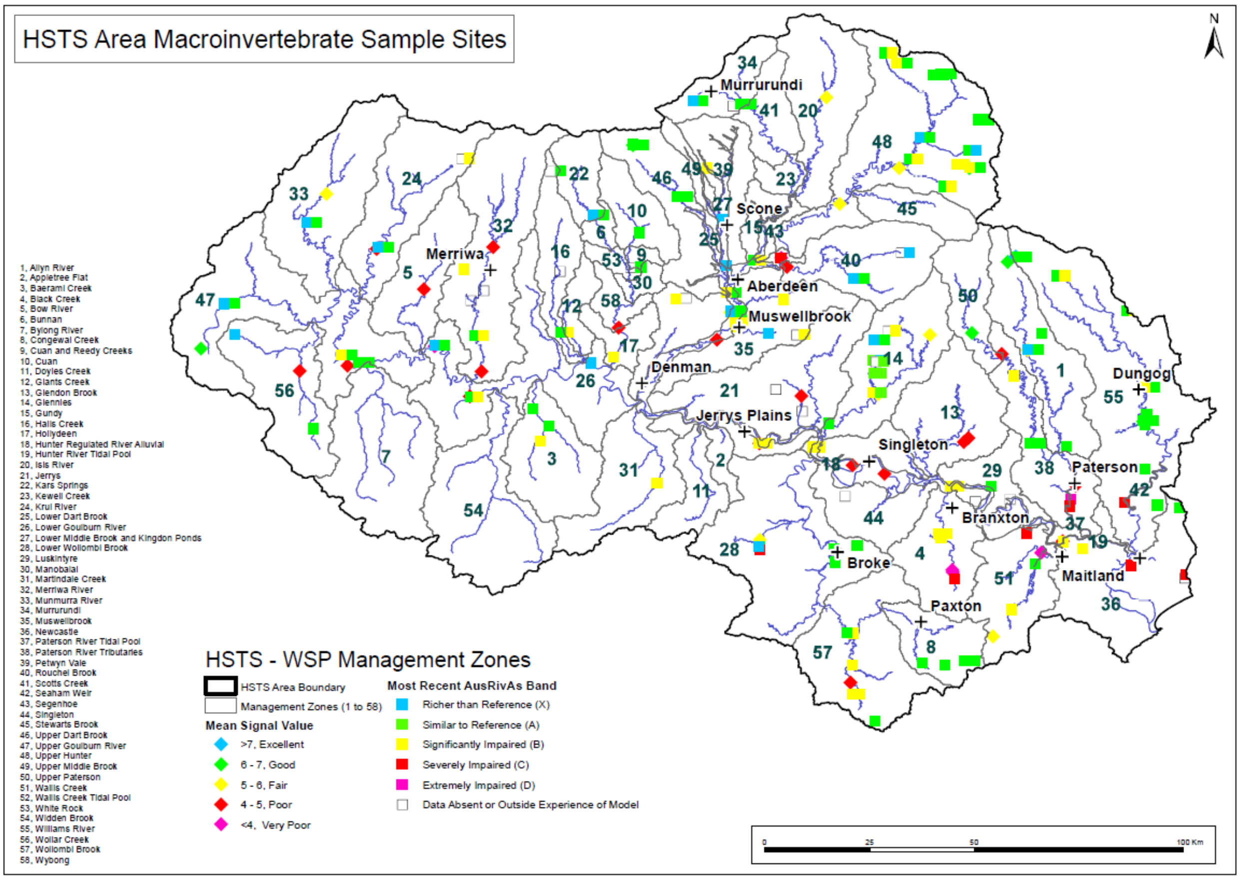


Figure 16: AUSRIVAS and SIGNAL scores for macroinvertebrates collected in the Hunter River catchment

Table 10: Site distribution and AUSRIVAS score for macroinvertebrates in the Hunter River catchment

Water sharing plan management zone	AUSRIVAS Band						SIGNAL	Total
	X	A	B	C	D	OEM		
Allyn River	1	3					2	6
Baerami Creek		2	1					3
Black Creek			3	1			2	6
Bow River							1	1
Congewai Creek		4						4
Cuan		1						1
Cuan and Reedy creeks		1				1		2
Glendon Brook							2	2
Glennies	2	7	2			2	2	15
Halls Creek		2	1				2	5
Hollydeen			1					1
Hunter Regulated River Alluvial	1	2	9			1	5	18
Isis River							1	1
Jerrys						2	1	3
Kars Springs	1	1						2
Krui River	1	1	1			1	1	5
Lower Dart Brook		1	1					2
Lower Goulburn River	2	2	1				2	7
Lower Middle Brook and Kingdon Ponds	2		1					3
Lower Wollombi Brook	1	4		1			1	7
Luskintyre		1	1			1		3
Martindale Creek			1					1
Merriwa River		1	2			2	2	7
Munmurra River	1	1					1	3
Murrurundi	1	3				1		5
Muswellbrook	1		3	1		2	1	8
Newcastle		1	2	2		1	1	7
Paterson River Tidal Pool							1	1
Paterson River Tributaries		2	1	1	1	1		6
Rouchel Brook	2	1				1	1	5
Singleton						1		1
Upper Dart Brook		4					1	5
Upper Goulburn River	2	4	1				2	9
Upper Hunter	2	13	7				3	25
Upper Paterson							2	2
Wallis Creek		1	1	1			2	5
Williams River		11	3	1			2	17
Wollar Creek	1	1					1	3
Wollombi Brook		2	4				1	7
Wybong							1	1
Totals	21	77	47	8	1	19	42	215

River regulation has been shown previously to have a significant impact on macroinvertebrate communities (e.g. Growns and Growns 2001, Marchant and Hehir 2002, DECC 2009). Salinity has also been suggested as a major contributor to impacts on macroinvertebrate communities (e.g. Kefford *et al.* 2005; Kefford *et al.* 2010; Cardno Ecology Lab Pty Ltd 2010 Dunlop *et al.* 2008, 2011; Cañedo Argüelles *et al.* 2013). In areas where flow regulation, land clearing, riparian degradation and saline waters all interact, it is often difficult to tease out the relative contributions of these confounding sources to altered macroinvertebrate communities. Further assessment of the community-level structure and its relationships with salinity has therefore been undertaken, specifically focusing on the effects of salinity on macroinvertebrates (Appendix E).

Impacts of saline water on Australian aquatic biota

Muschal (2006) assessed the the risk of elevated salinity to aquatic biota from the Hunter River. She found the aquatic biota of tributaries had a greater risk of impairment from high salinity than that of the Hunter River. High salinities in the tributaries were attributed to the combined factors of naturally saline geologies, increased liberation of salts due to modification of the landscape, and reduced dilution by flushing flows. There are also a number of other recent scientific publications that suggest increased levels of salinity can affect aquatic communities (e.g. Kefford *et al.* 2005; Kefford *et al.* 2010; Cardno Ecology Lab Pty Ltd 2010 ; Dunlop *et al*. 2008, 2011; Cañedo Argüelles *et al.* 2013; etc.). This prompted a specific analysis of macroinvertebrate data from the Hunter River catchment as part of the current salinity assessment. The analysis was led by Dr Ben Kefford of the University of Technology, Sydney (UTS) and was based on macroinvertebrate samples collected by OEH (and its predecessor organisations) over the past two decades as part of the Monitoring, Evaluation and Reporting (MER) and earlier Monitoring River Health Initiative (MRHI) Programs. The results of this analysis (Kefford *et al.* 2013) are included as Appendix E.

Although the Kefford *et al.* (2013) study was correlative and thus could not prove causality, it made the interim conclusion that salinity changes were likely (at least partly) to be causing changes in macroinvertebrate community structure in the Hunter River catchment. Large-scale changes in macroinvertebrate community structure were observed with relatively small changes in EC, including changes below 600 µS/cm and 900 µS/cm, the current targets for salinity levels in the upper and mid/lower Hunter River, respectively. Changes in community structure associated with similarly low salinity levels have been observed in Victoria and South Australia (Kefford *et al.* 2005, Kefford *et al.* 2010), the Appalachia Mountains, USA (Pond 2010, USEPA 2011, Passmore *et al.* 2012) and France (Piscart *et al.* 2005a, Piscart *et al.* 2005b, Piscart *et al.* 2006). If confounding factors were actually the cause of observed community changes (as opposed to the salinity itself), they would need to be invoked in a number of geographically distant locations with different causes of increased salinity. Furthermore changes in salinity below 600 or 900 µS/cm have been shown experimentally to affect the growth of stream macroinvertebrates (Kefford and Nugegoda 2005; Hassell *et al.* 2006; Kefford *et al.* 2006a,b; Kefford *et al.* 2007b), microinvertebrates (Kefford *et al.* 2007a) and freshwater fish (Boeuf and Payan 2001).

Important support for salinity impacts can also be found in the ACARP study on the effects of mine water salinity on freshwater biota (Cardno Ecology Lab Pty Ltd 2010). Cardno Ecology Lab Pty Ltd (2010) found that discharge waters from mines in the Hunter and Illawarra/Macarthur regions induced deleterious responses in a range of aquatic biota. Arthropods were the most sensitive organisms tested, with the mayfly *Atalophlebia* spp. being the most sensitive of these. The salinity levels at which effects occurred were below those reported in the literature for sodium chloride (NaCl) based solutions and highlighted the need for site-specific toxicity information that takes into account the variable composition of saline mine waters, including the consideration of other constituents (Cardno Ecology Lab Pty Ltd 2010).

Cardno Ecology Lab Pty Ltd (2010) used species sensitivity distribution (SSD) curves for single-species toxicity information to develop protective concentration (PC) values that protect a large proportion of the aquatic species present in the receiving waters. In Brennans Creek/Georges River (where West Cliff Colliery discharges) the SSD curve suggested a conductivity of 585 µS/cm to protect 95 per cent of species and a value of 921 µS/cm to protect 80 per cent of species. For Tea Tree Hollow (where Tahmoor Colliery discharges) the respective values were 1000 µS/cm and 1146 µS/cm; and for Bowmans Creek (where Ravensworth Colliery discharges) the respective values were 876 µS/cm and 1992 µS/cm. According to Cardno Ecology Lab Pty Ltd (2010), the small PC 95 per cent values determined for Brennans Creek/Georges River were strongly influenced by the sensitivity of the mayfly *Atalophlebia* sp. in the laboratory tests. No cladocerans, leptophlebiids or atyid shrimps were collected from Bowmans Creek and consequently, no field toxicity estimates were able to be derived for these taxa in Bowmans Creek (Cardno Ecology Lab Pty Ltd 2010).

Up until recently, the focus on salinity has primarily been associated with total dissolved solids (measured in milligrams per litre) or electrical conductivity [measured in microsiemens per centimetre (µS/cm)]. What is clear from Kellet *et al.* (1989) and many others is that surface waters, groundwaters and coal mine discharges often have very different ionic compositions. Different ions (sodium [Na^+], calcium [Ca^{2+}], magnesium [Mg^{2+}], potassium [K^+], chloride [Cl^-], bicarbonate [HCO_3^-], sulfate [SO_4^{2-}] and the salts they form) can induce varying degrees of toxicity to aquatic life (for example, Young 1923; Mossier 1971; Nelson 1968; Held and Peterka 1974; Rawson and Moore 1944; Farag and Harper 2012). Farag and Harper (2012) recently reviewed the potential effects of sodium bicarbonate ($NaHCO_3$), a major by-product of coalbed natural gas production, on aquatic life. They cited Mount *et al.* (1997) who completed more than a thousand acute experiments and developed a multiple regression model that described the toxicity of common ions in various combinations to zooplankton and fathead minnows (*Pimephales promelas*). One of the major findings of Mount *et al.* (1997) was that all major ions have a lethal concentration, and the toxicity of a mixture of salts is generally equivalent to the additive toxicity of the individual salts (Farag and Harper 2012).

Farag and Harper (2012) constructed a database of toxicity evaluations of sodium bicarbonate ($NaHCO_3$) on aquatic life and used these data to establish acute and chronic criteria for the protection of aquatic life. Chronic toxicity was observed at concentrations that ranged from 450 to 800 milligrams $NaHCO_3$ per litre (also defined as 430 to 657 milligrams HCO_3- per litre or total alkalinity expressed as 354 to 539 milligrams $CaCO_3$ per litre) and the specific concentration depended on the sensitivity of the four species of invertebrates and fish exposed. Acute and chronic criteria of 459 and 381 milligrams $NaHCO_3$ per litre, respectively, were calculated to protect 95 per cent of the most sensitive species (Farag and Harper 2012). More recently, OEH (2012) also found toxic effects of West Cliff mine water, citing bicarbonate as an important potential contributor to the toxic effects. Other potential toxicants found in the mine water at levels exceeding the ANZECC/ARMCANZ (2000) guidelines were aluminium, nickel, zinc, cobalt and copper (OEH 2012).

If protection of 95 per cent of species was used to identify a suitable target for ecosystem protection in the Hunter River catchment[10], then the ACARP results suggest

[10] In most cases the 95 per cent protection level trigger values should apply to ecosystems that could be classified as slightly to moderately disturbed, although a higher protection level could be applied to slightly disturbed ecosystems where the management goal is no change in biodiversity (ANZECC/ARMCANZ 2000).

that 900 µS/cm may potentially be an appropriate upper level target for EC levels overall (albeit slightly higher than the 876 µS/cm 95 per cent protection level calculated by Cardno Ecology Lab Pty Ltd 2010 for Bowmans Creek). It needs to be recognised that the Scheme salinity targets themselves only apply to the main stem of the Hunter River between Glenbawn Dam and Singleton and not in the tributaries. Nevertheless, based on the scientific evidence available and adopting a precautionary approach, the upper salinity target for the Scheme (currently set at 900 µS/cm in the lower sector) should not be raised without further justification and experimentation. The 600 µS/cm target currently set for salinity levels in the upper sections of the Hunter River may actually provide a more conservative level of protection from salinity impacts in these areas than those further downstream where the 900 µS/cm target applies. However, caution needs to be exercised in these conclusions since such a focus purely on EC may mask the effects of different ionic compositions and any additional effects of other constituents in the mine and power generation water discharges. The results of Farag and Harper (2012) and OEH (2012) suggest greater caution needs to be exercised with mine water high in sodium bicarbonate ($NaHCO_3$). There may also be issues associated with metal/metalloid pollution (e.g. aluminium, nickel, zinc, cobalt and copper) since levels for some of these pollutants have been found in mine waters at levels exceeding ANZECC/ARMCANZ (2000) guidelines for the protection of aquatic ecosystems (e.g. OEH 2012).

It is clear that further experimental studies are required to fully understand the environmental effects of the highly variable saline mine water compositions discharged to the Hunter River catchment. Kefford *et al.* (2013) make a number of recommendations for the specific types of experimental studies required in this context, including experimental mesocosm studies; field studies at targeted sites; and long-term laboratory experiments to determine the chronic and sublethal salinity sensitivity of macroinvertebrate taxa. A program investigating the whole of effluent toxicity of the various mine waters prior to discharge is also required to see:

1. whether any toxicity exists, and
2. the degree of dilution (if any) required to mitigate any potential toxic effects.

Ecosystem health summary

Limited information is available on the macroinvertebrate community structure of the Hunter River prior to the implementation of the Scheme. It is therefore impossible to make any before and after Scheme comparisons in terms of macroinvertebrate health. There is also insufficient understanding of macroinvertebrates in ‘naturally’ saline areas (e.g. Saltwater Creek) prior to the extensive land clearing and development in the catchment. Overall, macroinvertebrate ‘health’ throughout the catchment is good on average based on the available data, but there are some areas that are quite poor in terms of macroinvertebrate health. A relatively high number of samples (n = 9) in the Hunter Regulated River Alluvial Zone were found to be in a significantly impaired (AUSRIVAS band B) condition.

A specific analysis of macroinvertebrate data from the Hunter River catchment was undertaken as part of the current salinity assessment (Kefford *et al.* 2013). This and other scientific research suggests that saline discharges can potentially have impacts on macroinvertebrate communities at conductivity levels similar to or below those currently being discharged by Scheme participants. In addition, simply focusing on total dissolved solids or EC does not necessarily allow for the effects of discharges of differing ionic composition or other contaminants (e.g. metals/metalloids) that may be in the mine and power generation water discharges. High levels of bicarbonate, in particular, have been shown to have toxic effects in some areas (e.g. Farag and Harper 2012, OEH 2012). Further experimental studies are required to fully understand the environmental effects of the highly variable saline mine and power generation water compositions currently being discharged to the Hunter River catchment. Kefford *et al.* (2013) make a number of recommendations for the specific types of experimental studies required in this context.

Given that the Scheme salinity targets only apply to the Hunter River between Glenbawn Dam and Singleton and not within any of the tributaries, and the targets themselves only apply during high or flood flow periods, the Regulation itself provides limited ability to control the more general impacts of high salinity waters on aquatic health. The weight of scientific evidence suggests that the salinity targets for the scheme should not be raised, but further work is required to better understand existing salinity impacts on ecosystem health in the Hunter River and its catchments. The major impact of the Regulation on ecosystem health is likely to have been the continued restriction of discharges to high and flood flows when the potential for dilution is at its greatest (as opposed to continuous or intermittent discharges regardless of flow conditions). As the Regulation does not regulate salinity levels in the tributaries, any impacts of high salinity discharges on ecosystem health in the Hunter River tributaries may be more appropriately managed through other means (e.g. through environment protection licence conditions).

7. Conclusions

There are various potential sources of salinity in the Hunter River catchment including rainfall, atmospheric deposition, run-off and infiltration, weathering of geological strata, groundwater and a variety of anthropogenic sources including the Scheme. Significant spatial variability in atmospheric deposition of salts occurs across the Hunter River catchment with salt loads generally decreasing with increasing distance from the coast. Some point sources of natural salt contamination existed prior to European settlement in the Central Lowlands (Jerrys Plains and surrounds) or were contemporaneous with it, as evidenced by early geographic names with salinity connotations – such as Saltwater Creek (Kellet *et al.* 1989). Widespread land clearing has probably exacerbated degradation of the land and promoted dryland salinity in some areas due to increased run-off, erosion and rising water tables, particulalrly in the Central Lowlands.

Since rising groundwater levels and/or EC can affect stream water quality (e.g. stream EC), any increase in groundwater level or EC could potentially have a confounding effect on the interpretation of Scheme effectiveness.There was little evidence that groundwater levels or the EC of groundwater have been rising in recent times (except perhaps in some very localised areas). This conclusion is affected to some degree by limited temporal sampling and a bias to current monitoring bores being located in alluvial areas often well away from the areas of major mining operations.

If future trends in groundwater level and conductivity are to be undertaken and related back to the impact of the Scheme (or mining and power generation), then a more comprehensive and representative groundwater monitoring program is required for the catchment.

In terms of addressing the three specific questions posed by the EPA (see the Introduction to this report), the following conclusions are made:

1. Has the Regulation impacted on aquatic ecosystems and associated environmental values since it commenced in 2002?

The major impact of the Regulation on ecosystem health is likely to have been the continued restriction of discharges to high and flood flows when the potential for dilution is at its greatest (as opposed to continuous or intermittent discharges regardless of flow conditions).

The assessment of the overall effectiveness of the Scheme on surface water quality relied upon the partitioning of available data into three major time periods: *before* Scheme operation (1970s and 1980s), *during the initial stages* of the Scheme (1990s) and *after formal commencement* of the Scheme (2000s to present). Provided these periods are adequate surrogates for the various stages of Scheme operation, and that natural EC sources have remained relatively constant between time periods, then the data suggests that the Scheme has:

- had little effect on flows and EC levels in the Hunter River upstream of Denman
- improved EC levels at (and immediately upstream of) Singleton and Greta, and
- potentially improved EC levels at monitoring stations between Denman and Singleton, but limited if any EC data were available at these latter stations during the 1970s & 1980s to clarify pre-existing EC levels prior to the Scheme commencing (in 'pilot' or 'full' implementation).

The generalised additive modelling (GAM) and non-linear time trend analysis support the conclusions from the assessment of the distribution of flow and EC levels above, that is:

- There is evidence of cyclical temporal trends in EC levels in the Hunter River at Muswellbrook, but EC levels do not appear to be either increasing or decreasing over time.
- There is evidence of cyclical temporal trends in EC levels in the Hunter River at Singleton, and EC levels appear to have declined over the most recent time periods.

If discharges under the Scheme were increasing conductivity levels in the Hunter River at times of high or flood flows, then such an increase would be reflected in the EC–flow relationships in recent times, with higher flows leading to higher EC levels. Such a pattern was not evident in the data from the Hunter River monitoring sites.

Limited information was available on the macroinvertebrate community structure of the Hunter River prior to the implementation of the Scheme. It is therefore impossible to make any before and after Scheme comparisons in terms of macroinvertebrate health. There is also insufficient understanding of macroinvertebrates in 'naturally' saline areas (e.g. Saltwater Creek) prior to the extensive land clearing and development that occurred in the catchment.

Based on the available data, macroinvertebrate 'health' throughout the Hunter catchment is on average good, but there are some areas that are quite poor in terms of macroinvertebrate health. A relatively high number of samples (n = 9) in the Hunter Regulated River Alluvial Zone were found to be in a significantly impaired (band B) condition.

Although salinity is one of several factors affecting stream macroinvertebrate communities in the Hunter River catchment, salinity appears to be a relatively important factor. A number of scientific studies suggest that saline discharges can potentially have impacts on macroinvertebrate communities at conductivity levels similar to or well below those currently being discharged by Scheme participants.

Assessment of the effectiveness of the Scheme is largely regulated and assessed on the basis of salinity expressed as either total dissolved solids [milligrams per litre (mg/L)] or EC [microsiemens per centimetre (µS/cm)]. Simply focusing on total dissolved solids or electrical conductivity does not necessarily allow for the effects of discharges of differing ionic composition or other contaminants (e.g. metals/metalloids) that may be in the mine water discharges. High levels of bicarbonate, in particular, have recently been shown to have potentially toxic effects in some areas (e.g. Farag and Harper 2012, OEH 2012).

Since the Scheme restricts discharges to periods of high and flood flows, the level of dilution achieved by the Scheme is very important in determining whether impacts to ecosystem health occur. The weight of scientific evidence currently suggests that the salinity targets for the Scheme should not be raised, but further work would be required to better understand existing salinity impacts on ecosystem health in the Hunter River and its tributaries. The Regulation itself does not address potential saline impacts on ecosystem health in the Hunter River tributaries.

Saline wastewater discharges under the Scheme contributed on average approximately 10 per cent of the entire salt load of the Hunter River at Singleton. Since the formal implementation of the Scheme in 2002, there has been a slight increase in the number of participants and on average industry participants have utilised 25 per cent of the given opportunities. However, in recent times significant salt loads (approximately 13.5 to 19.8 per cent of total annual salt load in the Hunter River) have been discharged to the Hunter River and the value of salt credits is increasing, while at the same time the utilization of the TAD has also increased (to 40–50 per cent).

2. Does the Regulation have the potential to impact on aquatic ecosystems and associated environmental values in the future?

If future discharges occur in a similar manner, frequency and EC concentration to those over the past two decades, then similar effects could be expected to those described above. However it is noted that over the past few years there has been an increasing demand (as indicated by the value of salt credits), salt load and TAD usage under the Scheme. Additional demand for saline discharge under the Scheme is also coming from new or expanded mining operations. While impacts on Hunter River EC levels over the past decade (as monitored at the three reference sites) appear limited at this stage, further assessment is required if the salt load and TAD utilisation continues to increase.

Ongoing monitoring of discharge demand, salt loads and TAD usage under the Scheme is required to assess the potential for future trends or changes to impact aquatic ecosystems and environmental values.

As mentioned above, the weight of scientific evidence suggests that current Scheme salinity targets should not be raised. Further scientific analysis and modelling would be required to support altering the Scheme salinity targets in the future.

As identified above, assessment of the effectiveness of the Scheme is largely regulated and assessed on the basis of salinity expressed as either total dissolved solids (mg/L) or EC (µS/cm). The potential effects of discharges of differing ionic composition or other contaminants (e.g. metals/metalloids) that may be in the mine water discharges still requires further investigation. Further experimental studies are recommended in order to fully understand the environmental effects of these discharges.

3. What other sources of salinity in the Hunter catchment could influence the operation of the Scheme in the future?

Hunter River salt loads can also be affected by the major tributaries such as the Goulburn River and Wollombi Brook.

While the Scheme itself does not apply to the Goulburn River upstream of Kerrabee, high salinity water from tributary sources can affect EC levels and discharge opportunities in the Hunter River downstream of their confluences. Goulburn River salt loads are highly variable and dependant on subcatchment source, but can at times be greater than the salt load measured in the Hunter River at Denman. Three mines (Ulan, Wilpinjong and Moolarben) currently have discharge licences in the Upper Goulburn River catchment, and further mining and CSG exploration is proposed for this area. With this likely expansion of mining and coal seam gas extraction, and the lack of real-time monitoring in the both the upper and lower sections of the Goulburn River catchment, strategic real-time monitoring of flow and salinity in other areas of the Goulburn River catchment is recommended.

Further assessment is necessary to fully understand the underlying mechanisms which yielded the high EC levels in Wollombi Brook at Warkworth, but these relatively high levels also have the potential to reduce the opportunities of the Scheme by increasing the EC contributed by Wollombi Brook waters where they join the Hunter River. Fortunately the very high EC levels measured in the mid to late 2000s have now declined, but still need ongoing monitoring.

Most other monitoring stations throughout the catchment showed little evidence of increasing EC levels, except potentially during the 2000 to 2007 drought. The interaction of rainfall, flow and groundwater contribution needs further assessment in these areas to fully understand the effects of drought on surface water EC levels in the Hunter River catchment.

A return to drought conditions in the Hunter River catchment could lead to reduced flow and increases in EC levels in the Hunter River and its tributaries and decrease the opportunities for saline discharges under the Scheme.

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Hunter–Central Rivers CMA: Lorna Adlem, Ingrid Berthold, Tina Clemens

NSW Department of Primary Industries: Tony Bernardi

Hunter Water: Michael Kendall

State Water: Martin Prendergast

University of Technology, Sydney: Dr Ben Kefford

Macquarie University: Associate Professor Grant Hose who peer reviewed the final report.

Industry and councils: Representatives from the following organisations responded to the request for monitoring data: Aluminium Metal Kurri Kurri, Anglo Coal (Dartbrook), Austar Coal Mine, BHPBilliton Mt Arthur Coal, Integra Coal Operations Pty Ltd, Liddell Coal Operators, Macquarie Generation, Moolarben Coal, Muswelbrook Coal Company, Redbank Power, Rio Tinto Coal and Allied, Rixs Creek Pty Ltd, Singleton Council, The Bloomfield Group, Wilpinjong Coal, Xstrata Bulga Coal Complex, Xstrata Mangoola Coal, Xstrata Oceanic Coal, Xstrata Ravensworth Open Cut Colliery, Xstrata United Collieries.

If there is anyone we have inadvertently missed, please accept our sincere apologies.

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Appendix A: Summary tables

Table A1: Land-use classification of water sharing plan management zones throughout the Hunter River catchment

Values for land use categories are percentages; area in km^2

Management zone	Catchment area (km^2)	AGR	CON	DEG	FOR	GRZ	H2O	MMI	RES	SRC	TRU	WST
Allyn River	490.78	0.19	17.48	1.36	10.40	67.46	1.03	0.01	1.56	0.01	0.50	0.00
Appletree Flat	69.78	4.87	73.76	0.00	0.00	20.96	0.03	0.06	0.00	0.00	0.32	0.00
Baerami Creek	422.83	0.35	92.47	0.00	0.00	6.87	0.30	0.00	0.00	0.00	0.01	0.00
Black Creek	374.49	10.68	15.16	1.30	7.71	48.75	2.88	0.68	6.32	4.46	1.91	0.14
Bow River	392.41	23.47	15.78	0.00	0.70	57.29	0.00	0.00	2.13	0.00	0.63	0.00
Bunnan	49.50	0.69	2.31	0.00	0.00	94.62	1.29	0.00	0.67	0.00	0.42	0.00
Bylong River	697.54	1.02	66.90	0.00	1.78	29.90	0.09	0.01	0.00	0.00	0.30	0.01
Congewai Creek	263.00	0.44	50.30	0.10	2.99	42.20	2.10	0.11	1.15	0.18	0.44	0.01
Cuan	218.91	0.19	6.32	0.00	0.00	93.06	0.00	0.08	0.00	0.00	0.36	0.00
Cuan and Reedy creeks	30.20	0.00	21.19	0.00	0.00	78.81	0.00	0.00	0.00	0.00	0.00	0.00
Doyles Creek	214.16	0.78	91.32	0.00	0.07	7.41	0.33	0.00	0.00	0.00	0.09	0.00
Giants Creek	108.21	0.36	57.81	0.00	0.00	41.80	0.00	0.00	0.00	0.00	0.03	0.00
Glendon Brook	469.65	0.04	11.01	0.21	0.03	85.44	1.59	0.02	1.33	0.00	0.33	0.00
Glennies	515.42	0.17	39.57	0.34	0.03	51.41	3.63	1.61	2.62	0.00	0.61	0.00
Gundy	121.07	1.47	11.48	0.01	0.00	83.01	0.12	0.00	0.27	3.52	0.11	0.00
Halls Creek	266.22	2.02	8.40	0.00	0.00	86.78	1.77	0.00	0.03	0.00	0.99	0.00
Hollydeen	131.54	1.70	45.40	0.00	0.00	47.84	1.62	0.19	0.00	2.18	1.07	0.00
Hunter Regulated River Alluvial	355.81	11.45	1.11	0.35	0.04	71.95	9.08	0.66	2.64	0.76	1.85	0.10
Hunter River Tidal Pool	2.30	0.40	0.00	0.00	0.00	12.62	86.96	0.00	0.00	0.00	0.02	0.00
Isis River	550.06	0.00	0.58	0.00	0.00	97.90	0.90	0.00	0.06	0.00	0.55	0.00
Jerrys	767.43	2.40	23.28	2.06	0.62	50.20	3.44	8.74	0.09	0.00	9.17	0.00
Kars Springs	173.34	2.91	4.67	0.82	0.00	89.92	1.47	0.00	0.03	0.00	0.18	0.00
Kewell Creek	71.48	0.07	18.68	2.12	8.36	68.83	1.94	0.00	0.00	0.00	0.00	0.00
Krui River	585.23	11.87	6.21	0.00	3.35	76.93	1.48	0.00	0.00	0.00	0.15	0.00
Lower Dart Brook	33.34	7.76	5.02	0.00	0.00	79.84	6.02	0.00	0.63	0.07	0.66	0.00
Lower Goulburn River	786.29	2.42	61.31	0.05	0.00	32.33	1.07	0.03	0.00	1.73	1.04	0.00
Lower Middle Brook and Kingdon Ponds	56.16	4.64	0.20	0.00	0.36	81.66	7.35	0.13	1.33	1.78	2.17	0.38
Lower Wollombi Brook	962.52	1.56	77.96	0.82	5.70	8.82	1.20	1.46	0.40	1.73	0.34	0.00
Luskintyre	192.19	0.56	23.24	0.03	0.04	72.02	0.95	0.03	2.16	0.00	0.98	0.00
Manobalai	53.82	2.54	29.41	0.00	0.00	66.48	1.25	0.00	0.00	0.19	0.12	0.00
Martindale Creek	462.47	0.35	85.74	0.00	0.03	13.20	0.51	0.00	0.00	0.00	0.16	0.00

AGR = Cultivation or intensive agriculture
CON = Conservation or natural areas
DEG = Abandoned or degraded land
FOR = Forestry
GRZ = Grazing or improved pasture
H20 = Natural water and wetlands
MMI = Mining, manufacturing or industrial
RES = Urban and rural residential
SRC = Services or recreation
TRU = Transport and utilities
WST = Waste disposal

Management zone	Catchment area (km^2)	AGR	CON	DEG	FOR	GRZ	H2O	MMI	RES	SRC	TRU	WST
Merriwa River	809.01	6.89	20.23	0.00	0.00	71.33	0.82	0.00	0.28	0.01	0.43	0.00
Munmurra River	694.11	6.57	9.49	0.00	2.34	80.13	1.08	0.00	0.02	0.01	0.36	0.00
Murrurundi	226.11	0.32	8.45	0.29	0.00	87.69	1.27	0.06	0.99	0.12	0.82	0.00
Muswellbrook	659.93	1.33	10.11	0.63	0.00	81.42	0.43	2.59	1.89	0.72	0.85	0.03
Newcastle	670.74	1.34	31.38	0.40	2.42	27.71	9.05	1.03	15.88	8.70	1.79	0.26
Paterson River Tidal Pool	1.20	0.32	0.00	0.00	0.10	21.38	78.10	0.00	0.05	0.00	0.05	0.00
Paterson River Tributaries	430.09	0.89	10.47	0.40	0.07	80.17	1.77	0.07	5.32	0.04	0.80	0.00
Petwyn Vale	249.05	0.22	20.44	0.88	0.00	75.25	0.14	0.27	1.50	0.24	0.94	0.12
Rouchel Brook	434.52	0.07	24.03	0.66	0.48	73.53	1.19	0.00	0.02	0.01	0.00	0.00
Scotts Creek	203.46	1.19	8.95	0.55	0.01	87.95	0.90	0.04	0.00	0.00	0.43	0.00
Seaham Weir	2.12	0.00	0.00	0.00	0.46	13.65	84.74	0.00	0.95	0.00	0.20	0.00
Segenhoe	18.53	13.41	0.03	0.00	0.00	73.69	11.95	0.00	0.35	0.54	0.04	0.00
Singleton	416.82	0.70	8.59	2.94	0.33	44.37	1.19	8.42	5.97	26.32	1.02	0.15
Stewarts Brook	192.29	0.01	28.76	0.55	0.00	69.43	1.22	0.00	0.00	0.00	0.03	0.00
Upper Dart Brook	398.39	1.36	14.12	0.46	0.20	82.06	1.07	0.07	0.43	0.03	0.22	0.00
Upper Goulburn River	994.54	2.94	60.74	0.00	5.96	26.81	0.36	0.81	1.84	0.00	0.55	0.00
Upper Hunter	1100.87	0.08	19.12	0.07	2.22	74.31	3.46	0.00	0.42	0.22	0.11	0.00
Upper Middle Brook	63.69	0.21	43.79	0.00	0.00	54.14	0.60	1.18	0.07	0.00	0.00	0.00
Upper Paterson	262.03	0.02	52.10	0.58	15.97	29.55	1.66	0.00	0.00	0.12	0.00	0.00
Wallis Creek	416.01	0.51	33.21	0.71	12.30	37.73	3.54	0.78	6.31	2.41	2.24	0.27
Wallis Creek Tidal Pool	0.24	1.34	0.00	0.00	0.00	36.14	59.87	0.00	1.14	0.65	0.86	0.00
White Rock	49.06	0.82	0.33	0.00	0.00	97.31	1.54	0.00	0.00	0.00	0.00	0.00
Widden Brook	708.37	0.57	86.57	0.00	2.48	9.53	0.84	0.00	0.00	0.00	0.01	0.00
Williams River	1273.16	0.18	31.61	0.41	4.16	58.32	1.55	0.04	3.09	0.13	0.51	0.00
Wollar Creek	532.00	1.12	64.24	0.00	0.00	34.16	0.00	0.00	0.07	0.00	0.40	0.00
Wollombi Brook	652.13	0.12	51.65	0.05	28.67	6.20	0.80	0.00	12.18	0.03	0.30	0.00
Wybong	94.05	2.89	47.89	0.00	0.00	47.62	1.08	0.02	0.00	0.00	0.49	0.00
Totals	**21440.66**	**2.44**	**35.26**	**0.39**	**3.08**	**52.25**	**1.74**	**0.79**	**2.00**	**1.15**	**0.87**	**0.02**

Table A2: Geological classification of water sharing plan management zones throughout the Hunter River catchment (Cc to Js)

Values represent percentage area of the catchment

Geological classification	Cc	Cg	Cgd	Cl	Cm	Cs	Csi	Cu	Cv	Dc	Dch	Dcl	Dl	Dm	Ds	Dsi	Js
Management zone	Carboniferous Conglomerate (Cc)	Carboniferous Granite (Cg)	Carboniferous Granitoid (Cgd)	Carboniferous Limestone (Cl)	Carboniferous Mudstone (Cm)	Carboniferous Sandstone (Cs)	Carboniferous Siltstone (Csi)	Carboniferous Undifferentiated (Cu)	Carboniferous Volcanics (Cv)	Devonian Chert (Dch)	Devonian Claystone (Dcl)	Devonian Conglomerate (Dc)	Devonian Limestone (Dl)	Devonian Mudstone (Dm)	Devonian Sandstone (Ds)	Devonian Siltstone (Dsi)	Jurassic Sandstone (Js)
Allyn River	19.49					45.19	0.51	29.2	2.79								
Appletree Flat																	
Baerami Creek																	
Black Creek			0.12					1.58									
Bow River																	0.49
Bunnan																	
Bylong River																	
Congewai Creek																	
Cuan																	
Cuan and Reedy creeks																	
Doyles Creek																	
Giants Creek																	2.79
Glendon Brook	41.21							32.23	11.89								
Glennies	28.52				3.34			43.19	5.21								
Gundy	25.62				6.1	14.54		40.89	6.95								
Halls Creek																	0.68
Hollydeen																	
Hunter Regulated River Alluvial								2.45	0.09								
Hunter River Tidal Pool																	
Isis River	2.64				10.3	16.52			0.94		12.16	3.02	2.44	18.55		8.87	
Jerrys	10.94				1.84			9.07									
Kars Springs																	
Kewell Creek	0.84					31.23			50.32								
Krui River																	0.13
Lower Dart Brook																	
Lower Goulburn River																	1.21
Lower Middle Brook and Kingdon Ponds															0.05		
Lower Wollombi Brook																	
Luskintyre	27.97		0.11			0.15		23.11	21.76								
Manobalai																	
Martindale Creek																	
Merriwa River																	1.55
Munmurra River																	

Geological classification	Cc	Cg	Cgd	Cl	Cm	Cs	Csi	Cu	Cv	Dc	Dch	Dcl	Dl	Dm	Ds	Dsi	Js
Management zone	Carboniferous Conglomerate (Cc)	Carboniferous Granite (Cg)	Carboniferous Granitoid (Cgd)	Carboniferous Limestone (Cl)	Carboniferous Mudstone (Cm)	Carboniferous Sandstone (Cs)	Carboniferous Siltstone (Csi)	Carboniferous Undifferentiated (Cu)	Carboniferous Volcanics (Cv)	Devonian Chert (Dch)	Devonian Claystone (Dcl)	Devonian Conglomerate (Dc)	Devonian Limestone (Dl)	Devonian Mudstone (Dm)	Devonian Sandstone (Ds)	Devonian Siltstone (Dsi)	Jurassic Sandstone (Js)
Murrurundi	10.41				5.12	4.67			0.84						0.17		
Muswellbrook	9.25				6.26			14.32									
Newcastle	0.5					3.23			1.97								
Paterson River Tidal Pool	0.68								0.98								
Paterson River Tributaries	18.7					21.91		9.85	23.24								
Petwyn Vale						0.05		9.91	6.88						0.12		
Rouchel Brook	27.48				31.11			32.51									
Scotts Creek	12.01				0.56	5.32			3.17								
Seaham Weir	6.16					9.93			9.48								
Segenhoe	10.29				5.99	4.94		28.17	0.05								
Singleton																	
Stewarts Brook	3.52				0.76	8.07	0.51	59.88		7.08				2.98		0.4	
Upper Dart Brook															2.79		
Upper Goulburn River		6.51															1.09
Upper Hunter	9.58			0.09	5.58	7.4	1.39	1.68	1.01	13.18	3.12	0.79	0.08	12.79	0.02	1.11	
Upper Middle Brook															2.19		
Upper Paterson	19.39				0.29	21.31		44.32									
Wallis Creek																	
Wallis Creek Tidal Pool																	
White Rock																	
Widden Brook																	
Williams River	5.55					54.82		23	9.04								
Wollar Creek																	
Wollombi Brook								0.43									
Wybong																	

Table A2 (continued: Jsh to H)

Geological classification	Jsh	Jss	Mv	Pd	Pg	Pi	Pm	Pn	Ps	Psh	Psi	Pt	Pv	Q	Sv	Tb	Tg	Ths	Tns	H
Management zone	Jurassic Shale (Jsh)	Jurassic Ss Shale (Jss)	Mesozoic Volcanics (Mv)	Permian Dalwood (Pd)	Permian Greta (Pg)	Permian Illawarra (Pi)	Permian Maitland (Pm)	Permian Newcastle (Pn)	Permian Sandstone (Ps)	Permian Shoalhaven (Psh)	Permian Singleton (Psi)	Permian Tomago (Pt)	Permian Volcanics (Pv)	Quaternary (Q)	Silurian Volcanics (Sv)	Tertiary Basalt (Tb)	Tertiary Gravel (Tg)	Triassic Hawkesbury Ss (Ths)	Triassic Narrabeen Ss (Tns)	Water (H)
Allyn River																2.82				
Appletree Flat											18.52					0.15			81.34	
Baerami Creek											19.79			1.16					79.05	
Black Creek				48.95	4.01		34.31				6.78			1.64					2.6	
Bow River	0.03													7.54		73.25			18.69	
Bunnan														0.06		59.24			40.7	
Bylong River			0.01							6.27	32.86			3.13		4.5			53.23	
Congewai Creek				1.87	0.69		51.38	0.08			1.71			11.2				0.03	33.03	
Cuan														3.37		79.01			17.62	
Cuan and Reedy creeks														15.5		43.12			41.38	
Doyles Creek											10.02					0.02			89.96	
Giants Creek														0.35		14.49			82.37	
Glendon Brook				0.67	1.66		3.12				7.33			1.89						
Glennies							0.67				14.33			3.13		1.62				
Gundy							4.26							0.88		0.78				
Halls Creek														1.81		64.4			33.12	
Hollydeen											15.81			12.06					72.13	
Hunter Regulated River Alluvial				8.59	0.04		1.26				1.53			86.04						
Hunter River Tidal Pool				0.01	0.03		2.53					0.19		97.24						
Isis River								0.01	0.01				0.03	0.21		24.3				
Jerrys					1.11		13.75				55.33			4.52		1.13			2.3	
Kars Springs														4.19		88.8			7.01	
Kewell Creek									4.43				12.31			0.86				
Krui River	1.76													4.36		93.76				
Lower Dart Brook											14.88			85.12						
Lower Goulburn River	1.18										13.11			6.91		8.83			68.77	
Lower Middle Brook and Kingdon Ponds			0.03				17.07		1.33		18.04			62.98					0.51	
Lower Wollombi Brook											16.67			6.92		0.69		10.6	65.11	
Luskintyre				14.99	1.69		6.92				3			0.28						
Manobalai														23.91		25.06			51.03	
Martindale Creek											15.09			0.89		0.08			83.94	
Merriwa River	3.04													4.24		65.13			26.04	
Munmurra River	25.85													1.31		72.85				
Murrurundi							8.9		2.22				14.51	2.42		43.44			7.31	

Geological classification	Jsh	Jss	Mv	Pd	Pg	Pi	Pm	Pn	Ps	Psh	Psi	Pt	Pv	Q	Sv	Tb	Tg	Ths	Tns	H
Management zone	Jurassic Shale (Jsh)	Jurassic Ss Shale (Jss)	Mesozoic Volcanics (Mv)	Permian Dalwood (Pd)	Permian Greta (Pg)	Permian Illawarra (Pi)	Permian Maitland (Pm)	Permian Newcastle (Pn)	Permian Sandstone (Ps)	Permian Shoalhaven (Psh)	Permian Singleton (Psi)	Permian Tomago (Pt)	Permian Volcanics (Pv)	Quaternary (Q)	Silurian Volcanics (Sv)	Tertiary Basalt (Tb)	Tertiary Gravel (Tg)	Triassic Hawkesbury Ss (Ths)	Triassic Narrabeen Ss (Tns)	Water (H)
Muswellbrook				0.89	3.41		14.71				44.39			4.07		0.52			2.16	0.02
Newcastle				1.27	0.03		7.7	11.45				16.7		51.98					0.22	4.95
Paterson River Tidal Pool														98.33						
Paterson River Tributaries				7.69	0.96		7.11							10.54						
Petwyn Vale			0.13		0.37		35.4		4.85		4.24		9.92	2.44		14.82			10.87	
Rouchel Brook														0.14		8.76				
Scotts Creek					1.8		19.39		11.87				36.71	1.64		7.21			0.33	
Seaham Weir														74.43						
Segenhoe							1.02							49.53						
Singleton							57				41.44			1.09					0.46	
Stewarts Brook																16.7	0.1			
Upper Dart Brook											31.62			6.21		38.9			20.49	
Upper Goulburn River	18.22	8.55				6.77				0.23	4.15			4.39	0.36	4.54			45.19	
Upper Hunter								4.69					0.12	0.28		35.56				1.53
Upper Middle Brook							12.18				21.97			1.87		42.93			18.86	
Upper Paterson																14.69				
Wallis Creek				25.68	2.21		36.1	8.43				9.45		11.23					6.91	
Wallis Creek Tidal Pool							24.5					6.19		69.31						
White Rock														13.6		59.89			26.51	
Widden Brook											26.16			1.13		3.19			69.52	
Williams River				0.3			0.95							4.56		1.77				
Wollar Creek			2.06			33.34					8.67		0.09	2.21		1.07			52.56	
Wollombi Brook				1	0.05		0.69				0.18					0.08		11.66	85.9	
Wybong														29.45		7.21			63.33	

Table A3: Salinity risk classification of water sharing plan management zones throughout the Hunter River catchment

Values represent percentage area of the catchment

Management zone	Saline area	Very high risk	High risk	Medium risk	Low risk	Very low risk
Allyn River	1.09	0	0.88	84.53	10.85	2.65
Appletree Flat	0.43	23.37	0	0	3.7	72.49
Baerami Creek	0.07	0	0	19.95	1.12	78.86
Black Creek	5.31	15.49	75.51	0	1.45	2.24
Bow River	0.29	0	0.27	68.55	3.82	27.07
Bunnan	0	0	0	56.74	16.06	27.2
Bylong River	0.28	38.96	0	0	3.26	57.5
Congewai Creek	1.56	17.12	45.72	0	10.02	25.58
Cuan	0.02	0	0	76.71	0	23.27
Cuan and Reedy creeks	0.05	0	0	46.18	2.83	50.93
Doyles Creek	0.14	9.02	0	0	1.39	89.44
Giants Creek	0.11	0.1	2.77	15.04	0.62	81.35
Glendon Brook	4.9	8.04	29.03	57.71	0.32	0
Glennies	2.44	13.26	12.05	53.5	17.41	1.34
Gundy	0	0	22.45	75.99	1.56	0
Halls Creek	0.58	3.3	0.52	66.76	4	24.85
Hollydeen	4.89	15.43	0	0	7.02	72.65
Hunter Regulated River Alluvial	1.25	11.77	19.42	0.58	66.98	0
Hunter River Tidal Pool	0.05	95.23	0.39	0	4.33	0
Isis River	0	0	0.12	75.97	0	23.92
Jerrys	2.81	61.22	8.66	20.36	5.73	1.22
Kars Springs	0	0	0	88.33	5.32	6.35
Kewell Creek	0	4.88	65.36	17.47	0	12.29
Krui River	0.02	0	0	90.68	2.56	6.73
Lower Dart Brook	0	26.4	0	0	73.6	0
Lower Goulburn River	0.38	12.21	0.82	13.04	8.22	65.34
Lower Middle Brook and Kingdon Ponds	0	44.05	0	0.06	55.13	0.77
Lower Wollombi Brook	0.63	18.4	0	0	6.94	74.03
Luskintyre	1.19	3.03	86.27	7.1	2.42	0
Manobalai	0.81	0	0	29.55	9.82	59.82
Martindale Creek	0.1	12.28	0	0	3.07	84.55
Merriwa River	0.09	0	1.56	63.87	3.9	30.58
Munmurra River	0.06	0	0	71.93	0.56	27.45

Management zone	Saline area	Very high risk	High risk	Medium risk	Low risk	Very low risk
Murrurundi	0	13.39	0	45.44	1.68	39.49
Muswellbrook	1.91	53.62	11.8	27.27	3.4	2.01
Newcastle	6.19	52.85	10.03	0.6	29.95	0.37
Paterson River Tidal Pool	0	94.7	2.35	0	2.95	0
Paterson River Tributaries	1.97	5.41	48.41	40.59	3.62	0
Petwyn Vale	0.06	44.25	4.83	28.05	1.61	21.2
Rouchel Brook	0	0	0	84.11	5.95	9.93
Scotts Creek	0	32.41	0.82	21.48	1.33	43.96
Seaham Weir	0	92.59	1.62	0.71	5.08	0
Segenhoe	0	0	2.49	34.72	62.8	0
Singleton	4.94	71.43	22.26	0	1.05	0.32
Stewarts Brook	0	0	0	58.11	16.7	25.19
Upper Dart Brook	0.01	34.66	2.63	37.07	3.44	22.19
Upper Goulburn River	0.9	9.72	7.96	9.49	3.8	68.13
Upper Hunter	0	0	0	56.1	8.08	35.82
Upper Middle Brook	0	34.68	1.3	43.36	0.94	19.71
Upper Paterson	0	0	0	56.49	35.03	8.48
Wallis Creek	4.24	28.5	55.38	0	4.96	6.92
Wallis Creek Tidal Pool	0	94.99	0	0	5.01	0
White Rock	0.54	0	0	58.23	11.26	29.97
Widden Brook	0	0	0	26.17	1.13	72.69
Williams River	1.41	2.47	8.01	71.28	16.1	0.73
Wollar Creek	1.91	42.07	0	0.04	0.69	55.28
Wollombi Brook	0	0.27	1.64	0	0.88	97.21
Wybong	0.8	0	0	9.19	10.05	79.96

Table A4: Water quality monitoring sites and median electrical conductivity levels throughout the Hunter River catchment

CAUTION: Data in this table have been collated from multiple sources over multiple time periods and while all due care has been taken in calculating summary statistics, OEH cannot vouch for the complete accuracy of all values sourced from third parties. As a consequence, data supplied in this table should be double-checked before relying on these numbers for any other purpose than those intended for this report.

Colour coding has been based on the general criteria for the salinity of irrigation water in the Hunter Valley (Creelman 1994, Croft and Associates1983) where:
blue represents low salinity (<280 µS/cm), green medium salinity (280–800 µS/cm), yellow high salinity (800–2300 µS/cm), orange very high salinity (2300–5500 µS/cm); and red extreme salinity waters (>5500 µS/cm).

Site code	Water sharing plan management zone	Geological classification	Geological legend	Land use category	Geological unit	Easting	Northing	Longitude	Latitude	Conductivity median (µS/cm)	Conductivity 80th percentile (µS/cm)	Conductivity N
WW_DB1	Allyn River	Cs	GRZ	M	Carboniferous Sandstone	358030.32	6428932.81	151.4927	-32.2673	135	200	14
HU02	Allyn River	Cu	FOR	L	Carboniferous Undifferentiated	355699.99	6444300.54	151.4702	-32.1285	97.5	115	2
HU01	Allyn River	Cs	H2O	M	Carboniferous Sandstone	359999.99	6423400.48	151.5127	-32.3175	278	314	2
WQ_210095	Allyn River	Cu	GRZ	H	Carboniferous Undifferentiated	364782.66	6400788.70	151.5603	-32.5220	429	640	36
210095	Allyn River	Cu	GRZ	H	Carboniferous Undifferentiated	364782.66	6400788.70	151.5603	-32.5220			0
210143	Allyn River	Cc	GRZ	L	Carboniferous Conglomerate	366953.04	6402891.35	151.5837	-32.5033			0
WQ_210072	Allyn River	Cu	GRZ	L	Carboniferous Undifferentiated	357753.42	6440266.90	151.4914	-32.1651	112	125	17
WQ_21010077	Allyn River	Cu	GRZ	L	Carboniferous Undifferentiated	366598.43	6399183.05	151.5794	-32.5367	315	398	35
210072	Allyn River	Cu	GRZ	L	Carboniferous Undifferentiated	357703.16	6440487.96	151.4909	-32.1631			0
210085	Allyn River	Cu	GRZ	L	Carboniferous Undifferentiated	366701.74	6399184.43	151.5805	-32.5367			0
WW2	Allyn River	Cu	H2O	L	Carboniferous Undifferentiated	357724.51	6440553.68	151.4911	-32.1625	90	100	26
WW1	Allyn River	Cu	H2O	L	Carboniferous Undifferentiated	367000.47	6401492.50	151.5840	-32.5159			0
210007	Allyn River	Cc	GRZ	M	Carboniferous Conglomerate	371203.84	6413591.62	151.6304	-32.4073			0
WQ_21010075	Allyn River	Cs	GRZ	M	Carboniferous Sandstone	363840.18	6412086.33	151.5519	-32.4200	222	278.5	45
WQ_21010157	Allyn River	Cs	GRZ	M	Carboniferous Sandstone	360049.14	6423644.04	151.5133	-32.3153	156	242	13
210111	Allyn River	Cs	GRZ	M	Carboniferous Sandstone	366706.61	6415085.36	151.5828	-32.3933			0
52003	Allyn River	Cs	GRZ	M	Carboniferous Sandstone	362746.76	6427461.13	151.5425	-32.2812	810	810	1
WQ_210085	Allyn River	Cu	GRZ	M	Carboniferous Undifferentiated	367070.17	6399732.67	151.5845	-32.5318	321	443	25
WQ_210022	Allyn River	Cs	H2O	M	Carboniferous Sandstone	359988.83	6424596.82	151.5128	-32.3067	192	250	197
WQ_21010076	Allyn River	Cs	H2O	M	Carboniferous Sandstone	364726.73	6407019.75	151.5606	-32.4658	280.5	321	16
WQ_21010239	Allyn River	Cs	H2O	M	Carboniferous Sandstone	361073.99	6419655.25	151.5236	-32.3514	336	960	4
210022	Allyn River	Cs	H2O	M	Carboniferous Sandstone	359997.63	6424641.29	151.5129	-32.3063			0
HUNT03D	Allyn River	Cs	H2O	M	Carboniferous Sandstone	359901.74	6423409.13	151.5117	-32.3174	179	284	13
HUNT03A	Allyn River	Cs	H2O	M	Carboniferous Sandstone	360093.65	6423489.42	151.5137	-32.3167			0
HUNT03B	Allyn River	Cs	H2O	M	Carboniferous Sandstone	359901.07	6423389.16	151.5117	-32.3176			0
HUNT03C	Allyn River	Cs	H2O	M	Carboniferous Sandstone	360039.67	6423444.31	151.5132	-32.3171			0
WQ_21010074	Allyn River	Cu	H2O	M	Carboniferous Undifferentiated	359255.94	6435985.57	151.5067	-32.2039	96	113	44
51191	Allyn River	Cc	GRZ	SAL	Carboniferous Conglomerate	368172.12	6400652.08	151.5964	-32.5236	751	751	1
WQ_210120	Appletree Flat	Tns	GRZ	VL	Triassic Narrabeen Ss	297835.25	6395433.60	150.8467	-32.5601	230	570	7
210120	Appletree Flat	Tns	GRZ	VL	Triassic Narrabeen Ss	297862.07	6395500.70	150.8470	-32.5595			0
HUNT584	Baerami Creek	Q	AGR	L	Quaternary	260300.63	6407508.33	150.4503	-32.4438	926	926	1
CJ_J23	Baerami Creek	Q	GRZ	L	Quaternary	260653.85	6411089.04	150.4550	-32.4116	520	520	1
CJ_J18	Baerami Creek	Q	TRU	L	Quaternary	261531.14	6414258.97	150.4651	-32.3832	810	810	1
CJ_J22	Baerami Creek	Psi	AGR	M	Permian Singleton	260343.67	6407653.60	150.4508	-32.4425	540	540	1
WQ_210060	Baerami Creek	Psi	AGR	M	Permian Singleton	260344.20	6407653.62	150.4508	-32.4425	785	1156	71
CJ_J20	Baerami Creek	Psi	GRZ	M	Permian Singleton	259783.90	6395325.58	150.4417	-32.5535	390	390	1
CJ_J21	Baerami Creek	Psi	GRZ	M	Permian Singleton	261292.99	6399810.38	150.4589	-32.5134	420	420	1

Site code	Water sharing plan management zone	Geological classification	Geological legend	Land use category	Geological unit	Easting	Northing	Longitude	Latitude	Conductivity median (µS/cm)	Conductivity 80th percentile (µS/cm)	Conductivity N
210060	Baerami Creek	Psi	GRZ	M	Permian Singleton	260488.44	6407523.91	150.4523	-32.4437			0
52191	Baerami Creek	Psi	GRZ	M	Permian Singleton	261980.39	6399855.48	150.4662	-32.5131	208	208	1
52238	Baerami Creek	Psi	H2O	M	Permian Singleton	263725.32	6403443.07	150.4857	-32.4812	807	807	1
K_17	Baerami Creek	Psi	CON	M	Permian Singleton	262604.90	6409793.02	150.4754	-32.4237	1253	1253	1
WW_DB4	Black Creek	Pd	CON	H	Permian Dalwood	348970.97	6372588.59	151.3874	-32.7742	675	850	26
WW_DB66	Black Creek	Pd	GRZ	H	Permian Dalwood	343141.58	6377433.56	151.3260	-32.7297	960	1490	16
WW_DB46	Black Creek	Pd	GRZ	SAL	Permian Dalwood	345861.53	6368785.56	151.3536	-32.8081	745	1000	24
WW_DB3	Black Creek	Pm	H2O	SAL	Permian Maitland	341060.58	6378813.60	151.3041	-32.7170	4000	31600	13
WW_DB7	Black Creek	Pd	RES	H	Permian Dalwood	347111.64	6367125.67	151.3667	-32.8233	2300	2300	1
WW_DB67	Black Creek	Pd	SRC	H	Permian Dalwood	342440.60	6376340.60	151.3184	-32.7395	300	330	16
WW_DB5	Black Creek	Pm	SRC	H	Permian Maitland	347001.94	6360919.86	151.3645	-32.8792	170	180	17
HU04	Black Creek	Pd	GRZ	H	Permian Dalwood			151.3522	-32.7944	623	757	2
HU33	Black Creek	Pd	GRZ	H	Permian Dalwood			151.3512	-32.7899	2600.5	3420	2
WQ_210069	Black Creek	Pd	AGR	H	Permian Dalwood	338347.43	6368810.98	151.2734	-32.8068	1454.5	1770	30
WQ_210101_P	Black Creek	Pd	AGR	H	Permian Dalwood	345487.58	6370998.89	151.3500	-32.7881	2805	3560	2
210069	Black Creek	Pd	AGR	H	Permian Dalwood	338308.71	6368887.98	151.2730	-32.8061			0
WW3	Black Creek	Pd	CON	H	Permian Dalwood	350487.39	6380354.97	151.4049	-32.7044	940	1430	55
WW13	Black Creek	Pd	CON	H	Permian Dalwood	349451.12	6373150.39	151.3927	-32.7693	1090	1160	23
A_SW4	Black Creek	Pg	CON	H	Permian Greta	342268.00	6362382.00	151.3142	-32.8653	1060	2170	49
A_SW5	Black Creek	Pg	CON	H	Permian Greta	340449.00	6361138.00	151.2945	-32.8763	1550	5710	35
MK7	Black Creek	Pg	CON	H	Permian Greta	342083.55	6362128.24	151.3122	-32.8676	489		1
MK8 & MK9	Black Creek	Pg	CON	H	Permian Greta	342227.24	6362566.40	151.3138	-32.8637	478		1
WW8	Black Creek	Pd	GRZ	H	Permian Dalwood	344003.67	6365430.11	151.3332	-32.8381			0
WW20	Black Creek	Pd	GRZ	H	Permian Dalwood	346069.57	6369235.37	151.3559	-32.8041	1030	1320	22
WW24	Black Creek	Pd	GRZ	H	Permian Dalwood	345887.07	6370381.85	151.3542	-32.7937	1280	1600	23
WQ_210063	Black Creek	Pd	GRZ	H	Permian Dalwood	344177.09	6373318.42	151.3364	-32.7670	2214	3714	12
WQ_210067	Black Creek	Pd	GRZ	H	Permian Dalwood	344279.35	6372177.73	151.3373	-32.7773	2417	3175	9
WQ_210068	Black Creek	Pd	GRZ	H	Permian Dalwood	343713.47	6370039.47	151.3309	-32.7965	2240	3424	40
210063	Black Creek	Pd	GRZ	H	Permian Dalwood	344400.87	6373388.48	151.3388	-32.7664			0
210068	Black Creek	Pd	GRZ	H	Permian Dalwood	343704.98	6369983.88	151.3308	-32.7970			0
HUNT542	Black Creek	Pd	GRZ	H	Permian Dalwood	346103.92	6368712.81	151.3562	-32.8088	1088.5	1277	2
WW71	Black Creek	Pd	H2O	H	Permian Dalwood	343641.95	6365385.36	151.3294	-32.8385	3000	3000	1
WW83	Black Creek	Pd	H2O	H	Permian Dalwood	343840.47	6368674.81	151.3320	-32.8088	2500	2500	1
WW91	Black Creek	Pd	H2O	H	Permian Dalwood	345289.64	6371058.69	151.3479	-32.7875	2160	3140	6
210101	Black Creek	Pd	H2O	H	Permian Dalwood	345308.25	6371084.82	151.3481	-32.7873			0
WW9	Black Creek	Pg	H2O	H	Permian Greta	344392.14	6365768.06	151.3374	-32.8351			0
MK3	Black Creek	Pg	MMI	H	Permian Greta	340529.97	6361193.83	151.2954	-32.8758			0
MK4	Black Creek	Pg	MMI	H	Permian Greta	341335.70	6361604.97	151.3041	-32.8722	428		1
MK6	Black Creek	Pg	MMI	H	Permian Greta	341900.37	6361643.97	151.3101	-32.8719	434		1
A_SW6	Black Creek	Pm	MMI	H	Permian Maitland	341169.00	6361542.00	151.3023	-32.8728	344	447	57
MK1	Black Creek	Pm	MMI	H	Permian Maitland	341162.67	6361540.08	151.3022	-32.8728	2140		1
MK2	Black Creek	Pm	MMI	H	Permian Maitland	341094.12	6361438.05	151.3015	-32.8737			0
MK5	Black Creek	Pm	MMI	H	Permian Maitland	341613.98	6361527.37	151.3070	-32.8730	429		1

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WW17	Black Creek	Pd	RES	H	Permian Dalwood	346205.20	6367017.58	151.3570	-32.8241			0
WW21	Black Creek	Pg	RES	H	Permian Greta	345653.06	6365556.14	151.3509	-32.8372	460	2600	3
MK10	Black Creek	Pg	RES	H	Permian Greta	342389.57	6362892.83	151.3156	-32.8608	541		1
WQ_210108	Black Creek	Pd	SRC	H	Permian Dalwood	344928.59	6371999.37	151.3442	-32.7790	1292.5	1615	2
WW16	Black Creek	Pm	SRC	H	Permian Maitland	346100.59	6364287.62	151.3554	-32.8487	295	470	6
WW10	Black Creek	Pd	TRU	H	Permian Dalwood	345878.53	6376602.53	151.3551	-32.7376	965	1500	12
A_SW2	Black Creek	Pg	TRU	H	Permian Greta	341926.00	6361601.00	151.3104	-32.8723	461.5	643	60
WW12	Black Creek	Psi	H2O	VH	Permian Singleton	335890.13	6376312.29	151.2485	-32.7388			0
WQ_210089	Black Creek	Pd	AGR	SAL	Permian Dalwood	343523.67	6378509.47	151.3303	-32.7201	2631	3367	21
WW19	Black Creek	Pd	GRZ	SAL	Permian Dalwood	346103.98	6369130.25	151.3563	-32.8050			0
WW40	Black Creek	Pd	GRZ	SAL	Permian Dalwood	344861.37	6373780.08	151.3438	-32.7629	1720	1910	7
WQ_21010168	Black Creek	Pd	GRZ	SAL	Permian Dalwood	346194.79	6368891.67	151.3572	-32.8072	944	1111.5	5
52024	Black Creek	Pd	GRZ	SAL	Permian Dalwood	343298.07	6378488.17	151.3279	-32.7203	957	957	1
WQ_21010247	Black Creek	Pm	GRZ	SAL	Permian Maitland	345859.45	6385676.89	151.3564	-32.6558	1585	1600	2
WW4	Black Creek	Q	GRZ	SAL	Quaternary	344798.61	6386553.49	151.3452	-32.6477	1455	2100	12
WW5	Black Creek	Pd	H2O	SAL	Permian Dalwood	348800.56	6382712.55	151.3873	-32.6829	795	2600	18
WW15	Black Creek	Pd	H2O	SAL	Permian Dalwood	345882.94	6370057.50	151.3541	-32.7966	720	800	13
WW11	Black Creek	Pd	H2O	SAL	Permian Dalwood	344909.13	6372117.40	151.3440	-32.7779	500	2425	5
WW18	Black Creek	Pd	H2O	SAL	Permian Dalwood	346291.63	6367155.89	151.3579	-32.8229	780	780	1
WW22	Black Creek	Pd	H2O	SAL	Permian Dalwood	342784.56	6379373.59	151.3226	-32.7122	1040	1890	11
WW14	Black Creek	Pd	H2O	SAL	Permian Dalwood	346300.56	6367177.65	151.3580	-32.8227	1470	1470	1
WW23	Black Creek	Pd	H2O	SAL	Permian Dalwood	345855.54	6372408.54	151.3542	-32.7754	910	1495	5
WW36	Black Creek	Pd	H2O	SAL	Permian Dalwood	347239.60	6374416.54	151.3693	-32.7575	1865	3200	34
WW77	Black Creek	Pd	H2O	SAL	Permian Dalwood	344887.20	6372129.59	151.3438	-32.7778			0
WQ_21010269	Black Creek	Pd	H2O	SAL	Permian Dalwood	345788.44	6370327.08	151.3531	-32.7942	1108	1264	2
WQ_21010270	Black Creek	Pd	H2O	SAL	Permian Dalwood	342546.34	6379248.16	151.3200	-32.7133	2326.5	2460	2
WQ_21010271	Black Creek	Pd	H2O	SAL	Permian Dalwood	344823.48	6372130.81	151.3431	-32.7778	277.5	299	2
210067	Black Creek	Pd	H2O	SAL	Permian Dalwood	344507.10	6371992.77	151.3397	-32.7790			0
210089	Black Creek	Pd	H2O	SAL	Permian Dalwood	343105.15	6378891.02	151.3259	-32.7166	1356.6	1736.4	4330
210108	Black Creek	Pd	H2O	SAL	Permian Dalwood	344004.46	6371785.24	151.3343	-32.7808			0
52039	Black Creek	Pd	H2O	SAL	Permian Dalwood	342787.46	6379356.23	151.3226	-32.7124	1040	1040	1
WW6	Black Creek	Pg	H2O	SAL	Permian Greta	348700.53	6382962.54	151.3862	-32.6807	835	960	24
WW95	Black Creek	Pm	H2O	SAL	Permian Maitland	341223.60	6378861.57	151.3058	-32.7166	6100	8900	13
WW96	Black Creek	Pm	H2O	SAL	Permian Maitland	340835.55	6378633.55	151.3016	-32.7186	6700	31080	13
WQ_21010329	Black Creek	Q	H2O	SAL	Quaternary	343305.82	6385792.29	151.3292	-32.6544	1504	1729	43
WQ_210131	Black Creek	Q	H2O	SAL	Quaternary	343917.05	6386899.81	151.3359	-32.6445	1531	1811	24
210131	Black Creek	Q	H2O	SAL	Quaternary	343907.49	6386910.75	151.3358	-32.6444			0
WW7	Black Creek	Pd	RES	SAL	Permian Dalwood	346335.58	6367075.61	151.3584	-32.8236	920	1490	9
CA83_166	Black Creek	Pm	CON	H	Permian Maitland	342894.09	6381838.36	151.3241	-32.6900	1900	1900	1
CA83_165	Black Creek	Pm	GRZ	H	Permian Maitland	343736.14	6383188.42	151.3334	-32.6779	8000	8000	1
HunterWater3	Black Creek	Pd	GRZ	H	Permian Dalwood	345991.90	6368688.89	151.3550	-32.8090	1034	1296	74
HunterWater2	Black Creek	Pm	GRZ	SAL	Permian Maitland	346492.50	6384777.30	151.3630	-32.6640	1118	1318	2
HunterWater1	Black Creek	Pm	H2O	H	Permian Maitland	346020.15	6384991.80	151.3580	-32.6620	1117.5	1321	2

