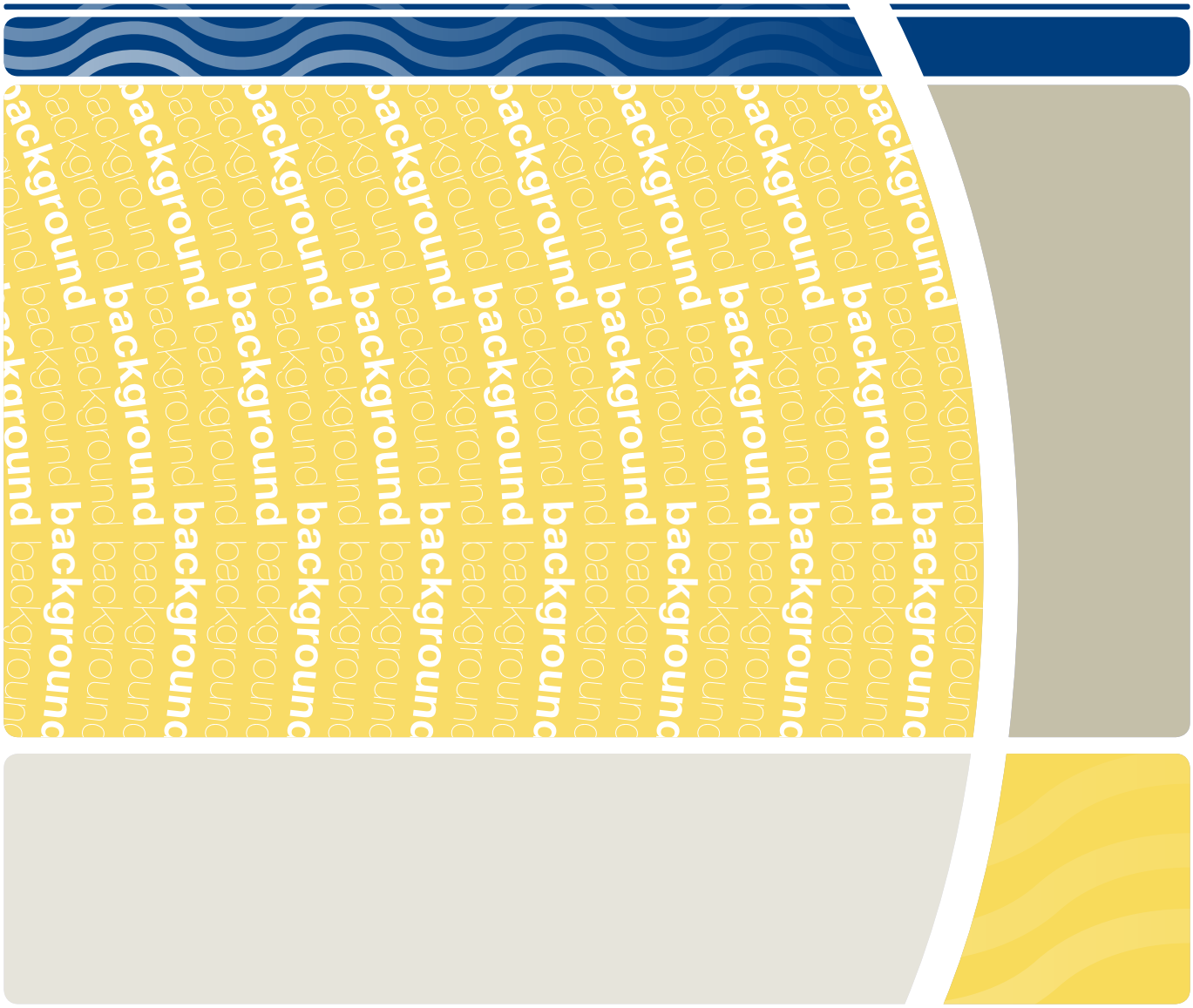
NSW GOVERNMENT | Office of Water

Water Sharing Plan

Bega and Brogo Rivers Area Regulated, Unregulated and Alluvial Water Sources

Background document



Leading policy and reform in sustainable water management

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The NSW Office of Water is a separate office within the Department of Environment, Climate Change and Water. The Office manages the policy and regulatory frameworks for the State's surface water and groundwater resources to provide a secure and sustainable water supply for all users. The Office also supports water utilities in the provision of water and sewerage services throughout New South Wales.

Water Sharing Plan for the Bega and Brogo Rivers Area Regulated, Unregulated and Alluvial Water Sources - Background

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Introduction

Water sharing plans (plans) are being progressively developed for rivers and groundwater systems across NSW following the introduction of the *Water Management Act 2000* (WMA 2000). These plans protect the health of our rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water. In July 2004, 31 plans commenced in NSW, bringing these water sources and some 80 per cent of water extracted in NSW under the management and licensing provisions of the WMA 2000.

In recent years, plans for the unregulated[1] rivers and groundwater systems have been completed using a 'macro' or broader-scale river catchment or aquifer system approach. Approximately 90 per cent of the water extracted in NSW is now covered by the WMA 2000. The macro planning process is designed to develop water sharing plans covering most of the remaining water sources across NSW. Each macro plan covers a large river basin rather than a single sub-catchment, or in the case of groundwater systems, cover a particular type of aquifer (e.g. fractured rock). These river basin or aquifer macroplans will generally apply to catchments or aquifers where there is less intensive water use. The preparation of the *Water Sharing Plan for the Bega and Brogo Rivers Area Unregulated, Regulated and Alluvial Water Sources* (water sharing plan or plan) commenced prior to the macroplan process, and therefore was developed via a slightly different process. However, the plan is consistent with the macro process.

The water sharing plan covers 12 water sources (refer to Appendix 1) and covers almost all of the water extraction within the Bega Valley.

Water sharing rules that the plan focuses on are:

- environmental water rules – the share of the water reserved for the environment
- access rules – which determine when extraction is allowed (for example above a set river flow rate)
- dealing rules – which control the trade of water, both the transfer of share components of an access licence and assignment of water allocation between access licences, as well as changing the location for water extraction.

In developing environmental water rules, access rules and dealing rules, other water management rules are considered, including:

- long-term average annual extraction limits – a growth-in-use assessment and management tool
- rules for granting access licences – what types of licences may be granted
- rules for granting works approvals – what types of set back conditions are required
- system operation rules.

[1] The supply of water in unregulated rivers is typically not controlled by releases of water from dams but rather is dependent solely on rainfall and natural river flows.

This document provides background to the development of the rules in the plan and includes:

- the purpose of the statutory plan
- a physical description of the Bega and Brogo catchments including land and water use
- the process of plan development including scope, history and basis for decisions
- the use of adaptive management
- the activities associated with implementation, monitoring and review of the plan.

The objectives of the plan are to:

- protect the important water dependent environmental, Aboriginal cultural and heritage values
- protect basic landholder rights
- manage water extraction from the rivers and the closely linked aquifers to ensure equitable sharing between users
- provide opportunities for market based trading of licences and water allocations
- provide flexibility for licensed water users in how they can use their water
- allow for adaptive management, that is, to allow changes to the plan to be made as a result of more information that will become available during the life of the plan.

This document is part of a range of material available specifically on the Bega and Brogo plan including:

- *the Water Sharing Plan for the Bega and Brogo Rivers Area Unregulated, Regulated and Alluvial Water Sources* – a legal instrument written in its required statutory format
- a guide to the plan – a plain English version of the plan explaining the key sections and rules
- report cards for each water source detailing background information on the water sources and the proposed management rules
- rules summary sheets – summarising the proposed management rules for each water source.

In addition, general information on the macro planning process is available in the Water sharing plans section of the NSW Office of Water website www.water.nsw.gov.au. Information available for download or viewing includes:

- *Macro water sharing plans – the approach for unregulated rivers. A report to assist community consultation* – explains the method used to classify and set water sharing rules for unregulated streams across the state
- *Guidelines for surface water sharing plan report cards* – explains the information presented in report cards
- *Setting the water sharing rules* – a one page brochure which outlines the key steps for developing the rules.

Purpose of the plan

Why are water sharing plans being prepared?

Expansion of water extraction across NSW in the 20th century has placed most valleys at or close to the limit of sustainable water extraction. This has seen increasing competition between water users (towns, farmers, industries and irrigators) for access to water. This has also placed pressure on the health and biological diversity of our rivers and aquifers.

Under the WMA 2000, the sharing of water must protect the water source and its dependent ecosystems and must protect basic landholder rights. Sharing or extraction of water under any other right must not prejudice these. Therefore, sharing water to licensed water users is effectively the next priority for water sharing. Among licensed water users, priority is given to water utilities and licensed stock and domestic use, ahead of commercial purposes such as irrigation and other industries. Water sharing plans provide a legal basis for sharing water between the environment and consumptive purposes.

Water sharing plans also recognise the economic benefits that commercial users such as irrigation and industry can bring to a region. Upon commencement access licences held under the *Water Act 1912* (WA 1912) are converted to access licences under the WMA 2000 and land and water rights are separated. This facilitates the trade of access licences and can encourage more efficient use of water resources. It also allows new industries to develop as water can move to its highest value use.

In conjunction with the WMA 2000, plans also set rules so that commercial users can also continue to operate productively. In general, commercial licences under the WMA 2000 are granted in perpetuity, providing greater commercial security of water access entitlements. Plans also define the access rules for commercial users for 10 years providing all users with greater certainty regarding sharing arrangements[2].

Benefits for water users

With the introduction of the water sharing plan, a number of benefits will flow to water users including:

- greater certainty for water users – the plan sets out the water sharing arrangements for a 10 year period
- clear trading and access rules which will help foster trading
- automatic conversion of licences in the plan area to perpetual water access licences providing greater security for water users – meaning the volumetric water access licences do not have to be renewed, however approvals for the works used to extract water under these access licences will need to be renewed.

[2] Security versus reliability. These terms are used differently across different jurisdictions, often interchangeably. The National Water Commission encourages the adoption of nationally consistent terminology based on the National Water Initiative. The definitions in the glossary relate to NWI-consistent use of these terms. In summary, security provides better tenure for an entitlement and does not necessarily provide greater reliability as this is determined by seasonal and climatic conditions.

The plan recognises the economic benefits to the region that are generated by commercial users such as irrigators and industry. Ten of the water sources covered by the plan are considered to have a high economic dependence on commercial extraction, they are:

- Candelo Creek Water Source
- Tantawangalo Water Source
- Mid Bega River Sands Water Source
- Mid Bega River Tributaries Water Source
- Bega and Brogo Regulated Rivers Water Source
- Lower Bega / Lower Brogo Rivers Tributaries Water Source
- Upper Bega / Bemboka Rivers Water Source
- Upper Bega / Bemboka Rivers Tributaries Water Source
- Wolumla Creek Water Source
- Sandy Creek Water Source

The water sharing plan sets rules so that commercial users can continue to operate productively while providing for the environment.

Environmental considerations

Water sharing plans are required to reserve water for the overall health of the river and to protect specific ecosystems that depend on river flows, such as wetlands, lakes, estuaries and floodplains. This share of water reserved for the environment is also intended to sustain the river system's aquatic fauna and flora.

Unregulated water sources

While there is only limited research on the importance of protecting very low flows, there is a body of evidence that suggests low flows are essential for maintaining water quality, allowing passage over riffles for fish and other fauna to pools used for drought refuge, and maintaining those parts of aquatic ecosystems that are most productive. For example, the faster flowing riffle areas between pools usually contain the highest abundance and diversity of aquatic fauna. It should also be noted that although many streams will naturally stop flowing in dry times, it is the increased frequency and duration of drying as a result of extraction that has the potential to impact on stream ecosystems.

Accordingly, in order to protect a proportion of these very low flows for the benefit of the environment, the plan imposes new access restrictions on days when flows are low. This is achieved by establishing 'cease to pump' rules that describe when water must not be extracted, depending on the amount of flow in the river on any given day.

Eight unregulated water sources were identified as having high in-stream values (Table 1). Where the in-stream values are at high risk from extraction, the cease to pump rule tends to be conservative. Appendix 2 details the threatened species considered when assessing the water source values (note this only included species that are likely to be sensitive to extraction).

Table 1: Water sources with a high in-stream value (based on initial assessment)

Water source	Description of in-stream value
Upper Brogo River	15 threatened species, more than 90% National Park
Lower Brogo / Lower Brogo Rivers Tributaries	20 threatened species and populations
Bega & Brogo Regulated Rivers	20 threatened species and populations
Upper Bega / Bemboka River Tributaries	19 threatened species and populations
Bega River Estuary Tributaries	18 threatened species and populations
Sandy Creek	18 threatened species and populations
Tantawangalo	19 threatened species and populations
Mid Bega River Tributaries	19 threatened species and populations

Existing rules

Some water sources within the plan area currently have an existing cease to pump condition as part of voluntary water sharing agreements. In other water sources there has been no previous history of a 'cease to pump' condition during low flow periods. These are mainly in water sources with few or no users.

Proposed rules

When the plan commences, surface water licences in all unregulated water sources will be subject to cease to pump rules (excluding licences held by local water utilities, licensed stock and domestic users, and licences used for food safety and essential dairy care). In some water sources where there is a significant difference between the current cease to pump rule and the proposed cease to pump rules a five year phase-in period is proposed to allow water users to adjust to the changes.

In instances where the existing cease to pump rule under the WA 1912 is based on a higher flow rate than the rule proposed by the plan, the existing cease to pump rule will take precedence.

Regulated water sources

Proposed rules

When the plan commences, water will be managed in the regulated system to provide for the environment. This includes providing flushes for the most environmentally valuable part of the system (i.e. the reach immediately downstream of the dam), ensuring a flow is provided at the end of the system, rules for uncontrolled access and supplementary access. These rules have been in place in the past and will remain during the water sharing plan with specific conditions of the current rule varying. For example:

- the current transparency rule is set at inflows up to 10 ML/day and when the plan commences this will be set at inflows up to 15 ML/day above 50 per cent dam level
- the first flush rule in place is currently set at a 12 hour delay and with commencement of the plan this will become a 24 hour delay.

Information relating to access rules is provided for in individual report cards available from NSW Office of Water's website at www.water.nsw.gov.au.

Alluvial water sources

Existing rules

In February 2007 the Bega Alluvial was embargoed (Water Shortage Zone GWMA 039) on the grounds that it was unlikely to have more water available than is sufficient to meet the existing requirements of licensed bores.

Proposed rules

When the plan commences, rules will also be set in place to set extraction levels, minimise interference between neighbouring bores and restricting extraction near contamination sources and sensitive environmental areas. These rules will be implemented through setting Long-Term Average Annual Extraction Limits (LTAAEL) and setting distance rules which specify how close a bore can be from a specified feature.

In instances where the existing cease to pump rule under the *WA 1912* is based on a higher flow rate than the rule proposed by the plan, the existing cease to pump rule will take precedence.

Description of the plan area

The Bega River Catchment is a coastal catchment situated on the far south coast of NSW. The 1,940 km^2 catchment is dominated by an escarpment which rises steeply from rounded foothills, a floodplain, and an estuary. The Bega River has two major arms that meet 20 kilometres upstream from the mouth of the river: the Bega-Bemboka arm (catchment area of 1020 km^2) and the Brogo River arm (800 km^2), with a further 120 km^2 below the junction. The Brogo River is regulated by Brogo Dam (9000 ML), while the Bega-Bemboka arm is mainly unregulated with flows supplemented by releases from Cochrane Dam (2700 ML). The Bega-Bemboka arm has a number of large tributaries along its mid and lower reaches: Sandy Ck (catchment area of 100 km^2), Tantawangalo Ck (360 km^2) and Wolumla Ck (130 km^2), while Double Ck (160 km^2) is the major tributary to the Brogo River. The Bega-Bemboka arm has large areas of uplands (tablelands) in its upper catchment, while Brogo has only a small proportion of uplands.

The Bega River starts at the confluence of the Bemboka River (430 km^2) and the smaller Tantawangalo Creek (360 km^2). The headwaters of the Bemboka River lie on the Kybeyan Range at elevations above 1200m. The Bega-Bemboka trunk stream is around 80 kilometres long, roughly equivalent to the length of the Brogo River. Most creeks in both arms of the catchment are short, not extending more than 35 kilometres from source to the trunk stream confluence. The only exception is Tantawangalo Creek in the Bega-Bemboka arm which extends past the escarpment into the uplands to more than 60 kilometres in length.

The Brogo arm is a tributary of the Bega River, which rises in Wadbilliga National Park, at elevations above 1200 metres. Brogo Dam is situated about two-thirds of the way up the Brogo River. The dam is operated to regulate flows dam past the confluence of the Bega and Brogo Rivers into the lower Bega River (downstream to the Jellat Jellat Creek confluence). The 120 km^2 of catchment area below the Bega and Brogo Rivers confluence is relatively flat with small streams; Jellat Jellat Creek being the largest stream.

Land use history

The traditional inhabitants of the Bega Valley Shire are the communities of the Monaro and Yuin nation; the Djiringanj, Thaua, Bidawahal and Ngarigo tribal groups. Colonisation and white settlement of the Bega Valley commenced during the 1830s. Beef cattle and small areas of cropping were undertaken initially, and by 1848, two dairy farms had been established in the region. During the 1860s, the population of the Bega Valley increased significantly as did the practice of dairy farming in the area. Dairy farming and beef farming largely supported the growth of the regional economy from the 1850s to the 1970s.

European settlement in the Bega Valley saw the removal of vegetation from riparian and wetland landscapes and surrounding hilltops, which led to catastrophic changes to riparian and wetland landscapes (Brooks & Brierley, 1997). Prior to European settlement, sediment had accumulated periodically for about 8,000 years in tributary swampy flats (upland wetlands) and within streams.[3] Streams were characterised by ill-defined channels. After the removal of vegetation and woody debris, a significant portion of this stored sediment was eroded and transported downstream. Dramatic changes to stream channels occurred including incision of streams on and below the escarpment, bank erosion, widening of streams in the middle cleared sections and the deposition of large sand sheets in the lower sections. Catchment hydrology was fundamentally changed following the clearing of vegetation by European settlers.

About half of the Bega River Catchment has been cleared for grazing. The river flats around Bega and along the adjoining Brogo River are used for intensive dairy farming. High stocking rates can be maintained throughout the year through the use of irrigation to promote feed (grass) growth. Subdivision of land is (e.g. along Tantawangalo Creek) placing increased demands on limited water resources. Most of these subdivisions are 'hobby farms' or small cottage industries which typically have higher water demands per unit area than grazing.

Rainfall

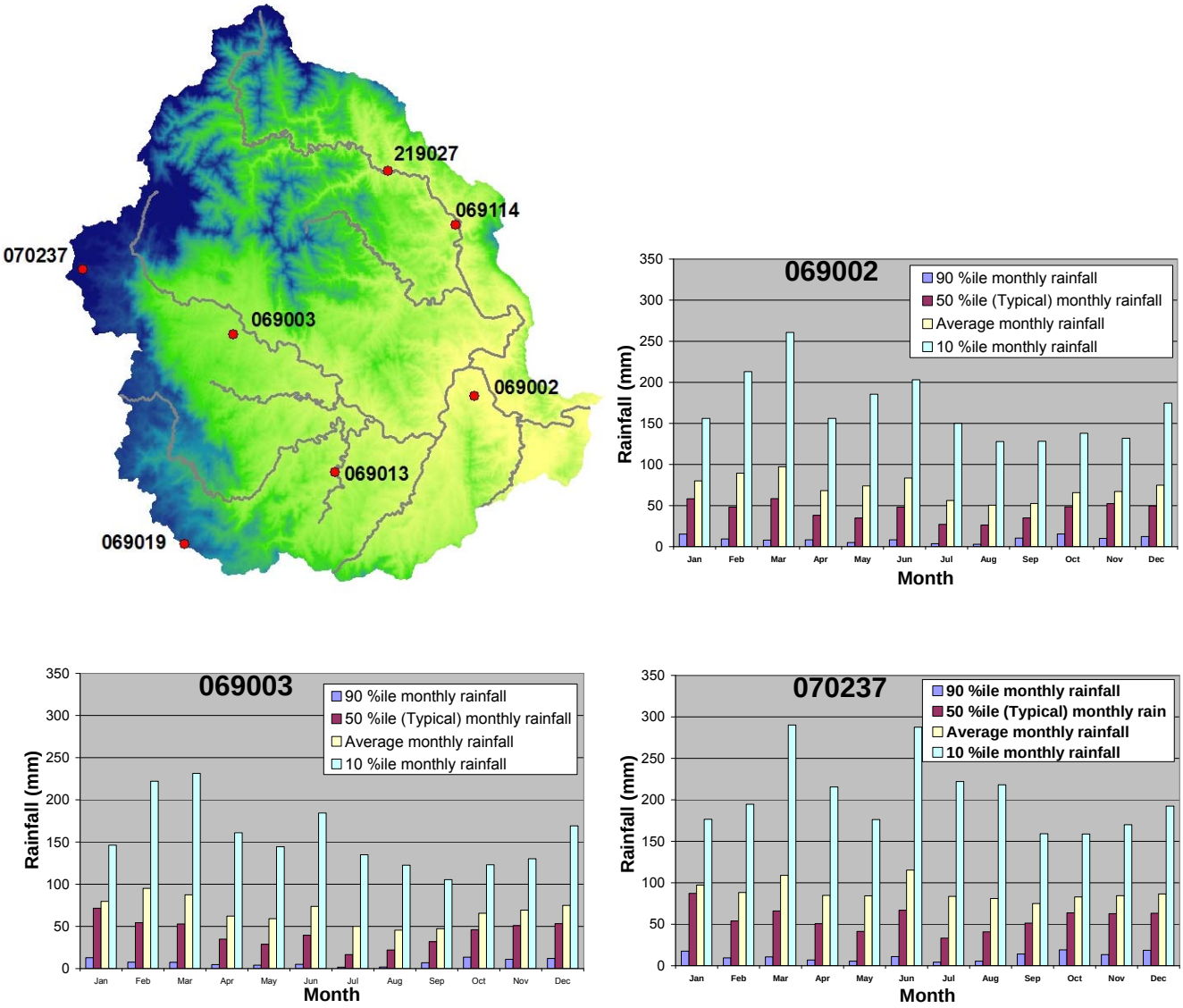
The supply and demand for water is affected by climate. Rainfall for the Bega Catchment averages 1100 mm/yr in the headwaters, and around 800 mm/yr in the foothills and on the coastal plain (Table 2). Rainfall intensity increases with elevation, with heaviest rainfall occurring between December and March along the coastal region (Figure 1).

Table 2: Rainfall station in Bega Catchment

Rainfall station	Station name location)	Average annual rainfall (mm)	Median (typical) annual rainfall (mm)
219027	Brogo Dam	850	750
069114	Brogo Bridge House	1030	950
069002	Bega (Newtown Road)	860	800
069013	Candelo Post Office	750	690
069003	Bemboka Post Office	810	760
069019	Cathcart (Mount Darragh)	1110	1060
070237	Nimmitabel (Cottesloe	850	750

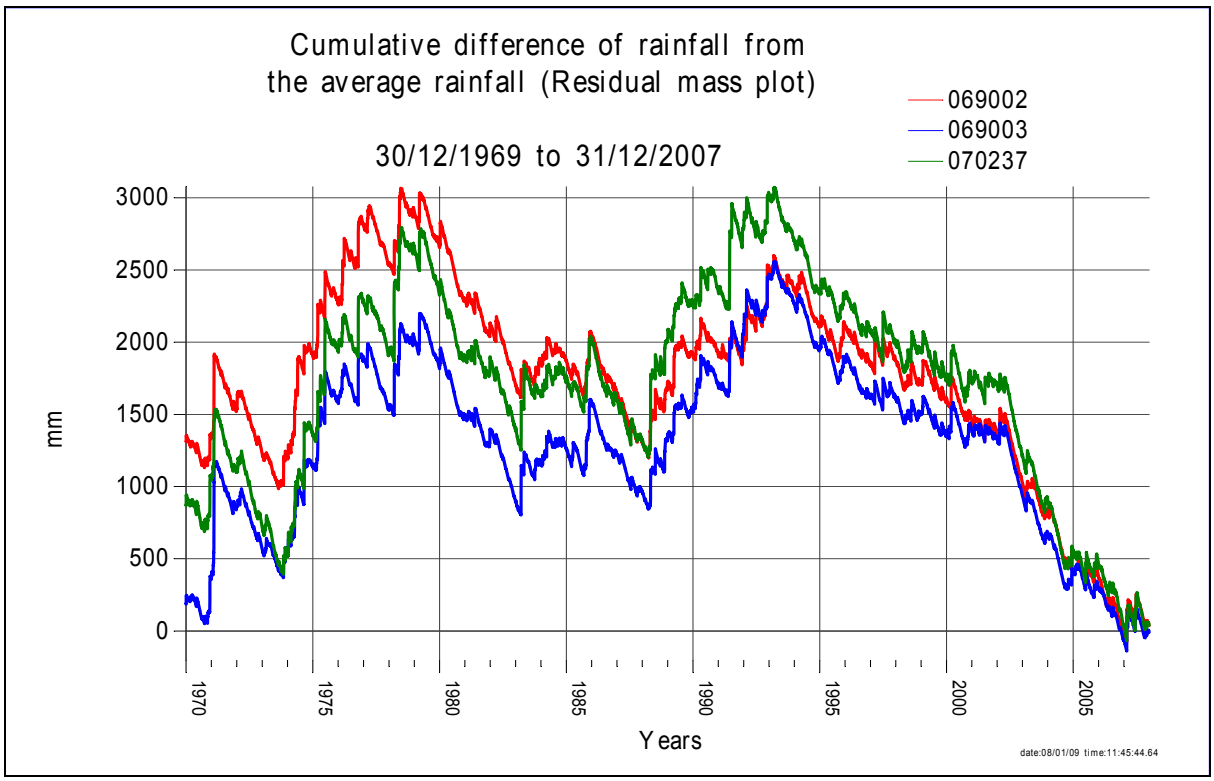
[3] After these areas of highly fertile soil were cleared by large, infrequent rainfall events, the swamps were incised by deep erosion gullies mobilising large quantities of bedload sediment. As these sediment slugs moved down the streams, bank erosion was exacerbated. Overall, about 21 million cubic metres of bedload sediments have been eroded from these incised swamps, stream banks and lower gullies since European settlement. About 11 per cent has passed through the estuary to the sea, about 10 million cubic metres in the Bega Sands Aquifer and the rest is in transit.

Figure 1: Rainfall stations and monthly rainfall patterns



As is typical of the region, Bega has experienced large fluctuations in annual rainfall, including several extended periods of above and below average rainfall since records began in 1870. Recent rainfall variations can be seen in the residual mass plot (see Figure 2) where the wetter than average periods are seen as an upward gradient, average rainfall as generally horizontal, and dryer than average periods shown as downward sloping lines. There has been a general downward trend from 1993 in the plot, indicating less than average rainfall over the period.

Figure 2: Rainfall residual mass plot



Streamflows

Streamflow is measured at nine gauging stations throughout the Bega catchment (Table 3 and Figure 3). Historic records of stream flows are also available for sites where gauging stations have been discontinued, such as the Bega River at Warraguburra. Other records are also kept such as dam water levels and release volumes from both Brogo and Cochrane Dams.

The frequency of stream flow may be described by a flow duration curve. The flow duration curve shows the percentage of time that flows of different sizes are exceeded (e.g. a flow that is exceeded 95 per cent of the time is shown as the 95th percentile flow and is considered to be a low flow, while a flow that is exceeded only 2 per cent of the time is considered to be a very high flow or flood). Figure 4 shows the estimates of the natural flow duration curves for three locations in the Bega River system. The vertical axis indicates the mean daily flow in megalitres per day (ML/d). Mean daily flow is in a log scale to clearly show the frequency of low flows.

Table 3: Stream gauging stations

Station number	Streamflow gauging station	Period of record
219026	Bega River at Warraguburra	Limit data – dam operation only
219001	Rutherford Creek at Brown Mountain	03/04/1924 – current
219003	Bemboka River at Morans Crossing	17/04/1943 – current
219006	Tantawangalo Creek at Tantawangalo Mountain	18/02/1951 – current
219013	Brogo River at North Brogo	12/11/1961 – current
219017	Double Creek near Brogo	08/07/1966 – current
219022	Tantawangalo Creek North of Candelo	30/11/1971 – current
219025	Brogo River at Angledale	04/11/1976 – current
219032	Bega River at Kanoona	01/01/1998 – current
219034	Candelo Creek at Greenmount Road (Yurammie)	04/06/2002 – current

Figure 3: Stream flow gauging stations

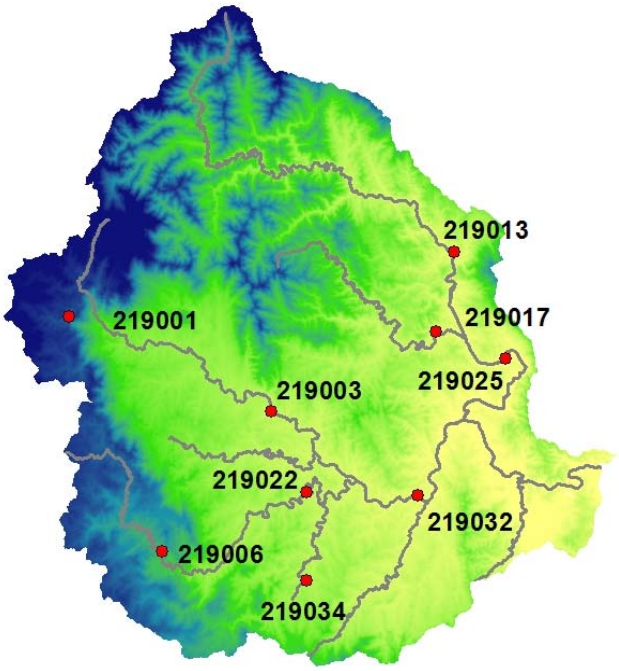
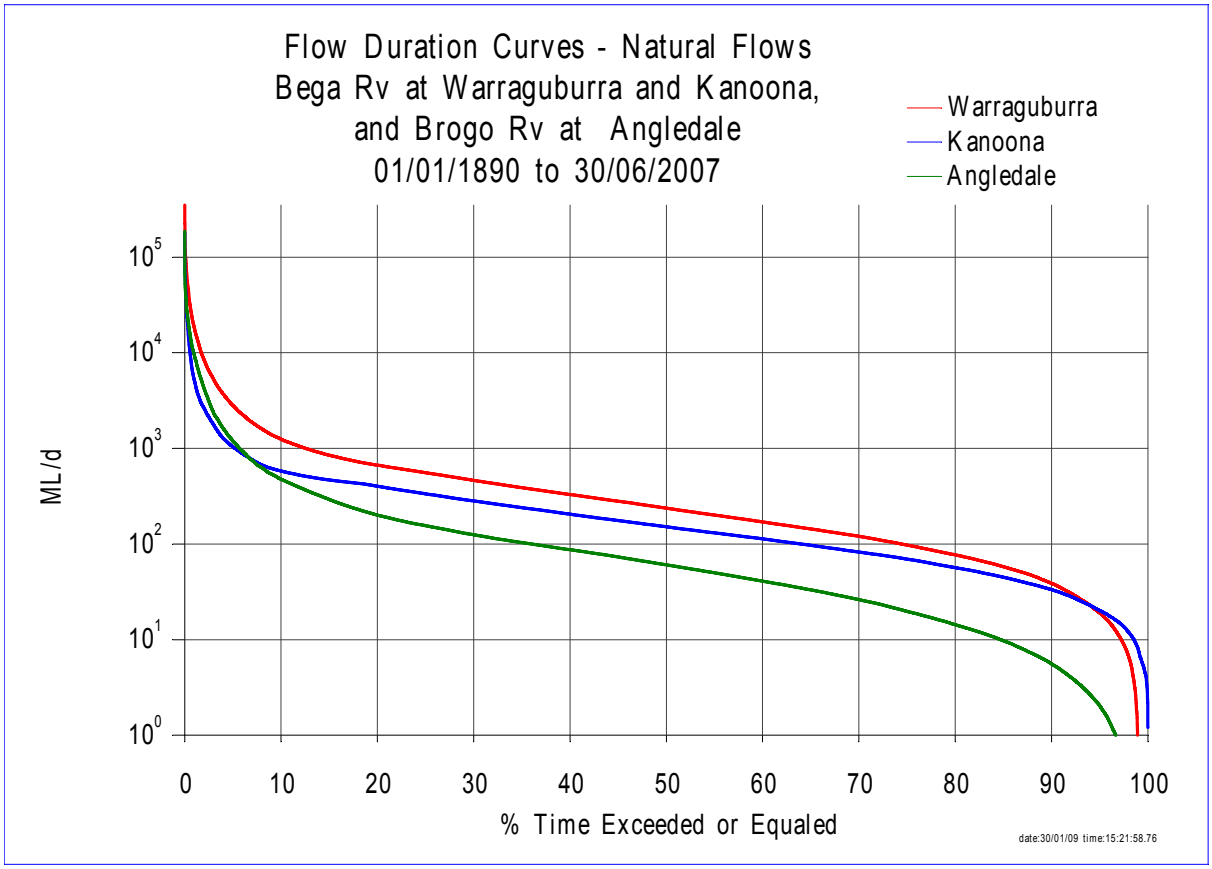


Figure 4: Flow duration curves for the main tributaries



Groundwater

An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be extracted. The volume of water stored, the rate of recharge, the volume of water extracted, and the rate at which water can move through the aquifer are all controlled by the geology of the aquifer.

Numerous groundwater studies have been undertaken in the Bega Valley, including Sundararamayya (1983), Russell (1999), Coastal and Marine Geosciences (1999), Thomas (2000), Russell (2003) and Parsons Brinkerhoff (2004). Pritchard (2004) is the most recent report and reviews the status of the groundwater resources in the Bega Valley

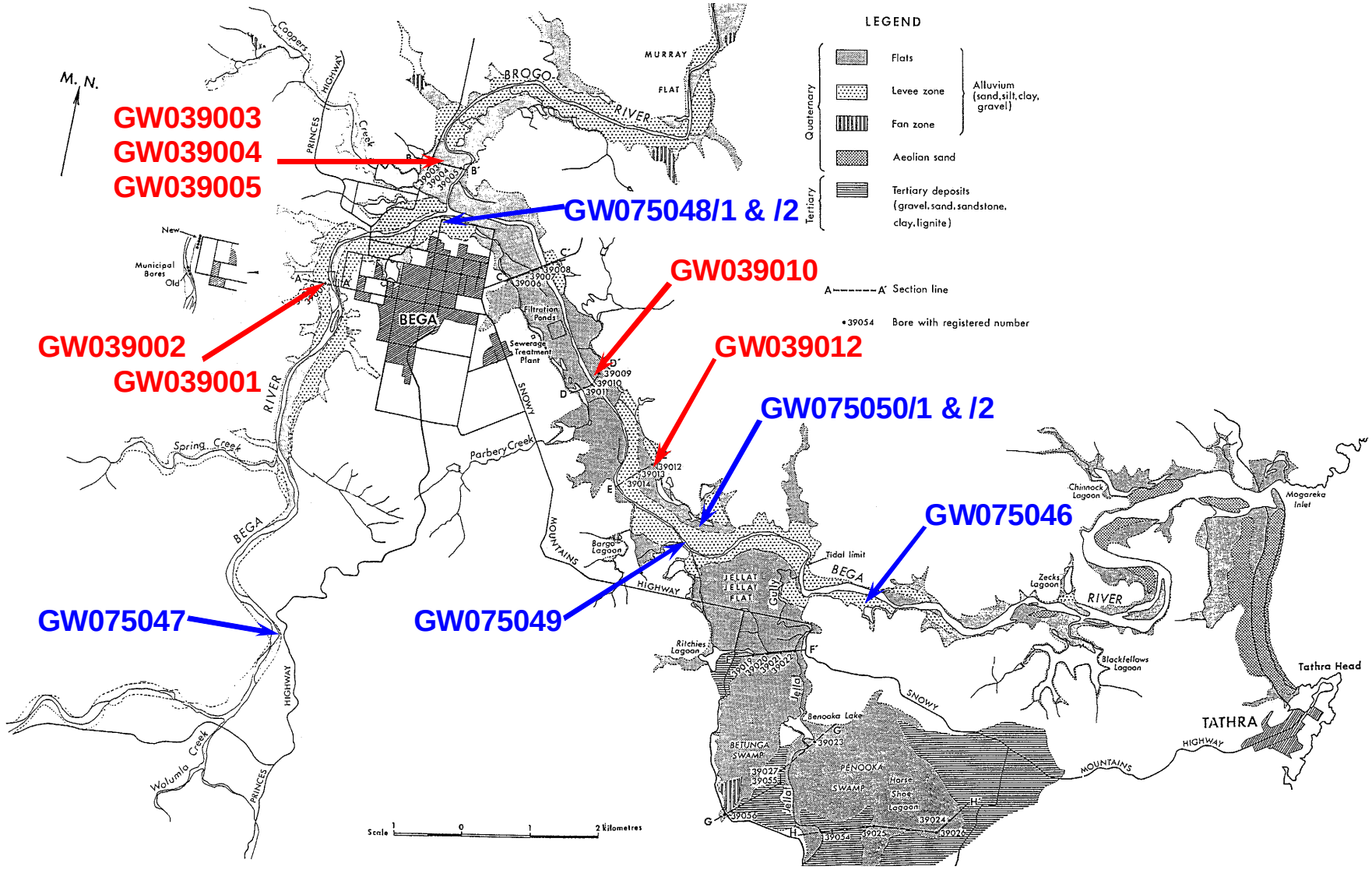
Apart from a small coastal sand aquifer located at Tathra, the main aquifer in the Bega Valley is the fractured rock of the Lachlan Fold Belt. Water recharges the aquifer from rainfall and river flows and filters through the rock system at varying speeds depending on its location in the landscape. Bores in this aquifer usually yield smaller amounts of groundwater. The groundwater in these systems do support base flows to rivers, wetlands, caves, terrestrial vegetation and hypogean ecosystems. Travel time of aquifer water to and from streams is relatively slow, being in the order of several years or decades, and therefore this aquifer is considered to be not highly connected to the river.

By far the highest utilised aquifer in the Bega Valley is alluvial (Figure 5). This consists of Quaternary and Tertiary sediments. The alluvial aquifer stretches from Kanoona Rocks on the Bega River, 5 kilometres downstream of the Angledale gauging station on the Brogo River to the estuary. The Bega River alluvium downstream of Kanoona to the Brogo River confluence increases in width to approximately 500 metres at the lower end (this area is referred to as the Mid Bega River Sands), while the Brogo River alluvium spreads to around 300 metres wide at the lower end. After they join, the alluvium ranges between 700 metres and 1.5 kilometres wide downstream to Jellat Jellat Creek.

There are 51 registered bores in the alluvial aquifer. Water users and regulators had until recent years, considered the volume of water extracted to be a small fraction of that which is available. For this reason the original *Bega-Bemboka River Flow Plan* (1999) excluded extraction rules for the Mid Bega River Sands. However, following a very dry spell in 2002 and early 2003 and continued pumping after the cessation of river flow in September 2002, monitoring revealed a substantial lowering of the groundwater level around the Bega Sands bore-field. The investigations that followed concluded that while the volume of stored water in the alluvial aquifer in the Mid Bega River Sands was large (approximately 12,000 ML), through-flow limitations caused localised depressions of groundwater level around extraction points (Parsons Brinckerhoff, 2004). The localised depression around the Bega Sands borefield was caused by nearby water extraction for irrigation (>20 ML/d) which, together with water extracted for town water supply, (~5 ML/d), caused a lowering of groundwater levels near the borefield. The pump intake levels fell to near the minimum operating levels. Following the suspension of extraction for irrigation in February 2003, the groundwater level around the borefield stabilised. Rainfall in the catchment and a return of surface flow in late February 2003 recharged the aquifer fully and restored groundwater levels.

The NSW Office of Water (and all relevant predecessors) has monitored groundwater in the Bega Sands since the 1960s (Figure 5). Under the macro planning process, the NSW Government assessed the sustainable yield of all groundwater systems in NSW. As a result, the then Department of Water and Energy in February 2007 embargoed the Bega Alluvial (*Water Shortage Zone GWMA 039*) on the grounds that it was unlikely to have more water available than is sufficient to meet the existing requirements of licensed bores. Saline inundation of the groundwater does not appear to be an issue presently as groundwater has been recharged periodically by river flows.

Figure 5: The Bega Sands Aquifer



Historical droughts

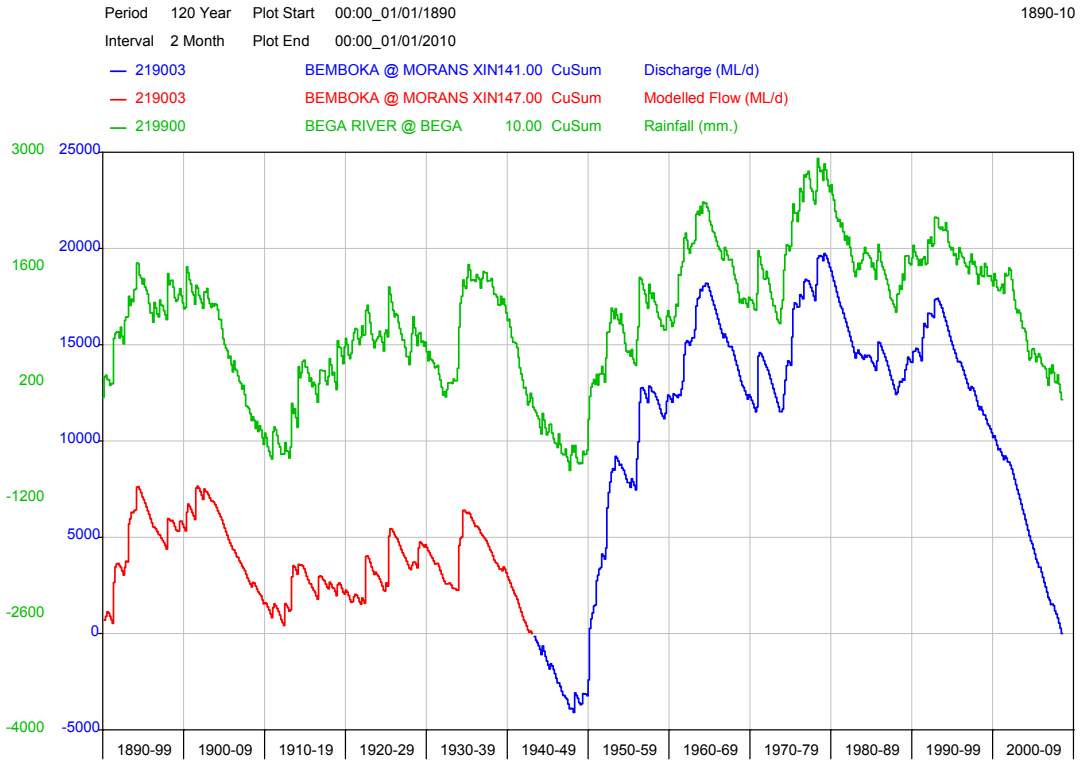
Public and scientific awareness of potentially changing climate is increasing each year. However, separating any potential climate changes from the inherent variability is particularly difficult. The latest science still shows some uncertainty around average changes, but tends to indicate that there may be more frequent extreme weather events. Understanding this uncertainty, the potential changes and the related management challenges that will result has become a focus for the management of water resources.

The complex problem of separating variability from change is illustrated in Figure 6. This is a plot of rainfall and runoff at Morans Crossing on the Bemboka River. The top line illustrates long-term rainfall, while the bottom line represents long-term runoff patterns. The plots are the cumulative sum of rainfall and runoff and their deviation from daily average level. This is a useful indication of 'wet' and 'dry' conditions and climatic variability. An upward trend in the plot indicates a wetter than average period and a downward trend is a drier period. The gradient points to how different the instantaneous numbers are from the average (i.e. a steeper line means it is either a lot wetter – upward, or a lot drier – downward, than average). The height of the peak or depth of the trough indicates how much persistence there has been in either a wet or dry period. A number of significant drought periods are highlighted by the plot:

- the Federation drought between 1902 and 1912
- the long drought from the mid-1930s to the late 1940s
- the 1960s and 1980s droughts
- the recent drought starting in the mid 1990s.

There are also wet periods – 1890s, 1950s and the mid-1970s. The period 1910-1930 shows a steady trend, getting neither wetter nor drier.

Figure 6: Residual mass curves of rainfall and runoff



Climate change and variability

In developing the plan, potential climate change was considered when assessing supply and demand for water, in framing access conditions and in determining the long-term average annual extraction limit. The Interagency Regional Panel concluded that the strategies for water management in the Bega Valley developed by the Healthy Rivers Commission Inquiry, the South Coast Water Management Committee, and the Southern Rivers Catchment Management Authority, were appropriate under various possible climate change scenarios.

The NSW Government's current assessment of the changes to climate in the south east region of NSW (DECC, 2008) indicates that average temperatures in the Bega Valley are likely to rise over the coming 40 years, however temperature alone is not a good indicator of future water demands. These are also driven by domestic usage in the case of town water supplies and crop water requirements in the case of irrigation. Furthermore, temperature rise alone is not necessarily indicative of evaporation and rainfall changes, which are more important factors in driving water demands.

Temperature rises are generally correlated with evaporation rises on a daily time-step because hotter temperatures tend to occur on drier days. However, it becomes much more complex when converting rises in average temperatures to rises in average evapotranspiration, with dew point and relative humidity also being factors. This is a new scientific area still being explored, but nonetheless it is still currently assumed that increases in temperature will result in increases in evapotranspiration.

The assessment also estimated that summer rainfall for South East NSW will increase by 20 per cent to 50 per cent on average, while in winter it is estimated that rainfall may decrease in the region by 10 per cent to 50 per cent on average. The Bega Valley is more likely to see a decrease at the lower end of the range, possibly even less then 10 per cent. Changes in autumn and spring rainfall are suggested to be relatively small.

The CSIRO was commissioned to investigate '*Water Availability in the Murray –Darling Basin'* (2008). Although this study did not cover the Bega Valley, it did consider long-term climatic trends for south eastern Australia. It predicted that the current drought (1997-2008) would occur once in more than 300 years without climate change.

The rules in the plan determine how the risk from climatic changes is apportioned between users and the environment. These are discussed in the section on implementation, monitoring and review.

Entitlement and use

Most of the water that is extracted from rivers and groundwater in the catchment is licensed and used for power generation, pastures and crops irrigation, dairy wash down, and by the food processing industry (Bega Cheese). There are also some unlicensed extractions in the form of basic landholder rights. The Brogo and Bemboka Rivers are dammed; Brogo Dam regulates the lower Brogo River for agricultural water supply, whereas Cochrane Dam on the Bemboka River feeds a small hydroelectric power station. The Brogo River downstream of Brogo Dam is declared as a 'regulated water source' whereas all other streams are classified as 'unregulated water sources'.

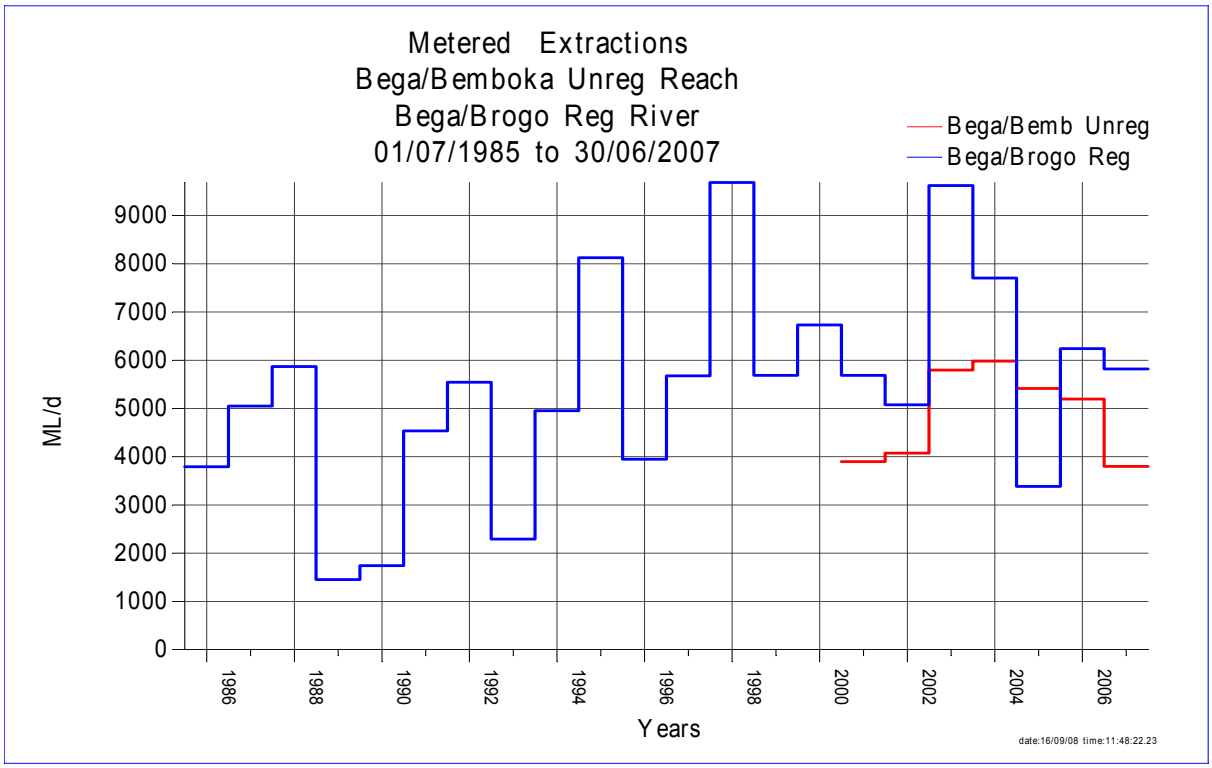
Not all licences are fully used at present. However, the plan is based on a future projection of the full development of all entitlements and rights (Table 4).

Table 4: Licence entitlement and estimated rights

Type of licence or right	Volume taken (entitlement or estimate), ML/year
Unregulated	26 836
General security (regulated)	13 954
High security (regulated)	223
Town water supply (regulated)	700
Groundwater	3 643
Riparian (estimated)	328
Harvestable rights	9 100
Total	**54 784**

Metered usage of the Bega and Brogo Regulated River, Bega-Bemboka Unregulated River, and extraction by Bega Valley Shire Council are shown in Figure 7. These indicate that no more than 65 per cent of regulated entitlement has historically been used with an average use of 34 per cent; and no more than 63 per cent of the Bega – Bemboka entitlement has been used with an average use of 51 per cent.

Figure 7: Metered usage on the Bemboka and Brogo Rivers



Impacts of extraction

The overall impact of extraction at the bottom of the catchment is shown in Figures 8, 9 and 10. Extractions from the unregulated rivers upstream of the Bega River's junction with the Brogo have increased the percentage of time of no river flows from 1 per cent to 8 per cent (Figure 8). River regulation on the other hand has increased the amount of water at low flow through releases from Brogo Dam (Figure 9). The net impact on stream flows downstream of the confluence is therefore not as severe, as the regulated river flows offset extractions from the unregulated system at low flows (Figure 10).

This demonstrates the need to consider water extraction and river health across the Bega Valley and the need to manage it in a single water sharing plan that recognises the interaction between the regulated rivers, the unregulated rivers and the highly connected alluvial groundwater.

Figure 8: Flow duration curves for the Bega River upstream of Brogo River confluence

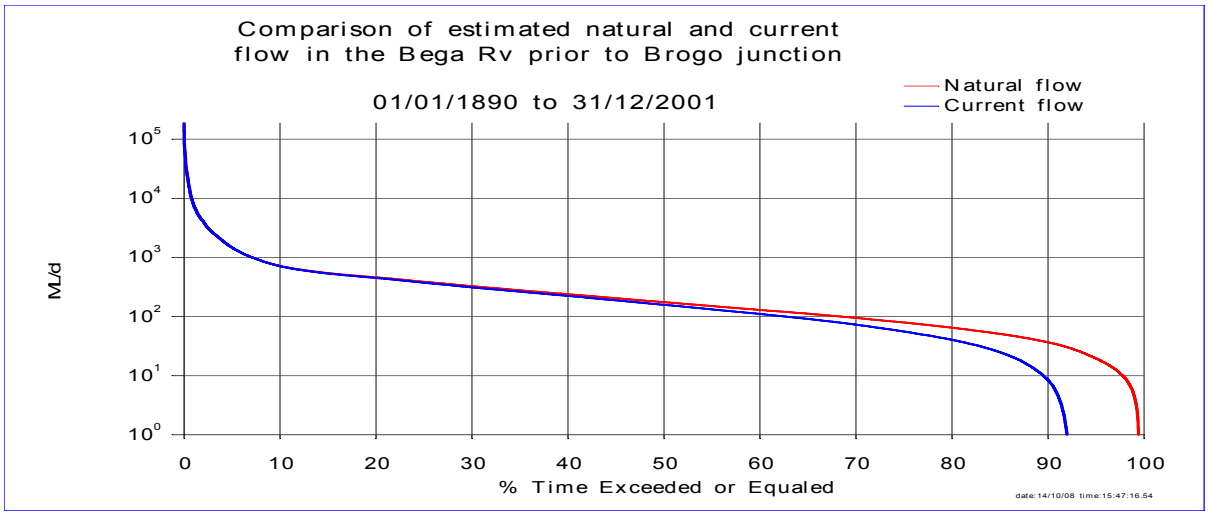


Figure 9: Flow duration curves for the Brogo River at Angledale

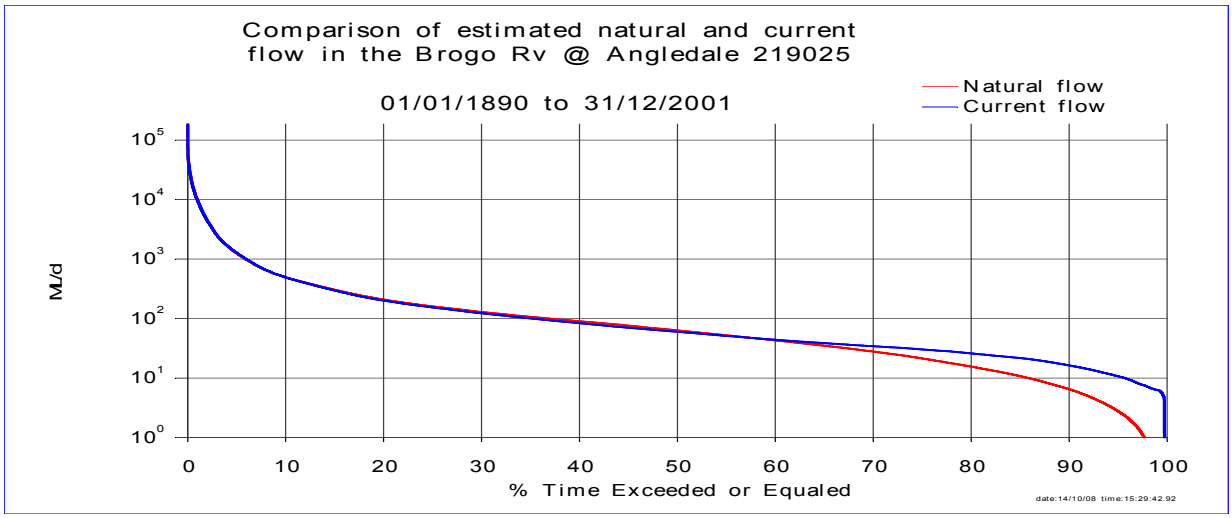
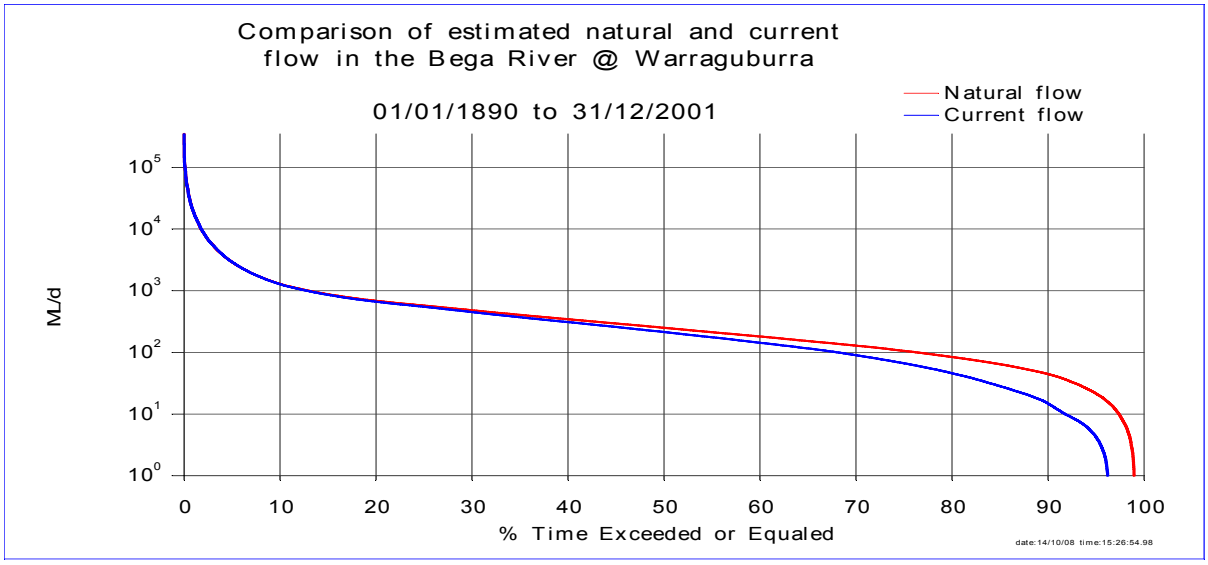


Figure 10: Flow duration curves for the Bega River at Warraguburra



Local water utility requirements

Bega Valley Shire Council (BVSC) is the only local water utility covered by the plan. The main urban centres serviced by BVSC include Bega, Merimbula, Eden, Pambula, and Bermagui. There are many smaller towns and villages in the Shire with a town water service, including Tathra, Pambula Beach, Tura Beach, Cobargo, Candelo, Wolumla and Bemboka (Figure 11). Characteristics of each are provided below.