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HU46	Bow River	Tb	AGR	M	Tertiary Basalt			150.2157	-32.1873	1987	2030	2
WQ_21010205	Bow River	Q	TRU	L	Quaternary	239283.69	6439034.57	150.2356	-32.1550	2060	2140	3
SWC_HU46	Bow River	Q	AGR	M	Quaternary	237585.15	6435599.82	150.2167	-32.1856			0
WQ_21010213	Bow River	Q	TRU	M	Quaternary	237275.06	6438583.24	150.2142	-32.1586	2135	2160	2
WQ_21010342	Bow River	Tns	CON	VL	Triassic Narrabeen Ss	237086.35	6425505.11	150.2086	-32.2764	1211.5	1513	12
WQ_21010206	Bow River	Tns	TRU	VL	Triassic Narrabeen Ss	229327.22	6430760.66	150.1278	-32.2272	230	460	2
WQ_21010354	Bunnan	Tns	GRZ	L	Triassic Narrabeen Ss	274280.63	6447206.75	150.6083	-32.0889	1172	1172	3
JJW37	Bunnan	Tns	H2O	L	Triassic Narrabeen Ss	274143.87	6447103.86	150.6068	-32.0898	901.5	1160	6
MK_OEH6	Bylong River	Psi	CON	VH	Permian Singleton	229950.98	6394612.50	150.1241	-32.5530	165	165	1
MK_OEH7	Bylong River	Psi	CON	VH	Permian Singleton	223901.00	6386812.53	150.0574	-32.6218	109	109	1
CJ_J34	Bylong River	Q	GRZ	L	Quaternary	230123.43	6407849.73	150.1297	-32.4338	1000	1000	1
CJ_J35	Bylong River	Q	GRZ	L	Quaternary	226006.39	6401650.12	150.0842	-32.4887	1900	1900	1
WQ_210062	Bylong River	Psi	AGR	VH	Permian Singleton	229996.39	6413531.12	150.1300	-32.3826	1647	1850	18
210062	Bylong River	Psi	GRZ	VH	Permian Singleton	230007.00	6413487.01	150.1301	-32.3830			0
WQ_21010209	Bylong River	Psi	TRU	VH	Permian Singleton	229163.61	6415428.84	150.1217	-32.3653	758.5	847	24
WQ_21010341	Bylong River	Psi	TRU	VH	Permian Singleton	228215.72	6415647.47	150.1117	-32.3631	2765	3420	16
WW_DB6	Congewai Creek	Pm	GRZ	VH	Permian Maitland	349317.03	6354260.06	151.3882	-32.9396	1060	1270	6
WW_DB78	Congewai Creek	Q	RES	L	Quaternary	336010.62	6359712.68	151.2468	-32.8885	1120	1120	1
WQ_210026	Congewai Creek	Pm	GRZ	H	Permian Maitland	338111.28	6351250.25	151.2678	-32.9651	450	485	29
WW92	Congewai Creek	Q	SRC	H	Quaternary	339525.58	6357437.63	151.2840	-32.9095			0
A_SW Q2	Congewai Creek	Q	CON	L	Quaternary	344856.00	6357243.00	151.3410	-32.9120	1570	2170	65
A_SW Q3	Congewai Creek	Q	CON	L	Quaternary	343320.00	6356699.00	151.3244	-32.9167	1435	1900	64
WQ_21010116	Congewai Creek	Pm	GRZ	L	Permian Maitland	338146.71	6351938.47	151.2683	-32.9589	505	505	1
210027	Congewai Creek	Pm	GRZ	L	Permian Maitland	343974.35	6348239.59	151.3300	-32.9931			0
WW25	Congewai Creek	Q	GRZ	L	Quaternary	338260.59	6351312.71	151.2694	-32.9646			0
WQ_21010117	Congewai Creek	Q	GRZ	L	Quaternary	341596.60	6347314.28	151.3044	-33.0011	326	326	1
WQ_21010115	Congewai Creek	Pm	H2O	L	Permian Maitland	338544.48	6356192.85	151.2733	-32.9206	549	549	1
WQ_21010191	Congewai Creek	Pm	H2O	L	Permian Maitland	344498.49	6348192.44	151.3356	-32.9936	247.5	298	2
A_SW Q1	Congewai Creek	Q	H2O	L	Quaternary	346228.00	6356157.00	151.3554	-32.9220	1665	1990	36
WW27	Congewai Creek	Q	H2O	L	Quaternary	338575.55	6354912.69	151.2734	-32.9321			0
WQ_21010120	Congewai Creek	Q	H2O	L	Quaternary	342452.45	6355734.84	151.3150	-32.9253	1143	1915	3
210026	Congewai Creek	Q	H2O	L	Quaternary	338307.02	6351286.74	151.2699	-32.9648			0
52222	Congewai Creek	Q	H2O	L	Quaternary	339967.33	6348482.37	151.2872	-32.9903	272	272	1
WQ_21010118	Congewai Creek	Tns	H2O	L	Triassic Narrabeen Ss	332596.63	6361062.49	151.2106	-32.8758	740	740	1
WQ_21010275	Congewai Creek	Tns	H2O	L	Triassic Narrabeen Ss	331865.50	6361127.70	151.2028	-32.8751	503	594	4
WQ_21010119	Congewai Creek	Q	SRC	L	Quaternary	339544.68	6357384.81	151.2842	-32.9100	430	1262.5	5
52193	Congewai Creek	Tns	CON	VH	Triassic Narrabeen Ss	348397.04	6349142.81	151.3775	-32.9856	211	211	1
WW26	Congewai Creek	Pm	GRZ	VH	Permian Maitland	344000.55	6348237.67	151.3303	-32.9931			0
HUNT574	Congewai Creek	Tns	GRZ	VH	Triassic Narrabeen Ss	344398.52	6348013.41	151.3345	-32.9952	247.5	298	2
A_SW C1	Congewai Creek	Q	H2O	SAL	Quaternary	347185.00	6357371.00	151.3659	-32.9112	1170	2020	46
WW93	Congewai Creek	Q	H2O	SAL	Quaternary	341500.58	6356662.61	151.3050	-32.9168			0
WQ_21010121	Congewai Creek	Q	H2O	SAL	Quaternary	347652.17	6356992.18	151.3708	-32.9147	873	873	1
WW148	Congewai Creek	Q	RES	SAL	Quaternary	336241.64	6359499.57	151.2493	-32.8904	610	770	12

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HunterWater5	Congewai Creek	Q	GRZ	L	Quaternary	338539.67	6357724.24	151.2735	-32.9068	478.5	599	74
HunterWater4	Congewai Creek	Q	GRZ	L	Quaternary	338302.83	6357808.16	151.2710	-32.9060	480.5	642	74
PR_12	Congewai Creek	Tns	H2O	L	Triassic Narrabeen Ss	331831.31	6361114.43	151.2024	-32.8752	481	963	3
PR_13	Congewai Creek	Q	H2O	SAL	Quaternary	336170.84	6359571.13	151.2485	-32.8898	472	826	3
JJCR	Cuan	Tb	GRZ	M	Tertiary Basalt	275728.92	6460174.22	150.6267	-31.9723	773	773	1
52384	Cuan	Q	GRZ	VL	Quaternary	280826.97	6449904.73	150.6782	-32.0659	620	620	1
WQ_21010310	Cuan	Tns	GRZ	VL	Triassic Narrabeen Ss	279496.94	6450993.14	150.6644	-32.0558	798	888	16
52239	Cuan and Reedy creeks	Q	GRZ	L	Quaternary	279325.87	6441639.67	150.6604	-32.1401	1230	1230	1
JJCW	Cuan and Reedy creeks	Q	GRZ	L	Quaternary	279191.62	6441285.39	150.6589	-32.1432	1306	1306	1
210087	Doyles Creek	Psi	GRZ	L	Permian Singleton	293301.85	6400687.85	150.7996	-32.5119			0
WQ_210087	Doyles Creek	Psi	H2O	L	Permian Singleton	293339.21	6400699.72	150.8000	-32.5118	940	2080	71
WQ_21010281	Doyles Creek	Psi	GRZ	VH	Permian Singleton	293263.37	6401641.09	150.7994	-32.5033			1
K_264	Doyles Creek	Psi	GRZ	L	Permian Singleton	292604.95	6399091.35	150.7918	-32.5262	1306	1306	1
JJGC	Giants Creek	Tns	GRZ	VL	Triassic Narrabeen Ss	267614.78	6425048.12	150.5323	-32.2873	2650	2650	1
WW_DB57	Glendon Brook	Cc	GRZ	M	Carboniferous Conglomerate	338254.63	6406039.52	151.2789	-32.4711	2800	3250	10
WW_DB61	Glendon Brook	Cc	GRZ	M	Carboniferous Conglomerate	353898.51	6406268.48	151.4453	-32.4712	960	1780	15
WW_DB14	Glendon Brook	Psi	GRZ	VH	Permian Singleton	340240.54	6395913.53	151.2983	-32.5627	1115	2000	12
WW_DB12	Glendon Brook	Cc	GRZ	SAL	Carboniferous Conglomerate	338753.62	6405339.46	151.2840	-32.4775	3300	4900	11
WW_DB17	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	344944.58	6401864.47	151.3493	-32.5097	800	2800	16
WW_DB56	Glendon Brook	Q	GRZ	SAL	Quaternary	341759.56	6399661.51	151.3151	-32.5291	530	660	15
WW_DB13	Glendon Brook	Q	H2O	SAL	Quaternary	341767.62	6399900.52	151.3152	-32.5270	1155	3200	10
WW_DB2	Glendon Brook	Cu	TRU	M	Carboniferous Undifferentiated	350746.50	6403556.51	151.4113	-32.4952	1850	2200	22
WW_DB8	Glendon Brook	Q	TRU	SAL	Quaternary	341831.58	6399414.46	151.3158	-32.5314	270	300	9
HU39	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	348299.99	6402300.67	151.3851	-32.5062	1190	1290	2
HU38	Glendon Brook	Q	GRZ	M	Quaternary	347499.99	6401300.69	151.3764	-32.5151	2519.5	3090	2
OC_EPL3	Glendon Brook	Pm	CON	H	Permian Maitland	350348.15	6400072.22	151.4065	-32.5266	873.5	4680	30
OC_EPL1	Glendon Brook	Pg	DEG	H	Permian Greta	350070.20	6400706.62	151.4037	-32.5209	3910	4065	65
OC_BDO	Glendon Brook	Pg	DEG	H	Permian Greta	349960.33	6400586.00	151.4025	-32.5219			0
OC_DB2	Glendon Brook	Pg	DEG	H	Permian Greta	350171.28	6400444.87	151.4047	-32.5232			0
OC_EPL2	Glendon Brook	Pg	DEG	H	Permian Greta	350264.27	6400348.51	151.4057	-32.5241	3390	3430	8
WW41	Glendon Brook	Cc	GRZ	H	Carboniferous Conglomerate	344382.85	6398003.92	151.3427	-32.5444			0
WW69	Glendon Brook	Cc	GRZ	H	Carboniferous Conglomerate	340219.61	6411363.47	151.3007	-32.4234	1210	1470	33
WQ_21010283	Glendon Brook	Cu	GRZ	H	Carboniferous Undifferentiated	348699.62	6402565.67	151.3894	-32.5039	1383	1383	1
WQ_210035	Glendon Brook	Psi	GRZ	L	Permian Singleton	339854.13	6396262.01	151.2942	-32.5595	1077	1425	56
210035	Glendon Brook	Psi	GRZ	L	Permian Singleton	339854.13	6396262.01	151.2942	-32.5595			0
210132	Glendon Brook	Psi	GRZ	L	Permian Singleton	339775.10	6396504.73	151.2934	-32.5573			0
WW136	Glendon Brook	Cc	GRZ	M	Carboniferous Conglomerate	339011.59	6404969.42	151.2867	-32.4809	1395	1840	12
WW42	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	345864.85	6416361.45	151.3615	-32.3791			0
WW68	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	338967.57	6407529.41	151.2867	-32.4578	1220	1620	21
WW75	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	338645.58	6410767.40	151.2838	-32.4285	1380	1990	33
WQ_21010328	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	347649.28	6401806.74	151.3781	-32.5106	1352	1571	24
210080	Glendon Brook	Cu	GRZ	M	Carboniferous Undifferentiated	338706.79	6405996.26	151.2837	-32.4716			0
WW120	Glendon Brook	Q	GRZ	M	Quaternary	348524.54	6401951.43	151.3874	-32.5094	785	1480	16

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WQ_210071	Glendon Brook	Q	GRZ	M	Quaternary	344031.65	6401196.54	151.3395	-32.5156	1005.5	1262	48
210071	Glendon Brook	Q	GRZ	M	Quaternary	343900.14	6401194.49	151.3381	-32.5156			0
WW135	Glendon Brook	Cc	H2O	M	Carboniferous Conglomerate	338108.63	6403351.47	151.2768	-32.4953	1265	1590	10
WQ_210099	Glendon Brook	Cc	H2O	M	Carboniferous Conglomerate	341767.07	6400606.50	151.3153	-32.5206	2135	2135	1
WW44	Glendon Brook	Cu	H2O	M	Carboniferous Undifferentiated	346359.44	6415395.36	151.3666	-32.3879			0
WW76	Glendon Brook	Cu	H2O	M	Carboniferous Undifferentiated	338668.54	6408244.46	151.2836	-32.4513	940	1300	23
WW132	Glendon Brook	Cu	H2O	M	Carboniferous Undifferentiated	338647.59	6408342.49	151.2834	-32.4504	1095	1470	22
WW137	Glendon Brook	Cu	H2O	M	Carboniferous Undifferentiated	338668.54	6408244.46	151.2836	-32.4513	1050	1500	23
WW129	Glendon Brook	Psi	GRZ	VH	Permian Singleton	338720.58	6397672.53	151.2824	-32.5466	1420	2400	12
WQ_21010252	Glendon Brook	Cc	GRZ	SAL	Carboniferous Conglomerate	348353.84	6403059.47	151.3858	-32.4994	1135	1383	2
OC_EPL4	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	350133.71	6400893.20	151.4044	-32.5192	3920	4520	35
WW61	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	353012.51	6405813.52	151.4358	-32.4752	3450	4200	12
WW115	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	353093.58	6405753.49	151.4367	-32.4757	970	1740	9
WW116	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	349575.57	6403076.45	151.3988	-32.4994	1280	2600	13
WW117	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	349491.51	6403041.47	151.3979	-32.4997	1290	2200	13
WW118	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	351851.49	6404600.44	151.4233	-32.4860	1370	1520	28
WW121	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	352923.53	6405670.49	151.4348	-32.4765	2900	3600	11
WW123	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	352152.54	6404702.48	151.4265	-32.4851	1050	1510	9
WW124	Glendon Brook	Cu	GRZ	SAL	Carboniferous Undifferentiated	353078.50	6405730.43	151.4365	-32.4759	1460	3200	9
WW140	Glendon Brook	Psi	GRZ	SAL	Permian Singleton	337978.60	6401286.48	151.2751	-32.5139	1890	1890	1
OC_EPL5	Glendon Brook	Q	GRZ	SAL	Quaternary	348715.19	6402081.27	151.3895	-32.5083	3545	3980	32
WW39	Glendon Brook	Q	GRZ	SAL	Quaternary	348773.55	6402032.49	151.3901	-32.5087	4000	4200	5
WW119	Glendon Brook	Q	GRZ	SAL	Quaternary	347438.56	6401180.52	151.3758	-32.5162	1040	1780	7
WW134	Glendon Brook	Q	GRZ	SAL	Quaternary	338530.61	6403422.49	151.2813	-32.4947	1280	1630	12
WW130	Glendon Brook	Q	GRZ	SAL	Quaternary	338491.61	6404763.43	151.2812	-32.4826	1180	1500	17
WQ_21010289	Glendon Brook	Q	GRZ	SAL	Quaternary	341801.56	6400207.80	151.3156	-32.5242	1360.5	1821	2
WW133	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	337794.55	6404133.45	151.2736	-32.4882	1340	1730	10
WW139	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	338732.62	6405271.47	151.2838	-32.4781	815	1340	12
WQ_210080	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	338654.69	6406002.05	151.2831	-32.4715	1520	1893	48
WQ_21010254	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	338876.07	6405096.22	151.2853	-32.4797	1190	1190	1
WQ_21010255	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	342783.98	6402263.83	151.3264	-32.5058	1413	1606	2
WQ_21010256	Glendon Brook	Cc	H2O	SAL	Carboniferous Conglomerate	347031.49	6407807.87	151.3725	-32.4564	848	956	2
OC_EPL6	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	347606.58	6401488.23	151.3776	-32.5135	1310	1690	34
WW37	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	352681.54	6403716.45	151.4320	-32.4941	380	530	6
WW38	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	352173.54	6404489.43	151.4267	-32.4870	730	960	24
WW94	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	343366.58	6403293.45	151.3328	-32.4966	1120	2300	24
WW101	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	351769.52	6403807.45	151.4223	-32.4931	900	950	23
WW107	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	343320.60	6404346.48	151.3325	-32.4871	1330	1460	14
WQ_21010250	Glendon Brook	Cu	H2O	SAL	Carboniferous Undifferentiated	344017.82	6400275.87	151.3392	-32.5239	760	1160	2
WW138	Glendon Brook	Psi	H2O	SAL	Permian Singleton	337777.61	6401071.51	151.2729	-32.5158	1880	1880	1
WQ_21010253	Glendon Brook	Psi	H2O	SAL	Permian Singleton	337803.82	6401652.07	151.2733	-32.5106	2572.5	3915	2
OC_WU	Glendon Brook	Q	H2O	SAL	Quaternary	348522.68	6402226.92	151.3875	-32.5069			0
WW43	Glendon Brook	Q	H2O	SAL	Quaternary	341636.61	6399683.52	151.3138	-32.5289	930	1310	15

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WW122	Glendon Brook	Q	H2O	SAL	Quaternary	348596.56	6402091.47	151.3882	-32.5082	835	1230	12
WW131	Glendon Brook	Q	H2O	SAL	Quaternary	338896.58	6406095.43	151.2857	-32.4707	1370	1515	10
WQ_21010251	Glendon Brook	Q	H2O	SAL	Quaternary	345231.20	6400793.75	151.3522	-32.5194	1352.5	1745	2
CA83_82	Glendon Brook	Pg	CON	H	Permian Greta	350249.83	6397844.24	151.4051	-32.5467			0
CA83_81	Glendon Brook	Pm	CON	H	Permian Maitland	350695.22	6398143.48	151.4099	-32.5440			0
CA83_76	Glendon Brook	Pm	CON	H	Permian Maitland	350528.20	6399027.28	151.4083	-32.5361	6500	6500	1
CA83_79	Glendon Brook	Pm	CON	H	Permian Maitland	350305.51	6398505.35	151.4058	-32.5407			0
CA83_80	Glendon Brook	Pm	GRZ	H	Permian Maitland	350966.62	6398414.88	151.4129	-32.5416			0
CA83_77	Glendon Brook	Pm	GRZ	H	Permian Maitland	351112.76	6399027.28	151.4145	-32.5361			0
CA83_164	Glendon Brook	Psi	GRZ	L	Permian Singleton	339783.38	6397440.61	151.2936	-32.5489	690	690	1
CA83_163	Glendon Brook	Psi	GRZ	VH	Permian Singleton	337382.50	6397426.69	151.2681	-32.5486	2000	2000	1
Webbers_US	Glendon Brook	Q	H2O	SAL	Quaternary	348595.49	6401994.09	151.3882	-32.5090	605	688	17
WW_DB23	Glennies	Cv	CON	H	Carboniferous Volcanics	335200.59	6417912.42	151.2484	-32.3636			0
WW_DB18	Glennies	Cu	CON	M	Carboniferous Undifferentiated	339200.59	6417912.42	151.2909	-32.3642			0
WW_DB20	Glennies	Psi	CON	VH	Permian Singleton	325900.60	6407937.43	151.1478	-32.4521			0
WW_DB21	Glennies	Q	GRZ	L	Quaternary	330000.62	6412462.44	151.1922	-32.4120	200	200	1
WW_DB22	Glennies	Q	GRZ	L	Quaternary	323086.62	6406774.31	151.1177	-32.4622			0
CAM003	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	328611.98	6420384.09	151.1789	-32.3403	841	941	12
TUR001	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	331014.98	6420926.03	151.2045	-32.3358	1440	1627	12
GOO001	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	331703.99	6427500.01	151.2130	-32.2766	546	666	12
CAM001	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328733.98	6425026.08	151.1810	-32.2985	689	867	12
STC001	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	330958.99	6422348.03	151.2042	-32.3230	1046	1198	12
GRE001	Glennies	Q	GRZ	M	Quaternary	329444.99	6417470.07	151.1872	-32.3667	1126	1312	12
WW_DB9	Glennies	Psi	GRZ	VH	Permian Singleton	329093.35	6407716.83	151.1817	-32.4546	520	540	3
NAT001	Glennies	Cu	GRZ	SAL	Carboniferous Undifferentiated	328701.98	6424955.08	151.1807	-32.2991	1071	1180	12
DAW001	Glennies	Q	GRZ	SAL	Quaternary	328486.98	6414965.09	151.1766	-32.3892	1379	1682	12
GOO006	Glennies	Cu	H2O	L	Carboniferous Undifferentiated	328999.98	6412651.08	151.1816	-32.4101	757	795	12
GLE001	Glennies	Cu	H2O	L	Carboniferous Undifferentiated	330088.98	6412615.05	151.1932	-32.4106	477	557	11
GLE002	Glennies	Q	H2O	L	Quaternary	329540.98	6411097.07	151.1871	-32.4242	509	666	11
GOO003	Glennies	Cc	H2O	M	Carboniferous Conglomerate	329384.98	6420140.07	151.1871	-32.3426	809	923	12
TDR001	Glennies	Cc	H2O	M	Carboniferous Conglomerate	330862.98	6420825.03	151.2029	-32.3367	809	1030	12
GOO002	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	330783.98	6422181.03	151.2023	-32.3244	747	840	12
WW_DB24	Glennies	Q	H2O	M	Quaternary	329036.61	6412817.43	151.1820	-32.4086	775	850	8
GOO005	Glennies	Q	H2O	M	Quaternary	328584.98	6414945.09	151.1776	-32.3894	808	918	12
WW_DB19	Glennies	Q	TRU	M	Quaternary	332375.65	6414762.47	151.2179	-32.3916			0
SC1_INTG	Glennies	Psi	CON	L	Permian Singleton	323632.85	6405854.26	151.1233	-32.4706			0
SC2_INTG	Glennies	Q	CON	L	Quaternary	322882.81	6405334.30	151.1152	-32.4751			0
GC1_INTG	Glennies	Psi	GRZ	L	Permian Singleton	326048.80	6408151.36	151.1494	-32.4502			0
GCMid_AC	Glennies	Q	GRZ	L	Quaternary	319347.62	6404562.36	151.0775	-32.4815			0
HU08	Glennies	Q	GRZ	L	Quaternary	329999.98	6412401.06	151.1922	-32.4125	255	260	2
GC4_INTG	Glennies	Psi	H2O	L	Permian Singleton	322047.39	6404632.71	151.1062	-32.4813			0
GCOCD_AC	Glennies	Q	H2O	L	Quaternary	319530.80	6403508.37	151.0792	-32.4910			0
GC2_INTG	Glennies	Q	H2O	L	Quaternary	323179.29	6407115.88	151.1187	-32.4591			0

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GC3_INTG	Glennies	Q	H2O	L	Quaternary	323022.53	6406146.25	151.1169	-32.4678			0
GCUP_AC	Glennies	Q	RES	L	Quaternary	320152.84	6405475.80	151.0862	-32.4734			0
HU06	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	340199.99	6426700.82	151.3030	-32.2851	188	188	1
MC2_INTG	Glennies	Psi	CON	VH	Permian Singleton	323336.19	6409225.61	151.1208	-32.4401			0
W8_INTG	Glennies	Psi	CON	VH	Permian Singleton	322471.93	6404425.78	151.1107	-32.4832			0
GCOCU_AC	Glennies	Q	GRZ	VH	Quaternary	319747.16	6404774.39	151.0818	-32.4797			0
D8_AC	Glennies	Q	GRZ	VH	Quaternary	319637.17	6404293.41	151.0805	-32.4840			0
GC5_INTG	Glennies	Psi	H2O	VH	Permian Singleton	321761.76	6404579.20	151.1032	-32.4817			0
W11_INTG	Glennies	Psi	H2O	VH	Permian Singleton	320091.00	6405693.59	151.0856	-32.4714			0
T3DAM_AC	Glennies	Psi	RES	VH	Permian Singleton	320232.84	6404402.69	151.0869	-32.4831			0
DI_AC	Glennies	Q	RES	VH	Quaternary	319818.14	6404692.05	151.0825	-32.4804			0
SC3_INTG	Glennies	Psi	CON	SAL	Permian Singleton	322267.55	6404563.86	151.1085	-32.4820			0
MC1N_INTG	Glennies	Psi	CON	SAL	Permian Singleton	323740.45	6409920.45	151.1252	-32.4339			0
MC3_INTG	Glennies	Q	CON	SAL	Quaternary	322477.82	6407269.34	151.1113	-32.4576			0
4P9_AC	Glennies	Psi	GRZ	SAL	Permian Singleton	320086.25	6403882.17	151.0852	-32.4878			0
4p8_AC	Glennies	Psi	GRZ	SAL	Permian Singleton	320207.45	6403874.90	151.0865	-32.4878			0
MC1S_INTG	Glennies	Psi	H2O	SAL	Permian Singleton	323841.48	6409850.83	151.1263	-32.4346			0
WQ_21010040	Glennies	Cv	CON	H	Carboniferous Volcanics	335340.88	6418335.89	151.2500	-32.3598	251	284	17
WQ_21010041	Glennies	Cv	CON	H	Carboniferous Volcanics	335164.62	6418177.75	151.2481	-32.3612	217	240	459
WQ_210084	Glennies	Cc	GRZ	H	Carboniferous Conglomerate	334435.19	6417888.53	151.2403	-32.3637	300	463	283
WQ_21010184	Glennies	Cc	GRZ	H	Carboniferous Conglomerate	334508.83	6417989.55	151.2411	-32.3628	249	252	11
210084	Glennies	Cc	GRZ	H	Carboniferous Conglomerate	334406.96	6417888.06	151.2400	-32.3637	264.5	292.5	5567
WQ_21010203	Glennies	Cc	H2O	H	Carboniferous Conglomerate	334342.08	6417254.86	151.2392	-32.3694	232	232	1
210023	Glennies	Cc	H2O	H	Carboniferous Conglomerate	334401.27	6417089.48	151.2398	-32.3709			0
WQ_21010046	Glennies	Cu	H2O	H	Carboniferous Undifferentiated	335778.10	6423854.76	151.2556	-32.3101	216	224	157
WQ_21010018	Glennies	Cv	H2O	H	Carboniferous Volcanics	335429.20	6418115.54	151.2509	-32.3618	232.5	238	6
210117	Glennies	Cv	H2O	H	Carboniferous Volcanics	335306.50	6418135.71	151.2496	-32.3616			0
WQ_210044	Glennies	Psi	GRZ	L	Permian Singleton	326056.71	6408164.84	151.1495	-32.4501	470	690	77
210044	Glennies	Psi	GRZ	L	Permian Singleton	326057.10	6408142.66	151.1495	-32.4503	360.1	542.1	7051
WQ_210122	Glennies	Q	H2O	L	Quaternary	318820.16	6402180.52	151.0714	-32.5029			0
210122	Glennies	Q	H2O	L	Quaternary	318820.16	6402180.52	151.0714	-32.5029			0
WQ_210098	Glennies	Q	TRU	L	Quaternary	320174.82	6405255.05	151.0864	-32.4754	425.5	600	2
210098	Glennies	Q	TRU	L	Quaternary	320202.42	6405288.82	151.0867	-32.4751			0
52036	Glennies	Q	TRU	L	Quaternary	320168.25	6405307.07	151.0863	-32.4749	602	602	1
WQ_21010185	Glennies	Cc	AGR	M	Carboniferous Conglomerate	328930.14	6417253.05	151.1817	-32.3686			0
WQ_21010049	Glennies	Cu	CON	M	Carboniferous Undifferentiated	335859.05	6424088.97	151.2565	-32.3080			0
WQ_21010175	Glennies	Cu	CON	M	Carboniferous Undifferentiated	337444.07	6419246.17	151.2725	-32.3519			0
WQ_21010176	Glennies	Cu	CON	M	Carboniferous Undifferentiated	337027.37	6422311.35	151.2686	-32.3242			0
WQ_21010178	Glennies	Cu	CON	M	Carboniferous Undifferentiated	338358.12	6422709.82	151.2828	-32.3208			0
WQ_21010179	Glennies	Cu	CON	M	Carboniferous Undifferentiated	338943.73	6422009.44	151.2889	-32.3272			0
WQ_21010180	Glennies	Cu	CON	M	Carboniferous Undifferentiated	339353.11	6419365.52	151.2928	-32.3511			0
WQ_21010181	Glennies	Cu	CON	M	Carboniferous Undifferentiated	339166.57	6421026.01	151.2911	-32.3361			0
WQ_210123	Glennies	Cu	CON	M	Carboniferous Undifferentiated	336650.50	6426397.41	151.2653	-32.2873	230	240	4

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WW46	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	331629.57	6424246.40	151.2116	-32.3060	710	760	3
WQ_21010259	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	329434.14	6418060.12	151.1872	-32.3614	972	1044	2
WQ_21010260	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	331637.28	6424230.11	151.2117	-32.3061	864.5	1049	2
WQ_210114	Glennies	Cm	GRZ	M	Carboniferous Mudstone	341052.08	6429240.05	151.3125	-32.2623	243	430	26
WW47	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328201.43	6416878.20	151.1739	-32.3719	890	890	1
WQ_21010187	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	332205.49	6415001.40	151.2161	-32.3894	232.5	270	2
WQ_21010261	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328827.16	6424426.82	151.1819	-32.3039	1086	1472	2
210123	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	336801.00	6426410.94	151.2669	-32.2872			0
52359	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328932.28	6425338.01	151.1832	-32.2957	708	708	1
WW50	Glennies	Cc	H2O	M	Carboniferous Conglomerate	329392.31	6420062.79	151.1871	-32.3433			0
WQ_21010186	Glennies	Cc	H2O	M	Carboniferous Conglomerate	329453.62	6420245.26	151.1878	-32.3417			0
WQ_21010183	Glennies	Cm	H2O	M	Carboniferous Mudstone	340468.03	6426247.75	151.3058	-32.2892			0
210114	Glennies	Cm	H2O	M	Carboniferous Mudstone	341023.30	6429272.87	151.3122	-32.2620	175.6	206.95	4550
WW48	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	330868.58	6422553.38	151.2032	-32.3211			0
WQ_21010042	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	338429.95	6418230.68	151.2828	-32.3612	214	227	187
WQ_21010043	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	336918.62	6421466.75	151.2673	-32.3318	215	241	197
WQ_21010044	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	338480.15	6421558.44	151.2839	-32.3312	214	227	178
WQ_21010045	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	339566.18	6424314.94	151.2959	-32.3065	215	224	157
WQ_21010050	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	338656.68	6419942.15	151.2855	-32.3458			0
WQ_21010051	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	332451.19	6414938.96	151.2187	-32.3900	985	985	1
WQ_21010177	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	338133.16	6420299.72	151.2800	-32.3425			0
WQ_21010182	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	340107.59	6425809.55	151.3019	-32.2931			0
WQ_210109	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	339098.88	6420548.07	151.2903	-32.3404	292.5	500	188
210109	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	339107.59	6420592.57	151.2904	-32.3400			0
WW45	Glennies	Q	H2O	M	Quaternary	328444.35	6415929.12	151.1763	-32.3805			0
WW49	Glennies	Q	H2O	M	Quaternary	328472.60	6416248.45	151.1767	-32.3776	850	1140	9
WQ_21010257	Glennies	Q	H2O	M	Quaternary	328842.08	6413026.06	151.1800	-32.4067	602.5	932	2
WQ_21010201	Glennies	Psi	H2O	VH	Permian Singleton	320092.27	6405663.95	151.0856	-32.4717	342	388	4
WQ_21010258	Glennies	Cu	GRZ	SAL	Carboniferous Undifferentiated	328267.01	6414746.39	151.1742	-32.3911	1862.5	1890	2
CA83_126	Glennies	Psi	CON	VH	Permian Singleton	322598.94	6406503.49	151.1124	-32.4645	641	641	3
K_151	Glennies	Cu	H2O	H	Carboniferous Undifferentiated	330104.98	6412690.05	151.1934	-32.4099	582	582	1
K_178	Glennies	Psi	CON	L	Permian Singleton	324004.98	6405890.22	151.1273	-32.4703	10390	10390	1
K_150	Glennies	Q	GRZ	L	Quaternary	330304.98	6412190.05	151.1954	-32.4145	2170	2170	1
K_145	Glennies	Q	H2O	L	Quaternary	323204.98	6407090.24	151.1190	-32.4593	1031	1031	1
K_144	Glennies	Q	TRU	L	Quaternary	320204.98	6405290.32	151.0867	-32.4751	1173	1173	1
K_155	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	328904.98	6417290.08	151.1814	-32.3683	1345	1345	1
K_158	Glennies	Cc	GRZ	M	Carboniferous Conglomerate	329104.98	6420190.07	151.1841	-32.3421	1512	1512	1
K_153	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328204.98	6414790.10	151.1735	-32.3907	2750	2750	1
K_159	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	330904.98	6422590.03	151.2036	-32.3208	1073	1073	1
K_160	Glennies	Cu	GRZ	M	Carboniferous Undifferentiated	328704.98	6424990.08	151.1807	-32.2988	1571	1571	1
K_152	Glennies	Q	GRZ	M	Quaternary	328904.98	6413090.08	151.1807	-32.4061	1115	1115	1
K_156	Glennies	Cc	H2O	M	Carboniferous Conglomerate	329404.99	6419190.07	151.1871	-32.3512	1342	1342	1
K_157	Glennies	Cc	H2O	M	Carboniferous Conglomerate	329404.98	6419990.07	151.1872	-32.3440	1258	1258	1

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K_154	Glennies	Cu	H2O	M	Carboniferous Undifferentiated	328304.99	6415190.10	151.1747	-32.3871	1344	1344	1
K_164	Glennies	Cc	GRZ	SAL	Carboniferous Conglomerate	327104.98	6414490.13	151.1618	-32.3932	2640	2640	1
K_161	Glennies	Cu	GRZ	SAL	Carboniferous Undifferentiated	327904.98	6426190.10	151.1724	-32.2879	2070	2070	1
K_148	Glennies	Cu	TRU	SAL	Carboniferous Undifferentiated	329704.98	6409290.06	151.1885	-32.4405	3320	3320	1
210094	Gundy	Cu	AGR	L	Carboniferous Undifferentiated	306554.03	6452363.66	150.9511	-32.0484			0
WQ_210052	Gundy	Cc	GRZ	M	Carboniferous Conglomerate	310724.65	6456689.87	150.9961	-32.0101	640	715	93
210030	Gundy	Cc	GRZ	M	Carboniferous Conglomerate	310609.27	6455778.26	150.9947	-32.0183			0
210057	Gundy	Cc	GRZ	M	Carboniferous Conglomerate	307904.68	6457391.39	150.9664	-32.0033			0
WQ_210065	Halls Creek	Tns	GRZ	L	Triassic Narrabeen Ss	265163.89	6426529.95	150.5067	-32.2734	1975	3010	74
HUNT577	Halls Creek	Tns	H2O	L	Triassic Narrabeen Ss	265404.43	6425914.20	150.5091	-32.2790	1528.5	1625	2
WQ_21010285	Halls Creek	Tb	GRZ	M	Tertiary Basalt	264650.17	6448686.02	150.5067	-32.0736			1
WQ_21010286	Halls Creek	Q	H2O	M	Quaternary	264118.03	6447597.49	150.5008	-32.0833	1014	1050	4
52347	Halls Creek	Tb	H2O	M	Tertiary Basalt	262431.83	6464127.51	150.4870	-31.9340	885	885	1
52405	Halls Creek	Tns	GRZ	SAL	Triassic Narrabeen Ss	265040.79	6440414.89	150.5088	-32.1482	1510	1510	1
WQ_21010210	Halls Creek	Q	H2O	SAL	Quaternary	270395.41	6419904.55	150.5606	-32.3342	3072	3340	21
210065	Halls Creek	Tns	H2O	SAL	Triassic Narrabeen Ss	264900.87	6426490.54	150.5039	-32.2737			0
WQ_21010193	Hollydeen	Q	AGR	L	Quaternary	276391.65	6420505.36	150.6244	-32.3300	3245	4060	32
WQ_21010359	Hollydeen	Q	AGR	L	Quaternary	278608.33	6425946.06	150.6492	-32.2814	1184	1184	1
MG_SW09	Hollydeen	Q	GRZ	L	Quaternary	278417.00	6424040.00	150.6467	-32.2985	2550	4780	139
HUNT579	Hollydeen	Q	GRZ	L	Quaternary	276301.68	6420314.76	150.6234	-32.3317	1246	1269	2
MG_W5	Hollydeen	Q	H2O	L	Quaternary	277610.00	6427220.00	150.6389	-32.2697	1385	2090.5	10
MG_SW06	Hollydeen	Q	H2O	L	Quaternary	278600.00	6425719.00	150.6491	-32.2834	2190	3200	139
MG_SW10	Hollydeen	Q	H2O	L	Quaternary	276143.00	6422007.00	150.6221	-32.3164	863	952	45
JJW77	Hollydeen	Q	H2O	L	Quaternary	278610.19	6425658.27	150.6492	-32.2840	1091.5	1184	2
JJW83	Hollydeen	Tns	GRZ	VH	Triassic Narrabeen Ss	278630.78	6420200.70	150.6481	-32.3332	2448.5	4040	6
JJW87	Hollydeen	Tns	SRC	VL	Triassic Narrabeen Ss	276906.07	6418343.19	150.6294	-32.3496	2180	5010	5
WQ_21010356	Hollydeen	Q	TRU	VL	Quaternary	276219.34	6417661.36	150.6219	-32.3556	2180	2180	3
MG_W3	Hollydeen	Psi	GRZ	SAL	Permian Singleton	283053.00	6428147.00	150.6969	-32.2624	9065	13770	10
MG_SW03	Hollydeen	Psi	GRZ	SAL	Permian Singleton	283089.00	6428124.00	150.6972	-32.2626	14562.5	25240	116
MG_PWD	Hollydeen	Psi	GRZ	SAL	Permian Singleton	283116.00	6423777.00	150.6965	-32.3018	2300	2480	14
JJBF	Hollydeen	Psi	GRZ	SAL	Permian Singleton	283099.05	6428126.98	150.6973	-32.2626	11850	11850	1
MG_W7	Hollydeen	Q	GRZ	SAL	Quaternary	279338.00	6426046.00	150.6570	-32.2806	8625	10007	8
WQ_21010204	Hollydeen	Q	GRZ	SAL	Quaternary	279386.80	6426118.41	150.6575	-32.2800	7880	30300	4
MG_W14	Hollydeen	Tns	GRZ	SAL	Triassic Narrabeen Ss	281175.00	6426922.00	150.6767	-32.2731	11100	15860	7
MG_SW07	Hollydeen	Tns	GRZ	SAL	Triassic Narrabeen Ss	279599.00	6426161.00	150.6598	-32.2797	8545	15040	118
MG_SW08	Hollydeen	Tns	GRZ	SAL	Triassic Narrabeen Ss	280290.00	6426061.00	150.6671	-32.2807	220	381	29
CJ_J19	Hollydeen	Q	H2O	SAL	Quaternary	276347.31	6420357.38	150.6239	-32.3313	2200	2200	1
MG_W9	Hollydeen	Q	H2O	SAL	Quaternary	278421.00	6423863.00	150.6467	-32.3001	1640	2305	10
MG_W11	Hollydeen	Q	H2O	SAL	Quaternary	277261.00	6421867.00	150.6339	-32.3179	1590	1900	7
MG_SW11	Hollydeen	Q	H2O	SAL	Quaternary	276379.00	6420271.00	150.6242	-32.3321	2290	3200	139
K_231	Hollydeen	Q	GRZ	L	Quaternary	278304.93	6423592.03	150.6454	-32.3026	2740	2740	1
K_229	Hollydeen	Q	H2O	L	Quaternary	276404.93	6420292.14	150.6245	-32.3319	2350	2350	1
K_230	Hollydeen	Q	H2O	L	Quaternary	276104.93	6422092.16	150.6217	-32.3156	929	929	1

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K_233	Hollydeen	Tns	GRZ	VL	Triassic Narrabeen Ss	283204.94	6429391.77	150.6988	-32.2512	15710	15710	1
K_323	Hollydeen	Tns	GRZ	VL	Triassic Narrabeen Ss	283204.94	6429271.77	150.6987	-32.2523	14210	14210	1
K_324	Hollydeen	Tns	GRZ	VL	Triassic Narrabeen Ss	283304.94	6430971.76	150.7002	-32.2370	451	451	1
K_332	Hollydeen	Tns	GRZ	VL	Triassic Narrabeen Ss	283204.94	6429391.77	150.6988	-32.2512	15060	15060	1
K_232	Hollydeen	Q	GRZ	SAL	Quaternary	279404.93	6426091.97	150.6577	-32.2802	16390	16390	1
K_336	Hollydeen	Q	GRZ	SAL	Quaternary	279404.93	6426091.97	150.6577	-32.2802	12160	12160	1
WW_DB31	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary	300000.77	6439512.35	150.8791	-32.1631			0
WW_DB35	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary	297850.75	6407112.50	150.8494	-32.4548	760	760	1
RT_SW Hobden Gully	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	313800.89	6402381.44	151.0180	-32.5003			0
RT_Dam 5S	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	311125.06	6400412.62	150.9892	-32.5176	372	503	24
RT_SWHG	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	313800.89	6402381.44	151.0180	-32.5003			0
RT_W4M	Hunter Regulated River Alluvial	Q	CON	SAL	Quaternary	321488.00	6390934.00	151.0976	-32.6047	6970	13880	35
RT_W3H	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	312791.00	6402614.00	151.0073	-32.4980	835	1150	39
WW_DB37	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300600.69	6439112.31	150.8853	-32.1668	460	590	2
RT_BAR	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	309821.58	6400581.60	150.9753	-32.5158	285	606	3
RT_W1H	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	309084.00	6402481.00	150.9679	-32.4986	690	917	132
RT_W14	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	323647.00	6390272.00	151.1205	-32.6110	4300	8065	80
WW_DB15	Hunter Regulated River Alluvial	Q	GRZ	VH	Quaternary	341094.61	6393080.54	151.3069	-32.5884	1700	1730	6
WW_DB42	Hunter Regulated River Alluvial	Pd	GRZ	SAL	Permian Dalwood	355548.02	6381201.76	151.4590	-32.6975	1000	1650	14
WW_DB36	Hunter Regulated River Alluvial	Q	H2O	H	Quaternary	352075.54	6386737.54	151.4228	-32.6471	710	800	27
WW_DB38	Hunter Regulated River Alluvial	Q	H2O	H	Quaternary	357291.30	6385681.98	151.4783	-32.6573	825	960	18
WW_DB28	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	361725.40	6382117.42	151.5250	-32.6900	845	860	6
RT_H1	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	318344.00	6400754.00	151.0661	-32.5157	640	779	126
RT_H2	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	316709.00	6398332.00	151.0482	-32.5373	640	800	144
RT_H3	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	318210.00	6396710.00	151.0639	-32.5521	629	783	130
RT_WL1	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	317735.00	6396942.00	151.0588	-32.5500	590	870	69
RT_W109	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306257.00	6400452.00	150.9374	-32.5164	670	880	151

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RT_W1M	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	321972.00	6392554.00	151.1031	-32.5902	640	820	86
RT_W3M	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324650.00	6390530.00	151.1313	-32.6089	715	980	160
RW_HR	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	318369.00	6403240.00	151.0668	-32.4933	560	777	9
RT_Final Dam (20N)	Hunter Regulated River Alluvial	Psi	MMI	VH	Permian Singleton	312500.00	6402300.00	151.0042	-32.5008	1290	3740	41
WW_DB30	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	300688.75	6429112.43	150.8842	-32.2570	380	520	12
WW_DB32	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	327025.64	6395412.54	151.1575	-32.5652	560	670	27
WW_DB39H	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	327025.64	6395412.54	151.1575	-32.5652			0
WW_DB39HB	Hunter Regulated River Alluvial	Q	SRC	L	Quaternary	301186.87	6429573.36	150.8896	-32.2529			0
BG_SW02	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	293471.42	6424314.11	150.8066	-32.2990			0
W4_H_CA	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	314073.13	6403815.12	151.0212	-32.4874			0
W3_H_CA	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	312726.48	6402514.87	151.0066	-32.4989			0
SM13_AC	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	318116.67	6402801.18	151.0640	-32.4972			0
HU19	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	306199.96	6400301.79	150.9367	-32.5177	605.5	681	2
RT_W4MB	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	321560.13	6390984.88	151.0984	-32.6043			0
W14_WW	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	323823.67	6390271.80	151.1224	-32.6111	7703		0
BG_W01	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	301102.46	6429186.85	150.8886	-32.2564	368		82
BG_W02	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	300114.19	6428480.81	150.8779	-32.2626	563.5		82
BG_W03	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	298869.22	6426989.14	150.8644	-32.2758	580		82
BG_W04	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	293531.84	6423782.47	150.8071	-32.3038	524		82
H1_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	318366.93	6400692.01	151.0663	-32.5162			0
WL1_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	317556.54	6396934.68	151.0569	-32.5500			0
H2_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	316694.37	6398294.61	151.0480	-32.5376			0
H3_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	318263.05	6396623.89	151.0644	-32.5529			0
W1_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	309020.15	6402482.43	150.9672	-32.4985			0
W10_CA	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306231.69	6400390.28	150.9371	-32.5169			0

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W1_WW	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324434.33	6390616.72	151.1290	-32.6081	742		0
W2_WW	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324248.49	6390485.80	151.1270	-32.6092	816		0
FIN_CA	Hunter Regulated River Alluvial	Psi	MMI	L	Permian Singleton	312543.96	6402319.69	151.0047	-32.5006			0
BG_END	Hunter Regulated River Alluvial	Q	MMI	VH	Quaternary	297369.28	6426755.14	150.8485	-32.2777			0
HU15	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary			151.1370	-32.5650	458	476	2
HU14	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary			151.2048	-32.5832	484	510	2
51185	Hunter Regulated River Alluvial	Q	GRZ	H	Quaternary	356946.82	6387851.77	151.4749	-32.6377	2360	2360	1
210064	Hunter Regulated River Alluvial	Q	H2O	H	Quaternary	350308.68	6384890.88	151.4037	-32.6635	729	892	7175
SC_SY	Hunter Regulated River Alluvial	Q	TRU	H	Quaternary	330882.88	6395807.52	151.1986	-32.5623			0
210002	Hunter Regulated River Alluvial	Q	TRU	H	Quaternary	301170.62	6429177.49	150.8893	-32.2565	451.5	605	7230
210009	Hunter Regulated River Alluvial	Q	TRU	H	Quaternary	352801.91	6382488.35	151.4299	-32.6855			0
W-HUNT-DRT	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary	299694.05	6435032.76	150.8749	-32.2035			0
HUNT572	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	316996.81	6399607.39	151.0515	-32.5258	997	1006	2
210125	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	314107.03	6403924.27	151.0216	-32.4864	698	898	5323
210127	Hunter Regulated River Alluvial	Psi	GRZ	L	Permian Singleton	317929.89	6402552.58	151.0620	-32.4994	741.75	926	6850
W-HUNTUP-DRT	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	299814.97	6436001.26	150.8763	-32.1947			0
MG_SW17	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	288266.00	6422118.00	150.7508	-32.3178	509	691	89
WW56	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	306100.66	6400262.47	150.9357	-32.5180	592	745	9
WQ_210008	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300350.69	6427741.51	150.8803	-32.2693	730	783	3
WQ_210056	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300296.05	6440074.99	150.8823	-32.1581	359.5	480	48
WQ_21010033	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	294137.20	6422791.42	150.8133	-32.3128	455	605	43
WQ_21010055	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	302257.49	6441588.64	150.9034	-32.1448			0
WQ_21010136	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	361692.34	6382471.81	151.5247	-32.6868	729	858.5	90
WQ_21010142	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300803.66	6430102.01	150.8856	-32.2481	363	459	87
WQ_21010172	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300594.71	6439282.23	150.8853	-32.1653	327	385	33

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WQ_21010321	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	303561.86	6442944.98	150.9175	-32.1328	318	330	16
WQ_210105	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	297886.51	6407326.32	150.8498	-32.4529	2040	4080	2
WQ_210128	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	316924.44	6398940.57	151.0506	-32.5318	443	458.5	140
210055	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	284703.34	6415039.62	150.7114	-32.3809	516	667.95	6935
210056	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300424.29	6439312.16	150.8835	-32.1650	389.5	501.5	5187
210083	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	304903.20	6403438.69	150.9236	-32.4892	675.7	878.5	7962
210105	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	297886.51	6407326.32	150.8498	-32.4529			0
210126	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	316688.35	6404138.21	151.0491	-32.4849	719	898	6003
21010055	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	302257.49	6441588.64	150.9034	-32.1448			0
21010056	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	302257.49	6441588.64	150.9034	-32.1448			0
HUNT576	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	306204.65	6400313.73	150.9368	-32.5176	1012	1014	2
HUNT583	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	304196.40	6443811.30	150.9244	-32.1251	702	717	2
REDBK_LDP	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	321841.71	6392366.56	151.1017	-32.5919			0
WQ_21010336	Hunter Regulated River Alluvial	Pm	H2O	L	Permian Maitland	337292.98	6393204.06	151.2664	-32.5867	634	795	19
WQ_21010173	Hunter Regulated River Alluvial	Psi	H2O	L	Permian Singleton	302204.04	6405393.53	150.8953	-32.4711			0
WQ_210127	Hunter Regulated River Alluvial	Psi	H2O	L	Permian Singleton	318004.86	6402565.03	151.0628	-32.4993	698	785.5	20
W-DISCHARGE-DRT	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	300201.29	6435672.96	150.8804	-32.1978			0
W-EPA2-DRT	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	299818.59	6435954.37	150.8764	-32.1952			0
MG_SW14	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	284756.00	6415200.00	150.7120	-32.3795	509	690	188
WW53	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	284732.74	6415170.05	150.7117	-32.3797	530	530	1
WW62	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	339811.05	6390689.93	151.2928	-32.6097			0
WQ_210001	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	328301.21	6395974.27	151.1711	-32.5604	704.5	900	408
WQ_210002	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	301107.52	6429240.28	150.8886	-32.2559	440	610	708
WQ_210009	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	352915.57	6382412.40	151.4311	-32.6862	706	858.5	325
WQ_210055	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	284758.61	6415096.27	150.7120	-32.3804	483	594.5	105

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WQ_210083	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	304903.84	6403405.43	150.9236	-32.4895	474	690	259
WQ_21010031	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	283756.09	6413998.67	150.7011	-32.3901	412	552	87
WQ_21010057	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306557.48	6442747.37	150.9492	-32.1351			0
WQ_21010061	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	304412.77	6443848.74	150.9267	-32.1248	712	768	6296
WQ_21010089	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	307683.52	6442591.29	150.9611	-32.1367	283	306	34
WQ_21010092	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306220.43	6400469.33	150.9370	-32.5162	688.5	886	242
WQ_21010093	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	317073.38	6399531.15	151.0523	-32.5265	428	568	13
WQ_21010135	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	295502.94	6424194.71	150.8281	-32.3004	385	452	44
WQ_21010166	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	299904.95	6431692.65	150.8764	-32.2336	318	336	2
WQ_21010200	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	330671.48	6396088.43	151.1964	-32.5597	655	655	1
WQ_21010327	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	282504.83	6412662.59	150.6875	-32.4019	494	577	18
WQ_21010337	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	332706.94	6392884.26	151.2175	-32.5889	613	684	17
210008	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	300609.68	6428944.59	150.8833	-32.2585			0
21010057	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306557.69	6442736.28	150.9492	-32.1352			0
21010058	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	307058.76	6442690.35	150.9545	-32.1357			0
21010061	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	304403.55	6443837.47	150.9266	-32.1249			0
HUNT854C	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	299804.80	6431513.20	150.8753	-32.2352	399	667	6
HUNT854A	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	300916.06	6432533.43	150.8873	-32.2262			0
HUNT854B	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	300894.98	6432550.76	150.8871	-32.2260			0
DART_LDP	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	299826.27	6435951.15	150.8765	-32.1952			0
WQ_21010154	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	300856.36	6428383.75	150.8858	-32.2636	552	1540	3
WQ_210129	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	327195.19	6395064.00	151.1592	-32.5684	543	581	128
210129	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	327223.36	6395064.49	151.1595	-32.5684	639.9	794.4	7126
HUNT506	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	300903.44	6427907.71	150.8862	-32.2679	954	1902	2
HUNT571	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	300700.62	6429112.77	150.8843	-32.2570	756.5	783	2

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MG_W15	Hunter Regulated River Alluvial	Q	SRC	L	Quaternary	282749.00	6414230.00	150.6905	-32.3878	459	1273	5
WQ_21010322	Hunter Regulated River Alluvial	Q	SRC	L	Quaternary	300613.85	6439748.48	150.8856	-32.1611	350	378	18
210001	Hunter Regulated River Alluvial	Q	SRC	L	Quaternary	328325.58	6395959.68	151.1714	-32.5605			0
210058	Hunter Regulated River Alluvial	Q	TRU	L	Quaternary	285904.46	6420090.68	150.7253	-32.3356			0
210128	Hunter Regulated River Alluvial	Psi	CON	VH	Permian Singleton	316753.75	6399026.18	151.0488	-32.5310	667.7	826.2	2495
210134	Hunter Regulated River Alluvial	Q	CON	VH	Quaternary	325140.53	6396015.35	151.1375	-32.5595	604.7	783.7	6513
WQ_21010091	Hunter Regulated River Alluvial	Q	GRZ	VH	Quaternary	297894.15	6407881.11	150.8500	-32.4479	563	702	36
WQ_21010344	Hunter Regulated River Alluvial	Q	GRZ	VH	Quaternary	283475.38	6417420.64	150.6989	-32.3592	445	564	24
WQ_210426	Hunter Regulated River Alluvial	Q	GRZ	VH	Quaternary	365750.64	6381241.11	151.5678	-32.6984	995	1040	30
210145	Hunter Regulated River Alluvial	Psi	H2O	VH	Permian Singleton	302230.48	6405352.67	150.8956	-32.4715			0
MG_SW15	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	282506.00	6413124.00	150.6876	-32.3977	525	703	189
WW54	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	344845.94	6390589.21	151.3464	-32.6114	780	780	1
WW55	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	365341.09	6379808.53	151.5632	-32.7113	995	1010	2
WW52	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	329237.60	6397442.73	151.1814	-32.5473	670	910	8
WQ_21010139	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	344788.57	6390584.21	151.3458	-32.6114	701	847	87
HUNT847C	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	344697.32	6390416.44	151.3448	-32.6129	794	1100	6
HUNT847A	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	344790.48	6390582.03	151.3458	-32.6114			0
HUNT847B	Hunter Regulated River Alluvial	Q	H2O	VH	Quaternary	344813.98	6390580.17	151.3461	-32.6114			0
210133	Hunter Regulated River Alluvial	Q	CON	SAL	Quaternary	314605.07	6404443.72	151.0270	-32.4818			0
RIX3	Hunter Regulated River Alluvial	Q	H2O	SAL	Quaternary	322594.21	6397348.81	151.1106	-32.5471	760	1430	145
WQ_21010248	Hunter Regulated River Alluvial	Q	H2O	SAL	Quaternary	340978.38	6392897.48	151.3056	-32.5900	642	950	2
CA83_86	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary	290609.97	6408383.08	150.7727	-32.4420	1730	1860	2
CA83_144	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary	308735.20	6402278.88	150.9641	-32.5003	637.5	927	24
CA83_2	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	321404.45	6391135.69	151.0968	-32.6029			0
CA83_160	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	299490.07	6426379.52	150.8709	-32.2814	660	660	1

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CA83_84	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	283332.31	6413065.72	150.6964	-32.3984	14200	20000	3
CA83_89	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	289580.66	6408020.65	150.7616	-32.4451	580	580	1
CA83_88	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	291146.37	6408064.14	150.7783	-32.4450	540	540	1
CA83_195	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	307315.33	6400009.09	150.9486	-32.5205	300	300	1
CA83_47	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	306090.44	6400294.06	150.9356	-32.5178			0
CA83_102	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	320360.59	6395158.03	151.0864	-32.5665	135	135	1
CA83_147	Hunter Regulated River Alluvial	Psi	H2O	L	Permian Singleton	314069.72	6403678.75	151.0212	-32.4886	735	950	22
CA83_65	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	283970.19	6414167.52	150.7034	-32.3886			0
CA83_145	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	310690.02	6400449.05	150.9846	-32.5172	735	990	23
K_69	Hunter Regulated River Alluvial	Q	GRZ	H	Quaternary	323904.98	6390291.23	151.1233	-32.6109	2510	2510	1
K_109	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	314604.98	6404390.50	151.0270	-32.4823	5730	5730	1
K_110	Hunter Regulated River Alluvial	Q	CON	L	Quaternary	314604.97	6404290.50	151.0270	-32.4832	1288	1288	1
K_70	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	324304.98	6390491.22	151.1276	-32.6092	11150	11150	1
K_76	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	300504.96	6440190.97	150.8845	-32.1571	467	467	1
K_167	Hunter Regulated River Alluvial	Psi	H2O	L	Permian Singleton	321004.97	6395091.31	151.0933	-32.5672	1645	1645	1
K_1	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	301104.96	6429190.96	150.8886	-32.2564	600	600	1
K_111	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	314904.97	6404190.49	151.0301	-32.4841	1614	1614	1
K_113	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	317104.97	6403990.42	151.0535	-32.4863	1582	1582	1
K_15	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	282104.94	6409991.85	150.6826	-32.4259	1260	1260	1
K_16	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	282204.94	6410191.85	150.6837	-32.4241	868	868	1
K_170	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	317204.98	6399990.42	151.0538	-32.5224	1643	1643	1
K_18	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	282504.94	6412671.83	150.6875	-32.4018	1157	1157	1
K_20	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	297904.96	6407291.11	150.8500	-32.4532	1237	1237	1
K_202	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	306204.97	6400490.79	150.9368	-32.5160	1268	1268	1
K_28	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	316804.98	6397791.43	151.0491	-32.5421	1409	1409	1

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K_4	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	284804.95	6415091.71	150.7125	-32.3805	802	802	1
K_71	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324304.98	6390691.22	151.1276	-32.6074	1365	1365	1
K_72	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324504.97	6390591.21	151.1297	-32.6083	1445	1445	1
K_73	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324604.98	6390491.21	151.1308	-32.6092	1425	1425	1
K_75	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	328504.98	6396291.10	151.1734	-32.5575	1421	1421	1
K_79	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	307704.97	6442690.70	150.9613	-32.1358	423	423	1
K_MAN_533_5_6	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	329204.98	6394891.08	151.1806	-32.5703			0
K_BLH_W4_2	Hunter Regulated River Alluvial	Q	WST	L	Quaternary	299904.96	6426391.01	150.8753	-32.2814	26500	26500	1
K_166	Hunter Regulated River Alluvial	Q	GRZ	VH	Quaternary	321804.97	6396491.28	151.1021	-32.5547	14540	14540	1
K_112	Hunter Regulated River Alluvial	Q	H2O	SAL	Quaternary	317104.97	6404090.42	151.0535	-32.4854	2620	2620	1
K_169	Hunter Regulated River Alluvial	Q	H2O	SAL	Quaternary	322704.98	6397491.26	151.1118	-32.5458	9650	9650	1
W3	Hunter Regulated River Alluvial	Q	H2O	L	Quaternary	324659.98	6390548.22	151.1314	-32.6087	715		0
W4	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary	321584.56	6390994.33	151.0987	-32.6042	5516		0
K_MAN_533_5	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	329204.98	6394891.08	151.1806	-32.5703	10960	10960	1
K_MAN_533_6	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	329204.98	6394891.08	151.1806	-32.5703	9830	9830	1
WW_DB39A	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	326982.11	6395437.41	151.1570	-32.5650	820	980	3
HU16	Hunter Regulated River Alluvial	Q	GRZ	L	Quaternary			150.8452	-32.2952	400	448	2
WW_DB39B	Hunter Regulated River Alluvial	Q	RES	L	Quaternary	301228.94	6429566.86	150.8900	-32.2530	1930	1930	1
HU17	Hunter Regulated River Alluvial	Q	AGR	L	Quaternary			150.8741	-32.2371	350.5	371	2
WW_DB29	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	370870.50	6378487.53	151.6220	-32.7238			0
THRCD	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	367893.00	6377534.00	151.5901	-32.7321			0
210430	Hunter River Tidal Pool	Q	H2O	L	Quaternary	371558.00	6378467.00	151.6294	-32.7241			0
WQ_21010138	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	371093.25	6378484.22	151.6244	-32.7239	737	857	224
WQ_21010287	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	373097.66	6378598.74	151.6458	-32.7231	665	761	67
WQ_21010288	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	377407.21	6378009.75	151.6917	-32.7289	681	781	62
WQ_210441	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	365828.18	6381053.65	151.5686	-32.7001	1000	1060	38
HUNTM1	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	367798.83	6378108.24	151.5892	-32.7269	780	1038.5	5
210451D	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	365611.01	6380397.00	151.5662	-32.7060			0
210451U	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	365825.00	6381148.00	151.5686	-32.6992			0

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OAKH RB	Hunter River Tidal Pool	Q	H2O	VH	Quaternary	365879.00	6381510.00	151.5692	-32.6960			0
HU22	Isis River	Dm	GRZ	M	Devonian Mudstone	318199.98	6482901.33	151.0801	-31.7750	577.5	585	2
210070	Isis River	Cm	GRZ	M	Carboniferous Mudstone	316305.47	6479083.72	151.0594	-31.8091			0
210118	Isis River	Cs	GRZ	M	Carboniferous Sandstone	314399.56	6461437.67	151.0359	-31.9679			0
WQ_210070	Isis River	Cm	H2O	M	Carboniferous Mudstone	316334.27	6479062.06	151.0597	-31.8093	580	650	48
WQ_210118	Isis River	Cs	H2O	M	Carboniferous Sandstone	314265.02	6461557.22	151.0345	-31.9668			0
WQ_21010212	Isis River	Dm	H2O	M	Devonian Mudstone	318132.76	6482864.66	151.0794	-31.7753	617	625	4
WQ_21010211	Isis River	Cs	TRU	M	Carboniferous Sandstone	312992.67	6459271.50	151.0206	-31.9872	620	675	19
RT_Coal Loader Dam	Jerrys	Q	CON	L	Quaternary	313273.00	6413706.00	151.0147	-32.3981	4610	5720	121
RT_Bob's Dump Tailings Dam	Jerrys	Psi	CON	VH	Permian Singleton	307540.25	6409215.63	150.9528	-32.4376	4900	6960	25
RT_Carrington Upstream	Jerrys	Psi	CON	VH	Permian Singleton	307656.79	6404708.63	150.9531	-32.4782	130	186	3
RT_Dam 10N	Jerrys	Psi	CON	VH	Permian Singleton	312740.00	6404020.00	151.0071	-32.4853	310	560	23
RT_Dam 15N	Jerrys	Psi	CON	VH	Permian Singleton	312043.00	6405938.00	151.0000	-32.4679	3940	5460	123
RT_Dam 25N	Jerrys	Psi	CON	VH	Permian Singleton	308189.00	6404497.00	150.9588	-32.4802	725	920	34
RT_Dam 2W	Jerrys	Psi	CON	VH	Permian Singleton	308500.00	6411000.00	150.9634	-32.4217	3695	4750	24
RT_Emu Creek Sediment Dam	Jerrys	Psi	CON	VH	Permian Singleton	311101.00	6408992.00	150.9906	-32.4402	500	750	56
RT_NSW2	Jerrys	Psi	CON	VH	Permian Singleton	311158.91	6408955.24	150.9912	-32.4405	4330	9000	33
RT_NSW3	Jerrys	Psi	CON	VH	Permian Singleton	311425.00	6410674.00	150.9944	-32.4251	230	230	1
RT_W11	Jerrys	Psi	CON	VH	Permian Singleton	310890.00	6407157.00	150.9880	-32.4567	692.5	1292	16
RT_STAP	Jerrys	Psi	CON	VH	Permian Singleton	315278.00	6402286.00	151.0337	-32.5014	204	320	17
RT_PCK_D	Jerrys	Q	CON	VH	Quaternary	312257.18	6414251.54	151.0040	-32.3930	4515	5355	10
RT_Bayswater Creek Downstream	Jerrys	Q	CON	SAL	Quaternary	313954.90	6413178.40	151.0218	-32.4029	2290	3090	7
RT_Bayswater Creek Midstream	Jerrys	Q	CON	SAL	Quaternary	312769.13	6414124.98	151.0094	-32.3942	3325	3850	8
RW_EPL2	Jerrys	Q	CON	SAL	Quaternary	316955.00	6405290.00	151.0522	-32.4746	5770	6630	45
RT_Carrington Billabong	Jerrys	Psi	GRZ	L	Permian Singleton	310397.00	6402088.00	150.9818	-32.5023	550	900	4
RT_NSW1	Jerrys	Psi	GRZ	L	Permian Singleton	304811.00	6407161.00	150.9234	-32.4556	1965	3430	4
RT_W5FARCD	Jerrys	Psi	GRZ	VH	Permian Singleton	313207.00	6403874.00	151.0120	-32.4867	4880	5540	84
RT_Carrington Downstream	Jerrys	Q	GRZ	VH	Quaternary	308993.43	6402920.45	150.9670	-32.4946	318	375	5
RT_W5FARCU	Jerrys	Psi	GRZ	SAL	Permian Singleton	313248.00	6404072.00	151.0125	-32.4849	1240	2300	91
RW_EPL4	Jerrys	Q	GRZ	SAL	Quaternary	316911.00	6405050.00	151.0516	-32.4767	787	1224	277
RT_Dam 18W	Jerrys	Psi	H2O	VH	Permian Singleton	306170.00	6407760.00	150.9380	-32.4505	3745	6690	18
RT_Dam 3W	Jerrys	Psi	H2O	VH	Permian Singleton	308470.00	6410430.00	150.9630	-32.4268	3140	4150	23
RT_Dam 4W	Jerrys	Psi	H2O	VH	Permian Singleton	308470.00	6410430.00	150.9630	-32.4268	3400	4610	27
RT_W4H	Jerrys	Psi	H2O	VH	Permian Singleton	308470.00	6410360.00	150.9629	-32.4274	705	955	74
RW_W103	Jerrys	Psi	H2O	VH	Permian Singleton	316732.00	6405320.00	151.0498	-32.4743	6250	7100	88
RW_EPL3	Jerrys	Q	H2O	SAL	Quaternary	317020.00	6404970.00	151.0528	-32.4775	720	908	271