1) Brogo-Bermagui water supply system

The Brogo-Bermagui water supply system supplies water to Bermagui, the villages of Quaama and Cobargo, settlements around Wallaga Lake, and a number of individual properties with a connection to the trunk main network. The main source of water for the system is the Brogo Regulated River, below the Brogo Dam. The Brogo River provides 90 per cent of the system's water due to its greater security of supply. There is no storage capacity in this system apart from the trunk main balance tanks and town reservoirs. Extraction from the Brogo River ranges between 0.5 and 3.5 ML/d.

2) Bega-Tathra water supply system

Bega-Tathra water supply system supplies water to the towns of Bega and Tathra, Kalaru village, small settlements and a number of individual properties with a connection to the trunk main network. The source of water for the system is the Mid Bega River Sands. Water is extracted from six bores aligned parallel to the Bega River. There is no storage capacity in this system apart from the trunk main balance tanks and town reservoirs. Extraction ranges between 2.0 and 8.0 ML/d.

3) Tantawangalo-Kiah water supply system

The Tantawangalo-Kiah water supply system supplies water to the towns of Merimbula, Tura Beach, Pambula, Pambula Beach and Eden, the villages of Candelo, Wolumla and South Pambula, small settlements and a number of individual properties with a connection to the trunk main network.

The northern source of water for the system is Tantawangalo Creek. Water extracted from Tantawangalo Creek fills Yellow Pinch Dam, a 3000 ML off-stream storage. Tantawangalo Creek also supplies water direct to the villages of Candelo and Wolumla and a number of properties with a trunk main connection upstream of Yellow Pinch Dam. Yellow Pinch Dam supplies the towns of Merimbula and Tura Beach and also areas south to Bellbird Hill, although these areas are often supplied from the southern source and storage. Extraction from Tantawangalo Creek ranges between 0 and 5 ML/d, depending on creek flow.

The southern source of water for the system, the Lower Towamba River, is covered by the Towamba River Water Sharing Plan. Water extracted from the Kiah borefield on the Lower Towamba River is used to fill Ben Boyd Dam, an 800 ML off-stream storage for the system, as well as to supply Eden and southern areas directly. Extraction from the Lower Towamba River ranges between 1 and 6 ML/d, depending on river flow and demand.

In recent years, urban water demand by towns and villages served by the Tantawangalo/Kiah scheme has been met by supply of about 1500 ML per annum from the Tantawangalo weir and 1400 ML per annum from the Kiah borefield, with the Yellow Pinch Dam and, to a lesser extent, the Ben Boyd Dam being used to supplement supplies at times of low flow in the source streams.

4) Bemboka water supply system

The Bemboka water supply system supplies water to the village of Bemboka only. Water is pumped directly from the Bemboka River to a small town water service reservoir. Extraction from the Bemboka River ranges between 0.05 and 0.5 ML/d.

During the term of this plan a pipeline will be constructed from the Mid Bega River Sands to Yellow Pinch Dam linking the Bega – Tathra Water Supply Scheme with the Tantawangalo-Kiah Water Supply System.

Current levels of entitlement for Bega Valley Shire Council are presented in Table 5.

Table 5: Current entitlement: Bega Valley Shire Council

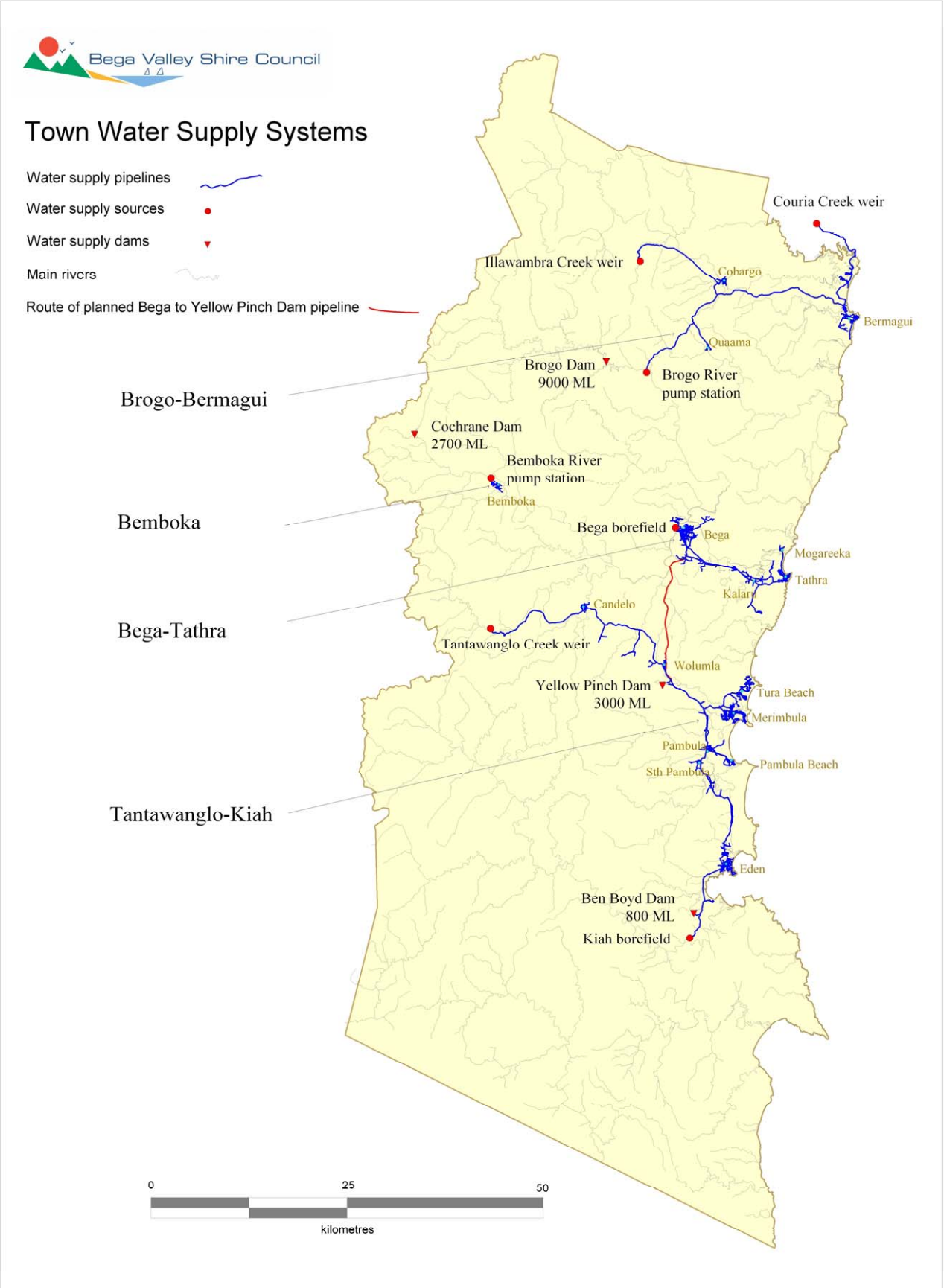
Water source	Entitlement (ML/year)
Regulated River	700
Mid Bega River Sands	2 640
Tantawangalo Creek	1 500
Bemboka River	66
Total	**4 906**

BVSC are working towards full compliance with Best Practice Water Management, and have recently engaged a consultant to prepare an Integrated Water Cycle Management strategy. Demand management is one of BVSC's key strategies to ensure that population growth is provided for by current entitlements of water.

Water sharing will be introduced for the Kiah borefield under the Water Sharing Plan for the Towamba River Water Unregulated and Alluvial Water Sources. In developing the draft water sharing plan, the Interagency Regional Panel has discussed the overall implications of both this plan and the Towamba River water sharing plan with BVSC and compared the environmental values of the various water sources.

The draft water sharing rules of both plans will reduce the volume of water council is able to extract from water sources during dry times. This will decrease the security of town water supply for all town water supply systems in the Shire and may increase the frequency and duration of water restrictions to residents. Council is undertaking water supply investigations and capital works planning to ensure an acceptable level of supply security is maintained within the plan rules. The Bega to Yellow Pinch Dam pipeline is a large part of the work required to improve water supply security in the south of the shire under the draft water sharing rules.

Figure 11: Urban Water Supply Network – Bega Valley Shire Council



Agricultural water requirements

The irrigated agricultural sector is primarily made up of dairy farming, an industry which is heavily reliant on water for irrigation of pastures to ensure the supply of feed. There are 96 dairy farms and 25,000 dairy cows in the catchment.

The common farm unit, as described in Applegate & McClintock (1999), is a farm area of around 280 ha (~ 670 acres), with irrigation being used on about 25 per cent of the farm. Farms generally rely on ryegrass pastures, summer grasses (kikuyu), with some forage crops for silage (corn or sorghum) grown during summer. Soil moisture availability limits growth in warmer seasons while air temperature limits growth in winter. Farmers irrigate their pasture to supplement the soil moisture store when it is not being maintained through rainfall alone - generally October to March. Irrigation can also occur at other times if conditions are dry and low soil moisture stores might otherwise limit growth[4].

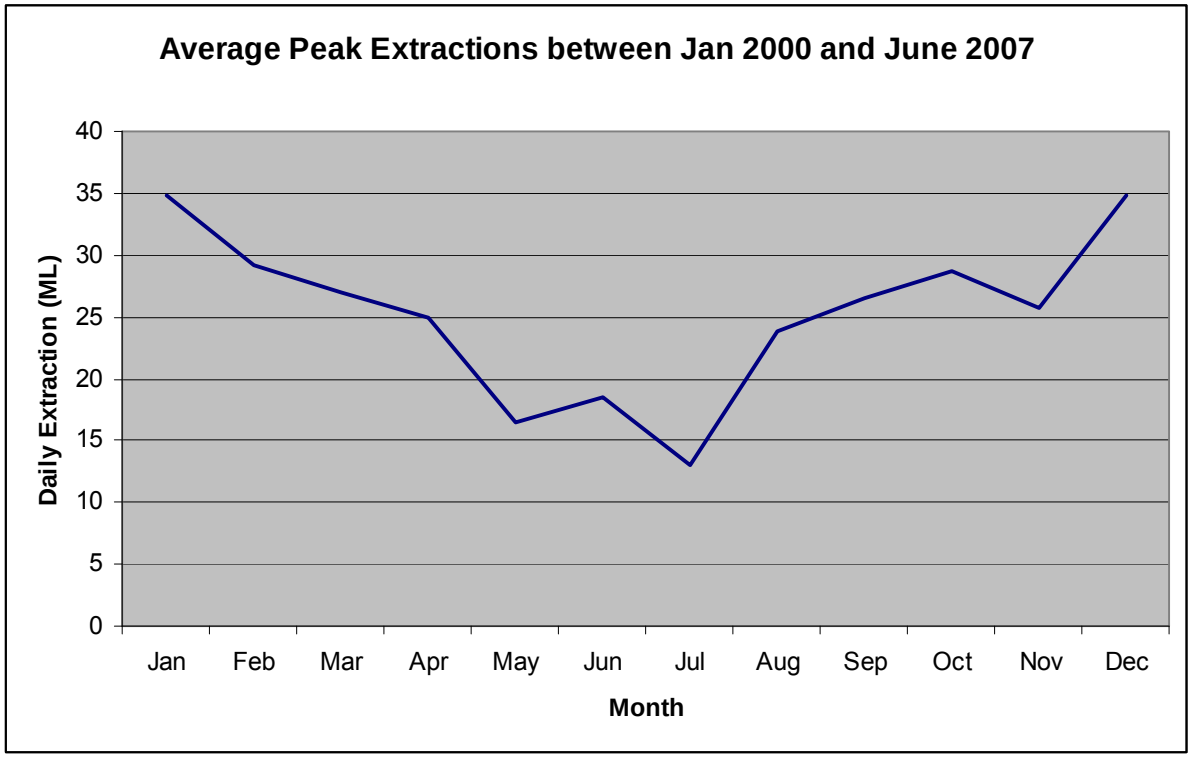
In dry months plant production without irrigation is minimal since it does not provide for current needs and allows for a build up of feed reserves for winter. The amount of irrigation water required is inversely proportional to rainfall and can range between 1.4 and 10 ML/Ha/year.

In recent years, the majority of water use along the Bemboka River and Upper Bega River has been metered. This metered data has been used to estimate the peak irrigation extractions. The maximum extraction in any one day since 2000 was 48 ML. Extraction exceeded 40 ML/day on 1 per cent of days and 30 ML/day on 8 per cent of days.

The metered extractions can be evaluated by looking at the peak daily extractions and finding the average for each month of the year, which shows a monthly pattern of peak extraction (see figure 12). Between January 2000 and June 2007, the average peak daily extractions were 35 ML/day in December and January. The peak extractions over these particularly dry years dip down to around 15 ML/day in winter.

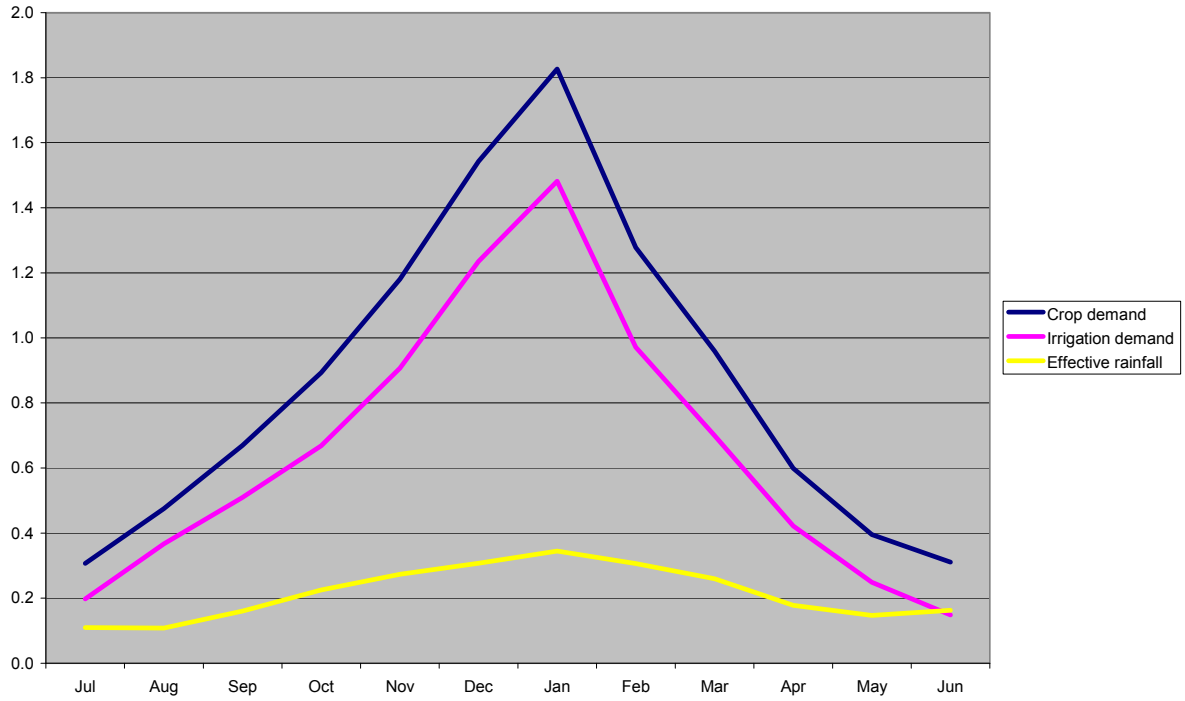
[4] Part of the reason for spray irrigation of ryegrass pastures is to create a microclimate that will help the ryegrass persist during dry hot days in summer, which enables production of some green feed in the cooler months when kikuyu is dormant. Members of the general public have expressed outrage at the 'wastefulness' of daytime irrigation spray, as this strategy is not generally known by the public.

Figure 12: Average peak daily extraction through the year



Metered extractions may not reflect demand as low flows on some days limit extraction. Crop demands can be estimated however. By making assumptions about pasture grown in the valley, a model of the volumes of water required can be simulated. Assumptions such as the optimum fertiliser application and the absence of diseases are likely to over predict crop water demand. Figure 13 shows crop water demands generated by the crop model adopted in the hydrology modelling. Average crop water demands are met by both rainfall and irrigation. When water is not available for extraction from the river, the irrigation demands cannot be met and each irrigator will either reduce the volume irrigated per hectare or reduce the area irrigated. The monthly crop water demands per hectare of intensively grazed pasture will be different every year and the volumes irrigated will vary between irrigators.

Figure 13: Estimated crop demands in the Bega Valley for a hectare of dairy pastures



Economic importance of irrigated agriculture and industry

Rural industries in the Bega Valley directly employ 1036 people or 8.3 per cent of the total workforce (ABS, 2007). These industries are dominated by livestock production for dairy products and cattle meat, and also include horticulture, wool production, and fat lambs.

The dairy industry dominates the Bega Valley economy. Bega Cheese Limited processes milk from 96 farms (stocking an estimated 25,000 dairy cows) in the Bega Valley. Bega Cheese Limited (BCL) employs 540 people in the cheese factory and packaging plant (www.Begacheese.com.au, 2007).

When value-adding services (processing, packaging and marketing) and flow-on activities (transport, finance and business services) are included, the dairy industry accounts for about 15 per cent of regional employment and 16 per cent of the Gross Regional Product (EconSearch Pty Ltd, June 2000).

The most recent estimates of the value of agricultural production from the Bega Valley were collected in 2001, when milk production represented 37.4 million of a total of 57.9 million, (ABS website). The value of current agricultural production from the Bega Valley appears to be considerably greater than these 2001 figures. In 2007-2008, BCL's outgoing expenses for supplier pay, wages, and contractors were around $95 million (pers. comm. Ken Garner, BCL). Assuming the proportion of milk production relative to total agricultural production has not changed considerably since 2001, the current total value of agriculture in the Bega Valley is estimated to be in excess of $140 million.

Irrigation is an important contributor to rural industries in the Bega Valley. On average, one quarter of the area of dairy farms in the valley is under irrigation. Irrigated crops and pasture play a vital role in maintaining milk production. During dry periods when water for irrigation has not been available, dairy herds have been maintained by carting-in feed from other districts. This is an expensive practice and rarely offers a long-term solution. With escalating costs of grain and fuel in recent years, transporting feed has become even less viable.

Developing the plan

Scope of the plan

The water sharing plan recognises that the water sources of the Bega Valley are linked, and would therefore benefit from being managed as a single entity. The plan includes all surface water extraction and extraction from connected alluvial aquifers.

The plan does not cover extraction from the fractured rock of the Lachlan Fold Belt or the coastal sand aquifers at Tathra. These aquifers contribute water to the alluvial and surface waters of the Bega Valley. Both these water sources will be included in a future groundwater plan that will cover the South Coast. That plan will consider the water requirements of this plan in setting sustainable yields for those aquifers.

This plan covers three distinctive types of water system:

1. the regulated Brogo and Bega Rivers Water Source. Regulated rivers typically refer to those rivers where large on-river headwater storages capture water during wetter periods and use the river to supply the stored water to meet downstream users' orders during dry times
2. the unregulated rivers which include most rivers in the Bega Catchment
3. the groundwater in the highly connected alluvial aquifer including the Mid Bega River Sands.

The plan, by incorporating the three different systems, enables water sharing that is equitable both within user groups and between the regulated, unregulated and highly connected alluvial users. Having one plan for the three systems also prevents 'double counting', in other words, that water is not accounted for twice. For example proposed increases in high flow extraction should not remove water already accounted for in assessments of likely inflows to the regulated river.

For the purposes of water planning, aquifer types have been grouped into four basic categories:

- porous rock aquifers found in rock formations such as sandstone or limestone – groundwater occurs within the pore space in the rock matrix
- fractured rock aquifers found in rock formations such as granite or basalt – groundwater in these rocks occurs mainly within the fractures and joints
- coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments
- alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

The aquifer types and groundwater sources that occur within the boundaries of the plan and their connectivity characteristics are given in Table 6. It is based on principles and recommendations in *Towards a National Framework for Managing the Impacts of Groundwater and Surface Water Interaction in Australia* by Sinclair Knight Merz (2006).

Table 6 Connectivity between aquifer types and surface water

Aquifer type	Level of connection between surface and groundwater	Level of impact on in-stream values	Estimated travel time between groundwater and unregulated river
Coastal sands	Significant (tidal section only)	Low due to connection with saline water	Days to months
Up-river Alluvial	Significant	High due to impact on base flows	Day to months
Coastal Floodplain Alluvial	Low – moderate	Low since not major contributor and low level of connection	Season
Fractured rock	Low – moderate	Low since not major contributor	Years to decades
Porous Rock	Low – moderate	Low since not major contributor	Years to decades

Water management units

Water sharing plans can include the following hydrological planning units.

Where appropriate, an extraction management unit (EMU), consisting of one or several water sources, is specified for the purpose of establishing a geographic area over which the long-term average annual extraction limit (LTAAEL) applies. An available water determination (AWD) is made for each licence category within the EMU and any growth in extraction above the LTAAEL is managed across the EMU, not at an individual water source level. The plan contains two EMUs, one for the regulated water source and one for all other water sources.

Where an EMU is not specified the LTAAEL applies to the water source and any growth in extraction above the LTAAEL is then managed at that level.

Regardless of whether an EMU is specified or not, daily access rules apply at the water source (WS) level. The unregulated rivers EMU is divided into 11 water sources. Their spatial extent is shown in Appendix 1.

A management zone (MZ), representing a portion of a water source, may then be specified so that more refined implementation of access or trading rules can be applied, if required. In the plan two water sources have been split into management zones for more refined management. These are:

- the Upper and Lower Estuary Management Zones
- the Upper and Lower Tantawangalo Creek Management Zones.

The regulated river reaches are used to manage high flow extraction when inflows occur from downstream tributaries.

The SCWMC extended the unregulated river water sources to include all alluvial aquifers, except the Bega Sands which only covered the bed of the river. The Interagency Regional Panel recommended managing surface and highly connected groundwater together. This is consistent with the national framework for managing the impacts of groundwater and surface water interaction (SKM 2006). The Bega Sands was divided into three sections:

- upstream of the Brogo River junction, incorporated into the Mid Bega River Sands Water Source
- the alluvial associated with the regulated river, incorporated into the Regulated Rivers Water Source
- the aquifer to the south of Bega Tathra Road (underlying the floodplains of Penooka Swamp and Jellat Jellat Creek), incorporated into the Bega River Estuaries/ Tributaries Water Source.

These water sources extend to the edge of the highly connected alluvial shown in Figure 16. The current boundary of the regulated river is defined by the following gazettes under Section 22C of the WA 1912:

Govt Gazette No 68 24-6-77	* Brogo River from Brogo Dam downstream to its junction with the Bega River
	* Bega River from its junction with the Brogo River downstream to its junction with Jellat Jellat Creek
Govt Gazette No 63 22-4-77	* Coopers Creek from its junction with the Brogo River to the upper limit of the lagoon section within portion 97, Parish of Bega.

The Interagency Regional Panel reviewed the appropriateness of the current boundary. This boundary does not include the storage impoundment which the panel recommended be included. The panel also considered the impact of pumping in the unregulated Mid Bega River Sands Water Source on the regulated river, and the extent to which the regulated water source can supply users. The panel decided to extend the regulated river boundary up the Bega River, 500 metres from the confluence with the Brogo River.

Project groups

State Interagency Panel

The State Interagency Panel (SIP) has overall responsibility for the statewide strategic direction of water sharing planning, to make certain that adequate resources are available from each agency and to ensure that the varying policy and statutory requirements of the relevant NSW Government agencies are met. The SIP also has the role of making water sharing decisions in cases where the Interagency Regional Panel (IRP), see below, cannot reach agreement or where the issue has statewide significance.

The SIP is chaired by the NSW Office of Water. The group has representatives from both the NSW Office of Water and the part of the Department of Environment, Climate Change and Water (DECCW), and Industry & Investment NSW (I&I NSW). There are also three Catchment Management Authority (CMA) representatives. The Office of Water is responsible for the overall project management.

Interagency Regional Panel

The NSW Government established the South Coast IRP in 2005 charged with completing all plans in the area. In most instances this involved new plans; however in other cases such as the Bega Valley it involved updating the existing plan in light of recent policy changes at the Commonwealth and State level. The IRP incorporated the Brogo and Bega Regulated Rivers and the Mid Bega Sands alluvial aquifer into what has now evolved into this new plan.

The IRP is an inter-agency group consisting of representatives from both NSW Office of Water and the part of the Department of Environment and Climate Change and Water (DECCW), and Industry and Investment NSW (I&I NSW). The Southern Rivers Catchment Management Authority is an observer on the IRP.

Appendix 3 lists the names of the South Coast IRP representatives and their areas of expertise. The panel had access to staff from their respective agencies to provide technical and scientific information. The key responsibilities of the panel are to:

- review the proposed flow rules as to their suitability and to ensure they were concurrent with state-wide policy
- amend any sections in the plan to ensure their legality
- develop flow rules for water sources not covered in the SCWMC's plan
- request the Office of Water to undertake hydrologic modelling as required to develop the plan
- assist the SRCMA with public consultation on the proposed plan
- review submissions from targeted consultation and public exhibition and make changes where necessary.

Where possible, the provisions in the draft SCWMC plan were upheld by the IRP when drafting the plan. Changes to the SCWMC plan were made where necessary to ensure:

- compliance with the WMA 2000
- compliance with the *National Water Initiative*
- simplicity and therefore easy implementation of operation
- consistency of state-wide policy positions where appropriate
- consistency of terminology with other water sharing plans.

The IRP also checked that the rules integrate well and were equitable and practical across the catchment. It adopted the HRC's 50 per cent environmental share as a reasonable trade-off between the environmental and socio-economic values on the basis that other rivers on the South Coast would receive a much higher environmental share. The panel recognised the practical limitations of being able to access 50 per cent in the very high flows or during very wet years. During these periods the environment would receive a greater share. They therefore recommended a limit based on accessing 50 per cent of all flows and a reasonable expectation of users being able to access their full entitlement.

A hydrologic model was developed for the Brogo River and Bega River downstream of Kanoona to assist the panel in understanding the impacts of decision options. This together with a previous model developed for upstream of Kanoona allowed the IRP to avoid the possibility of water being accounted for twice, once in the surface water assessment and again in the groundwater assessment (double counting). The model also allows assessment of the impact of growth in use and additional entitlement on existing users and the environment. A large range of reference material was used in addition to the knowledge and experience of stakeholders, agency staff, technical support staff and Interagency Regional Panel members.

In addition, the Interagency Regional Panel was assisted by *Macro water sharing plans – the approach for unregulated rivers. A report to assist community consultation*. The manual explains the method used to classify and set indicative water sharing rules for unregulated streams across NSW.

Policy context

There are a number of national and state policies that impact on and direct the development of plans.

National Water Initiative

The NSW Government is a partner to the National Water Initiative (NWI) which was signed by the Council of Australian Governments (CoAG) in June 2004. The NWI recognises the continuing imperative to increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and groundwater systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction.
The NWI has a number of relevant requirements for water planning in Clauses 23, 25, 35 to 40, 52, 78, 79 and Schedule E (refer to the National Water Commission website www.nwc.gov.au in the Water Reform section for details). This intergovernmental agreement contains provisions on water planning including:

- settling the trade-offs between the competing uses must be based on the best available science and socio-economic analysis, as well as consultation with the community
- ensuring that environmental and other public-benefit outcomes are provided for through planned and adaptive environmental water on a statutory basis and achieved, including actions to sustain high-conservation value rivers, reaches, and groundwater areas
- providing for water trading to enhance water markets
- recognising and addressing surface and groundwater connectivity
- managing local impacts in groundwater areas as well as protecting groundwater dependent ecosystems (GDEs)
- providing for indigenous consultation and aboriginal cultural and commercial entitlements,
- assessing and addressing interception
- monitoring and reporting on implementation.

The Intergovernmental Agreement on a NWI sets out outcomes and guidelines and timelines for water plans and planning processes. The National Water Commission (NWC) is an independent statutory body responsible for providing advice to CoAG on the implementation of the NWI and national water issues and undertakes a biennial assessment of each states' progress with implementing the NWI for this purpose.

Natural Resources Commission

The macro plans also comply with the NSW Natural Resources Commission (NRC) statewide standards and contribute to the relevant statewide targets such as Targets 5 and 6 (see www.nrc.gov.au for details) which is a requirement of the State Plan, Priority E4 (see www.nsw.gov.au/stateplan for details). The NRC was established in 2003 to provide the NSW Government with independent advice on natural resource management issues. To achieve this it has developed and recommended a Standard for Quality Natural Resource Management and 13 statewide targets for natural resource management in NSW, which have been embedded in the NSW State Plan. As with the National Water Initiative, the components of the State Standard focus on the use of the best available knowledge, use of appropriate information management systems, delivery of integrated outcomes, engagement of the community and regular monitoring, measuring, evaluation and reporting to specify how delivery of the targets is progressing. The NRC reviews plans against this Standard and its associated targets (Table 7).

Table 7: Contribution of the plan to the relevant NRC statewide targets

Relevant statewide target	Plan's contribution
By 2015 there is an increase in the recovery of threatened species populations and ecological communities (Target 3)	– some access and trading rules developed to help protect water dependent threatened species where these were identified and the risk to these from extraction is high
By 2015 there is an improvement in the condition of riverine ecosystems (Target 5)	– sets a defined share of water for riverine ecosystems – protection of very low flows – trading rules to maintain or reduce entitlement in high value streams – adaptive management, giving the ability to adjust rules once information becomes available or at the end of plan period.
By 2015 there is an improvement in the ability of groundwater systems to support their groundwater dependent ecosystems and designated beneficial uses (Target 6)	– sets distance rules to GDEs for new bores – extractions from alluvial aquifers managed using connected surface water rules – trading rules designed to protect groundwater sources – local area impact management rules
By 2015 there is an improvement in the condition of important wetlands, and the extent of those wetlands is maintained (Target 8)	– trading rules to maintain or reduce entitlement in high conservation value water sources – protection of very low flows
By 2015 there is an improvement in the condition of estuaries and coastal lake ecosystems (Target 9)	– commence to pump rules introduced to protect first flush to estuaries
Natural resource decisions contribute to improving or maintaining economic sustainability and social well-being (Target 12)	– plans provide a defined share to water and defined certainty of access – separation of land and water enhances trading and value of licences – establishment of perpetual and compensable water access licences provides security for business investment – water markets encourage movement of water licences to high value uses – rules developed which consider community dependence on water extraction

Historical water planning

The Bega-Brogo plan draws on the expertise and decisions reached during previous efforts to develop water sharing and river management plans, in particular:

- the Bega-Bemboka River Flow Plan
- the recommendations of the Healthy Rivers Commission Inquiry
- the recommendations of the South Coast Water Management Committee
- water sharing arrangements negotiated with water users through the Southern Rivers CMA.

Bega-Bemboka River Flow Plan

The Bega-Bemboka River Flow Plan (Flow Plan), (Corbett and McPhee, 1999) was developed by the Bega Valley Water Management Committee (WMC) (Appendix 3), which was established in 1996 by the Far South Coast Catchment Management Committee.

The WMC had a range of community representatives (including water users and environmental interests), and engaged in rigorous discussions, aided by commissioned studies to produce the original Flow Plan. The commissioned studies covered a range of river management matters including hydrological modelling, ecological condition, riverine habitat assessment, water quality assessment, wetland assessment, and socio-economic factors relating to water management.

The Flow Plan identified a range of river flow conditions and water extraction management regimes to preserve flows to Kanoona Rocks to protect refuge pools. The Flow Plan also involved an agreement with Eraring Energy regarding storage of water in Cochrane Dam and releases during dry times for irrigation. The Flow Plan built upon a history of cooperative water sharing between water users which had begun during previous drought periods. Past failure of river flows due to competition for water access during droughts highlighted important lessons on the need to share water between users by rostering pumping times along the river.

The key aim of the Flow Plan was to ensure that river pools were kept full and connected by surface flow during low flow periods. A river flow gauge was installed at Kanoona Rocks, in order to help set access conditions for pumping and for triggering a ‘cease to pump’ declaration, so that at least the minimum environmental flow was maintained. This regime was endorsed by the former Department of Land and Water Conservation (DLWC) and a trial began in 1998/99. This trial demonstrated the success of the plan in protecting the minimum environmental flow, while rostering water among licensed users equitably and efficiently. The trial included voluntary installation of time and event meters for each significant water user. This allowed the DLWC to monitor individual compliance with the plan’s water rostering regime. Pumping hours were allocated according to a user’s proportion of the total active licensed entitlement and calibration of each pump. Rostering of pumping hours was triggered when daily river flows fell below identified levels. Irrigators were required to check the daily restriction level prior to starting their pumps. Restrictions were adjusted daily by the DLWC in order to maintain the target environmental flow of 2 ML/day at Kanoona. On the basis of the trial the river flow plan was adopted by the DLWC as an operational plan. The plan has continued to operate successfully through the past decade of exceptional droughts to this day, with qualified support from irrigators, basic rights water users and environmental interests.

Healthy Rivers Commission Inquiry

In 2000 the Healthy Rivers Commission of NSW (HRC) led an inquiry into the health of the Bega River Catchment which concluded that the management of water extraction, wetlands, the estuary, river vegetation and environmental weeds could be improved. In May 2000 the HRC published the *'Independent Inquiry into the Bega River System'* which made recommendations to government and the community on matters most critical to river health. The HRC's analysis of the allocation of stream flows concluded that the then management of the water resource was not sustainable. The HRC's expert advice indicated that it was important to maintain for as long as possible the connection between habitat in the Bega-Bemboka and tributary streams, particularly Tantawangalo Creek. The HRC proposed cease to pumps[5] (CTPs) for other water sources, and supported the Flow Plan as an initial prescription for environmental flows and recognised it as an important and ground-breaking step.

The HRC recommended a 50/50 daily sharing arrangement between users and the environment as a reasonable first approximation. It established an expert panel (Young 1999) to develop flow rules for the Regulated (Brogo) River. It recommended that hydrologic modelling should be undertaken before these rules were adopted.

For further details on the recommendations see the full report *'Independent Inquiry into the Bega River System: Final Report', Healthy Rivers Commission, May 2000*.

The South Coast Water Management Committee

In 1999 the Minister for Land and Water Conservation established the South Coast Water Management Committee (SCWMC). Appendix 3 lists the members and the stakeholder group they represented.

The HRC's recommendations formed the basis of many of the provisions in the Bega Catchment Plan drafted by the SCWMC. The SCWMC also recommended a staged approach to change to limit adverse social and economic impacts. In essence, it proposed that water users be given time to adapt to new rules. The SCWMC set the following vision for a water sharing plan:

The vision for this plan is that the water source and the dependent ecosystems of the Bega Valley will be protected and enhanced, whilst the social, cultural and economic future of the catchment community is recognised and fostered.

[5] 'Cease To Pump' refers to a specified stream flow or stream height, below which licensed extractions are not permitted.

Southern Rivers Catchment Management Authority

Following the SCWMC's discontinuation at the end of 2004, a draft Bega River Catchment (Unregulated River) Water Sharing Plan was developed by the Southern Rivers CMA. The SCWMC had agreed on a range of decisions for inclusion in the final draft plan that was to be sent to the Minister. This stage of the draft plan involved drafting additional clauses to incorporate the intent of the SCWMC's consensus position into the framework of NSW Government policy at the time and the requirements of the WMA 2000. While remaining consistent with the SCWMC's consensus, this process involved the development of additional detail and proposed rules for a range of issues including:

- water access rules for the proposed Bega to Yellow Pinch Dam pipeline and Tantawangalo Weir
- Cochrane Dam Licence conditions (including rules for a drought reserve and for management of water held in Cochrane Dam for irrigation purposes)
- water access rules for the Bega River Sands
- links between the plan and the Bega River Health Agreement (BRHA).

The plan was submitted to the former Department of Natural Resources (DNR) in 2005 to be finalised. The SRCMA was involved in ongoing negotiations with the DNR to resolve inconsistencies between the plan and NSW Government policy and the WMA 2000.

Other considerations

There are a number of policies and water related issues that require consideration with the development of this plan and the associated water sharing rules.

Mandatory conditions

The plan sets out a number of standard conditions that will be applied to water access licences and water supply work approvals. These mandatory conditions are designed to protect the rights of all users in the water source and the environmental water rules of the plan. They cannot be removed or altered unless the plan itself is amended.

Currently, surface water licence holders and basic rights users have been digging sumps in the sandy bed of some streams to access water. This has been particularly the case in the Mid Bega River Sands. There is a legal requirement under the *WMA 2000* for such activities to obtain a work approval prior to construction. It is proposed that work approvals will also be created, separate to the issued water access licences, when the water sharing plan commences and the WA 1912 licences are converted across to the *WMA 2000*.

Basic landholder rights users will need to comply with sump guidelines currently being developed through the SRCMA. For licensed users it is proposed that mandatory conditions be applied to all works where limits and rules will apply to the use of sumps, particularly to the size of works. Works that do not meet the mandatory conditions will require a new approval or an amendment which will require an assessment to demonstrate the minimal harm requirement to the vicinity of the water source. This is likely to include works such as spear points or permanent structures.

Protecting Aboriginal values

Aboriginal cultural values could be affected by water extraction from aquifers. One of the draft plan's objectives is to protect, preserve, maintain or enhance the Aboriginal cultural and heritage values of these water sources.

Most information about groundwater-related Aboriginal values resides in indigenous communities. The HRC consultation with the Aboriginal community took the form of several meetings with Aboriginal community representatives, arranged after discussions with representatives of the Bega Local Aboriginal Land Council. The Aboriginal community had concerns about the following water sharing issues:

- loss of water from the river
- poor water quality
- reduced numbers of fish and other wildlife
- loss or degradation of wetlands.

Members of the Interagency Regional Panel held meetings with Bega Aboriginal representatives to discuss the proposed water sharing plan and to target specific areas for protection of Aboriginal cultural values. These initial consultation sessions have provided some insights into Aboriginal cultural values in the Bega catchment. Aboriginal communities have indicated that water sharing rules should protect natural in-stream values. Whilst Aboriginal groups acknowledge the rights of commercial water users, they believe that this should not be at the expense of the environment. In their view, the priority for water sharing plans should be to provide for natural flowing rivers with healthy aquatic biodiversity. This is consistent with the proposed provisions of the draft plan.

Licences for Aboriginal cultural purposes may be granted throughout the Bega Valley. These can be used for purposes such as manufacturing traditional artefacts, hunting, fishing, gathering, recreation and ceremonial purposes. Follow up meetings are planned with these representatives and the wider Aboriginal community during the public exhibition period.

Protecting environmental values

Water sharing plans are required to reserve water for the overall health of the river and aquifers and to protect specific ecosystems that depend on river flows, such as wetlands, lakes, estuaries and floodplains and groundwater dependent ecosystems. This share of water reserved for the environment, is also intended to sustain the river and groundwater system's aquatic fauna and flora.

Key environmental assets

In-stream value is the value of retaining water in a river. Three different types of values contribute to in-stream value: ecological (intrinsic), economic (non-extractive use) and place (cultural) values. In-stream value is used in two ways in developing the plan. Firstly to identify high conservation values and secondly to assess the risk to in-stream values.

No threatened fish species listed under NSW legislation occur in the Bega Valley. One threatened fish species, the Australian grayling, is listed as vulnerable under Federal *Environment Protection Biodiversity and Conservation Act (EPBC) 1999*. Threats to Australian grayling include:

- construction of dams or weirs, which prevent downstream and upstream migration (to and from the sea) that is essential for completion of the species' life cycle[6];
- land clearing, resulting in siltation and water quality decline;
- smothering of gravel beds by fine sediment; and
- competition from introduced brown trout.

The NSW Fish Survey (Harris and Silveira 1997) found good populations of fish in the Brogo River with 15 native species found, which was rated in the top 10 sites across NSW. The same survey found only four native fish species in the Bemboka River, reflecting the pressure on fish populations due to loss of river corridor habitat, excessive sedimentation leading to habitat decline and water extraction. The operation of Brogo Dam (i.e. releasing water during times of low stream flow) may have had a positive impact on fish populations in the lower Brogo River for example maintains pool connectivity and thus aids migration. A subsequent environmental study (DIPNR 2000) concluded that the mean native fish richness in the Brogo and Bega catchments was greater than that in the Bemboka sub-catchment (Harris and Gerhrke 1997).

Of the eight threatened bird species identified as occurring in the Bega Valley (based on data provided by DECCW), none are specifically in-stream species, and four are listed as slightly sensitive to water extraction. The remaining four are listed as having a secondary relationship to extraction. All of the listed bird species are known to occur along the regulated river sections of the Brogo River.

Of the five threatened frogs identified, four are known to occur in both the regulated and unregulated river areas in the Bega Valley. Platypuses are known to occur within the Brogo regulated river and near Morans Crossing on the Bemboka River.

An endangered ecological community (EEC) is an assemblage of species occupying a particular area (plant or animal communities) that is in danger of becoming extinct. These EECs are listed in schedules of the *Threatened Species Conservation Act 1995*. In the case of plant communities, where these forests/woodlands occur on alluvial floodplains, it is assumed that the vegetation uses groundwater to sustain transpiration and growth. Groundwater extraction can effectively lower the water table, having a negative impact on the vegetation community. One threatened ecological community (freshwater wetlands on coastal floodplains) occurs within the Brogo regulated river alluvial floodplain section and Bega River Floodplain.

[6] The Australian grayling is amphidromous and is thought to require breeding migration opportunities in Autumn and Spring (Morris et al). Levels of water extraction may therefore also impact on this species by creating additional barriers by a lack of surface water flow linking freshwater and estuarine river reaches at a time when migration for the completion of breeding cycles is required. Excessive water extraction could limit flows across the Bega Sands in Autumn and Spring.

High conservation value areas

Areas with high in-stream or aboriginal values are considered to have high conservation value. Clause 25 of the *Intergovernmental Agreement on a National Water Initiative* requires Water sharing plans to identify and acknowledge surface and groundwater systems of high conservation value. The plan identifies two key water sources with high conservation value:

- Upper Brogo Water Source (above Brogo Dam). Its value is demonstrated by the extent that it lies within the Wadbilliga National Park as well as identified in-stream high species diversity and presence of threatened species
- Bega River Estuary Tributaries Water Source which falls within the Bournda National Park as well as identified in-stream threatened species present and an absence of alien species.

These will be given special protection in the plan via a 'no trades in' rule. This means that no further increase in water entitlement is allowed in these areas.

The following management zones also limit trades into these areas due to their conservation values:

- Lower Bega River Estuaries Management Zone
- Upper Tantawanglo Management Zone.

Groundwater dependent ecosystems

The plan must consider groundwater dependent ecosystems (GDEs). GDEs are ecosystems which have their species composition and natural ecological processes determined to some extent by the availability of groundwater. GDEs can include:

- cave systems
- wetlands
- water dependent endangered ecological communities.

No caves were identified in the Bega Valley.

Groundwater dependent wetland ecosystems are typically areas where the water table is at the surface, or periodically at the surface. While the degree of groundwater dependency is variable, groundwater plays a critical role in wetlands found on alluvial floodplains. Many wetlands are extremely species rich with a mixture of plants and animals and are often considered to have high conservation value.

Two types of wetlands have been identified within the Bega catchment:

- Upland pluvial wetlands – generally grassy unincised drainage lines on gently sloping or flat areas of ground. They commonly support sedges, grasses or rushes and may occasionally include remnant stands of paperbark.
- Upland phreatic wetlands – usually areas of upland heaths or bogs which may support paperbark or tea tree species, plus wet heath land shrubs, hummock grasses, rushes and sedges (Green 1999).

Parsons Brinkerhoff (2004) noted that a number of lagoons and wetlands are present on the Mid Bega River Sands Water Source. These floodplain groundwater dependent ecosystems appear to be unconnected to the river as they appear to be perched above the normal river bed level, and so may not be in direct connection with the river or the groundwater system. Until further studies are conducted to confirm this assessment, water sharing arrangements will address floodplain GDEs through the setting of bore distance rules rather than river management rules.

The draft plan sets out a schedule of high priority (high conservation value) GDEs. Their location is mapped and proposed distance rules will cover new or replacement bores which will not be permitted within a buffer zone around the GDE. Existing bores will not be affected by the proposed buffer zones and are able to continue operating (i.e. within the existing conditions of their access licences). The GDE schedule may be updated after gazettal of the plan. Any proposed changes to the GDE schedule will be discussed with those landholders who may be affected. Updating of the schedule is considered to be an amendment to the plan, and as such would require the concurrence of the Minister of the Environment and the Minister of Water.

The Interagency Regional Panel did not select any high priority GDEs for the schedule, agreeing rather to protect those GDEs in the Bega Sands south of the Bega Tathra road (Betunga Swamp and Penooka Swamp) through zoning of this area. Since groundwater and surface water is managed together a trading rule is proposed that will protect these areas.

The community may nominate wetlands and NSW Office of Water will work with the environmental water management sections of DECCW to identify, map, and list EECs during the life of the plan.

Protecting estuary health

The Bega River Estuary is a key environmental asset within the Bega Valley. BVSC has prepared a draft Estuary Management Plan for the Bega River estuary, in accordance with the recommendations of the former Healthy Rivers Commission. The plan was developed in accordance with the State Government's Estuary Management Program and helps to satisfy *Coastal and Marine Management Target C2: Protecting and Rehabilitating Estuaries* of the SRCMA's *Catchment Action Plan* (CAP) *2007* and contributes to the implementation of Target E4 of the NSW State Plan.

The Bega River Estuary Management Plan provides strategic direction and specific focus for the short and long-term sustainable management of the Bega River estuary waterway, its tributaries, surrounding foreshore lands, and its catchment. The plan is designed to be consistent with, and where relevant, inform other strategic documents such as the Bega Valley Shire Local Environmental Plan (LEP) and the water sharing plan.

The Bega River Estuary Management Plan covers the tidal section of the Bega River (i.e. the estuary). This extends from the river entrance at Mogareeka Inlet to Jellat Jellat and the Penooka Wetlands. Activities beyond the banks of the estuary can have a significant impact on its health. Therefore, depending on the issue, the entire water catchment has also been considered as part of the plan. The entire catchment of the Bega River covers an area of 1,930km^2.

The inter-relationship between inflows from the catchment and estuarine health is a key issue discussed in the estuary management plan. During the community consultation phase of the preparation of the estuary management plan, a high degree of public interest was shown in the issues of water extraction, environmental flows, and resulting impacts on the estuary.

The Bega River Estuary is one of several ICOLLs (intermittently closed and open lakes and lagoons) on the south coast of NSW. The tidal influence would naturally extend 14.6 kilometres upstream from the sea. The regulated river extends to junction with Jellat Jellat Creek: this is 3 kilometres downstream of the tidal limit. During dryer periods a sand barrage is constructed between these two points to prevent the intrusion of salt into the regulated river section.

The estuary's values can be threatened by excessive water extraction. Since estuarine processes are complex NSW Office of Water and DECCW (environmental water) have adopted 'salinity sensitive to freshwater inflows' as a basis for determining environmental flows to estuaries. The size and shape of estuaries vary which, when combined with freshwater inflows, determine the estuary's overall sensitivity of changed salinity levels due to freshwater extraction. An analysis was undertaken by a group of estuary specialists from NSW Office of Water and DECCW (environmental water) to determine how sensitive each of the State's estuaries are to changes in freshwater inflows. The study found the Bega Estuary has a medium sensitivity to low flows and high flows. For more information on the estuary refer to the NSW Office of Water document *Determining Freshwater Requirements of Estuaries for the Macro Water Sharing Plans and the Estuary Processes Study* (WBM, 2006).

The volume of the Bega Estuary is small relative to average stream flows. Therefore the very high flows are environmentally less important than for estuaries with a greater estuary volume to stream flow ratio. As discussed earlier, extraction from the estuary at the low flow end is partially off-set by operational surpluses associated with regulated river releases. Medium flows and freshes are therefore a more important component of flow to be considered in the plan.

Maintaining ecosystem functions

To maintain ecological functions in streams it is necessary to maintain a range of hydrological features. To achieve this outcome, the NSW government developed the following river flow objectives (RFOs):

- **RFO 1:** Protect pools in dry times
- **RFO 2:** Protect natural low flows
- **RFO 3:** Protect important rises in water levels
- **RFO 4:** Maintain wetland and floodplain inundation
- **RFO 5:** Mimic natural drying in temporary waterways
- **RFO 6:** Maintain natural flow variability
- **RFO 7:** Maintain natural rates of change in water levels
- **RFO 8:** Maintain groundwater for ecosystems
- **RFO 9:** Minimise effects of weirs and other structures
- **RFO 10:** Minimise effects of dams on water quality
- **RFO 11:** Make water available for unforseen events
- **RFO 12:** Maintain or rehabilitate estuarine processes and habitats.

Source: http://www.environment.nsw.gov.au/ieo/Bega/report-04.htm

These objectives were considered in the various stages of developing the draft plan.

The upland and escarpment sections of streams in the Bega River catchment are 'generally in good health; native riparian vegetation is generally intact and there is little erosion. Stream conditions are generally good for native fauna' (HRC, 2000). The HRC identified that in the middle sections of the catchment (between the escarpment and the aggrading sandy reaches of the lower section) 'the numbers and diversity of both fish and macro-invertebrates are generally lower than desirable, as aquatic fauna are affected by the impacts of:

- changed flow patterns
- the poor condition of native riparian vegetation
- elevated nutrient levels.

The lower section is dominated by vast quantities of sediment, which can lead to extended absence of flows during the irrigation season since flows travel through the sediment, rather than along the surface of the river bed. Because sediment is still moving through the system, the channel form is not stable and has limited environmental value at present. Native riparian vegetation is in extremely poor condition. The sand, absence of low flows, destruction of wetlands and limited food sources means there is little worthwhile habitat for aquatic fauna (HRC, 2000).7

The River Health Status Report of the Bega Catchment (DIPNR 2005) gives a snapshot of comparative river condition and supports the HRC findings. Estuaries in a pristine state have nutrient-rich fresh waters from the catchment, which mix with highly oxygenated waters from the ocean, making them the most biologically productive regions of the marine environment. Many forms of marine life spawn in estuaries and many species of water birds are dependent on estuaries for breeding and feeding.

[7] There is evidence of impaired macro-invertebrate species diversity in pool-edge habitats, relative to that in riffle sections (Growns 1998), and evidence of temperature stratification at low flows (Chessman 2001). High nutrient inputs over time and temperature stratification at low flows could potentially lead to toxic cyanobacteria blooms in pools or impounded reaches, such as above the Jellat Jellat barrage.

Estuarine biota have differing tolerances to and dependencies on fresh and saline waters. Estuaries are therefore inhabited by much more diverse biota than rivers with diversity supplemented species from both fluvial and marine origin. Nutrients and pollutants are dispersed by both tidal and fresh water inflows and the relative importance of these dispersion processes will change in relation to the level of fresh water flow (Pierson et al 2002).

The HRC recommended a 50/50 sharing arrangement between users and the environment as a reasonable first approximation in the absence of greater certainty. This percentage share is consistent with other highly developed valleys such as the Hunter. Although more studies had occurred since the HRC inquiry, the panel could not establish any technical reason for changing this percentage sharing arrangement and adopted it in the rules of the draft plan that apply to the regulated river system.

First flush rules

In their assessment of flow objectives the HRC considered that the main emphasis should be on preserving the first flush after a low flow period. Medium flushes are important for river ecology and the estuary as they have a role in triggering life cycle stages in biota such as effects in migration, spawning success, advection of eggs and larvae, species competition and distribution, general productivity, food supply and water quality (Pierson *et al* 2002). Protecting the first flush also provides equity both between and within systems by allowing them to recharge groundwater ad reach the end of system. The plan contains first flush provisions for the regulated river and unregulated rivers. The current regulated river 12 hour first flush rule is proposed to be extended to 24 hours for equity across the catchment and to ensure water reaches the bottom of the catchment.

For the unregulated water sources, a 24 hour first flush rule is proposed after 30 days in a class (including very low flows) before a new class is declared for users to extract water from the higher class. Users in the Upper Bega/Bemboka Rivers and the Mid Bega Sands will have their access rules based on the first flush flows arriving at the Kanoona Gauge.

Protecting basic landholder rights

Under the WMA 2000, extraction of water for **basic landholder rights** (BLR) does not require a licence, although in the case of accessing groundwater under BLR the bore must still be approved by the Office of Water. BLR include water for domestic and stock purposes extracted from a water source fronting a landholder's property or from any aquifer underlying the land, harvestable rights and for native title rights.

The principles of the WMA 2000 also require that water sharing must protect BLR. The plan does this by including an estimate of the water requirements for BLR at the start of the plan. There are currently no extractions for native title rights. However, these rights may be activated during the plan's 10 year term.

Furthermore, the access rules apply to licensed water users but not to extractions for BLR. This in effect affords these BLR users some additional protection.

Domestic and stock rights can be restricted by the Minister to protect the environment or public health, or to preserve existing basic landholder rights. These restrictions are outside the framework of the plan. The Office of Water is developing a regulation which will limit extractions under domestic and stock rights to a reasonable volume where they are metered and more clearly define what is considered to be reasonable purposes, which is important where they are not metered.

The Bega Valley Water Management Committee identified basic landholder rights extraction as an issue for future planning of water use in the Bega Catchment. Van Osgood (1999) undertook an investigation of riparian water use in the Bega Valley Catchment. This was used to estimate BLR requirements for the plan.

Water sharing in a catchment management context

An objective of the plan is to manage water extraction consistent with other catchment management initiatives. Understanding the drivers of the river ecology requires an appreciation of the significance of the geomorphologic changes in the Bega Valley.

The Healthy Rivers Commission's Final Report (2000, p. 35) recommends that 'the highest priority for managing river health in the Bega system is to improve management of the river corridor. Almost as important is the management of flows and extraction from the river, but the value of improvement to river flows will be reduced unless a more stable and 'green' river corridor is achieved'.