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RT_Bayswater Creek Upstream	Jerrys	Q	MMI	L	Quaternary	312552.71	6414363.67	151.0071	-32.3920	3260	3750	8
RT_Dam 17N	Jerrys	Psi	MMI	VH	Permian Singleton	311809.70	6406210.70	150.9976	-32.4654	5600	7680	3
RT_Dam 17W	Jerrys	Psi	MMI	VH	Permian Singleton	311809.70	6406210.70	150.9976	-32.4654	580	580	1
RT_Dam 2S	Jerrys	Psi	MMI	VH	Permian Singleton	308331.00	6399119.00	150.9592	-32.5287	330	390	17
RT_D9N	Jerrys	Psi	MMI	VH	Permian Singleton	311489.00	6402303.00	150.9934	-32.5006	5170	5590	17
RT_PCK_U	Jerrys	Psi	MMI	VH	Permian Singleton	311466.24	6413621.62	150.9954	-32.3985	6840	8180	11
RT_W9D14W	Jerrys	Psi	MMI	VH	Permian Singleton	311516.00	6413616.00	150.9960	-32.3986	5540	9360	69
W3_P_CA	Jerrys	Psi	CON	L	Permian Singleton	305607.32	6407200.47	150.9319	-32.4554			0
CLD_CA	Jerrys	Q	CON	L	Quaternary	313274.58	6413701.54	151.0147	-32.3981			0
NSW1_CA	Jerrys	Psi	GRZ	L	Permian Singleton	304842.04	6407144.91	150.9237	-32.4558			0
W5_FD_CA	Jerrys	Psi	GRZ	L	Permian Singleton	313269.19	6403790.76	151.0127	-32.4875			0
CAR_CA	Jerrys	Psi	GRZ	L	Permian Singleton	310413.09	6402054.34	150.9819	-32.5026			0
PAR_CA	Jerrys	Psi	H2O	L	Permian Singleton	305747.19	6407229.10	150.9334	-32.4552			0
SM4_AC	Jerrys	Q	H2O	L	Quaternary	318560.40	6406620.74	151.0695	-32.4628			0
NSW2_CA	Jerrys	Psi	CON	VH	Permian Singleton	311117.98	6408944.59	150.9908	-32.4406			0
NSW3_CA	Jerrys	Psi	CON	VH	Permian Singleton	311370.51	6410572.60	150.9938	-32.4260			0
W11_CA	Jerrys	Psi	CON	VH	Permian Singleton	310842.26	6407120.69	150.9875	-32.4570			0
DAM15N_CA	Jerrys	Psi	CON	VH	Permian Singleton	311891.52	6405948.51	150.9984	-32.4678			0
DAM11ND_CA	Jerrys	Psi	CON	VH	Permian Singleton	312893.37	6403892.63	151.0087	-32.4865			0
DAM11N_CA	Jerrys	Psi	CON	VH	Permian Singleton	312820.36	6404041.34	151.0079	-32.4851			0
ECK_CA	Jerrys	Psi	H2O	VH	Permian Singleton	310688.42	6409104.15	150.9863	-32.4391			0
W9_CA	Jerrys	Psi	MMI	VH	Permian Singleton	311469.25	6413620.68	150.9955	-32.3985			0
WOO_CA	Jerrys	Psi	MMI	VH	Permian Singleton	308956.98	6399769.83	150.9660	-32.5230			0
BW_EPA7	Jerrys	Pm	TRU	VH	Permian Maitland	306908.00	6414795.00	150.9472	-32.3872	3678		30
BW_EPA8	Jerrys	Q	TRU	VH	Quaternary	311667.00	6414740.00	150.9978	-32.3885			0
HU03	Jerrys	Q	CON	SAL	Quaternary	314399.98	6411701.50	151.0262	-32.4163	4470	4780	2
W5F_FU_CA	Jerrys	Psi	GRZ	SAL	Permian Singleton	313247.05	6404108.21	151.0125	-32.4846			0
BC3_INTG	Jerrys	Psi	H2O	SAL	Permian Singleton	321033.99	6408536.94	151.0962	-32.4459			0
BC2_INTG	Jerrys	Psi	H2O	SAL	Permian Singleton	321173.99	6409041.80	151.0977	-32.4414			0
BC1_INTG	Jerrys	Psi	H2O	SAL	Permian Singleton	321237.25	6410312.34	151.0987	-32.4300			0
SM1_AC	Jerrys	Q	TRU	SAL	Quaternary	318683.41	6407090.90	151.0709	-32.4586			0
WQ_210076	Jerrys	Pm	H2O	H	Permian Maitland	310099.23	6420509.12	150.9823	-32.3362	3159.5	5800	52
210076	Jerrys	Pm	H2O	H	Permian Maitland	310109.48	6420464.94	150.9824	-32.3366			0
WQ_210077	Jerrys	Pm	TRU	H	Permian Maitland	308742.49	6420050.88	150.9678	-32.3401	2670	3488	7
WQ_210078	Jerrys	Pm	TRU	H	Permian Maitland	307977.48	6416220.70	150.9589	-32.3745	3281	4400	33
210078	Jerrys	Pm	TRU	H	Permian Maitland	308006.34	6416187.98	150.9592	-32.3748			0
WQ_21010220	Jerrys	Q	AGR	L	Quaternary	291855.07	6409255.25	150.7861	-32.4344	6975	8650	7
HUNTM5	Jerrys	Psi	CON	L	Permian Singleton	314697.03	6408116.76	151.0287	-32.4487	4920	5990	3
WQ_210115	Jerrys	Q	CON	L	Quaternary	316545.38	6415570.88	151.0498	-32.3818	3500	4290	9
210059	Jerrys	Q	CON	L	Quaternary	314026.65	6413339.60	151.0226	-32.4015			0
WQ_210043	Jerrys	Q	GRZ	L	Quaternary	292980.18	6410809.38	150.7984	-32.4206	6900	7802	19
210043	Jerrys	Q	GRZ	L	Quaternary	292807.00	6410994.39	150.7966	-32.4189			0

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CJ_M17	Jerrys	Q	H2O	L	Quaternary	315039.22	6418688.35	151.0344	-32.3534	1030	1650	18
CJ_M34	Jerrys	Q	H2O	L	Quaternary	295531.45	6412126.24	150.8258	-32.4092	8250	8500	2
MA_SW03	Jerrys	Q	H2O	L	Quaternary	298165.05	6413452.14	150.8541	-32.3977	6220		0
WQ_21010291	Jerrys	Q	H2O	L	Quaternary	295531.45	6412126.24	150.8258	-32.4092	6052.5	7500	2
WQ_210113	Jerrys	Q	H2O	L	Quaternary	315046.39	6418782.14	151.0345	-32.3526	1020	1413.5	20
210113	Jerrys	Q	H2O	L	Quaternary	315104.49	6418694.47	151.0351	-32.3534			0
CJ_M12	Jerrys	Q	MMI	L	Quaternary	312552.53	6414386.57	151.0071	-32.3918	5950	6500	16
210045	Jerrys	Psi	TRU	L	Permian Singleton	302301.76	6407591.78	150.8968	-32.4513			0
WQ_210110	Jerrys	Psi	H2O	Water	Permian Singleton	311963.40	6415486.28	151.0011	-32.3818	680	680	1
MA_SW02	Jerrys	Pm	CON	VH	Permian Maitland	300860.98	6415904.94	150.8832	-32.3761	8100		0
CJ_M14	Jerrys	Psi	CON	VH	Permian Singleton	313947.11	6416325.76	151.0223	-32.3746	6020	7500	22
WQ_210074	Jerrys	Psi	CON	VH	Permian Singleton	313225.31	6417983.21	151.0150	-32.3595	1307.5	8550	12
HVO3 LDP	Jerrys	Psi	CON	VH	Permian Singleton	312964.31	6403922.73	151.0094	-32.4862			0
HVO4 LDP	Jerrys	Psi	CON	VH	Permian Singleton	305719.81	6407171.11	150.9331	-32.4557			0
MTOWN_LDP	Jerrys	Psi	CON	VH	Permian Singleton	319936.64	6412886.48	151.0853	-32.4066			0
210050	Jerrys	Q	CON	VH	Quaternary	318403.43	6408583.81	151.0682	-32.4451			0
CJ_M15	Jerrys	Psi	GRZ	VH	Permian Singleton	308995.63	6412120.05	150.9689	-32.4116	260	310	13
210074	Jerrys	Psi	GRZ	VH	Permian Singleton	313104.77	6418391.36	151.0138	-32.3558			0
210096	Jerrys	Psi	GRZ	VH	Permian Singleton	288934.07	6408129.28	150.7548	-32.4440			0
MA_SW01	Jerrys	Pg	H2O	VH	Permian Greta	300987.55	6416324.37	150.8847	-32.3723	8550		0
CJ_M20	Jerrys	Psi	H2O	VH	Permian Singleton	317704.98	6411844.02	151.0614	-32.4156	6060	10000	21
210110	Jerrys	Q	H2O	VH	Quaternary	311908.73	6414886.31	151.0004	-32.3872	3318.95	3776.05	5960
BAYSWPSD	Jerrys	Q	H2O	VH	Quaternary	311761.90	6414937.17	150.9989	-32.3867			0
MA_SW24	Jerrys	Psi	MMI	VH	Permian Singleton	297114.70	6415953.70	150.8434	-32.3750			0
CJ_M16	Jerrys	Psi	TRU	VH	Permian Singleton	310148.73	6412619.15	150.9812	-32.4073	1040	1300	17
WQ_210045	Jerrys	Psi	TRU	VH	Permian Singleton	302458.08	6407295.36	150.8984	-32.4540	8711.5	9400	16
52212	Jerrys	Psi	TRU	VH	Permian Singleton	309301.72	6413201.16	150.9724	-32.4019	6580	6580	1
CJ_M10	Jerrys	Q	TRU	VH	Quaternary	311870.71	6414640.66	150.9999	-32.3894	2875	3100	16
CJ_M7	Jerrys	Q	TRU	VH	Quaternary	310899.25	6412918.62	150.9893	-32.4048	7200	17000	17
CJ_M19	Jerrys	Psi	CON	SAL	Permian Singleton	318638.50	6415029.01	151.0719	-32.3870	5400	8000	13
WQ_210042	Jerrys	Psi	CON	SAL	Permian Singleton	316488.62	6414039.24	151.0489	-32.3956	1412	2600	47
WQ_210049	Jerrys	Psi	CON	SAL	Permian Singleton	317656.70	6411897.68	151.0609	-32.4151	675	1350	2
WQ_21010266	Jerrys	Psi	CON	SAL	Permian Singleton	317128.24	6416124.97	151.0561	-32.3769	1200	2400	2
WQ_210121	Jerrys	Psi	CON	SAL	Permian Singleton	316392.37	6412096.48	151.0475	-32.4131	712.5	920	4
210049	Jerrys	Psi	CON	SAL	Permian Singleton	317702.12	6411987.24	151.0614	-32.4143			0
210121	Jerrys	Psi	CON	SAL	Permian Singleton	316401.98	6412085.57	151.0476	-32.4132			0
LIDD_LDP	Jerrys	Psi	CON	SAL	Permian Singleton	314432.27	6413610.83	151.0270	-32.3991			0
210115	Jerrys	Q	CON	SAL	Quaternary	316509.16	6415492.58	151.0494	-32.3825			0
NAR_LDP	Jerrys	Q	CON	SAL	Quaternary	316938.69	6405287.06	151.0520	-32.4746			0
WQ_210116	Jerrys	Psi	H2O	SAL	Permian Singleton	316556.50	6414961.06	151.0498	-32.3873	3715	4240	8
210042	Jerrys	Psi	H2O	SAL	Permian Singleton	316451.80	6413994.20	151.0485	-32.3960			0
210116	Jerrys	Psi	H2O	SAL	Permian Singleton	316604.95	6414884.31	151.0503	-32.3880			0
CJ_M18	Jerrys	Q	H2O	SAL	Quaternary	316830.32	6416161.14	151.0529	-32.3765	1340	1550	17

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210130	Jerrys	Q	H2O	SAL	Quaternary	317551.48	6405784.41	151.0586	-32.4702	1297.35	1675	6382
210075	Jerrys	Pm	TRU	SAL	Permian Maitland	308000.52	6416986.49	150.9593	-32.3676			0
CJ_M26	Jerrys	Psi	TRU	SAL	Permian Singleton	317545.65	6408575.03	151.0591	-32.4450	2050	3750	4
CJ_M13	Jerrys	Q	TRU	SAL	Quaternary	314582.65	6411850.05	151.0282	-32.4150	5650	6450	20
210077	Jerrys	Q	TRU	SAL	Quaternary	309003.58	6419689.80	150.9705	-32.3434			0
CA83_25	Jerrys	Pg	GRZ	H	Permian Greta	300974.36	6415509.82	150.8844	-32.3797	4900	6650	7
CA83_200	Jerrys	Pm	TRU	H	Permian Maitland	306893.41	6415717.98	150.9473	-32.3788			0
CA83_26	Jerrys	Pm	TRU	H	Permian Maitland	307391.19	6418541.75	150.9531	-32.3535	7500	9600	7
CA83_199	Jerrys	Pm	TRU	H	Permian Maitland	306296.08	6415301.65	150.9408	-32.3825	1630	1630	1
CA83_22	Jerrys	Pm	TRU	H	Permian Maitland	304992.80	6418523.65	150.9277	-32.3532	6300	6300	1
CA83_72	Jerrys	Psi	CON	L	Permian Singleton	316559.49	6413592.85	151.0496	-32.3996			0
CA83_36	Jerrys	Psi	CON	L	Permian Singleton	317204.43	6411533.03	151.0560	-32.4183			0
CA83_39	Jerrys	Q	CON	L	Quaternary	315201.81	6418650.35	151.0361	-32.3538	1030	1650	16
CA83_38	Jerrys	Q	CON	L	Quaternary	316369.33	6415853.74	151.0480	-32.3792			0
CA83_148	Jerrys	Psi	GRZ	L	Permian Singleton	313459.77	6403533.77	151.0146	-32.4898	1932	2822	7
CA83_87	Jerrys	Q	GRZ	L	Quaternary	291102.88	6408673.03	150.7780	-32.4395	440	440	1
CA83_198	Jerrys	Q	GRZ	L	Quaternary	292407.64	6410006.78	150.7921	-32.4277	6750	6750	1
CA83_124	Jerrys	Q	GRZ	L	Quaternary	308800.20	6402908.82	150.9649	-32.4947	223	1575	7
CA83_16	Jerrys	Q	H2O	L	Quaternary	295655.05	6412253.87	150.8271	-32.4081	8060	8220	2
CA83_157	Jerrys	Psi	MMI	L	Permian Singleton	314279.70	6405758.56	151.0238	-32.4699	5825	6900	2
CA83_201	Jerrys	Q	H2O	Water	Quaternary	311755.63	6415181.66	150.9988	-32.3845	1600	1600	1
CA83_177	Jerrys	Pm	CON	VH	Permian Maitland	301010.56	6417283.72	150.8851	-32.3637	1150	1150	1
CA83_158	Jerrys	Psi	CON	VH	Permian Singleton	314568.27	6416885.50	151.0291	-32.3696	4000	4000	2
CA83_37	Jerrys	Psi	CON	VH	Permian Singleton	318889.28	6414562.76	151.0745	-32.3913			0
CA83_73	Jerrys	Psi	CON	VH	Permian Singleton	317544.40	6413587.85	151.0600	-32.3998	1200	1420	13
CA83_71	Jerrys	Psi	CON	VH	Permian Singleton	317064.44	6413622.84	151.0549	-32.3994	4500	13000	13
CA83_67	Jerrys	Psi	CON	VH	Permian Singleton	315119.62	6413307.87	151.0342	-32.4020	6360	6900	13
CA83_66	Jerrys	Psi	CON	VH	Permian Singleton	315224.61	6411987.99	151.0351	-32.4139	6900	7450	10
CA83_68	Jerrys	Psi	CON	VH	Permian Singleton	316149.53	6412167.98	151.0449	-32.4124	1350	1440	3
CA83_70	Jerrys	Psi	CON	VH	Permian Singleton	316949.45	6412032.99	151.0534	-32.4138	4850	12300	12
CA83_35	Jerrys	Psi	CON	VH	Permian Singleton	315559.58	6409388.23	151.0381	-32.4374			0
CA83_167	Jerrys	Psi	CON	VH	Permian Singleton	316439.50	6408658.30	151.0473	-32.4441	4050	4100	2
CA83_32	Jerrys	Psi	CON	VH	Permian Singleton	314599.67	6407963.36	151.0276	-32.4501	4900	4900	1
CA83_174	Jerrys	Psi	CON	VH	Permian Singleton	314379.69	6406703.48	151.0250	-32.4614	290	290	1
CA83_150	Jerrys	Psi	CON	VH	Permian Singleton	312439.86	6406483.50	151.0044	-32.4630	7470	9610	12
CA83_129	Jerrys	Psi	CON	VH	Permian Singleton	310285.06	6405683.57	150.9813	-32.4699	440	600	2
CA83_137	Jerrys	Psi	CON	VH	Permian Singleton	310835.01	6406338.51	150.9873	-32.4641	1239	1800	18
CA83_127	Jerrys	Psi	CON	VH	Permian Singleton	310225.07	6406153.53	150.9808	-32.4656	540	660	21
CA83_132	Jerrys	Psi	CON	VH	Permian Singleton	310400.05	6406618.48	150.9827	-32.4615	386	470	19
CA83_140	Jerrys	Psi	CON	VH	Permian Singleton	309975.09	6406763.47	150.9782	-32.4601	648	730	16
CA83_154	Jerrys	Psi	CON	VH	Permian Singleton	310245.07	6407273.42	150.9812	-32.4556	519.5	900	24
CA83_153	Jerrys	Psi	CON	VH	Permian Singleton	310845.01	6407173.43	150.9876	-32.4566	16390	19100	24
CA83_133	Jerrys	Psi	CON	VH	Permian Singleton	310880.01	6407828.37	150.9881	-32.4507	160	290	17

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CA83_155	Jerrys	Psi	CON	VH	Permian Singleton	309965.09	6403703.75	150.9775	-32.4877	530	670	21
CA83_205	Jerrys	Psi	CON	VH	Permian Singleton	309254.30	6411756.28	150.9716	-32.4150	675	675	1
CA83_186	Jerrys	Psi	CON	VH	Permian Singleton	308528.63	6410958.28	150.9637	-32.4220	350	350	1
CA83_187	Jerrys	Psi	CON	VH	Permian Singleton	308375.17	6410910.65	150.9620	-32.4224	505	600	2
CA83_128	Jerrys	Psi	DEG	VH	Permian Singleton	310270.06	6405263.61	150.9811	-32.4737	600	600	1
CA83_136	Jerrys	Psi	DEG	VH	Permian Singleton	310800.01	6405233.61	150.9867	-32.4740	725	1355	12
CA83_181	Jerrys	Psi	DEG	VH	Permian Singleton	311489.95	6404168.71	150.9938	-32.4838	2800	2800	1
CA83_143	Jerrys	Psi	DEG	VH	Permian Singleton	311504.95	6403043.81	150.9937	-32.4939	2865.5	3690	4
CA83_139	Jerrys	Psi	DEG	VH	Permian Singleton	310805.01	6403658.75	150.9864	-32.4882	1600	3300	17
CA83_157B	Jerrys	Psi	DEG	VH	Permian Singleton	310244.66	6412039.97	150.9821	-32.4126			0
CA83_173	Jerrys	Psi	DEG	VH	Permian Singleton	309979.01	6412042.55	150.9793	-32.4125	641	1000	2
CA83_188	Jerrys	Psi	DEG	VH	Permian Singleton	309656.63	6412019.34	150.9759	-32.4127	432.5	545	2
CA83_204	Jerrys	Psi	DEG	VH	Permian Singleton	310324.61	6412413.93	150.9831	-32.4092	1500	1500	1
CA83_189	Jerrys	Psi	DEG	VH	Permian Singleton	309615.37	6411851.70	150.9754	-32.4142	420	420	1
CA83_156	Jerrys	Psi	DEG	VH	Permian Singleton	309759.80	6411877.49	150.9770	-32.4140	4640	4970	18
CA83_171	Jerrys	Psi	DEG	VH	Permian Singleton	309455.47	6411715.01	150.9737	-32.4154	460	600	3
CA83_107	Jerrys	Pm	GRZ	VH	Permian Maitland	304346.91	6408057.20	150.9186	-32.4475	390	390	3
CA83_80B	Jerrys	Psi	GRZ	VH	Permian Singleton	289015.26	6409223.93	150.7559	-32.4341			0
CA83_85	Jerrys	Psi	GRZ	VH	Permian Singleton	289087.75	6408397.58	150.7565	-32.4416	930	930	1
CA83_17	Jerrys	Psi	GRZ	VH	Permian Singleton	295495.57	6409789.32	150.8249	-32.4303	170	170	1
CA83_18	Jerrys	Psi	GRZ	VH	Permian Singleton	296147.95	6409803.82	150.8319	-32.4302	860	2600	3
CA83_20	Jerrys	Psi	GRZ	VH	Permian Singleton	296147.95	6409803.82	150.8319	-32.4302	232	232	1
CA83_51	Jerrys	Psi	GRZ	VH	Permian Singleton	313759.74	6406513.49	151.0184	-32.4630			0
CA83_123	Jerrys	Psi	GRZ	VH	Permian Singleton	313619.76	6404128.71	151.0165	-32.4845	1430	1430	4
CA83_49	Jerrys	Psi	GRZ	VH	Permian Singleton	309174.35	6412052.87	150.9708	-32.4123			0
CA83_210	Jerrys	Psi	GRZ	VH	Permian Singleton	308160.86	6411244.03	150.9598	-32.4194	300	300	1
CA83_208	Jerrys	Psi	GRZ	VH	Permian Singleton	308092.06	6411005.90	150.9591	-32.4215	500	500	1
CA83_112	Jerrys	Pm	H2O	VH	Permian Maitland	303758.38	6408645.74	150.9125	-32.4421	5200	5200	3
CA83_185	Jerrys	Psi	H2O	VH	Permian Singleton	308544.50	6410257.13	150.9637	-32.4284	8350	9500	2
CA83_176	Jerrys	Pg	MMI	VH	Permian Greta	301924.66	6417709.10	150.8949	-32.3600	4600	4600	1
CA83_24	Jerrys	Pg	MMI	VH	Permian Greta	301942.77	6415880.89	150.8947	-32.3765	168	198	5
CA83_168	Jerrys	Psi	MMI	VH	Permian Singleton	316634.48	6408008.36	151.0493	-32.4500	4450	4500	2
CA83_175	Jerrys	Psi	MMI	VH	Permian Singleton	315389.60	6407493.40	151.0359	-32.4544	2900	2900	1
CA83_125	Jerrys	Psi	MMI	VH	Permian Singleton	314409.69	6406238.52	151.0253	-32.4656	991	991	3
CA83_142	Jerrys	Psi	MMI	VH	Permian Singleton	312019.90	6405678.57	150.9997	-32.4702	2820	4414.5	5
CA83_138	Jerrys	Psi	MMI	VH	Permian Singleton	312404.87	6405268.61	151.0038	-32.4740	660	806	4
CA83_130	Jerrys	Psi	MMI	VH	Permian Singleton	310750.02	6405713.57	150.9863	-32.4697	400	400	1
CA83_134	Jerrys	Psi	MMI	VH	Permian Singleton	310610.03	6404588.67	150.9845	-32.4798	850	1180	9
CA83_121	Jerrys	Psi	MMI	VH	Permian Singleton	306780.38	6407748.38	150.9445	-32.4507	368	368	3
CA83_48	Jerrys	Psi	MMI	VH	Permian Singleton	307025.36	6406878.46	150.9469	-32.4586	5150	6400	2
CA83_131	Jerrys	Psi	MMI	VH	Permian Singleton	311184.98	6402498.86	150.9902	-32.4988	430	430	1
CA83_141	Jerrys	Psi	MMI	VH	Permian Singleton	310940.00	6402988.81	150.9877	-32.4943	157	277	10
CA83_182	Jerrys	Psi	MMI	VH	Permian Singleton	310395.05	6403243.79	150.9820	-32.4919	1280	1560	2

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CA83_194	Jerrys	Psi	MMI	VH	Permian Singleton	310745.02	6399049.17	150.9849	-32.5298			0
CA83_53	Jerrys	Psi	MMI	VH	Permian Singleton	311502.00	6413572.90	150.9958	-32.3990	10900	15000	16
CA83_207	Jerrys	Psi	MMI	VH	Permian Singleton	308401.63	6410254.48	150.9622	-32.4284	200	200	1
CA83_206	Jerrys	Psi	MMI	VH	Permian Singleton	308618.59	6410095.73	150.9645	-32.4298	9000	9000	1
CA83_172	Jerrys	Psi	MMI	VH	Permian Singleton	308330.19	6410074.57	150.9614	-32.4300	1680	1680	1
CA83_54	Jerrys	Q	MMI	VH	Quaternary	312197.68	6414275.83	151.0033	-32.3928	4125	4900	14
CA83_52	Jerrys	Q	MMI	VH	Quaternary	311009.23	6413051.14	150.9905	-32.4036	8100	17000	16
CA83_48B	Jerrys	Psi	TRU	VH	Permian Singleton	313744.67	6417021.26	151.0203	-32.3683			0
CA83_230	Jerrys	Psi	TRU	VH	Permian Singleton	310128.76	6412949.69	150.9811	-32.4044	28800	28800	1
CA83_50	Jerrys	Psi	TRU	VH	Permian Singleton	310177.60	6412682.15	150.9816	-32.4068	990	1500	15
CA83_202	Jerrys	Psi	TRU	VH	Permian Singleton	310077.02	6412638.31	150.9805	-32.4072	4500	4500	1
CA83_203	Jerrys	Psi	TRU	VH	Permian Singleton	310203.39	6412535.15	150.9818	-32.4081	800	800	1
CA83_74	Jerrys	Psi	CON	SAL	Permian Singleton	316394.50	6414072.80	151.0479	-32.3953	6300	7600	2
CA83_75	Jerrys	Psi	CON	SAL	Permian Singleton	316094.53	6414457.77	151.0448	-32.3918	3800	19000	12
CA83_152	Jerrys	Psi	CON	SAL	Permian Singleton	314294.70	6407223.43	151.0242	-32.4567	14475	16100	12
CA83_21	Jerrys	Psi	GRZ	SAL	Permian Singleton	295727.53	6410354.72	150.8275	-32.4252	417	417	1
CA83_33	Jerrys	Psi	GRZ	SAL	Permian Singleton	318649.30	6406693.48	151.0705	-32.4622			0
CA83_56	Jerrys	Q	H2O	SAL	Quaternary	311864.33	6414830.20	150.9999	-32.3877	2900	3250	15
CA83_114	Jerrys	Tb	H2O	SAL	Tertiary Basalt	302080.81	6407295.92	150.8944	-32.4539	1800	1800	3
CA83_55	Jerrys	Q	MMI	SAL	Quaternary	312617.98	6414417.14	151.0078	-32.3915	6000	6550	15
CA83_57	Jerrys	Q	TRU	SAL	Quaternary	311947.67	6414623.67	151.0008	-32.3896	6200	9500	14
K_319	Jerrys	Pm	GRZ	H	Permian Maitland	318304.98	6416590.37	151.0687	-32.3729	1456	1456	1
K_214	Jerrys	Pm	H2O	H	Permian Maitland	310104.97	6420490.64	150.9824	-32.3364	5790	5790	1
K_228	Jerrys	Pm	TRU	H	Permian Maitland	306704.97	6414790.76	150.9451	-32.3872	1953	1953	1
K_108	Jerrys	Q	AGR	L	Quaternary	317004.98	6404890.42	151.0526	-32.4782	2530	2530	1
K_128	Jerrys	Psi	CON	L	Permian Singleton	315004.97	6418890.47	151.0341	-32.3516	1801	1801	1
K_309	Jerrys	Psi	CON	L	Permian Singleton	315004.97	6418690.47	151.0340	-32.3534	928	928	1
K_123	Jerrys	Q	CON	L	Quaternary	316804.97	6415790.42	151.0526	-32.3799	4560	4560	1
K_320	Jerrys	Q	CON	L	Quaternary	316104.98	6416590.44	151.0453	-32.3725	1703	1703	1
K_114	Jerrys	Psi	H2O	L	Permian Singleton	316504.97	6413190.43	151.0489	-32.4033	4130	4130	1
K_120	Jerrys	Psi	H2O	L	Permian Singleton	316504.97	6411790.43	151.0486	-32.4159	3730	3730	1
K_254	Jerrys	Psi	H2O	L	Permian Singleton	302504.96	6407890.92	150.8990	-32.4486	9200	9200	1
K_125	Jerrys	Q	H2O	L	Quaternary	315804.98	6417090.45	151.0422	-32.3680	5670	5670	1
K_132	Jerrys	Q	H2O	L	Quaternary	316204.98	6419890.44	151.0470	-32.3428	1039	1039	1
K_19	Jerrys	Q	H2O	L	Quaternary	292404.95	6409791.35	150.7921	-32.4297	6750	6750	1
K_106	Jerrys	Psi	MMI	L	Permian Singleton	314804.97	6408390.49	151.0299	-32.4463	5520	5520	1
K_315	Jerrys	Cc	GRZ	M	Carboniferous Conglomerate	319204.98	6418590.35	151.0786	-32.3550	340	340	1
K_316	Jerrys	Cc	GRZ	M	Carboniferous Conglomerate	319404.97	6418390.34	151.0807	-32.3568	591	591	1
K_163	Jerrys	Cu	GRZ	M	Carboniferous Undifferentiated	324904.98	6427990.18	151.1409	-32.2712	1583	1583	1
K_313	Jerrys	Cu	GRZ	M	Carboniferous Undifferentiated	319304.97	6417690.34	151.0795	-32.3631	877	877	1
K_314	Jerrys	Cu	GRZ	M	Carboniferous Undifferentiated	319504.97	6418590.34	151.0818	-32.3551	600	600	1
K_317	Jerrys	Cu	GRZ	M	Carboniferous Undifferentiated	319104.97	6417490.35	151.0774	-32.3649	860	860	1
K_318	Jerrys	Psi	GRZ	M	Permian Singleton	318904.97	6417190.35	151.0752	-32.3676	904	904	1

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K_130	Jerrys	Cc	H2O	M	Carboniferous Conglomerate	320804.98	6423090.30	151.0965	-32.3147	1236	1236	1
K_215	Jerrys	Pm	H2O	Water	Permian Maitland	311204.97	6418290.60	150.9936	-32.3564	1923	1923	1
K_192	Jerrys	Pm	MMI	Water	Permian Maitland	305904.96	6417590.79	150.9372	-32.3618	1950	1950	1
K_MAS_590_6	Jerrys	Psi	GRZ	VH	Permian Singleton	295604.96	6409991.21	150.8261	-32.4285	1625	1625	1
K_213	Jerrys	Pm	H2O	VH	Permian Maitland	309804.97	6419690.65	150.9790	-32.3435	2050	2050	1
K_DR_SC3_1	Jerrys	Pm	H2O	VH	Permian Maitland	300404.96	6415291.00	150.8783	-32.3816	4300	4300	1
K_DR_SC3_3	Jerrys	Pm	H2O	VH	Permian Maitland	300404.96	6415291.00	150.8783	-32.3816	6100	6100	1
K_DR_SC2_1	Jerrys	Pg	MMI	VH	Permian Greta	301804.96	6416090.95	150.8933	-32.3746	168	168	1
K_DR_SC2_2	Jerrys	Pg	MMI	VH	Permian Greta	301804.97	6416190.94	150.8933	-32.3737	209	209	1
K_124	Jerrys	Psi	CON	SAL	Permian Singleton	317004.98	6416090.41	151.0548	-32.3772	4050	4050	1
K_321	Jerrys	Psi	CON	SAL	Permian Singleton	317004.98	6416090.41	151.0548	-32.3772	2260	2260	1
K_105	Jerrys	Q	CON	SAL	Quaternary	314604.97	6411890.49	151.0285	-32.4147	6520	6520	1
K_312	Jerrys	Psi	DEG	SAL	Permian Singleton	319604.98	6410490.34	151.0813	-32.4281	12010	12010	1
K_162	Jerrys	Cu	GRZ	SAL	Carboniferous Undifferentiated	325904.98	6428090.15	151.1515	-32.2704	1990	1990	1
K_118	Jerrys	Psi	H2O	SAL	Permian Singleton	317704.98	6409190.40	151.0609	-32.4395	2630	2630	1
K_115	Jerrys	Q	H2O	SAL	Quaternary	318604.97	6406790.37	151.0700	-32.4613	3160	3160	1
MGW02	Jerrys	Q	H2O	Water	Quaternary	311516.62	6415065.99	150.9963	-32.3855	2414	2596	393
BWGM1D15	Jerrys	Q	CON	SAL	Quaternary	313917.27	6413289.82	151.0214	-32.4019	2893	3232	97
SW39	Jerrys	Psi	GRZ	VH	Permian Singleton	307353.96	6398648.75	150.9487	-32.5328	388		7
Plaschett	Jerrys	Pm	H2O	VH	Permian Maitland	309839.01	6419827.61	150.9794	-32.3423	6501.724976	7499	1352
JJW11	Kars Springs	Q	GRZ	L	Quaternary	267294.80	6461899.12	150.5379	-31.9551	694.5	807	6
WQ_21010355	Kars Springs	Tb	GRZ	L	Tertiary Basalt	267413.60	6462151.76	150.5392	-31.9528	807	807	3
WQ_21010227	Kars Springs	Tns	GRZ	L	Triassic Narrabeen Ss	271943.07	6453323.01	150.5850	-32.0333	720	835	6
53046	Kars Springs	Tns	H2O	L	Triassic Narrabeen Ss	271433.79	6453908.48	150.5797	-32.0279	658	658	1
JJW30	Kars Springs	Tb	GRZ	M	Tertiary Basalt	273100.49	6453405.54	150.5973	-32.0328	786.5	835	6
210142	Kewell Creek	Cs	GRZ	H	Carboniferous Sandstone	311751.35	6461489.06	151.0079	-31.9670			0
HU25	Krui River	Tb	GRZ	L	Tertiary Basalt			150.1145	-32.1012	813	856	2
WQ_21010170	Krui River	Tb	TRU	L	Tertiary Basalt	227993.93	6445308.50	150.1178	-32.0958	700	950.5	5
SWC_CD03	Krui River	Tb	GRZ	M	Tertiary Basalt	227792.86	6444898.64	150.1156	-32.0994			0
SWC_HU25	Krui River	Tb	GRZ	M	Tertiary Basalt	227792.86	6444898.64	150.1156	-32.0994			0
SWC_TE7_8	Krui River	Tb	GRZ	M	Tertiary Basalt	227792.86	6444898.64	150.1156	-32.0994			0
HUNT511	Krui River	Tb	GRZ	M	Tertiary Basalt	227904.57	6445117.44	150.1168	-32.0975	652	700	2
53033	Krui River	Tb	GRZ	M	Tertiary Basalt	244436.93	6466721.06	150.2975	-31.9067	782	782	1
WQ_210037	Krui River	Q	GRZ	VL	Quaternary	225554.52	6433855.52	150.0887	-32.1984	869	1017	43
WQ_210092	Krui River	Tb	GRZ	VL	Tertiary Basalt	225841.69	6441388.33	150.0939	-32.1306	777	834	65
210092	Krui River	Tb	GRZ	VL	Tertiary Basalt	225997.34	6441570.11	150.0956	-32.1290			0
WW70	Krui River	Q	H2O	VL	Quaternary	225183.99	6433738.26	150.0847	-32.1994	870	915	5
210037	Krui River	Q	H2O	VL	Quaternary	225506.47	6433887.52	150.0882	-32.1981			0
W-STP-DRT	Lower Dart Brook	Psi	CON	L	Permian Singleton	298844.37	6436036.87	150.8661	-32.1942			0
HUNT585	Lower Dart Brook	Psi	GRZ	L	Permian Singleton	298799.01	6436107.66	150.8656	-32.1936	1284	1409	2
WQ_21010264	Lower Dart Brook	Q	GRZ	L	Quaternary	297662.06	6441564.64	150.8547	-32.1442	397.5	795	2
210032	Lower Dart Brook	Q	GRZ	L	Quaternary	297323.75	6442911.15	150.8514	-32.1320			0
W-DART-DRT	Lower Dart Brook	Q	H2O	L	Quaternary	299615.37	6435644.35	150.8742	-32.1979			0

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W-DARTUP-DRT	Lower Dart Brook	Q	H2O	L	Quaternary	298733.26	6436340.68	150.8650	-32.1915			0
WQ_210088	Lower Dart Brook	Q	H2O	L	Quaternary	298962.02	6438351.53	150.8678	-32.1734	1676	2180	50
WQ_21010090	Lower Dart Brook	Q	H2O	L	Quaternary	298738.47	6436306.12	150.8650	-32.1918	3643	4247	38
WQ_21010320	Lower Dart Brook	Q	H2O	L	Quaternary	293857.60	6452336.57	150.8167	-32.0464	651.5	679.5	10
MK_OEH2	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	243612.37	6409633.79	150.2735	-32.4209	342	342	1
MK_OEH3	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	243641.56	6409633.42	150.2738	-32.4209	350	350	1
WW_DB25	Lower Goulburn River	Q	GRZ	L	Quaternary	270000.83	6418412.42	150.5560	-32.3476	1080	1200	117
MK_OEH5	Lower Goulburn River	Q	TRU	L	Quaternary	240924.05	6411421.46	150.2455	-32.4042	4160	4160	1
HU47	Lower Goulburn River	Q	GRZ	L	Quaternary			150.3150	-32.4176	1250	1360	2
HU11	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss			150.2385	-32.3095	1120	1140	2
WQ_210003	Lower Goulburn River	Q	AGR	L	Quaternary	274843.24	6415189.87	150.6067	-32.3776	1660	1660	1
WQ_210031	Lower Goulburn River	Q	AGR	L	Quaternary	271881.06	6418976.34	150.5761	-32.3429	885	1103	394
210003	Lower Goulburn River	Q	AGR	L	Quaternary	274901.94	6415091.33	150.6073	-32.3785			0
210031	Lower Goulburn River	Q	AGR	L	Quaternary	271712.87	6418714.06	150.5743	-32.3452	833.5	1083.5	6639
JJGY	Lower Goulburn River	Psi	GRZ	L	Permian Singleton	277756.90	6411437.57	150.6368	-32.4120	865	865	1
CJ_J32	Lower Goulburn River	Q	GRZ	L	Quaternary	242953.86	6411970.83	150.2672	-32.3997	460	460	1
SWC_HU47	Lower Goulburn River	Q	GRZ	L	Quaternary	247603.60	6410300.48	150.3161	-32.4158			0
HUNT507C	Lower Goulburn River	Q	GRZ	L	Quaternary	271599.55	6418312.07	150.5730	-32.3488	719	1170	4
WQ_210016	Lower Goulburn River	Psi	H2O	L	Permian Singleton	247970.45	6410269.01	150.3200	-32.4162	1060	1200	175
CJ_J17	Lower Goulburn River	Q	H2O	L	Quaternary	253338.15	6411563.40	150.3774	-32.4057	1000	1000	1
MG_SW12	Lower Goulburn River	Q	H2O	L	Quaternary	271631.00	6418627.00	150.5734	-32.3460	989	1330	127
MG_SW13	Lower Goulburn River	Q	H2O	L	Quaternary	276436.00	6413762.00	150.6233	-32.3908	1141	1367	140
SWC_HU10	Lower Goulburn River	Q	H2O	L	Quaternary	271702.61	6418612.74	150.5742	-32.3461			0
WQ_21010208	Lower Goulburn River	Q	H2O	L	Quaternary	281242.17	6409273.66	150.6733	-32.4322	810	1213	3
HUNT507A	Lower Goulburn River	Q	H2O	L	Quaternary	271650.88	6418748.15	150.5736	-32.3449			0
HUNT507B	Lower Goulburn River	Q	H2O	L	Quaternary	271661.53	6418527.61	150.5737	-32.3469			0
JJGS	Lower Goulburn River	Q	H2O	L	Quaternary	271643.47	6418613.55	150.5735	-32.3461	1008	1008	1
CJ_J33	Lower Goulburn River	Psi	TRU	L	Permian Singleton	241186.41	6411403.25	150.2482	-32.4044	5200	5200	1
HUNT588	Lower Goulburn River	Psi	GRZ	M	Permian Singleton	247701.27	6410117.98	150.3171	-32.4175	882.5	889	2
210016	Lower Goulburn River	Psi	H2O	M	Permian Singleton	247980.97	6410224.88	150.3201	-32.4166	1071.05	1300.8	3560
CJ_J31	Lower Goulburn River	Psi	TRU	M	Permian Singleton	247360.64	6409564.74	150.3133	-32.4224	1200	1200	1
CJ_J29_	Lower Goulburn River	Q	GRZ	VH	Quaternary	273297.34	6408666.84	150.5887	-32.4361	1300	1300	1
SWC_HU11	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	240082.11	6422100.46	150.2394	-32.3078			0
WQ_21010160	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	240074.85	6422219.89	150.2394	-32.3067	960	1140	4
HUNT07	Lower Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	240004.93	6422007.23	150.2386	-32.3086	960	1140	4
CJ_J28	Lower Goulburn River	Tns	GRZ	SAL	Triassic Narrabeen Ss	273488.72	6409057.33	150.5908	-32.4326	1400	1400	1
CJ_J24	Lower Goulburn River	Q	TRU	SAL	Quaternary	273727.12	6412491.00	150.5942	-32.4017	2400	2400	1
WQ_21010229	Lower Goulburn River	Q	TRU	SAL	Quaternary	273727.12	6412491.00	150.5942	-32.4017	1166	3892	22
K_3	Lower Goulburn River	Q	AGR	L	Quaternary	271704.92	6418692.42	150.5742	-32.3454	1064	1064	1
K_12	Lower Goulburn River	Q	H2O	L	Quaternary	281304.94	6409291.89	150.6740	-32.4320	1269	1269	1
K_8	Lower Goulburn River	Psi	GRZ	VH	Permian Singleton	276204.92	6411392.17	150.6203	-32.4121	1285	1285	1
CJ_MPR_KP0	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	300097.79	6473860.86	150.8872	-31.8535	2344.5	2530	2

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CJ_MPR_KP2	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	300288.34	6473609.15	150.8892	-31.8558	4310.5	4385	2
CJ_MPR_KP4	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	299548.65	6471964.89	150.8810	-31.8705	1245	1390	2
WW63	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	299182.49	6470500.63	150.8768	-31.8836	1130	1160	2
WW64	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	298531.65	6464318.83	150.8687	-31.9392			0
WQ_21010029	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	297324.78	6452339.56	150.8534	-32.0470	675	676	7
WQ_21010314	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	297744.75	6462619.11	150.8600	-31.9544	686.5	749	14
WQ_21010315	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	297210.13	6452403.83	150.8522	-32.0464	678.5	757	4
WQ_21010316	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	294593.18	6457564.80	150.8256	-31.9994	699.5	778	6
WQ_21010319	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	297805.16	6444806.43	150.8569	-32.1150	737	773	5
53048	Lower Middle Brook and Kingdon Ponds	Q	GRZ	L	Quaternary	297691.76	6453412.80	150.8575	-32.0374	671	671	1
CJ_MPR_KP5	Lower Middle Brook and Kingdon Ponds	Q	H2O	L	Quaternary	299472.82	6468865.14	150.8796	-31.8984	1105.5	1270	2
WW65	Lower Middle Brook and Kingdon Ponds	Q	H2O	L	Quaternary	297759.34	6462550.63	150.8601	-31.9550	680	680	3
WQ_21010263	Lower Middle Brook and Kingdon Ponds	Q	H2O	L	Quaternary	298976.84	6441413.28	150.8686	-32.1458	478	956	2
210093	Lower Middle Brook and Kingdon Ponds	Q	H2O	L	Quaternary	297448.18	6462313.76	150.8568	-31.9571			0
52241	Lower Middle Brook and Kingdon Ponds	Q	H2O	L	Quaternary	298638.10	6442315.02	150.8652	-32.1376	1030	1030	1
53032	Lower Middle Brook and Kingdon Ponds	Q	GRZ	VH	Quaternary	294428.20	6465584.47	150.8256	-31.9271	316	316	1
RT_Comleroi Creek	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	315475.00	6397385.00	151.0349	-32.5456	388	724	114
RT_Dam 25S	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	315345.07	6397454.33	151.0335	-32.5449	257	388	28
RT_W27	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	316448.00	6392956.00	151.0444	-32.5857	279	380	27
WW_DB75	Lower Wollombi Brook	Q	GRZ	L	Quaternary	321994.83	6374974.68	151.1000	-32.7487	600	1200	91
WW_DB80	Lower Wollombi Brook	Tns	GRZ	L	Triassic Narrabeen Ss	315429.85	6380212.18	151.0310	-32.7004	1031	2240	11
WW_DB74	Lower Wollombi Brook	Q	GRZ	VL	Quaternary	312750.67	6380887.60	151.0026	-32.6939	740	1160	5
WW_DB81	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314408.02	6385649.01	151.0212	-32.6512	605	760	6
RT_WOLLBK	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314419.00	6385714.00	151.0213	-32.6506	775	980	132
WW_DB73	Lower Wollombi Brook	Q	H2O	L	Quaternary	318990.94	6376040.30	151.0682	-32.7386	840	1170	3
WW_DB76	Lower Wollombi Brook	Q	H2O	L	Quaternary	314361.70	6395027.50	151.0226	-32.5667	935	3990	10
RT_W2WOLL	Lower Wollombi Brook	Q	H2O	L	Quaternary	314916.00	6396358.00	151.0287	-32.5548	700	1230	56
RT_W2WARK	Lower Wollombi Brook	Q	H2O	L	Quaternary	314314.00	6395044.00	151.0220	-32.5665	933.5	2410	68
RT_PCK_U2	Lower Wollombi Brook	Psi	H2O	VH	Permian Singleton	313197.31	6397223.73	151.0106	-32.5467			0
WBRK_WW	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314404.74	6385663.84	151.0212	-32.6511	719		0

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WAR_CA	Lower Wollombi Brook	Q	H2O	L	Quaternary	314267.59	6395054.80	151.0216	-32.5664			0
W2W_CA	Lower Wollombi Brook	Q	H2O	L	Quaternary	314875.01	6396315.38	151.0283	-32.5551			0
COM_CA	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	315473.06	6397358.30	151.0348	-32.5458			0
W27_WW	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	316393.31	6392761.40	151.0437	-32.5874	272		0
HU07	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss			150.9373	-32.7251	294	310	2
CJ_M25	Lower Wollombi Brook	Q	CON	L	Quaternary	311841.51	6391436.76	150.9950	-32.5986	700	1050	9
UC_SW1	Lower Wollombi Brook	Q	CON	L	Quaternary	309250.00	6394500.00	150.9680	-32.5705	1477	2940	2
UC_SW2	Lower Wollombi Brook	Q	CON	L	Quaternary	311910.00	6392160.00	150.9959	-32.5921	2130	2430	92
WQ_21010094	Lower Wollombi Brook	Q	CON	L	Quaternary	311841.51	6391436.76	150.9950	-32.5986	838	838	1
210004	Lower Wollombi Brook	Q	CON	L	Quaternary	315355.66	6394852.15	151.0331	-32.5684	734.7	1797.7	6980
210028	Lower Wollombi Brook	Psi	GRZ	L	Permian Singleton	314305.29	6385692.90	151.0201	-32.6508	675.5	843	4437
WQ_210024	Lower Wollombi Brook	Q	GRZ	L	Quaternary	317333.45	6379204.71	151.0511	-32.7098	1207	1207	1
WQ_210028	Lower Wollombi Brook	Q	GRZ	L	Quaternary	314084.57	6385954.99	151.0178	-32.6484	570	845.5	75
WQ_21010123	Lower Wollombi Brook	Q	GRZ	L	Quaternary	315394.96	6382596.32	151.0311	-32.6789			0
BU_W2	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	316465.28	6382585.30	151.0425	-32.6792	533.5	762	26
CJ_J2	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314407.23	6385650.13	151.0212	-32.6512	1100	1100	1
BU_LR1	Lower Wollombi Brook	Q	H2O	L	Quaternary	322076.21	6374797.52	151.1008	-32.7503	500	967.5	35
BU_LR5	Lower Wollombi Brook	Q	H2O	L	Quaternary	316870.26	6379890.65	151.0463	-32.7035	540	924	31
BU_W4	Lower Wollombi Brook	Q	H2O	L	Quaternary	317146.39	6384515.86	151.0501	-32.6619	592	784	36
CJ_J1	Lower Wollombi Brook	Q	H2O	L	Quaternary	312395.54	6380766.06	150.9988	-32.6949	600	600	1
CJ_M22	Lower Wollombi Brook	Q	H2O	L	Quaternary	314252.53	6395051.07	151.0214	-32.5664	770	1500	9
CJ_M23	Lower Wollombi Brook	Q	H2O	L	Quaternary	312332.80	6392676.31	151.0005	-32.5875	680	940	7
UC_SW3	Lower Wollombi Brook	Q	H2O	L	Quaternary	312524.50	6392858.80	151.0026	-32.5859	810	2620	97
UC_SW4	Lower Wollombi Brook	Q	H2O	L	Quaternary	314340.00	6395060.00	151.0223	-32.5664	962	2045	95
WW147	Lower Wollombi Brook	Q	H2O	L	Quaternary	314252.58	6395051.20	151.0214	-32.5664			0
WQ_21010106	Lower Wollombi Brook	Q	H2O	L	Quaternary	313699.01	6387001.53	151.0139	-32.6389	1004	1004	1
WQ_21010124	Lower Wollombi Brook	Q	H2O	L	Quaternary	319340.61	6370434.48	151.0708	-32.7892	522	522	1
210024	Lower Wollombi Brook	Q	H2O	L	Quaternary	317605.71	6379187.53	151.0540	-32.7100			0
52038	Lower Wollombi Brook	Q	H2O	L	Quaternary	321998.85	6372245.09	151.0995	-32.7733	543	543	1
52240	Lower Wollombi Brook	Q	H2O	L	Quaternary	321791.16	6375406.93	151.0979	-32.7448	366	366	1
UC_SW5	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	313667.10	6396193.00	151.0154	-32.5560	6350	8640	71
UC_SW6	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	311031.00	6396668.00	150.9874	-32.5513	1170	1850	21
WQ_210004	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	316585.04	6394625.95	151.0461	-32.5706	945	1800	387
WAMBO_LDP	Lower Wollombi Brook	Q	MMI	VH	Quaternary	313094.60	6393129.04	151.0087	-32.5836			0
WQ_210048	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	318422.57	6362775.25	151.0595	-32.8581	450	530	86
WQ_21010095	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	306568.19	6375806.21	150.9356	-32.7386	168	168	1
WQ_21010159	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	305383.85	6375006.56	150.9228	-32.7456	204	294	5
WQ_210135	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	318402.80	6363850.82	151.0595	-32.8484	385.5	470	24
210048	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	318422.57	6362775.25	151.0595	-32.8581			0
210135	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	318402.80	6363850.82	151.0595	-32.8484			0
HUNT05	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	305303.21	6374816.39	150.9219	-32.7473	241	310	6
52030	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	306652.85	6375743.53	150.9365	-32.7392	334	334	1
WQ_21010096	Lower Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	319952.17	6361549.85	151.0756	-32.8694	434	1110	3

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WQ_21010102	Lower Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	318205.24	6360342.06	151.0567	-32.8800	67	67	1
WQ_21010122	Lower Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	310301.77	6380592.59	150.9764	-32.6961			0
CJ_M24	Lower Wollombi Brook	Q	CON	SAL	Quaternary	309870.54	6393447.45	150.9744	-32.5801	2210	2600	7
52221	Lower Wollombi Brook	Psi	GRZ	SAL	Permian Singleton	326334.47	6376262.79	151.1465	-32.7378	1118	1118	1
UC_DAM1	Lower Wollombi Brook	Psi	H2O	SAL	Permian Singleton	313170.37	6396564.71	151.0102	-32.5526	1110	1829	180
BU_LR2	Lower Wollombi Brook	Q	H2O	SAL	Quaternary	321111.95	6377363.28	151.0910	-32.7270	3940	5120	36
WQ_21010277	Lower Wollombi Brook	Q	TRU	SAL	Quaternary	321173.15	6377400.08	151.0917	-32.7267	3083	4800	2
CA83_110	Lower Wollombi Brook	Psi	CON	L	Permian Singleton	317291.63	6385297.02	151.0518	-32.6549	16600	16600	2
CA83_211	Lower Wollombi Brook	Q	CON	L	Quaternary	310666.59	6390592.88	150.9823	-32.6060	5400	5400	1
CA83_18B	Lower Wollombi Brook	Q	CON	L	Quaternary	310833.61	6392576.22	150.9845	-32.5882			0
CA83_11	Lower Wollombi Brook	Q	CON	L	Quaternary	312594.26	6392617.97	151.0033	-32.5881			0
CA83_222	Lower Wollombi Brook	Q	GRZ	L	Quaternary	316992.39	6379701.92	151.0476	-32.7053	850	850	1
CA83_13	Lower Wollombi Brook	Q	H2O	L	Quaternary	313429.35	6393160.78	151.0123	-32.5833	365	365	1
CA83_180	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	315106.48	6398192.19	151.0311	-32.5382	3600	4400	2
CA83_98	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	315350.05	6397524.12	151.0336	-32.5443	3050	3100	2
CA83_99	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	313659.00	6396612.48	151.0154	-32.5522	4190	5000	2
CA83_212	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	311501.68	6393139.90	150.9917	-32.5832	1150	1150	1
CA83_113	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	309942.85	6392478.79	150.9750	-32.5889	3000	3000	3
CA83_196	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	313123.15	6394357.74	151.0092	-32.5725	500	500	1
CA83_9	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	314779.41	6389451.59	151.0259	-32.6170			0
CA83_184	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	322086.44	6379381.80	151.1018	-32.7090	550	610	2
CA83_220	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	321105.21	6378435.37	151.0912	-32.7174	270	270	1
CA83_10	Lower Wollombi Brook	Q	CON	VH	Quaternary	313867.77	6394851.83	151.0173	-32.5682			0
CA83_12	Lower Wollombi Brook	Q	CON	VH	Quaternary	312065.37	6391351.42	150.9974	-32.5994			0
CA83_197	Lower Wollombi Brook	Q	CON	VH	Quaternary	311550.39	6392061.24	150.9920	-32.5929	2150	2150	1
CA83_191	Lower Wollombi Brook	Psi	DEG	VH	Permian Singleton	314006.95	6395492.07	151.0189	-32.5624	14200	14200	1
CA83_183	Lower Wollombi Brook	Psi	DEG	VH	Permian Singleton	321627.14	6378386.65	151.0967	-32.7179	350	525	3
CA83_221	Lower Wollombi Brook	Psi	DEG	VH	Permian Singleton	320875.56	6379019.93	151.0888	-32.7120	17900	17900	1
CA83_193	Lower Wollombi Brook	Psi	TRU	VH	Permian Singleton	313888.64	6397162.25	151.0179	-32.5473	172.5	200	2
CA83_8	Lower Wollombi Brook	Psi	CON	SAL	Permian Singleton	316748.83	6389583.81	151.0469	-32.6161			0
K_218	Lower Wollombi Brook	Psi	CON	L	Permian Singleton	313004.97	6388791.56	151.0069	-32.6226	550	550	1
K_219	Lower Wollombi Brook	Q	CON	L	Quaternary	311104.97	6390691.62	150.9870	-32.6052	611	611	1
K_220	Lower Wollombi Brook	Q	CON	L	Quaternary	311004.97	6392391.63	150.9863	-32.5898	1637	1637	1
K_37	Lower Wollombi Brook	Q	CON	L	Quaternary	314904.97	6396391.49	151.0286	-32.5544	1169	1169	1
K_43	Lower Wollombi Brook	Q	GRZ	L	Quaternary	322004.98	6374691.29	151.1001	-32.7513	653	653	1
K_50	Lower Wollombi Brook	Q	GRZ	L	Quaternary	314904.97	6385691.50	151.0265	-32.6509	995	995	1
K_39	Lower Wollombi Brook	Q	H2O	L	Quaternary	315104.97	6395491.49	151.0306	-32.5626	1138	1138	1
K_41	Lower Wollombi Brook	Q	H2O	L	Quaternary	315004.97	6395691.49	151.0295	-32.5608	1270	1270	1
K_47	Lower Wollombi Brook	Q	H2O	L	Quaternary	317504.98	6379391.42	151.0530	-32.7081	772	772	1
K_UC_2_4	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	313704.98	6396190.53	151.0158	-32.5561	14100	14100	1
K_38	Lower Wollombi Brook	Q	CON	VH	Quaternary	314304.97	6395091.51	151.0220	-32.5661	1157	1157	1
K_44	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	318404.98	6362691.41	151.0593	-32.8589	475	475	1
K_UC_3_1	Lower Wollombi Brook	Psi	CON	SAL	Permian Singleton	315404.97	6396491.48	151.0339	-32.5536	1900	1900	1

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K_UC_3_2	Lower Wollombi Brook	Psi	CON	SAL	Permian Singleton	315404.97	6396491.48	151.0339	-32.5536	2200	2200	1
K_UC_3_3	Lower Wollombi Brook	Psi	CON	SAL	Permian Singleton	315404.97	6396491.48	151.0339	-32.5536	2200	2200	1
SW01	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314409.97	6385706.52	151.0212	-32.6507	880	988	41
SW06	Lower Wollombi Brook	Q	CON	VH	Quaternary	309060.96	6389555.70	150.9650	-32.6151	370	492	25
SW07	Lower Wollombi Brook	Q	CON	L	Quaternary	311282.97	6390675.62	150.9889	-32.6054	446	591	20
SW40	Lower Wollombi Brook	Q	H2O	L	Quaternary	311913.97	6391105.60	150.9957	-32.6016	621		0
SW41	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	306751.96	6391151.78	150.9407	-32.6003			0
SW05	Lower Wollombi Brook	Q	CON	L	Quaternary	311899.97	6392163.60	150.9958	-32.5921	2050	2140	42
SW08	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	308482.97	6392150.72	150.9594	-32.5916	353		0
SW03	Lower Wollombi Brook	Q	H2O	L	Quaternary	312512.97	6392869.57	151.0024	-32.5858	2244	3269	42
MW15	Lower Wollombi Brook	Q	MMI	VH	Quaternary	313054.97	6393111.56	151.0083	-32.5837			0
SW32	Lower Wollombi Brook	Q	CON	L	Quaternary	309957.97	6393666.66	150.9754	-32.5782	1107		0
SW48	Lower Wollombi Brook	Q	CON	L	Quaternary	309645.97	6394332.67	150.9722	-32.5721			0
SW02	Lower Wollombi Brook	Q	H2O	L	Quaternary	314355.97	6395038.51	151.0225	-32.5666	2423	3610	41
SW47	Lower Wollombi Brook	Psi	CON	VH	Permian Singleton	308180.97	6395029.72	150.9567	-32.5656			0
PR_4	Lower Wollombi Brook	Q	AGR	L	Quaternary	321711.22	6374960.43	151.0970	-32.7488	405	1011	3
PR_6	Lower Wollombi Brook	Q	GRZ	L	Quaternary	320048.18	6371249.65	151.0785	-32.7820	370	370	1
PR_T1	Lower Wollombi Brook	Psi	H2O	L	Permian Singleton	314299.47	6381751.48	151.0193	-32.6863	398	398	1
PR_3	Lower Wollombi Brook	Q	H2O	L	Quaternary	317395.72	6379519.77	151.0518	-32.7070	510	1584	3
PR_2	Lower Wollombi Brook	Q	H2O	L	Quaternary	314254.84	6385928.57	151.0196	-32.6487	536	838	3
PR_1	Lower Wollombi Brook	Q	H2O	L	Quaternary	314411.82	6395057.56	151.0231	-32.5664	643	1373	3
PR_T3	Lower Wollombi Brook	Psi	H2O	VH	Permian Singleton	318109.35	6376045.61	151.0588	-32.7384	594	594	1
PR_5	Lower Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	322171.36	6372120.99	151.1013	-32.7745	514	631	2
PR_T2	Lower Wollombi Brook	Q	H2O	SAL	Quaternary	321229.22	6377393.90	151.0923	-32.7268	3520	3520	1
PR_TS	Lower Wollombi Brook	Q	H20	L	Quaternary			151.0674	-32.8153	422	540	67
WQ_210064	Luskintyre	Pd	GRZ	H	Permian Dalwood	350071.28	6384711.48	151.4011	-32.6651	777	1025.5	300
51192	Luskintyre	Cc	H2O	H	Carboniferous Conglomerate	353209.99	6390753.87	151.4356	-32.6110	1140	1140	1
52011	Luskintyre	Pg	RES	H	Permian Greta	350029.94	6387266.54	151.4011	-32.6420	3370	3370	1
WQ_21010242	Luskintyre	Cc	TRU	H	Carboniferous Conglomerate	353500.88	6390438.77	151.4386	-32.6139	866	1375	2
WQ_21010245	Luskintyre	Cc	H2O	L	Carboniferous Conglomerate	348325.92	6391281.85	151.3836	-32.6056	1011.5	1159	26
WQ_21010246	Luskintyre	Cc	GRZ	VH	Carboniferous Conglomerate	345105.74	6391919.94	151.3494	-32.5994	171	1920	4
51001	Luskintyre	Pm	GRZ	SAL	Permian Maitland	346615.24	6390698.98	151.3653	-32.6106	8000	8000	1
WQ_21010358	Manobalai	Q	AGR	L	Quaternary	280016.93	6435717.29	150.6664	-32.1936	1463	1463	3
WQ_21010364	Manobalai	Q	AGR	L	Quaternary	280016.93	6435717.29	150.6664	-32.1936	380	380	1
JJGO	Manobalai	Q	AGR	L	Quaternary	280591.94	6435833.91	150.6725	-32.1927	1029	1029	1
JJHV	Manobalai	Q	AGR	L	Quaternary	280591.87	6435837.00	150.6725	-32.1926	1515	1515	1
JJW55	Manobalai	Q	GRZ	L	Quaternary	279873.09	6435487.05	150.6648	-32.1956	1136.5	1463	4
JJM	Manobalai	Tns	GRZ	VL	Triassic Narrabeen Ss	283600.87	6436339.90	150.7045	-32.1887			0
WW_DB44	Martindale Creek	Psi	GRZ	L	Permian Singleton	285507.77	6399135.67	150.7163	-32.5244	325	455	40
CJ_J26	Martindale Creek	Psi	GRZ	L	Permian Singleton	285402.49	6398386.62	150.7150	-32.5311	860	860	1
210090	Martindale Creek	Psi	GRZ	L	Permian Singleton	283400.39	6400400.81	150.6942	-32.5126			0
CJ_J25	Martindale Creek	Psi	H2O	L	Permian Singleton	285011.38	6399408.73	150.7111	-32.5219	620	620	1
CJ_J27	Martindale Creek	Psi	H2O	L	Permian Singleton	284202.07	6399950.64	150.7026	-32.5168	960	960	1

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WQ_210090	Martindale Creek	Psi	GRZ	VH	Permian Singleton	283397.03	6400556.06	150.6942	-32.5112	618.5	811	66
WQ_21010196	Martindale Creek	Psi	GRZ	VH	Permian Singleton	285902.18	6390691.89	150.7186	-32.6006	199.5	250	2
HUNT580	Martindale Creek	Psi	H2O	VH	Permian Singleton	285802.73	6390512.25	150.7175	-32.6022	199.5	250	2
K_11	Martindale Creek	Q	GRZ	L	Quaternary	281604.94	6402291.89	150.6755	-32.4952	1231	1231	1
K_10	Martindale Creek	Q	H2O	L	Quaternary	280804.94	6405591.93	150.6678	-32.4653	1277	1277	1
K_5	Martindale Creek	Psi	GRZ	VH	Permian Singleton	283504.94	6400491.79	150.6953	-32.5118	761	761	1
HU48	Merriwa River	Tns	CON	VL	Triassic Narrabeen Ss			150.3399	-32.3640	1384	1548	2
HU26	Merriwa River	Tb	AGR	VL	Tertiary Basalt			150.3646	-32.0967	1075	1090	2
WQ_21010214	Merriwa River	Q	H2O	L	Quaternary	255649.91	6459602.86	150.4142	-31.9733	957	957	1
WQ_21010215	Merriwa River	Q	H2O	L	Quaternary	253099.92	6458276.64	150.3869	-31.9847	468	900	3
WQ_21010280	Merriwa River	Q	H2O	L	Quaternary	251226.47	6445925.62	150.3639	-32.0956	1027	1027	1
53030	Merriwa River	Tb	GRZ	M	Tertiary Basalt	245536.17	6440307.44	150.3022	-32.1450	317	317	1
WW74	Merriwa River	Jsh	AGR	VL	Jurassic Shale	250031.90	6441113.80	150.3500	-32.1387	1120	1280	2
SWC_HU26	Merriwa River	Tb	AGR	VL	Tertiary Basalt	251381.13	6445995.98	150.3656	-32.0950			0
SWC_HU48	Merriwa River	Tns	CON	VL	Triassic Narrabeen Ss	249781.31	6416304.16	150.3408	-32.3622			0
WQ_210066	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	249004.55	6423544.64	150.3345	-32.2968	1150	1756	95
WQ_21010192	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	248310.90	6424903.37	150.3275	-32.2844	630	982	26
210066	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	248979.81	6423596.60	150.3343	-32.2963	1598.2	2100	3763
HUNT578	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	248202.55	6424712.02	150.3263	-32.2861	1008	1034	2
52392	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	247051.38	6432973.74	150.3163	-32.2114	2160	2160	1
53018	Merriwa River	Tns	GRZ	VL	Triassic Narrabeen Ss	249621.28	6435375.67	150.3442	-32.1903	8130	8130	1
WQ_210091	Merriwa River	Jsh	H2O	VL	Jurassic Shale	250315.14	6441498.04	150.3531	-32.1353	971.5	1044	72
WQ_21010309	Merriwa River	Jsh	H2O	VL	Jurassic Shale	249742.95	6440962.43	150.3469	-32.1400	1020	1130	16
WQ_21010284	Merriwa River	Tns	H2O	VL	Triassic Narrabeen Ss	248056.75	6432076.67	150.3267	-32.2197	1452	1452	1
210091	Merriwa River	Jsh	RES	VL	Jurassic Shale	250403.71	6440967.60	150.3539	-32.1401			0
WW_DB45	Munmurra River	Jsh	GRZ	VL	Jurassic Shale	212687.86	6448492.94	149.9568	-32.0633	740	740	1
HU28	Munmurra River	Q	GRZ	M	Quaternary			150.0072	-31.9823	815	840	2
SWC_HU21a	Munmurra River	Jsh	GRZ	SAL	Jurassic Shale	207705.57	6442634.16	149.9023	-32.1148			0
WW79	Munmurra River	Q	H2O	L	Quaternary	214802.29	6454579.13	149.9809	-32.0090			0
WQ_21010216	Munmurra River	Q	H2O	L	Quaternary	213406.75	6453321.58	149.9658	-32.0200	934	991	27
SWC_HU21b	Munmurra River	Tb	AGR	M	Tertiary Basalt	209898.76	6444712.11	149.9261	-32.0967			0
SWC_HU28	Munmurra River	Tb	GRZ	M	Tertiary Basalt	217304.66	6457808.50	150.0083	-31.9806			0
SWC_HU34	Munmurra River	Jsh	GRZ	VL	Jurassic Shale	211086.95	6442618.38	149.9381	-32.1158			0
WW78	Munmurra River	Q	GRZ	VL	Quaternary	218513.43	6436874.96	150.0150	-32.1695			0
WQ_210086	Munmurra River	Jsh	H2O	VL	Jurassic Shale	218332.28	6442781.14	150.0148	-32.1162	778	830	71
210086	Munmurra River	Jsh	H2O	VL	Jurassic Shale	218303.66	6442791.45	150.0145	-32.1161			0
53047	Munmurra River	Jsh	H2O	VL	Jurassic Shale	213234.03	6450721.56	149.9632	-32.0434	668	668	1
WW_DB47	Murrurundi	Tns	TRU	VL	Triassic Narrabeen Ss	294500.72	6483562.24	150.8301	-31.7650	360	470	33
WQ_21010223	Murrurundi	Q	H2O	L	Quaternary	300564.47	6482506.17	150.8939	-31.7756	481	485	4
WW84	Murrurundi	Q	RES	L	Quaternary	301134.56	6481638.42	150.8997	-31.7835	395	470	2
210199	Murrurundi	Q	TRU	L	Quaternary	300802.04	6481490.36	150.8962	-31.7848			0
HUNT582	Murrurundi	Tb	GRZ	M	Tertiary Basalt	291099.94	6481508.80	150.7938	-31.7829	411	494	2
WQ_21010312	Murrurundi	Tb	H2O	M	Tertiary Basalt	291106.71	6481642.05	150.7939	-31.7817	456	628	9

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53004	Murrurundi	Pm	GRZ	VH	Permian Maitland	299334.06	6480444.76	150.8805	-31.7940	779	779	1
WW85	Murrurundi	Pm	H2O	VH	Permian Maitland	295308.16	6483764.77	150.8387	-31.7633			0
WQ_21010019	Murrurundi	Pm	RES	VH	Permian Maitland	294403.27	6484048.78	150.8292	-31.7606	411	494	2
HUNT510	Murrurundi	Pm	RES	VH	Permian Maitland	300896.50	6481015.26	150.8971	-31.7891	560.5	600	2
WW_DB58	Muswellbrook	Cc	GRZ	H	Carboniferous Conglomerate	310062.88	6434572.60	150.9847	-32.2094	3778	3778	1
WW_DB11	Muswellbrook	Cu	GRZ	L	Carboniferous Undifferentiated	309400.73	6445012.30	150.9798	-32.1152			0
HU21	Muswellbrook	Cu	AGR	L	Carboniferous Undifferentiated	309799.97	6444501.63	150.9839	-32.1198	340	360	2
BG_SW05	Muswellbrook	Psi	CON	VH	Permian Singleton	294697.72	6424998.24	150.8197	-32.2930			0
BG_MT	Muswellbrook	Psi	CON	VH	Permian Singleton	294884.20	6426074.68	150.8219	-32.2833			0
BG_WW	Muswellbrook	Psi	CON	VH	Permian Singleton	294506.67	6426512.60	150.8180	-32.2793			0
BG_SW01	Muswellbrook	Psi	CON	VH	Permian Singleton	294228.73	6426604.71	150.8151	-32.2784			0
BG_SW03	Muswellbrook	Psi	CON	VH	Permian Singleton	294361.43	6427384.39	150.8167	-32.2714			0
BG_SW04	Muswellbrook	Psi	CON	VH	Permian Singleton	294849.02	6428737.25	150.8221	-32.2593			0
BG_NDS	Muswellbrook	Psi	TRU	VH	Permian Singleton	297649.31	6428532.01	150.8518	-32.2617			0
CJ_M3	Muswellbrook	Pm	GRZ	H	Permian Maitland	306215.27	6429396.55	150.9429	-32.2554	490	710	12
CJ_M5	Muswellbrook	Pm	GRZ	H	Permian Maitland	302957.98	6430726.56	150.9086	-32.2428	6875	7450	10
MA_SW17	Muswellbrook	Pm	GRZ	H	Permian Maitland	300246.00	6421359.00	150.8778	-32.3268	3335		0
MA_SW18	Muswellbrook	Pm	GRZ	H	Permian Maitland	300903.00	6419386.00	150.8844	-32.3447	2615		0
WQ_21010148	Muswellbrook	Q	GRZ	H	Quaternary	306102.42	6426600.15	150.9411	-32.2806	1465	2125	10
WQ_21010149	Muswellbrook	Q	GRZ	H	Quaternary	305038.69	6426058.34	150.9297	-32.2853	755	804	2
MA_SW05	Muswellbrook	Pm	H2O	H	Permian Maitland	301051.12	6419374.59	150.8860	-32.3449			0
WQ_21010153	Muswellbrook	Pm	RES	H	Permian Maitland	301355.69	6428393.58	150.8911	-32.2636	1895	2250	6
WW80	Muswellbrook	Q	RES	H	Quaternary	301400.72	6427412.39	150.8914	-32.2725	1550	2200	19
CJ_M4	Muswellbrook	Pm	SRC	H	Permian Maitland	301726.88	6429356.34	150.8952	-32.2550	3370	4800	9
HUNT573	Muswellbrook	Cu	AGR	L	Carboniferous Undifferentiated	309704.85	6444514.90	150.9829	-32.1197	337.5	361	2
21010059	Muswellbrook	Q	AGR	L	Quaternary	310001.71	6444287.54	150.9860	-32.1218			0
21010060	Muswellbrook	Q	AGR	L	Quaternary	309901.75	6444585.13	150.9850	-32.1191			0
WQ_21010295	Muswellbrook	Cm	CON	L	Carboniferous Mudstone	311145.35	6445728.53	150.9984	-32.1090	474	556	39
WQ_21010088	Muswellbrook	Cu	GRZ	L	Carboniferous Undifferentiated	309914.30	6445428.31	150.9853	-32.1115	281.6	327	4
MA_SW14	Muswellbrook	Psi	GRZ	L	Permian Singleton	295631.06	6423138.06	150.8292	-32.3099	2845		0
210033	Muswellbrook	Psi	GRZ	L	Permian Singleton	286802.77	6422594.67	150.7354	-32.3132			0
53010	Muswellbrook	Psi	GRZ	L	Permian Singleton	288682.85	6434418.58	150.7580	-32.2070	1090	1090	1
MG_SW02	Muswellbrook	Q	GRZ	L	Quaternary	286917.00	6423773.00	150.7369	-32.3026	3940	5465	137
WQ_21010265	Muswellbrook	Q	GRZ	L	Quaternary	286918.26	6423817.40	150.7369	-32.3022	5500	6000	2
210088	Muswellbrook	Q	GRZ	L	Quaternary	286507.97	6421390.34	150.7320	-32.3240			0
WQ_210015	Muswellbrook	Cm	H2O	L	Carboniferous Mudstone	310462.25	6445405.27	150.9911	-32.1118	360	430	186
210015	Muswellbrook	Cm	H2O	L	Carboniferous Mudstone	310452.60	6445416.18	150.9910	-32.1117	342	473.7	5994
CJ_J4	Muswellbrook	Q	H2O	L	Quaternary	301070.89	6428058.90	150.8880	-32.2666	2200	2200	1
WQ_21010151	Muswellbrook	Q	H2O	L	Quaternary	302304.48	6426626.34	150.9008	-32.2797	158.5	803	4
WQ_21010141	Muswellbrook	Pm	RES	L	Permian Maitland	301291.87	6427804.43	150.8903	-32.2689	1860	2580	147
WW81	Muswellbrook	Q	RES	L	Quaternary	301137.43	6427894.57	150.8887	-32.2681	1540	2000	38
WQ_21010047	Muswellbrook	Cm	CON	M	Carboniferous Mudstone	311100.64	6445594.61	150.9979	-32.1102	337	373	80
WQ_21010296	Muswellbrook	Cm	CON	M	Carboniferous Mudstone	311221.46	6445696.67	150.9992	-32.1093			0

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WQ_21010298	Muswellbrook	Cm	CON	M	Carboniferous Mudstone	311252.45	6445553.06	150.9995	-32.1106			0
210097	Muswellbrook	Cm	CON	M	Carboniferous Mudstone	310584.79	6446427.95	150.9926	-32.1026			0
WQ_21010143	Muswellbrook	Cc	GRZ	M	Carboniferous Conglomerate	312907.66	6429534.64	151.0139	-32.2553	1050	1160	11
52346	Muswellbrook	Cc	GRZ	M	Carboniferous Conglomerate	313229.16	6426215.38	151.0167	-32.2853	1020	1020	1
53007	Muswellbrook	Cc	GRZ	M	Carboniferous Conglomerate	310423.10	6434572.70	150.9885	-32.2095	2520	2520	1
WW97	Muswellbrook	Cu	GRZ	M	Carboniferous Undifferentiated	307058.66	6435296.33	150.9530	-32.2024			0
WQ_21010262	Muswellbrook	Cu	GRZ	M	Carboniferous Undifferentiated	320901.41	6436367.15	151.1000	-32.1950	1396	1563	18
WQ_21010145	Muswellbrook	Q	GRZ	M	Quaternary	311163.84	6427527.92	150.9950	-32.2731	342.5	437	2
WQ_21010144	Muswellbrook	Pm	H2O	M	Permian Maitland	311394.16	6427809.51	150.9975	-32.2706	1013	1210	10
W-Lt,Pd3-DRT	Muswellbrook	Psi	CON	VH	Permian Singleton	302117.58	6435873.78	150.9007	-32.1963			0
W-Lt,Pd1-DRT	Muswellbrook	Psi	CON	VH	Permian Singleton	302141.42	6435982.75	150.9010	-32.1953			0
W-REA_S4_DAM-DRT	Muswellbrook	Psi	CON	VH	Permian Singleton	301671.23	6435660.75	150.8960	-32.1981			0
W-JD2-DRT	Muswellbrook	Psi	CON	VH	Permian Singleton	301659.08	6436945.64	150.8961	-32.1866			0
W-SD-DRT	Muswellbrook	Psi	CON	VH	Permian Singleton	301909.46	6435186.04	150.8984	-32.2025			0
MA_SW04	Muswellbrook	Psi	CON	VH	Permian Singleton	294262.84	6419453.28	150.8139	-32.3429	9045		0
BEN_LDP	Muswellbrook	Psi	CON	VH	Permian Singleton	294207.34	6426654.71	150.8149	-32.2780			0
BENG	Muswellbrook	Psi	CON	VH	Permian Singleton	295999.96	6428002.17	150.8342	-32.2662			0
MA_SW23	Muswellbrook	Pg	DEG	VH	Permian Greta	302503.00	6420431.00	150.9016	-32.3356			0
MA_SW10	Muswellbrook	Pg	GRZ	VH	Permian Greta	302466.73	6420806.34	150.9013	-32.3322			0
MA_SW12	Muswellbrook	Pg	GRZ	VH	Permian Greta	302204.72	6421714.54	150.8987	-32.3240	5100		0
MA_SW15	Muswellbrook	Pm	GRZ	VH	Permian Maitland	298853.82	6424847.56	150.8638	-32.2951	3160		0
MA_SW16	Muswellbrook	Pm	GRZ	VH	Permian Maitland	298752.33	6424783.60	150.8627	-32.2957	1560		0
MA_SW28	Muswellbrook	Pm	GRZ	VH	Permian Maitland	298190.00	6424890.00	150.8568	-32.2946			0
W-ND-DRT	Muswellbrook	Psi	GRZ	VH	Permian Singleton	301650.35	6437393.86	150.8961	-32.1825			0
W-JD1-DRT	Muswellbrook	Psi	GRZ	VH	Permian Singleton	301883.81	6436977.34	150.8985	-32.1863			0
MG_SCU1	Muswellbrook	Psi	GRZ	VH	Permian Singleton	287658.00	6425511.00	150.7451	-32.2871	2663	2900	2
MG_SW16	Muswellbrook	Psi	GRZ	VH	Permian Singleton	285860.00	6424331.00	150.7258	-32.2974	500	681	159
MG_RWD	Muswellbrook	Psi	GRZ	VH	Permian Singleton	284819.00	6425509.00	150.7150	-32.2865	765.5	831	60
MA_SW13	Muswellbrook	Psi	GRZ	VH	Permian Singleton	295070.60	6422787.18	150.8232	-32.3130	420		0
WW125	Muswellbrook	Q	GRZ	VH	Quaternary	306113.70	6434389.40	150.9428	-32.2104			0
WQ_21010147	Muswellbrook	Q	GRZ	VH	Quaternary	308392.40	6426089.26	150.9653	-32.2856	355	506	2
52349	Muswellbrook	Q	GRZ	VH	Quaternary	290695.74	6434590.17	150.7794	-32.2058	1590	1590	1
MA_SW07	Muswellbrook	Pg	H2O	VH	Permian Greta	301800.00	6420460.00	150.8942	-32.3352	3800		0
WQ_21010146	Muswellbrook	Q	H2O	VH	Quaternary	308620.73	6426470.71	150.9678	-32.2822	1200	1405	10
W-REA-DRT	Muswellbrook	Psi	MMI	VH	Permian Singleton	301955.17	6436119.34	150.8991	-32.1941			0
W-EHD-DRT	Muswellbrook	Psi	MMI	VH	Permian Singleton	301589.84	6436199.98	150.8952	-32.1933			0
W-JD3-DRT	Muswellbrook	Psi	MMI	VH	Permian Singleton	302163.57	6436562.65	150.9014	-32.1901			0
W-EP-DRT	Muswellbrook	Psi	MMI	VH	Permian Singleton	301601.84	6436615.74	150.8954	-32.1895			0
WQ_21010152	Muswellbrook	Pm	RES	VH	Permian Maitland	302511.14	6428105.64	150.9033	-32.2664	222.5	286	2
MTART_LDP	Muswellbrook	Pm	TRU	VH	Permian Maitland	298480.75	6424802.46	150.8598	-32.2955			0
MG_SW01	Muswellbrook	Psi	TRU	VH	Permian Singleton	284041.00	6419087.00	150.7053	-32.3443	904.5	1973	152

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CJ_M6	Muswellbrook	Pg	GRZ	SAL	Permian Greta	301670.48	6420771.04	150.8929	-32.3324	4750	6800	16
MA_SW09	Muswellbrook	Pg	GRZ	SAL	Permian Greta	302032.45	6421064.22	150.8968	-32.3298			0
MG_W2	Muswellbrook	Q	GRZ	SAL	Quaternary	288624.00	6427138.00	150.7557	-32.2726	4785	5280	10
JJSA	Muswellbrook	Q	GRZ	SAL	Quaternary	289187.17	6428162.45	150.7619	-32.2635	5980	5980	1
JJSP	Muswellbrook	Q	GRZ	SAL	Quaternary	287359.57	6427991.35	150.7425	-32.2647	1918	1918	1
WQ_21010150	Muswellbrook	Q	H2O	SAL	Quaternary	303269.93	6426889.22	150.9111	-32.2775	2280	2830	11
52025	Muswellbrook	Q	H2O	SAL	Quaternary	307499.96	6426443.87	150.9559	-32.2822	1700	1700	1
CJ_M35	Muswellbrook	Psi	TRU	SAL	Permian Singleton	294571.69	6419486.59	150.8172	-32.3427	11000	11000	1
CA83_45	Muswellbrook	Pm	CON	H	Permian Maitland	302793.52	6430588.02	150.9068	-32.2441			0
CA83_44	Muswellbrook	Pm	CON	H	Permian Maitland	305979.31	6429212.34	150.9403	-32.2570			0
CA83_30	Muswellbrook	Pg	GRZ	H	Permian Greta	301626.00	6424487.96	150.8932	-32.2989			0
CA83_31	Muswellbrook	Pm	GRZ	H	Permian Maitland	300820.50	6425293.45	150.8848	-32.2915	4320	4320	1
CA83_46	Muswellbrook	Pm	RES	H	Permian Maitland	301888.46	6428723.61	150.8968	-32.2607			0
CA83_27	Muswellbrook	Pm	SRC	H	Permian Maitland	300784.30	6423248.03	150.8840	-32.3099			0
CA83_117	Muswellbrook	Psi	CON	L	Permian Singleton	295010.05	6425383.96	150.8231	-32.2896	861	861	4
CA83_14	Muswellbrook	Psi	CON	L	Permian Singleton	295163.91	6423085.12	150.8243	-32.3103	9830	12500	3
CA83_120	Muswellbrook	Q	AGR	VH	Quaternary	298956.09	6435086.14	150.8671	-32.2028	190	10595	5
CA83_42	Muswellbrook	Pd	CON	VH	Permian Dalwood	304739.38	6428587.85	150.9270	-32.2624			0
CA83_43	Muswellbrook	Pg	CON	VH	Permian Greta	305590.13	6429927.33	150.9363	-32.2505			0
CA83_29	Muswellbrook	Pd	GRZ	VH	Permian Dalwood	303571.86	6422922.21	150.9135	-32.3133			0
CA83_28	Muswellbrook	Pg	GRZ	VH	Permian Greta	302277.64	6422234.37	150.8996	-32.3193			0
CA83_23	Muswellbrook	Pg	GRZ	VH	Permian Greta	302531.05	6421193.56	150.9021	-32.3287	5700	8450	7
CA83_15	Muswellbrook	Psi	GRZ	VH	Permian Singleton	297870.02	6421691.34	150.8527	-32.3234	10960	12300	3
CA83_119	Muswellbrook	Psi	GRZ	VH	Permian Singleton	286050.01	6423003.67	150.7275	-32.3094	285	285	4
CA83_118	Muswellbrook	Psi	GRZ	VH	Permian Singleton	289118.15	6426524.33	150.7608	-32.2782	4590	4590	4
CA83_41	Muswellbrook	Pg	MMI	VH	Permian Greta	303861.48	6429139.93	150.9178	-32.2573			0
K_236	Muswellbrook	Pm	GRZ	H	Permian Maitland	300504.96	6425190.99	150.8814	-32.2923	6120	6120	1
K_BLH_W2_2	Muswellbrook	Pm	GRZ	H	Permian Maitland	301004.97	6423490.97	150.8864	-32.3077	8800	8800	1
K_BLH_W3_2	Muswellbrook	Pm	GRZ	H	Permian Maitland	304104.96	6422890.85	150.9191	-32.3137	9800	9800	1
K_87	Muswellbrook	Q	GRZ	L	Quaternary	286604.95	6430491.60	150.7351	-32.2420	1804	1804	1
K_90	Muswellbrook	Q	GRZ	L	Quaternary	286504.95	6430791.60	150.7341	-32.2393	1437	1437	1
K_99	Muswellbrook	Q	GRZ	L	Quaternary	288004.95	6427591.53	150.7493	-32.2684	4880	4880	1
K_205	Muswellbrook	Q	H2O	L	Quaternary	302604.96	6426490.90	150.9040	-32.2810	3860	3860	1
K_235	Muswellbrook	Q	TRU	L	Quaternary	286904.94	6423791.59	150.7368	-32.3024	4940	4940	1
K_237	Muswellbrook	Pg	GRZ	VH	Permian Greta	302204.96	6421390.92	150.8987	-32.3269	6510	6510	1
K_DR_RC_1	Muswellbrook	Pg	GRZ	VH	Permian Greta	302204.96	6421390.92	150.8987	-32.3269	5700	5700	1
K_DR_RC_3	Muswellbrook	Pg	GRZ	VH	Permian Greta	302204.96	6421390.92	150.8987	-32.3269	6730	6730	1
K_102	Muswellbrook	Psi	GRZ	VH	Permian Singleton	286304.95	6432891.61	150.7324	-32.2203	739	739	1
K_83	Muswellbrook	Psi	GRZ	VH	Permian Singleton	286304.95	6434091.61	150.7327	-32.2095	910	910	1
K_204	Muswellbrook	Psi	CON	SAL	Permian Singleton	294504.95	6419591.24	150.8165	-32.3417	10670	10670	1
K_86	Muswellbrook	Q	GRZ	SAL	Quaternary	287204.94	6428191.57	150.7409	-32.2628	5560	5560	1
K_206	Muswellbrook	Q	H2O	SAL	Quaternary	306104.97	6426590.77	150.9411	-32.2807	2560	2560	1
DAM1_2	Muswellbrook	Pm	CON	H	Permian Maitland	305293.57	6431270.80	150.9335	-32.2384	5150	5630	101

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MCC23	Muswellbrook	Psi	CON	H	Permian Singleton	306906.26	6430283.74	150.9504	-32.2475	5140	10580	33
MCC9	Muswellbrook	Pm	DEG	H	Permian Maitland	303865.46	6430460.95	150.9182	-32.2454	4160	5550	24
MCC12	Muswellbrook	Pm	GRZ	H	Permian Maitland	306224.57	6429445.57	150.9430	-32.2550	6210	9890	97
MCC27	Muswellbrook	Pm	GRZ	H	Permian Maitland	303915.37	6430906.85	150.9188	-32.2414	8630	12200	31
MCC24	Muswellbrook	Q	GRZ	H	Quaternary	306490.26	6429835.76	150.9459	-32.2515	4900	6510	29
2OCV	Muswellbrook	Pm	MMI	H	Permian Maitland	306024.77	6431567.57	150.9413	-32.2358	5145	5540	92
MCC25	Muswellbrook	Cu	CON	VH	Carboniferous Undifferentiated	307014.77	6431674.93	150.9518	-32.2350	1790	3320	20
1OCV	Muswellbrook	Pm	CON	VH	Permian Maitland	305398.96	6430077.80	150.9343	-32.2491	4945	5550	44
MCC26	Muswellbrook	Pm	CON	VH	Permian Maitland	304233.56	6430732.94	150.9221	-32.2430	3560	6550	34
MCC8	Muswellbrook	Q	GRZ	SAL	Quaternary	305845.47	6426648.58	150.9384	-32.2801	2340	6260	37
MCC7	Muswellbrook	Q	H2O	SAL	Quaternary	305953.77	6426627.18	150.9395	-32.2803	1640	6570	36
WQ_21010323	Muswellbrook	Psi	GRZ	VH	Permian Singleton	298305.46	6429165.09	150.8589	-32.2561	417	454.5	15
WQ_21010324	Muswellbrook	Cc	GRZ	H	Carboniferous Conglomerate	309995.69	6435540.74	150.9842	-32.2007	1785	2170	18
WW_DB27	Newcastle	Q	H2O	L	Quaternary	364550.48	6377762.61	151.5545	-32.7296	940	1100	7
WW_DB41	Newcastle	Q	H2O	L	Quaternary	379000.45	6366387.65	151.7072	-32.8339	20226	27500	19
WW_DB40	Newcastle	Q	H2O	VH	Quaternary	378010.49	6364892.60	151.6964	-32.8473	30369	38664	25
THRC	Newcastle	Q	H2O	L	Quaternary	367713.00	6377492.00	151.5882	-32.7324			0
HUNT902	Newcastle	Q	RES	L	Quaternary	392400.68	6369557.23	151.8507	-32.8067			0
HUNT901	Newcastle	Q	TRU	L	Quaternary	392495.96	6370267.89	151.8518	-32.8003			0
BG1_DC	Newcastle	Pn	CON	VH	Permian Newcastle	365638.53	6361245.64	151.5637	-32.8787	750	918	52
BGCU_DC	Newcastle	Pn	CON	VH	Permian Newcastle	366750.06	6361176.49	151.5756	-32.8795	499	561	21
S9_DC	Newcastle	Pn	CON	VH	Permian Newcastle	367870.18	6362055.47	151.5877	-32.8717	835	1126	34
ABV_2	Newcastle	Pt	CON	VH	Permian Tomago	371156.57	6366771.86	151.6234	-32.8295			0
ABV_3	Newcastle	Pt	CON	VH	Permian Tomago	371369.31	6367171.05	151.6258	-32.8260			0
ABV_4	Newcastle	Pt	CON	VH	Permian Tomago	371411.32	6367360.42	151.6263	-32.8243			0
ABV_5	Newcastle	Pt	CON	VH	Permian Tomago	371526.08	6367716.14	151.6275	-32.8211			0
ABV_6_11	Newcastle	Pt	CON	VH	Permian Tomago	371600.26	6368112.61	151.6284	-32.8175			0
S10_DC	Newcastle	Pt	GRZ	VH	Permian Tomago	369213.53	6363448.87	151.6022	-32.8593	1160	1410	47
THRCU	Newcastle	Q	GRZ	VH	Quaternary	367795.00	6377354.00	151.5891	-32.7337			0
ABV_1	Newcastle	Pt	TRU	VH	Permian Tomago	370777.82	6366481.07	151.6194	-32.8321			0
BG2_DC	Newcastle	Pn	CON	VL	Permian Newcastle	365026.62	6360373.72	151.5570	-32.8865	370	1022	14
BG3_DC	Newcastle	Pn	CON	VL	Permian Newcastle	364952.91	6360313.93	151.5562	-32.8870	705	872	12
52012	Newcastle	Cs	FOR	H	Carboniferous Sandstone	391076.18	6386083.56	151.8385	-32.6575	224	224	1
210458	Newcastle	Q	GRZ	L	Quaternary	364435.00	6377790.00	151.5533	-32.7294			0
WW67	Newcastle	H	H2O	L	Water	379400.93	6362813.93	151.7110	-32.8662			0
WW28	Newcastle	Q	RES	L	Quaternary	384450.42	6355187.64	151.7640	-32.9355			0
WW32	Newcastle	Q	RES	L	Quaternary	383875.42	6354412.64	151.7578	-32.9424			0
WW98	Newcastle	Q	RES	L	Quaternary	381478.53	6357008.95	151.7325	-32.9187			0
WW102	Newcastle	Q	RES	L	Quaternary	382500.40	6357862.58	151.7435	-32.9112			0
WW106	Newcastle	Pn	SRC	L	Permian Newcastle	379650.48	6354912.66	151.7126	-32.9374			0
WW113	Newcastle	Pt	SRC	L	Permian Tomago	379400.44	6360212.62	151.7107	-32.8896			0
WW114	Newcastle	Pt	SRC	L	Permian Tomago	379100.44	6360812.62	151.7075	-32.8842			0
WW29	Newcastle	Q	SRC	L	Quaternary	384200.42	6356187.64	151.7615	-32.9264			0

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WW30	Newcastle	Q	SRC	L	Quaternary	384300.42	6355712.64	151.7625	-32.9307			0
WW31	Newcastle	Q	SRC	L	Quaternary	384450.42	6355662.64	151.7641	-32.9312			0
WW33	Newcastle	Q	SRC	L	Quaternary	384240.42	6355812.64	151.7618	-32.9298			0
WW59	Newcastle	Q	SRC	L	Quaternary	375250.44	6358237.58	151.6660	-32.9070			0
WW103	Newcastle	Q	SRC	L	Quaternary	379175.46	6354562.65	151.7075	-32.9405			0
WW105	Newcastle	Q	SRC	L	Quaternary	379600.46	6354912.60	151.7121	-32.9374			0
WW104	Newcastle	Q	SRC	L	Quaternary	379700.47	6355022.60	151.7132	-32.9365			0
210456	Newcastle	H	TRU	L	Water	386238.00	6360819.00	151.7838	-32.8849			0
WQ_21010165	Newcastle	Q	AGR	VH	Quaternary	367927.23	6378320.64	151.5906	-32.7250	843.5	1000	4
BL1	Newcastle	Pt	CON	VH	Permian Tomago	367897.00	6370281.00	151.5891	-32.7975	4800	5520	313
WW126	Newcastle	Pt	CON	VH	Permian Tomago	373075.50	6361287.67	151.6432	-32.8792			0
HuntM4A	Newcastle	Pt	CON	VH	Permian Tomago	367872.39	6372586.93	151.5892	-32.7767	644	1160	4
BKDP	Newcastle	Pt	CON	VH	Permian Tomago	368558.05	6368707.01	151.5960	-32.8118			0
EM1	Newcastle	Pt	CON	VH	Permian Tomago	368541.99	6367430.21	151.5956	-32.8233	389	560	120
EM2	Newcastle	Pt	CON	VH	Permian Tomago	368148.28	6369611.97	151.5917	-32.8036	150	200	123
WM10	Newcastle	Pt	CON	VH	Permian Tomago	368451.98	6367369.99	151.5946	-32.8238	411	570	248
WM3	Newcastle	Pt	CON	VH	Permian Tomago	367438.03	6371444.01	151.5844	-32.7870	1080	2180	300
WM4	Newcastle	Pt	CON	VH	Permian Tomago	367960.00	6370616.99	151.5899	-32.7945	390	2120	313
WM5	Newcastle	Pt	CON	VH	Permian Tomago	366846.99	6370932.02	151.5780	-32.7915	1580	3000	215
WM6	Newcastle	Pt	CON	VH	Permian Tomago	368073.07	6369965.20	151.5910	-32.8004	190	240	296
WM7	Newcastle	Pt	CON	VH	Permian Tomago	367887.99	6370376.02	151.5891	-32.7966			0
WM8	Newcastle	Pt	CON	VH	Permian Tomago	367840.90	6370227.94	151.5885	-32.7980			0
WM9	Newcastle	Pt	CON	VH	Permian Tomago	367538.96	6369519.99	151.5852	-32.8043			0
WM12	Newcastle	Pt	DEG	VH	Permian Tomago	367540.01	6372262.14	151.5856	-32.7796	1470	2850	209
WW60	Newcastle	Pt	GRZ	VH	Permian Tomago	370750.44	6362062.56	151.6185	-32.8720			0
WW128	Newcastle	Pt	GRZ	VH	Permian Tomago	373450.46	6361862.57	151.6473	-32.8741			0
WW127	Newcastle	Q	GRZ	VH	Quaternary	373300.46	6361862.64	151.6457	-32.8741			0
HUNT508	Newcastle	Q	GRZ	VH	Quaternary	381597.85	6372416.68	151.7357	-32.7798	743.5	960	2
210432	Newcastle	Q	GRZ	VH	Quaternary	377459.00	6378142.00	151.6923	-32.7277			0
210455	Newcastle	Q	GRZ	VH	Quaternary	368162.00	6378933.00	151.5932	-32.7195			0
210112	Newcastle	Q	H2O	VH	Quaternary	378008.43	6366485.12	151.6966	-32.8329			0
210448	Newcastle	H	H2O	VH	Water	376768.00	6367608.00	151.6835	-32.8226			0
WW57	Newcastle	Pn	RES	VH	Permian Newcastle	375760.50	6356872.66	151.6713	-32.9193			0
WW34	Newcastle	Pt	RES	VH	Permian Tomago	377450.41	6360387.66	151.6898	-32.8878			0
WW35	Newcastle	Pt	RES	VH	Permian Tomago	377600.41	6360212.66	151.6914	-32.8894			0
WW66	Newcastle	Pt	RES	VH	Permian Tomago	379950.40	6359362.64	151.7164	-32.8973			0
WW73	Newcastle	Pt	RES	VH	Permian Tomago	370200.50	6373887.59	151.6142	-32.7652			0
WW58	Newcastle	Q	SRC	VH	Quaternary	375650.46	6359212.57	151.6704	-32.8982			0
BL2	Newcastle	Pt	GRZ	SAL	Permian Tomago	369852.00	6372347.00	151.6103	-32.7791	2660	4310	312
NEH	Newcastle	Pt	GRZ	SAL	Permian Tomago	370236.00	6372464.14	151.6144	-32.7781	1300	3480	105
WM11	Newcastle	Pt	GRZ	SAL	Permian Tomago	370053.90	6372361.04	151.6125	-32.7790	1470	3240	354
WQ_21010171	Newcastle	Q	GRZ	SAL	Quaternary	381707.99	6372606.50	151.7369	-32.7781	743.5	960	2
51019	Newcastle	Q	GRZ	SAL	Quaternary	371710.56	6376338.78	151.6307	-32.7433			0

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BGC_S7_DC	Newcastle	Tns	CON	VL	Triassic Narrabeen Ss	364153.59	6360788.79	151.5478	-32.8826	337	415	50
BGC_S8_DC	Newcastle	Pn	TRU	VH	Permian Newcastle	365644.17	6361153.88	151.5638	-32.8795	770	941	45
HU18	Newcastle	Q	GRZ	VH	Quaternary			151.5881	-32.7279	750	820	2
210409	Paterson River Tidal Pool	Q	H2O	L	Quaternary	369238.00	6383269.00	151.6053	-32.6805			0
210410	Paterson River Tidal Pool	Q	GRZ	VH	Quaternary	373245.00	6379624.00	151.6475	-32.7139			0
WW87	Paterson River Tidal Pool	Q	H2O	VH	Quaternary	370056.73	6395035.81	151.6156	-32.5745	400	530	3
WQ_210409	Paterson River Tidal Pool	Q	H2O	VH	Quaternary	369239.81	6383283.60	151.6053	-32.6804	352	394	2
210406	Paterson River Tidal Pool	Q	H2O	VH	Quaternary	370303.00	6392399.00	151.6179	-32.5983			0
Paterson River Strawberry Patch	Paterson River Tidal Pool	Q	H2O	VH	Quaternary	373263.31	6379573.33	151.6477	-32.7143	785	970	2
HU32	Paterson River Tidal Pool	Q	H2O	VH	Quaternary			151.6156	-32.6082	381.5	415	2
WW_DB48	Paterson River Tributaries	Cs	AGR	M	Carboniferous Sandstone	359175.47	6417987.43	151.5032	-32.3662			0
WW_DB55	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	361700.47	6411062.45	151.5290	-32.4290	290	330	4
WW_DB53	Paterson River Tributaries	Pm	GRZ	VH	Permian Maitland	373199.78	6379409.52	151.6470	-32.7158	475	645	20
WW_DB54	Paterson River Tributaries	Q	GRZ	VH	Quaternary	370400.45	6391912.54	151.6189	-32.6027	330	400	4
WW_DB52	Paterson River Tributaries	Q	H2O	VH	Quaternary	368400.50	6385012.58	151.5966	-32.6647	300	600	9
WQ_21010083	Paterson River Tributaries	Q	GRZ	H	Quaternary	368294.36	6389536.26	151.5961	-32.6239	293	338	41
WQ_210079	Paterson River Tributaries	Cv	RES	H	Carboniferous Volcanics	368653.39	6397912.89	151.6011	-32.5484	305	386	128
210079	Paterson River Tributaries	Cv	GRZ	L	Carboniferous Volcanics	367793.17	6398334.01	151.5920	-32.5445	260.2	331.9	3678
WQ_21010082	Paterson River Tributaries	Pd	GRZ	L	Permian Dalwood	364443.35	6391181.24	151.5553	-32.6086	557.5	1030.5	40
WQ_21010240	Paterson River Tributaries	Pd	GRZ	L	Permian Dalwood	366385.69	6391917.12	151.5761	-32.6022	761	1122	2
WQ_21010308	Paterson River Tributaries	Cv	H2O	L	Carboniferous Volcanics	369099.61	6396111.32	151.6056	-32.5647	267	335	45
WW89	Paterson River Tributaries	Q	H2O	L	Quaternary	363000.47	6400612.44	151.5413	-32.5234	250	250	1
WQ_21010080	Paterson River Tributaries	Q	H2O	L	Quaternary	362981.20	6400620.05	151.5411	-32.5233	227	273	41
WW88	Paterson River Tributaries	Cu	TRU	L	Carboniferous Undifferentiated	366265.01	6399110.96	151.5758	-32.5373			0
WQ_210041	Paterson River Tributaries	Cs	AGR	M	Carboniferous Sandstone	357047.53	6418179.55	151.4806	-32.3642	239	295	90
WQ_21010238	Paterson River Tributaries	Cs	AGR	M	Carboniferous Sandstone	359240.85	6418143.92	151.5039	-32.3648	183	201	2
WQ_21010054	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	361644.10	6411058.34	151.5284	-32.4290			0
WQ_210130	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	362928.69	6406518.53	151.5414	-32.4701	1639	1676	24
210021	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	355704.25	6421287.44	151.4668	-32.3360	167.1	191	5407
210104	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	355406.58	6421693.46	151.4637	-32.3323			0
52002	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	357242.14	6417132.20	151.4825	-32.3737	1130	1130	1
52203	Paterson River Tributaries	Cs	GRZ	M	Carboniferous Sandstone	357344.89	6417252.31	151.4836	-32.3726	1180	1180	1
51201	Paterson River Tributaries	Cu	GRZ	M	Carboniferous Undifferentiated	360884.56	6401143.34	151.5189	-32.5183	226	226	1
WW90	Paterson River Tributaries	Cs	H2O	M	Carboniferous Sandstone	361646.16	6409789.38	151.5282	-32.4404	210	260	41
WQ_210021	Paterson River Tributaries	Cs	H2O	M	Carboniferous Sandstone	355770.45	6421266.21	151.4675	-32.3362	215	245	71
WQ_21010078	Paterson River Tributaries	Cs	H2O	M	Carboniferous Sandstone	358193.76	6418317.73	151.4928	-32.3631	190	219	42
210041	Paterson River Tributaries	Cs	H2O	M	Carboniferous Sandstone	357001.74	6418090.19	151.4801	-32.3650			0
WQ_21010079	Paterson River Tributaries	Cs	TRU	M	Carboniferous Sandstone	361472.87	6409836.23	151.5264	-32.4400	206	237	44
WW72	Paterson River Tributaries	Cv	TRU	M	Carboniferous Volcanics	370800.46	6396187.46	151.6237	-32.5642			0
51035	Paterson River Tributaries	Q	GRZ	VH	Quaternary	369133.32	6388032.60	151.6048	-32.6376	243	243	1
210902	Paterson River Tributaries	Cv	H2O	VH	Carboniferous Volcanics	369104.00	6396070.00	151.6056	-32.5651			0
WQ_210406	Paterson River Tributaries	Q	H2O	VH	Quaternary	370293.54	6392390.06	151.6178	-32.5984	280.5	348.5	40

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51200	Paterson River Tributaries	Q	H2O	VH	Quaternary	368987.83	6386254.28	151.6030	-32.6536	323	323	1
WQ_210410	Paterson River Tributaries	Q	RES	VH	Quaternary	373583.07	6379492.02	151.6511	-32.7151	537	674.5	45
WQ_21010241	Paterson River Tributaries	Cv	TRU	SAL	Carboniferous Volcanics	359803.11	6407528.75	151.5083	-32.4606	1325	1910	4
WQ_210093	Petwyn Vale	Q	H2O	L	Quaternary	297438.50	6462324.66	150.8567	-31.9570	655	695	53
210012	Petwyn Vale	Q	GRZ	M	Quaternary	301506.34	6444291.51	150.8960	-32.1203			0
CJ_MPR_KPP	Petwyn Vale	Q	GRZ	VH	Quaternary	301360.92	6474264.02	150.9006	-31.8500	3407	3530	2
CJ_MPR_KP1	Petwyn Vale	Pm	TRU	VH	Permian Maitland	301901.87	6474277.87	150.9063	-31.8500	1512	1512	1
HU34	Rouchel Brook	Cm	GRZ	L	Carboniferous Mudstone	310999.97	6442401.59	150.9962	-32.1390	617.5	735	2
WQ_21010326	Rouchel Brook	Cm	H2O	L	Carboniferous Mudstone	311146.85	6442600.83	150.9978	-32.1372	521.5	552	16
WQ_210014	Rouchel Brook	Cc	GRZ	M	Carboniferous Conglomerate	315968.01	6441103.33	151.0486	-32.1515	429	559	83
210014	Rouchel Brook	Cc	GRZ	M	Carboniferous Conglomerate	315968.01	6441103.33	151.0486	-32.1515			0
210025	Rouchel Brook	Cc	GRZ	M	Carboniferous Conglomerate	318904.44	6444694.09	151.0804	-32.1196			0
21010064	Rouchel Brook	Cc	GRZ	M	Carboniferous Conglomerate	316453.07	6440890.30	151.0537	-32.1535			0
210029	Rouchel Brook	Cm	GRZ	M	Carboniferous Mudstone	319808.29	6444288.72	151.0899	-32.1234			0
210005	Rouchel Brook	Cu	GRZ	M	Carboniferous Undifferentiated	325704.64	6451589.10	151.1537	-32.0585			0
53001	Rouchel Brook	Cu	GRZ	M	Carboniferous Undifferentiated	334060.28	6446238.16	151.2413	-32.1080	639	639	1
WQ_21010063	Rouchel Brook	Cc	H2O	M	Carboniferous Conglomerate	316102.28	6440983.77	151.0500	-32.1526			0
21010063	Rouchel Brook	Cc	H2O	M	Carboniferous Conglomerate	316102.28	6440983.77	151.0500	-32.1526			0
52387	Rouchel Brook	Cc	H2O	M	Carboniferous Conglomerate	324524.90	6440002.77	151.1391	-32.1628	5500	5500	1
WQ_210029	Rouchel Brook	Cm	H2O	M	Carboniferous Mudstone	319800.03	6444222.03	151.0898	-32.1240	426.5	515	36
K_80	Rouchel Brook	Cm	H2O	L	Carboniferous Mudstone	311104.97	6442590.58	150.9974	-32.1373	425	425	1
BCSW9_BH	Scotts Creek	Q	H2O	L	Quaternary	302309.62	6480477.12	150.9119	-31.7942			0
BCSW2_BH	Scotts Creek	Pg	GRZ	VH	Permian Greta	306038.10	6476134.69	150.9504	-31.8340	793.3		
SF4_BH	Scotts Creek	Pg	GRZ	VH	Permian Greta	306075.96	6475389.38	150.9507	-31.8407			0
BCSW8_BH	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304453.88	6476708.97	150.9338	-31.8285	3097		
BCSW6_BH	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304848.38	6476875.22	150.9380	-31.8271	757.6		
BCSW7_BH	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304621.51	6476701.02	150.9356	-31.8286	3409		
SF2_BH	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	305171.94	6476363.71	150.9413	-31.8318			0
SF3_BH	Scotts Creek	Pg	H2O	VH	Permian Greta	306147.09	6475938.61	150.9515	-31.8358			0
BCSW3_BH	Scotts Creek	Pg	H2O	VH	Permian Greta	305986.01	6475400.80	150.9497	-31.8406	789.7		
SF1_BH	Scotts Creek	Ps	H2O	VH	Permian Sandstone	304924.53	6476703.75	150.9388	-31.8287			0
BCSW1_BH	Scotts Creek	Ps	H2O	VH	Permian Sandstone	305459.40	6476270.13	150.9443	-31.8327	805.7		
BCSW4_BH	Scotts Creek	Pv	GRZ	VL	Permian Volcanics	305924.14	6474608.68	150.9489	-31.8477	770.8		
BCSW5_BH	Scotts Creek	Pv	GRZ	VL	Permian Volcanics	305589.63	6474568.20	150.9454	-31.8480	737.7		
WQ_210061	Scotts Creek	Q	GRZ	L	Quaternary	303610.82	6478771.53	150.9253	-31.8098	622.5	709	44
210061	Scotts Creek	Q	GRZ	L	Quaternary	303601.57	6478760.26	150.9252	-31.8099			0
WQ_21010219	Scotts Creek	Q	H2O	L	Quaternary	302308.91	6480476.83	150.9119	-31.7942	517	525	4
WQ_21010313	Scotts Creek	Q	H2O	L	Quaternary	302308.27	6480510.09	150.9119	-31.7939	559	587	11
WQ_210119	Scotts Creek	Cc	CON	M	Carboniferous Conglomerate	309762.48	6470325.03	150.9886	-31.8870			0
210119	Scotts Creek	Cc	CON	M	Carboniferous Conglomerate	309693.18	6469979.93	150.9878	-31.8901	462		1
CJ_MPR_IN2	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304902.48	6476254.09	150.9384	-31.8327	389	389	1
CJ_MPR_IN3	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304153.17	6475727.79	150.9304	-31.8373	2055	2060	3
CJ_MPR_IN5	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304784.34	6475259.79	150.9370	-31.8417	139	139	1

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CJ_MPR_IN6	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	303182.08	6475222.75	150.9201	-31.8417	221	221	1
CJ_MPR_IN7	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304239.90	6474848.00	150.9312	-31.8453	140.5	143	4
CJ_MPR_PR1	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304855.54	6476773.24	150.9380	-31.8280	867.5	956	4
WQ_21010221	Scotts Creek	Q	GRZ	VH	Quaternary	304202.15	6480546.29	150.9319	-31.7939	971	1016	4
CJ_MPR_PR2	Scotts Creek	Pg	H2O	VH	Permian Greta	306024.58	6476125.90	150.9503	-31.8341	708.5	811	2
CJ_MPR_PR3	Scotts Creek	Pg	H2O	VH	Permian Greta	306147.34	6475237.86	150.9514	-31.8421	623	811	3
CJ_MPR_IN1	Scotts Creek	Pm	H2O	VH	Permian Maitland	304199.04	6476701.91	150.9311	-31.8286	2629	3460	4
CJ_MPR_PR4	Scotts Creek	Pv	GRZ	VL	Permian Volcanics	305610.41	6474495.70	150.9456	-31.8487	809	885	2
CJ_MPR_PR7	Scotts Creek	Pv	H2O	VL	Permian Volcanics	305230.69	6473621.23	150.9414	-31.8565	842	858	2
PR7_US	Scotts Creek	Pv	GRZ	VL	Permian Volcanics	305233.29	6473622.82	150.9414	-31.8565	848	867	2
IN6B	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	303186.24	6475225.30	150.9201	-31.8417	421	421	1
PR2_DS	Scotts Creek	Pg	H2O	VH	Permian Greta	306028.60	6476122.28	150.9503	-31.8341	950.5	951	2
IN2A	Scotts Creek	Ps	GRZ	VH	Permian Sandstone	304899.29	6476256.18	150.9384	-31.8327	401	401	1
WQ_21010081	Seaham Weir	Q	H2O	H	Quaternary	382133.00	6385739.98	151.7431	-32.6597	199.5	326	242
21010062	Segenhoe	Q	AGR	L	Quaternary	305004.24	6445490.59	150.9333	-32.1101			0
WQ_210094	Segenhoe	Cu	H2O	L	Carboniferous Undifferentiated	306541.19	6453039.99	150.9511	-32.0423	593.5	651	20
WQ_21010174	Segenhoe	Q	H2O	L	Quaternary	306497.43	6448879.86	150.9498	-32.0798	612	711	31
210107	Segenhoe	Cm	GRZ	M	Carboniferous Mudstone	308096.39	6454233.98	150.9678	-32.0318			0
WQ_210030	Segenhoe	Cc	H2O	M	Carboniferous Conglomerate	310688.32	6456101.37	150.9956	-32.0154	638	640	4
210052	Segenhoe	Cc	H2O	M	Carboniferous Conglomerate	310866.77	6456670.32	150.9976	-32.0103			0
WQ_210012	Segenhoe	Cs	H2O	M	Carboniferous Sandstone	312247.88	6459679.29	151.0128	-31.9834	233	350	2
K_78	Segenhoe	Cu	AGR	L	Carboniferous Undifferentiated	304304.97	6444190.82	150.9256	-32.1217	1085	1085	1
RT_W20	Singleton	Psi	CON	VH	Permian Singleton	318146.00	6393505.00	151.0625	-32.5810	1080	3510	155
RT_D11N	Singleton	Psi	CON	SAL	Permian Singleton	317970.00	6388053.00	151.0596	-32.6301	210	2060	19
RT_D12S	Singleton	Psi	CON	SAL	Permian Singleton	317970.00	6388053.00	151.0596	-32.6301	455	723	100
RT_D25N	Singleton	Psi	DEG	VH	Permian Singleton	320660.00	6392080.00	151.0890	-32.5943	1890	2310	16
RT_W15	Singleton	Pm	GRZ	H	Permian Maitland	323921.00	6388805.00	151.1232	-32.6243	4820	8060	169
RT_W5	Singleton	Pm	H2O	H	Permian Maitland	323505.00	6386553.00	151.1183	-32.6446	7075	10580	124
RT_EOC Dam	Singleton	Psi	H2O	VH	Permian Singleton	316501.00	6398553.00	151.0460	-32.5352	2620	3660	113
RP_SWP	Singleton	Psi	MMI	L	Permian Singleton	318932.73	6393901.98	151.0710	-32.5776	708	798	23
RT_D15S	Singleton	Pm	MMI	VH	Permian Maitland	322799.00	6386530.00	151.1108	-32.6446	4995	7190	102
RT_D1S	Singleton	Psi	MMI	VH	Permian Singleton	321752.00	6387627.00	151.0998	-32.6346	1220	3720	96
RT_D3S	Singleton	Psi	MMI	VH	Permian Singleton	321400.00	6387450.00	151.0960	-32.6361	2250	3430	17
RT_DS	Singleton	Psi	MMI	VH	Permian Singleton	321700.00	6386050.00	151.0990	-32.6488			0
RT_W18	Singleton	Psi	MMI	VH	Permian Singleton	321067.00	6390774.00	151.0931	-32.6061	6240	8010	181
RT_W21	Singleton	Psi	MMI	VH	Permian Singleton	321161.00	6390116.00	151.0940	-32.6121	680	1140	87
RT_W23	Singleton	Psi	MMI	VH	Permian Singleton	321387.00	6389939.00	151.0964	-32.6137	800	850	31
RT_W25	Singleton	Psi	MMI	VH	Permian Singleton	321278.00	6389929.00	151.0952	-32.6138	2690	4330	79
RT_WW5	Singleton	Psi	TRU	L	Permian Singleton	318909.00	6393389.00	151.0707	-32.5822	270	320	29
W5_WW	Singleton	Pm	H2O	H	Permian Maitland	323479.54	6386705.62	151.1181	-32.6432	5740		0
WW5_WW	Singleton	Psi	CON	L	Permian Singleton	318879.75	6393357.22	151.0703	-32.5825	316		0
W15_WW	Singleton	Pm	H2O	L	Permian Maitland	323960.93	6389582.12	151.1237	-32.6173	4468		0
LKJD_CA	Singleton	Psi	GRZ	VH	Permian Singleton	316955.11	6400252.51	151.0512	-32.5200			0

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EOC_CA	Singleton	Psi	H2O	VH	Permian Singleton	316501.11	6398450.89	151.0460	-32.5361			0
W22_WW	Singleton	Psi	CON	SAL	Permian Singleton	318259.34	6388486.49	151.0628	-32.6263	268		0
LKJ_CA	Singleton	Psi	H2O	SAL	Permian Singleton	316781.72	6400094.15	151.0493	-32.5214			0
CJ_J3	Singleton	Pm	H2O	H	Permian Maitland	323777.58	6389159.19	151.1217	-32.6211			0
WQ_21010267	Singleton	Pm	H2O	H	Permian Maitland	323777.58	6389159.19	151.1217	-32.6211	4684.5	8650	2
52231	Singleton	Pm	H2O	H	Permian Maitland	323733.74	6388029.32	151.1210	-32.6313	5370	5370	1
RIX9	Singleton	Psi	CON	VH	Permian Singleton	325357.73	6400140.71	151.1406	-32.5223	5790	7400	169
RIX10	Singleton	Psi	CON	VH	Permian Singleton	323711.01	6398378.66	151.1227	-32.5380	610	1296	84
CJ_M21	Singleton	Psi	DEG	VH	Permian Singleton	316485.67	6398743.05	151.0459	-32.5335	3800	4700	17
RIX1	Singleton	Psi	GRZ	VH	Permian Singleton	326451.84	6401702.70	151.1525	-32.5084	250	615	143
RIX7	Singleton	Psi	H2O	VH	Permian Singleton	325842.78	6400309.36	151.1458	-32.5209	176	285	169
WQ_21010249	Singleton	Psi	H2O	VH	Permian Singleton	339250.77	6392903.07	151.2872	-32.5897	2007.5	3255	2
HVO8 LDP	Singleton	Psi	H2O	VH	Permian Singleton	316954.24	6400222.20	151.0512	-32.5202			0
WARK_LDP	Singleton	Psi	H2O	VH	Permian Singleton	320865.50	6391521.53	151.0911	-32.5993			0
RIX6	Singleton	Psi	MMI	VH	Permian Singleton	325461.77	6401425.06	151.1419	-32.5108	4300	8000	169
RIX8	Singleton	Psi	MMI	VH	Permian Singleton	325549.97	6401243.91	151.1428	-32.5124	4955	6860	169
MTHOR_LDP	Singleton	Psi	MMI	VH	Permian Singleton	321953.99	6385397.59	151.1016	-32.6547			0
210099	Singleton	Psi	SRC	VH	Permian Singleton	330908.89	6376594.66	151.1954	-32.7355			0
RIX5	Singleton	Psi	WST	VH	Permian Singleton	325422.46	6399765.03	151.1412	-32.5257	191	250	169
RIX4	Singleton	Psi	WST	VH	Permian Singleton	325466.19	6399589.05	151.1416	-32.5273	220	270	169
BULGA_LDP	Singleton	Psi	CON	SAL	Permian Singleton	322538.59	6382986.69	151.1073	-32.6766			0
WQ_21010268	Singleton	Pm	GRZ	SAL	Permian Maitland	326566.79	6387455.71	151.1511	-32.6369	12000	24000	2
BU_W8	Singleton	Pm	H2O	SAL	Permian Maitland	322434.51	6384839.20	151.1066	-32.6598	11200	14700	33
WQ_21010290	Singleton	Pm	H2O	SAL	Permian Maitland	335361.59	6398163.09	151.2467	-32.5417	725	1450	2
BU_Dam	Singleton	Psi	H2O	SAL	Permian Singleton	322605.92	6382868.59	151.1080	-32.6776	4955	6200	36
RIX2	Singleton	Psi	H2O	SAL	Permian Singleton	324485.93	6400124.93	151.1313	-32.5223	1310	2260	149
CA83_62	Singleton	Pm	GRZ	H	Permian Maitland	323867.96	6389131.47	151.1227	-32.6214	10100	12200	2
CA83_63	Singleton	Pm	GRZ	H	Permian Maitland	324125.45	6388560.83	151.1253	-32.6266	15500	15500	1
CA83_161	Singleton	Pm	GRZ	H	Permian Maitland	334800.68	6397858.16	151.2407	-32.5444	12000	12000	1
CA83_162	Singleton	Pm	GRZ	H	Permian Maitland	335496.59	6397962.54	151.2481	-32.5435	1600	1600	1
CA83_109	Singleton	Pm	GRZ	H	Permian Maitland	324375.98	6387141.17	151.1277	-32.6394	1080	1080	1
CA83_216	Singleton	Psi	AGR	VH	Permian Singleton	321905.50	6379855.02	151.1000	-32.7047	680	680	1
CA83_83	Singleton	Pm	CON	VH	Permian Maitland	322385.68	6385352.69	151.1061	-32.6552			0
CA83_179	Singleton	Psi	CON	VH	Permian Singleton	316491.34	6399514.42	151.0461	-32.5266	328	405	2
CA83_190	Singleton	Psi	CON	VH	Permian Singleton	316526.14	6398310.50	151.0462	-32.5374	5900	5900	1
CA83_1	Singleton	Psi	CON	VH	Permian Singleton	320792.05	6388985.33	151.0899	-32.6222			0
CA83_192	Singleton	Psi	CON	VH	Permian Singleton	322629.25	6382520.35	151.1082	-32.6808	290	290	1
CA83_215	Singleton	Psi	CON	VH	Permian Singleton	322135.15	6380335.19	151.1025	-32.7004	1489	1489	1
CA83_61	Singleton	Pm	DEG	VH	Permian Maitland	322364.80	6385951.17	151.1060	-32.6498	11950	18000	2
CA83_64	Singleton	Psi	DEG	VH	Permian Singleton	316456.54	6398895.06	151.0456	-32.5321	3500	3500	1
CA83_223	Singleton	Psi	DEG	VH	Permian Singleton	322462.23	6379855.02	151.1059	-32.7048	10060	10060	1
CA83_101	Singleton	Psi	GRZ	VH	Permian Singleton	318196.05	6399727.12	151.0643	-32.5249	180	180	1
CA83_7	Singleton	Psi	GRZ	VH	Permian Singleton	318850.47	6394399.49	151.0702	-32.5731			0

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CA83_6	Singleton	Psi	GRZ	VH	Permian Singleton	318655.61	6393933.24	151.0681	-32.5772			0
CA83_213	Singleton	Pm	MMI	VH	Permian Maitland	322677.96	6386452.23	151.1095	-32.6453	10820	10820	1
CA83_5	Singleton	Psi	MMI	VH	Permian Singleton	318968.77	6393432.18	151.0713	-32.5818			0
CA83_170	Singleton	Psi	MMI	VH	Permian Singleton	319462.87	6390398.02	151.0760	-32.6092	19500	19500	1
CA83_4	Singleton	Psi	MMI	VH	Permian Singleton	320228.37	6390892.12	151.0842	-32.6049			0
CA83_169	Singleton	Psi	MMI	VH	Permian Singleton	320249.24	6390272.76	151.0843	-32.6105	1830	2000	2
CA83_3	Singleton	Psi	MMI	VH	Permian Singleton	321007.78	6390467.61	151.0924	-32.6089			0
CA83_281	Singleton	Psi	MMI	VH	Permian Singleton	320840.76	6389931.76	151.0906	-32.6137			0
CA83_104	Singleton	Psi	MMI	VH	Permian Singleton	320993.86	6383362.39	151.0909	-32.6729	5850	5850	1
CA83_58	Singleton	Psi	MMI	VH	Permian Singleton	322865.86	6381706.13	151.1106	-32.6882	2617.5	5100	2
CA83_225	Singleton	Psi	MMI	VH	Permian Singleton	323220.77	6381128.53	151.1142	-32.6934	1230	1230	1
CA83_224	Singleton	Psi	MMI	VH	Permian Singleton	323005.04	6379778.47	151.1117	-32.7056	1400	1400	1
CA83_100	Singleton	Pm	RES	VH	Permian Maitland	332107.51	6387266.44	151.2101	-32.6395	1540	1540	1
CA83_59	Singleton	Psi	TRU	VH	Permian Singleton	322531.82	6383355.44	151.1073	-32.6732	12088	12088	1
CA83_60	Singleton	Psi	MMI	SAL	Permian Singleton	321460.12	6385018.66	151.0962	-32.6581	270	8400	13
CA83_103	Singleton	Pm	SRC	SAL	Permian Maitland	332782.54	6387057.67	151.2173	-32.6414	215	215	1
K_68	Singleton	Pm	H2O	H	Permian Maitland	323804.98	6389191.23	151.1220	-32.6208	11570	11570	1
K_135	Singleton	Psi	GRZ	VH	Permian Singleton	319604.97	6401490.34	151.0796	-32.5093	12440	12440	1
K_340	Singleton	Psi	MMI	VH	Permian Singleton	321704.98	6383991.29	151.0986	-32.6674	13770	13770	1
K_67	Singleton	Pm	GRZ	SAL	Permian Maitland	325204.98	6388491.19	151.1368	-32.6273	16260	16260	1
WQ_210025	Stewarts Brook	Dch	GRZ	M	Devonian Chert	328206.11	6460082.09	151.1817	-31.9823	326.5	382	16
WQ_21010073	Stewarts Brook	Dch	GRZ	M	Devonian Chert	328205.92	6460093.18	151.1817	-31.9822	285	372	28
210013	Stewarts Brook	Dch	GRZ	M	Devonian Chert	328225.00	6460082.41	151.1819	-31.9823			0
210019	Stewarts Brook	Dm	GRZ	M	Devonian Mudstone	330102.36	6458594.51	151.2015	-31.9960			0
WQ_21010222	Stewarts Brook	Dsi	TRU	M	Devonian Siltstone	324156.19	6460334.80	151.1389	-31.9794	229	377	4
52369	Upper Dart Brook	Q	AGR	L	Quaternary	288336.79	6458688.27	150.7597	-31.9881	452	452	1
WQ_210124	Upper Dart Brook	Q	GRZ	L	Quaternary	290678.56	6456242.92	150.7839	-32.0106	560	972	7
210124	Upper Dart Brook	Q	GRZ	L	Quaternary	290746.28	6456166.66	150.7846	-32.0113			0
W-WHD-DRT	Upper Dart Brook	Psi	MMI	L	Permian Singleton	298856.50	6435672.85	150.8661	-32.1975			0
W-WHD-PIPE-DRT	Upper Dart Brook	Psi	MMI	L	Permian Singleton	298802.67	6435677.29	150.8655	-32.1975			0
WQ_21010161	Upper Dart Brook	Tb	GRZ	M	Tertiary Basalt	279177.60	6471043.16	150.6656	-31.8750	385	907	3
HUNT08	Upper Dart Brook	Tb	GRZ	M	Tertiary Basalt	279097.46	6470808.48	150.6647	-31.8771	689	907	3
W-WSD-DRT	Upper Dart Brook	Psi	CON	VH	Permian Singleton	298600.68	6435757.47	150.8634	-32.1967			0
W-EPA4-DRT	Upper Dart Brook	Psi	GRZ	VH	Permian Singleton	298426.14	6435873.36	150.8616	-32.1956			0
W-EVA-DRT	Upper Dart Brook	Psi	GRZ	VH	Permian Singleton	295990.35	6436134.91	150.8358	-32.1928			0
W-E2-DRT	Upper Dart Brook	Psi	H2O	VH	Permian Singleton	296049.94	6436286.64	150.8365	-32.1915			0
W-CBD-DRT	Upper Dart Brook	Psi	H2O	VH	Permian Singleton	298111.28	6435710.58	150.8582	-32.1971			0
W-E9-DRT	Upper Dart Brook	Psi	H2O	VH	Permian Singleton	296351.84	6436264.75	150.8397	-32.1917			0
W-D.Dam-DRT	Upper Dart Brook	Psi	H2O	VH	Permian Singleton	298338.56	6436014.24	150.8607	-32.1944			0
K_77	Upper Dart Brook	Psi	CON	L	Permian Singleton	298404.96	6436391.06	150.8615	-32.1910	4370	4370	1
HU23	Upper Dart Brook	Tb	GRZ	M	Tertiary Basalt			150.6647	-31.8781			0
MK_OEH4	Upper Goulburn River	Psi	GRZ	L	Permian Singleton	221318.46	6419342.62	150.0396	-32.3281	522	522	1

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WW_DB26	Upper Goulburn River	Tns	GRZ	VL	Triassic Narrabeen Ss	199653.41	6430853.91	149.8133	-32.2188	616	710	75
HU09	Upper Goulburn River	Psi	GRZ	VH	Permian Singleton			150.0514	-32.3512	1345	1570	2
HU45	Upper Goulburn River	Q	GRZ	L	Quaternary			149.7372	-32.3146	325	370	2
EPL4_UL	Upper Goulburn River	Q	MMI	L	Quaternary	195295.30	6424656.15	149.7652	-32.2735			0
EPL1_UL	Upper Goulburn River	Pi	MMI	VH	Permian Illawarra	195758.21	6427240.99	149.7709	-32.2503			0
SW08_UL	Upper Goulburn River	Jsh	CON	VL	Jurassic Shale	195887.46	6439219.06	149.7761	-32.1425	100		0
SW04_UL	Upper Goulburn River	Pi	CON	VL	Permian Illawarra	191270.03	6430159.25	149.7243	-32.2228	420		0
EPL6_UL	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	192089.04	6433157.45	149.7339	-32.1960	478		0
SW07_UL	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	196032.74	6435609.26	149.7765	-32.1750	157		0
SW03_UL	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	192141.94	6433170.39	149.7345	-32.1959	872		0
SW06_UL	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	195489.32	6431597.41	149.7695	-32.2110	173		0
SW02_UL	Upper Goulburn River	Tns	TRU	VL	Triassic Narrabeen Ss	197216.53	6430887.26	149.7875	-32.2179	705		0
EPL3_UL	Upper Goulburn River	Pi	CON	SAL	Permian Illawarra	194883.63	6428466.05	149.7620	-32.2390	673		0
SW05_UL	Upper Goulburn River	Pi	CON	SAL	Permian Illawarra	194218.59	6428422.96	149.7550	-32.2392	645		0
SW01_UL	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193353.49	6423655.66	149.7443	-32.2819	573		0
EPL2_UL	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193596.71	6424114.34	149.7470	-32.2779			0
WQ_21010207	Upper Goulburn River	Jss	CON	H	Jurassic Ss Shale	202056.22	6440784.85	149.8419	-32.1300	624	643	3
210006	Upper Goulburn River	Psi	AGR	L	Permian Singleton	227180.54	6417694.99	150.1013	-32.3444	1006.2	1277.35	295
ML_LC1	Upper Goulburn River	Q	AGR	L	Quaternary	195125.76	6417680.16	149.7612	-32.3363	3129	3919	3
ML_SH04	Upper Goulburn River	Q	CON	L	Quaternary	196350.64	6425442.11	149.7766	-32.2667	172	358	9
ML_SW11	Upper Goulburn River	Q	CON	L	Quaternary	196346.53	6425651.86	149.7767	-32.2648	195	320	29
ML_BOX2	Upper Goulburn River	Q	CON	L	Quaternary	196398.53	6425658.03	149.7772	-32.2647			0
HUNT587	Upper Goulburn River	Psi	GRZ	L	Permian Singleton	221296.69	6419209.93	150.0393	-32.3293	785	803	2
ML_SH12	Upper Goulburn River	Q	GRZ	L	Quaternary	192818.70	6419994.28	149.7374	-32.3148	277	311	8
ML_SH11	Upper Goulburn River	Q	GRZ	L	Quaternary	194920.03	6418851.87	149.7594	-32.3256			0
ML_BOXDAM	Upper Goulburn River	Q	GRZ	L	Quaternary	197666.33	6425720.21	149.7907	-32.2645			0
ML_SH1	Upper Goulburn River	Q	GRZ	L	Quaternary	192934.47	6423603.62	149.7398	-32.2823			0
ML_RC2	Upper Goulburn River	Q	GRZ	L	Quaternary	192921.08	6420181.70	149.7386	-32.3131	296	379	7
ML_MC5	Upper Goulburn River	Q	GRZ	L	Quaternary	194836.91	6418834.80	149.7585	-32.3258			0
SWC_HU09	Upper Goulburn River	Psi	H2O	L	Permian Singleton	222601.27	6417009.98	150.0525	-32.3494			0
WQ_210006	Upper Goulburn River	Psi	H2O	L	Permian Singleton	227373.76	6417866.71	150.1034	-32.3429	1047.5	1399	106
52407	Upper Goulburn River	Psi	H2O	L	Permian Singleton	224801.08	6417638.02	150.0760	-32.3443	908	908	1
ML_SW12	Upper Goulburn River	Cg	CON	M	Carboniferous Granite	193698.06	6424501.95	149.7482	-32.2744	560	775	28
ML_SH06	Upper Goulburn River	Cg	GRZ	M	Carboniferous Granite	193258.84	6423098.83	149.7431	-32.2869	904	1196	12
WQ_210046	Upper Goulburn River	Cg	GRZ	M	Carboniferous Granite	193250.68	6422436.52	149.7428	-32.2929	431	580	50
ML_SH13	Upper Goulburn River	Pi	CON	VH	Permian Illawarra	196220.26	6429382.13	149.7765	-32.2311	678	724	7
ML_GR1	Upper Goulburn River	Pi	CON	VH	Permian Illawarra	196255.23	6429470.65	149.7769	-32.2304	798	989	5
ML_BnX2	Upper Goulburn River	Pi	CON	VH	Permian Illawarra	196510.69	6429375.95	149.7796	-32.2313	180	203	2
ML_SH10	Upper Goulburn River	Pi	GRZ	VH	Permian Illawarra	197063.14	6417557.33	149.7817	-32.3379	2508	3061	14
ML_SH07	Upper Goulburn River	Pi	GRZ	VH	Permian Illawarra	195781.10	6418370.30	149.7683	-32.3302			0
ML_SW08	Upper Goulburn River	Pi	GRZ	VH	Permian Illawarra	197404.65	6417416.14	149.7853	-32.3392	2550	2850	29
ML_MC4	Upper Goulburn River	Pi	GRZ	VH	Permian Illawarra	195744.10	6418509.94	149.7680	-32.3289	3406	3416	3
WQ_21010360	Upper Goulburn River	Psi	GRZ	VH	Permian Singleton	224292.17	6416506.39	150.0703	-32.3544	1534	1534	2

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ML_SH08	Upper Goulburn River	Q	GRZ	VH	Quaternary	199591.09	6414107.63	149.8074	-32.3696	2579	5120	9
ML_SW09	Upper Goulburn River	Q	GRZ	VH	Quaternary	200573.14	6412282.67	149.8172	-32.3863	2050	2820	29
ML_MC1	Upper Goulburn River	Q	GRZ	VH	Quaternary	199744.16	6414300.21	149.8091	-32.3679	4559	4996	4
SWC_HU53	Upper Goulburn River	Jsh	CON	VL	Jurassic Shale	213489.43	6428194.46	149.9592	-32.2464			0
WQ_21010339	Upper Goulburn River	Jsh	CON	VL	Jurassic Shale	224533.24	6433583.62	150.0778	-32.2006	1058.5	1160	24
ML_SH01	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197394.11	6431340.28	149.7896	-32.2138	158	336	14
ML_SH02	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197977.89	6431273.75	149.7957	-32.2146	602	799	7
ML_SW01	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	198577.89	6431542.27	149.8022	-32.2123	710	800	29
ML_SW02	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197264.77	6431211.29	149.7882	-32.2150	715	830	29
ML_SW10	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	198067.37	6426141.14	149.7951	-32.2608	85	120	12
ML_GR3	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197809.76	6431477.36	149.7940	-32.2127	769	794	4
ML_BC2	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197431.32	6431740.79	149.7901	-32.2102	260	264	5
ML_GR4	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	198539.83	6431245.53	149.8017	-32.2150			0
ML_GR2	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197169.52	6431032.91	149.7871	-32.2165			0
ML_BnX1	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197868.99	6429099.62	149.7939	-32.2341	55	55	4
ML_BX1	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197975.53	6428445.68	149.7948	-32.2401			0
SWC_HU35	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	202994.01	6433103.05	149.8494	-32.1994			0
SWC_HU36	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	202484.60	6431700.41	149.8436	-32.2119			0
WQ_210059	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	219816.81	6411099.24	150.0212	-32.4020	4800	6031	43
WQ_21010017	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	199775.58	6431036.95	149.8147	-32.2172	774	1400	208
WQ_21010169	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197277.87	6431240.08	149.7883	-32.2147	1327	1475	9
WQ_21010338	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	222651.38	6429591.99	150.0567	-32.2361	974.5	1036	24
WQ_21010361	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	221906.43	6428894.47	150.0486	-32.2422	1128	1128	2
52406	Upper Goulburn River	Tns	CON	VL	Triassic Narrabeen Ss	197045.77	6430764.63	149.7857	-32.2189	695	695	1
WQ_21010340	Upper Goulburn River	Js	GRZ	VL	Jurassic Sandstone	218275.68	6428516.45	150.0100	-32.2447	1038	1196	18
ML_SH03	Upper Goulburn River	Pi	GRZ	VL	Permian Illawarra	197954.50	6425962.71	149.7938	-32.2624	79	167	5
WQ_21010195	Upper Goulburn River	Psi	GRZ	VL	Permian Singleton	221413.59	6419412.96	150.0406	-32.3275	948	1150	31
WW51	Upper Goulburn River	Jsh	H2O	VL	Jurassic Shale	224408.65	6433376.23	150.0764	-32.2024	920	950	4
WQ_21010218	Upper Goulburn River	Tns	RES	VL	Triassic Narrabeen Ss	203489.30	6435065.23	149.8553	-32.1819	904	1034	26
HUNT512	Upper Goulburn River	Tns	TRU	VL	Triassic Narrabeen Ss	197187.89	6431093.06	149.7873	-32.2160	1123	1600	3
ML_BX2	Upper Goulburn River	Pi	CON	SAL	Permian Illawarra	195811.71	6427793.01	149.7717	-32.2454			0
WQ_21010217	Upper Goulburn River	Jss	GRZ	SAL	Jurassic Ss Shale	201437.76	6442220.97	149.8358	-32.1169	1530	2875	3
ML_SH05	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193226.50	6423443.68	149.7429	-32.2838	674	868	17
ML_SH09	Upper Goulburn River	Q	GRZ	SAL	Quaternary	198873.42	6416048.69	149.8004	-32.3520			0
ML_SW07	Upper Goulburn River	Q	GRZ	SAL	Quaternary	194915.94	6416639.65	149.7586	-32.3456	2435	2820	28
ML_GR0	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193508.82	6423989.40	149.7460	-32.2790			0
ML_MC7	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193263.75	6423391.46	149.7432	-32.2843	1015	1424	9
ML_MC3	Upper Goulburn River	Q	GRZ	SAL	Quaternary	198209.35	6416675.21	149.7936	-32.3461			0
ML_MC2	Upper Goulburn River	Q	GRZ	SAL	Quaternary	199215.18	6415365.83	149.8038	-32.3582			0
WQ_21010362	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193488.87	6423909.32	149.7458	-32.2797	713	713	2
210046	Upper Goulburn River	Q	GRZ	SAL	Quaternary	193308.49	6423637.37	149.7438	-32.2821			0
ML_SW05	Upper Goulburn River	Q	TRU	SAL	Quaternary	193258.42	6423163.32	149.7431	-32.2864	785	1050	29
WQ_21010311	Upper Goulburn River	Psi	GRZ	L	Permian Singleton	221350.00	6419326.84	150.0399	-32.3283	998	1152	18