The need for an integrated approach to achieve a healthy river requires that the plan links with and supports the improved management of the river corridor. The Bega River Health Agreement was developed by the SCWMC in order to achieve this integration.

During targeted consultation the proliferation of Casuarinas along the Brogo River was discussed. It now may take a couple of days for water to travel from the dam to the confluence thereby reducing the effectiveness of the first flush rule. This interaction between water sharing and species pioneering re-establishment of riparian vegetation is acknowledged and it is considered acceptable that the first flush will not be as effective as desired. The general view is that this issue requires further consideration.

Water interception activities

Changed land-use activities can intercept significant quantities of water. Examples of this include an increased farm dam capacity in a catchment or significant areas of new forestry plantations. Under the National Water Initiative, significant interception activities will require a water access licence.

The Healthy Rivers Commission reviewed available Bega Catchment information, papers on the subject, and a number of projects in forest hydrology. They concluded that current forestry effects cannot be shown to be significant on a catchment scale, although there are likely to be significant impacts in the smaller tributaries. Farm dams require an access licence only when:

- they are located on a 3rd-order (or greater) river, irrespective of the dam capacity or purpose
- if they exceed the maximum harvestable right dam capacity for the property, which is a capacity that enables the landholder the ability to capture 10 per cent of the mean annual runoff from their property
- if they are on a permanent (spring fed) 1st and 2nd order streams.

The volume of licensed farm dams was considered in the plan. The provisions relating to harvestable rights are unaffected by the rules of the plan as they are established by the Harvestable Rights Order gazetted on 23 March 2001 under section 54 of the WMA 2000. It classifies the Bega catchment's minor streams as non-permanent 1st and 2nd order streams as shown on topographic maps.

The volume of potential unlicensed farm dam extraction was calculated to assess the likely significance for water interception. In the Bega catchment 107,500 hectares are privately owned. If every landholder activated their full harvestable right this would equate to an estimated harvestable rights dam capacity of 9,100 ML (based on a HR factor of 0.085 from the web-based calculator). This is well in excess of what is currently constructed. Although the full activation of harvestable rights is considered to be highly unlikely, the plan must allow for people to take up their rights. Future plans will need to continue to assess harvestable rights to ensure additional water interception activities are accounted for and managed appropriately.

Development of future water supplies

BVSC has secured $10 million from the Federal Government for the Bega to Yellow Pinch Dam pipeline under the Prime Minister's Water Smart Project. This pipeline will protect environmental flows (low flows) on Tantawangalo Creek by reducing extraction during low flows and opportunistically extracting larger volumes of water during higher river flows in the Mid Bega Sands. This will also improve water supply security to towns in the southern part of Bega Valley Shire as well as meet projected urban water demands of the Shire until 2045.

Of particular interest to dairy farmers in the Bega Valley is the plan's high flow conversion rules which will likely result in development of new off stream storages. This will help shift reliance on extraction from low flows towards greater reliance on extraction from high flows. In 2005, the Bega River Catchment Water Storages Committee (BRCWSC) commissioned Snowy Mountains Engineering Corporation (SMEC) to investigate the feasibility of a range of water storage options for the Bega River catchment. The study (SMEC 2008) found that off stream storages were quite effective in increasing the percentage of days where full irrigation requirements were able to be met. Modelling of on-stream storages showed that they were slightly less effective in increasing the percentage of days that full irrigation requirements were able to be met.

Any development of new water storages in the Bega Valley must be undertaken within the bounds of the plan. The plan is not prescriptive in endorsing any particular option since economic considerations vary over time. Instead, the plan sets a framework within which development of future water supplies can occur in a sustainable manner.

Specific access in unregulated water sources

Aboriginal Cultural and Community Development Licences

If there is sufficient water available for development in high flows, then the needs of the Aboriginal community are considered first.

In some areas within the Bega catchment, Aboriginal groups may apply for Aboriginal Community Development water access licences. These allow Aboriginal persons, or organisations, to extract water from high flows and use that water for commercial purposes such as irrigation.

Since granting these Aboriginal Community Development access licences would mean less water in the river to meet other users or environmental needs, it will be necessary to limit the total volume that can be extracted. The limit will be a proportion of the river flow, and will never exceed 500 ML/y. The government does not propose to limit the volume assigned to each individual Aboriginal Community Development licence, only the total volume per water source.

The Interagency Regional Panel decided that no new licences would be granted in water sources with high conservation value or in areas that could not support high flow licences, other than those required to allow conversions to protect in-stream values. The plan makes provision for the granting of Aboriginal Community Development licences in the following water sources:

- Upper Bega/ Bemboka Rivers
- Tantawangalo Creek
- Mid Bega River Sands
- Lower Bega/ Lower Brogo Rivers Tributaries.

At the commencement of this plan there are no holders of Native Title Rights. The plan recognises that the exercise of native title rights may increase during the term of this plan as a result of the granting of Native Title Rights under the Commonwealth's *Native Title Act 1993*. Further information for Aboriginal water users is available on the NSW Office of Water's website at www.water.nsw.gov.au.

High flow conversion

Many of the coastal unregulated rivers within NSW have extreme competition for water during dry periods. In-stream values can be stressed during these low flow periods, wildlife becomes concentrated in particular locations and water quality can deteriorate through eutrophication. Therefore, there is merit in developing incentives that aim to move extraction out of the low flows and into the higher flows, as an attempt to improve environmental conditions and reduce competition.

By moving extraction from periods of low flow to periods of relatively higher flow, over time, streams may be de-stressed and river conditions may improve. An incentive is however required as low flow extraction is cheap and convenient and more reliable – water users simply pump the water when it's available subject to access conditions which are met more often relative to high flow licences. To utilise higher flows, it would generally be necessary to construct an on-farm water storage. Water could then be pumped during periods of higher flow and stored for use at a later time. This is a much more expensive approach to irrigation but can provide enhanced security for water users.

An incentive proposed by the plan is to allow those licences that convert to higher flows to be granted additional volumes of water. In the plan it is proposed that for every 1 unit of a normal unregulated river access licence entitlement surrendered, 3 units of higher flow access licence entitlement will be granted. The high flow access commences at the 30th percentile which is the flow that is exceeded 30 per cent of days.

Given that the purpose of the high flow conversions is to 'de-stress' low flows in coastal river systems, a detailed assessment was undertaken to ensure that there is an overall environmental benefit achieved.

The conversion has been recommended in specified water sources only if the following criteria are met:

- the water source is classified as having important in-stream values at high risk from extraction or in water sources having high hydrological stress
- there are adequate mechanisms in place to ensure the surrendered low flow is reserved for the environment
- there is a no highly sensitive estuary or other identified high flow sensitive feature such as a wetland within the Extraction Management Unit
- there is no existing high flow stress (i.e. significant extraction already in the high flow periods)
- the conversion would not significantly impact on tidal pool users or Town Water Supplies.

In addition, while trading of higher flow entitlements is possible, the plan proposes that it will be constrained as follows:

- trading within the water source will generally be permissible
- cease and commence to pump levels at the new location will always be the 30th percentile flow.

Conversions to high flow extraction

To utilise higher flows, generally it would be necessary to construct on-farm storages. Water can then be pumped during periods of higher flow and stored and used at a later time, especially to buffer periods of low or zero flows. This is a much more expensive approach to irrigation but may enhance security for water users as they become less affected by cease-to-pump constraints.

The plan allows for users to convert some, or all, of their entitlement up into a higher flow access class. On the unregulated system, users will be able to convert their existing entitlement into high flow entitlements. The purpose of high flow conversions is to reduce hydrologic stress during periods of low stream flow. The SCWMC recommended a target of 20 per cent reduction at low flow for the unregulated rivers. To achieve this level of reduction, a conversion rate of 3:1 is required. The IRP acknowledged the importance of setting the conversion rate high enough to create sufficient incentive for water users to invest in the infrastructure required to extract and store water from high stream flows. However, if HFCs do not sufficiently reduce hydrologic stress during low flow periods, then there is no justification for these conversions.

Table 8 shows the amount of water available for conversion into high flow for each water source to achieve the 20 per cent reduction target in low flow hydrologic stress for the entire catchment. Reflecting their conservation value, no conversions are allowed in the Upper Brogo River or in the Bega River Estuary Tributaries Water Sources.

High flow conversion is proposed in two stages. Environmental and hydrologic monitoring following the first stage will be used in deciding whether to allow stage 2 conversions to high flow water access licences.

High flows in the Lower Bega and Lower Brogo Rivers catchment can be provided to either regulated river users as supplementary water access or to the unregulated users as high flow access. The NSW Office of Water will first establish any supplementary water access claims. Conversions of general security water to supplementary water are currently not allowed under the WMA 2000, therefore, the remaining water will be assigned to allow for conversions to unregulated high flow.

Table 8: Assigned Water in High Flows

Water Source	Assigned High Flow Conversion Water	
	Stage 1 ML/y	Stage 2 ML/y
Upper Bega/Bemboka Rivers	4948	2733
Upper Bega/Bemboka Rivers Tributaries	833	417
Sandy Creek	312	156
Tantawangalo Creek	1774	1145
Candelo Creek	262	181
Wolumla Creek	521	260
Mid Bega River Sands	744	630
Mid Bega River Tributaries	173	Nil
Upper Brogo River	Nil	Nil
Lower Bega Lower Brogo Tributaries Regulated River (supplementary water)	404	461
Bega River Estuary Tributaries	Nil	Nil
Total	**9971**	**5983**

Hydrologic modelling

A more detailed understanding of stream hydrology, the impact of extractions, the operation of the regulated river, and the interactions between the regulated, unregulated and groundwater systems, is needed to address some of the more complex water sharing issues. Hydrologic modelling provides the basis for a better understanding of these processes and interactions.

The HRC recommended against the granting of new licences (including high flow licences), unless catchment modelling indicated how increased usage can be managed without adverse river impact. Current 'rule of thumb' water management triggers are based on observations at current usage levels. These will need to be amended if usage reaches full entitlement. Modelling can assist in predicting likely changes to assist in exploring various scenarios of water extraction impacts against key environmental values.

The model relies on calibrations against historical stream flow, rainfall, dam operation and water extraction activities. The model can then be used to:

- create 'natural' stream flow sequences by removing dams and estimated extraction
- assess reliability to different categories of licence under current and full development
- assess the interaction between the unregulated rivers, groundwater and the regulated river,
- assess the likely improvement to environmental flows and impact on users of flow rules.

The Integrated Quality and Quantity Model (IQQM) cannot forecast flows or determine flood levels, determine the state of the catchment in the future, explicitly assess the impacts of catchment change, or assess the effectiveness of individual farm cropping practices or operation.

NSW Office of Water developed and calibrated an IQQM model for the Bemboka and Upper Bega Unregulated Rivers, down to Kanoona. This model was provided to SMEC (2008) as part of their investigation of water storage options for the Bemboka and upper Bega River. The initial model consisted of three reaches and simulated the operation of Cochrane Dam and irrigation. SMEC modified the initial model, disaggregating the three river reaches of the model into the proposed water sources.

NSW Office of Water also developed an IQQM model for the Brogo and Lower Bega Regulated Rivers. This model simulated the operation of Brogo Dam and the behaviour of the regulated irrigators from the dam to the end of the regulated river at the confluence of Jellat Jellat Creek. A simple water balance model of the highly connected aquifer in the lower reaches of the Brogo River and Bega River was added to the regulated river model.

The two models were connected using the output flows at Kanoona from the Bemboka model as input flows in the Brogo model. The IRP used the outputs of both models to assess the implication of current development and full development scenarios, as well as various changes to Regulated River operations.

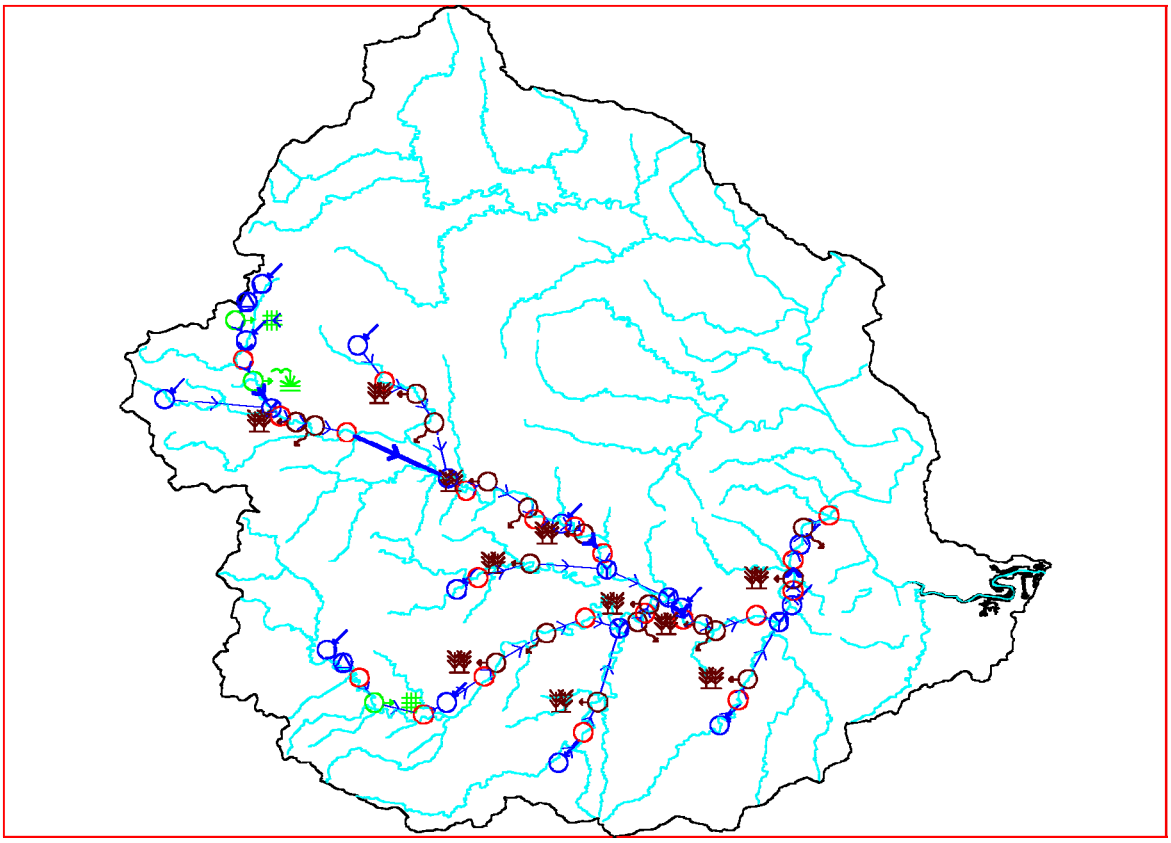
Extension of stream flow records

To understand what the likely implications of the different scenarios, the long-term climate, not just the weather conditions in recent years, must be understood. Wherever possible, measured flows up to 2009 were used at all of the different inflow locations represented in the model. Not all the streamflow gauging stations in the Bega Valley have been measuring inflows to the system for long periods, yet there have been historic droughts that may be worth considering when making decisions. Hence it is important to estimate inflows that would have occurred during earlier historical periods, especially in the early 1900s which had some of the worst droughts on record. These inflows are estimated using a type of model called a rainfall run-off model which allows us to estimate streamflows from historic rainfall records. This model simulates rainfall as it moves through a catchment. Using measured rainfall and a representation of evaporation, the model is calibrated on a daily time-step to a shorter period of measured streamflows. Streamflow for the full period of recorded rainfall in combination with a long-term representation of evaporation, can then be simulated, extending streamflow sequences back to the Federation drought of the early 1900s.

Configuration of IQQM hydrologic models

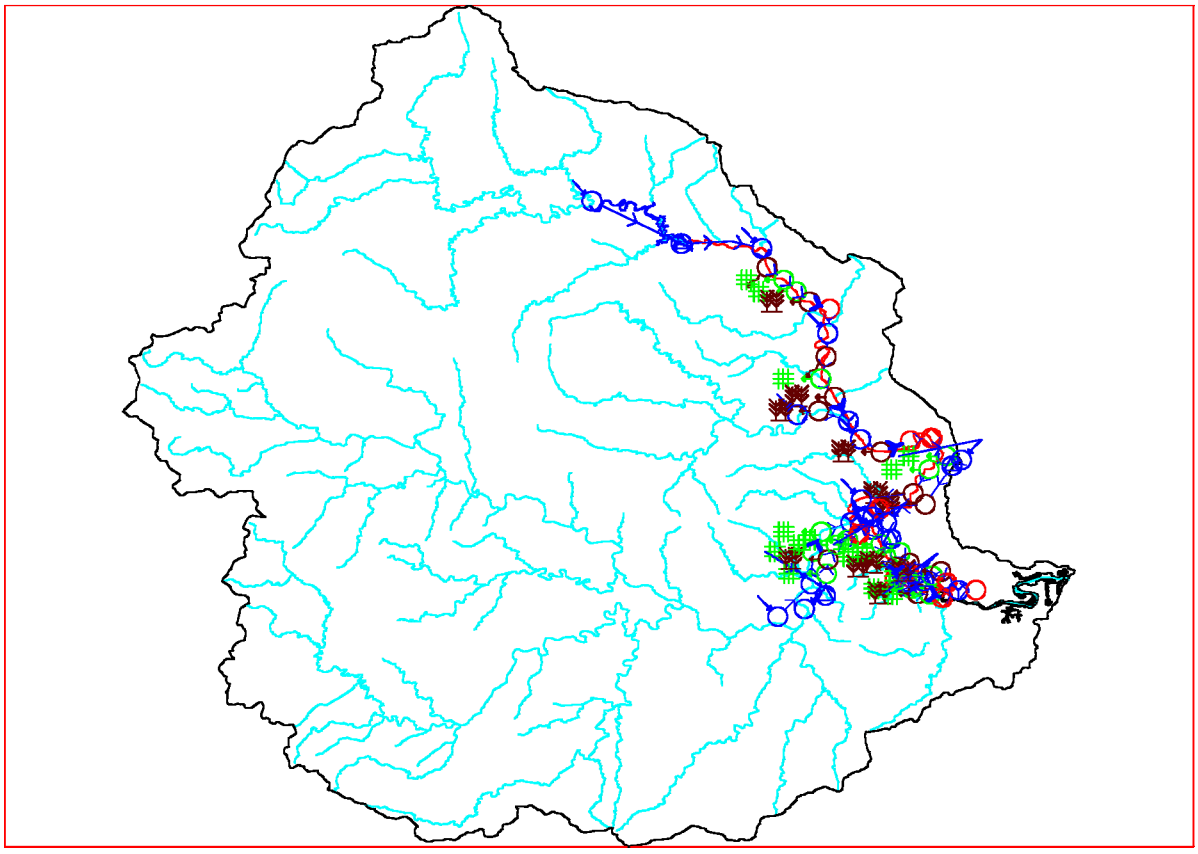
The IQQM hydrologic model simulates the movement of water into and through the river system. The Bemboka Unregulated model includes the simulation of Cochrane Dam, irrigators in each of the Water Sources (note four irrigator nodes were used along the Bemboka and Upper Bega Rivers), and the town water supply weir on Tantawangalo Creek. The configuration of the Bemboka Unregulated model is shown in Figure 14. More detail images of the schematic diagram of the model are presented in Appendix 5.

Figure 14: Configuration of Bega-Bemboka Unregulated River Hydrologic IQQM Model



The Brogo Regulated model includes the simulation of Brogo Dam, irrigators along the river (Note 5 irrigator nodes were used down the length of the regulated reaches of river.) and the town water supply pumps below the dam. The model was adapted to include a water balance model of the alluvial aquifer in the lower reaches of the Bega and Brogo Rivers. The configuration of the Brogo Regulated model is shown in Figure 15. More detail images of the schematic diagram of the model are presented in Appendix 5.

Figure 15: Configuration of Brogo Regulated River Hydrologic IQQM model



Key observations from the hydrologic analysis and IQQM models

The IQQM model simulated interactions between water sources as well as between the unregulated system, the alluvial and the regulated system. This interaction increases as usage increases to full development, and centres on the Mid Bega Sands Water Source which provides the link between the Upper Bega Bemboka River and the regulated Lower Bega River, and from which the greatest volume of alluvial water is extracted.

Access to groundwater by surface water licences in the Mid Bega Sands Water Source has a direct impact on surface water flows. Measured groundwater levels and water balance modelling illustrates that drawing down the alluvial groundwater during dry periods can significantly reduce subsequent freshes and base flows which in turn reduces inflows into the regulated Lower Bega River where a third of the regulated entitlement is located. Reduced inflow in turn results in greater releases from Brogo Dam and a reduction in reliability for all regulated users.

In a typical year there would be adequate access on the unregulated flows in the Upper Bega / Bemboka Rivers to allow all licence holders to extract their full annual entitlement. In dry years, however, river flow and daily access rules would limit extractions to a proportion of entitlement. This is the case for most unregulated rivers across the State.

In practice, during years when river flows or access rules do not prevent the taking of full entitlement, total usage is less than total entitlement as some licence holders have not yet developed their properties or installed the infrastructure to allow the extraction of their full entitlement. As current unregulated licence holders develop their properties and begin to access their full annual entitlement they will need to extract water in higher flows, typically in the 80th to 50th percentile range, to store water in off-river dams. These higher flows need to be set aside for existing licence holders, rather than committing them to new licences that could result from high flow conversions or allocated to environmental flows. This flow range is also required for regulated river users to access full entitlement through access to high flows and for river estuary environmental requirements.

Current operating rules for the regulated river are based on flow rates in the unregulated river. If there is sufficient flow in the unregulated river (e.g. 30 ML/day at Kanoona) to provide for the demands of water users downstream of the Bega-Brogo confluence, the amount of water released from Brogo Dam is reduced accordingly. As unregulated licences activate to full development over time, a higher flow rate will be required for the same volume of unregulated water to reach the confluence. The impact of increased extractions from the unregulated river on the operation and delivery of water in the regulated system was investigated using a hydrologic model.

The model shows that as unregulated users move into higher stream flows, the flow at Kanoona will drop below 30 ML/day more frequently, reducing the security of supply for water users between Kanoona and the Brogo confluence, and triggering more frequent releases from Brogo Dam to meet water demands downstream of the Brogo confluence. This increased demand for releases from Brogo Dam will be partially off-set by contributing flows from tributaries in which the volume of extraction does not increase.

Defining water extraction limits

The plan adopts a ‘long-term planning approach’ to sustainable water use by setting a long-term average annual extraction limit (LTAAEL), monitoring the benefits and impacts of the water management rules, and reviewing the LTAAEL and management rules if required.

LTAAELs are calculated as the average amount of water that can be extracted each water year from the unregulated streams and alluvial aquifers, based on the current level of entitlement, plus an estimate of the current basic landholder rights usage, plus an allowance for ‘acceptable growth’. ‘Acceptable growth’ includes increases in the LTAAEL through the granting of new Aboriginal Cultural or Community Development Licences, increased entitlements through High Flow Conversions, and the roll-out of tidal pool licences to reflect history of use. In some years the level of extraction will exceed this figure as carryover provisions allow more water extraction in some years as a result of underutilised account water from previous years. The LTAAEL does not include water taken through interception for farm dams within their harvestable right.

The plan establishes a monitoring, evaluation and review process which will enable the LTAAELs established by this plan to be amended in future plans if the water sharing arrangements encapsulated by this plan are not maintaining or improving the health of riverine and groundwater dependent ecosystems. Such assessments will require consideration of water sharing externalities such as climatic variability and dry sequences. This adaptive management process is discussed later in this document.

Determining the long-term average annual extraction limit

In setting the LTAAEL for a regulated river the first consideration must be to the current level of entitlement and possible interception and its relationship to possible future flows. During the period modelled in IQQM (1890 to 2007) the mean annual flow was estimated at 406,000 ML/year. During the dryer period from 1950 onwards the mean annual flow was estimated at 337,588 ML/year. The percentage of current level of entitlement and possible interception to flow is therefore

- 13.5 per cent of the full modelled record
- 16.2 per cent of the dryer period since 1950.

Averages are not the only consideration since they do not consider the variability. In the driest calendar year 1982, the Bega catchment received inflows of just 20,000 ML or 36 per cent of current entitlement and possible interception. In the driest water year (financial year) 2003/2004 inflow of 24,000 ML. If environmental requirements are also included, the current commitments are well above flows for driest years. Conversely, the current level of commitment is only 4 per cent of the wettest year and in wet years it is unlikely that all entitlement would be used as much of the crop water requirement would be met by rainfall. Provided that environmental water is protected through flow rules, the appropriate extraction limit is somewhere between these extremes, at an acceptable level of risk to users. It could be argued that with a rule that protects 50 per cent of high flows for the environment, that the LTAAEL should be boundless. In other words that entitlement would allow extraction of 50 per cent even in the wettest year on record.

There are several problems with a boundless limit. Firstly, during dry years existing users will try to gain full entitlement through accessing higher flow classes and high flows. Allocating too much additional entitlement will reduce existing user's access and therefore their reliability.

The second problem relates to reasonable expectation. If entitlement is issued at very low levels of reliability then it creates an expectation that water sharing rules will be relaxed during droughts. The HRC concluded that neither the interests of water users nor the longer term environmental health of the river would be served by perceived entitlements that are not matched by real availability of water under various conditions.

In deciding on the level of risk, it is important to consider the frequency which users receive less than 100 per cent reliability and the duration of restricted access periods. Figure 16 is a graph of the percentage of time and annual flow in the Bega River at Warraguburra. The three curves represent the frequency that annual flows exceed different volumes based on 3 different periods; the entire period modelled, the drier 50 year period at the start of the last century, and the more recent 14 year period prior to 2007. At 109,822 ML/y (twice the current level of entitlement to account for the environment's 50 per cent share) the current level of commitments would not be achieved 17 per cent of the time and 47 per cent over recent years.

Figure 17 is a plot of annual flow. Under the current level of entitlement and a 50 per cent environmental share there would be 10 instances in the period of record where the full access to entitlement would not be achieved. As this is increased to 141,730 ML/y the number of instances increases to 15 and the duration of instances increases from one to two years to three to four years in duration. [8]

[8] This figure is based on a 20 % reduction of hydrologic stress during low flow, and a 3:1 ratio for converting to 'high flow only' licences. This is discussed in detail later in this document.

The second consideration is what elements of the flow regime are stressed. HRC analysis of the allocation of streamflows in the Bega catchment concluded that the then management of the water resource was not sustainable. The introduction of cease to pump rules will go some way to achieving an environmentally sustainable level of extraction.

Shifting extractions from an over-stressed part to a less stressed part of the flow regime is another strategy of ensuring an environmentally sustainable level of extraction. Currently there is little utilisation of higher flow in the unregulated rivers. Modelling suggested that the median flows are typically only reduced by 10 per cent at Kanoona on the Bega River, unlike the low flows where they are reduced to 2 ML/day.

In weighing up the risks from increased high flow extraction and the risks from increased annual entitlement against the benefits of improvements in low flow stress, the IRP, in consultation with the community, proposed:

- that the LTAAEL be based on existing entitlement plus permitted growth in high flow
- that permitted growth could only come from converting low flow access entitlements to high flow access only entitlements.

It is important to note that sustainability is not the same as 100 per cent drought security. No system can be considered fully ‘drought proof’. Sustainability involves assessing and agreeing on acceptable hydrologic, ecologic and economic risks. The sustainable level of take needs to assess the amount of water intercepted by activities, such as farm dams as well as that extracted to determine the overall impact on the environment and downstream users.