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WW_DB33	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	323550.65	6459612.26	151.1324	-31.9858	265	390	14
WW_DB34	Upper Hunter	Cs	TRU	M	Carboniferous Sandstone	333200.64	6466312.28	151.2356	-31.9269	325	500	4
HU50	Upper Hunter	Pn	CON	L	Permian Newcastle	347599.99	6466500.66	151.3879	-31.9272	29.5	36	2
HU13	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	321399.98	6457601.26	151.1092	-32.0036	340	420	2
HU20	Upper Hunter	Cs	GRZ	M	Carboniferous Sandstone	333299.98	6466300.95	151.2367	-31.9270	220	270	2
53501	Upper Hunter	Pn	CON	L	Permian Newcastle	347379.90	6470635.64	151.3862	-31.8899	44	44	1
55001	Upper Hunter	Pn	CON	L	Permian Newcastle	347635.66	6466669.76	151.3883	-31.9257	32	32	1
54538	Upper Hunter	Pn	FOR	L	Permian Newcastle	344920.76	6467281.02	151.3597	-31.9198	70	70	1
WQ_210019	Upper Hunter	Dch	AGR	M	Devonian Chert	338190.28	6473052.97	151.2895	-31.8668	71	95	21
WQ_21010155	Upper Hunter	Cc	GRZ	M	Carboniferous Conglomerate	335601.04	6468687.05	151.2614	-31.9058	133	163	3
WQ_21010072	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	321468.78	6457792.88	151.1100	-32.0019	267	325	29
210038	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	323336.24	6459100.74	151.1300	-31.9904			0
210039	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	321506.38	6457804.63	151.1104	-32.0018	299.7	374.1	4847
53034	Upper Hunter	Cm	GRZ	M	Carboniferous Mudstone	342473.41	6462101.77	151.3330	-31.9662	465	465	1
210017	Upper Hunter	Cs	GRZ	M	Carboniferous Sandstone	337509.40	6464669.96	151.2809	-31.9423			0
21010068	Upper Hunter	Cs	GRZ	M	Carboniferous Sandstone	339952.72	6471694.50	151.3079	-31.8793			0
WQ_21010067	Upper Hunter	Dch	GRZ	M	Devonian Chert	339371.82	6477983.90	151.3028	-31.8225	505	545	17
210018	Upper Hunter	Dch	GRZ	M	Devonian Chert	331259.37	6467518.62	151.2153	-31.9157			0
210138	Upper Hunter	Dch	GRZ	M	Devonian Chert	346779.44	6484716.69	151.3821	-31.7628			0
210140	Upper Hunter	Dch	GRZ	M	Devonian Chert	338972.98	6482901.08	151.2994	-31.7781			0
52376	Upper Hunter	Dch	GRZ	M	Devonian Chert	337383.14	6473644.57	151.2811	-31.8614	774	774	1
53490	Upper Hunter	Dch	GRZ	M	Devonian Chert	349257.67	6477993.88	151.4072	-31.8238	255	255	1
WQ_21010012	Upper Hunter	Dcl	GRZ	M	Devonian Claystone	328983.48	6470131.29	151.1917	-31.8918	456	456	1
WQ_21010069	Upper Hunter	Dcl	GRZ	M	Devonian Claystone	328983.30	6470142.38	151.1917	-31.8917	572	850	27
WQ_210081	Upper Hunter	Dm	GRZ	M	Devonian Mudstone	333323.88	6487801.29	151.2406	-31.7331	442.5	570	64
WQ_21010071	Upper Hunter	Dm	GRZ	M	Devonian Mudstone	324289.43	6466336.79	151.1414	-31.9253	971	985	7
210081	Upper Hunter	Dm	GRZ	M	Devonian Mudstone	333305.11	6487789.90	151.2404	-31.7332			0
HUNT11	Upper Hunter	Cc	H2O	M	Carboniferous Conglomerate	335499.86	6468508.00	151.2603	-31.9074	133	163	3
WQ_210005	Upper Hunter	Cs	H2O	M	Carboniferous Sandstone	333348.13	6466454.96	151.2372	-31.9256	211	271	289
WQ_210017	Upper Hunter	Cs	H2O	M	Carboniferous Sandstone	337528.83	6464637.00	151.2811	-31.9426	112.5	149	74
WQ_21010068	Upper Hunter	Cs	H2O	M	Carboniferous Sandstone	340210.90	6471521.10	151.3106	-31.8809	70	102	14
WQ_210018	Upper Hunter	Dch	H2O	M	Devonian Chert	331259.89	6467494.25	151.2153	-31.9159	216	335	107
WQ_21010066	Upper Hunter	Dch	H2O	M	Devonian Chert	344519.54	6485059.85	151.3583	-31.7594	486	532	26
210139	Upper Hunter	Dch	H2O	M	Devonian Chert	342677.20	6480385.79	151.3381	-31.8013			0
WQ_21010070	Upper Hunter	Dm	H2O	M	Devonian Mudstone	325667.22	6464297.62	151.1556	-31.9439	228	346.5	25
WQ_21010317	Upper Hunter	Dsi	H2O	M	Devonian Siltstone	323502.74	6459857.75	151.1319	-31.9836	328	373	16
WQ_21010006	Upper Hunter	Cm	H2O	Water	Carboniferous Mudstone	316454.89	6454920.21	151.0564	-32.0270	336	410	77
WQ_21010001	Upper Hunter	H	H2O	Water	Water	311289.34	6446108.31	151.0000	-32.1056	330	370	489
WQ_21010002	Upper Hunter	H	H2O	Water	Water	309352.86	6448689.74	150.9800	-32.0820	360	380	204
WQ_21010003	Upper Hunter	H	H2O	Water	Water	310708.71	6450933.28	150.9948	-32.0620	340	375	248
WQ_21010004	Upper Hunter	H	H2O	Water	Water	312952.61	6452693.85	151.0189	-32.0465	350	380	156
WQ_21010005	Upper Hunter	H	H2O	Water	Water	314810.44	6454424.67	151.0389	-32.0312	350	411	133
WQ_21010048	Upper Hunter	H	H2O	Water	Water	315651.02	6454439.90	151.0478	-32.0312	313	323	19

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WQ_21010188	Upper Hunter	H	H2O	Water	Water	311229.84	6446262.48	150.9994	-32.1042			0
WQ_21010065	Upper Hunter	Tb	GRZ	VL	Tertiary Basalt	343265.73	6488389.56	151.3456	-31.7292	422	449.5	15
53493	Upper Hunter	Tb	GRZ	VL	Tertiary Basalt	341488.52	6488774.91	151.3269	-31.7255	274	274	1
54002	Upper Hunter	Tb	GRZ	VL	Tertiary Basalt	339898.57	6488688.27	151.3101	-31.7260	224	224	1
54003	Upper Hunter	Tb	GRZ	VL	Tertiary Basalt	332411.78	6491153.15	151.2316	-31.7027	489	489	1
54007	Upper Hunter	Tb	GRZ	VL	Tertiary Basalt	329969.17	6493541.75	151.2062	-31.6808	182	182	1
HU55	Upper Hunter	Tb	CON	VL	Tertiary Basalt	352199.99	6462500.93	151.4359	-31.9639	22	22	1
HU56	Upper Hunter	Pn	FOR	L	Permian Newcastle	347300.00	6465600.70	151.3846	-31.9353	35	35	1
WW_DB51	Upper Paterson	Cs	CON	M	Carboniferous Sandstone	351225.56	6422662.46	151.4194	-32.3230			0
WW_DB50	Upper Paterson	Cc	GRZ	M	Carboniferous Conglomerate	347000.58	6428287.35	151.3755	-32.2717	155	160	2
WW_DB49	Upper Paterson	Cs	SRC	M	Carboniferous Sandstone	354800.57	6422287.43	151.4574	-32.3269	175	180	2
HU30	Upper Paterson	Cc	GRZ	M	Carboniferous Conglomerate	348699.99	6427300.66	151.3934	-32.2808	194	202	2
HU31	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	354799.99	6422400.56	151.4574	-32.3258	167.5	182	2
WQ_210073	Upper Paterson	Cs	GRZ	M	Carboniferous Sandstone	347064.51	6431672.62	151.3767	-32.2412	133	159	21
WQ_21010022	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	352870.47	6421290.83	151.4367	-32.3356	175	200	189
WQ_21010023	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	352116.45	6422632.65	151.4289	-32.3234	180	205	186
WQ_21010024	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	351700.45	6422748.52	151.4245	-32.3223	190	224	83
WQ_21010052	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	351853.95	6423837.50	151.4263	-32.3125	157	182	29
210073	Upper Paterson	Cs	H2O	M	Carboniferous Sandstone	347100.52	6431784.06	151.3771	-32.2402			0
WQ_21010020	Upper Paterson	Cs	SRC	M	Carboniferous Sandstone	354402.10	6422144.73	151.4531	-32.3281	803	884	16
WQ_21010053	Upper Paterson	Cs	SRC	M	Carboniferous Sandstone	354163.56	6422363.06	151.4506	-32.3261	156.5	174	18
210102	Upper Paterson	Cs	SRC	M	Carboniferous Sandstone	354761.56	6422027.94	151.4569	-32.3292			0
WW86	Upper Paterson	Cs	H2O	Water	Carboniferous Sandstone	354250.53	6421512.36	151.4514	-32.3338			0
WQ_21010021	Upper Paterson	Cs	H2O	Water	Carboniferous Sandstone	354718.97	6421716.84	151.4564	-32.3320	162	190	335
HU54	Upper Paterson	Cu	CON	M	Carboniferous Undifferentiated	345200.07	6439401.14	151.3582	-32.1713	244	244	1
HU57	Upper Paterson	Cu	CON	M	Carboniferous Undifferentiated	345300.41	6439500.70	151.3593	-32.1704	181	181	1
WW_DB65	Wallis Creek	Pm	CON	H	Permian Maitland	353283.88	6365648.38	151.4324	-32.8374	555	890	14
WW_DB70	Wallis Creek	Pm	CON	H	Permian Maitland	358724.50	6364706.93	151.4904	-32.8466	230	270	31
WW_DB59	Wallis Creek	Pd	GRZ	H	Permian Dalwood	361570.71	6378144.34	151.5228	-32.7258	780	1790	9
WW_DB60	Wallis Creek	Pd	GRZ	H	Permian Dalwood	361570.71	6378144.34	151.5228	-32.7258			0
WW_DB62	Wallis Creek	Pm	GRZ	H	Permian Maitland	351138.21	6362033.78	151.4089	-32.8697	230	305	35
WW_DB63	Wallis Creek	Pm	GRZ	H	Permian Maitland	350595.13	6361865.88	151.4031	-32.8712	210	260	40
WW_DB71	Wallis Creek	Q	H2O	L	Quaternary	357509.59	6357986.42	151.4763	-32.9071	550	600	13
WW_DB69	Wallis Creek	Q	H2O	VH	Quaternary	363250.51	6373686.13	151.5400	-32.7662	885	1360	4
WW_DB64	Wallis Creek	Pd	H2O	SAL	Permian Dalwood	355177.47	6368291.86	151.4530	-32.8138	890	1250	33
WW_DB10	Wallis Creek	Pg	SRC	H	Permian Greta	358808.47	6367382.05	151.4917	-32.8225	140	170	22
WW_DB68	Wallis Creek	Pt	TRU	SAL	Permian Tomago	362150.49	6366512.65	151.5272	-32.8308	500	575	20
WC-RV_DC	Wallis Creek	Pm	GRZ	H	Permian Maitland	360401.55	6363768.54	151.5081	-32.8553	899	1068	39
SC2U_DC	Wallis Creek	Pn	CON	VH	Permian Newcastle	364953.99	6363265.83	151.5567	-32.8604	660	766	14
SC1U_DC	Wallis Creek	Pn	CON	VH	Permian Newcastle	365580.52	6362309.20	151.5632	-32.8691	166	650	9
WC-LP_DC	Wallis Creek	Q	SRC	VH	Quaternary	364068.48	6376318.27	151.5491	-32.7426	895	1156	48
SC3U_DC	Wallis Creek	Pm	GRZ	SAL	Permian Maitland	362145.03	6366599.94	151.5272	-32.8300	585	716	13
WCU_DC	Wallis Creek	Q	H2O	SAL	Quaternary	361892.71	6366943.53	151.5245	-32.8269	661	769	19

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HA_31	Wallis Creek	Pd	CON	H	Permian Dalwood	356565.66	6370381.84	151.4682	-32.7952	2100	3000	15
WW112	Wallis Creek	Q	CON	H	Quaternary	354375.91	6355474.45	151.4424	-32.9293			0
HA_3	Wallis Creek	Pd	GRZ	H	Permian Dalwood	356723.29	6372435.70	151.4702	-32.7767	150	170	11
210053	Wallis Creek	Pd	GRZ	H	Permian Dalwood	358098.10	6370200.61	151.4845	-32.7970			0
51182	Wallis Creek	Pd	GRZ	H	Permian Dalwood	360465.06	6379782.16	151.5112	-32.7109	422	422	1
WQ_210054	Wallis Creek	Pm	GRZ	H	Permian Maitland	360425.84	6363879.43	151.5084	-32.8543	899	1070	39
210054	Wallis Creek	Pm	GRZ	H	Permian Maitland	360427.09	6363790.73	151.5084	-32.8551			0
HA_2	Wallis Creek	Pd	CON	L	Permian Dalwood	357607.31	6371764.59	151.4795	-32.7828	2390	3030	17
HA_14	Wallis Creek	Pd	CON	L	Permian Dalwood	358658.43	6371409.99	151.4907	-32.7862	510	940	17
HUNTM4B	Wallis Creek	Pm	GRZ	L	Permian Maitland	362299.46	6372511.05	151.5297	-32.7767	644	1160	4
HA_9	Wallis Creek	Q	GRZ	L	Quaternary	358192.27	6372345.93	151.4858	-32.7777	1300	1950	25
HUNT590	Wallis Creek	Q	GRZ	L	Quaternary	357698.70	6361511.69	151.4789	-32.8753	646.5	878	2
WW109	Wallis Creek	Q	H2O	L	Quaternary	357228.63	6357100.73	151.4732	-32.9150	711	830	2
WQ_21010194	Wallis Creek	Q	H2O	L	Quaternary	357798.91	6361701.66	151.4800	-32.8736	646.5	878	2
210036	Wallis Creek	Q	H2O	L	Quaternary	357506.22	6357993.47	151.4763	-32.9070			0
WQ_21010226	Wallis Creek	Pm	SRC	L	Permian Maitland	364340.57	6379447.72	151.5525	-32.7144	1798	2683	2
WW110	Wallis Creek	Pn	CON	VH	Permian Newcastle	353879.56	6351831.64	151.4366	-32.9621	262	380	3
WM2	Wallis Creek	Pt	CON	VH	Permian Tomago	366795.99	6371894.02	151.5776	-32.7828	924	1890	120
WQ_21010279	Wallis Creek	Pm	GRZ	VH	Permian Maitland	363564.00	6375245.40	151.5436	-32.7522	1227	1604	2
WM1	Wallis Creek	Pt	GRZ	VH	Permian Tomago	363563.99	6371317.05	151.5430	-32.7876			0
WQ_210047	Wallis Creek	Q	GRZ	VH	Quaternary	364235.72	6377516.79	151.5511	-32.7318	725	937	220
WQ_21010197	Wallis Creek	Q	GRZ	VH	Quaternary	364415.93	6375988.96	151.5528	-32.7456	901	1290	58
WQ_21010278	Wallis Creek	Q	GRZ	VH	Quaternary	363748.95	6376789.33	151.5458	-32.7383	1240	1360	3
HA_62	Wallis Creek	Q	H2O	VH	Quaternary	359670.57	6372699.66	151.5017	-32.7747	1525	2230	26
210453	Wallis Creek	Q	H2O	VH	Quaternary	363251.00	6373693.00	151.5400	-32.7662			0
WQ_21010272	Wallis Creek	Pt	TRU	VH	Permian Tomago	364792.11	6367655.05	151.5556	-32.8208	1580	2560	4
HA_44	Wallis Creek	Pd	GRZ	SAL	Permian Dalwood	356824.96	6371882.69	151.4712	-32.7817	1327.5	1740	16
WQ_210053	Wallis Creek	Pd	GRZ	SAL	Permian Dalwood	357894.32	6370042.44	151.4823	-32.7984	1154	1309	15
WQ_21010243	Wallis Creek	Pm	GRZ	SAL	Permian Maitland	363157.20	6380285.35	151.5400	-32.7067	1895	1980	2
HA_A	Wallis Creek	Pd	H2O	SAL	Permian Dalwood	357866.38	6370030.94	151.4820	-32.7985	920	1000	27
WW99	Wallis Creek	Pd	H2O	SAL	Permian Dalwood	357864.55	6370031.84	151.4820	-32.7985			0
WQ_21010274	Wallis Creek	Pg	H2O	SAL	Permian Greta	353355.31	6368534.57	151.4336	-32.8114	1122.5	1930	2
WW111	Wallis Creek	Pm	H2O	SAL	Permian Maitland	362061.33	6366519.81	151.5263	-32.8307	697	750	21
WQ_21010273	Wallis Creek	Pm	H2O	SAL	Permian Maitland	362045.57	6366530.37	151.5261	-32.8306	640.5	747	28
HA_B	Wallis Creek	Q	H2O	SAL	Quaternary	358706.05	6371355.22	151.4912	-32.7867	995	1100	26
HA_D	Wallis Creek	Q	H2O	SAL	Quaternary	359010.07	6371932.51	151.4945	-32.7815	975	1100	26
HA_E	Wallis Creek	Q	H2O	SAL	Quaternary	359081.02	6372432.54	151.4953	-32.7770	995	1200	26
WW100	Wallis Creek	Pm	RES	SAL	Permian Maitland	353267.28	6368208.58	151.4326	-32.8143			0
HA_1	Wallis Creek	Pd	SRC	SAL	Permian Dalwood	357334.32	6371206.18	151.4765	-32.7878	2490	3250	17
HU49	Wallis Creek	Q	GRZ	L	Quaternary			151.4384	-32.9326	1113	1576	2
SC_S6_DC	Wallis Creek	Pn	TRU	VH	Permian Newcastle	364301.48	6362661.54	151.5496	-32.8658	369	411	34
SC_S5_DC	Wallis Creek	Pn	CON	VH	Permian Newcastle	363549.80	6363234.91	151.5417	-32.8605	205	256	19
SC_S4_DC	Wallis Creek	Pt	CON	VH	Permian Tomago	362480.45	6363742.82	151.5303	-32.8558	653	1018	42

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SC_S2_DC	Wallis Creek	Pt	TRU	VH	Permian Tomago	362241.91	6366568.84	151.5282	-32.8303	630	766	43
HunterWater8	Wallis Creek	Pd	SRC	H	Permian Dalwood	356472.21	6369290.01	151.4670	-32.8050	1060	1424	73
HunterWater7	Wallis Creek	Pd	H2O	SAL	Permian Dalwood	357865.59	6370086.38	151.4820	-32.7980	865	1014	74
HunterWater6	Wallis Creek	Pd	H2O	SAL	Permian Dalwood	358689.38	6371428.91	151.4910	-32.7860	887	1085	43
HU37	Wallis Creek	Pm	GRZ	VH	Permian Maitland			151.5418	-32.7535	1677.5	2310	2
WQ_21010164	Wallis Creek Tidal Pool	Pm	GRZ	L	Permian Maitland	362399.87	6372700.97	151.5308	-32.7750	644	1160	4
WW108	Wallis Creek Tidal Pool	Q	H2O	VH	Quaternary	366434.34	6376998.63	151.5745	-32.7367	1195	1391	4
210428	Wallis Creek Tidal Pool	Q	H2O	VH	Quaternary	366448.00	6376992.00	151.5746	-32.7368			0
210457	Wallis Creek Tidal Pool	Q	H2O	VH	Quaternary	366429.00	6376944.00	151.5744	-32.7372			0
WQ_21010357	White Rock	Q	GRZ	L	Quaternary	279092.77	6440900.20	150.6578	-32.1467	1294	1294	3
JJWUS	White Rock	Q	GRZ	L	Quaternary	278972.08	6441060.89	150.6566	-32.1452	972	972	1
JJW48	White Rock	Q	H2O	SAL	Quaternary	279005.52	6440693.06	150.6568	-32.1486	1080	1294	7
MK_OEH1	Widden Brook	Tns	AGR	VL	Triassic Narrabeen Ss	252882.65	6411581.74	150.3725	-32.4055	126	126	1
CJ_J16	Widden Brook	Q	H2O	L	Quaternary	254358.82	6405844.38	150.3867	-32.4575	420	480	2
WQ_21010224	Widden Brook	Q	H2O	L	Quaternary	253907.08	6409228.88	150.3828	-32.4269	450	760	26
WQ_21010330	Widden Brook	Psi	CON	M	Permian Singleton	256467.95	6385644.50	150.4039	-32.6400	88.5	95	2
WQ_21010335	Widden Brook	Psi	CON	M	Permian Singleton	250302.04	6378800.04	150.3364	-32.7003	214.3	244	2
CJ_J10	Widden Brook	Psi	GRZ	M	Permian Singleton	252201.55	6397901.41	150.3617	-32.5286	460	460	1
CJ_J12	Widden Brook	Psi	GRZ	M	Permian Singleton	252429.97	6386173.16	150.3610	-32.6343	420	420	1
WQ_210034	Widden Brook	Psi	GRZ	M	Permian Singleton	252482.23	6399095.73	150.3650	-32.5179	249	303.5	35
WQ_21010331	Widden Brook	Psi	GRZ	M	Permian Singleton	252201.55	6397901.41	150.3617	-32.5286	314.5	370	2
WQ_21010334	Widden Brook	Psi	GRZ	M	Permian Singleton	253163.13	6386395.42	150.3689	-32.6325	109	115	2
210034	Widden Brook	Psi	GRZ	M	Permian Singleton	252402.60	6398894.02	150.3641	-32.5197			0
CJ_J13	Widden Brook	Psi	H2O	M	Permian Singleton	254661.25	6385828.26	150.3847	-32.6379	110	110	1
CJ_J15	Widden Brook	Psi	H2O	M	Permian Singleton	252043.39	6395150.36	150.3593	-32.5534	350	350	1
SWC_HU40	Widden Brook	Psi	H2O	M	Permian Singleton	251390.02	6381110.92	150.3486	-32.6797			0
WQ_21010332	Widden Brook	Psi	H2O	M	Permian Singleton	253552.88	6392663.78	150.3747	-32.5761	260.5	365	2
WQ_21010333	Widden Brook	Psi	H2O	M	Permian Singleton	253552.88	6392663.78	150.3747	-32.5761	352	453	2
WQ_21010198	Widden Brook	Q	H2O	VL	Quaternary	254012.41	6410307.83	150.3842	-32.4172	407	510	3
WW_DB72	Williams River	Q	H2O	VH	Quaternary	382500.42	6375312.59	151.7457	-32.7538	32160	64000	2
W02	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357299.99	6445600.52	151.4874	-32.1169	65.5	73	2
WQ_21010233	Williams River	Cs	GRZ	L	Carboniferous Sandstone	383708.38	6411433.51	151.7631	-32.4281	1267	1394	2
W14	Williams River	Cs	H2O	L	Carboniferous Sandstone	383500.00	6406700.23	151.7603	-32.4708	275.5	290	2
WQ_21010026	Williams River	Cc	GRZ	H	Carboniferous Conglomerate	382498.88	6385733.22	151.7470	-32.6598	495	610	2
HUNT504	Williams River	Q	GRZ	H	Quaternary	380002.45	6387411.01	151.7206	-32.6444	111	111	1
53060	Williams River	Cs	CON	L	Carboniferous Sandstone	380002.40	6432883.10	151.7264	-32.2343	115	115	1
WQ_21010158	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357363.78	6445849.96	151.4881	-32.1147	54	70	9
HUNT04D	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357301.00	6445616.23	151.4874	-32.1168	51	65	14
HUNT04A	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357412.94	6445574.55	151.4886	-32.1172			0
HUNT04B	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357417.79	6445632.28	151.4886	-32.1167			0
HUNT04C	Williams River	Cu	CON	L	Carboniferous Undifferentiated	357405.42	6445572.23	151.4885	-32.1172			0
51002	Williams River	Q	CON	L	Quaternary	386663.89	6386674.08	151.7915	-32.6518	8000	8000	1
WW142	Williams River	Cs	GRZ	L	Carboniferous Sandstone	383568.98	6414718.16	151.7620	-32.3985			0

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WQ_21010156	Williams River	Cs	GRZ	L	Carboniferous Sandstone	383601.63	6407034.83	151.7614	-32.4678	255.5	290	6
210010	Williams River	Cs	GRZ	L	Carboniferous Sandstone	387746.38	6397014.57	151.8043	-32.5586			0
WQ_21010230	Williams River	Cv	GRZ	L	Carboniferous Volcanics	389262.69	6402541.99	151.8211	-32.5089	697.5	815	2
SEAH1	Williams River	Cv	GRZ	L	Carboniferous Volcanics	381105.00	6385316.00	151.7321	-32.6634			0
WW144	Williams River	Cs	H2O	L	Carboniferous Sandstone	383706.12	6414938.28	151.7635	-32.3965			0
WQ_210903	Williams River	Cs	H2O	L	Carboniferous Sandstone	383698.09	6414941.40	151.7634	-32.3965	148	160	7
HUNT02	Williams River	Cs	H2O	L	Carboniferous Sandstone	383499.67	6406911.68	151.7603	-32.4689	275.5	384	4
51043	Williams River	Cs	H2O	L	Carboniferous Sandstone	384034.41	6405943.27	151.7659	-32.4777	1455	1455	1
HUNT849B	Williams River	Cs	H2O	L	Carboniferous Sandstone	384207.89	6408500.98	151.7680	-32.4546			0
HUNT849C	Williams River	Cs	H2O	L	Carboniferous Sandstone	384200.53	6408487.59	151.7680	-32.4548			0
WQ_210010	Williams River	Cs	RES	L	Carboniferous Sandstone	387445.06	6397088.79	151.8011	-32.5579	210.5	346	66
WW141	Williams River	Cs	CON	M	Carboniferous Sandstone	376775.47	6432412.35	151.6921	-32.2382			0
WQ_21010085	Williams River	Cs	CON	M	Carboniferous Sandstone	372395.22	6433942.05	151.6458	-32.2239	63.5	70	10
210137	Williams River	Cs	CON	M	Carboniferous Sandstone	374108.36	6435637.73	151.6642	-32.2088			0
WQ_210011	Williams River	Cs	GRZ	M	Carboniferous Sandstone	376453.43	6423481.31	151.6875	-32.3187	190	267	51
WQ_21010231	Williams River	Cs	GRZ	M	Carboniferous Sandstone	383065.46	6406263.54	151.7556	-32.4747	554	900	2
WQ_21010232	Williams River	Cs	GRZ	M	Carboniferous Sandstone	380541.03	6411467.21	151.7294	-32.4275	1057.5	1145	2
WQ_21010282	Williams River	Cs	GRZ	M	Carboniferous Sandstone	386098.50	6417286.15	151.7892	-32.3756	1143	1143	1
210011	Williams River	Cs	GRZ	M	Carboniferous Sandstone	376434.60	6423481.08	151.6873	-32.3187			0
51018	Williams River	Cs	GRZ	M	Carboniferous Sandstone	384101.64	6395276.52	151.7653	-32.5739	7500	7500	1
HUNT849A	Williams River	Cs	GRZ	M	Carboniferous Sandstone	384210.14	6408305.86	151.7680	-32.4564	136	216	3
WQ_21010162	Williams River	Cu	GRZ	M	Carboniferous Undifferentiated	365916.85	6441309.45	151.5781	-32.1567	22.5	34	4
WQ_210104	Williams River	Cu	GRZ	M	Carboniferous Undifferentiated	362061.77	6439716.54	151.5370	-32.1706	75	99.5	45
210136	Williams River	Cu	GRZ	M	Carboniferous Undifferentiated	371166.40	6436443.41	151.6331	-32.2012			0
210144	Williams River	Cu	GRZ	M	Carboniferous Undifferentiated	368639.48	6431499.37	151.6056	-32.2455			0
HUNT09	Williams River	Cu	GRZ	M	Carboniferous Undifferentiated	365796.89	6441108.28	151.5768	-32.1585	22.5	34	4
WQ_210007	Williams River	Cs	H2O	M	Carboniferous Sandstone	377223.72	6431374.02	151.6967	-32.2476	212	212	1
WQ_21010084	Williams River	Cs	H2O	M	Carboniferous Sandstone	374694.82	6434713.65	151.6703	-32.2172	82	84	17
WQ_21010236	Williams River	Cs	H2O	M	Carboniferous Sandstone	379198.51	6425399.45	151.7169	-32.3017	180	210	2
WQ_21010237	Williams River	Cs	H2O	M	Carboniferous Sandstone	385392.16	6417344.65	151.7817	-32.3750	944	1458	2
HUNT509	Williams River	Cs	H2O	M	Carboniferous Sandstone	383803.09	6414809.57	151.7645	-32.3977	160	160	2
210100	Williams River	Q	H2O	M	Quaternary	377101.67	6429787.01	151.6952	-32.2619			0
WW82	Williams River	Cs	RES	M	Carboniferous Sandstone	383193.92	6414614.02	151.7580	-32.3994			0
WQ_21010086	Williams River	Cs	RES	M	Carboniferous Sandstone	376550.58	6432485.67	151.6897	-32.2375			0
WQ_21010087	Williams River	Cs	RES	M	Carboniferous Sandstone	376550.58	6432485.67	151.6897	-32.2375			0
WQ_21010235	Williams River	Cs	RES	M	Carboniferous Sandstone	383304.73	6414792.71	151.7592	-32.3978	1089	1458	2
210903	Williams River	Cs	RES	M	Carboniferous Sandstone	383432.29	6415148.99	151.7606	-32.3946			0
WQ_210417	Williams River	Cs	RES	VH	Carboniferous Sandstone	385300.52	6393316.74	151.7778	-32.5917	120	265	3
210452	Williams River	Q	GRZ	SAL	Quaternary	382352.00	6375361.00	151.7441	-32.7533			0
RYTC1	Williams River	Q	GRZ	SAL	Quaternary	382352.00	6375361.00	151.7441	-32.7533			0
WQ_21010233B	Williams River	Cs	TRU	SAL	Carboniferous Sandstone	381475.78	6411943.96	151.7394	-32.4233			0
HU41	Wollar Creek	Pi	RES	VH	Permian Illawarra			149.9490	-32.3630	2210	2320	2
WOL1_WJ	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	212984.18	6419859.34	149.9513	-32.3213	2160	2510	24

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WILU_WJ	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	202865.89	6421997.36	149.8446	-32.2994	630	700	11
WILPC_WJ	Wollar Creek	Q	GRZ	VH	Quaternary	203553.35	6421022.80	149.8516	-32.3084	1820	2800	11
CC3_WJ	Wollar Creek	Pv	TRU	VH	Permian Volcanics	206760.86	6414702.85	149.8837	-32.3662	4310	5700	17
WOL2_WJ	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	212936.92	6418705.14	149.9504	-32.3317	1795	2590	26
CC2_WJ	Wollar Creek	Q	GRZ	SAL	Quaternary	208016.07	6417658.65	149.8979	-32.3399	6060	6900	26
CC1_WJ	Wollar Creek	Q	GRZ	SAL	Quaternary	208476.99	6419309.22	149.9033	-32.3251	6800	8650	25
WILD_WJ	Wollar Creek	Q	GRZ	SAL	Quaternary	209571.05	6420332.07	149.9152	-32.3162	1880	2790	11
WILNC_WJ	Wollar Creek	Q	GRZ	SAL	Quaternary	205726.36	6419356.71	149.8741	-32.3240	1035	1290	8
52388	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	216031.72	6401635.26	149.9782	-32.4863	628	628	1
53011	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	199520.50	6423588.86	149.8097	-32.2842	725	725	1
ML_SW04	Wollar Creek	Pi	TRU	VH	Permian Illawarra	199655.76	6423587.47	149.8111	-32.2843	1140	1770	29
ML_SW15	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	199522.13	6424322.31	149.8099	-32.2776			0
WQ_210082	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	213152.25	6417937.91	149.9525	-32.3387	2000	2380	39
WQ_21010225	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	213020.34	6415292.20	149.9503	-32.3625	1780	2080	2
WQ_21010343	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	213172.01	6419892.17	149.9533	-32.3211	2320	4700	18
210082	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	213152.25	6417937.91	149.9525	-32.3387			0
WOL3	Wollar Creek	Q	GRZ	SAL	Quaternary	213775.53	6409405.71	149.9565	-32.4157	200	240	13
CC4	Wollar Creek	Psi	GRZ	SAL	Permian Singleton	206463.90	6412666.94	149.8799	-32.3844	5500	6000	15
CC5	Wollar Creek	Psi	GRZ	VH	Permian Singleton	207957.67	6416653.84	149.8970	-32.3489			0
WIL2	Wollar Creek	Q	GRZ	VH	Quaternary	211205.97	6420484.19	149.9326	-32.3153	3590	4750	15
WIL1	Wollar Creek	Q	GRZ	SAL	Quaternary	203878.16	6420745.89	149.8550	-32.3110	1395	1700	13
MC1	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	199591.38	6423610.46	149.8104	-32.2840	520	648	10
WO1	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	777930.00	6418180.00	149.9528	-32.3387	730		0
WO2	Wollar Creek	Pi	GRZ	VH	Permian Illawarra	777640.00	6419000.00	149.9495	-32.3314	690		0
WC4	Wollar Creek	Q	GRZ	VH	Quaternary	772180.00	6420330.00	149.8912	-32.3208	350		0
WC6	Wollar Creek	Q	GRZ	VH	Quaternary	774580.00	6420860.00	149.9165	-32.3154	1220		0
WC1	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	767680.00	6422970.00	149.8427	-32.2981	240		0
WC2	Wollar Creek	Pi	GRZ	SAL	Permian Illawarra	768350.00	6422450.00	149.8499	-32.3026	220		0
WC3	Wollar Creek	Q	GRZ	SAL	Quaternary	770010.00	6420860.00	149.8680	-32.3165	0		0
WC5	Wollar Creek	Q	GRZ	SAL	Quaternary	773970.00	6420420.00	149.9101	-32.3195	1460		0
WC7	Wollar Creek	Q	GRZ	SAL	Quaternary	775100.00	6421050.00	149.9219	-32.3135	1440		0
WC8	Wollar Creek	Q	GRZ	SAL	Quaternary	775680.00	6420830.00	149.9281	-32.3154	1190		0
CC1	Wollar Creek	Q	GRZ	SAL	Quaternary	772730.00	6418150.00	149.8976	-32.3403	3090		0
CC2	Wollar Creek	Q	GRZ	SAL	Quaternary	772970.00	6418950.00	149.8999	-32.3330	3340		0
WW_DB77	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	324400.64	6356712.64	151.1222	-32.9137	450	520	143
WW_DB79	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	320274.36	6361591.21	151.0791	-32.8691	470	600	11
HU42	Wollombi Brook	T	RES	VL	Triassic			151.1326	-33.0312	280	430	2
WQ_21010104	Wollombi Brook	T	H2O	L	Triassic	333103.75	6346064.53	151.2133	-33.0111	377	377	1
WQ_21010129	Wollombi Brook	T	RES	L	Triassic	331496.83	6344406.63	151.1958	-33.0258	1081	1081	1
WW150	Wollombi Brook	T	CON	VL	Triassic	328220.58	6336662.74	151.1593	-33.0951			0
WW151	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	326300.65	6353912.59	151.1420	-32.9393	460	560	13
WQ_210051	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	327728.18	6358472.03	151.1581	-32.8984	525	679	45
WQ_21010103	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	333206.47	6364854.89	151.2178	-32.8417	1026	1026	1

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WQ_21010105	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	323786.85	6351780.54	151.1147	-32.9581	423	423	1
WQ_210106	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	326580.10	6352994.80	151.1448	-32.9476	394.5	1975	8
210106	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	326580.10	6352994.80	151.1448	-32.9476			0
WQ_21010114	Wollombi Brook	T	FOR	VL	Triassic	334809.37	6335800.53	151.2297	-33.1039	286	286	1
WW146	Wollombi Brook	T	GRZ	VL	Triassic	327670.67	6337622.73	151.1536	-33.0864			0
WQ_21010108	Wollombi Brook	T	GRZ	VL	Triassic	327855.14	6338952.79	151.1558	-33.0744			0
WQ_21010110	Wollombi Brook	T	GRZ	VL	Triassic	327337.97	6341805.40	151.1508	-33.0486	272	272	1
52194	Wollombi Brook	T	GRZ	VL	Triassic	325936.93	6340848.91	151.1356	-33.0570	181	181	1
WW149	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	325767.61	6354489.60	151.1364	-32.9340	539	870	8
WQ_21010097	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	321099.88	6359685.07	151.0875	-32.8864	351	351	1
WQ_21010098	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	325608.94	6354497.22	151.1347	-32.9339	461	461	1
WQ_21010099	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	329194.82	6359151.94	151.1739	-32.8925	639	639	1
WQ_21010125	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	327285.25	6355447.36	151.1528	-32.9256	336	336	1
WQ_21010127	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	325424.93	6351687.72	151.1322	-32.9592	304	304	1
WQ_21010128	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	325305.29	6349999.64	151.1306	-32.9744	357	357	1
WQ_21010132	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	326602.83	6354359.48	151.1453	-32.9353	423	423	1
WQ_21010134	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	327285.25	6355447.36	151.1528	-32.9256	250	250	1
WQ_21010137	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	327285.25	6355447.36	151.1528	-32.9256	224	224	1
210051	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	327707.34	6358593.68	151.1579	-32.8973			0
WW153	Wollombi Brook	T	H2O	VL	Triassic	326804.10	6346650.58	151.1460	-33.0048	409	590	7
WQ_21010100	Wollombi Brook	T	H2O	VL	Triassic	330061.10	6345302.48	151.1806	-33.0175	388	388	1
WQ_21010109	Wollombi Brook	T	H2O	VL	Triassic	325596.35	6345190.91	151.1328	-33.0178	341	341	1
WW145	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	331312.58	6360216.66	151.1967	-32.8832			0
WQ_21010101	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	328001.55	6352997.55	151.1600	-32.9478	461	461	1
WQ_21010276	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325496.57	6347651.55	151.1322	-32.9956	211	300	2
52037	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325866.74	6347755.73	151.1362	-32.9947	403	403	1
HUNT543	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	324498.32	6355409.20	151.1230	-32.9255	495	748	3
WW152	Wollombi Brook	T	RES	VL	Triassic	330625.63	6335312.74	151.1848	-33.1077			0
WW154	Wollombi Brook	T	RES	VL	Triassic	322300.66	6346712.67	151.0978	-33.0035			0
WQ_21010107	Wollombi Brook	T	RES	VL	Triassic	329194.51	6341405.34	151.1706	-33.0525	293	293	1
WQ_21010112	Wollombi Brook	T	RES	VL	Triassic	329243.29	6335394.42	151.1700	-33.1067	279	279	1
WQ_21010113	Wollombi Brook	T	RES	VL	Triassic	331649.86	6335502.67	151.1958	-33.1061	278	278	1
WQ_21010126	Wollombi Brook	T	RES	VL	Triassic	327423.73	6336937.56	151.1508	-33.0925	317	317	1
WQ_21010130	Wollombi Brook	T	RES	VL	Triassic	331483.70	6345171.72	151.1958	-33.0189	794	794	1
WQ_21010131	Wollombi Brook	T	RES	VL	Triassic	326317.02	6346712.19	151.1408	-33.0042	667	667	1
52020	Wollombi Brook	T	RES	VL	Triassic	330673.87	6334612.91	151.1852	-33.1140	154	154	1
WQ_21010167	Wollombi Brook	Tns	TRU	VL	Triassic Narrabeen Ss	324607.38	6355588.62	151.1242	-32.9239	356	467	3
PR_18	Wollombi Brook	T	H2O	L	Triassic	332315.85	6345096.25	151.2047	-33.0197	395	395	1
PR_16	Wollombi Brook	T	CON	VL	Triassic	328403.22	6346358.03	151.1631	-33.0077	438	438	1
PR_21	Wollombi Brook	T	CON	VL	Triassic	340528.45	6344530.83	151.2925	-33.0260	550	550	1
PR_T5	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	319757.05	6357693.41	151.0728	-32.9041	197	197	1
PR_T10	Wollombi Brook	Tns	CON	VL	Triassic Narrabeen Ss	330766.16	6362125.31	151.1912	-32.8659	596.5	751	2
PR_T13	Wollombi Brook	T	GRZ	VL	Triassic	326880.82	6342035.77	151.1459	-33.0465	443	443	1

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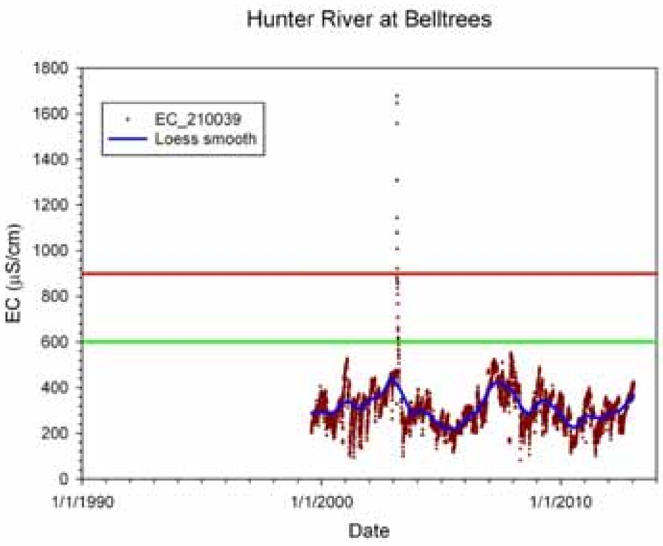
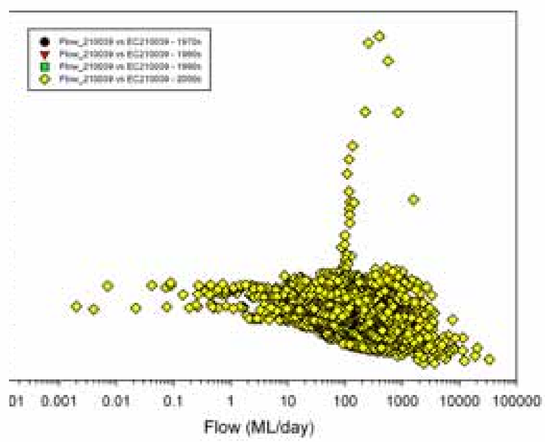
PR_24	Wollombi Brook	T	GRZ	VL	Triassic	327273.04	6340458.18	151.1499	-33.0607	276	276	1
PR_T4	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	320478.03	6360677.39	151.0810	-32.8774	407	407	1
PR_T9	Wollombi Brook	Tns	GRZ	VL	Triassic Narrabeen Ss	330721.96	6359597.47	151.1903	-32.8887	518	568	2
PR_23	Wollombi Brook	T	H2O	VL	Triassic	325917.76	6344348.01	151.1361	-33.0255	303	303	1
PR_19	Wollombi Brook	T	H2O	VL	Triassic	335399.96	6346084.96	151.2379	-33.0113	476	476	1
PR_20	Wollombi Brook	T	H2O	VL	Triassic	337986.66	6344568.83	151.2653	-33.0253	329	329	1
PR_14	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325971.96	6354009.46	151.1385	-32.9384	374.5	405	2
PR_T6	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	326914.20	6354637.19	151.1487	-32.9328	700	700	1
PR_10	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325060.95	6354465.37	151.1288	-32.9341	400	502	3
PR_9	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	324713.46	6355570.11	151.1253	-32.9241	393	520	3
PR_8	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	323749.58	6357575.21	151.1154	-32.9059	436.5	484	2
PR_11	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	326981.94	6357517.20	151.1499	-32.9069	594	727	2
PR_7	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	320249.90	6361555.30	151.0788	-32.8694	387	481	3
PR_T8	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	328253.59	6358769.29	151.1638	-32.8958	313.5	320	2
PR_T11	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	331457.52	6364042.49	151.1990	-32.8488	745	745	1
PR_15	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325754.21	6351810.41	151.1357	-32.9581	373	373	1
PR_T7	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	329180.29	6352199.57	151.1725	-32.9552	404.5	472	2
PR_22	Wollombi Brook	Tns	H2O	VL	Triassic Narrabeen Ss	325290.82	6347572.57	151.1300	-32.9963	366	366	1
PR_17	Wollombi Brook	T	RES	VL	Triassic	331007.31	6344672.05	151.1906	-33.0233	398	398	1
PR_25	Wollombi Brook	T	RES	VL	Triassic	327765.71	6337545.67	151.1546	-33.0871	271	271	1
PR_26	Wollombi Brook	T	RES	VL	Triassic	331315.11	6335552.36	151.1922	-33.1056	159	159	1
PR_T12	Wollombi Brook	T	RES	VL	Triassic	322839.54	6346630.50	151.1036	-33.0044	300	300	1
HU44	Wybong	Q	H2O	L	Quaternary			150.6346	-32.2698	3350	3470	2
WQ_21010365	Wybong	Q	AGR	L	Quaternary	280126.92	6432824.19	150.6669	-32.2197	3850	3850	1
WQ_21010363	Wybong	Q	GRZ	L	Quaternary	277604.13	6427466.08	150.6389	-32.2675	317	317	1
MG_SW04	Wybong	Q	H2O	L	Quaternary	280029.00	6432615.00	150.6658	-32.2216	1496	2760	140
210040	Wybong	Q	H2O	L	Quaternary	277335.31	6427260.46	150.6360	-32.2693	1587	2620.1	6145
JJW60	Wybong	Q	H2O	L	Quaternary	280041.88	6432638.98	150.6660	-32.2214	1757	2660	7
JJW72	Wybong	Q	GRZ	SAL	Quaternary	277352.09	6427307.06	150.6362	-32.2689	1608.5	3140	6
MG_SW05	Wybong	Q	H2O	SAL	Quaternary	277508.00	6427251.00	150.6378	-32.2694	1830.5	2640	128
WQ_210040	Wybong	Q	H2O	SAL	Quaternary	277429.52	6427262.54	150.6370	-32.2693	1486	2364.5	110
WQ_21010228	Wybong	Q	H2O	SAL	Quaternary	280026.60	6432666.69	150.6658	-32.2211	2212	3290	5
K_2	Wybong	Q	GRZ	L	Quaternary	277504.93	6427292.07	150.6378	-32.2690	1960	1960	1
K_234	Wybong	Q	H2O	L	Quaternary	280004.93	6432591.93	150.6656	-32.2218	2080	2080	1

Appendix B: Long-term trends in flow and electrical conductivity

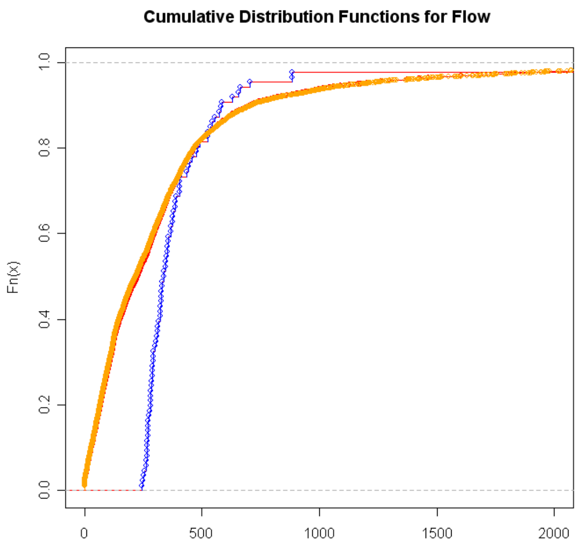
Hunter River stations

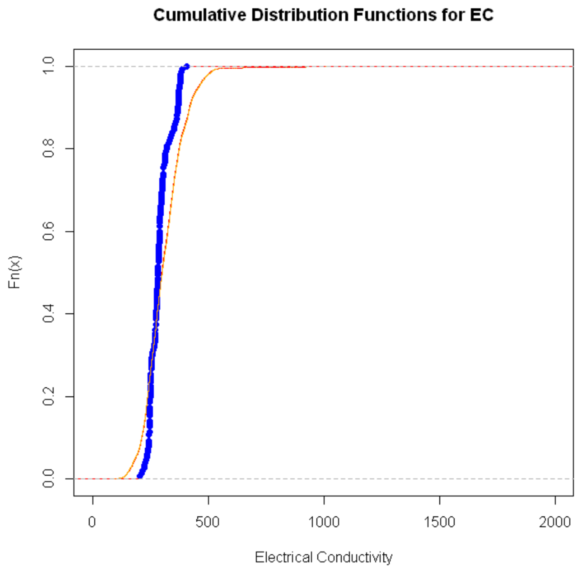
Station 210039 Hunter River at Belltrees





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	226.1	NA	338.8	218.7
EC (µS/cm)	299.7	NA	283	301.3

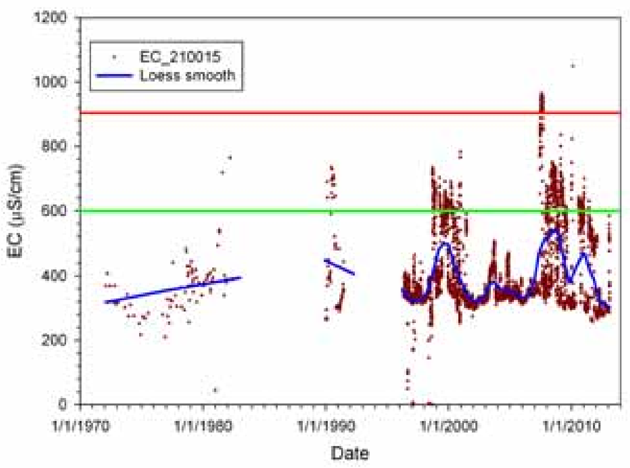


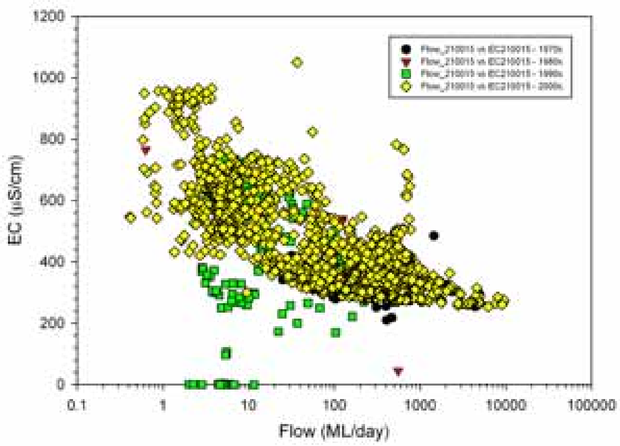


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Limited sampling at Belltrees during the 1970s to 1990s makes comparisons between periods difficult. At this point there appears to be no trend in conductivity levels at this site.

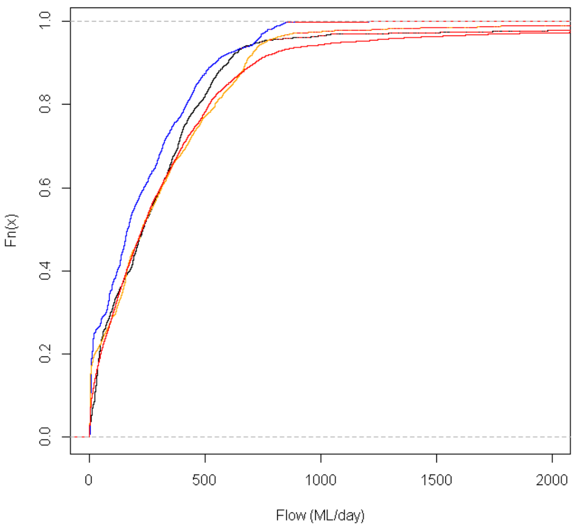
Station 210015 Hunter River at downstream Glenbawn Dam



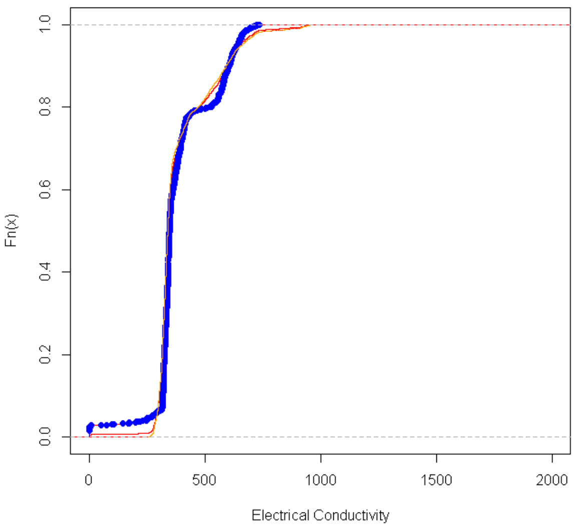


Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	229.71	343.17	167.15	227.3
EC (µS/cm)	342	370	347.1	340.5

Cumulative Distribution Functions for Flow



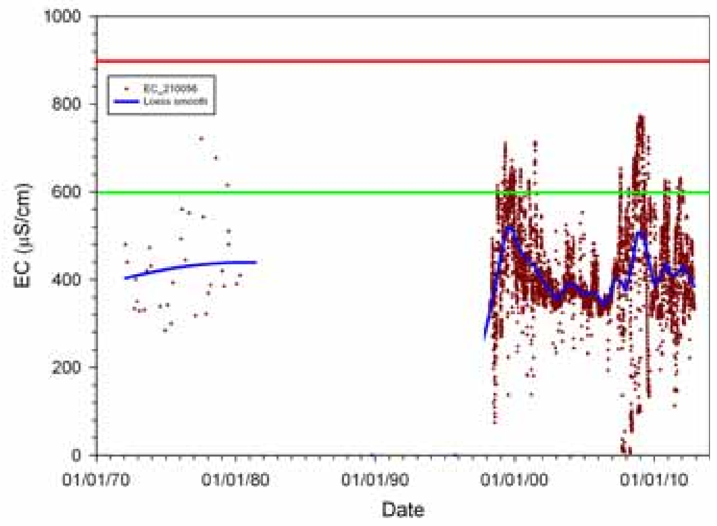
Cumulative Distribution Functions for EC

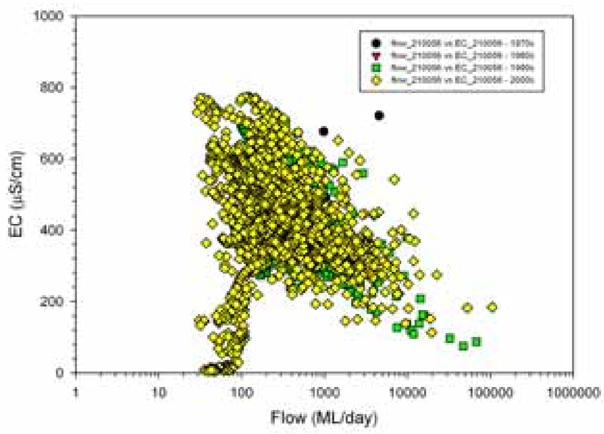


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

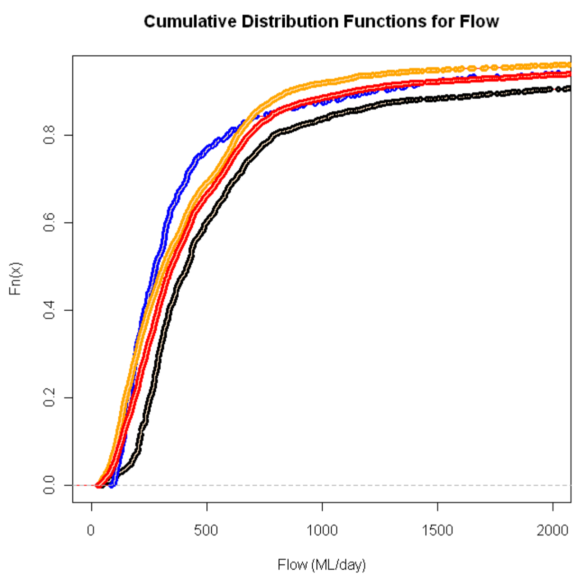
Temporal variability in flow and EC levels downstream of Glenbawn Dam are noticeable, with flows in the 2000s generally being higher than in the 1970s & 1980s or 1990s. However, the distribution of EC levels does not appear to have changed markedly between time periods.

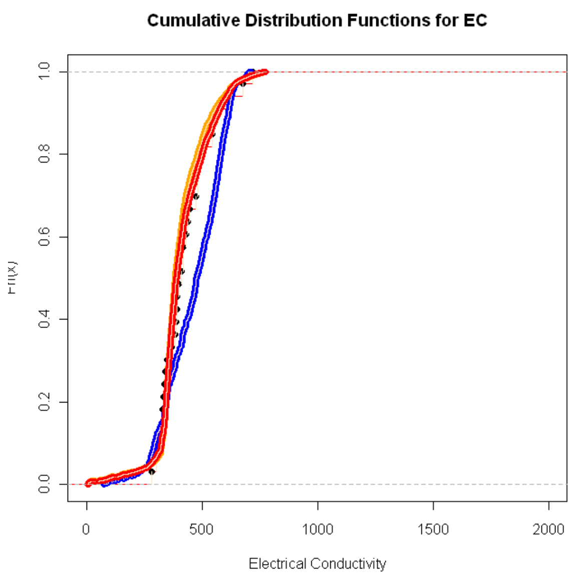
Station 210056 Hunter River at Aberdeen





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	398.86	416.09	277.1	314.8
EC (µS/cm)	389.5	410	475.8	384

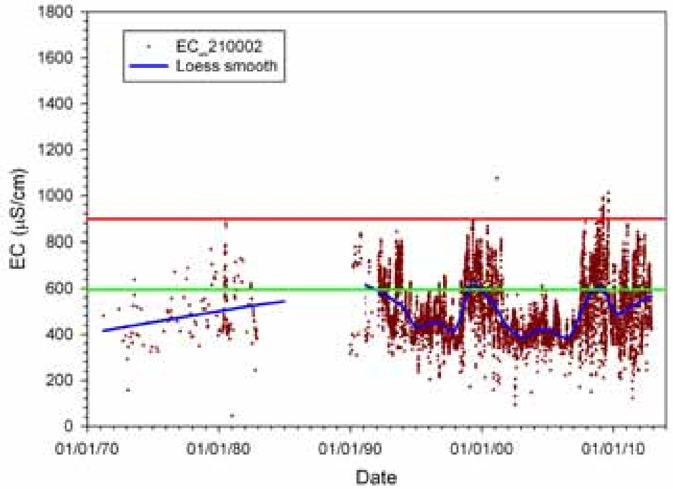


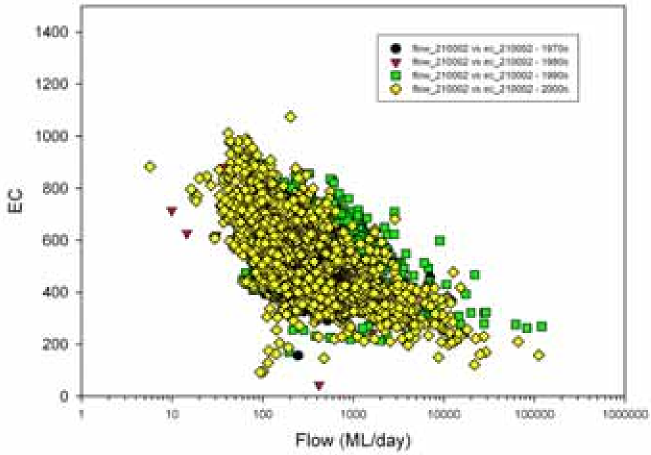


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

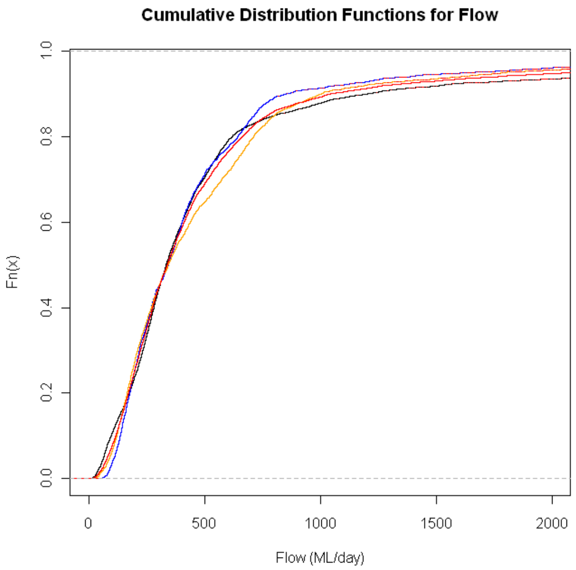
Relatively limited EC data is available for the Hunter River at Aberdeen. Flows appear to be relatively similar between the 1990s and 2000s, although higher flows were recorded during the 1990s and increased medium flows were recorded in the 2000s, potentially as a result of river regulation. Even higher flows were recorded in the 1970s but there is a large gap in flow records between 1978 and 1998. Continuous EC records were only available from March 1998, but the distribution of EC records suggests slightly higher EC for the period monitored in the 1990s compared to those recorded in the 2000s. EC in the 1970s & 1980s was similar to the 2000s.

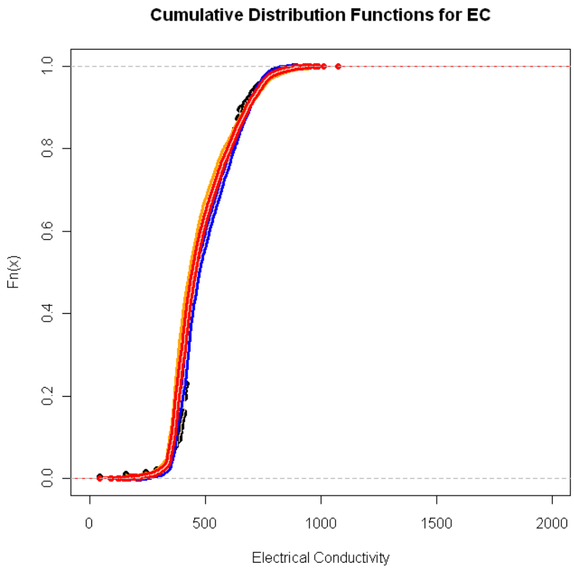
Station 210002 Hunter River at Muswellbrook Bridge





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	338.4	333.72	343.2	342.8
EC (µS/cm)	451.1	457	466.9	440.8

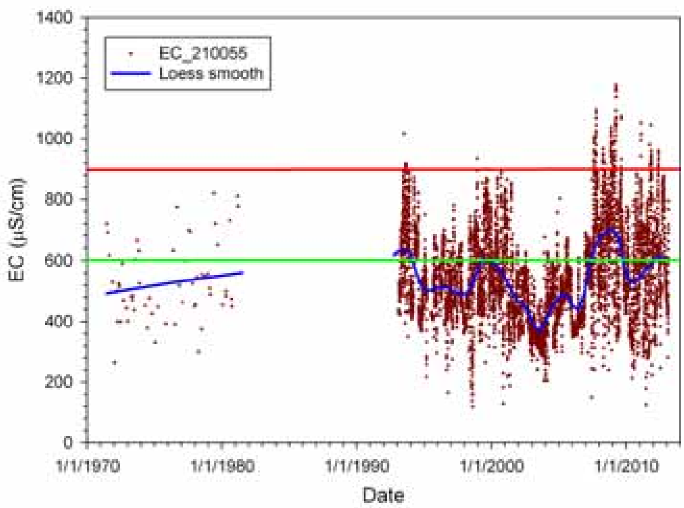


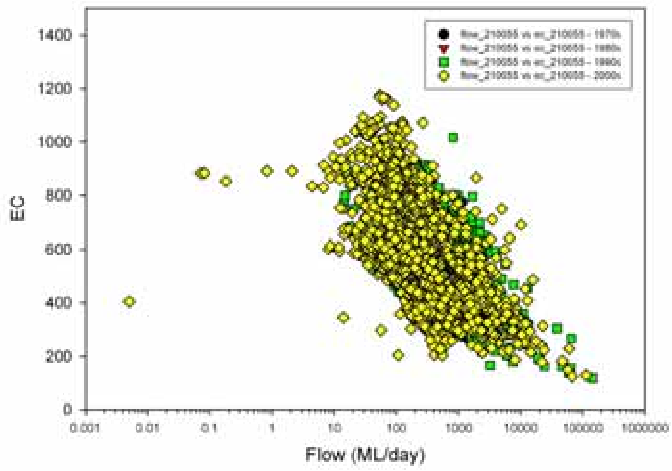


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

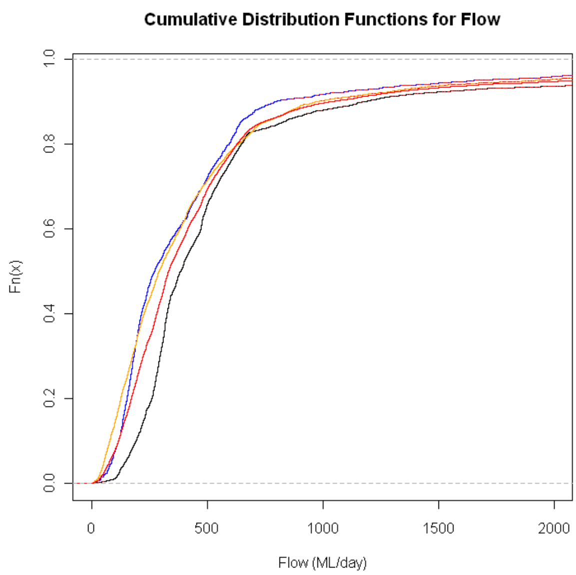
Assessment of the distribution of flow and EC records for station 210002 over the various time periods showed relatively little change in either flow or EC. Median flow over the period 1970 to 2013 was 338.4 ML/day. Median EC over the period 1970 to 2013 was 451.1 µS/cm.

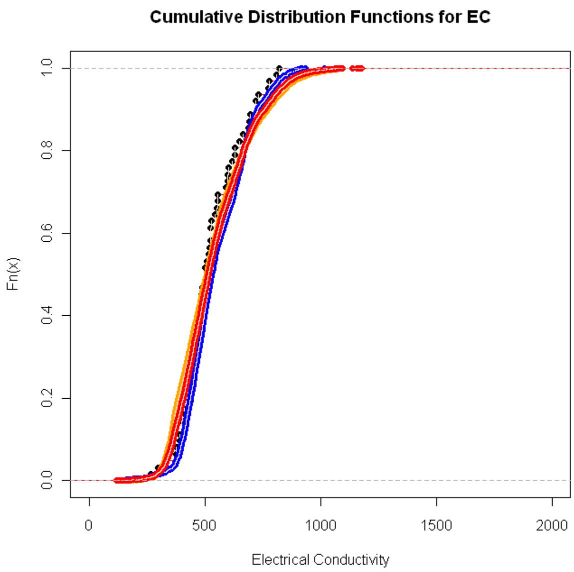
Station 210055 Hunter River at Denman





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	333.1	383.4	272.5	291.9
EC (µS/cm)	515.5	500	529.2	509.4

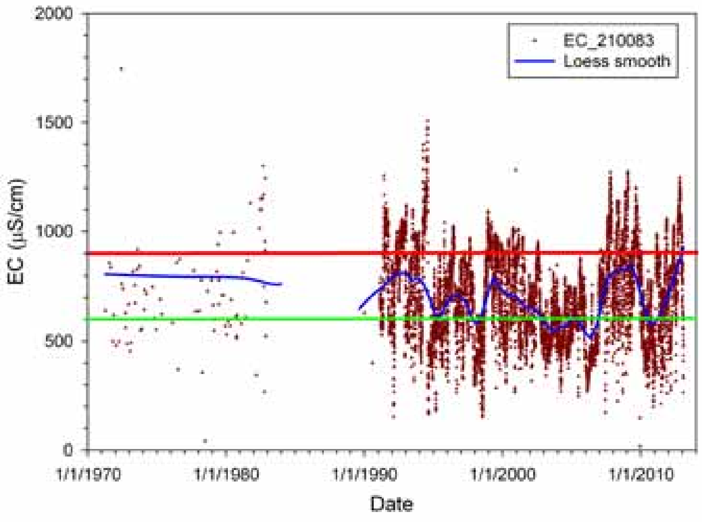


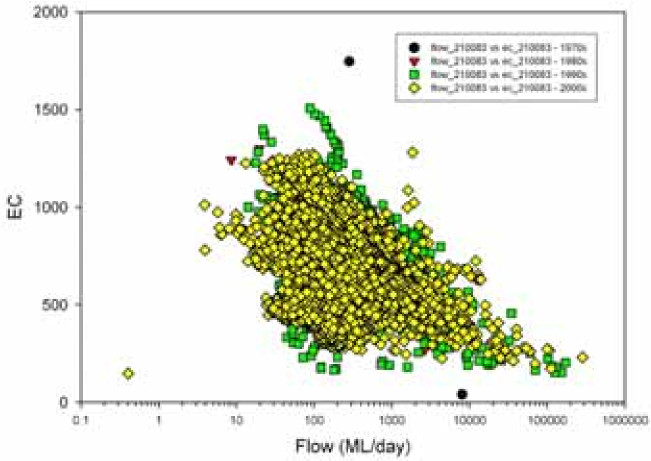


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

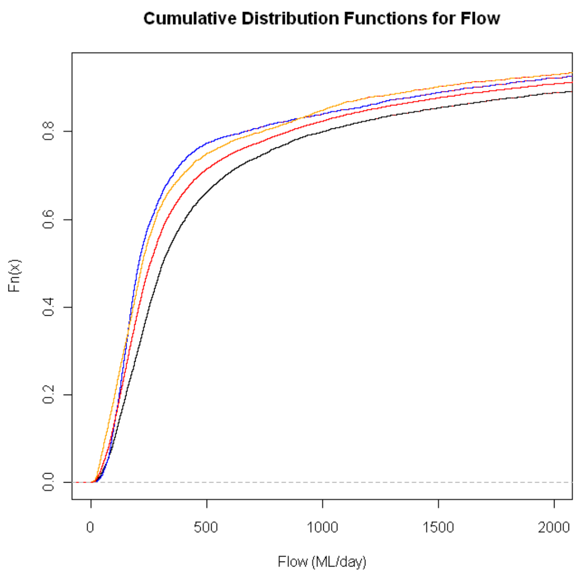
Assessment of the distribution of flow and EC records for station 210055 over the various time periods showed relatively little change. Slightly higher flows were recorded in the 1970s, however the distribution of EC levels was similar for all periods. There were fewer EC records for the 1970s & 1980s compared to more recent periods. Some EC levels exceeded the 900 µS/cm level, usually associated with lower flow in the river. Median flow over the period 1970 to 2013 was 333.1 ML/day. Median EC over the period 1970 to 2013 was 515.5 µS/cm.

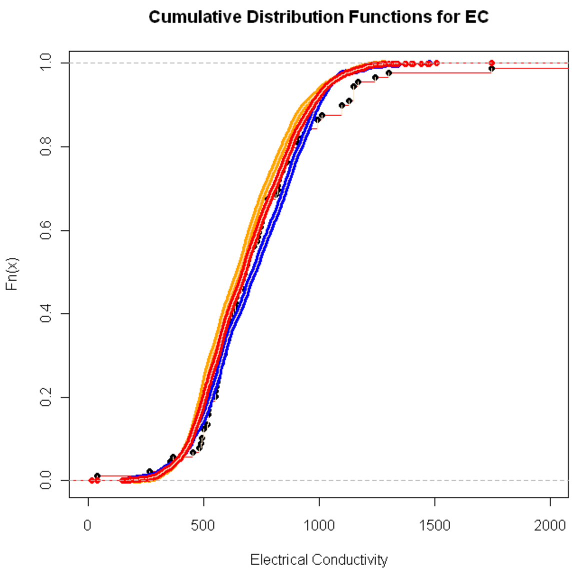
Station 210083 Hunter River at Liddell





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	257.1	311.7	207.2	223.5
EC (µS/cm)	675.7	681	717.6	652

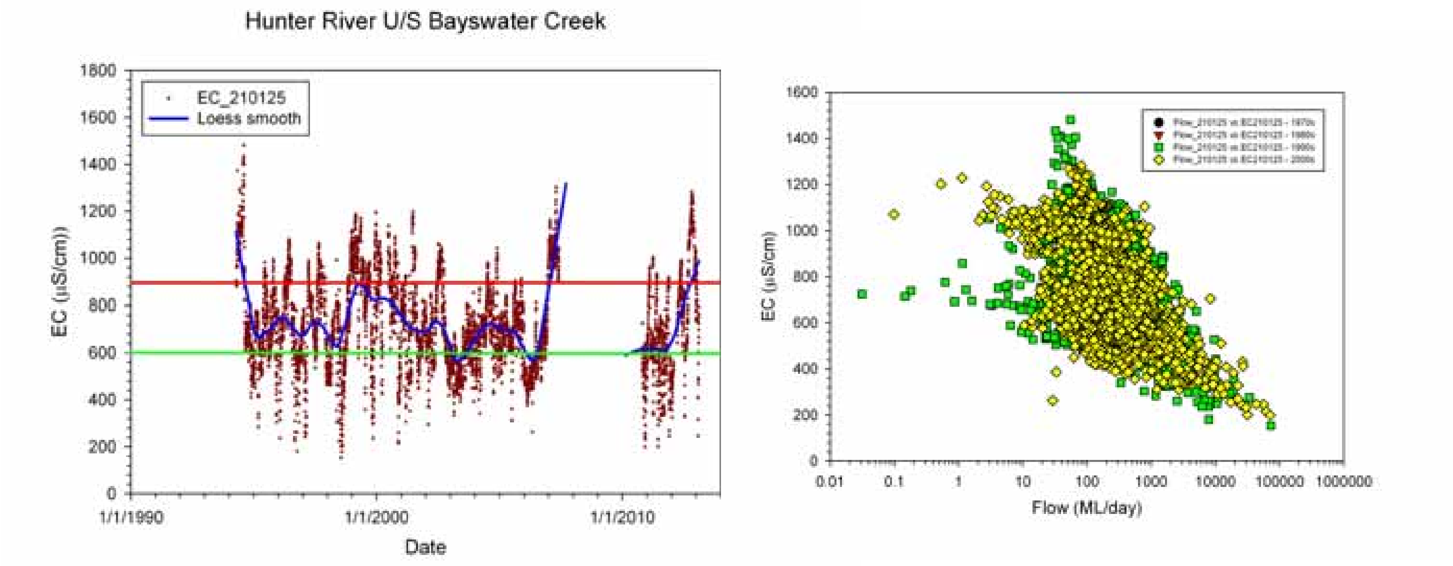




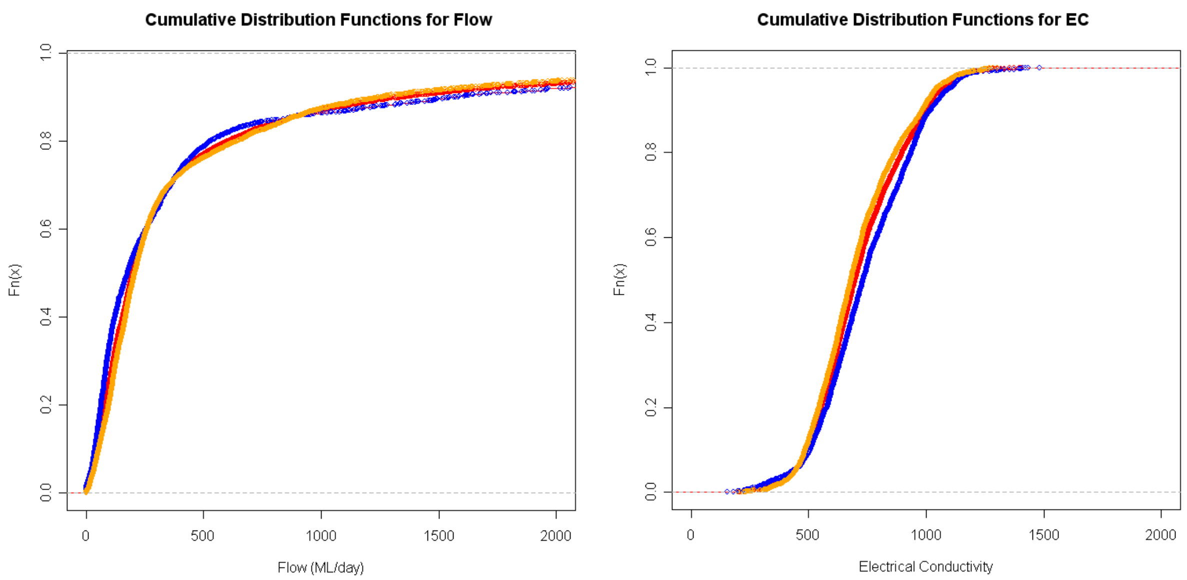
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210083 suggests higher flows in the 1970s & 1980s compared to the 1990s and 2000s. The distribution of EC levels was similar for most periods, however there appeared to be some higher EC levels in the 1970s & 1980s and EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level for longer periods than at Denman. Again these higher EC levels were usually associated with lower flow in the river. Median flow over the period 1970 to 2013 was 257.1 ML/day. Median EC over the period 1970 to 2013 was 675.7 µS/cm.

Station 210125 Hunter River at upstream Bayswater Creek



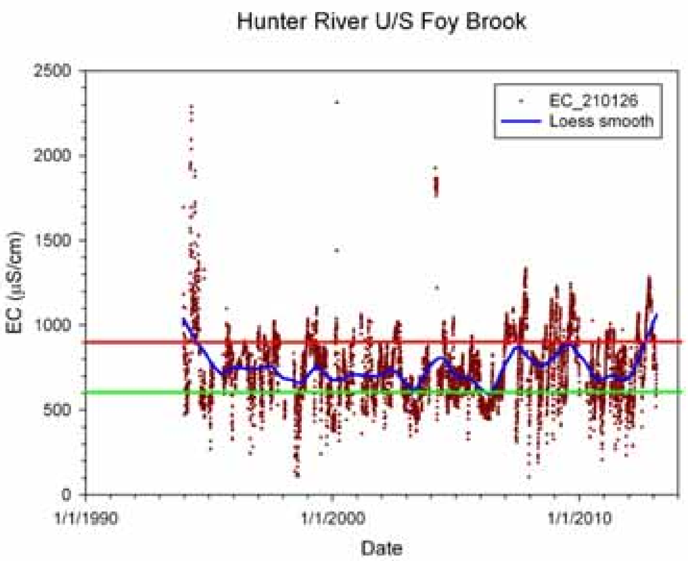
Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	199.9	NA	176.8	207.3
EC (µS/cm)	698	NA	732.3	680.5

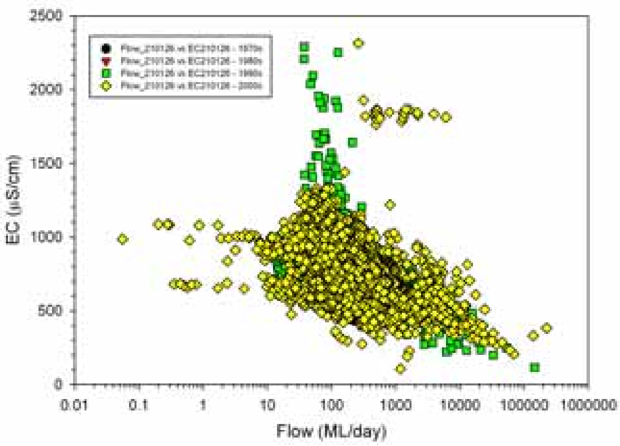


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

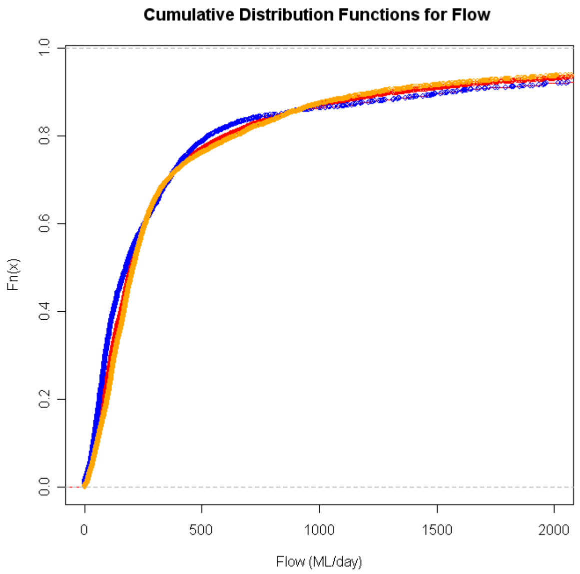
Assessment of the distribution of flow and EC records for station 210125 suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was similar but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median flow over the period 1990 to 2013 was 199.9 ML/day. Median EC over the period 1990 to 2013 was 698 µS/cm. This station was damaged during the 2007 floods and took a while to become fully operational again, explaining the gap in records in the late 2000s.

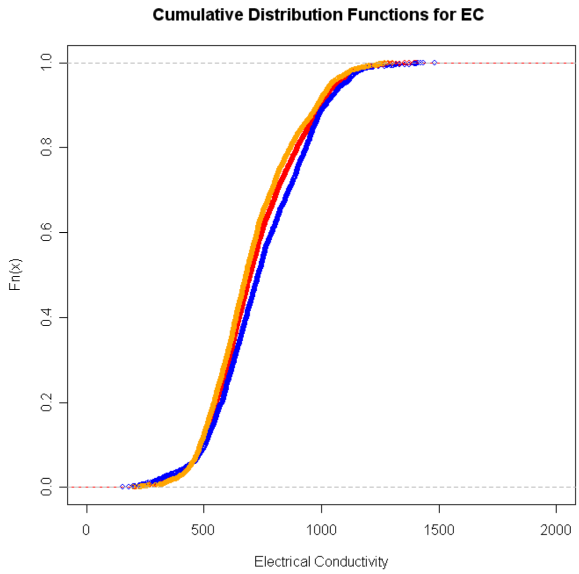
Station 210126 Hunter River at upstream Foy Brook





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	224.3	NA	276.7	213.9
EC (µS/cm)	719	NA	758.1	705.4

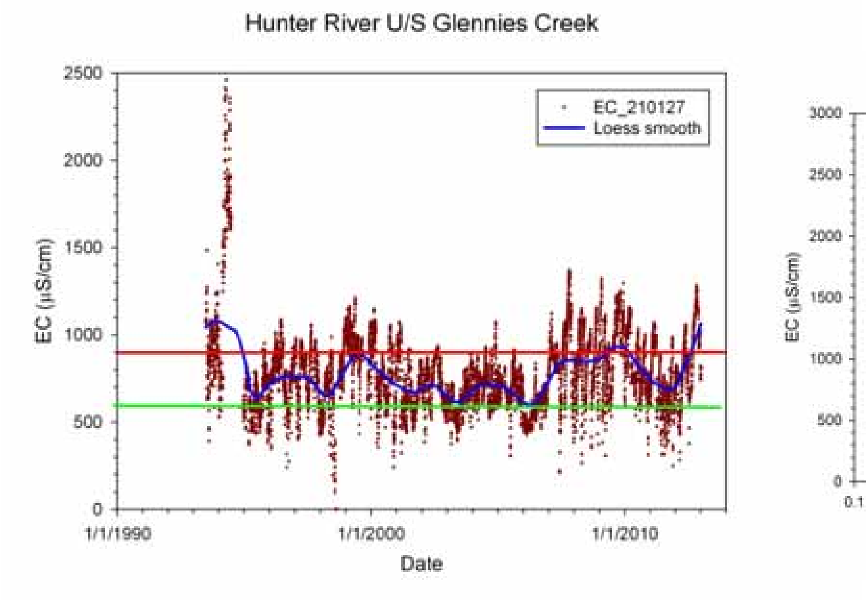


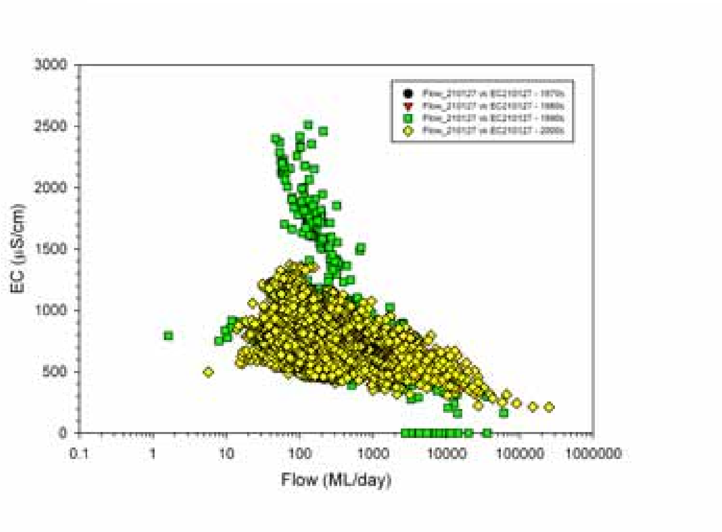


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

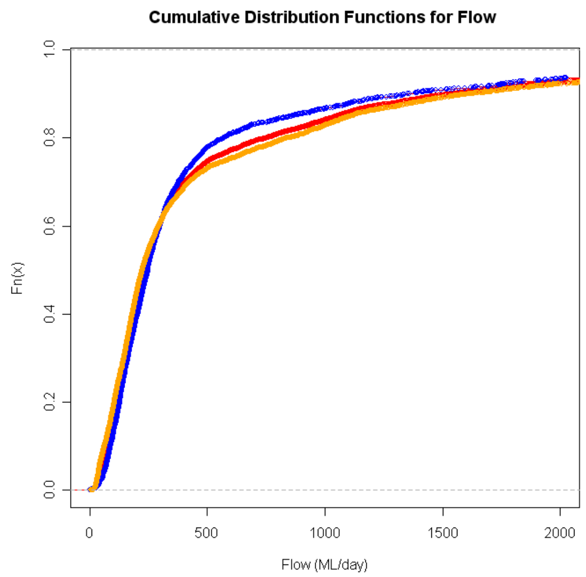
Assessment of the distribution of flow and EC records for station 210126 suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was also similar but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median flow over the period 1990 to 2013 was 224.3 ML/day. Median EC over the period 1990 to 2013 was 719 µS/cm.

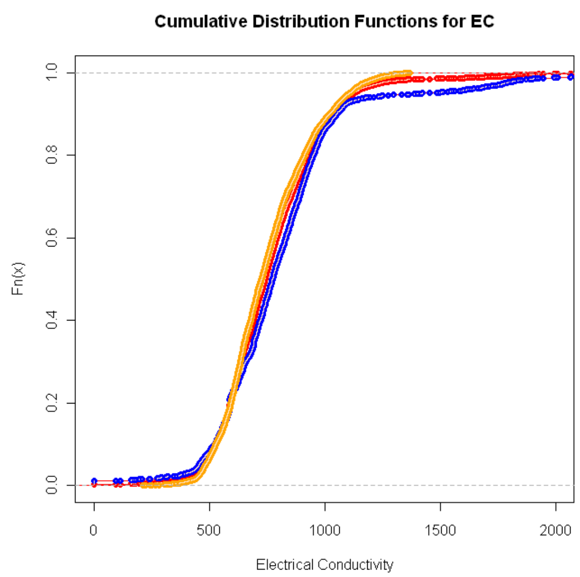
Station 210127 Hunter River at upstream Glennies Creek





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	232.9	NA	247.2	224.1
EC (µS/cm)	741.4	NA	774.3	726.5

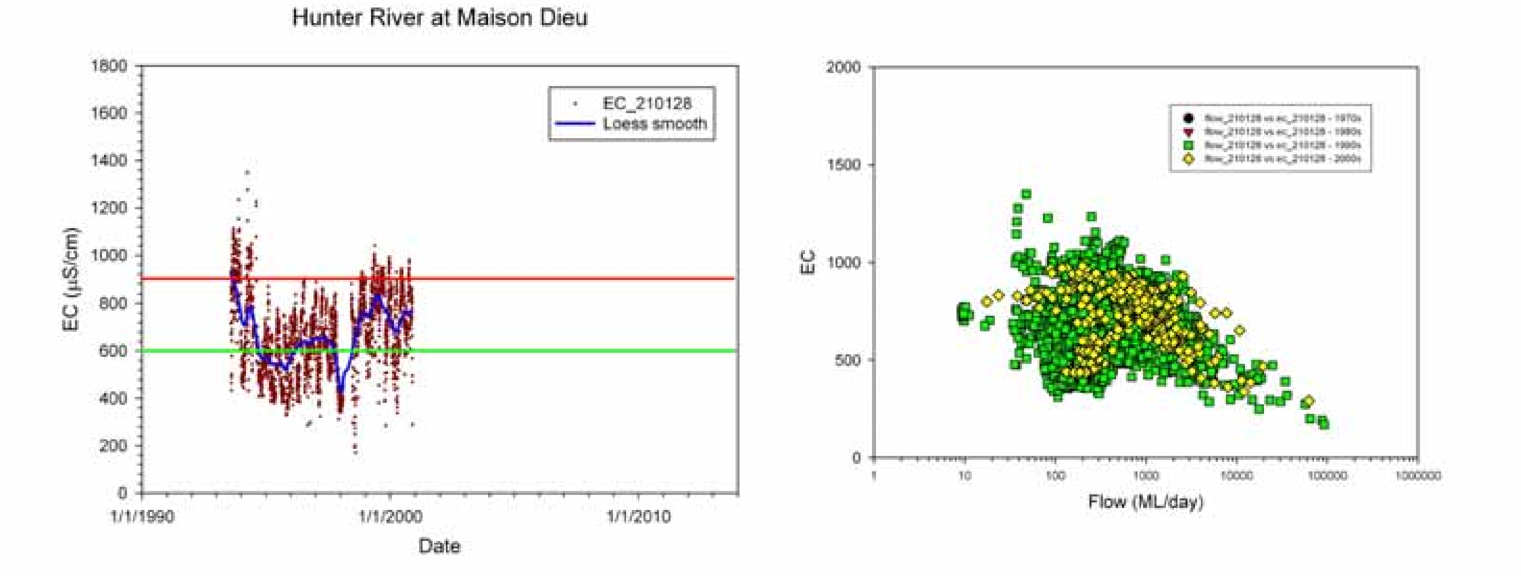




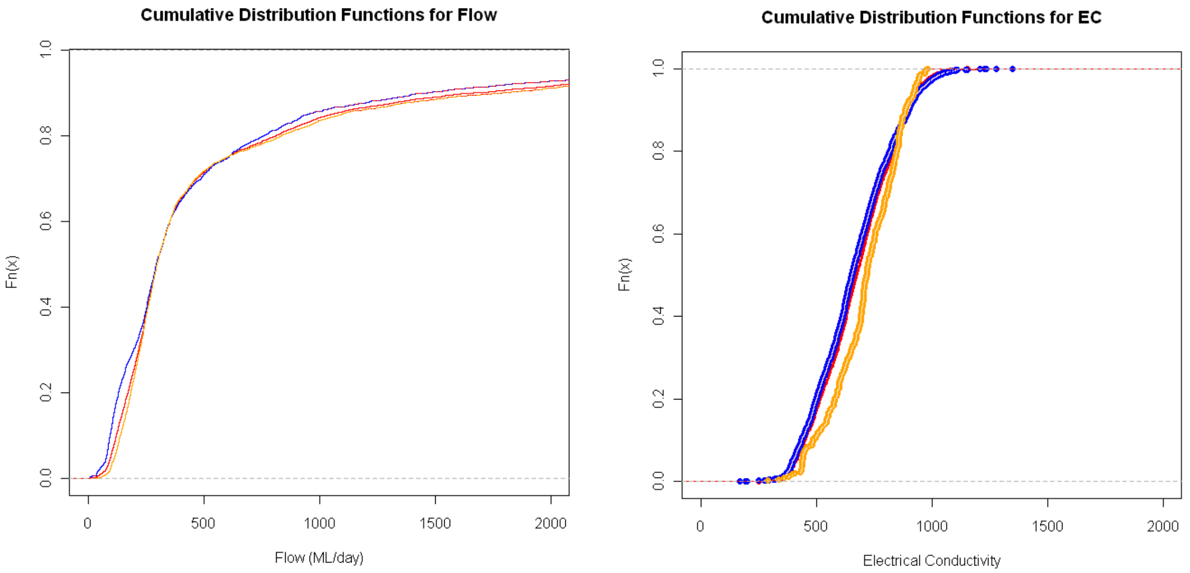
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210127 suggests similar flows in the 1990s and 2000s, but comparatively more high flows in the 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was similar but EC levels in the 2000s were generally lower than in the 1990s. At times EC levels exceeded the 900 µS/cm level. Median flow over the period 1990 to 2013 was 232.9 ML/day. Median EC over the period 1990 to 2013 was 741.4 µS/cm.

Station 210128 Hunter River at Maison Dieu



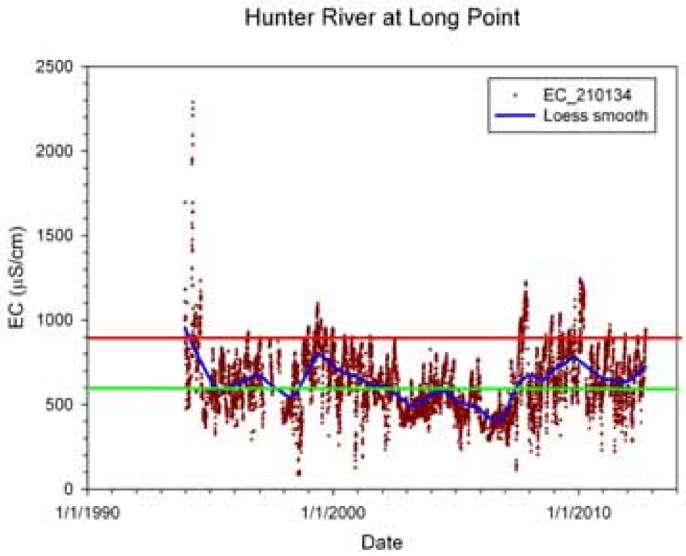
Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	297	NA	295	297.8
EC (µS/cm)	666	NA	653.8	719.3

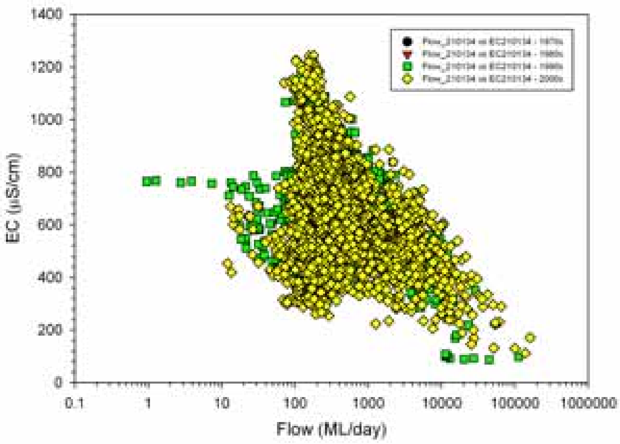


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

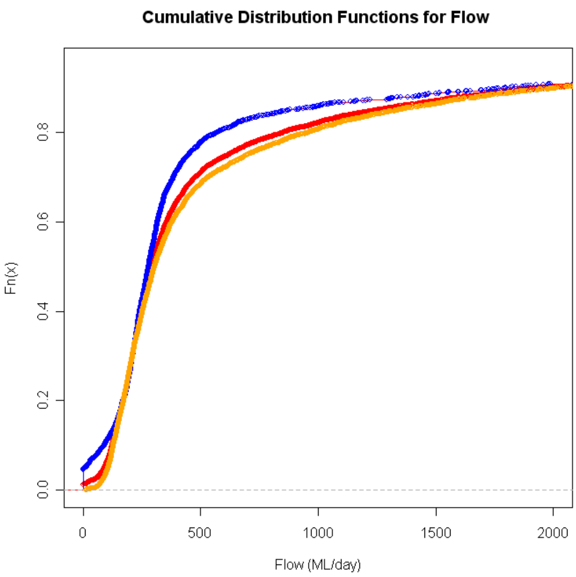
Assessment of the distribution of flow and EC records for station 210128 suggests similar flows in the 1990s and 2000s. No flow or EC data were available at this site for the 1970s & 1980s. The distribution of EC levels was also similar but EC levels were only recorded between July 1993 and November 2000, making inter-decade comparisons less meaningful. At times EC levels exceeded the 900 µS/cm level. Median flow over the period 1990 to 2013 was 297 ML/day. Median EC over the period 1993 to 2000 was 666 µS/cm.

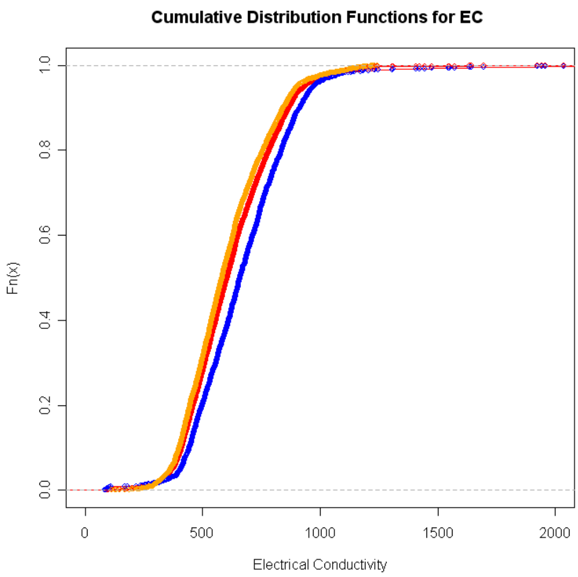
Station 210134 Hunter River at Long Point





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	224.3	NA	276.7	213.9
EC (µS/cm)	719	NA	758.1	705.4

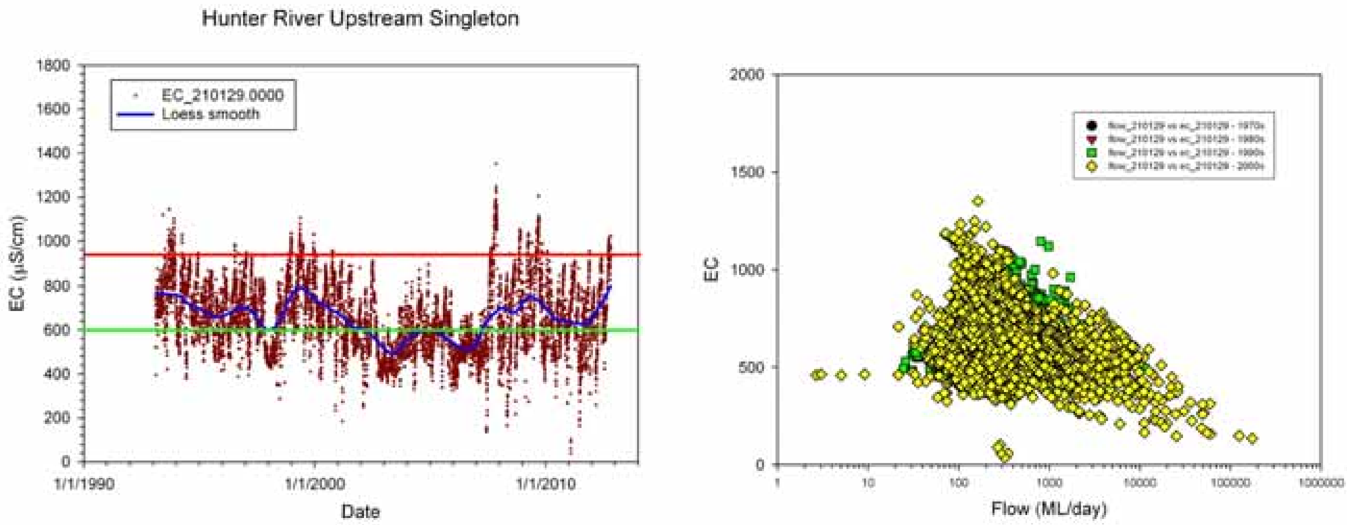




Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

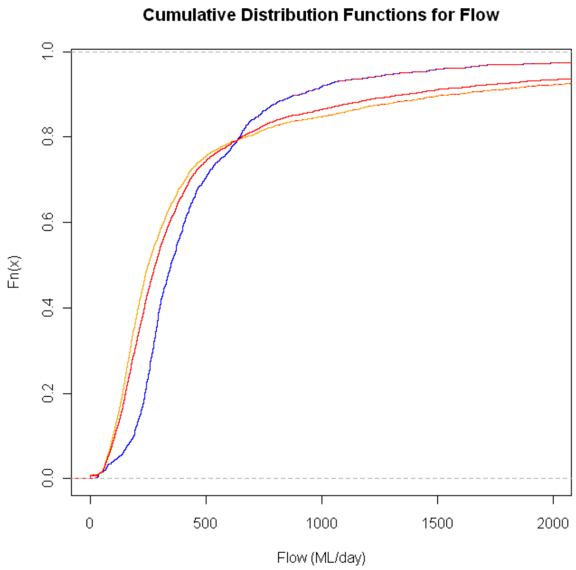
Assessment of the distribution of flow and EC records for station 210134 suggests higher flows in the 2000s compared to the 1990s. No flow or EC data were available at this site for the 1970s & 1980s. In contrast, EC levels in the 2000s were generally lower than in the 1990s. Fewer EC levels exceeded the 900 µS/cm level than at sites further upstream, potentially as a result of diluting flows from Glennies Creek. Median flow over the period 1990 to 2013 was 224.3 ML/day. Median EC over the period 1990 to 2013 was 719 µS/cm.

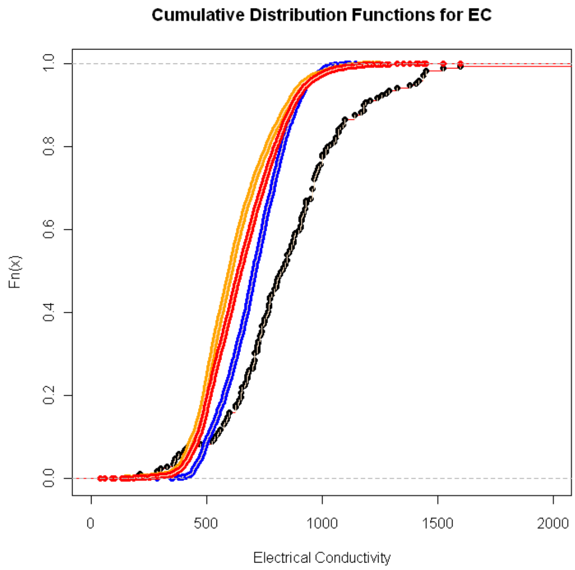
Station 210129 Hunter River at upstream Singleton



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	281.2	371*	349	250.9
EC (µS/cm)	639.9	831*	706.9	602.2

*Data from station 210001



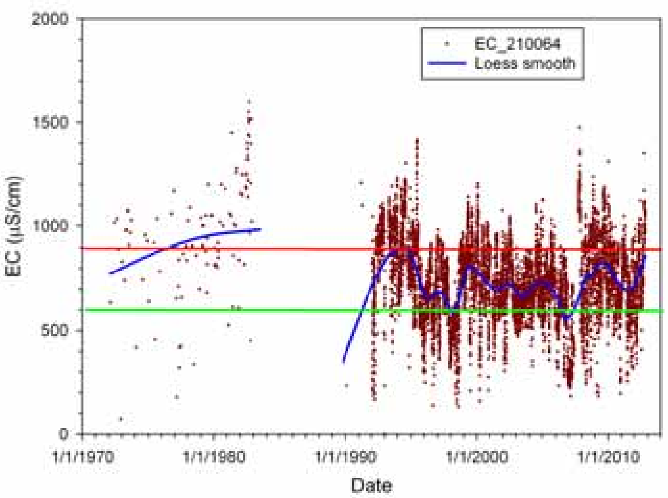


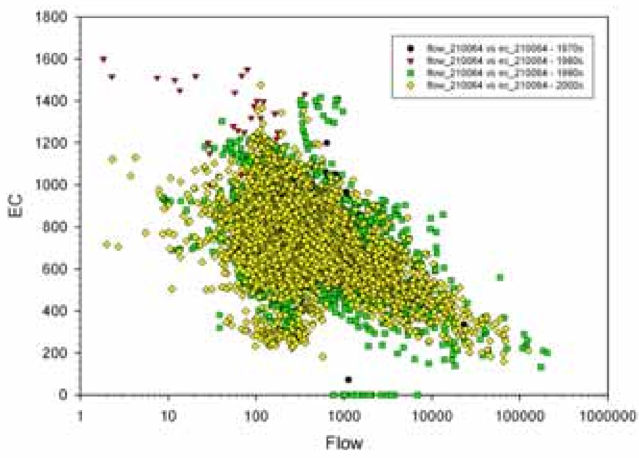
EC data for 1970s & 1980s from station 210001

Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

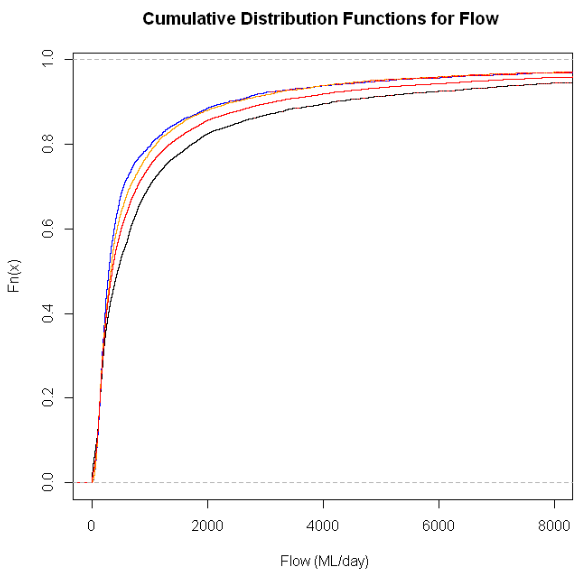
Assessment of the distribution of flow and EC records for station 210129 suggests higher small to medium flows in the 1990s compared to the 2000s; but more high flows in the 2000s. If data from the Singleton gauge (station 210001) are included, then flows were even higher (median = 371 ML/day) in the 1970s & 1980s. EC levels in the 2000s were generally lower than in the 1990s and much lower than EC levels measured at station 210001 in the 1970s & 1980s. Fewer EC levels exceeded the 900 µS/cm over the period 1990 to 2013. Median flow over the period 1990 to 2013 was 281.2 ML/day. Median EC over the period 1990 to 2013 was 639.9 µS/cm, much lower than the median EC level of 831 µS/cm recorded at station 210001 in the 1970s & 1980s.

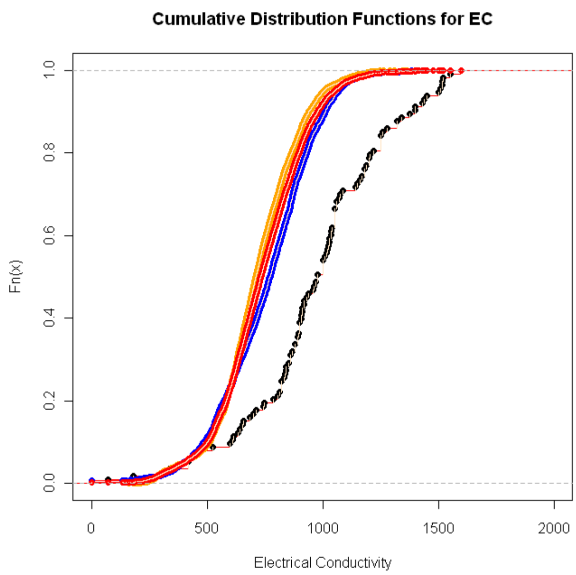
Station 210064 Hunter River at Greta





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	353	448	292.9	327.6
EC (µS/cm)	731.9	979	771.8	710.9



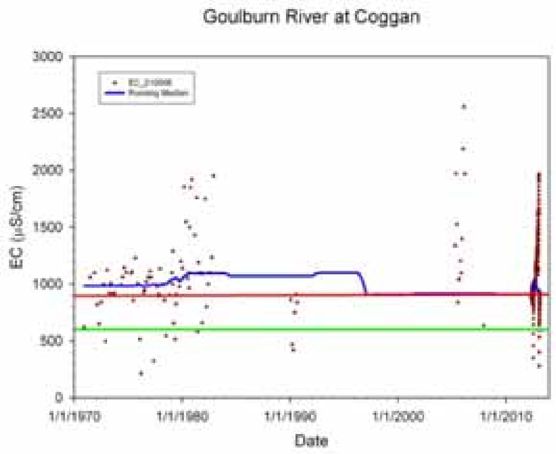


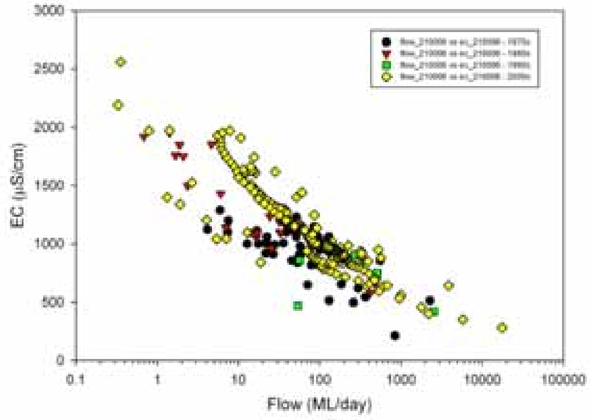
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210064 suggests higher flows in the 1970s & 1980s but similar flows in the 1990s to 2000s. EC levels in the 2000s were generally lower than in the 1990s and much lower than EC levels in the 1970s & 1980s. EC levels exceeded the 900 µS/cm more frequently over the period 1990 to 2013 at Greta than at Singleton. Median flow over the period 1970 to 2013 was 353 ML/day. Median EC over the period 1990 to 2013 was 731.9 µS/cm, much lower than the median EC level of 979 µS/cm recorded during the 1970s & 1980s.

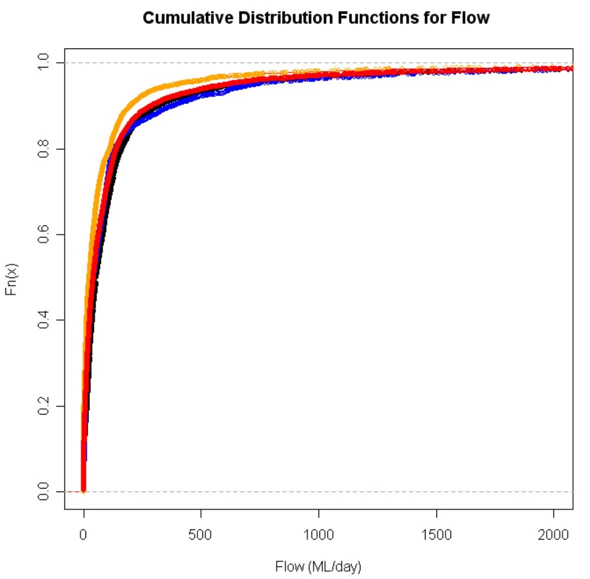
Goulburn River stations

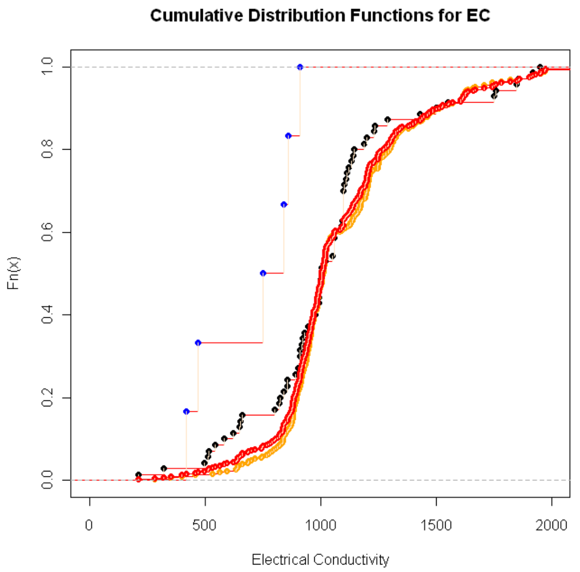
Station 210006 Goulburn River at Coggan





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	41.7	53.9	41.9	24.51
EC (µS/cm)	1007	1005	795	1010.4

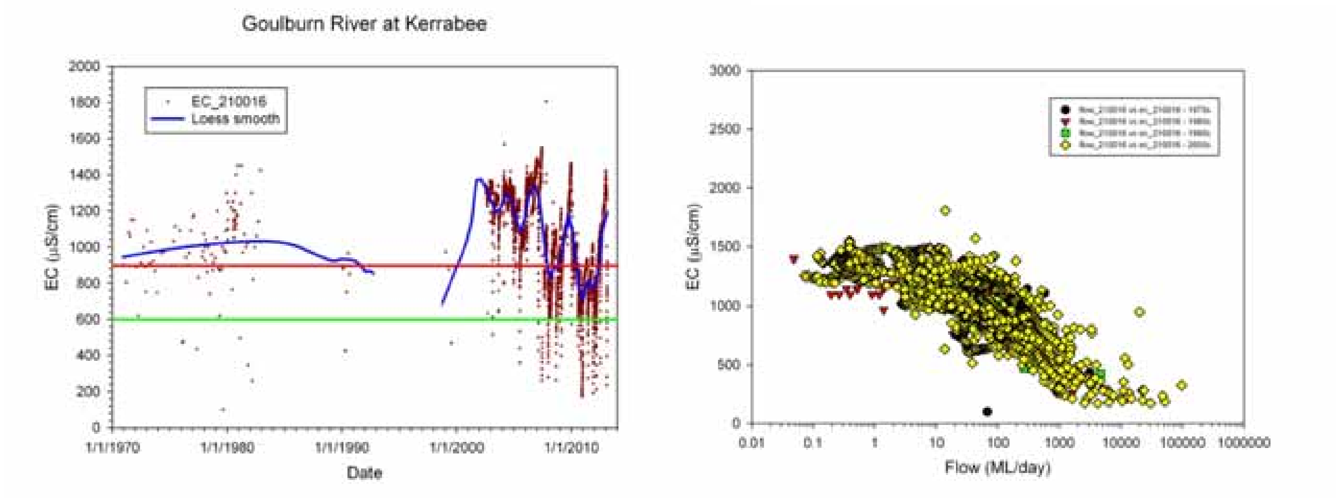




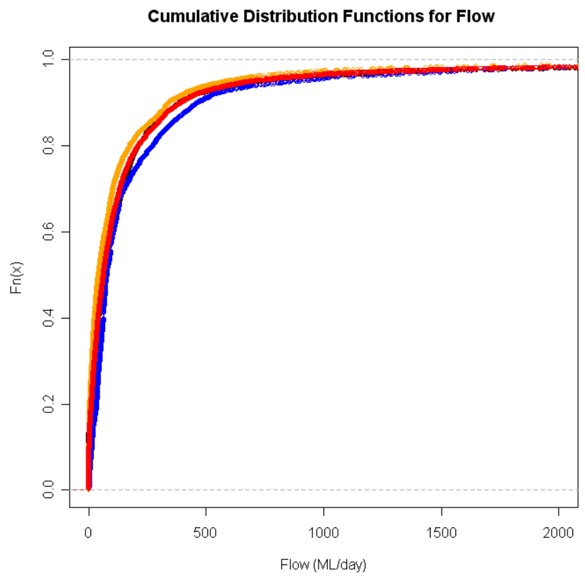
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

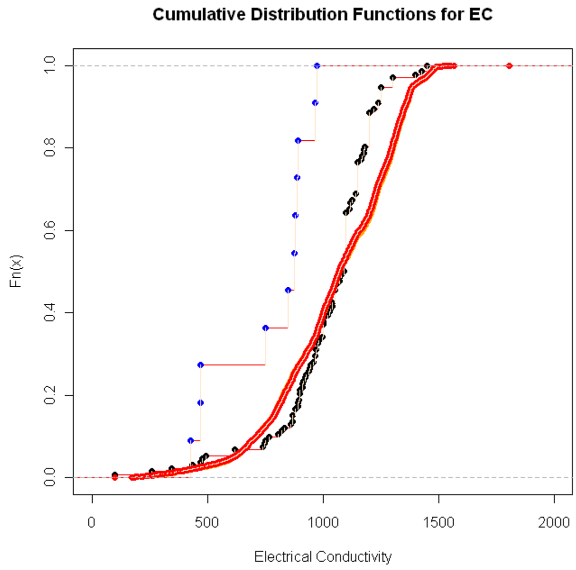
Limited sampling of the Goulburn River at Coggan during the 1970s to 2000s makes comparisons between periods difficult. At this point there appears to be no trend in conductivity levels at this site but further analysis is warranted as more EC data are collected over time. Median EC level over the period of record was 1007 µS/cm.

Station 210016 Goulburn River at Kerrabee



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	63.7	68.94	78.8	42.42
EC (µS/cm)	1070.4	1090.5	876	1070.8

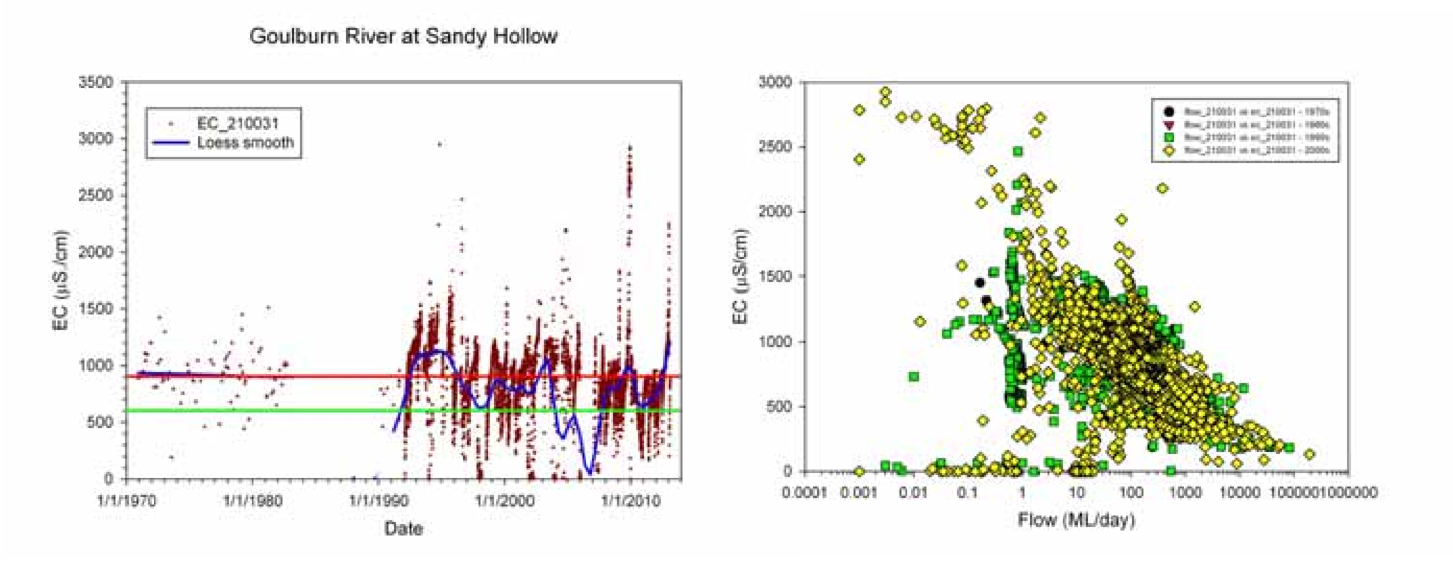




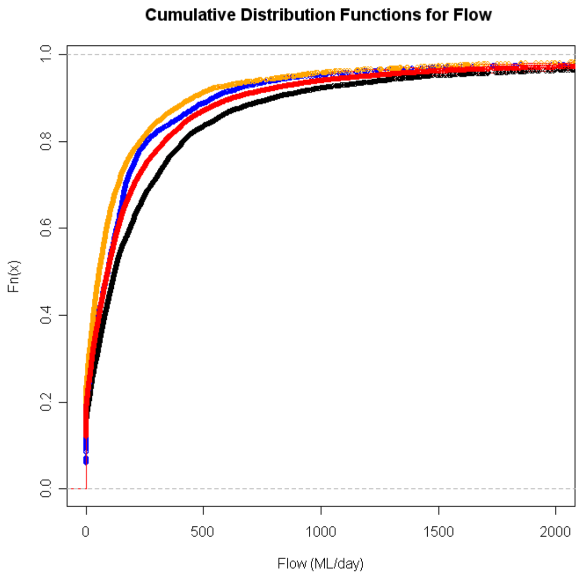
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

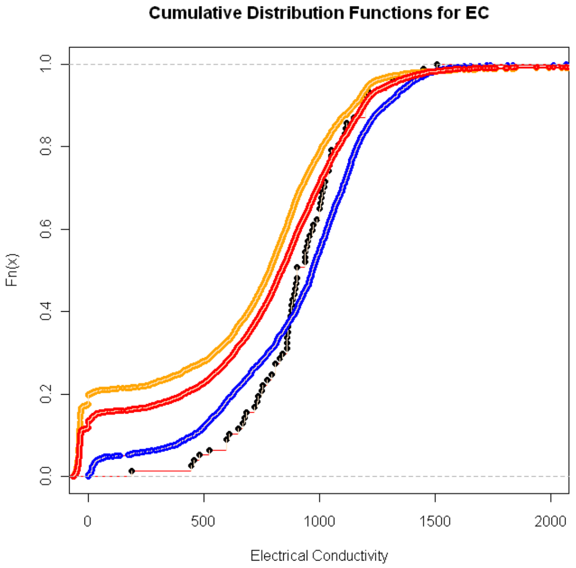
Assessment of the distribution of flow and EC records for station 210016 suggests higher flows in the 1990s compared to other periods. Very few EC records were available for the 1990s, but the EC levels in the 2000s were similar to EC levels in the 1970s & 1980s, with some higher EC records overall in the 2000s. EC levels frequently exceeded 1000 µS/cm but there appears to be a declining trend since the mid 2000s. Cyclical patterns were also evident in the data and these require further assessment. Median flow over the period 1970 to 2013 was 63.7 ML/day. Median EC over the period 1970 to 2013 was 1070.4 µS/cm.

Station 210031 Goulburn River at Sandy Hollow



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	93.3	124	94	57.2
EC (µS/cm)	837.5	905	970.3	786.2



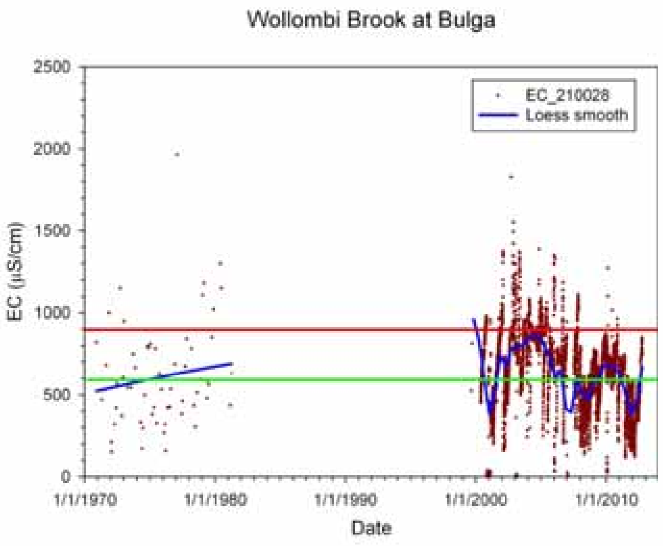


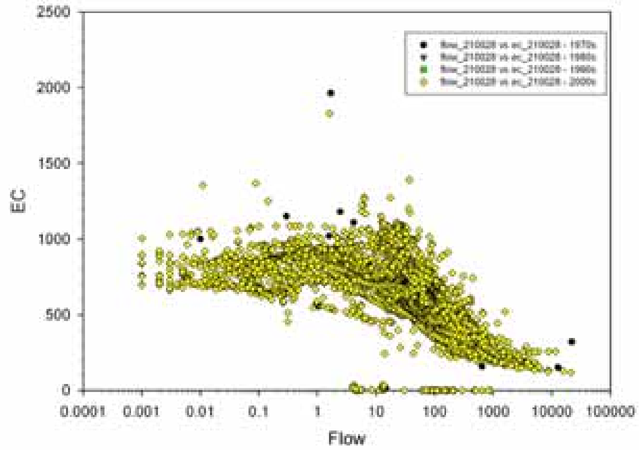
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210031 suggests higher flows in the 1970s & 1980s compared to more recent periods. EC records for the 1970s & 1980s and 1990s were higher than EC records in the 2000s. EC levels frequently exceeded 1000 µS/cm and again there appears to be a declining trend since the 1990s. Some relatively high EC levels (2500 to 3000 µS/cm) have been recorded in recent times. Cyclical patterns were also evident in the data for the Goulburn River at Sandy Hollow, but not as pronounced as at Kerrabee. These patterns require further assessment. Median flow over the period 1970 to 2013 was 93.3 ML/day. Median EC over the period 1970 to 2013 was 837.5 µS/cm.

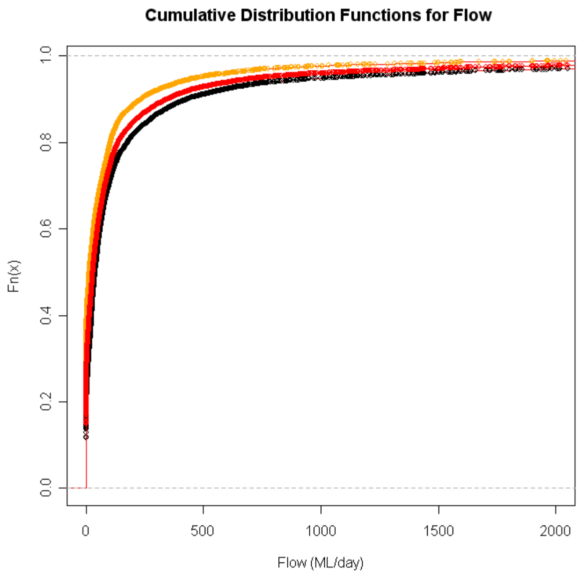
Wollombi Brook stations

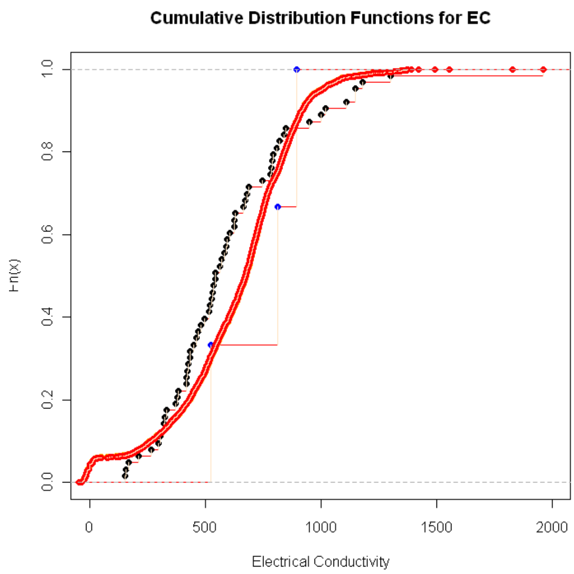
Station 210028 Wollombi Brook at Bulga





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	28.98	38.52	NA	14.42
EC (µS/cm)	674	546	813	675.5

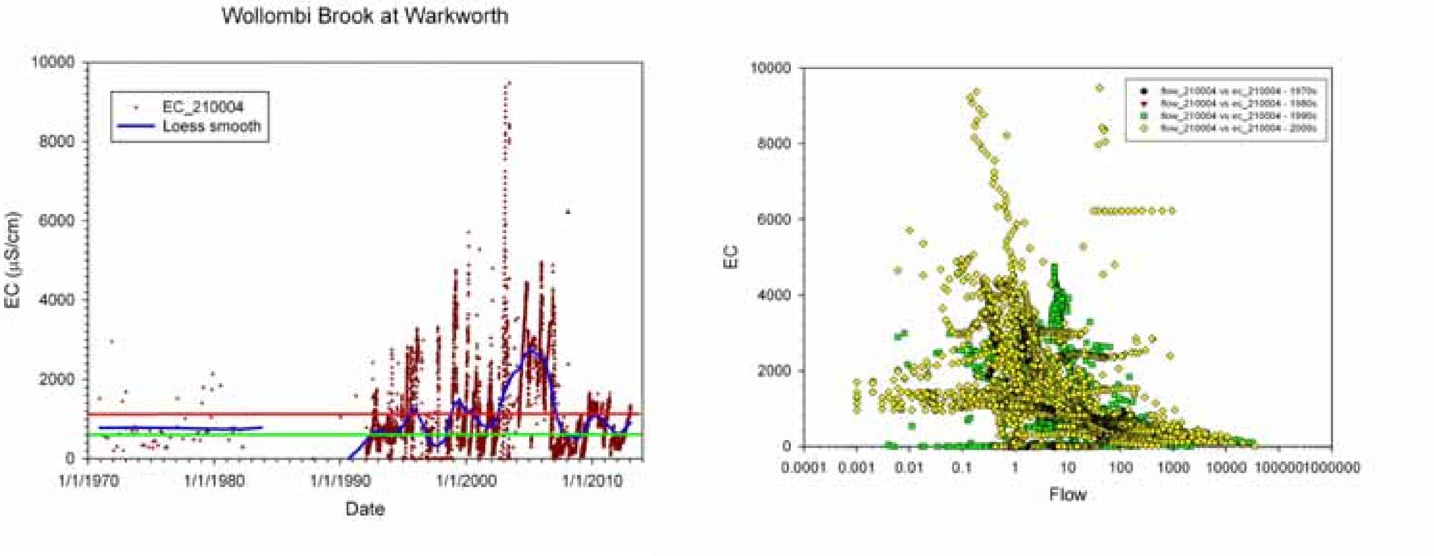




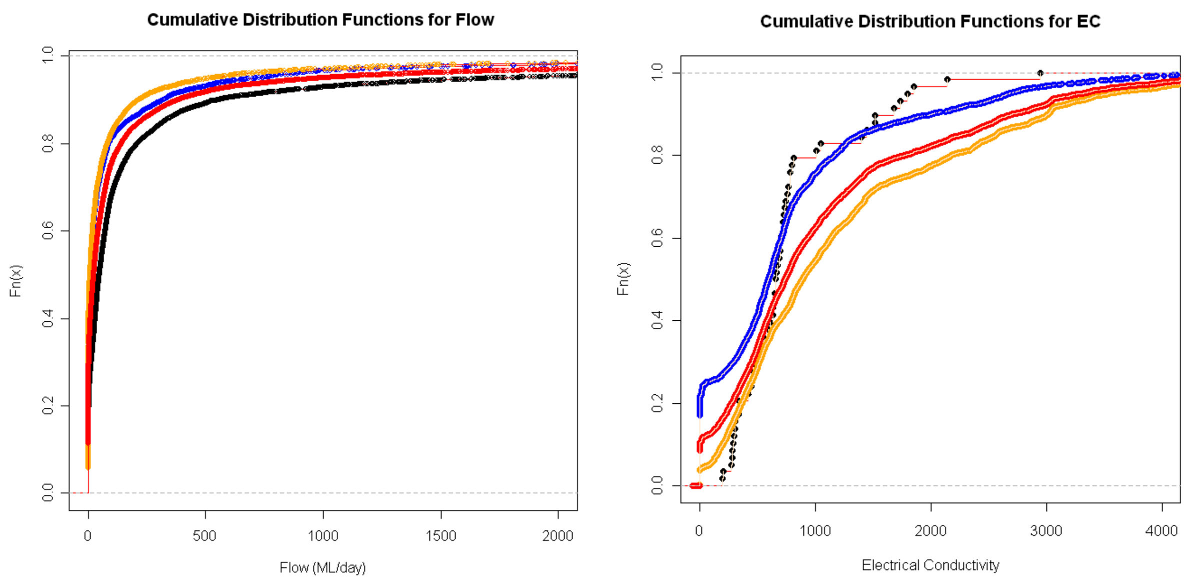
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210028 suggests higher flows in the 1970s & 1980s compared to the 2000s. Limited flow data was available for the 1990s. EC records for the 1970s & 1980s and 1990s were slightly lower than EC levels in the 2000s but this may be affected to some degree by sample size differences. EC levels exceeded 1000 µS/cm on some occasions and there appears to be a declining trend since the early 2000s. Median flow over the period 1970 to 2013 was 28.98 ML/day. Median EC over the period 1970 to 2013 was 674 µS/cm.

Station 210004 Wollombi Brook at Warkworth



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	24.04	48.34	12.15	835
EC (µS/cm)	740.5	660	595.7	891.1

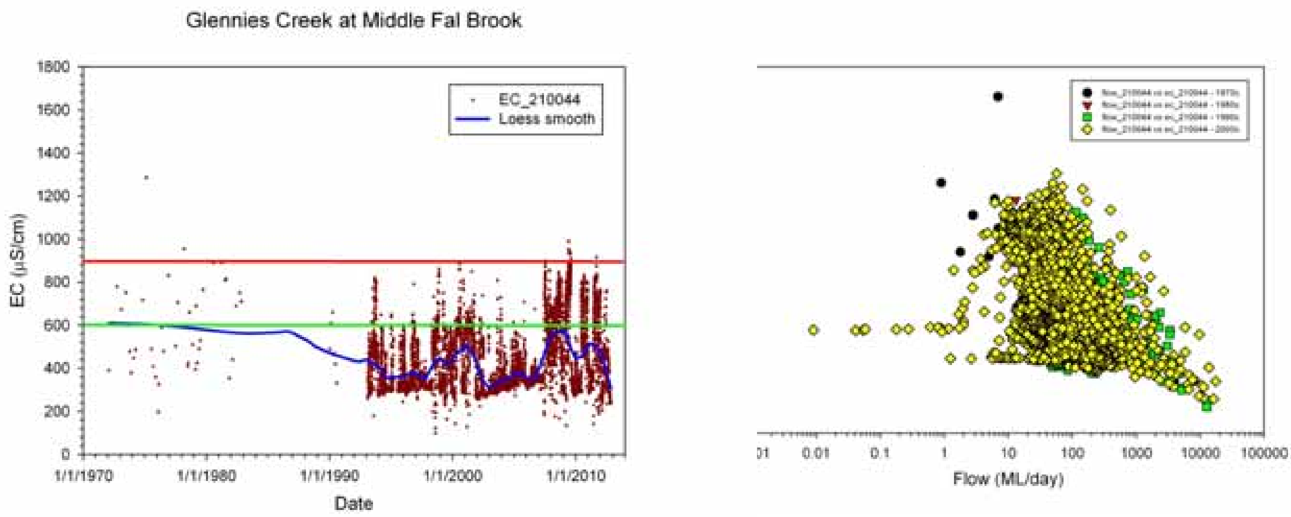


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

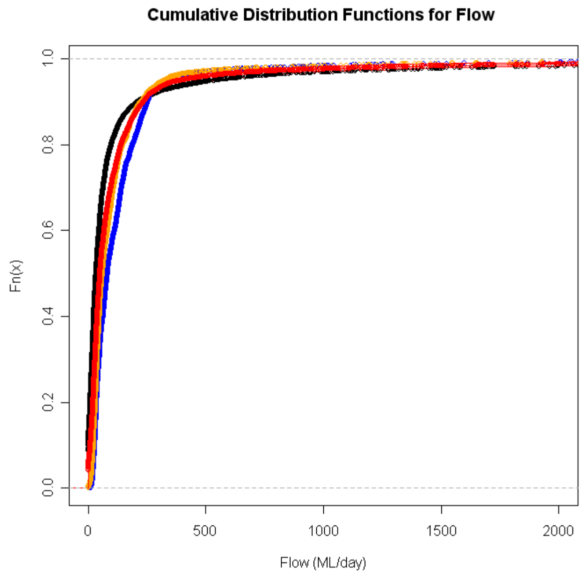
Assessment of the distribution of flow and EC records for station 210004 suggests higher flows in the 1970s & 1980s compared to the 1990s and 2000s. EC records for the 1970s & 1980s and 1990s were obviously lower than EC levels in the 2000s. EC levels exceeded 1000 µS/cm for most of the 2000s with some very high EC levels (approaching 10,000 µS/cm) recorded. The EC–flow relationship demonstrates that EC concentrations were often not well-correlated with flow. This is clearly different to the patterns of EC and flow upstream at Bulga. Overall, the EC data implies impacts either from groundwater moving into Wollombi Brook and/or from mining. Further assessment is necessary to fully understand the underlying mechanisms yielding high EC levels in Wollombi Brook at Warkworth. Median flow over the period 1970 to 2013 was 24.04 ML/day. Median EC over the period 1970 to 2013 was 740.5 µS/cm. Median EC levels during the 2000s has been 891.1 µS/cm.