Figure 16: Estimated annual flow duration curves

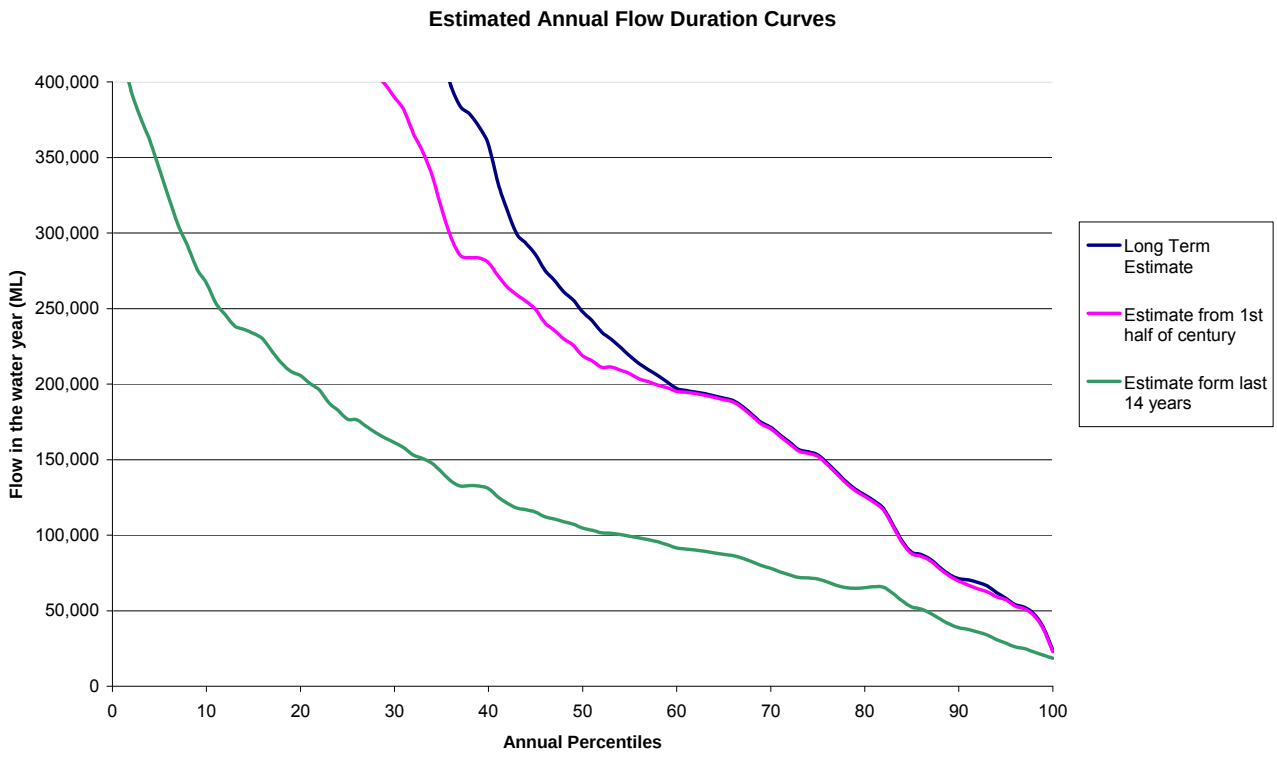
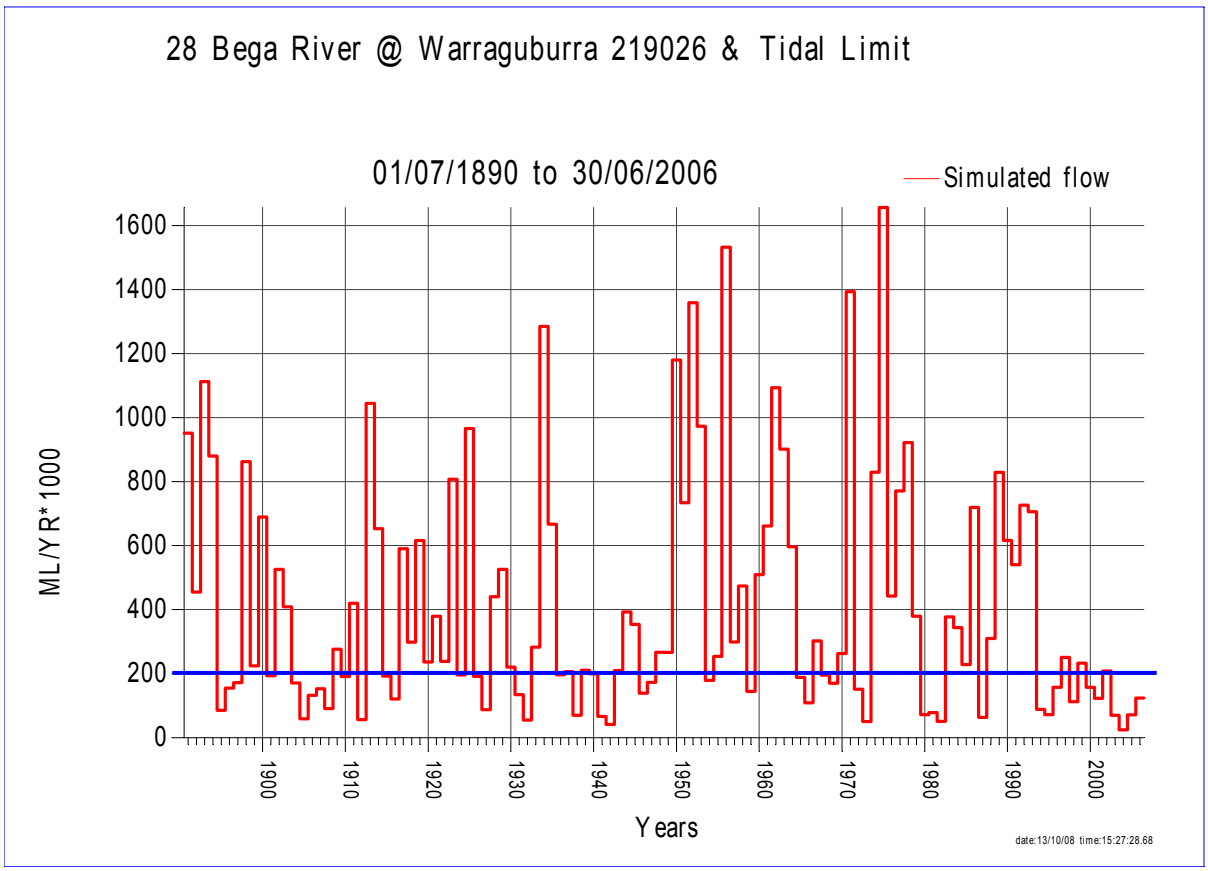


Figure 17: Annual Flow Bega River at Warraguburra Gauging Station



Rules for unregulated water sources

Background

All the unregulated rivers in the Bega Valley were embargoed as part of the whole south coast embargo on 4 July 2007.[9] A previous embargo was gazetted on May 15 2003 for applications for surface water licences under (Part 2) the WA 1912. This embargo excluded the Murrah and Bega estuary as well as the Upper Brogo River.

Prior to these gazetted embargoes an administrative embargo (where licence applications are accepted but not processed) had been in force since the early 1990s. The current level of entitlements for each water source is given in Table 9. Reinfelds *et al* (2004) looked at the patterns and effects of licensed surface water extraction in the Bega-Bemboka River and concluded that the Bega-Bemboka River system has one of the highest levels of surface-water diversion of any NSW South Coast catchment (but is still low when compared to diversions in most of the Murray-Darling Basin catchments).

Table 9: Entitlement in each unregulated water source

Water source	Unregulated	Local water utility	Stock and domestic	Total
Upper Bega/Bemboka Rivers	9 369.5	66	58.5	9 494
Upper Bega/Bemboka Rivers Tributaries	2 351.5	-	8.5	2 360
Sandy Creek	1 346.5	-	5.5	1 352
Tantawangalo Creek	3 942	1 500	25	5 467
Candelo Creek	1 161	-	49.0	1 210
Wolumla Creek	1 781	-	31.5	1 812.5
Mid Bega River Sands	4 053	2 640	46	6 739
Mid Bega River Tributaries	52	-	6	58
Upper Brogo River	-	-	-	Nil
Lower Bega Lower Brogo Tributaries	17 12.3	-	51.1	1 763.4
Bega River Estuary Tributaries	208	-	15	223
Total	**25 747.8**	**4 206**	**296.1**	**30 748.9**

Cease to pump rules

Cease to pumps (CTPs) are primarily used to achieve the River Flow Objective 1 (protect natural water levels) and River Flow Objective 2 (protect natural low flows). In estimating cease to pump rules the HRC aimed to preserve flows along the whole length of stream.

[9] Exceptions include water supply for stock, private domestic purposes, town or village water supply, Aboriginal cultural purposes (<10 ML/y), permits for water for road construction and maintenance and water carters for drought relief purposes etc still apply.

It is not possible to install and maintain an accurate river gauging network to measure flows in every river reach and on every minor tributary. The most practical and cost effective strategy is to maintain a smaller network of representative river flow gauging stations for use as operational flow reference points. For the Upper Bega/Bemboka Rivers Tributaries, the Mid Bega River Tributaries and the Lower Bega Lower Brogo River Tributaries water sources (see Table 3) the CTP flows are set at the river gauge on Double Creek, near Brogo. The reference river flow gauge for Wolumla Creek Water Source is the Candelo Creek gauge as flow conditions in these two sub-catchments are more closely correlated. This is in accord with recommendations made by the Healthy Rivers Commission (2000).

Because the flows in these water sources will not always correlate perfectly with the reference gauge, extractions may also only occur when there is a visible flow at the extraction point. Extraction therefore must stop when a flow is no longer visible along the length of the river. The rule established in the plan provides for an additional minimum level of protection for environmental health water. It ensures that at least river pools are kept full and river habitat features are kept connected for as long as there is a surface flow.

Bennett and Brooks (2004) used temperature data loggers and the river gauge at Kanoona to determine if stratification occurred in the nearby pool and at what flow stratification occurred. Thermal stratification was evident in the pool when flows ranged from less than 5 ML/day to approximately 150 ML/day. The minimum observed flow that effectively broke down the thermal stratification was approximately 500 ML/day; however it was not clear if stratification can be broken down by lower flows. These observations suggest that medium to high flows are required for de-stratification.

Reinfelds *et al* (2005) undertook an assessment of infra-red aerial photography and Daedalus airborne multi-spectral scanner imagery for environmental flow analysis of the Bega-Bemboka River. At 6 ML/day the Daedalus image indicated that in one reach of the Bega-Bemboka River a section up to 100m long probably did not have a continuous surface flow path. This observation coincided with a 6 ML/day at Kanoona. It is important to note that this study represents a point in time, and it is not known what extractions were being taken at the time or immediately prior to image capture.

Based on the results of the above-mentioned studies and considerations of the economic and community impacts of access rules, the Interagency Regional Panel decided to retain the CTP levels proposed by the HRC and SCWMC. The current percentage of time when extraction is permitted is given in Table 10.

Table 10: Cease to pump and high flow access rules

Water source	Reference points	Access to very low flow		Limit to change	High flow access
Upper Bega/Bemboka Rivers	Bega River at Kanoona (Gauge 210932)	Accredited	2 ML/d (100^{th})	2 - 5 ML/d (100^{th}-99.5^{th})	160 ML/d (50^{th})
		Not accredited	5 ML/d (99.5^{th})		
Upper Bega/Bemboka Rivers Tributaries	Double Creek near Brogo (Gauge 219017)	2 ML/d (79^{th})		1- 3 ML/d (86^{th} - 74^{th})	28 ML/d (30^{th})
Sandy Creek	Candelo Creek at Greenmount Road (Gauge 219034)	3 ML/d (74^{th})		1.5 -4.5 ML/d (86^{th} - 65^{th})	14 ML/d (30^{th})
Tantawangalo Creek	Tantawangalo Creek at Candelo Dam Site (Gauge 219022)	2 ML/d (99^{th}) 5ML/d (97^{th})		3- 7ML/d (98^{th} – 92^{nd})	60ML/d (50^{th})
Candelo Creek	Candelo Creek at Greenmount Road (Gauge 219034)	3 ML/d (74^{th})		1.5 -4.5 ML/d (85^{th} - 65^{th})	14 ML/d (30^{th})
Wolumla Creek	Candelo Creek at Greenmount Road (Gauge 219034)	3 ML/d (74^{th})		1.5 -4.5 ML/d (85^{th} - 65^{th})	35 ML/d (15^{th})
Mid Bega River Sands	Monitoring bore (GW039001)	Accredited	4.5 m AHD	4.5 m - surface	160 ML/d (50^{th})
		Not accredited	5.5 m AHD		
Mid Bega River tributaries	Double Creek near Brogo (Gauge 219017)	2 ML/d (79^{th})		1 - 3 ML/d (86^{th} - 74^{th})	11 ML/d (50^{th})
Lower Bega Lower Brogo tributaries	Double Creek near Brogo (Gauge 219017)	2 ML/d (79^{th})		1 - 3 ML/d (86^{th} - 74^{th})	28 ML/d (30^{th})
Upper Brogo River	Not Required				
Bega River Estuary tributaries	Visible flow required upstream and downstream of pump to be permitted to pump.				

High flow thresholds

It is cost effective to only pump once directly from the rivers when there is a demand for the water, and not to store water. Virtually all the development of irrigation on the unregulated rivers has started out in this way. Many town water supplies also start out the same way. This is termed 'run of the river extraction'. As the proportion of lower flows being extracted has grown, some operations have moved to pumping from high flows into storage. Pumping into storages improves reliability and generally has less impact on the riverine ecosystem.

To improve the health of the riverine ecosystem through a reduced reliance on low flows, conversions that allow access to the higher flows are provided for in the plan. The plan allows unregulated access licences, with access to the low flows, to convert to high flow licences with a conversion rate of 3 to 1. Setting the threshold for high flow licences requires a balance between the frequency of access, the protection of lower flows for other users and the in-stream environment. The higher the threshold, the less desirable it is to convert to high flow licences as the frequency of access is reduced. The lower the threshold, the greater the risk it may reduce the opportunities for downstream licence holders to access water, and the higher the impact on the riverine ecosystem.

A parallel set of flow thresholds in the regulated river system has been proposed to allow similar access to higher flows on the regulated river system. Further detail is provided in the regulated river section.

The thresholds for high flow category licence access are set out for each water source in Table 8. The Lower Bega Lower Brogo tributaries threshold is higher than other high flow access to reflect the need to provide uncontrolled flow requirements in the regulated river first. Generally the 50th percentile flow is used as the access threshold for the high flow licences, but in water sources where the 50th percentile is relatively small compared to the pump capacities that would be expected to be installed if high flow access was to be used, a higher flow (lower percentile) has been adopted. Similarly, in water sources which are already heavily committed (e.g. Wolumla Creek) the high flow access threshold has been set at a higher flow (15th percentile).

Comparison with Macro approach

The 'macro planning' process is the current approach of the NSW Office of Water to developing plans and is described in the manual *Macro water sharing plans – the approach for unregulated rivers. A report to assist community consultation* (DNR 2006). It was designed to develop broader-scale plans covering most of the remaining water sources in the State. Each macro plan covers a large river basin not a single sub-catchment. In this process, a risk and value assessment results in a classification for each water source. The classification assisted in determining the optimal balance between extraction and retention of water in-stream for each water source. These broad-scale relative assessments showed where water sharing rules needed to strongly protect valuable natural assets by limiting extraction or to provide for extraction by water users where there is significant community dependence on extraction. Generic indicative rules were developed for each classification to expedite the development of the plans by Interagency Regional Panels. Where necessary, the panels refined these indicative rules to reflect local circumstances.

The macro approach combined existing data with a risk management framework to explicitly manage the trade-offs required to develop plans. The Interagency Regional Panel classified each of the Bega Valley's water sources as high, medium or low on the basis of its in-stream values, and then determined the risks to these values. A comparison was then made against community dependence.

The Bega-Brogo plan was not developed under the macro approach. However, the Interagency Regional Panel checked that the rules in the plan were consistent with the indicative CTP rules from the macro-approach. The rules proved consistent, and therefore were not revised.

The panel understands that access to groundwater in connected systems such as the Mid Bega Sands can have a significant impact on river connectivity. The macro approach allows groundwater extraction in connected systems only where there are low risk to environmental values and high economic dependency on water extraction. This is the case in the Mid Bega Sands, provided enough medium flow passes through the system to allow connectivity.

In addition, general information is also available on the macro planning process in *Macro water sharing plans – the approach for unregulated rivers. A report to assist community consultation* This explains the method used to classify and set water sharing rules for unregulated streams across the State.

Trading of access entitlement

The water market is an effective and equitable way for water users to reallocate water between themselves based on their own business requirements. The NWI sets out guidelines for water trading. Trading can occur either on a permanent or temporary basis. Trading of water entitlement needs to be addressed in the plan within a framework that maximises the flexibility for users to be able to use water for its highest value purpose but does not adversely impact on water sources or other users.

In addition, the Interagency Regional Panel recommended that:

- no trading from the regulated system to the unregulated system be permitted, based on the substantial level of existing commitment in each system and the potential third party impacts
- no trading between unregulated water sources be permitted, based on the level of existing commitment in each water source and the potential third party impacts.

Trading within each water source is permitted except where management zones restrict trades-in to protect environmental assets. Comments are sought as to whether additional management zones are needed within the unregulated areas of the plan, minimising trades into certain areas within the water source (e.g. upstream of a location or into a high ecological valuable area).

Cochrane Dam releases

Earring Energy, the current owner of Cochrane Dam will require a water supply works approval and a major utility access licence. An access licence is required because it uses a small volume (10 ML/yr) in conveyance losses and power generation in diverting water from the dam to the outlet.

In developing the plan the SCWMC and panel recognised that, from time to time, the Bega Valley Water Users Association and Eraring Energy may negotiate a commercial risk-management arrangement regarding storage and release of water from Cochrane Dam into the Bemboka River for irrigation purposes. Water released from Cochrane Dam during natural low flow events has the effect of artificially elevating low flow levels along the trunk stream of the Bemboka River. The aim of river management during such times is to maintain a connecting flow of no less than 2 ML/day at Kanoona. This keeps fish refuge pools full and connected by surface flows along the river upstream from Kanoona and enables some aeration of water as it flows over riffles. This flow also ensures that there is water for basic rights along the river upstream from Kanoona. During peak stress periods a flow of approximately 12 ML/day at Morans Crossing is necessary to achieve a minimum flow of 2 ML/day at Kanoona.

It is important to note that while maintaining a minimum flow of 2 ML/d at Kanoona is the stated aim of river management during natural low flow times, this flow is not sufficient to provide a connecting surface flow through the Bega Sands section to the Brogo River confluence. Using Cochrane Dam releases to maintain a flow of no less than 2 ML/day at Kanoona is for the benefit of water users and the environment along the trunk stream upstream of Kanoona only.

A working group set up by the SCWMC recommended the following environmental flow rules for Cochrane Dam which have been incorporated into the plan:

- between the first day of October and the last day of March in any year, if inflows to Cochrane Dam fall below 3.5 ML/day then all inflows are to be transmitted downstream on a daily basis
- the transparent inflows detailed above are not required to be passed if the Cochrane Dam drought reserve is activated.

The catchment area upstream from Cochrane Dam is less than 25 per cent of the total catchment area upstream from the Brown Mountain Power Station. Several significant tributaries contribute to flows in the Bemboka River downstream of Cochrane Dam and above the power station. During low flow periods in winter months, when evapo-transpiration is typically low and irrigation demand is also low, storing of inflows to Cochrane Dam will not normally have a significant impact on downstream flows in the Bemboka River. During low flow periods in warmer months the inflows into Cochrane Dam typically become a more significant portion of downstream flows and are thus protected in this plan.

Cochrane Dam drought reserve

The purpose of the Cochrane Dam drought reserve storage is to ensure that adequate water supply is available between October and March for essential community needs and environmental maintenance along the Bega / Bemboka River upstream of Kanoona.

Cochrane Dam is to be operated such that at the 1 October in any water year, a minimum storage of 500 ML is set aside for those purposes of:

- access licences with access to very low flow along the Bega / Bemboka River upstream of Kanoona
- BLRs along the Bega / Bemboka River upstream of Kanoona
- TWS along the Bega / Bemboka River upstream of Kanoona
- maintenance of river connectivity from Cochrane Dam to Kanoona
- other matters the Minister considers essential.

When the district is drought declared and inflows in the three months prior to 31 March are less than the 1 in 20 year minimum inflow sequence, then on 30 June, a minimum storage of 500 ML is set aside. Releases from Cochrane Dam may not be made until there is sufficient water available for the Cochrane Dam drought reserve to meet this minimum requirement or the purposes as specified above. If the Cochrane Dam drought reserve has been credited on 30 June and the drought declaration is removed prior to 1 October, then releases may be made for any purpose subject to there being sufficient water available in Cochrane Dam to the purposes specified above.

When the district is drought declared and inflows to the Cochrane Dam for the three months prior to 30 June are less than the 1 in 20 year minimum inflow sequence, then the Minister may require that on 1 October, a minimum storage of 800 ML is set aside. Releases from Cochrane Dam may not be made until there is sufficient water available for the Cochrane Dam drought reserve to meet this minimum requirement or the purposes as specified above. If the Cochrane Dam drought reserve has been increased to 800 ML and the drought declaration is removed during the period 1 October to 31 March, then the volume of water in the Cochrane Dam drought reserve shall be reduced to equal 500 ML minus any water already released from the Cochrane Dam drought reserve since 1 October in that water year.

Access to very low flow

Access to very low stream flows is permitted for those activities that are considered to be 'critical human needs' or 'animal health requirements'. Although the level of extraction is small relative to entitlement it is in direct competition with environmental water requirements at its most critical time, therefore this access is limited to very specific licences. Licences with access to very low flows include:

- domestic supply
- town water supply
- fruit washing
- cleaning of dairy plant, processing and equipment for the purpose of hygiene
- poultry washing and misting
- cleaning of enclosures used for intensive animal production for the purposes of hygiene.

These licences are listed in a schedule in the plan. Their allowances are calculated based on a maximum volume of 20,000 litres (0.02 ML) per day for each farming purpose (dairy wash down) licence held in each water source. The Bega Cheese factory will have access to the very low flows for the purpose of hygiene.

The water supply for the township of Bemboka is sourced from the Upper Bega/Bemboka Rivers Water Source. There is no alternate water source for this town water supply system. Releases from the drought storage reserve in Cochrane Dam include an allowance for town water supply. At the commencement of this plan this licence will be added to the schedule which lists licences with access to very low flows. The onset of very low flows should trigger the introduction of a demand reduction strategy for Bemboka town water supply to limit total demand to 0.2 ML/d during very low flows.

BVSC also supplies 41 rural properties with a connection to the trunk main upstream of Candelo. Due to the configuration of pumps and height of these properties, water from Tantawangalo may be needed from time to time during very low flows to maintain supply. The plan will restrict this to 0.2 ML/d in the very low flow.

The plan provides an estimate of the water requirements of domestic and stock rights within each of the water sources. Activation of domestic and stock rights may increase during the life of the plan. The plan cannot limit or restrict these rights, but the WMA 2000 itself provides for restrictions on domestic and stock Basic Landholders' Rights, through the Reasonable Use Guidelines.

Total daily extraction limits

One of the plan's objectives is to maintain a contribution of flow from the Bemboka Water Source to water sources downstream of the Bega River's junction with the Brogo River and to the Bega estuary. Another objective is to provide for the protection of the natural seasonal variation of low flows during dry periods. These two objectives are achieved through the use of total daily extraction limits (TDELs). These will be introduced both above and below Kanoona. The plan allows for TDELs in other water sources, if required.

A TDEL is the total volume of water that may be extracted daily under access licences from an unregulated river in a particular flow class. They are used where peak daily demands exceed supply and a CTP alone is not sufficient to ensure an adequate environmental share of the water within that flow class. No TDEL was set for high flow licences as the level of annual entitlement is likely to limit daily extraction.

Operating to TDELs is not much different to what was proposed in the Bega Brogo Water Management Plan (BBWMP) except there will be a cap on the amount of daily extraction and it will operate both above and below Kanoona. The planned environmental water will be the top 41 per cent of A class flows (when flow is above ground in the Bega Sands). No TDEL has been established for B class flows above Kanoona because the peak daily demand is less than the TDEL for that class. That is, it is highly unlikely that the water will ever need to be rationed in this flow class.

By setting the flow classes upstream and downstream on the same trigger at Kanoona means that all users will change classes at the same time. In developing the TDEL for the Mid Bega River Sands recharge from rainfall (2 ML/d) and a factor to account for increased area (1.25) were applied. An area factor was not applied to the below ground extraction as tributary inflows surface flows would normally not occur. Each category of licence will be assigned a TDEL based on proportion of entitlement at the time of exhibition.

Individual daily extraction limits

Where TDELs are established by the plan each licence holder can also be assigned an individual daily extraction limit (IDEL) which is their individual portion or share of the TDEL. Where users on a stream initiate rostering arrangements, they can share the water in what ever equitable arrangement they develop, provided their aggregated extractions do not exceed the TDEL. Rostering can offer flexibility in meeting the requirements of individual water users within the constraints of the overarching TDEL.

Table 11: Sharing between upstream and downstream Bemboka/Bega and the environment

Flow class	Bemboka Bega Water Source	Mid Bega Sands Water Source	Percentage of top of flow class
Very low flow	**Very low flow access users only**	**Very low flow access users only**	
A	S&D 0.2 LWU (Bemboka) 0.2 Major water utility 0.01 Unreg 29.59 Total 30.0	Below Surface level S&D 0.15 LWU 4.7 Unreg 7.15 Total 12.00	30 + 12 = 63 % 65 + 2
		Above Surface level S&D 0.15 LWU 6.7 Unreg 12.0 Total 18.85	18.85 +30 = 59% 1.25(65) + 2
B	A plus additional Unreg 32.0	A plus additional LWU 6.1 Unreg 12.5	62 + 37.6 = 50 % 1.25(160) +2

- the major water utility is the Brown Mountain Power Station
- extractions by Bega Cheese are included in the 'unreg' TDEL
- the distinction between A1 and A2 class flows is whether surface flow is visible immediately downstream of the Princes Highway bridge
- in developing the TDELs for the Mid Bega Sands, the flow percentiles at Kanoona were multiplied by 1.25 to estimate the equivalent flow percentiles at the Bega-Brogo confluence.

Users that do not want to participate in rostering arrangements will receive an individual daily share. In addition, an IDEL can provide greater certainty regarding a user's share. For example, an IDEL assigned to Bega Cheese to access 1.3 ML/day when flow is below ground level in the Mid Bega Sands Water Source and 2.0 ML/day when it is above provides clarification of share allocation.

IDELs may also be assigned to users who operate outside of any rostering arrangements. This assignment may occur in instances where licence holders do not agree to a rostering system or to those that systematically breach such arrangements. This strategy ensures that the share of the TDEL assigned to each licence is maintained.

Carryover and water accounts

A water allocation account will be established for each water access licence. Water is credited to the account when an available water determination is made, and debited when water is extracted. There is enormous variation in the annual flow volumes between years. The plan allows unregulated river licences (subject to compliance with daily access rules) to:

- withdraw up to 200 per cent of entitlement in any one year
- carry over up to 100 per cent from one water year to the next
- provided that the volume of water taken over any three consecutive water years does not exceed 300 per cent of annual entitlement.

Unregulated river available water determination

Each year, an available water determination will be made defining how much of the share component will be available under each category of licence. Specific purpose access licences such as domestic and stock or local water utility access licences, will generally always receive 100 per cent of their share component, although in years of exceptional drought daily access rules may limit extraction so that the full annual entitlement cannot be realised.

Generally the available water determination for general unregulated river, unregulated river high flow and aquifer access licences will be 1 megalitre per unit share. However for the first year of the plan, a one-off announcement of 2 megalitres per share is proposed. This, combined with the carryover rules, will enable licence holders to use up to twice their water allocation in a year provided that over a consecutive three year period they do not exceed the sum of their water allocations for those three years.

An available water determination of less than 1 megalitre per unit share may be made if the long-term average annual extraction limit is being exceeded, although this is unlikely as the limit is based on the level of existing entitlements plus the granting of specific new access licences.

Integrating with the Bega River Health Agreement

The South Coast Water Management Committee negotiated a Bega River Health Agreement (BRHA) during the development of the Bega River Catchment water sharing plan. The vision of the Agreement 'is that the water sources and the dependent ecosystems of the Bega River Catchment will be protected and enhanced, while the social, cultural and economic future of the catchment community is recognised and fostered.'

The BRHA sets out targets that are both aspirational and measurable on a range of catchment issues. The South Coast Water Management Committee (SCWMC) based their cease to pump rules on the understanding that there would be a trade off between flow rules and other measures to improve river health through a commitment of users to the River Health Agreement.