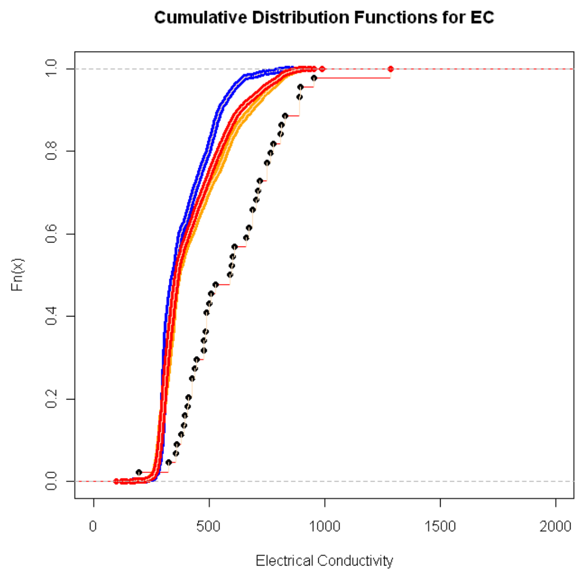
Glennies Creek stations

Station 210044 Glennies Creek at Middle Falbrook



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	50.36	33.39	81.74	60.17
EC (µS/cm)	361.4	594.5	348.2	365.8

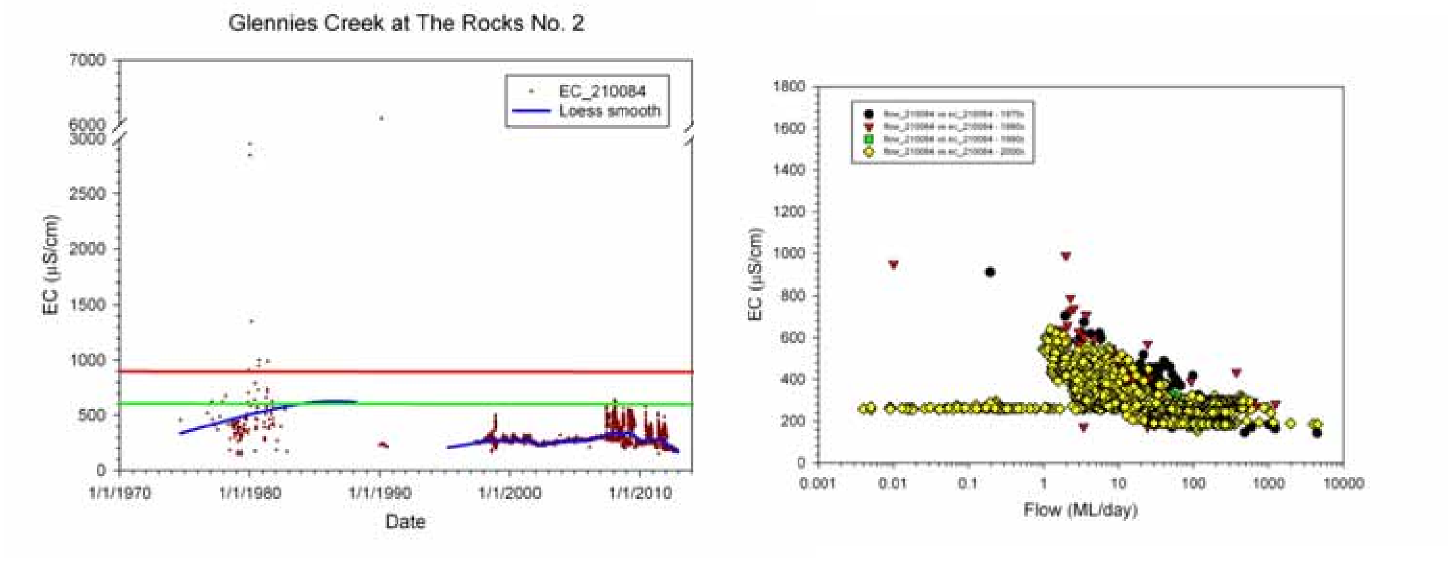




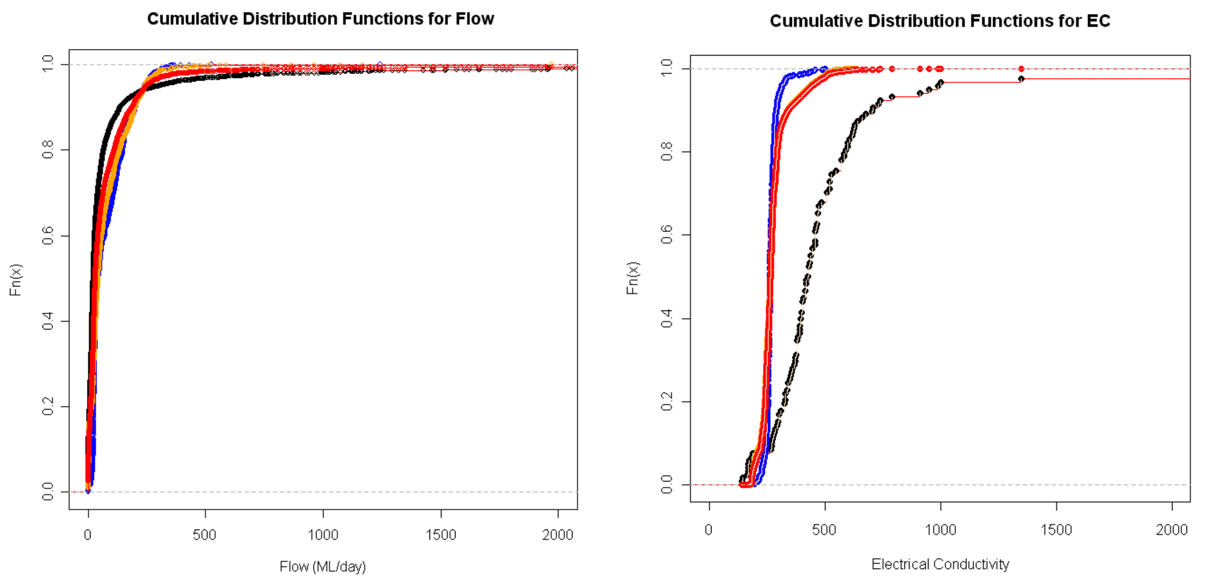
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210044 suggests higher flows in the 1990s and 2000s compared to the 1970s & 1980s. EC records for the 1970s & 1980s were limited (Glennies Creek Dam was constructed in 1983) but appear to have been higher than EC levels in either the 1990s or 2000s. Higher EC levels occurred in the 2000s compared to the 1990s, but EC levels rarely exceed 900 µS/cm. Median flow over the period 1970 to 2013 was 50.36 ML/day. Median EC over the period 1970 to 2013 was 361.4 µS/cm.

Station 210084 Glennies Creek at The Rocks No. 2



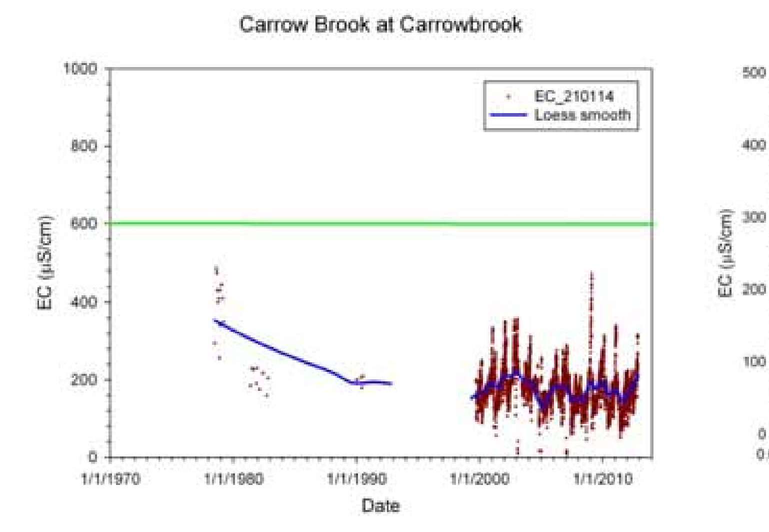
Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	31.05	22.24	43.6	42.94
EC (µS/cm)	265	427.5	263.3	265

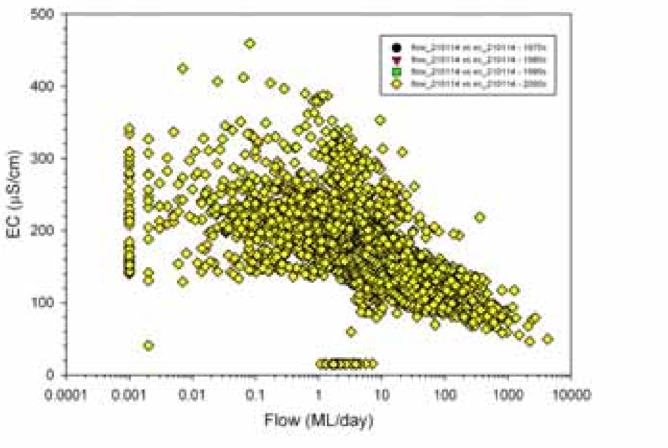


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

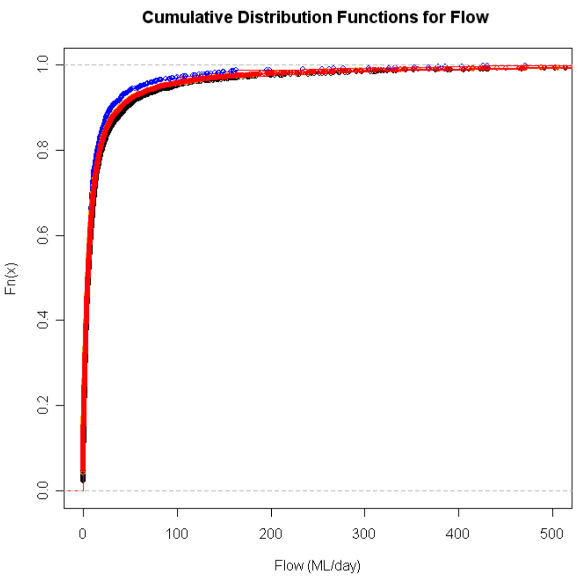
Station 210084 is downstream of Glennies Creek Dam (Glennies Creek Dam was constructed in 1983). Assessment of the distribution of flow and EC records for station 210044 suggests higher flows in the 1990s and 2000s compared to the 1970s & 1980s. EC records for the 1970s & 1980s were limited but indicate higher EC levels (median = 427.5 µS/cm) than EC levels in the 1990s and 2000s (median = 263–265 µS/cm). EC levels now rarely exceed 600 µS/cm. Median flow over the period 1970 to 2013 was 31.05 ML/day. Median EC over the period 1970 to 2013 was 265 µS/cm.

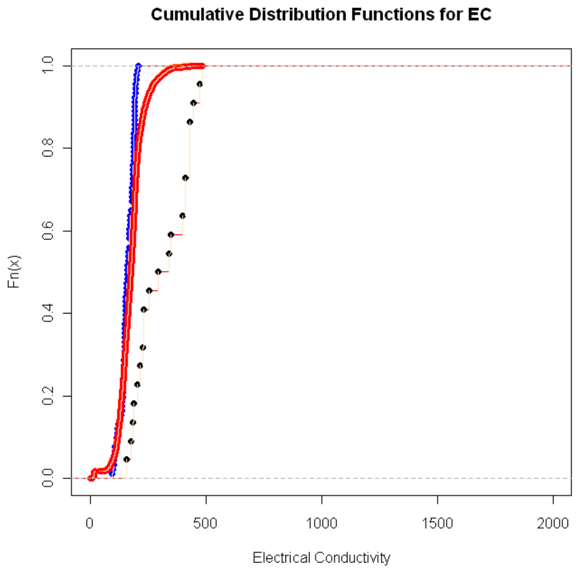
Station 210114 Carrow Brook at Carrowbrook





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	5.43	5.89	5.39	5.21
EC (µS/cm)	175.8	317	161	176



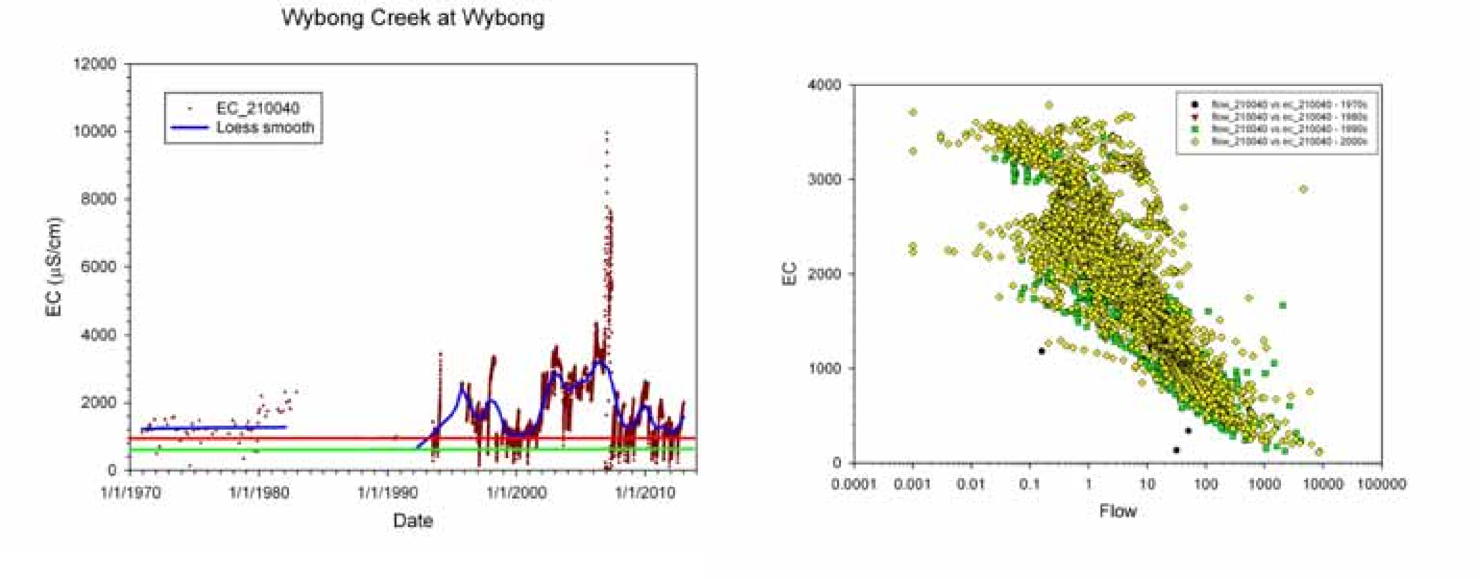


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

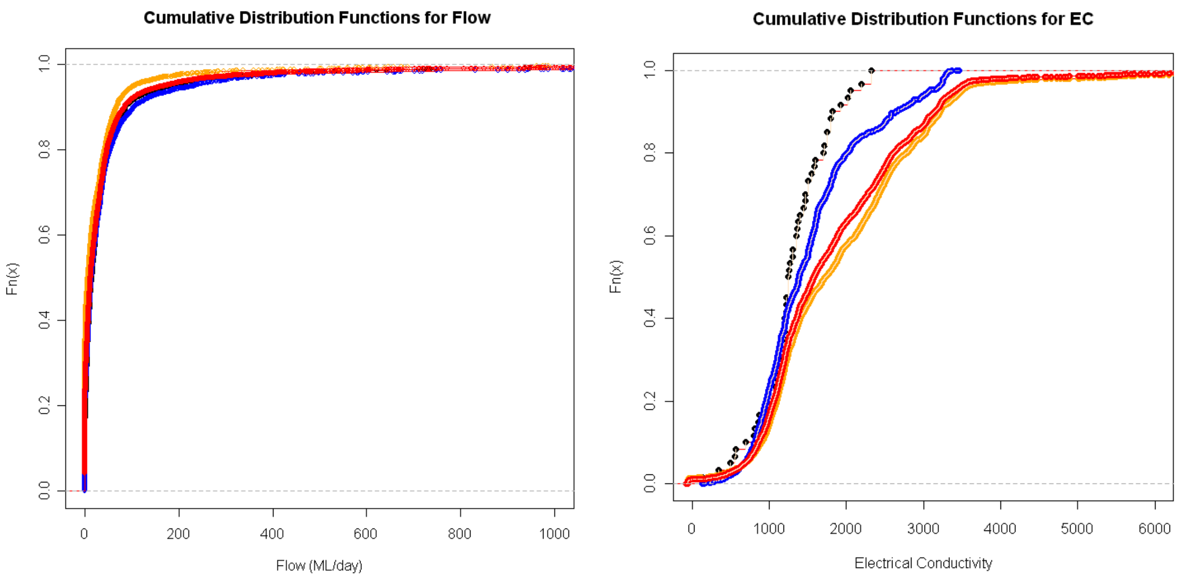
Station 210114 is upstream of Glennies Creek Dam (Glennies Creek Dam was constructed in 1983). Assessment of the distribution of flow and EC records for station 210114 suggests flows were similar in all periods. Limited EC data was available for the 1970s & 1980s. EC records for the 1990s and 2000s were similar. EC levels are low and have not exceeded 600 µS/cm. Median flow over the period 1970 to 2013 was 5.43 ML/day. Median EC over the period 1970 to 2013 was 175.8 µS/cm.

Other stations

Station 210040 Wybong Creek at Wybong



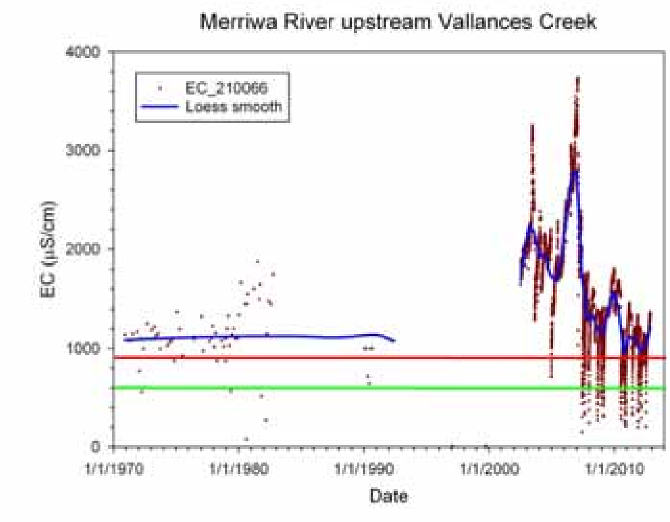
Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	12.7	15.52	14.35	7.2
EC (µS/cm)	1578.8	1256	1387.2	1728.1

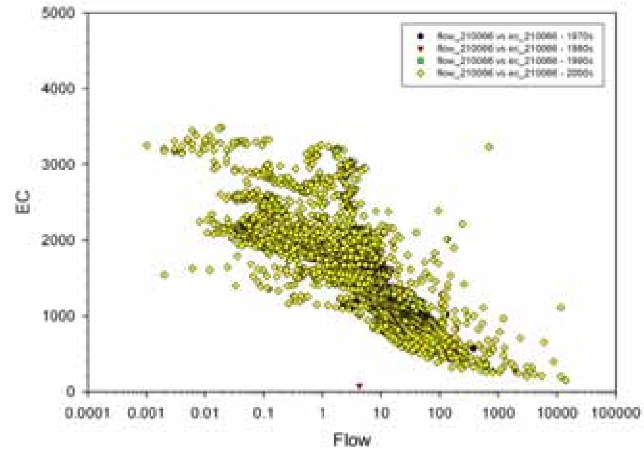


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

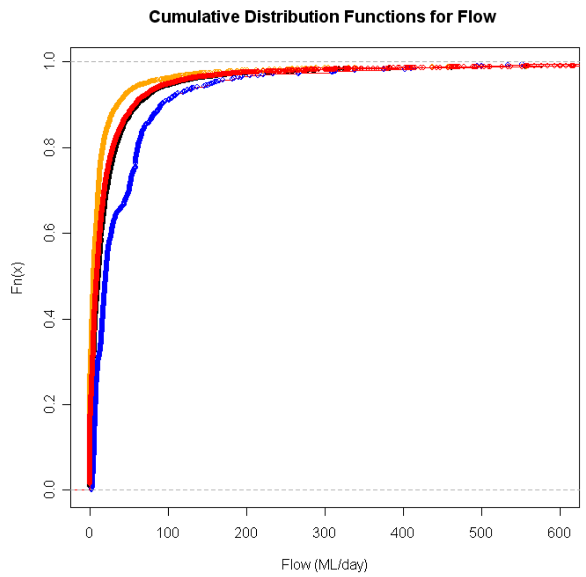
Assessment of the distribution of flow and EC records for station 210040 suggests flows were similar in all periods. Limited EC data was available for the 1970s & 1980s but it appears that EC levels in the 2000s have been significantly higher (median = 1728.1 µS/cm) than in either the 1990s or 1970s & 1980s. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought. Further assessment of EC levels is required for Wybong Creek. Median flow over the period 1970 to 2013 was 12.7 ML/day. Median EC over the period 1970 to 2013 was 1578.8 µS/cm.

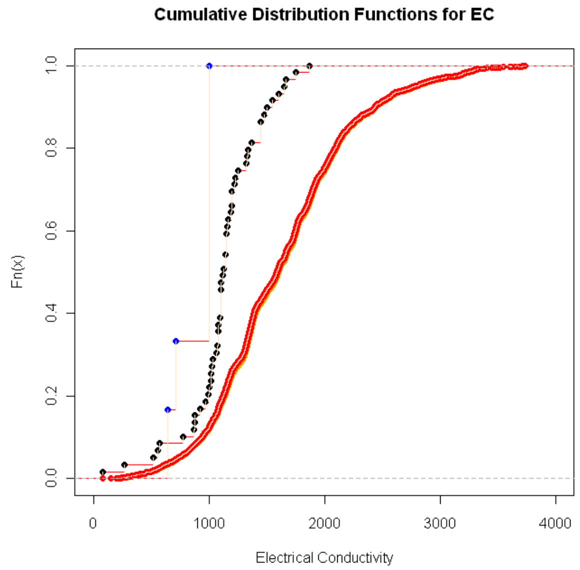
Station 210066 Merriwa River at upstream Vallances Creek





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	9.23	11.06	20.7	5.07
EC (µS/cm)	1590	1130	1000	1598.2

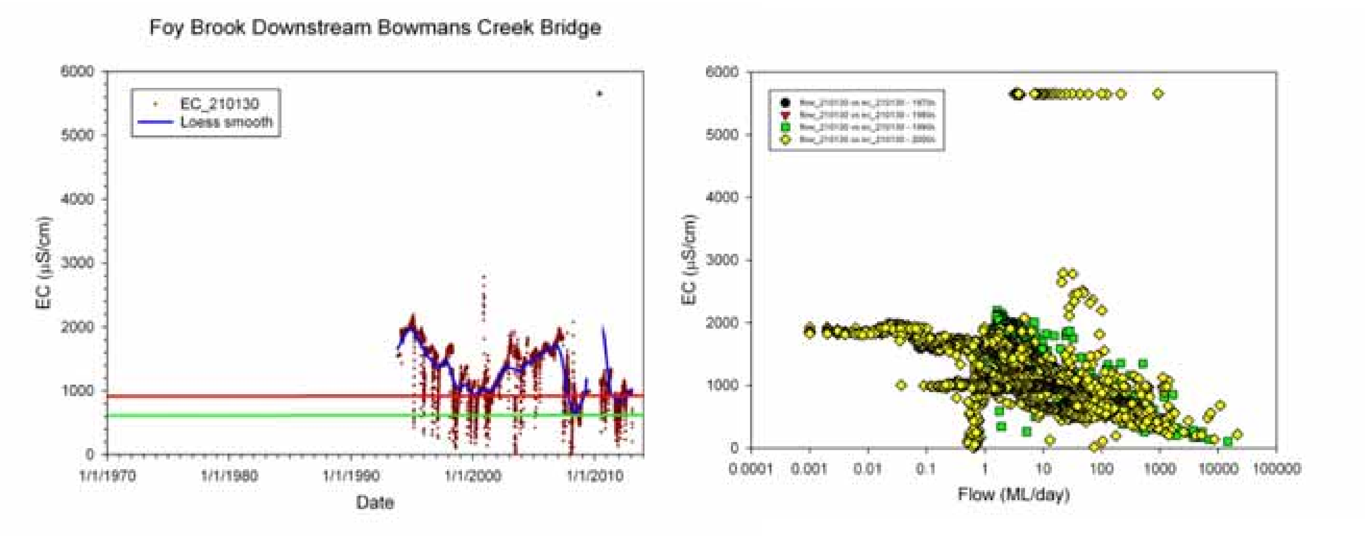




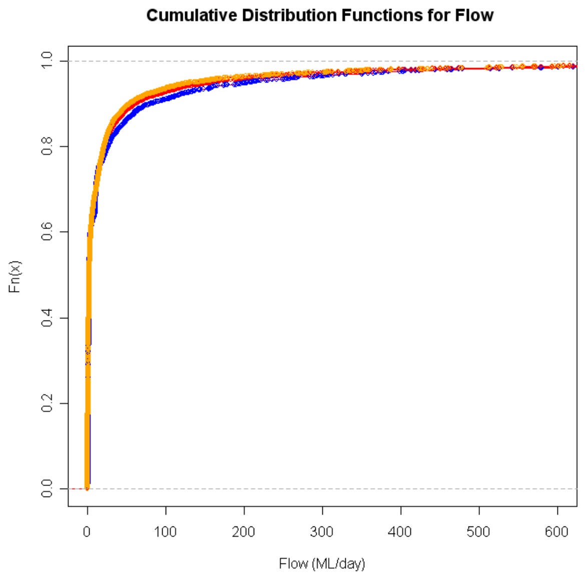
Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

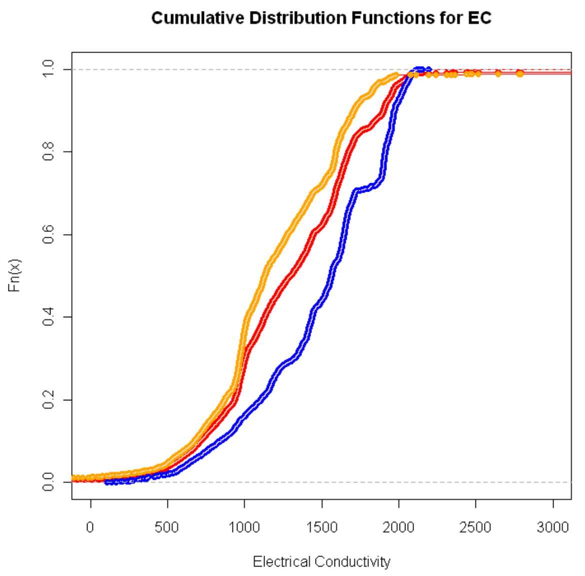
Assessment of the distribution of flow and EC records for station 210066 suggests flows were much lower in the 2000s compared to either the 1970s & 1980s or the 1990s. Limited EC data was available for the 1970s & 1980s or 1990s, but it appears that EC levels in the 2000s have been significantly higher (median = 1598.2 µS/cm) than in earlier periods. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought. Since that time however, EC levels have declined significantly. Further assessment of EC levels is required for the Merriwa River. Median flow over the period 1970 to 2013 was 9.23 ML/day. Median EC over the period 1970 to 2013 was 1590 µS/cm.

Station 210130 Foy Brook at downstream Bowmans Creek Bridge



Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	2.8	NA 2.8 2.76		
EC (µS/cm)	1297.3	NA	1563	1129.7

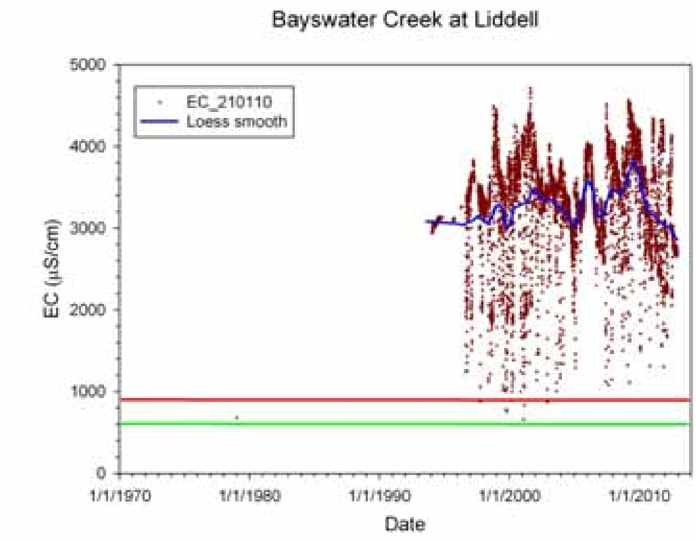


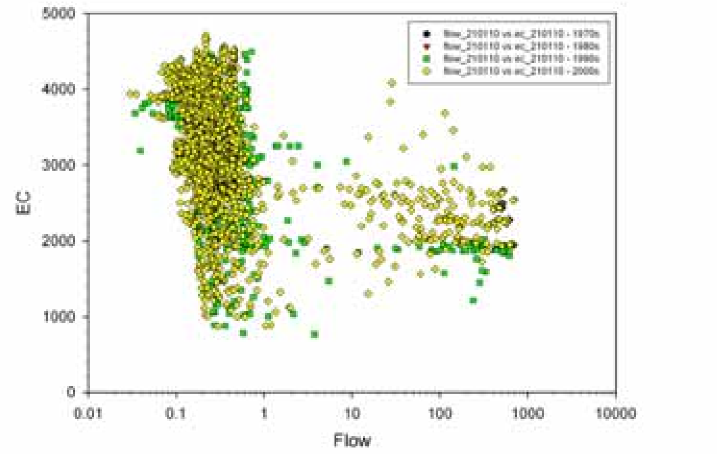


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210130 suggests flows were similar in the 1990s and 2000s. No flow data were available for the 1970s & 1980s. Limited EC data was available for the 1970s & 1980s, but EC levels were higher in the 1990s compared to the 2000s. There was a clear increasing trend in EC levels from the early 2000s to about 2007 which coincides with drought. However, since that time EC levels have declined significantly, although there is a clear outlier (~6000 µS/cm) and a gap in the EC record. Further assessment of EC levels is required for Foy Brook. Median flow over the period 1970 to 2013 was 2.8 ML/day. Median EC over the period 1970 to 2013 was 1297.3 µS/cm.

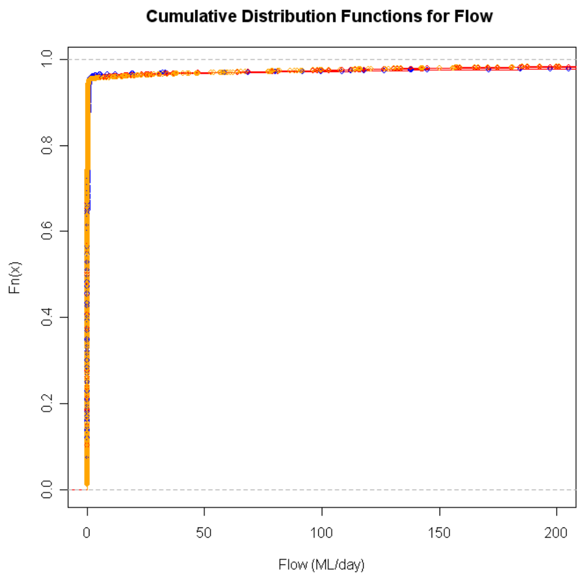
Station 210110 Bayswater Creek at Liddell

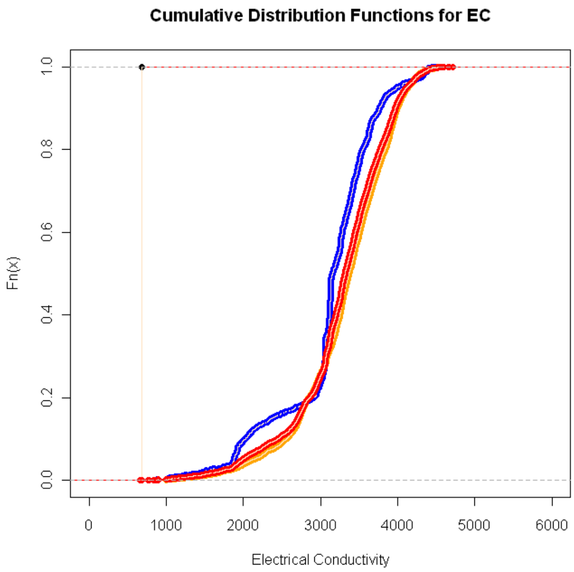




Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	0.24	NA	0.26	0.23
EC (µS/cm)	3118.9	NA*	3157.5	3370

*One value for conductivity at 680 µS/cm.

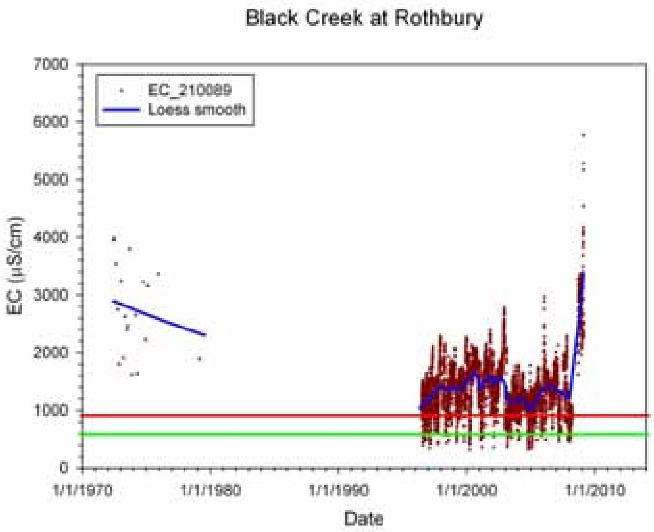


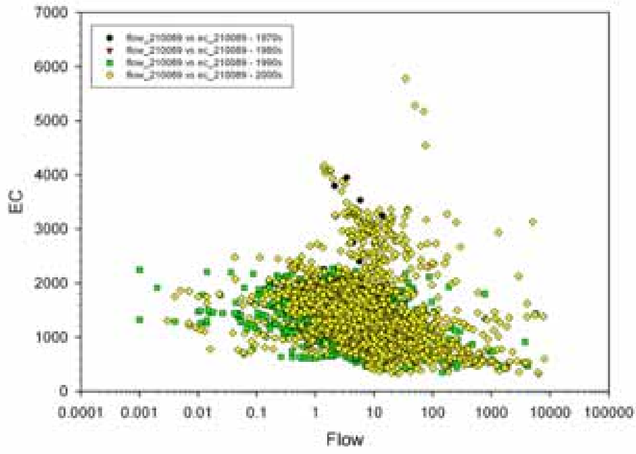


Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

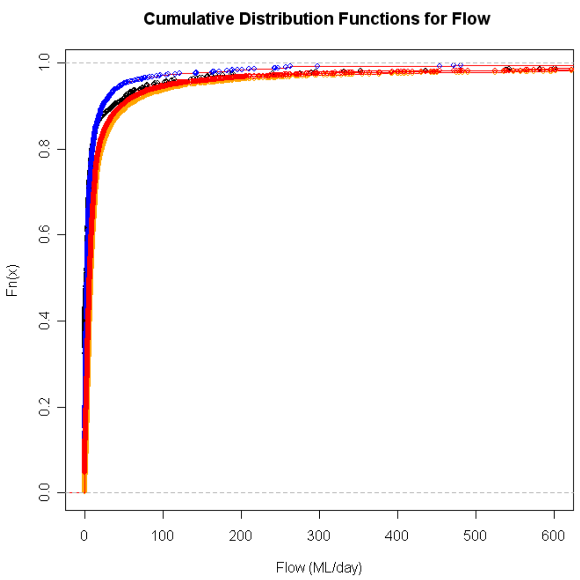
Assessment of the distribution of flow and EC records for station 210110 suggests flows were similar in the 1990s and 2000s. No flow data were available for the 1970s & 1980s. Overall flows are low (median = 0.24 ML/day). No EC data were available for the 1970s & 1980s, but EC levels were higher in the 2000s compared to the 1990s. EC levels have remained relatively consistent over the past two decades (median = 3118.9 µS/cm), however maximum levels can be high (approaching 5000 µS/cm). While a flow concentration relationship exists for Bayswater Creek it also appears to be influenced by discharges at relatively higher flow rates. Further assessment of EC levels is required for Bayswater Creek.

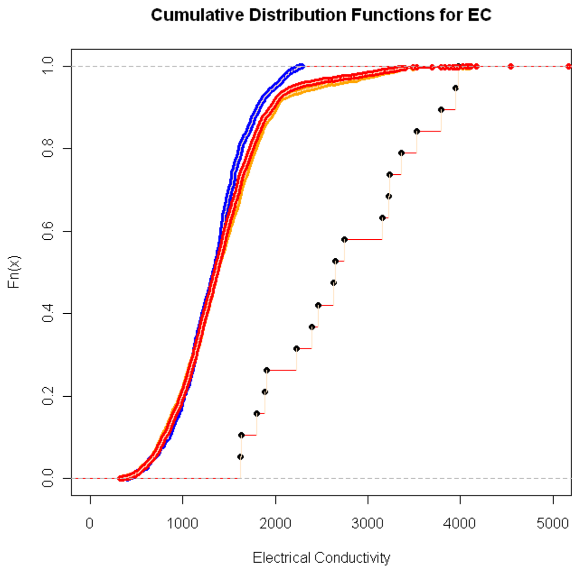
Station 210089 Black Creek at Rothbury





Period	1970 to 2013	1970s & 1980s	1990s	2000s
Flow (ML/day)	6.6	2.751	3.34	8.364
EC (µS/cm)	1360.5	2652	1346.1	1362.5





Red Line = 1970–2013
Black Line = 1970s & 1980s
Blue Line = 1990s
Orange Line = 2000s

Assessment of the distribution of flow and EC records for station 210089 suggests higher flows in the 2000s compared to the 1970s & 1980s and 1990s. EC records for the 1970s & 1980s were limited but appear to have been higher than EC levels in either the 1990s or 2000s. Higher EC levels occurred in the 2000s compared to the 1990s and EC levels often exceed 900 µS/cm. Median flow over the period 1970 to 2013 was 6.6 ML/day. Median EC over the period 1970 to 2013 was 1360.5 µS/cm.

Appendix C: Generalised additive modelling (GAM) results

Hunter River at Muswellbrook Bridge (210002)

```
Family: gaussian
Link function: identity

Formula:
ec210002_OR ~ s(logflow210002) + s(logflow_lag1_210002) +
s(time) + sin_time + cos_time

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 488.6429     0.9951 491.062   <2e-16 ***
sin_time    -27.4416     1.4138 -19.410   <2e-16 ***
cos_time      1.5884     1.4347   1.107    0.268
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘
’ 1

Approximate significance of smooth terms:
                         edf Ref.df      F p-value
s(logflow210002)       7.946  8.446  35.60  <2e-16 ***
s(logflow_lag1_210002) 7.970  8.470  21.68  <2e-16 ***
s(time)                8.989  9.489 387.56  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘
’ 1

R-sq.(adj) =  0.556   Deviance explained = 55.8%
GCV score = 7427.4   Scale est. = 7399.7    n = 7482
One extreme outlier removed due to its high influence.
```

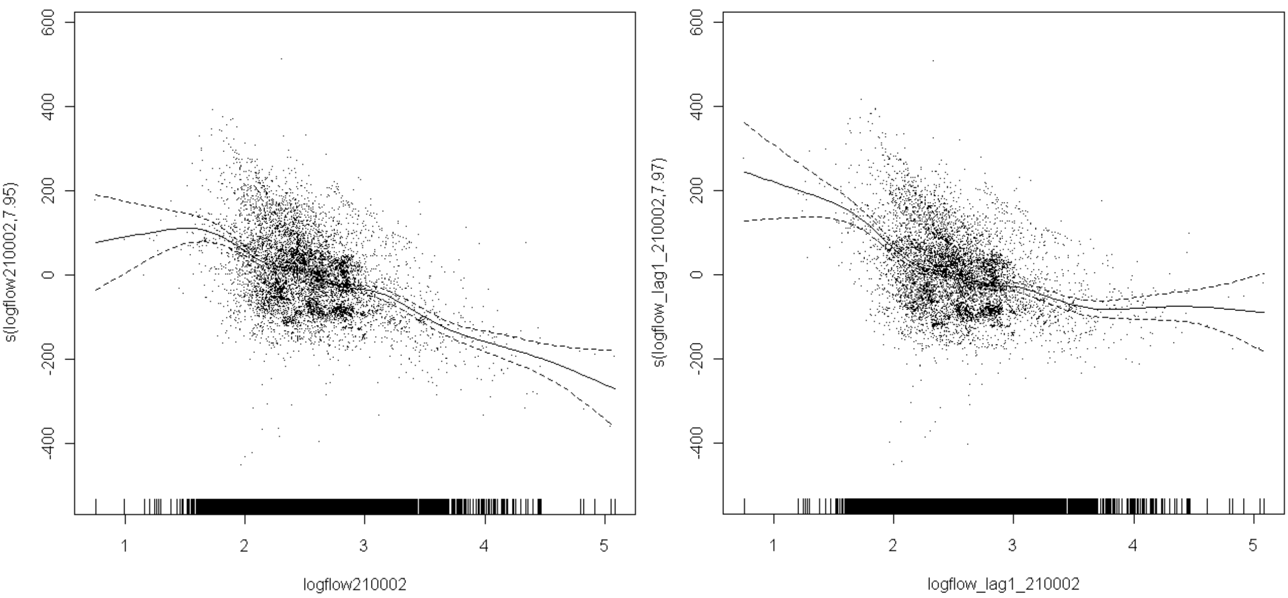


Figure C1. Non-linear trend for flow (left) and lag1 flow (right) for Hunter River at Muswellbrook Bridge (Station 210002)

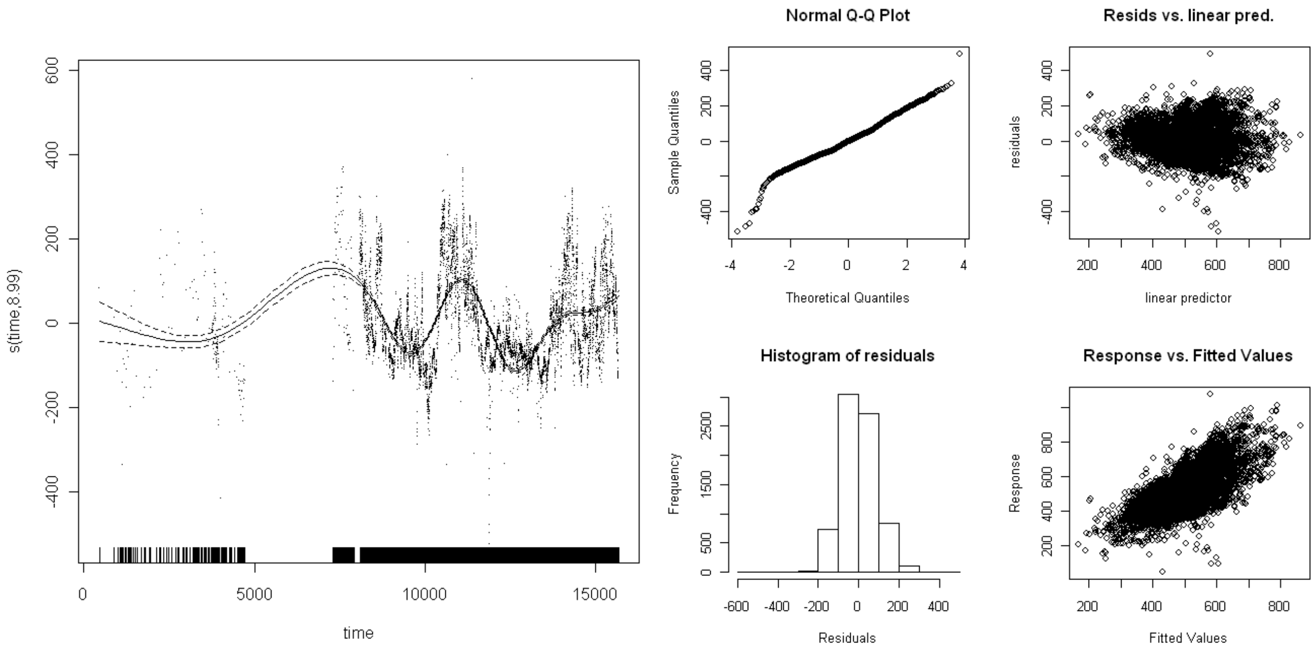


Figure C2. Non-linear trend for time (left) and GAM diagnostics (right) for Hunter River at Muswellbrook Bridge (Station 210002)

Hunter River at Singleton (210129, with early EC data from 210001)

```
Family: gaussian
Link function: identity

Formula:
ec_singleton ~ s(logflow210001) + s(logflow_lag1_210001) +
s(time) + sin_time + cos_time

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  657.440      1.500  438.18   <2e-16 ***
sin_time     -44.795      2.135  -20.98   <2e-16 ***
cos_time     -22.307      2.155  -10.35   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘
’ 1

Approximate significance of smooth terms:
                         edf Ref.df      F p-value
s(logflow210001)       8.016  8.516  16.57  <2e-16 ***
s(logflow_lag1_210001) 7.684  8.184  11.73  <2e-16 ***
s(time)                8.974  9.474 290.64  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘
’ 1
```

```
R-sq.(adj) =  0.398   Deviance explained =   40%
GCV score =  16460   Scale est. = 16398     n = 7287
```

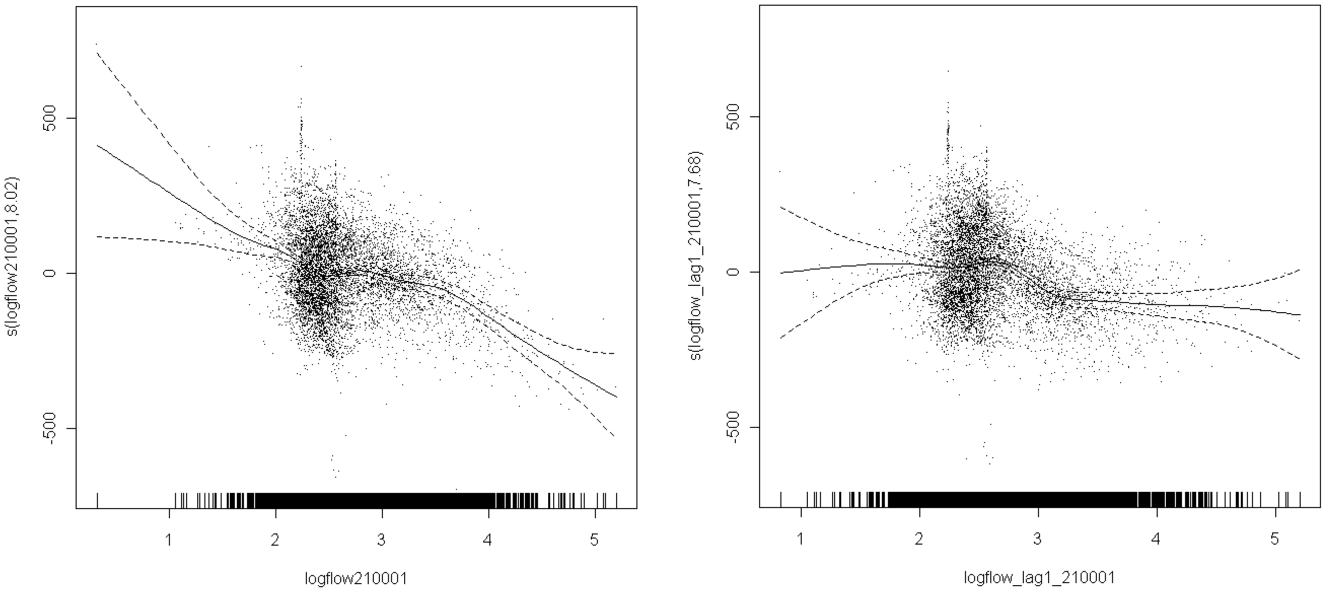


Figure C3. Non-linear trend for flow (left) and lag1 flow (right) for Hunter River at Singleton (Station 210129/210001)

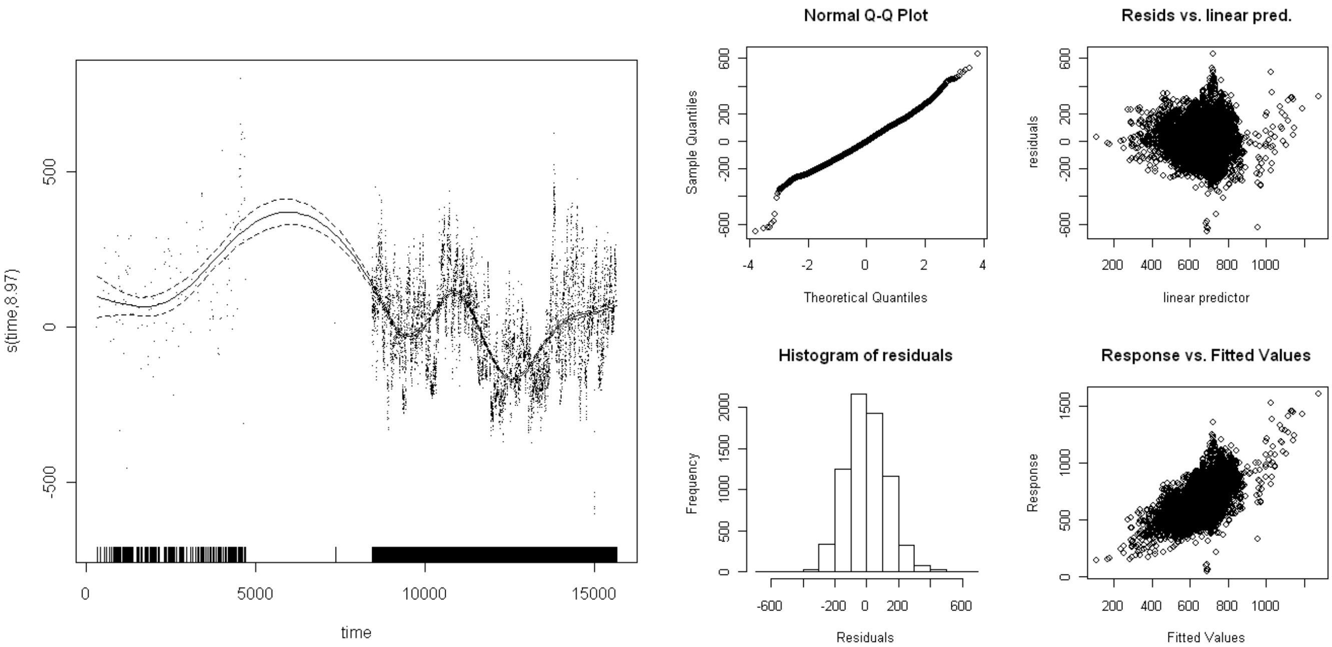


Figure C4. Non-linear trend for time (left) and GAM diagnostics (right) for Hunter River at Singleton (Station 210129/210001)

Note: Further more detailed modelling using GAMs could potentially improve the fit of these models (see also Wood 2006 for a more detailed description of the GAM methodology employed and interpretation of plots). Insufficient time was available to pursue more detailed statistical modelling, but the time trends presented above appear to be reasonable estimates of potential trends and these appear to agree with the assessments in Appendix B.

Appendix D: Macroinvertebrates in the Hunter River catchment

Table D1: Water sharing plan management zone, AUSRIVAS band or SIGNAL score and electrical conductivity (EC) level

Where annotated, edge samples are identified as "_E" after the site code; riffle samples as "_R" after the site code. SIGNAL scores represent an average across habitats and samples.

Macroinvertebrate colour coding has been applied to identify sites considered to be in good to very good condition (blue and green), fair condition or disturbed condition (yellow) and poor to very poor or severely to extremely impaired condition (red and pink).

EC colour coding has been based on the general criteria for the salinity of irrigation water in the Hunter Valley (Creelman 1994, Croft and Associates 1983) where: blue represents low salinity (<280 µS/cm), green medium salinity (280–800 µS/cm), yellow high salinity (800–2300 µS/cm), orange very high salinity (2300–5500 µS/cm); and red extreme salinity waters (>5500 µS/cm).

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
HU02	-32.128	151.470		6.3	Allyn River	97.5	115	2
52003_E	-32.281	151.542	A		Allyn River	810	810	1
HUNT03_E	-32.317	151.514	X		Allyn River	179	284	13
HUNT03_R	-32.317	151.514	A		Allyn River			
HU01	-32.317	151.513		5.7	Allyn River	278	314	2
51191_E	-32.524	151.596	A		Allyn River	751	751	1
HUNT584_E	-32.444	150.450	A		Baerami Creek	926	926	1
52191_E	-32.513	150.466	B		Baerami Creek	208	208	1
52238_E	-32.481	150.486	A		Baerami Creek	807	807	1
HUNT542_E	-32.809	151.356	C		Black Creek	1088.5	1277	2
HU04	-32.794	151.352		4	Black Creek	623	757	2
HU33	-32.790	151.351		3.7	Black Creek	2600.5	3420	2
52024_E	-32.720	151.328	B		Black Creek	957	957	1
52039_E	-32.712	151.323	B		Black Creek	1040	1040	1
52039_R	-32.712	151.323	B		Black Creek			
HU46	-32.187	150.216		4.6	Bow River	1987	2030	2
52222_E	-32.990	151.287	A		Congewai Creek	272	272	1
52193_E	-32.986	151.377	A		Congewai Creek	211	211	1
52193_R	-32.986	151.377	A		Congewai Creek			
HUNT574_E	-32.995	151.334	A		Congewai Creek	247.5	298	2
52239_E	-32.140	150.660	OEM		Cuan and Reedy creeks	1230	1230	1
52239_R	-32.140	150.660	A		Cuan and Reedy creeks			
52384_E	-32.066	150.678	A		Cuan	620	620	1
HU39	-32.506	151.385		4.7	Glendon Brook	1190	1290	2
HU38	-32.515	151.376		4.3	Glendon Brook	2519.5	3090	2
HU08	-32.413	151.192		5.2	Glennies	255	260	2
GOO006_E	-32.410	151.182	B	3.7	Glennies	757	795	12
GOO006_R	-32.410	151.182	A	4.9	Glennies			
52036_E	-32.475	151.086	A		Glennies	602	602	1

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
GOO004_R	-32.369	151.183	A	5.2	Glennies			
GOO004_E	-32.369	151.183	A	3.9	Glennies			
CAM003_E	-32.340	151.179	A	3	Glennies	841	941	12
CAM003_R	-32.340	151.179	X	5.1	Glennies			
GOO001_E	-32.277	151.213	OEM	4.2	Glennies	546	666	12
GOO001_R	-32.277	151.213	B	5.8	Glennies			
52359_E	-32.296	151.183	X		Glennies	708	708	1
52359_R	-32.296	151.183	A		Glennies			
HU06	-32.285	151.303		5.5	Glennies	188	188	1
GOO003_E	-32.343	151.187	OEM	3.8	Glennies	809	923	12
GOO003_R	-32.343	151.187	A	5.2	Glennies			
HUNT577_R	-32.279	150.509	B		Halls Creek	1528.5	1625	2
HUNT577_E	-32.279	150.509	A		Halls Creek			
52347_E	-31.934	150.487	OEM		Halls Creek	885	885	1
52347_R	-31.934	150.487	A		Halls Creek			
52405_E	-32.148	150.509	OEM		Halls Creek	1510	1510	1
HUNT579_E	-32.332	150.623	B		Hollydeen	1246	1269	2
51185_E	-32.638	151.475	OEM		Hunter Regulated River Alluvial	2360	2360	1
HU17	-32.237	150.874		5.3	Hunter Regulated River Alluvial	350.5	371	2
HUNT572_E	-32.526	151.052	B		Hunter Regulated River Alluvial	997	1006	2
HUNT572_R	-32.526	151.052	B		Hunter Regulated River Alluvial			
HUNT576_E	-32.518	150.937	B		Hunter Regulated River Alluvial	1012	1014	2
HUNT576_R	-32.518	150.937	B		Hunter Regulated River Alluvial			
HUNT583_E	-32.125	150.924	A		Hunter Regulated River Alluvial	702	717	2
HUNT583_R	-32.125	150.924	B		Hunter Regulated River Alluvial			
HU19	-32.518	150.937		4.7	Hunter Regulated River Alluvial	605.5	681	2
HU16	-32.295	150.845		4.5	Hunter Regulated River Alluvial	400	448	2
HU14	-32.583	151.205		4.3	Hunter Regulated River Alluvial	484	510	2
HU15	-32.565	151.137		4.6	Hunter Regulated River Alluvial	458	476	2
HUNT854_E	-32.236	150.875	X		Hunter Regulated River Alluvial	399	667	6
HUNT854_R	-32.236	150.875	A		Hunter Regulated River Alluvial			

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
HUNT506_E	-32.268	150.886	B		Hunter Regulated River Alluvial	954	1902	2
HUNT571_E	-32.257	150.884	B		Hunter Regulated River Alluvial	756.5	783	2
HUNT571_R	-32.257	150.884	B		Hunter Regulated River Alluvial			
HUNT847_E	-32.611	151.347	B		Hunter Regulated River Alluvial	794	1100	6
HU22	-31.775	151.080		5.1	Isis River	577.5	585	2
HUNTM5_E	-32.449	151.029	OEM		Jerrys	4920	5990	3
52212_E	-32.402	150.972	OEM		Jerrys	6580	6580	1
HU03	-32.416	151.026		4.4	Jerrys	4470	4780	2
53046_E	-32.028	150.580	X		Kars Springs	658	658	1
53046_R	-32.028	150.580	A		Kars Springs			
HU25	-32.101	150.115		4.5	Krui River	813	856	2
53033_E	-31.907	150.298	OEM		Krui River	782	782	1
53033_R	-31.907	150.298	B		Krui River			
HUNT511_R	-32.097	150.117	A		Krui River	652	700	2
HUNT511_E	-32.097	150.117	X		Krui River			
HUNT585_R	-32.194	150.866	A		Lower Dart Brook	1284	1409	2
HUNT585_E	-32.194	150.866	B		Lower Dart Brook			
HU47	-32.418	150.315		4.3	Lower Goulburn River	1250	1360	2
HUNT507_E	-32.347	150.574	X		Lower Goulburn River	719	1170	4
HUNT588_E	-32.417	150.317	A		Lower Goulburn River	882.5	889	2
HUNT588_R	-32.417	150.317	B		Lower Goulburn River			
HUNT07_E	-32.308	150.239	X		Lower Goulburn River	960	1140	4
HUNT07_R	-32.308	150.239	A		Lower Goulburn River			
HU11	-32.310	150.239		4	Lower Goulburn River	1120	1140	2
53048_E	-32.037	150.858	X		Lower Middle Brook and Kingdon Ponds	671	671	1
52241_E	-32.138	150.865	X		Lower Middle Brook and Kingdon Ponds	1030	1030	1
53032_E	-31.927	150.826	B		Lower Middle Brook and Kingdon Ponds	316	316	1
52038_E	-32.773	151.100	A		Lower Wollombi Brook	543	543	1
52240_E	-32.745	151.098	A		Lower Wollombi Brook	366	366	1
52030_E	-32.739	150.936	A		Lower Wollombi Brook	334	334	1
HUNT05_R	-32.747	150.922	C		Lower Wollombi Brook			
HUNT05_E	-32.740	150.936	X		Lower Wollombi Brook	241	310	6
HU07	-32.725	150.937		5.4	Lower Wollombi Brook	294	310	2
52221_E	-32.738	151.147	A		Lower Wollombi Brook	1118	1118	1
51192_E	-32.611	151.436	A		Luskintyre	1140	1140	1
52011_E	-32.642	151.401	OEM		Luskintyre	3370	3370	1
51001_E	-32.611	151.365	B		Luskintyre	8000	8000	1

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
HUNT580_E	-32.602	150.718	B		Martindale Creek	199.5	250	2
53030_E	-32.145	150.302	B		Merriwa River	317	317	1
HU26	-32.097	150.365		4.2	Merriwa River	1075	1090	2
HU48	-32.364	150.340		4.4	Merriwa River	1384	1548	2
52392_E	-32.211	150.316	OEM		Merriwa River	2160	2160	1
53018_E	-32.190	150.344	OEM		Merriwa River	8130	8130	1
HUNT578_E	-32.286	150.326	A		Merriwa River	1008	1034	2
HUNT578_R	-32.286	150.326	B		Merriwa River			
HU28	-31.982	150.007		5.3	Munmurra River	815	840	2
53047_E	-32.043	149.963	X		Munmurra River	668	668	1
53047_R	-32.043	149.963	A		Munmurra River			
HUNT582_R	-31.783	150.794	A		Murrurundi	411	494	2
HUNT582_E	-31.783	150.794	X		Murrurundi			
53004_E	-31.794	150.880	OEM		Murrurundi	779	779	1
HUNT510_E	-31.789	150.897	A		Murrurundi	560.5	600	2
HUNT510_R	-31.789	150.897	A		Murrurundi			
HUNT573_E	-32.120	150.983	C		Muswellbrook	337.5	361	2
HU21	-32.120	150.984		3.9	Muswellbrook	340	360	2
53010_E	-32.207	150.758	B		Muswellbrook	1090	1090	1
52346_E	-32.285	151.017	OEM		Muswellbrook	1020	1020	1
52346_R	-32.285	151.017	B		Muswellbrook			
53007_E	-32.209	150.989	B		Muswellbrook	2520	2520	1
52349_E	-32.206	150.779	OEM		Muswellbrook	1590	1590	1
52025_E	-32.282	150.956	X		Muswellbrook	1700	1700	1
52012_E	-32.658	151.838	A		Newcastle	224	224	1
HUNTM1_E	-32.730	151.589	B		Newcastle	780	1038.5	5
HUNT902_E	-32.807	151.851	OEM		Newcastle			0
HUNT901_E	-32.800	151.852	C		Newcastle			0
HUNT508_E	-32.780	151.736	C		Newcastle	743.5	960	2
HU18	-32.728	151.588		4.5	Newcastle	750	820	2
51019_E	-32.743	151.631	B		Newcastle			0
HU32	-32.608	151.616		4.9	Paterson River Tidal Pool	381.5	415	2
52203_E	-32.373	151.484	OEM		Paterson River Tributaries	1180	1180	1
52002_E	-32.374	151.483	B		Paterson River Tributaries	1130	1130	1
51201_E	-32.518	151.519	A		Paterson River Tributaries	226	226	1
51201_R	-32.518	151.519	A		Paterson River Tributaries			
51035_E	-32.638	151.605	D		Paterson River Tributaries	243	243	1
51200_E	-32.654	151.603	C		Paterson River Tributaries	323	323	1
HU34	-32.139	150.996		4.7	Rouchel Brook	617.5	735	2
53001_E	-32.108	151.241	OEM		Rouchel Brook	639	639	1
53001_R	-32.108	151.241	X		Rouchel Brook			

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
52387_E	-32.163	151.139	X		Rouchel Brook	5500	5500	1
52387_R	-32.163	151.139	A		Rouchel Brook			
52231_E	-32.631	151.121	OEM		Singleton	5370	5370	1
52369_E	-31.988	150.760	A		Upper Dart Brook	452	452	1
52369_R	-31.988	150.760	A		Upper Dart Brook			
HUNT08_R	-31.877	150.665	A		Upper Dart Brook	689	907	3
HUNT08_E	-31.876	150.665	A		Upper Dart Brook			
HU23	-31.878	150.665		6.4	Upper Dart Brook	808		2
HUNT587_R	-32.329	150.039	A		Upper Goulburn River	785	803	2
HUNT587_E	-32.329	150.039	B		Upper Goulburn River			
HU45	-32.315	149.737		6.1	Upper Goulburn River	325	370	2
52407_E	-32.344	150.076	A		Upper Goulburn River	908	908	1
52407_R	-32.344	150.076	A		Upper Goulburn River			
HU09	-32.351	150.051		4.6	Upper Goulburn River	1345	1570	2
52406_E	-32.219	149.786	X		Upper Goulburn River	695	695	1
HUNT512_E	-32.217	149.788	X		Upper Goulburn River	1123	1600	3
HUNT512_R	-32.217	149.788	A		Upper Goulburn River			
53501_E	-31.890	151.386	A		Upper Hunter	44	44	1
53501_R	-31.890	151.386	X		Upper Hunter			
55001_E	-31.926	151.388	B		Upper Hunter	32	32	1
55001_R	-31.926	151.388	A		Upper Hunter			
HU50	-31.927	151.388		6.9	Upper Hunter	29.5	36	2
54538_E	-31.920	151.360	B		Upper Hunter			
54538_R	-31.920	151.360	B		Upper Hunter	70	70	1
53034_E	-31.966	151.333	A		Upper Hunter	465	465	1
53034_R	-31.966	151.333	B		Upper Hunter			
HU13	-32.004	151.109		5.4	Upper Hunter	340	420	2
HU20	-31.927	151.237		5.9	Upper Hunter	220	270	2
52376_E	-31.861	151.281	X		Upper Hunter	774	774	1
52376_R	-31.861	151.281	A		Upper Hunter			
53490_E	-31.824	151.407	A		Upper Hunter	255	255	1
53490_R	-31.824	151.407	A		Upper Hunter			
HUNT11_E	-31.907	151.260	A		Upper Hunter	133	163	3
HUNT11_R	-31.907	151.260	B		Upper Hunter			
53493_E	-31.725	151.327	A		Upper Hunter	274	274	1
53493_R	-31.725	151.327	A		Upper Hunter			
54002_E	-31.726	151.310	A		Upper Hunter	224	224	1
54002_R	-31.726	151.310	A		Upper Hunter			
54003_E	-31.703	151.232	B		Upper Hunter	489	489	1
54003_R	-31.703	151.232	A		Upper Hunter			
54007_E	-31.681	151.206	A		Upper Hunter	182	182	1

Site code	Latitude	Longitude	AUSRIVAS band	SIGNAL score	Water sharing plan management zone	EC median (µS/cm)	EC 80th percentile (µS/cm)	EC N
54007_R	-31.681	151.206	B		Upper Hunter			
HU30	-32.281	151.393		6.1	Upper Paterson	194	202	2
HU31	-32.326	151.457		4.7	Upper Paterson	167.5	182	2
51182_E	-32.711	151.511	C		Wallis Creek	422	422	1
HUNTM4_E	-32.777	151.530	A		Wallis Creek	644	1160	4
HUNT590_E	-32.875	151.479	B		Wallis Creek	646.5	878	2
HU49	-32.933	151.438		5.5	Wallis Creek	1113	1576	2
HU37	-32.753	151.542		3.4	Wallis Creek	1677.5	2310	2
HUNT504_E	-32.644	151.721	C		Williams River	111	111	1
53060_E	-32.234	151.726	A		Williams River	115	115	1
53060_R	-32.234	151.726	B		Williams River			
HUNT04_E	-32.117	151.489	A		Williams River			
HUNT04_R	-32.117	151.489	A		Williams River	51	65	14
W02	-32.117	151.487		7.2	Williams River	65.5	73	2
51002_E	-32.652	151.792	A		Williams River	8000	8000	1
51043_E	-32.478	151.766	A		Williams River	1455	1455	1
HUNT02_R	-32.469	151.760	A		Williams River	275.5	384	4
HUNT02_E	-32.469	151.760	A		Williams River			
HUNT849_E	-32.455	151.768	A		Williams River	136	216	3
W14	-32.471	151.760		6.4	Williams River	275.5	290	2
51018_E	-32.574	151.765	A		Williams River	7500	7500	1
HUNT09_E	-32.158	151.577	A		Williams River			
HUNT09_R	-32.158	151.577	B		Williams River	22.5	34	4
HUNT509_R	-32.398	151.765	A		Williams River	160	160	2
HUNT509_E	-32.398	151.765	B		Williams River			
52388_E	-32.486	149.978	A		Wollar Creek	628	628	1
53011_E	-32.284	149.810	X		Wollar Creek	725	725	1
HU41	-32.363	149.949		4.5	Wollar Creek	2210	2320	2
52194_E	-33.057	151.136	B		Wollombi Brook			
52194_R	-33.057	151.136	B		Wollombi Brook	181	181	1
52037_E	-32.995	151.136	B		Wollombi Brook	403	403	1
HUNT543_R	-32.926	151.123	B		Wollombi Brook	495	748	3
HUNT543_E	-32.925	151.125	A		Wollombi Brook			
52020_E	-33.114	151.185	A		Wollombi Brook	154	154	1
HU42	-33.031	151.133		4.4	Wollombi Brook	280	430	2
HU44	-32.270	150.635		4.3	Wybong	3350	3470	2

Data sourced from OEH’s macroinvertebrate database; Chessman 1997a, b; and Hunter–Central Rivers CMA.

Appendix E: Salinity and stream macroinvertebrate community structure – the case of the Hunter River Catchment, eastern Australia

Contents

Salinity and stream macroinvertebrate community structure – the case of the Hunter River catchment, eastern Australia

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Summary

Salinisation is an important and increasing threat to freshwater biodiversity of streams and rivers. However, determining the specific threat that salinity poses can be complicated due to salinity being confounded with other changes in the environment, variation in the ionic proportions of salinity and temporal variation in salinity levels (i.e. pulse, press or ramp).

Here we use a weight-of-evidence approach to evaluate the role of salinity on stream macroinvertebrate community structure in the Hunter River and adjoining catchments (Karuah River, Lake Macquarie & Tuggerah Lakes and Manning River) on the Central Coast of New South Wales, Australia. In terms of investigating the ecological effect of salinity, the Hunter River is a complicated catchment. The Hunter has varied geology, extensive land clearing in some areas, salinity originating from discharges of waste water from coal mines and electrical generation and seepage of saline groundwater often exacerbated by agricultural practices. The ionic composition of salinity differs between the differing salinity sources. Pulses of increased salinity as stream discharges rise are considered to be more common in the Hunter than in other Australian catchments.

$SPEAR_{salinity}$ is a macroinvertebrate trait-based index designed to detect the effects of salinity by using information about the salinity sensitivity of macroinvertebrate families, mostly from laboratory toxicity tests. $SPEAR_{salinity}$, was found to decline with increasing electrical conductivity (EC). $SPEAR_{salinity\text{-}pulse}$, a novel index that combines salinity sensitivity information and traits which indicate a population's resilience following a salinity pulse, also declined with increasing EC. There were stronger relationships between $SPEAR_{salinity\text{-}pulse}$ and EC than with $SPEAR_{salinity}$ and EC, especially in the riffle habitat. EC was not the only environmental factor included in the best linear models to describe both $SPEAR_{salinity}$ and $SPEAR_{salinity\text{-}pulse}$. However, for $SPEAR_{salinity\text{-}pulse}$ EC was the most important factor identified in both the edge and riffle habitats. These results suggest that salinity pulses are ecologically important in the Hunter River catchment.

Large-scale changes in macroinvertebrate community structure (by pooling samples within predefined EC categories) were observed with relatively small changes in EC, including changes below 600 microsiemens per centimetre (µS/cm) and 900 µS/cm[1], which are the current targets for salt levels in the upper and mid/lower Hunter River, respectively. For example, as EC increases from <100 µS/cm to 100–199 µS/cm there was a turnover of

[1] That is the salinity from saline water disposal in these sections of the Hunter River is managed with the aim that it does not rise above these targets.

approximately 4 per cent of families across 16 samples, from 100 µS/cm to 200–599 µS/cm a 10 per cent turnover, from 100 µS/cm to 600–899 µS/cm a 16 per cent turnover and from 100 µS/cm to 900–8130 µS/cm a 19 per cent turnover. Multivariate analysis of individual samples shows that EC was included in the best set of environmental variables to describe the macroinvertebrate community structure in both the riffle and edge habitat.