The plan will link water access to the BRHA through dual cease to pumps (CTP). NSW Office of Water of Water will hold the list of accredited users. Accredited users will have access to the lower CTP.

For those water sources with TDELs the accreditation scheme will allow those accredited to access flow below the A Class and above the Very Low Flow Class, in the Low Flow Class. In the case of the Upper Bega/Bemboka Rivers Water Source this is between 2 and 5 ML/day at Kanoona. The proposed TDEL for this water source is 30 ML/day for all uses, with individual IDELs issued based on the same proportion of the TDEL as its share component bears to all share component of licences in that category. For example, if there are 30 extractors all with the same entitlements it means each would have an IDEL of 1 ML/day. The plan allows that group rostering can exist and the roster group will share in the total for all in the rostering group. Therefore those that are accredited would be in one group and those that are not, in another. The same would occur in the Bega Sands as described in the next chapter. If this option is adopted users will have until year six of the plan before the higher CTP is introduced.

Tantawangalo water source and weir and Yellow Pinch Dam

Tantawangalo Weir provides a vital source of water supply security for the Tantawangalo-Kiah Town Water Supply Scheme, servicing the southern parts of Bega Valley Shire, including the towns of Merimbula, Tura Beach, Pambula Beach, Pambula and Eden and several villages, settlements and individual properties supplied directly from the main trunk pipeline.

Since 2003, BVSC has operated extraction from the weir according to protocols which reduce extraction as flow in the creek declines through releasing water downstream via the weir scour valve. These protocols were developed following the very dry period between mid-2002 and early 2003, when the majority of water flowing in the creek at the weir was extracted for town water supply. At this time there was no alternative water supply for the villages of Candelo and Wolumla and the 176 rural properties upstream of Yellow Pinch Dam. Extraction of these low flows significantly reduced the volume of water flowing downstream of the weir, impacting on the volume of water remaining for the environment as well as water for essential domestic and stock basic rights.

Since 2003 BVSC has installed pumping, valving, pressure control and tank infrastructure to enable water to be pumped upstream of Yellow Pinch Dam in times of drought. This has enabled BVSC to reduce volumes extracted from the weir during drought times and further improve the operational protocols developed in 2003, to comply with the Healthy Rivers Commission (HRC) Recommendations of 2000.

The HRC recommended that Council should not be permitted to extract more than 50 per cent of the flow at any time, with special provisions to allow greater extraction if available supplies are temporarily unable to meet demand (after the imposition of restrictions) (HRC 2000 p143). No cease to pump (CTP) rule was suggested for Tantawangalo weir by the HRC.

A 5 ML/day measured at the Candelo Dam Site gauging station in the Tantawangalo Creek Water Source was suggested by the HRC for extractions for commercial activities. A socio-economic assessment undertaken by the SCWMC indicates that this CTP may cause significant impacts on water users in this water source in some years. A five year phase-in period was established to allow water users to adjust from the previous Tantawangalo Creek Voluntary Water Sharing Agreement (having a CTP of 2 ML/day) to this plan. In some cases this adjustment may require water users to invest in off-stream water storage, develop alternative stock feed sources or possibly change enterprise.

The plan recommends:

- a 2 ML/day CTP (measured at Tantawangalo Creek at the Candelo Dam site gauge) for all commercial activities in the Tantawangalo Creek Water Source
- a restriction of 0.2 ML/d for town water supply for flows below 2 ML/day (measured at Tantawangalo Creek at the Tantawangalo Mountain gauge)
- a restriction of town water supply extraction to 50 per cent of daily flows, when flows are above 2 ML/day (measured at Tantawangalo Creek at the Tantawangalo Mountain gauge).

Bores constructed adjacent to rivers

The panel has determined that groundwater and streams of third order or higher are highly connected in the alluvial sediments. Any new bores constructed within 40 m of the top of the high bank of any third order or above stream, or lagoon, could impact on daily stream flows. New bores will be allowed if:

- the water supply work being used to take water from alluvial sediments is drilled into the underlying parent material, and constructed as set out in the plan
- the water is extracted as part of a dealing involving the conversion of an unregulated river access licence to an aquifer access licence.

Where the 40 metre distance restrictions cannot be met, the Minister may grant a water supply work approval provided:

- a hydrogeological study undertaken by the applicant, and assessed as adequate by the Minister
- an application to the Minister by the licence holder provides evidence that no drawdown of the groundwater at the outside edge of the perimeter of the groundwater dependent ecosystem in Schedule 4 of the plan occurs.

Construction of dams

For the strategy of shifting extraction from low flow to higher flows to be effective requires the construction of dams. There are two types of dams:

Off-river dams

Capture of water in a runoff harvesting dam requires no licence if the dam is within the maximum harvestable right dam capacity for the property on which it is located. These have been considered in setting the extraction limit for the Bega Valley.

Extraction of water beyond the permissible harvestable right is covered by a category of access licence established by regulation under section 57 (1) (l) of the WMA 2000. The Water Management (General) Regulation 2004 currently allows for the establishment of unregulated river (high flow) access licences. The water sharing plan defines the conversion rules from a normal unregulated river access licence to these high flow licences. The plan proposes a conversion factor of 3 to 1.

Converting to the higher flow access also results in reduced frequency of access. An off-river dam can be utilised to pump water at a higher rate and store it until it is required for use, thus buffering the flow availability.

In river dams

Under the NSW weirs policy on river dams on 3rd order streams or greater are permitted subject to: the Farm Dams Policy (harvestable rights), the State Weirs Policy and a minimal harm test under the WMA 2000.

Under the Farm Dams Policy, a farm dam that is less than the maximum harvestable rights dam capacity is considered a basic landholder right and can be built on a 1st or 2nd order stream without the need for a water access licence.

Under the State Weirs Policy, the construction of new weirs is discouraged, but can be done where 'it can be demonstrated that the primary component of the proposal is necessary to maintaining the essential social and economic needs of the affected community' (DLWC, 1997).

Assuming the in-stream storage can meet this criteria then an application could be made and these would be assessed against the minimal harm test under the *WMA2000*.

The plan will not permit applications for dams in high conservation areas. The Office of Water is seeking input into the identification of any other locations, in addition to the Upper Brogo River Water Source, Upper Bega River Estuaries Management Zone; and the Upper Tantawangalo Management Zone where applications for in-river storages might be undesirable.

In-river dams can also be important for utilising high flow conversions. If the dam is approved for construction, it may have transparency rules imposed as approval conditions which could require passing of all flows up to the high flow access threshold. Thus such a dam would only capture high flow water and store it in-river rather than on-farm. Other transparency rules might be designed which result in the in-river dam capturing a combination of low and high flows, but these are more complex to administer.

Rules for regulated water sources

Background

Brogo Dam is operated by State Water. It has a capacity of 8,980 ML and was constructed in 1976. The main regulated river was embargoed for accepting applications for water licences for all purposes on 11 March 1983. This was extended to include the Coopers Creek reach on 3 June 1983.

There is no water development above the dam with 70 per cent covered by National Park. The outflow capacity of the dam is 750 ML/day but normal releases are approximately 70 to 80 ML/day during peak irrigation in summer. BVSC extracts between 1 and 3 ML/day, depending on the time of year, from an offtake that is 4 kilometres downstream of the dam. Minimum outflow from the dam is 4 ML/day. Under normal conditions, about 1 ML/day is currently required to supply the Brogo-Bermagui water supply system.

The regulated system is divided into four reaches:

- 1A – Brogo River from the upper reaches of Brogo Dam to the North Brogo Gauge (gauging station number 219025)
- 1B – Brogo River from the North Brogo Gauge to the Angledale Gauge (gauging station number 219025)
- 1C – Brogo River from the Angledale Gauge to the Bega River junction
- 2 – Bega River from the Brogo River junction to downstream to its junction with Jellat Jellat Creek.

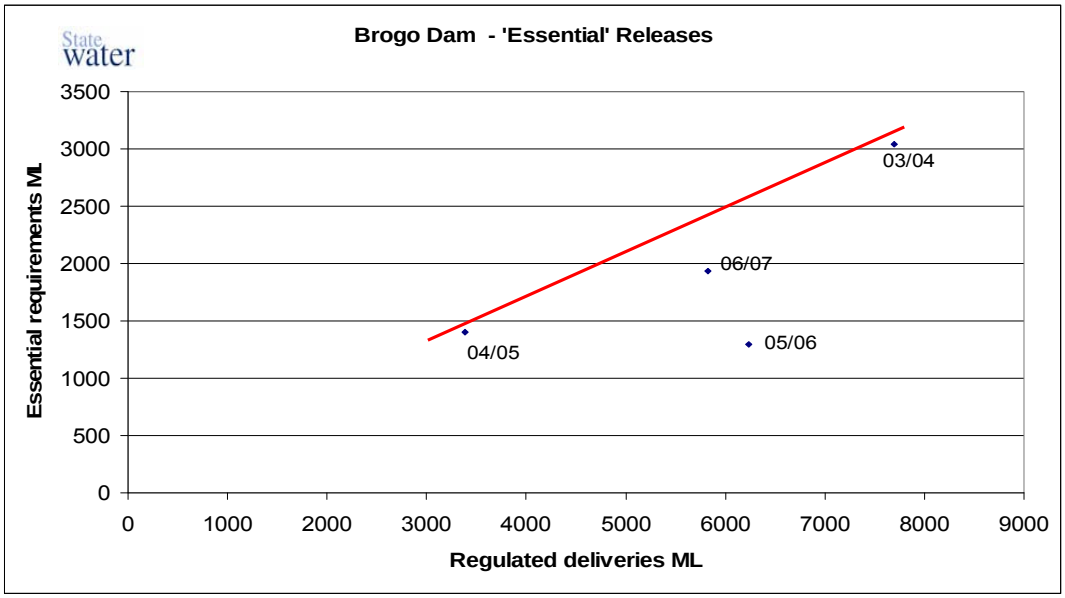
In operating the river, State Water releases water to meet water orders plus system losses, taking into account tributary inflows. System losses include evaporation, losses associated with transferring water from the dam to the user's pump, metering inaccuracies, and end of system losses. The regulated river has a high percentage annual loss relative to releases (Figure 18). Useful downstream inflows which supplement releases to meet downstream demands are 1,400 ML/year. Therefore, any reduction in useful inflow will reduce reliability to regulated river entitlement holders.

A sand weir or barrage has been periodically erected across the Bega River near the tidal limit to prevent salt water intrusion into the lower freshwater reaches of the river where water is extracted by licensed irrigators and stock and domestic users. The barrage is usually only erected when freshwater flows are very low and/or the entrance to Mogareeka Inlet is closed. The barrage is erected by excavating sand from the bed of the river. It can remain in place, subject to periodic openings, for as little as a few weeks up to several months, being washed out by higher stream flows (around 100 ML/d).

State Water currently uses the gauge at Angledale and a steady visible flow at Apps Crossing to re-establish the benchmark flows required each year. If Kanoona is greater than 50 ML/day then irrigators from the Bega Junction to the end of system are considered to have enough water and State Water only runs the river to a visible flow at Apps Crossing.

Seventy eight per cent of entitlement in the Brogo is below the lowest gauge at Angledale. Therefore there is a level of hydrological uncertainty when considering impacts downstream. Daily decisions to let out water are currently based on changes to water levels rather than volumes at some locations. Current operation triggers are also based on current usage. This will not be the case once all unregulated and regulated entitlements are being used.

Figure 18: Water releases and metered extraction from the regulated river source



Impact of river regulation

River regulation alters the natural flow regime. The flow regime is regarded by many aquatic ecologists to be the key driver of aquatic ecosystems. Bunn and Arthington (2002) identified four key principles to highlight the important mechanisms that link hydrology and aquatic biodiversity:

- flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition
- aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes
- maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species
- the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes.

Examination of the changes to the flow regime was the starting point in the development of the environmental requirements. The Interagency Regional Panel focused on the following elements of the flow regime and used the IQQM model to asses the changes from natural.

Seasonal redistribution – Refers to shifting the timing of flow from one season to another. Figure 19 shows there is a seasonal redistribution.

No drying out – The Brogo River is understood to naturally have a very persistent flow and natural drying would be expected to be very infrequent. The regulation of the Brogo River means the river rarely dries out as there is an ongoing requirement for the Local Water Utility. Currently the minimum discharge that is maintained, even when there is no downstream demand, is 10 ML/day. As the periods of no downstream demand occur in wet periods it is valuable to keep the river wet at this time. The Healthy Rivers Commission recommended increasing this to 15 ML/day, which has been adopted.

Removal of freshes – Brogo Dam has minimal impact on high flows because it is so small. This impact will increase if all licences are fully developed. The dam fills quickly and spills under current levels of irrigation development and long-term historical conditions, over 60 per cent of the time. It is estimated that under a full development scenario spills events may be 14 per cent less frequent.

Constant flow – The the HRC expert panel recommended a set of rules to introduce more variability into the river. These may be effective in the upper reaches, however in the lower reaches dominated by sand, the alluvial acts as a buffer. Small daily increases as recommended by the HRC would be quickly smoothed out. IQQM modelling and measured release patterns indicated that natural variation was less than current release patterns, due to the variability of the irrigators' demands, therefore eliminating the need to introduce variability.

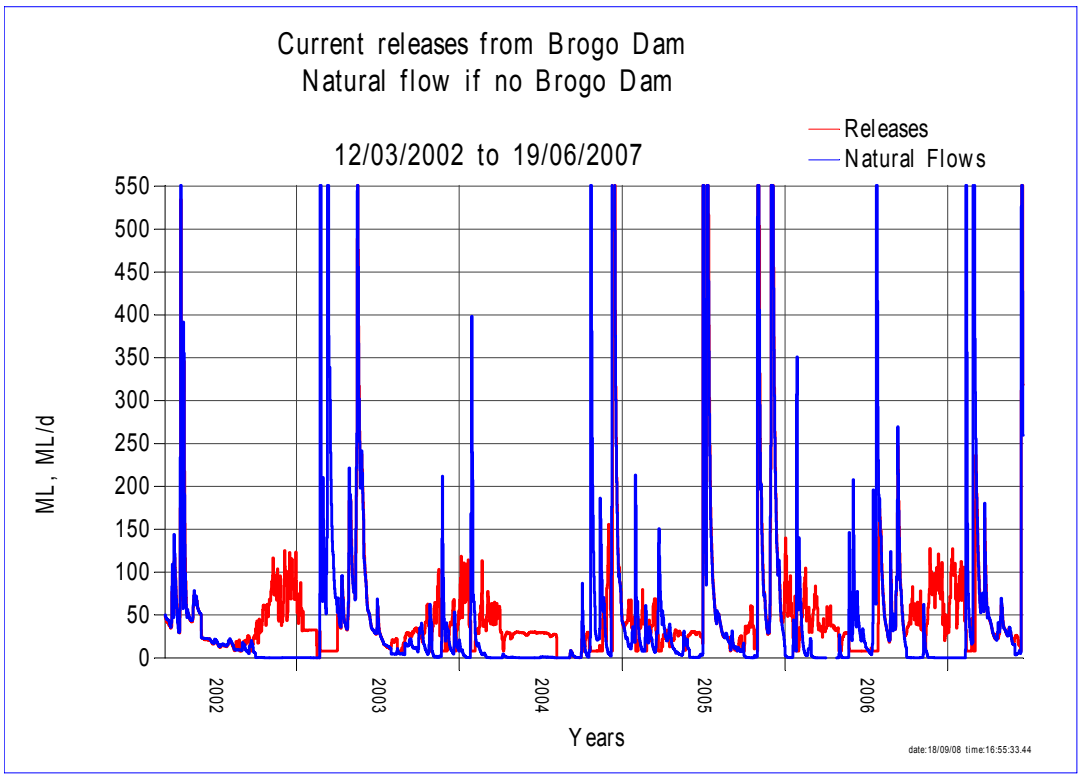
Loss of floodplain connectivity – The dam and extraction rate are too small to affect flows which connect the river with the floodplain.

Loss of volume downstream – The annual volume was considered as part of the LTAAEL. As regulation tends to supplement low flow and Brogo Dam has little impact on high flows, it is loss of volume in the midrange that is considered most important.

Cold water from dam – Water temperature is an important regulator of the natural ecological processes in rivers and streams. Dams have the potential to alter the natural temperature characteristics of the water associated with aquatic ecosystems, creating potential for serious ecological impacts (Preece 2004). Brogo Dam had a variable level intake mechanism installed in 1995 to improve the ability to mitigate the effects of cold water pollution and improve the water quality of releases by not releasing the anoxic water at the bottom of the storage. Water is usually drawn off between 2 to 4.5 m below the water surface for operational releases. An assessment by Preece (2004) classified Brogo Dam as having a medium impact.

Water quality decline when dam level low – Following a dry spell and the release of up to 85 per cent of the water in the dam to meet downstream entitlements, the quality of the water left in the dam is relatively poor, with water high in iron, colour and turbidity released downstream. This can lower the quality of water supplied to town water supply customers on the Brogo-Bermagui water supply system.

Figure 19: Comparison of current releases from Brogo Dam to modelled natural flow



Environmental water requirements

The Interagency Regional Panel looked at the potential for transparency rules (where all inflow to the dam is released, up to a specified flow rate) and translucency (where a percentage of inflow to the dam is released, above the specified transparency flow rate). The maximum release capacity from the dam is 750 ML/day; therefore at times these rules would be limited by physical constraints.

The panel discussed IQQM modelling results to assess how a transparency and translucency rule would benefit the environment. Modelling shows that a 90/20 rule, where the dam is transparent up to the 90th percentile and 20 per cent translucency afterwards would only reduce big spills one per cent of the time. It is possible that a transparency-translucency rule could 'join shorter droughts' by preventing the dam from refilling in between droughts. This could have an impact on users.

For most of the time a transparency-translucency rule would not affect the low flows as they are dominated by water released for orders. The medium flows would benefit most, however a natural spill would release better quality water than a transparency-translucency rule. The water at the bottom of the dam is of poor quality, being much colder than the ambient water temperature and much lower in dissolved oxygen. If smaller freshes are let through, the dam remains at a lower level, decreasing the frequency of larger freshes, which are important for fish passage and scouring. The translucency aspect of the rule appeared to be limited in its effectiveness, mostly due to the very small size of the dam and therefore the relatively frequent spilling.

The panel examined specific events and found a transparency rule would be sufficient to secure some environmental benefit (macro-invertebrate populations, maintaining some medium freshes). The 15 ML/day recommended by the HRC was adopted by the panel. This represents an increase of 5 ML/day from the existing operational rule. Hydrologic modelling by the Office of Water indicates that

this increase would have no discernable impact on users' reliability under normal circumstances. However, during unusually dry conditions, a 15 ML/day transparency rule would decrease the security for water users. Subsequently, the panel recommended that the 15 ML transparency rule apply only when the storage volume in Brogo Dam is at least 50 per cent. Below 50 per cent storage, no transparency rule will apply.

The end of system requirements are dependent on the operation of the sand barrage. The IQQM modelling assumed that the barrage is operated for fish passage requirements. These requirements are the main environmental requirement and are currently accounted as end of system losses.

The Brogo River is still in relatively good condition at present compared with other rivers in the Bega Valley. The panel concluded there was no reason to significantly change existing operational practice; however the condition may deteriorate over time. The panel recommended that the plan contain a provision that could allow an Environmental Contingency Allowance (ECA) of 500 ML/y to be introduced once monitoring and increased knowledge of the environmental requirements of the system was achieved. The ECA could be used for:

- flushing algal blooms
- fish kills from tributary inflows (i.e. low dissolved oxygen after bush fires)
- scouring below dams to reset biofilms
- mitigating cold water pollution.

Trading of access licences

The Interagency Regional Panel recommends unfettered trade within the regulated river water source. As groundwater and surface water is to be managed as one regulated resource, unrestricted trading between the groundwater and surface water licences will be allowed.

Due to the narrow floodplain, the lag effect between river flow changes and groundwater level fluctuations is minimal and therefore any general security surface water licence traded into the alluvial aquifer will be subject to the same operational rules as the regulated river licences in relation to uncontrolled flows and supplementary water.

To ensure that the reliability of share components for existing users in unregulated streams does not decrease, trading from regulated streams to unregulated streams will not be allowed. Prohibiting trade from regulated to unregulated streams will also allow for all current entitlements on the unregulated streams to be activated while still allowing for some protection of the variation in stream flow in unregulated streams.

Level of security

Section 58 of the WMA 2000 sets the priorities between different categories of licence in the following order:

- local water utility access licences, major utility access licences and domestic and stock access has the highest priority; followed by
- regulated river (high security); then
- all other access licences for example general security; with
- supplementary water access licences have priority below all other licences.

If one access licence (the *higher priority licence*) has priority over another access licence (the *lower priority licence*), then if the water allocations under them have to be diminished, the water allocations of the higher priority licence are to be diminished at a lesser rate than the water allocations of the lower priority licence. As from 1January 2006, an amendment to the WMA 2000 meant that plans could provide for different rules of priority. The panel recommended that the order of security be the same as the WMA 2000.

Regulated river available water determination

Licences with a higher priority are afforded a greater level of reliability. The level of reliability is established by the rules used for the Available Water Determination (AWD). This is an assessment undertaken by the Office of Water of the amount of available water for sharing. The process used is basically a 'balance sheet' with the water in the headwater storage balanced against the demands of the environment, consumptive use, and system requirements. The major elements of this 'balance sheet' are described below.

Total resources

The total resource available is determined by considering the volume of water available in storages, together with a minimum set of expected inflows which can be expected during the water year. The minimum inflows are based on the worst recorded drought.

High priority system supply requirements

These requirements include planned environmental water, (such as an Environmental Contingency Allowance), domestic and stock, high security entitlements and Local Water Utilities. Some of the high priority requirements are also required to be supplied in the following water year, so additional water is set aside for future seasons. This is called a storage reserve.

System losses

System losses include evaporation, losses associated with transferring water from the dams to the user's pump, and losses associated with maintaining end of system flows. These end of system flows are maintained for the purpose of ensuring ordered water is available and/or meeting downstream minimum environmental flows or domestic and stock (riparian) requirements.

General security allocation calculation

When the above three factors have been determined, the general security allocation may be calculated. The water available for general security use is determined by subtracting the high priority system supply requirements and the system losses from the total resources. This remaining volume is then divided among the general security licensed entitlements. If the remaining resource is larger than the total entitlements, then 100 per cent allocation is declared. If the remaining resource is less, then the resource is shared out in proportion to entitlement, resulting in an allocation of less than 100 per cent.

A new AWD is calculated in July (at the start of the water year) and updated after a major inflow. Due to the size of the Brogo Dam relative to entitlement, the maximum start of year allocation for General Security users is 40 per cent.

Currently in regulated rivers, movement of surface water into the adjoining alluvial aquifer is accounted for as a loss to the system. By including extractions from these aquifers in the water accounting system, the level of entitlements will increase but the volume of water loss will decrease. Therefore the total water volume accounted for will be the same. Groundwater extractions will be managed together with surface water extractions on an annual basis through the AWD.

In working out the annual available water determination (AWD) the future risk of failure and impact are considered against the losses forgone for use of water now. This risk is encapsulated in the forecast sequence of inflows adopted. The lower the adopted sequence volume, the higher the conservativeness. Being too conservative in the assessment would limit the percentage of time the storages can support full allocation and reduce the overall productivity of the system. Not being conservative enough could result allocating water that does not actually materialise and potentially result in mid-year reductions in the AWD with severe impact on users who will have planted crops based on the presumption that the AWD will be delivered.

Sharing the pain

It has historically been the case that high security users receive an allocation equal to 100 per cent of their entitlement even if general security users are on zero allocation. However, this does not encourage high security users to conserve water during dry periods.

It was decided by the Interagency Regional Panel that high security users should be on 100 per cent allocation when the maximum start of year allocation for general security users is 40 per cent. Below this level, the plan allows for a 1 per cent reduction in high security allocation for every 2 per cent reduction in general security allocation. As a result, when general security allocations reach zero, high security allocations reach 80 per cent, and will be maintained at this level for as long as storage conditions permit.

Bega Valley Shire Council as the local water utility is responsible for managing demand (i.e. town water supply consumption), taking into account the needs of other users and broader community expectations. Council has a comprehensive and formally adopted water supply policy which includes trigger levels for applying water restrictions across all of its own town water supply systems. Restrictions to the consumption of reticulated water are regulated by the *Local Government Act (LGA) 1993*. General provisions for water restrictions are defined in Part 2 of the *Local Government (Water Services) Regulation 1999.*

Council's water supply policy is available on its website at www.begavalley.nsw.gov.au/Your Council/policies/2-4-1.pdf.

Conversions

The agreement under the *National Water Initiative* (Clause 60) requires that all states establish arrangements to facilitate trade, including (where appropriate) water entitlement exchange rates to manage differences in entitlement reliability, and supply loss and supply source constraints.

Within the regulated water source, this requires the implementation of a conversion factor between general security and high security entitlements. Water sharing plans do not generally set this figure, rather they require that the Minister establish a conversion factor that protects the environmental water, domestic and stock rights, Native Title Rights and the reliability of supply to all other access licences in this water source.

Establishing a conversion rate needs accounts for both the hydrologic and economic conditions present in the valley. Such issues as the industries present in the valley and their desired level of security (both general and high security), the volume of entitlement likely to convert, the length of drought sequences and the ability of minimum inflow sequences to provide high security needs must be taken into account. The Interagency Regional Panel recommends a flat conversion rate which assumes all general security entitlement can be converted. The panel also recommends unlimited conversions between general security and high security entitlement.

Conversion rates are based on average relative reliabilities. To avoid the situation of conversions during drought as a way to 'manufacture' water, which could impact on general security reliability, a licence converted from general security to high security, can only come into operation once Brogo dam reaches full capacity.

Carryover

Carryover in a regulated river allows individual entitlement holders to carry over part of their unused allocation from one year to the next. This allows entitlement holders to decide how to use their allocation in the short and long term to best suit their individual business risk profile. This promotes better use of water between years rather then force use in the current year and enables business flexibility.

One effect of allowing carryover is that as sleeper entitlements carry water across from one year to another, it reduces the AWD to active users. During targeted consultation, water users recommended against carryover.

The panel decided against carryover at the start of the plan. The plan has a provision allowing the Minister to introduce a 10 per cent carryover when 75 per cent of general security entitlement has been activated. The Minister will seek advice from water users prior to introducing any carryover. Groundwater licences will have the same carryover rules as surface water licences. Carryover water is lost from the account once the dam spills.

Access to high flows in the regulated river

Historically access to off-allocation flow has been announced when triggers for tributary inflows or dams spills have occurred. This can lead to a situation where some water users may have traditionally used more than their licensed entitlement (in ML). Under the WMA 2000 all water extraction that is not BLR needs to be licensed or exempt from having a licence. These past extractions that were additional to general security entitlement will be formalised as a supplementary water entitlement. Users that can demonstrate a history of use of off-allocation water or a usage in any year that exceeds their total entitlements (in ML) will be granted a supplementary licence at the commencement of the plan. This entitlement is in addition to their existing entitlement.

In addition to supplementary water, the plan will provide for the declaration of uncontrolled flows to allow general security licence holders greater access to water through high flow extraction from tributary inflows when their allocations are reduced below 100 per cent. In any one year, a licence holder may extract their allocation (in that year) plus water during uncontrolled flow events, providing the volume they extract is not greater than their total entitlement (in ML). This also helps where users have used their allocation, as they will not have to wait for a new AWD before extracting water.

The Interagency Regional Panel recommended that up to 50 per cent of daily high flows can be extracted as uncontrolled flows and supplementary flow in line with the HRC recommendation. Ordered water is not affected by this high flow access rule but still forms part of the 50 per cent share. Water users must advise State Water of their meter readings prior to commencing and immediately after extraction of water during uncontrolled and supplementary events or otherwise water will be debited as account water.

The Interagency Regional Panel has aligned high flow in the unregulated system to high flow access in the regulated system. The triggers for uncontrolled and supplementary access are set out in Table 12. To provide an opportunity to access high flows on the regulated river similar to that provided on the unregulated rivers, links between unregulated higher flow classes and, uncontrolled and supplementary access provided on the regulated river were derived as follows:

B flow class (generally above the 80th percentile flows) is currently undeveloped on the unregulated rivers, but access to this middle flow class would be needed if licence holders were to try and extract their annual entitlements. Similarly, access to uncontrolled is provided on the regulated rivers to allow licence holders to access their annual entitlements when AWD are less that 100 per cent.