Although the current study is correlative and thus cannot prove causality, we make the interim conclusion that salinity changes are likely (at least partly) to be causing the changes in macroinvertebrate community structure. This interim conclusion is made after considering that macroinvertebrate community structure changes have occurred at similar salinity levels elsewhere in Australia and overseas. Across these other locations salinity increases have a variety of causes and potentially a range of differing confounding factors. It would, thus, appear unlikely that salinity plays no causal role. Additionally, laboratory studies have shown that the magnitude of salinity changes observed in the Hunter do cause changes in the growth rates of some macroinvertebrate species. This interim conclusion should be reviewed in light of further studies, which we recommend, designed to establish causal relationships between salinity and changes in macroinvertebrate community structure in the Hunter catchment.

Introduction

Salinisation is the process of increasing salinity of land and inland waters and can be either the result of natural process (primary salinisation) or the activity of humans (secondary salinisation). Secondary salinisation of rivers and streams is a major and growing problem in many regions of the world and threatens freshwater organisms, their population and communities and the ecological functions and services they produce (Cañedo Argüelles *et al.* 2013).

Determining the specific ecological impact of salinisation can be complicated by confounding factors, variations in ionic composition and the temporal pattern of salinity increase. Salinity does not occur in isolation and can co-occur with other environmental stressors (Kefford 1998, Szöcs *et al.* 2012). These other stressors can have their own effects on freshwater biodiversity and increase or decrease the environmental effects of salinity (Hall and Anderson 1995). Salinity is itself made up of component major ions (Williams and Sherwood 1994) typically chiefly: sodium (Na^{+}), Calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), chloride (Cl-), carbonate (CO_2^{3-}) bicarbonate (HCO_3^{2-}) and sulphate (SO_4^{-}). The proportions of these and other ions in saline waters can have a greater effect on toxicity than total salinity (Mount *et al.* 1997, Farag and Harper 2012, Cañedo Argüelles *et al.* 2013). Salinity is typically a press or a ramp (Lake 2000) disturbance (Schäfer *et al.* 2011) but it can in some regions, e.g. the Hunter River catchment, be a short-term pulse disturbance (DEC 2006) and these different types of disturbances will most likely affect different groups of organisms (Schäfer *et al.* 2011). Consequently, determining the effect of salinity change in a catchment with a variety of environmental stressors, variable ionic proportions of saline water and the temporal pattern of the delivery of this saline water is a challenge.

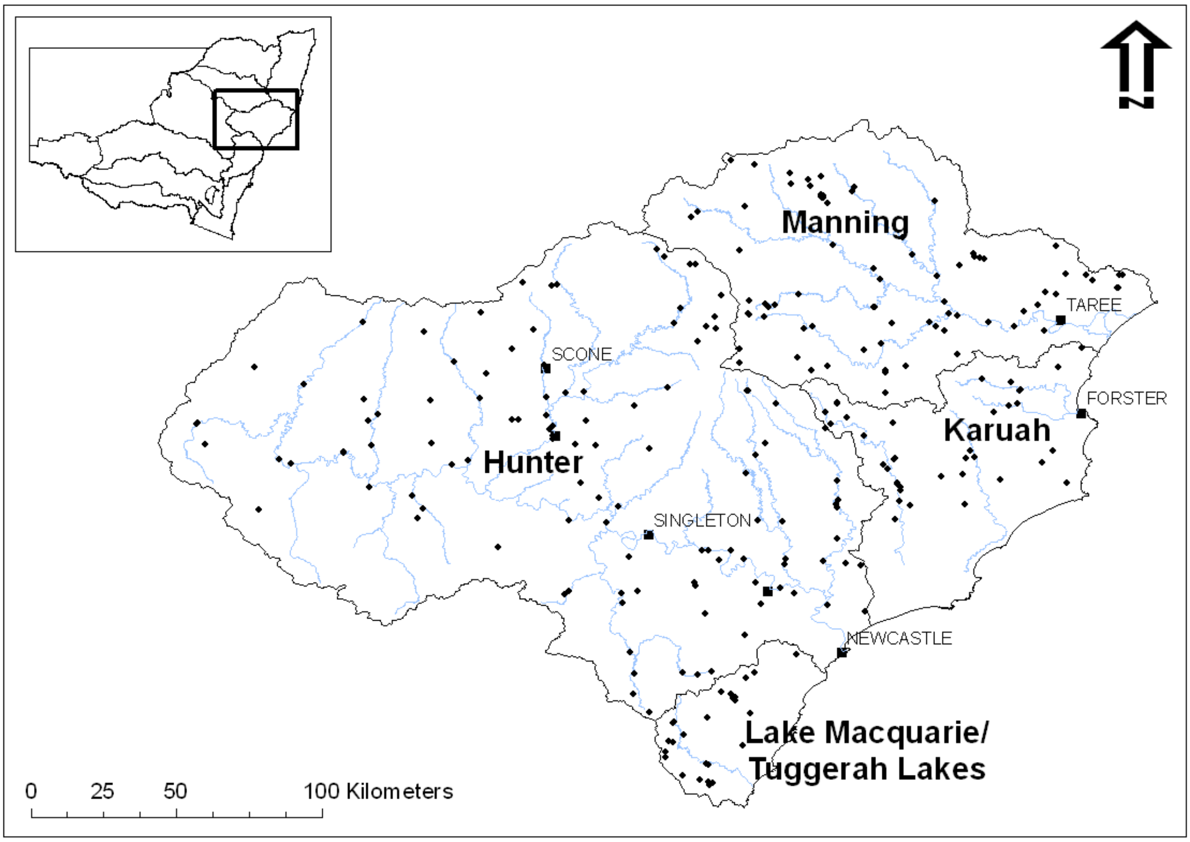

Figure E1: Map showing the region studied

Sites examined are marked by small black diamonds, major towns with larger squares.

The Hunter catchment (Figure E1) is a very important coal mining and associated electricity generation region and both of these activities generate saline water which is often disposed of to the Hunter River (DEC 2006). Since 1994 the disposal of saline water in some places of the Hunter catchment is limited to periods of elevated flow to help dilute the saline discharge. Furthermore there are now upper targets on salinity in the Hunter River set in terms of EC: in the mid and lower Hunter River (affected by saline mine water discharges) EC of 900 µS/cm standardised to 25 °C (hereafter µS/cm) and in the upper Hunter River 600 µS/cm. That is, the salinity from saline water disposal in these sections of the Hunter River is managed with the aim that it does not rise above 600 or 900 µS/cm. These targets are now generally not exceeded (see http://www.epa.nsw.gov.au/licensing/hrsts/success.htm). Prior to 1994 the lower Hunter River would at times have monthly mean EC up to 1800 µS/cm (DEC 2006); such high salinities are now only recorded in tributaries. It is important to recognise that the Hunter River Salinity Trading Scheme targets apply only to the main stem of the Hunter River between Glenbawn Dam and Singleton and not within any of the tributaries. The targets also apply only during high or flood flow periods. As a result, the Scheme may actually have limited influence over stream salinity levels for the majority of the time and the catchment and limited ability to control any ecological effects of saline water in the broader Hunter River catchment.

Within the Hunter catchment there are also uncontrolled inputs of salt associated with agriculture (Chessman *et al.* 1997) and natural inputs of saline water from the underlying geology (Kellet *et al.* 1989). The catchment has at least four different geologies – Permian sediments, Triassic sandstones, erosion-resistant Devonian & Carboniferous rocks and tertiary basalt flows & igneous intrusions (Chessman *et al.* 1997) – all of which have different levels of salinity in their run-off.

The ionic proportions of salinity associated with agriculture, mining and natural inputs are likely to be different. In Australian inland waters the salinity associated with agriculture typically has an ionic proportions similar to sea water (Herczeg *et al.* 2001), which is approximately 85 per cent sodium chloride (NaCl). Saline effluents from coal extractions are not similar to sea water and are also highly variable in terms of ionic proportions (Lincoln-Smith 2010, Dahm *et al.* 2011, Dunlop *et al.* 2011). Salinity guidelines in Australia have been developed assuming ionic proportions similar to sea water and there are currently no Australian guidelines to protect aquatic life related to individual major ions (ANZECC and ARMCANZ 2000).

Salinity in the Hunter can occur as a series of short-term pulses (DEC 2006) unlike other Australian regions where it is generally considered a press or ramp disturbance (Schäfer *et al.* 2011). When water flow increases in the Hunter River, salinity often increases for a few hours before declining to low levels (DEC 2006). This is thought to be because the rising water level dissolves salts that have accumulated on the dry banks of river and on the soil surface but these salts are soon transported downstream and the increased volume of water dilutes the salinity, resulting in lower salinity than immediately before and after the rise in water level. If salinity pulses are a common stressor, then the types of organisms in the Hunter catchment most at risk from salinity will likely be different from regions where salinity is a press or ramp disturbance (Schäfer *et al.* 2011).

The aim of this report is to examine patterns in stream macroinvertebrate community in the Hunter River and adjoining catchments (Figure E1) and relate them to complex patterns of salinity in the region using a method that has been suggested can detect effects of salinity on macroinvertebrates and not from other factors. This method is the SPEcies At Risk from salinity ($SPEAR_{salinity}$) biomonitoring index (Schäfer *et al.* 2011). We also aimed to determine if there was any evidence that salinity targets such as 600 and 900 µS/cm were more generally protective of large-scale community structure in the Hunter and adjoining catchments.

Methods

The data set

The Hunter River catchment (32–33°S, 150–152°E) is located near Newcastle in coastal New South Wales (NSW), Australia. It occupies 22,000 km^2 with an elevation range from sea level to 1600 m, and the climate is mostly warm temperate with rainfall ranges 600–1200 mm/year (Chessman *et al.* 1997). Stream macroinvertebrate and associated environmental data was obtained from the NSW Office of Environment and Heritage, from the Hunter River catchment and also from sites in the following adjoining catchments: Karuah River, Lake Macquarie & Tuggerah Lakes and Manning River (Figure E1) all of which fall within the area managed by the Hunter–Central Rivers Catchment Management Authority. All catchments are coastal in that they drain east to the Pacific Ocean and not into the Murray–Darling Basin.

Macroinvertebrate sampling followed the Australian River Assessment System (AUSRIVAS) protocols (see http://ausrivas.ewater.com.au/). These protocols define the reach of river to be sampled, the method of sampling, sorting and identification of macroinvertebrates, and the environmental data that is collected at each site. Data includes samples collected during the 1990s for the national Monitoring River Health Initiative, and more recent samples collected since 2006 for the Monitoring Evaluating and Reporting program. Associated with the macroinvertebrate samples are a range of measurements on the environmental characteristics of the site.

Using a data set that had been collected according to AUSRIVAS protocols meant that outputs from the AUSRIVAS model could be applied to our analyses. The AUSRIVAS model compares the assemblage collected from a site to those assemblages that would be expected if the site were in reference condition, and gives observed over expected (O/E) scores for each sample (Turak *et al.* 1999). Macroinvertebrate samples were collected from the edge habitat from all sites sampled, and, where present, riffle habitat.

Most sites were sampled on only one occasion (69 per cent and 65 per cent for edge and riffle, respectively) but some were sampled on multiple occasions, of which twice was the most common (18 per cent and 24 per cent for edge and riffle habitats respectively). A few sites were sampled up to 14 and 9 occasions for edge and riffle habitats respectively. To avoid issues of pseudoreplication, for sites which were sampled on multiple occasions, only one sampling event was randomly picked for analysis (and the data from the other sampling events was not examined). The exception to this was for relative family retention, where all samples were analysed (see below).

For some sites there were two replicate edge habitat samples taken from the same site on the same date; for analysis the mean abundance of each taxa recorded was calculated to avoid any issue of pseudoreplication. However, for the indices $SPEAR_{salinity}$ and $SPEAR_{salinity\text{-}pulse}$ (see below) the absolute difference between these two replicate samples was calculated to provide information on the repeatability (precision) of these indices.

Trait-based stressor-specific biomonitoring indices: SPEAR

The approach we used here to determine the ecological effect of salinity while reducing the impact of confounding variables was to look at changes in the distribution of traits, or attributes, of the organisms present rather than changes in their taxonomic identity. Traits of organisms are more stable than the identity of organisms in the absence of human disturbances and specific (combinations of) traits can identify particular anthropogenic stressors (Statzner and Bêche 2010). The SPEcies At Risk (SPEAR) is a stream macroinvertebrate index based on traits selected to be specific to particular stressors: pulse exposure to pesticides (Liess and Von der Ohe 2005), press exposure to organic toxicants (Beketov and Liess 2008) and press and ramp exposure to salinity (Schäfer *et al.* 2011). The term ‘pulse’ refers to episodic or short-term stress, ‘press’ refers to a stress of relatively constant intensity and ‘ramp’ as a slowly increasing intensity, relative to the lifetime of the organisms (Lake 2000).

The premise of SPEAR is that a key trait is physiological sensitivity (Kefford *et al.* 2012b) to the general class of contaminant under consideration e.g. organic toxicants in the case of pesticides and salinity in the case of salinisation (Schäfer *et al.* 2011). For contaminants that tend to have pulse exposure traits that indicate the ability of organisms to avoid the stress and for their populations to recover following the cessation of the stress, avoidance and resilience traits, respectively, are used.

$SPEAR_{salinity}$ was developed in southern Victoria and South Australia, where salinity appears to be mostly a press or ramp disturbance. The only trait that it uses is tolerance to elevated salinities of stream macroinvertebrate families (Schäfer *et al.* 2011), mostly as derived from acute salinity tolerance experiments using lethality as the end-point or response variable (Kefford *et al.* 2003, Kefford *et al.* 2006a, Dunlop *et al.* 2008, Kefford *et al.* 2012c). That is, taxa are regarded as at risk or not at risk of salinity based on experimental determination of their salinity tolerance. This is unlike other commonly used macroinvertebrate indices e.g. Stream Invertebrate Grade Number Average Level (SIGNAL) (Chessman 1995) where the sensitivity/tolerance is assigned to taxa based on observations of their occurrence in the field along a variety of gradients of human disturbances.

Here we calculated $SPEAR_{salinity}$ as per Schäfer *et al.* (2011). Briefly, all families observed in the current study were associated with the families listed in Schäfer *et al.* (2011); in the case of chironomid sub-families these were combined to the family level (i.e. Chironomidae). In the cases of any families not listed in Schäfer *et al.* (2011), these were assigned a risk (or not) at the order level. $SPEAR_{salinity}$ was then calculated as per:

$$\mathrm{SPEAR} = \frac{\sum_i^n \log_{10}(x_i) * y_i}{\sum_i^n \log_{10}(x_i)} \qquad (1)$$

where n is the number of taxa observed in a sample, x_i is the abundance of the i^{th} taxa and y_i is 1 if the i^{th} taxa at risk of salinity (defined as taxa with medium tolerance or with 72 h LC50 < 35 mS/cm) as listed in Schäfer *et al.* (2011), else 0 for taxa at risk of salinity.

We also derived a novel index in the SPEAR family called $SPEAR_{salinity\text{-}pulse}$. This index used the physiological tolerance of families to salinity as per Schäfer *et al.* (2011) and also the resilience traits of life-cycle length and dispersal ability and the avoidance trait (spending > 8 weeks out of the water) of macroinvertebrate families as given in Schäfer *et al.* (2011). The logic of $SPEAR_{salinity\text{-}pulse}$ followed that of $SPEAR_{pesticides}$ (pesticide contamination typically occurs in pulses). That is, for a taxa to be considered sensitive to salinity-pulses (as for pesticides) it had to be sensitive to salinity (as for organic toxicants), had to have low ability to avoid the pollution by being out of the water and had to have low population resilience to quickly recover following the spike in salinity (as for pesticides).

$SPEAR_{salinity\text{-}pulse}$ was calculated as per equation 1, except for y_i to be 1 a taxa had to meet ALL of the following requirements as listed in Schäfer *et al.* (2011):

- not at risk of salinity (as with $SPEAR_{salinity}$)
- number of generations ≤2 and time to first reproduction ≥0.5 years
- dispersal ability given as “low” or “some strong drifting or flying taxa”, and
- duration of life out of water <8 weeks or “fully aquatic” or “short” or “few weeks”.

So taxa which were at risk of salinity pulses were salinity sensitive, had low population resilience to quickly recover from a pulse disturbance and limited ability to avoid a pulse by being out of the water.

For comparative purposes with the two SPEAR indices, data on AUSRIVAS’s observed to expected ratio (at 50 per cent probability; O/E50); AUSRIVAS’s O/E50 SIGNAL and the SIGNAL2 index (Chessman 2003) were calculated at each site. AUSRIVAS is a predictive model very similar to the UK RIVPACS (Marchant *et al.* 1999, Turak *et al.* 1999). These three indices are widely used in Australia to assess the environmental health of macroinvertebrate stream communities.

Relationship between macroinvertebrates index and environmental variables

To examine the relationship between the two SPEARs and the other indices and environmental variables, automatic model building using linear regression with forward selection of environmental variables was conducted. The null model from which all other models were evaluated included only the intercept term. The modelling was undertaken as per Schäfer *et al.* (2011), except that model selection was based on the Bayesian information criterion (BIC) instead of Akaike's Information Criterion. Hierarchical partitioning (Chevan and M. 1991) was used to determine the independent explanatory power of the physicochemical variables selected for the best-fitting model.

The geographic variables latitude, longitude and altitude were omitted from analysis as we were interested in the response of the macroinvertebrates to environmental variables and not to variables which indirectly affect the biota by acting on other variables (e.g. temperature). We also removed variables which had > 25 per cent missing values. This left the following variables: EC (µS/cm), pH, dissolved oxygen (mg/L), turbidity (NTU), alkalinity (mg/L) and water temperature (°C), distance from source (m) (DFSM), rainfall (mm), slope (m/km), mode stream width (m), season (autumn or spring) and flow (none, low, moderate). Additionally the percentage cover of substrates (bedrock, boulder, cobble, pebble, gravel, sand, silt and clay) in the edge and riffle habitats was used in the analysis of edge and riffle macroinvertebrate samples, respectively. Sites with one or more missing value for these variables were excluded from the analysis.

Relative family retention

To determine if the salinity targets for the Hunter River of 600 and 900 µS/cm have any ecological basis in the region, we determined the relative family retention (RFR) rates using the method described in Kefford *et al.* (2010). This method looks at large-scale patterns in the change of taxonomical composition along a gradient of a stressor (salinity in this case). It is able to look at large scales by pooling (or amalgamating) multiple samples with similar levels of the stressor; these pooled sample sets (PSS) with similar levels of the stressor give an approximation of the complete set of taxa present at this level of contamination.

Table E1: Electrical conductivity categories and the number of pooled sample sets (PSS) used
Each PSS consists of 16 randomly chosen edge samples.

EC category (µS/cm)	no of PSS	Notes
<100	6	
100–199	5	
200–599	6	
600–899	4	600 µS/cm is the EC limit for upper Hunter
900–8130	4	900 µS/cm is the EC limit for lower and mid Hunter, 8130 µS/cm is the maximum salinity at any site examined.

Briefly, five EC categories were defined (Table E1) to encompass the EC limits in the current Hunter River (600 and 900 µS/cm) with respect to changes in macroinvertebrate relative species retention (RSR) previously observed in South Australia and Victoria (Kefford *et al.* 2010, Kefford *et al.* 2012a) and to maintain similar numbers of samples across all EC categories. Then, within each EC category samples are pooled; in the current study each PSS consisted of 16 samples from the edge habitat. (Note RFR was not calculated for the riffle habitat as the method requires a relatively large number of samples.) To form the PSS, samples were randomly selected, without replacement, from those available within the EC category until 16 samples were selected. The process was repeated for the next PSS until < 16 samples remained from an EC category.

Jaccard's Index (JI; or the proportion of taxa in common) was calculated between all pairs of PSS. From the mean Jaccard's Index between the PSS the relative family retention was calculated. If we have the ordinal contamination categories i ranging from 1 to n, referring to least (1) and most (n) contaminated, then $j_{x,y}$ with $x \neq y$ is the mean JI between categories x and y, and $j_{x,x}$ and $j_{y,y}$ are the mean JI's within categories x and y, respectively. The RFR between contamination categories x and y is $j_{x,y}/j_{x,x}$ (Kefford *et al.* 2010). So, a RFR of 0.9, for example, would indicate that across 16 samples 90 per cent of families are common to both EC categories but 10 per cent are only found in one or the other EC category and thus there is a 10 per cent turnover of families.

Note that unlike the other analyses performed for this report, RFR was calculated based on all edge samples available including when multiple samples had been taken from the same site on different dates. This was because: (a) the method requires a large number of samples; and (b) no consideration was made as to the causal relationship between EC and RFR; and (c) the aim was to document changes in RFR between the EC categories.

Traditional Primer analysis

Some standard methods of multivariate analysis of stream macroinvertebrate community data were also conducted using the software package Primer (Clarke and Gorley 2006) for both edge and riffle habitat data separately. In particular, the macroinvertebrate abundance data was converted to presence/absence data and the Bray-Curtis index was calculated between samples. From the Bray-Curtis index, non-metric multi-dimensional scaling (MDS) ordination was conducted in order to visualise the multivariate data. Differences in the community composition were then examined between EC categories (Table E1), AUSRIVAS bands and the catchments examined in the study using Analysis of Similarity (ANOSIM) (Clarke and Warwick 2001).

Stepwise searches for the best combination of environmental variables (BVSTEP routine in Primer) were also conducted with both the edge and riffle habitat, separately. This analysis searches for the best set of environmental variables, summarised by the Euclidean distance between the different environmental variable, to explain the Spearman Rank correlation of the environmental variables with the Bray-Curtis similarity of the macroinvertebrate community. Environmental variables considered were: $\log_{10}$ DFSM, rainfall, slope, stream width mode, temperature, $\log_{10}$ EC, square root turbidity, pH, $\log_{10}$ alkalinity, and percentage cover of bedrock, boulder, cobble, pebble, gravel, sand, silt and clay. Note the percentage cover of the substrates used were from the relevant habitat (edge or riffle). Sites with one or more missing value for these variables were excluded from the analysis.

Results

SPEAR$_{salinity}$

Where two replicate samples were taken from the same site from the habitat on the same occasion (date), the mean absolute difference in SPEAR$_{salinity}$ was 0.070 (stdev 0.049, range = 0.004–0.168, n=10). This generally indicated a small difference in SPEAR$_{salinity}$ for replicate samples collected from the same site at the same occasion.

In both the riffle and the edge habitat there were significant negative linear correlations between SPEAR$_{salinity}$ (Schäfer *et al.* 2011) and log_{10} transformed electrical conductivity (EC) – see Figure E2 (P<0.001 & P = 0.012; r = -0.435 & r = -0.226; n = 250 & n = 124, for edge and riffle habitats, respectively). However, r^2 values were low with EC only explaining 19 per cent and 6 per cent, for edge and riffle habitats respectively, of the variation in SPEAR$_{salinity}$.

a) b)

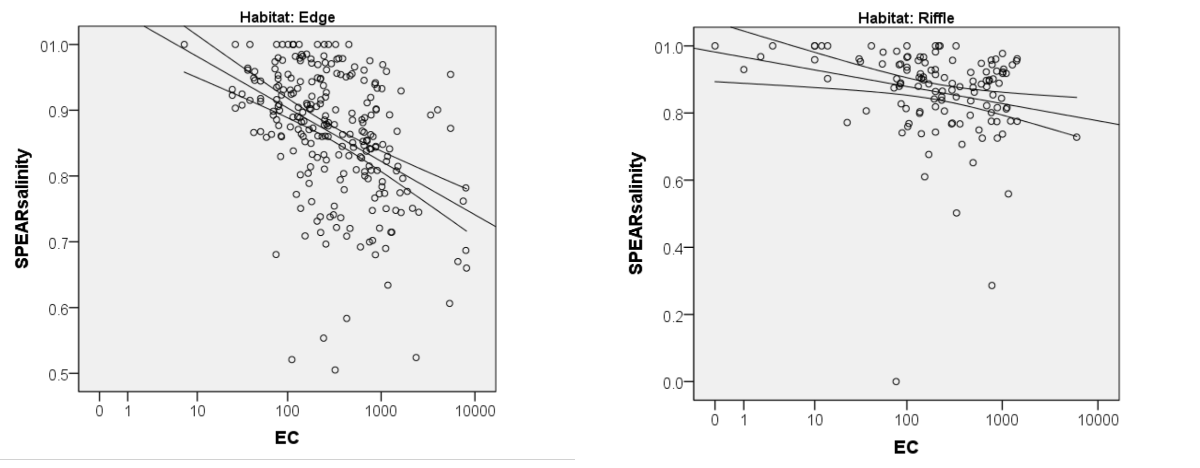

Figure E2: The relationship between SPEAR$_{salinity}$ and electrical conductivity in µS/cm at 25 °C from (a) edge habitat and (b) riffle habitat

Note the different minimum values on the y-axis.

SPEAR$_{salinity-pulse}$

Where two replicate samples were taken from the same site from the edge habitat on the same occasion, the mean absolute difference in SPEAR$_{salinity-pulse}$ was 0.080 (stdev 0.073, range = 0.013–0.256, n=10). Again this indicates a small difference in SPEAR$_{salinity-pulse}$ for replicate samples collected from the same site at the same occasion.

The values of the newly derived SPEAR$_{salinity-pulse}$ index were approximately 50 per cent less than the existing SPEAR$_{salinity}$ index. The former index requires a taxon to be both salinity sensitive and its population to have traits that indicate low resilience, while the latter index only that a taxon was salinity sensitive. Furthermore, both SPEAR$_{salinity-pulse}$ and SPEAR$_{salinity}$ were correlated (P <0.001; r= 0.752 & r=0.623; n= 251 & 147, for edge and riffle habitats, respectively, see Figure E3).

a) b)

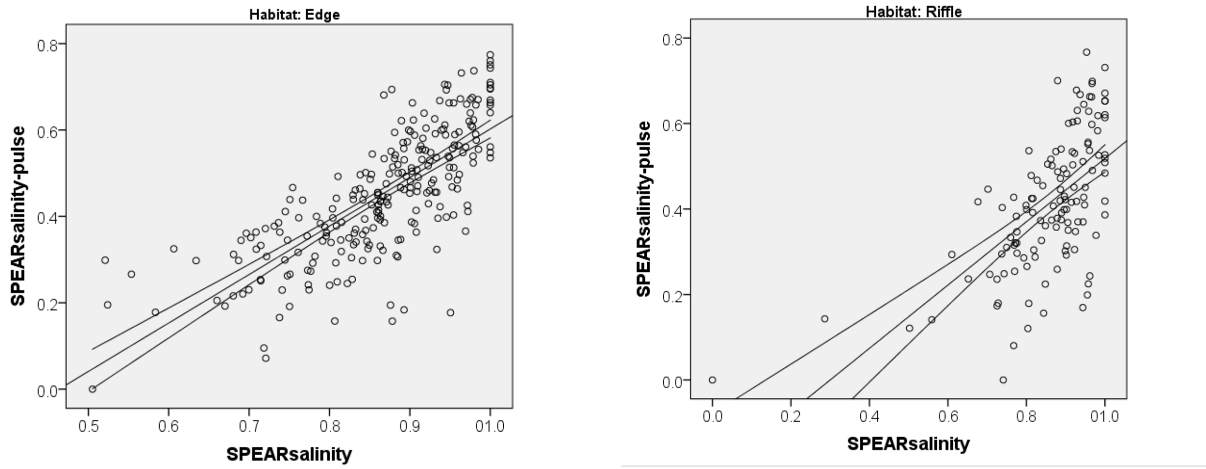

Figure E3: The relationship between SPEAR$_{salinity}$ and SPEAR$_{salinity\text{-}pulse}$ from (a) edge habitat and (b) riffle habitat

SPEAR$_{salinity\text{-}pulse}$ was significantly negatively correlated with $\log_{10}$ transformed EC in both habitats (P <0.001; r = -0. 487 & r = -0.479; n = 250 & n = 124, for edge and riffle habitats, respectively) and these correlations were stronger than for SPEAR$_{salinity}$ and EC (Figure E4), with r^2 values of 24 per cent and 23 per cent, respectively, for the edge and riffle habitats.

a) b)

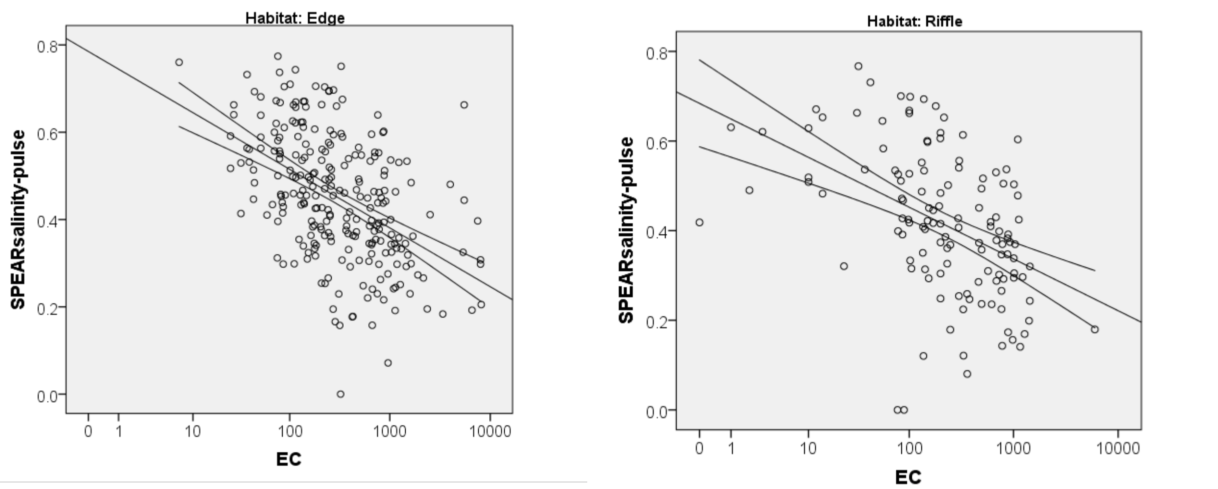

Figure E4: The relationship between SPEAR$_{salinity\text{-}pulse}$ and electrical conductivity in µS/cm at 25 °C from (a) edge habitat and (b) riffle habitat

What environmental variables best predict macroinvertebrate indices?

Environmental variables, like EC, are generally correlated with other environmental variables and showing that EC is correlated with $SPEAR_{salinity}$ and $SPEAR_{salinity-pulse}$ does not imply causality. In fact, establishing definitive causality between EC and $SPEAR_{salinity}$ as well as $SPEAR_{salinity-pulse}$ would require experimentation. However, we determined what environmental variables were generally accepted to influence stream macroinvertebrate communities and best described $SPEAR_{salinity}$, $SPEAR_{salinity-pulse}$ and three other commonly used macroinvertebrate indices (Table E2), as this increases the weight of evidence that a particular environmental variable, such as salinity, causes the change in the macroinvertebrate index.

EC was selected in the set of environmental variables best explaining $SPEAR_{salinity}$, $SPEAR_{salinity-pulse}$ in both habitats (Table E2), however, unlike in Schäfer *et al.* (2011), EC was never the only variable selected.

Table E2. Explanatory power of environmental variables (and transformations) for the macroinvertebrate indices, as determined in hierarchical partitioning, and goodness of fit measures: r^2 and Bayesian information criterion (BIC)

(Presented for the (a) edge and (b) riffle habitats. Variables with no percentage given for a particular macroinvertebrate index were not selected in describing that index and variables not displayed were not selected in describing any of the macroinvertebrate indices. A full list of environmental variables considered is listed in the 'Methods' section of this report.)

Variable relevance (%)	**$SPEAR_{salinity}$**	**$SPEAR_{salinity-pulse}$**	**AUSRIVAS's O/E50**	**AUSRIVAS's O/E50 SIGNAL**	**SIGNAL2**
(a) Edge habitat					
EC (log_{10})	30%	46%			48%
Dissolved oxygen	20%	10%	20%		
Turbidity (Sqrt)		10%		50%	9.3%
pH		6.1%			
Alkalinity log				50%	
Temperature					17%
Season					5.6%
DFSM (log_{10})	8.9%		9.1%		
Stream width mode	28%	9.3%	38%		
Edge silt %		11%	33%		11%
Edge sand %	13%	7.8%			8.3%
r^2	0.327	0.394	0.214	0.095	0.533
BIC	-1059	-981	-629	-988	-254

Variable relevance (%)	$SPEAR_{salinity}$	$SPEAR_{salinity-pulse}$	AUSRIVAS's O/E50	AUSRIVAS's O/E50 SIGNAL	SIGNAL2
(b) Riffle habitat					
EC (log_{10})	25%	56%	50%		62%
Turbidity	14%	9.2%			
Temperature					15%
Season		18%		37%	6.7%
Slope		16%			12%
Riffle clay %	60%				4.3%
Riffle silt %			50%		
Riffle sand %				19%	
Riffle pebble %				44%	
Riffle cobble %					1.1%
r^2	0.329	0.556	0.264	0.217	0.715
BIC	-645	-465	-364	-601	-167

In both habitats the best model explaining $SPEAR_{salinity-pulse}$ had higher r^2 values than $SPEAR_{salinity.}$ For $SPEAR_{salinity-pulse}$ EC was always clearly the most important environmental variable in the model (Table E2). For $SPEAR_{salinity}$, although EC was the most important variable in the edge habitat, the next most important variable (stream width mode) explained only 2 per cent less variation than EC. In the riffle habitat, the most important variable in explaining $SPEAR_{salinity}$ was the percentage of clay in the riffle (60 per cent) followed by EC (25 per cent). Collectively these results suggest that that salinity pulses may be ecologically significant in the Hunter catchment.

EC was generally not selected as explaining the AUSRIVAS observed/expected ratio with at a ≥ 50 per cent probability (O/E50) or the AUSRIVAS observed SIGNAL/expected SIGNAL (O/E50 SIGNAL) indices; the exception being O/E50 in the riffle habitat where EC and percentage of silt in the riffle were equally important (50 per cent). EC was the most important variable in both habitats in explaining the SIGNAL2 index (Chessman 2003), accounting for 48 per cent and 62 per cent of the variance explained by the model for edge and riffle habitats, respectively. The r^2 of the best models in explaining the SIGNAL2 index were higher than any of the other macroinvertebrate indices calculated.

Relative family retention

All samples from the edge habitat were classified into one of five EC categories (Table E1). The EC category boundaries were set to have similar number of pooled sample sets (PSS) in each category and to have category boundaries at the current EC targets for the Hunter River Salinity Trading Scheme of 600 µS/cm in the upper Hunter and 900 µS/cm in the lower and mid Hunter. Each PSS consisted of 16 randomly selected (without replacement) samples from the edge habitat within the relevant EC category (Table E1).

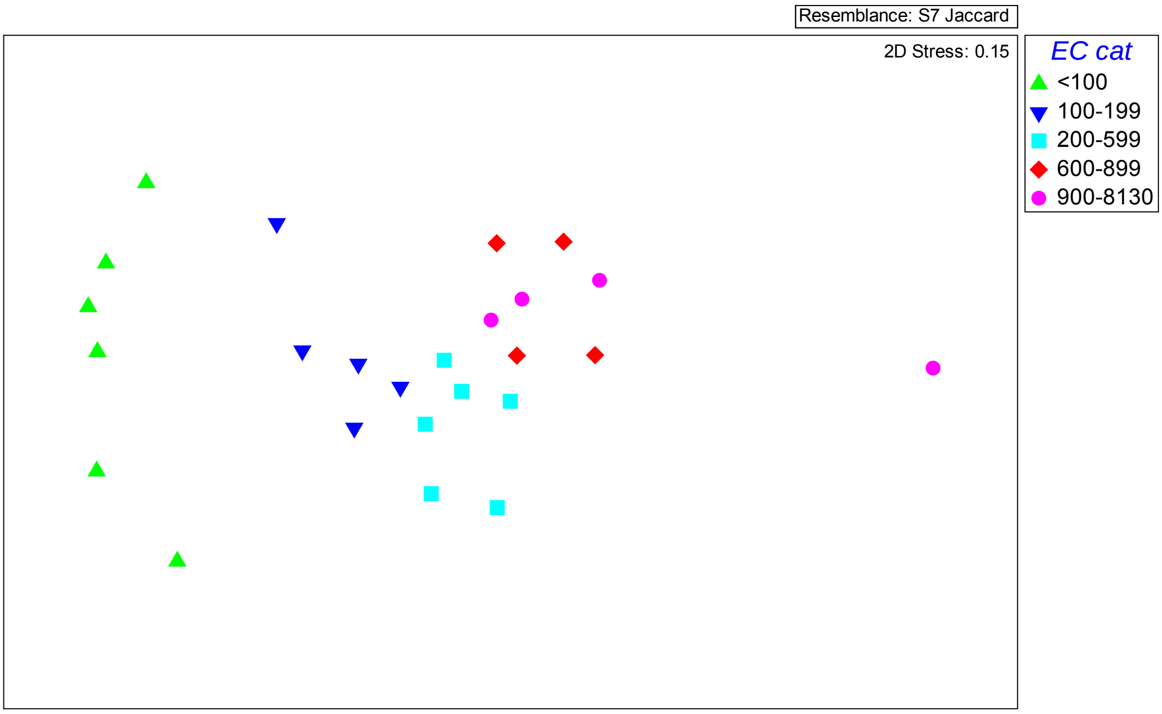

Figure E5: Non-metric multi-dimensional scaling plot of the pooled sample sets
Each point represents 16 randomly selected edge samples from the indicated EC categories.

Analysis of Similarity (ANOSIM) revealed a significant difference in similarity (as defined by Jaccard's Index) between the EC categories (Global R = 0.517, P <0.00001). Pair-wise comparisons show significant differences (R = 0.276–1, P = 0.019–0.002, see upper triangle in Table E3) between all categories, except between the two highest categories (600–899 µS/cm and 900–8130 µS/cm, R = 0, P = 0.543). This indicates that the community across multiple (16) samples is different between each of the EC categories, except between 600–899 µS/cm and 900–8130 µS/cm. This is shown graphically in Figure E5.

In this analysis relative family retention (RFR) rates were calculated because invertebrates were generally identified to family level and not to species level as previously (Kefford *et al.* 2010, Kefford *et al.* 2012a) with the previous studies using relative species retention (RSR) rates. The RFR between the EC categories <100 µS/cm and 100–199 µS/cm was 0.96 (lower triangle in Table E3) indicating that across 16 samples, 96 per cent of families were present in both of these categories and the remaining 4 per cent were present in only one of these categories. Between the EC <100 µS/cm and 200–599 µS/cm the RFR was 0.90 so changes in salinity below 600 µS/cm do appear to result in regional changes in the pool of families present (Table E3).

Table E3: Results of relative family retention

(The top right triangle gives the mean Jaccard's Index (JI) within and between the EC categories (µS/cm), and in brackets are analysis of similarity (ANOSIM) pair-wise R statistics. The bottom left triangle gives relative family retention (RFR) across 16 samples between EC categories.)

EC category	<100	100–199	200–599	600–899	900–8130
<100	0.66	0.63 (0.62)[a]	0.59 (0.92[a])	0.55 (1)[a]	0.53 (0.90)[a]
100–199	0.96	0.70	0.68 (0.35)[a]	0.65 (0.65)[a]	0.61 (0.57)[a]
200–599	0.90	0.98	0.71	0.69 (0.28)[b]	0.65 (0.36)[b]
600–899	0.84	0.94	0.97	0.71	0.69 (0)
900–8130	0.81	0.88	0.92	0.97	0.65

[a] P <0.05

[b] P <0.01

Traditional Primer analysis

Edge habitat

In the edge habitat ANOSIM indicated significant differences (P <0.0001) in the similarity (as defined by the Bray-Curtis index applied to presence/absence data) between the EC categories (Table E1); catchments the sites were located in; and the AUSRIVAS O/E Bands. However these differences were not large with Global R's of 0.090 and 0.100 for the EC categories and catchments, respectively. This indicates that despite the statistical significance, the practical difference in the invertebrate community between sites between EC categories and catchments is low, and ordinations illustrate this graphically (Figures E6 and E7). Pair-wise comparisons of the EC categories did indicate some greater differences when the changes in EC, e.g. <100 versus 900–8130 µS/cm, R = 0.354 (P <0.0001) and <100 vs. 600–899 µS/cm, R = 0.213 (P <0.0001). However, there was no evidence of a difference between 200–599 µS/cm and 600–899 µS/cm, R = -0.024 (P=0.754) or between 200–599 µS/cm and 900–8130 µS/cm, R = 0.029 (P = 0.119) (Figure E6). So while increases in EC from a low base (<100 µS/cm) to levels greater than current targets in the Hunter (600 and 900 µS/cm) were associated with changes in community structure, more modest changes in EC were not.

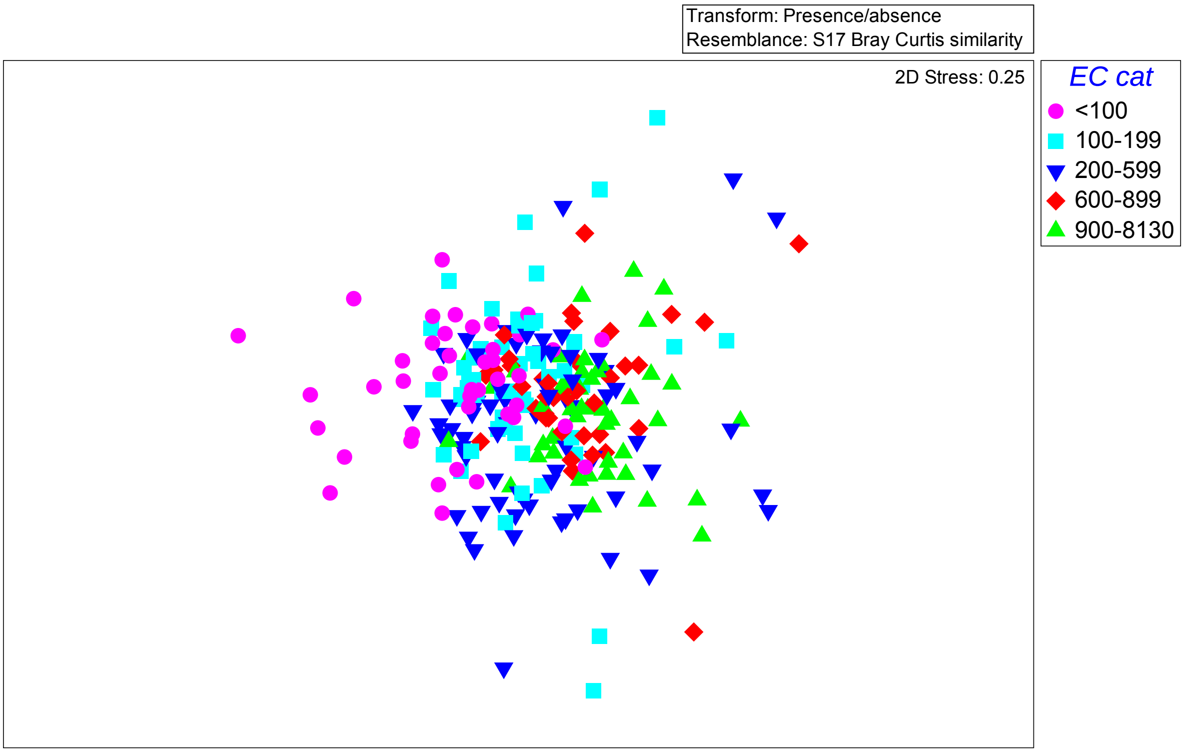

Figure E6: Non-metric multi-dimensional scaling plot of edge samples showing differences between the EC categories

Each point represents a site sampled once from the edge habitat.

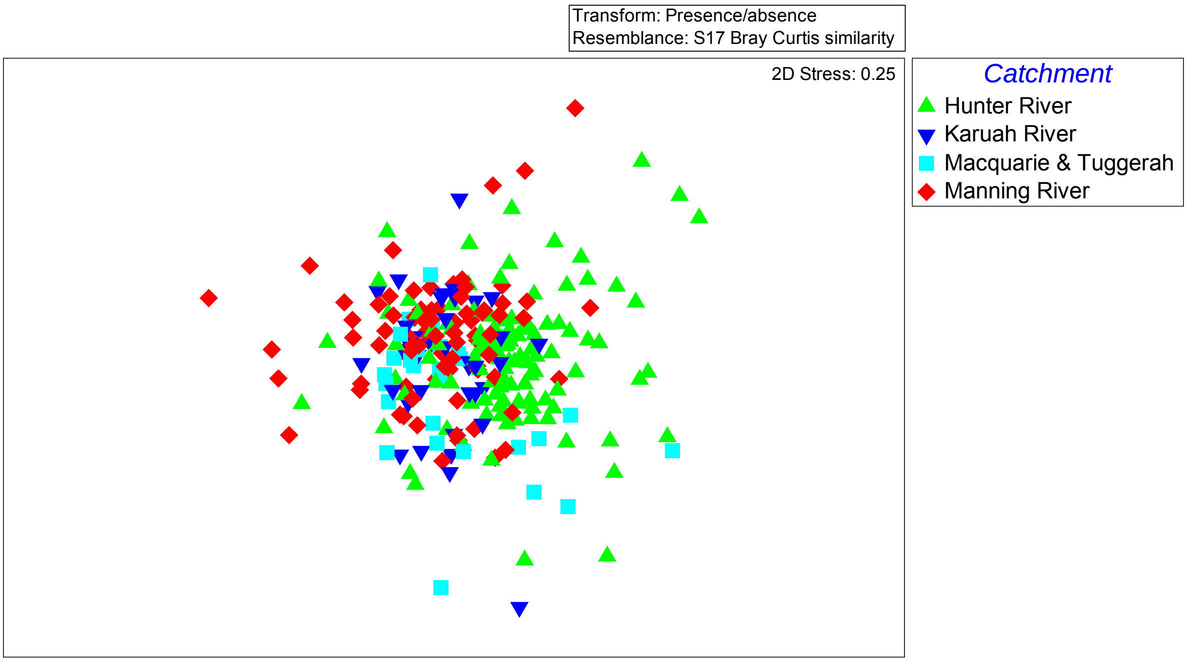

Figure E7: Non-metric multi-dimensional scaling plot of edge samples showing differences between the catchments

Each point represents a site sampled once from the edge habitat.

The difference between the AUSRIVAS O/E bands was greater with a Global R of 0.263 and was largely driven by differences between bands X and A with band C (Figure E8).

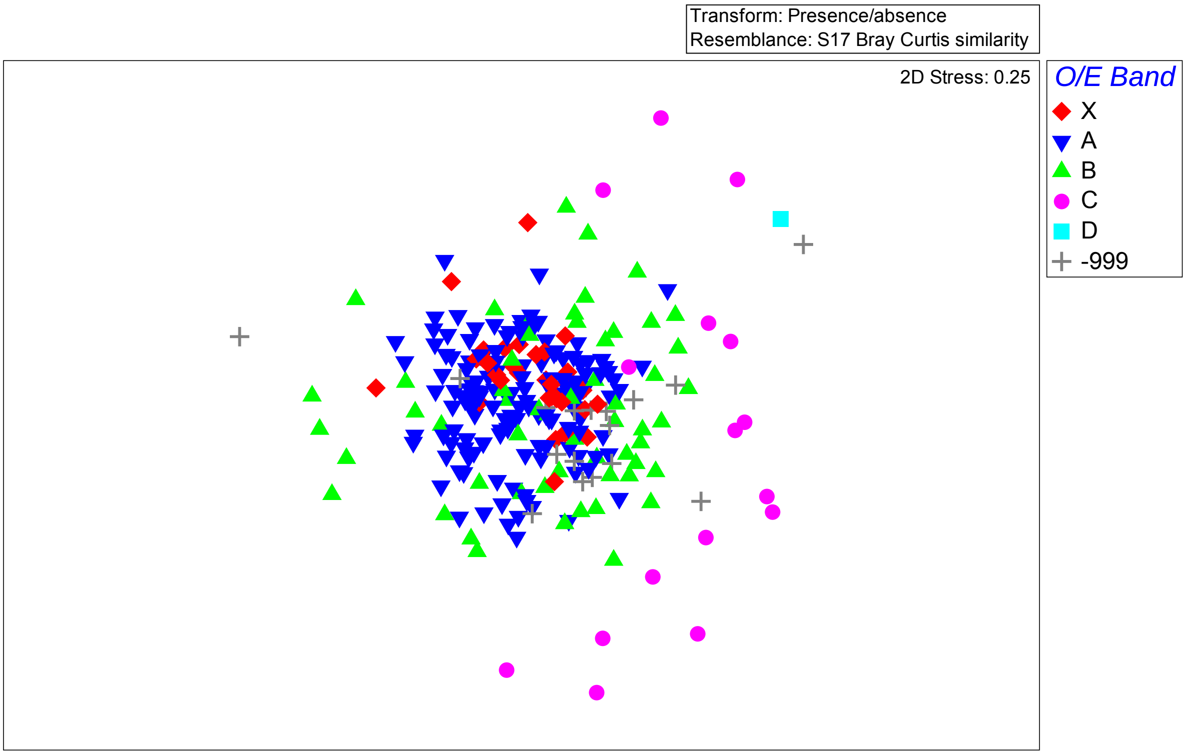

Figure E8: Non-metric multi-dimensional scaling plot of edge samples showing differences between the AUSRIVAS O/E bands.
Each point represents a site sampled once from the edge habitat. – 999 indicates that the band could not be calculated as the site characteristics were outside the experience of the AUSRIVAS model.

Stepwise searches for the best combination of environmental variables (BVSTEP routine in Primer) were conducted to explain the Spearman Rank correlation of the Bray-Curtis similarity of the macroinvertebrate community at the edge habitat to the Euclidean distance to the environmental variables. This analysis found a statistically significant relationship (Rho = 0.443, P <0.001) with the following combination of variables (and transformations) giving the greatest explanatory power: DFSM ($\log_{10}$), rainfall, EC ($\log_{10}$), Turbidity (Sqrt), pH, percentage of silt in the edge and percentage of clay in the edge. The BVSTEP did not select any other models.

Riffle habitat

There were significant differences (P <0.0001–0.0006) in the Bray-Curtis similarity index (applied on presence/absence data) of riffle samples between the EC categories (Table E1), catchments and the AUSRIVAS O/E bands. Unlike the edge habitat, the Global R (0.212) value for differences between the EC categories in the riffle habitat was of practical significance, with sites generally ordinated along the EC gradient (Figure E9). However, for the catchments and O/E bands, the Global R values were lower, 0.088 and 0.112, respectively, with ordinations not showing clear separation of samples between the categories (Figures E10 and E11).

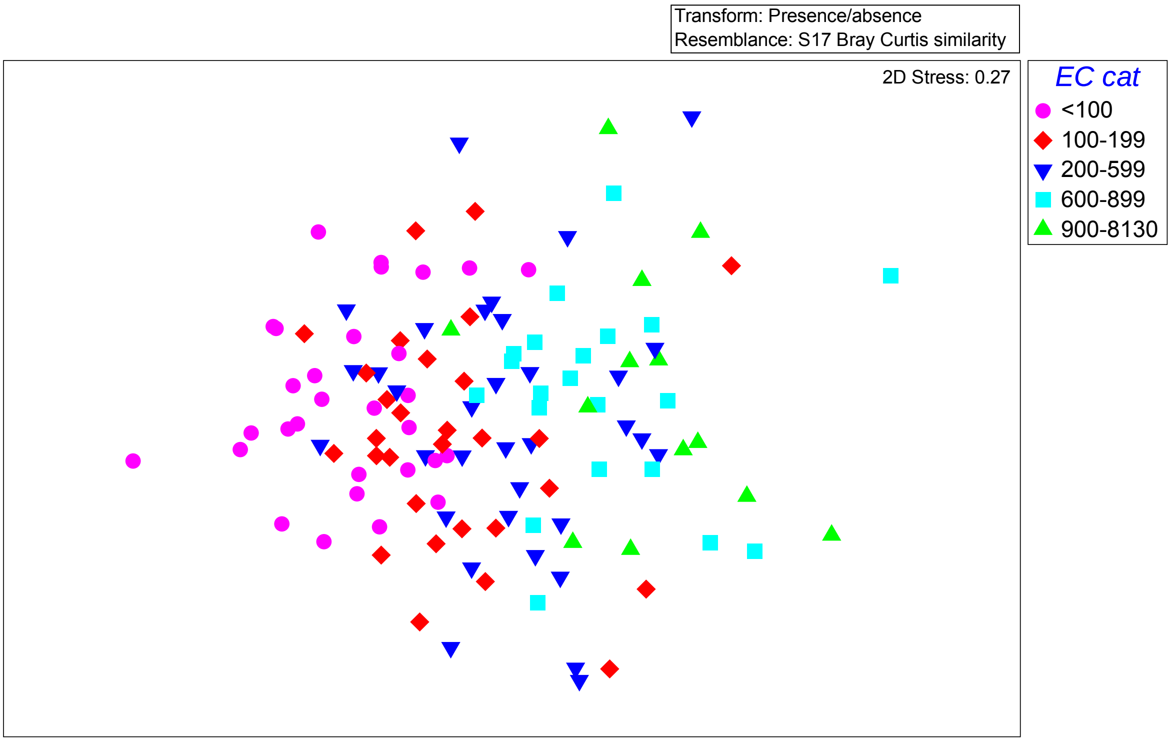

Figure E9: Non-metric multi-dimensional scaling plot of riffle samples showing differences between the EC categories
Each point represents a site sampled once from the riffle habitat.

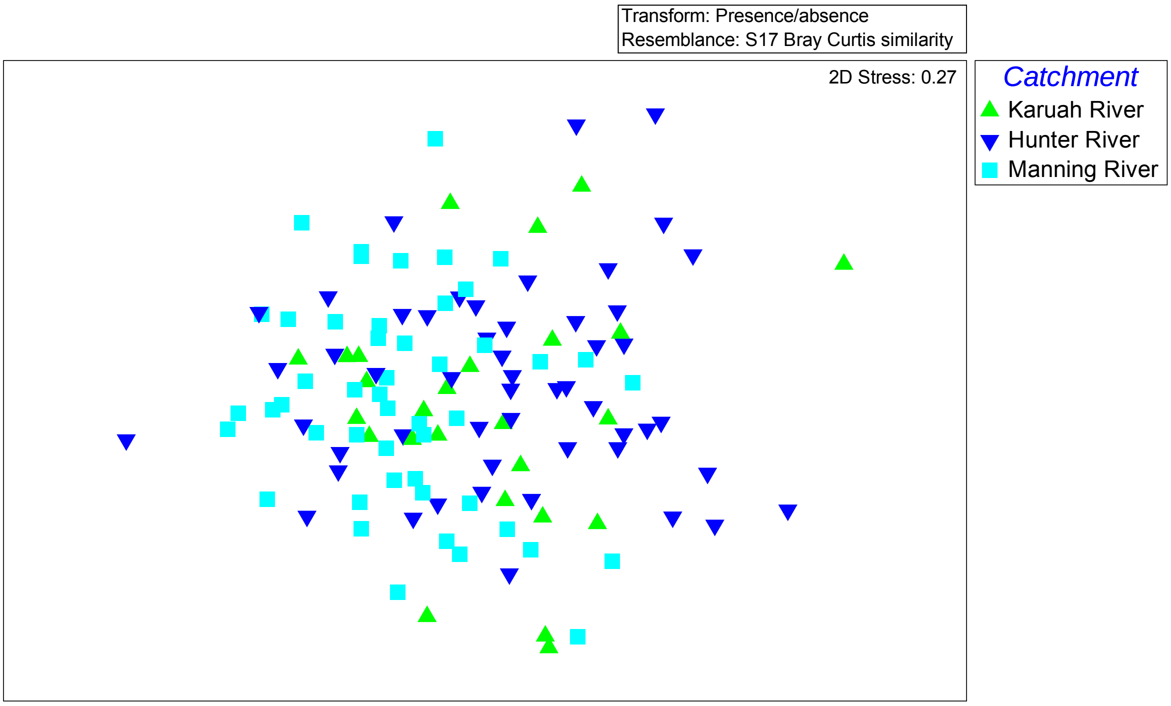

Figure E10: Non-metric multi-dimensional scaling plot of riffle samples showing differences between the catchments
Each point represents a site sampled once from the riffle habitat.

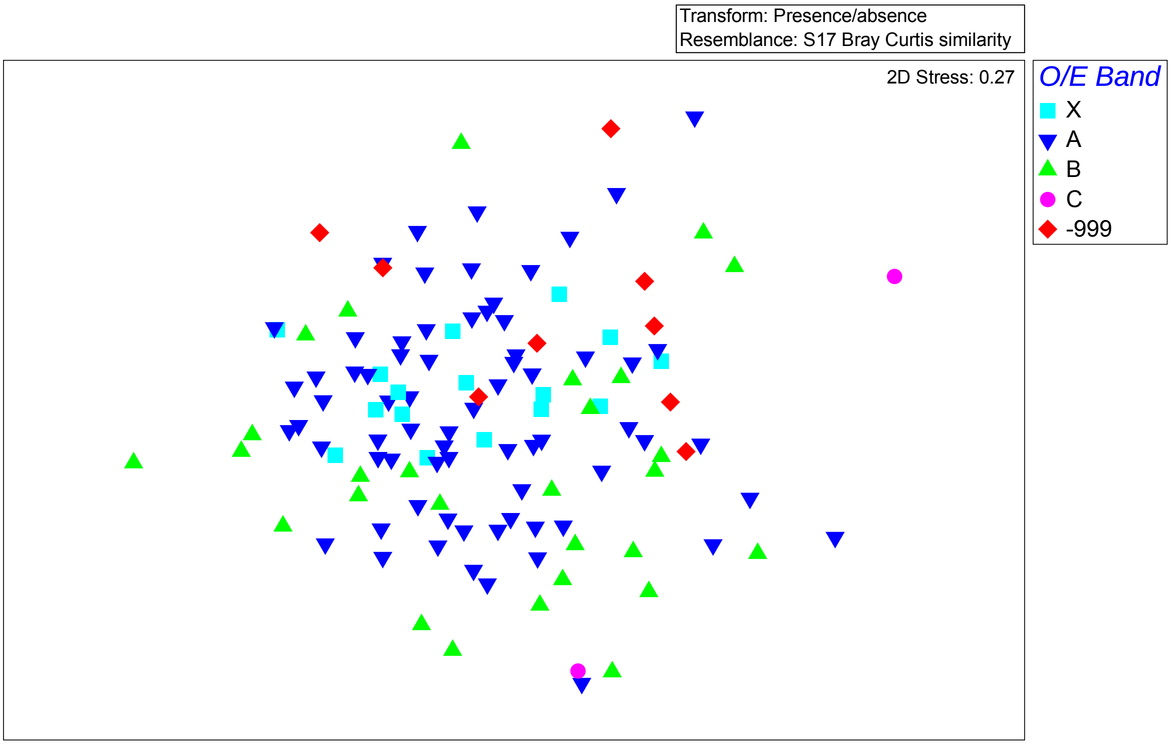

Figure E11: Non-metric multi-dimensional scaling plot of riffle samples showing differences between the AUSRIVAS O/E bands
Each point represents a site sampled once from the riffle habitat. – 999 indicates that the band could not be calculated.

Stepwise searches for the best combination of environmental variables (BVSTEP routine in Primer) were conducted to explain the Spearman Rank correlation of the Bray-Curtis similarity of the macroinvertebrate community at the riffle habitat to the Euclidean distance to the environmental variables. This analysis found a statistically significant relationship (Rho = 0.383, P <0.001) with the following combination of variables (and transformations) giving the greatest explanatory power: DFSM (log_{10}), EC (log_{10}), pH, percentage of sand in riffle and percentage of silt in riffle. It is noteworthy that in the ten best models (Rho = 0.363–0.383) that BVSTEP selected all included EC (log_{10}).

Discussion

There were correlations between $SPEAR_{salinity}$ and log_{10} transformed EC in both the edge and riffle habitats. However, the strengths of these correlations were not great (r^2 of 19 per cent and 6 per cent in edge and riffle, respectively) and certainly less than in southern Victoria (50 per cent and 44 per cent) and South Australia (45 and 38 per cent) (Schäfer *et al.* 2011). Unlike in southern Victoria (Schäfer *et al.* 2011), the best linear model to describe $SPEAR_{salinity}$ in the Hunter included several variables other than log_{10} transformed EC (Table E2). Furthermore log_{10} transformed EC explained less than or about the same amount of variation in $SPEAR_{salinity}$ than another variable in both habitats. The difference could not be due to different taxonomic resolution as the data was analysed at the family level in all regions.

Several factors could be important for explaining the differences between the Hunter and that observed by Schäfer *et al.* (2011) in southern Victoria and South Australia. While the minimum salinity were similar in all regions, the maximum salinity were markedly greater in southern Victoria (22,950 µS/cm) and South Australia (61,500 µS/cm) than in the current study in the Hunter (8,130 µS/cm) and the higher salinity levels might have forced a stronger relationship with $\log_{10}$ EC. There are streams in the Hunter catchment that have had EC > 10,000 recorded but these were not sampled in the dataset examined. Future studies should specifically target such streams. Additional factors which might have been important are higher salinity levels in the Hunter often occur as short-term pulses (DEC 2006), variation in ionic proportions of waters with elevated salinity (Lincoln-Smith 2010, Dahm *et al.* 2011, Dunlop *et al.* 2011) altering the effect of a particular level of EC and the possibility of other pollution in saline water disposed from mining or electrical generation.

Although very little salinity tolerance information was available for stream macroinvertebrates from NSW for developing the $SPEAR_{salinity}$ index, it would seem unlikely that this is the reason for stronger relationships in Victoria and South Australia. This is because related stream macroinvertebrates generally have similar laboratory measured salinity tolerances regardless of whether collected in Victoria, Tasmania or Queensland (Allan 2006, Dunlop *et al.* 2008) and even eastern Australia, South Africa, France or Israel (Kefford *et al.* 2012c).

The novel index $SPEAR_{salinity\text{-}pulse}$ had stronger linear correlations with $\log_{10}$ transformed EC than $SPEAR_{salinity}$ especially in the riffle habitat (r^2 of 24 per cent and 23 per cent for the edge and riffle, respectively). Although $\log_{10}$ transformed EC was not the only variable selected to explain $SPEAR_{salinity\text{-}pulse}$, $\log_{10}$ transformed EC was the most important variable in both habitats (Table E2). These results suggest that in the Hunter River catchment pulses of salinity may be ecologically relevant.

The EC measurements consisted of spot measures of salinity made while collecting the macroinvertebrate samples. In investigating relationships between $SPEAR_{salinity\text{-}pulse}$ and spot EC, there is an implicit assumption that there is a positive correlation between the spot EC and the maximum EC occurring during salinity pulses. While some positive correlation seems reasonable – sites with very low salinity would likely not have these salinity pulses as few salts would be expected to be deposited on the dry banks – the correlation would unlikely to be one-to-one and there could be some outlying sites. So the correlations between $SPEAR_{salinity\text{-}pulse}$ and spot EC are quite remarkable.

Consideration of the relative family retention rates between the EC categories (Table E1) show that changes in salinity below 600 µS/cm do result in changes in the regional pool of families (Table E3). For example, if salinity increases from < 100 µS/cm to the range of 600–899 µS/cm in the edge habitat there is a 16 per cent turnover in species across 16 samples for this dataset (Table E3). This large-scale (regional) change was much less evident at the site scale (see Figure E7). This is the result of reduced ‘noise’ by pooling samples, providing a more complete list of species. That is, when single samples are considered many taxa are not recorded not because they do not live at a particular salinity but due to other environmental factors, past disturbance and even chance that they were not collected in that sample. The variability in individual macroinvertebrate family detections based on a single rapid-based assessment (RBA) sample can often be very high (Gillies *et al.* 2009). When multiple samples are pooled the chances that such species have not been sampled, if they in fact do live at a particular salinity, is reduced.

The reasons for selecting EC category boundaries at 600 µS/cm and 900 µS/cm is that these are the current limits of the Hunter River Salinity Trading Scheme in the upper and middle/lower Hunter, respectively (DEC 2006). The observation that changes in salinity below 600 µS/cm and 900 µS/cm were associated with regional turnover of families suggesting that these limits may not fully protect the stream macroinvertebrate community from impacts of salinity. If short-term pulses of salinity are responsible for these community level changes, then the salinity levels indicated by the EC categories will almost certainly underestimate the level of salinity during the damaging pulses. This is because it is extremely unlikely that the spot measurements of EC during macroinvertebrate collection will capture the level of salinity during a pulse.

Although it is not proven, there is a reasonable case that the changes in community below 600 µS/cm and 900 µS/cm are caused by salinity. Changes in community structure associated with similarly low salinity have been observed in Victoria and South Australia (Kefford *et al.* 2005, Kefford *et al.* 2010), the Appalachia mountains, USA (Pond 2010, USEPA 2011, Passmore *et al.* 2012) and France (Piscart *et al.* 2005a, Piscart *et al.* 2005b, Piscart *et al.* 2006). So if confounding factors are really the cause in the community change, they need to be invoked in a number of geographically distant locations with different causes of increased salinity. In the case of the French studies, the increase in salinity resulted from discharges from soda factories, and salinity (and component ions) was the only environmental parameter which changed upstream and downstream of the discharge (Piscart *et al.* 2005a, Piscart *et al.* 2005b, Piscart *et al.* 2006). Furthermore, changes in salinity below 600 or 900 µS/cm have been experimentally shown to affect the growth of stream macroinvertebrates (Kefford and Nugegoda 2005, Hassell *et al.* 2006, Kefford *et al.* 2006b, Kefford *et al.* 2007b), microinvertebrates (Kefford *et al.* 2007a) and freshwater fish (Boeuf and Payan 2001).

Research needs

From the data currently available it is impossible to definitively determine the extent to which salinity in the Hunter Catchment is a **causal** factor for changes in stream macroinvertebrate communities. This is because the current non-experimental data does not capture the fine-scale temporal salinity variation, variation in ionic composition of the saline water or other potential contaminants.

To establish the causal relationship between salinity and stream macroinvertebrate communities a research program would be required involving each of the following elements:

- experimental mesocosm studies where various salinity treatments are implemented and the response of the stream macroinvertebrate community observed. These experiments should also manipulate other factors potentially confounded with salinity in the Hunter catchment and deliver salinity as pulse, ramp and press disturbances so as to disentangle the effect of salinity and these other factors. These experimental treatments should be maintained for extended periods (e.g. 6 months to one year) so that all components of the organisms' lifecycle are considered and there is a sufficient period for long-term effects of salinity to occur. It would be useful for mesocosm experiments to not only determine the response of macroinvertebrate community structure to salinity but to also consider the effect of salinity on major food items of macroinvertebrates (e.g. algae and decay rate of leaves) in case salinity is affecting macroinvertebrates indirectly through alterations to the food chain. The purpose of these mesocosm experiments would be to demonstrate causal connection between salinity and changes in stream macroinvertebrate community.

- field studies at selected sites where, in addition to measuring standard macroinvertebrate, and associated environmental variables, major food items of macroinvertebrates, ionic composition and other potential contaminants are measured periodically, and EC, water temperature and discharge are logged continuously. Where possible sites could be co-located at existing water quality monitoring sites to reduce costs. The purpose of such a field study would be to ensure that (1) the aforementioned mesocosms are environmentally realistic and (2) the responses of the invertebrates to salinity (and other factors) are similar in the mesocosm and in real streams. It is important to make these comparisons because if mesocosm experiments are poorly designed they can underestimate the response of macroinvertebrates in real streams (Beketov *et al.* 2008, Liess and Beketov 2011, Schäfer *et al.* 2012).
- long-term laboratory experiments to determine the chronic and sub-lethal salinity sensitivity of macroinvertebrate taxa from the Hunter which appear to be salinity sensitive. Experiments should look at how salinity sensitivity is altered by other co-occurring environmental stressors and variation in ionic proportions that occur in the Hunter. Some initial steps in laboratory experiments have been undertaken by Lincoln-Smith *et al.* (2010) and PhD student R. Dowse (RMIT University) but further experimental work is still required. The purpose of these laboratory experiments would be to aid in the interpretation of results of the aforementioned mesocosm and field studies.

Conclusion

As expected, it is clear that salinity is one of several factors affecting stream macroinvertebrate communities in the Hunter River catchment. However, salinity would appear to be a relatively important factor because it was consistently selected in the best models to explain univariate macroinvertebrate indices and multivariate community structure, and has previously been demonstrated to be associated with changes in regional family composition. Studies elsewhere have observed changes in macroinvertebrate community structure at similar salinity levels and laboratory experiments have shown that such salinity can alter the growth of stream macroinvertebrate species. It is thus reasonable to conclude in the interim, that changes in salinity below 600 µS/cm and 900 µS/cm can potentially impact on macroinvertebrate communities, until subsequent studies along the lines of those outlined in the ‘Research needs’ section of this report confirm or refute this conclusion.

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