High Flow Category licences with access in the higher flows on the unregulated rivers (general above the 50th percentile flows) is provided to allow enterprise prepared to store water to develop through conversion of licences with access to the lower flows, de-stressing the lower flows. Similarly conversion of regulated licences to Supplementary Licence is proposed to provide the same opportunity on the regulated river.

Historically rules for declaring Off Allocation have had a similar frequency of occurrence to that of the 80th percentile on the unregulated rivers; hence, this could occur on unregulated rivers provided an existing trigger could be adopted for declaring Uncontrolled flows. Using the same structure of trigger as used in the existing Off Allocation trigger, but increasing the flow magnitude so that it has a similar frequency to that of the 50 percentile, provides an appropriate trigger for declaring Supplementary flows. In this way Uncontrolled parallels B class flow access in the unregulated river access, and Supplementary parallels the High Flow Licence access in the unregulated river access.

Table 12: Regulated river operation rules

Rule	Historically	Upon plan commencement
Transparency rule	inflows up to 10 ML/d	Inflows up to 15 ML/d
First flush	12 hour delay	24 hour delay
End of system	Based on barrage licence conditions	Based on barrage licence conditions
Uncontrolled access	Off-allocation rules	
	Reach 1A > 50 ML/day over spillway on rising dam and 20 ML/day on a falling dam level	> 50 ML/day over spillway on rising dam and 20 ML/day on a falling dam level
	Reach 1B > 50ML/d at North Brogo gauge on a rising river and 20 ML/day on a falling river	> 50 ML/day over spillway plus > 50ML/d at North Brogo gauge on a rising river and 20 ML/day on a falling river
	Reach 1C > 50 ML/day at Angledale on a rising river and 15 ML/day on a falling river	> 50 ML/day at Angledale on a rising river and 15 ML/day on a falling river
	Reach B > 50 ML/day at Angledale on a rising river and 15 ML/day on a falling river; and Visible flow downstream of the Bega bridge; and > 30 ML/day at Kanoona on a rising river and visible flow on a falling river	> 50 ML/day at Angledale on a rising river and 15 ML/day on a falling river, and Visible flow downstream of the Bega bridge and > 65 ML/day at Kanoona
Supplementary access	Off allocation rules as above	
	Reach 1A	> 100 ML/day for over spillway
	Reach 1B	>100 ML/day over spillway plus > 100 ML/d at North Brogo gauge
	Reach 1C	> 100 ML/day at the Angledale Gauge (gauging station number 219025)
	Reach B	> 100 ML/day at the Angledale Gauge (gauging station number 219025 or (b) the flows at the Kanoona Gauge (gauging station number 219032) exceed 160 ML/day

* Note for all flow levels these must have occurred for the preceding 24 hour period

Sand barrage

A sand weir or barrage has been erected periodically across the Bega River near the tidal limit for many years (licensed since at least 1981). The purpose of the barrage is to prevent salt water intrusion into the lower freshwater reaches of the river. The barrage is usually erected only when freshwater flows are very low and/or the Bega River entrance at Mogareeka is closed.

The barrage is erected by excavating sand from the bed of the river. It can remain in place for as little as a few weeks up to several months, being washed out by higher stream flows (around 100 ML/d). The barrage is currently licensed by the Department of Lands (Licence No.193125).

The majority of freshwater fish in the Bega system are migratory. Adults and juveniles regularly move between the estuarine and freshwater. The barrage creates a barrier in the stream and may restrict the upstream and downstream movement of fish within the river. The location of the barrage at the freshwater-estuarine interface makes it more problematic than a similar structure further up the catchment as it prevents fish from moving between the two different habitats. During early May 2009, the barrage had to be breached to enable a large number of estuarine fish congregating upstream of the barrage to move downstream to the estuary.

The HRC considered the best way of managing the barrage to meet the needs of water users without causing serious adverse impact upon river health. Options reviewed included 'no barrage', 'barrage with fishway' and 'barrage management'.

The operating agreement negotiated by the HRC involves a trial of continuing to allow the barrage to be erected when required and breached for two to three days every few weeks to allow fish passage between estuarine waters and freshwaters. During breaching, State Water shall release additional water from Brogo Dam to reduce the ingress of saline water into the lower reaches of the Bega River. The frequency of breaching is dependent on whether high stream flows have occurred during the previous winter. Breaching is required every four weeks if high flows have occurred, and every six weeks if high flows have not occurred.

As part of this agreement, NSW Fisheries are to monitor fish accumulation prior to breaching and fish movement post breaching. However, no fish monitoring has occurred to date as the barrage has been breached by natural freshes before sampling could commence. The installation and operation of the barrage remains an issue which requires further investigation and consideration.

The existing licensing arrangements will continue until the plan has commenced. A Water Supply Works Approval will be required under the WMA 2000 once the plan commences and the application will need to demonstrate the minimal harm requirements. The works approval could be written with on-going conditions thereby foregoing the need to reapply on an annual basis. Under the WMA 2000, the land occupier will still require a permissive occupancy permit from the Department of Lands to authorise the works.

Rules for alluvial water sources

Background

The Mid Bega Sands Water Source extends from the junction of Bega River and Wolumla Creek to the defined limit of the regulated water source. This water source is relatively complex and is impacted by:

- upstream surface water extraction
- surface water and groundwater extraction within the water source
- the regulated water source.

Large volumes of sand have been deposited in the Bega River Sands Water Source as the result of catchment erosion and sedimentation processes occurring during European settlement. The SCWMC reasoned that the original river bed has been built up by these sand deposits with the result that stream flow volumes that were previously surface flows now occur as below-surface flows. These sand deposits have, in effect, created a new highly-connected aquifer overlying the previous river bed. The SCWMC concluded that extraction from this new aquifer would be permitted by holders of surface water licences.

Considering the highly-connected nature of the lower reaches of the Bega River with the alluvial aquifers, the Interagency Regional Panel decided to consider these as one resource. The combined volume of groundwater and surface water entitlement is 6,739 ML/y. Assuming that 70 per cent of this entitlement is utilised, then current annual extraction would average about 4,700 ML.

Local rainfall is estimated to recharge the aquifers in the Bega Sands water source by 700 ML/yr on average, which represents about 10 per cent of entitlement and 15 per cent of current usage. Water extracted from the Mid Bega Sands Water Source is therefore predominantly surface water from the Bega River flowing over Kanoona Rocks (Pritchard, 2004).

Current management of the Mid Bega Sands provides for unlimited extraction by surface water licences until the Monitoring Bore GW039001 (Figure 5) reaches a level of 5.5m AHD. Extraction is then restricted until the bore reaches 4.5 metres AHD at which time extraction by surface water users must cease. In addition to groundwater extraction by these surface water licences, extraction of groundwater by BVSC for the Bega-Tathra water supply system, Bega Co-op for cheese production, and by farms for stock and domestic purposes is also licensed.

Parsons Brinkerhoff (2004) calculated the safe yield and sustainable yield based on rainfall recharge. The Bemboka arm above the Brogo confluence is considered to have a safe yield of 975 ML/y and a sustainable yield of 685 ML/y. The safe yield is based on 30 per cent of the average annual rainfall recharge allowing for permeability of soils and evapo-transpiration. Sustainable yield is that percentage of safe yield which is allowed to be extracted after considering environmental requirements.

The 30 per cent rainfall recharge figure and the 70 per cent sustainable yield figure recommended by Parsons Brinkerhoff (30 per cent for maintenance for the environment) is consistent with the process as described in the *Macro water sharing plans – the approach for groundwater. A report to assist community consultation*. This approach uses a rapid assessment of the reliance on groundwater extraction by the local community (Socio-economic risk) and the environmental risk to determine a sustainable yield. The socio-economic risk is the degree to which the community accesses a groundwater resource to maintain community living standards. There are two main assets considered in this assessment:

- financial assets – considered security of access, purpose of groundwater use, rate of return to user, regional significance of the groundwater based enterprise, level of development as a percentage of local government GPD
- social assets – considered current employment, employment potential and community multipliers.

A significant factor in this evaluation is the measure of security of access. The potential risk of licensed users not obtaining the required water supply may be alleviated by access to alternative supplies, reticulated supply or nearby water surface supplies for example. Given that there is high connectivity between groundwater and surface water in the area, this is considered to be a potential high risk to the town water supply bores as alternative supplies are currently limited.

The environmental assessment considered the risk to GDEs, water quality, aquifer integrity (potential compaction of the aquifer), rarity, diversity and special features within the water source. The 70 per cent figure is the highest percentage allowable for extraction and reflects the high community reliance of extraction relative to environmental risks. The assessment assumed that extraction was independent of the GDEs and that distance rules are sufficient.

There are six town water supply bores for the Bega-Tathra water supply system, located adjacent to the Bega River to a depth of approximately 17 m below river bed level. The bottom 6 m of the bores are screened with pump intakes situated approximately 2 m above the screened sections. Located in high water yielding alluvium with pump intakes up to 9 m below the standing water level in surface flow times in the river, each bore has a capacity of approximately 45 L/s.

In dry times, the combined effects of upstream water extraction for irrigation reducing inflows to recharge the Mid Bega Sand Water Source, extraction from the Mid Bega Sands Water Source, and extraction from the Bega-Tathra bores, cause the groundwater level in the vicinity of the borefield to drop. If the groundwater level around the bores drops too far they will reach the minimum operating levels of the bore pumps. For this reason, the plan aims to protect the security of town water supply from the Bega borefield.

The SRCMA set up a working group, predominantly of SCWMC members and the Interagency Regional Panel, to consider the issue of incorporating the Mid Bega's alluvial into the plan. In determining the water sharing rules the following were considered:

- the regulated river boundary
- the existing rate of extraction
- interference from groundwater extraction close to town water supply bores
- the volume of water within the sands above the Cease to Pump (CTP)
- the current extraction rate
- the TDEL (proposed rate of daily extraction) below ground level
- the volume beneath the CTP available for critical human needs.

As there is interaction between each of these factors, the factors cannot be considered independently. Hence, modelling is used to simulate the water movements. Figure 20 is made up of four sequences: measured inflows to the Mid Bega Sands, measured water level at the monitoring bore, simulated aquifer volumes under current development, and simulated aquifer volumes under full development. The red dotted line is drawn to correspond with the estimated volume of water at the 5.5 m water level in the aquifer.

Observations from the simulation of the aquifer are:

- the current modelled volumes only dip down below the 11000 ML (estimated 5.5 m level) mark once in the sequence
- at unrestricted full development of access licences this will occur more often and for longer periods
- the 4.5m cease to pump limits the draw down, although the TWS bores will continue to draw the aquifer down
- generally it is the faster draw down at the start of a dry period that extends the duration of restriction
- some small freshes will not make it through to the regulated river due to these flows recharging the aquifer.

Following discussions with the SRCMA working group in November 2008 the Bega Valley drought continued through 2009. The readings from monitoring bore GW039001 (Figure 21) indicate that the groundwater level did not drop below the CTP level of 4.5 m AHD. This in part can be attributed to the rostering arrangements among irrigators that managed extractions to an average of 6 ML/day.

Figure 20: Measured inflows, groundwater levels, current and full development volumes

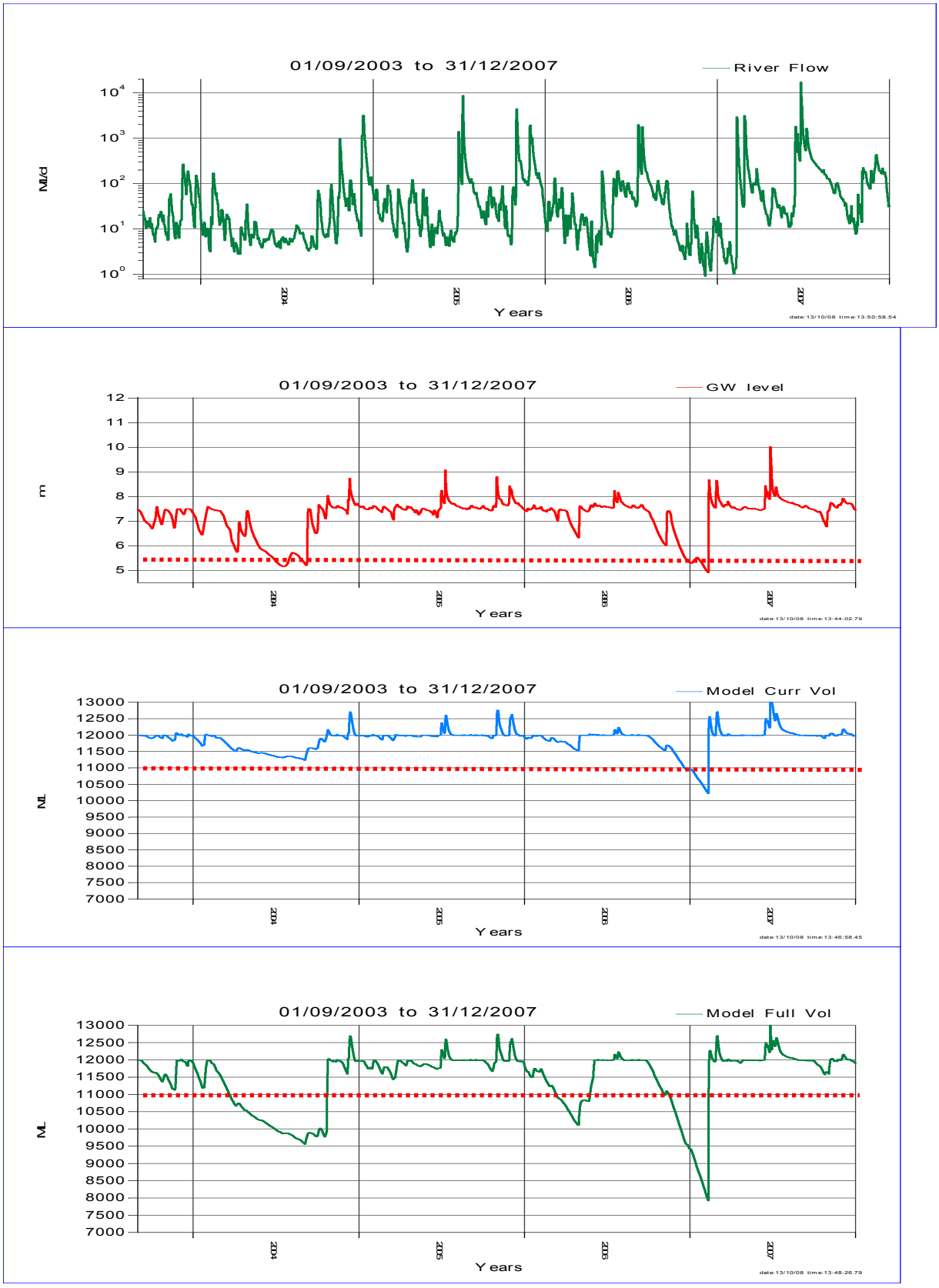
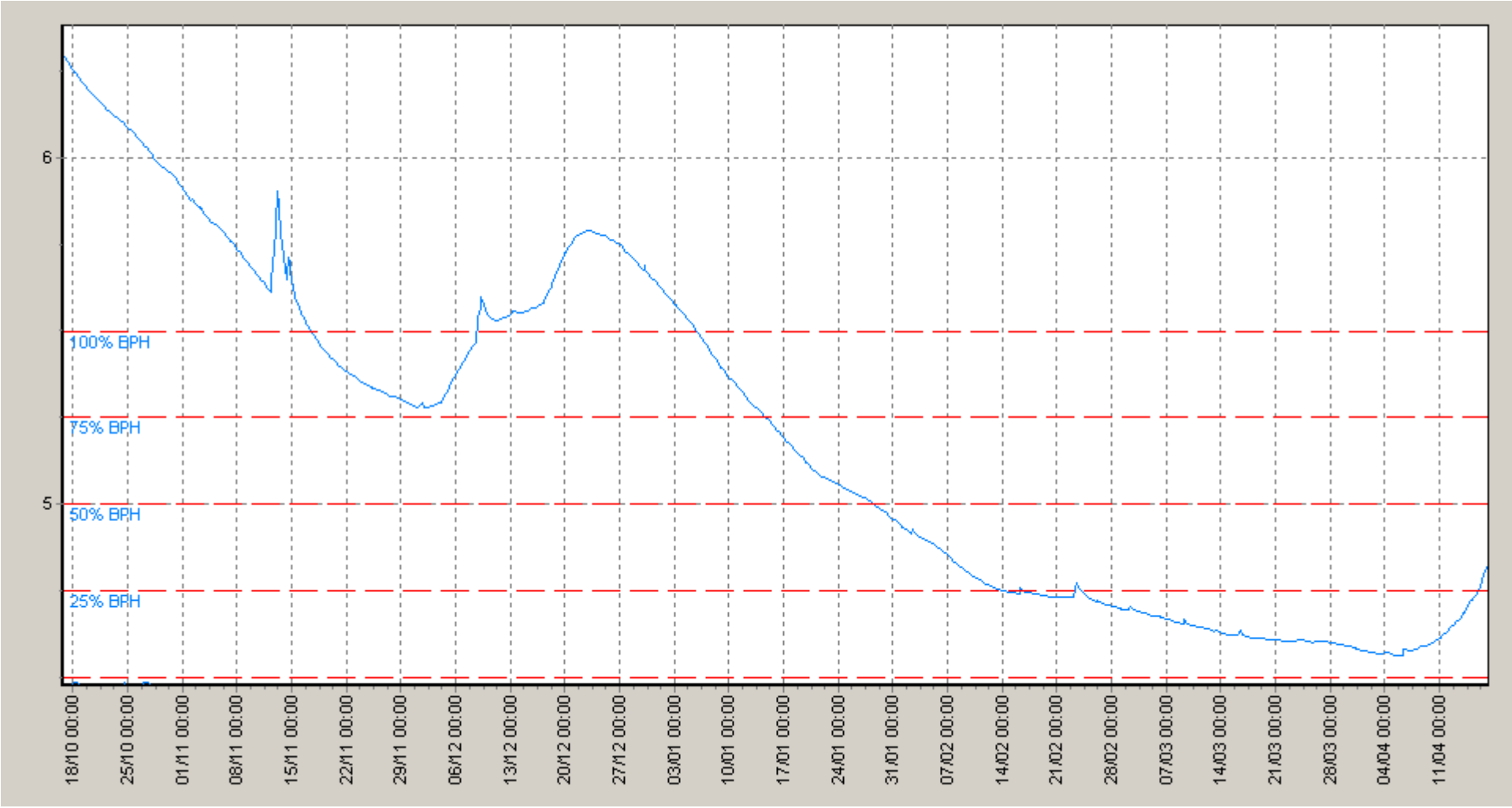


Figure 21: Groundwater level observations at 'The Ranch', October 2008 to April 2009



Defining the regulated river boundary

The current regulated river boundary covers only the regulated river, i.e. its bed and banks. As discussed previously, extraction from the highly connected alluvial aquifer will now be included in the regulated river water source. Where the unregulated river meets the regulated river, a boundary needs to be established to ensure that water extracted reflects the source of water and State Water is capable of supplying water to that extraction point. Options for a boundary included a groundwater level, a transfer exclusion zone, and extending the boundary up the unregulated river.

After considering the options, the Interagency Regional Panel recommended extending the boundary of the Brogo Regulated River 500 metres upstream of the Brogo River junction. This is the approximate width of the Brogo alluvial unregulated water source at the junction. This boundary also places a reasonable limit on the expected impact of groundwater extraction from the Bega sands aquifer on the surface flows in the Brogo River.

Five hundred metres is considered a reasonable estimate of the extent of influence from any extraction from the groundwater system. Estimates of the area and time of influence of extraction from the Bega Sands groundwater system were based on aquifer parameters adopted from reports and assessments of the aquifer (Parsons Brinkerhoff 2004), and input to a simple distance-drawdown model[10].

The rate of drawdown within a given system will vary with the rate of extraction and the extent of the drawdown effect will increase with time. The resultant area of influence will also be impacted upon by the presence of any recharge or discharge boundaries.

Modelled rates of groundwater extraction ranging from 20 to 100 L/second for periods of 30 to 100 days demonstrated that the majority of the drawdown effect would be contained within 500 m from the pumped bore. With regard to time, it was estimated that a drawdown effect would extend to 500 m during periods of no flow (no recharge) with a period of continuous pumping, greater than 100 days. During periods of river flow, the adjoining river would provide a recharge boundary which would limit the extent of drawdown from the groundwater system.

Consequently, based on the extent of alluvium at the Bega/Brogo junction and the expected area of influence of extraction from the alluvial sands aquifer, it was recommended that the regulated part of the Brogo river extend 500 m upstream of the confluence of the Brogo and Bega River channels.

Distance rules from town water supply bores

As part of the macro planning process for groundwater management each aquifer is subject to an accessibility risk assessment. This requires a rapid assessment of the reliance on groundwater extraction by the local community as described in the start of this section

Connectivity between surface water and alluvial groundwater requires that mitigation measures are put in place in the plan to minimise the risk of impact to an aquifer from extraction and protect current users.

[10] Domenico, P.A. and Schwartz, F.W., 1990. Physical and Chemical Hydrogeology. John Wiley and Sons Inc., New York. ISBN 0-471-50744-X based on approximation formula (Theis equation):

$s = (Q/4.\pi.T)*(-0.577216-\ln u+u-(u2/2.2!)+(u3/3.3!)-(u4/4.4!)+\ldots$ where $u = r^2.S/4.T.t$.

Mitigation actions to reduce risk to aquifer assets may include actions such as:

- implementing policy decisions, such as staged releases of unassigned water, managing groundwater/surface water interactions and basic landholder rights extraction
- specifying local impact management rules (as rules in the plan) such as boundary conditions on extraction around groundwater-dependent ecosystems, strategic monitoring networks, trigger levels for water level/quality monitoring or extraction volume restrictions[11].

Given the importance of the town water supply scheme to the Bega Valley community, the Interagency Regional Panel determined that all new bores in the area would require a distance rule of 500 m from any town water supply bore.

BVSC access to higher flows

The proposed pipeline from Bega to Yellow Pinch Dam would serve a number of important functions, including:

- improvement to water supply security for Yellow Pinch Dam by enabling it to be filled from high flows occurring in the Bega River
- provision of an alternative sustainable source of town water for the Tantawangalo/Kiah supply scheme, thereby reducing reliance of the scheme on supply from Tantawangalo Creek during low flows and very low flows
- reducing reliance on the Mid Bega Sands if water is available in Yellow Pinch.

Under the plan, BVSC shall be able to extract from the Mid Bega Sands for the purpose of transferring water to Yellow Pinch Dam and the Tantawangalo/Kiah Town Water Supply Scheme, provided they comply with their TDEL. BVSC will be able to increase their access licence in the Mid Bega Sands Water Source by up to 500 ML/year, subject to an equivalent reduction in their access licence in the Tantawangalo Creek Water Source. Council's access will increase as water level and stream flow increase (Table 13). The TDEL when extracting from very low flows will be averaged over 4 weeks during January and over 2 weeks for all other months to allow for operational flexibility for council without compromising access for other water users.

Table 13: Proposed TDELs for BVSC in the Mid Bega Sands

Flow class	Proposed total daily extraction limit (ML/day)
Very low flow	3.5
A1 class: no surface flow	4.7
A2 class: surface flow	6.7
B class	12.8
C class	Maximum pumping capacity

The TDELs will mean that council in most instances will not be able to supply both the Bega–Tathra requirements and fill Yellow Creek Dam in A Class except during periods of low demand (wet winters).

[11] Bish et al

Establishing TDEL for below ground access

In establishing the total TDEL of 12 ML/day (4.7 LWU and 7.2 other) for below ground extraction the following were considered:

The storage volume – It has been calculated that between 2000 and 3000 ML of water is stored in the sands above 4.5m AHD. Extracting at a total of the TDELs of 12 ML/day this would provide 5.6 months (167days) supply. At an unrestricted rate (peak daily demand at full activation) this would provide supply of 58 days.

Impact of extraction on BVSC water supply – Groundwater levels in the aquifer in February 2003 prior to the return of the river flow and groundwater recovery show groundwater levels depressed 2.6 to 3.3 m. Parsons Brinckerhoff (2004) recommended the establishment of extraction exclusion zones around BVSC bore fields of 2 kilometres. This would take in many of the existing extractors. By limiting the extraction to above 4.5AHD and setting a TDEL of 7.2 for non LWU extractors a less restrictive exclusion limit of 500 metres can protect BVSC water supply.

Current level of extraction – The level of extraction has varied over time. In November 2008, the level of irrigator extraction was 6.0 ML/day and Bega Cheese 1.3 ML/day. This means that as more unregulated users activate, the existing extractors' share of the water stored will be reduced.

Impact on the environment – The frequency and duration of flow reaching the regulated river is reduced by the TDEL as small freshes are able to recharge the aquifer and flow through during shorter dry periods.

Consultation

There has been extensive consultation with key stakeholders in the Bega Community throughout the various planning stages described above. The HRC received 64 written submissions as well as 17 Public Hearing submissions. The SCWMC held approximately 15 formal meetings regarding development of the draft plan. These meetings involved extensive input from up to 20 different stakeholder representatives with an obligation to represent their stakeholders' views in the Committee's consensus deliberations The SCWMC carried out a comprehensive socio-economic assessment as well as an assessment of environmental factors. In addition, many of the complex or contentious issues required numerous working group meetings that reported back to the full committee. The committee and its working groups had access to a comprehensive Integrated Quantity and Quality Model (IQQM) hydrological model for the Bemboka River system. Agency representatives and stakeholder representatives brought specialist expertise to a broad range of technical issues.

In 2004, the SCWMC ran four public meetings across the sub-catchments of the Bega River catchment in order to explain the key elements of the draft plan at that time and to gain feedback from interested people. These meetings were well-attended (total approximately 200 people) and resulted in broad general acceptance by the catchment community and support for the draft plan's provisions. To complement the public consultation meetings a brochure and series of posters were released in 2003, along with a series of media items explaining and drawing attention to the draft plan and its provisions.

The SRCMA recently facilitated a meeting between the Interagency Regional Panel and stakeholders. Panel members also met with the regulated river users and participated in workshops facilitated by SRCMA.

While developing the plan, the participating agencies (the Office of Water/DECCW, I&I NSW and the CMAs) have identified areas where better data is needed for making future water planning decisions. Similarly, the community have suggested areas where further analysis or data gathering is required.

SRCMA managed the consultation process, and ensured that all stakeholders and interested parties had an opportunity to examine and comment on the proposed water sharing rules. In particular, the SRCMA encouraged stakeholders to provide:

- local knowledge and expertise – for example, there may be other natural or socio-economic values that have not yet been considered by the Interagency Regional Panel
- feedback on the practical elements of the proposed water sharing rules – to make certain they are easily implemented by the licence holders
- confirmation that there are no unintended outcomes from the plan – it is essential that this be given due consideration before the plan is finalised
- specific comments on the Minister's notes included in the plan.

Public exhibition of the draft water sharing plan

Public exhibition of the proposed water sharing plan was held in the plan area from 6 October to 16 November 2009. The objectives of public exhibition were:

- to provide background to stakeholders as to why the water sharing plan is being developed, how it has been developed to date, what rules are proposed in the various areas and how stakeholders can provide feedback
- to formally consult with a broad range of stakeholders to explain the proposed water sharing rules and how they will be implemented
- to seek feedback from stakeholders and the general community about the proposed water sharing rules.

Refining water sharing rules as a result of public exhibition

The Interagency Regional Panel reviewed all submissions as well as matters raised at the meetings and as a result made some changes to the rules (Table 14).

Table 14: Refined water sharing rules based on public exhibition

Water Source	Change to water source rules	Justification
All plan area	The installation of new bores may be permitted closer than minimum distances if a hydrologic assessment can demonstrate that the impact of the new bores will be within acceptable limits	
Tantawangalo	The Council's TDEL from Tantawangalo Weir during periods of very low flow will be set at 0.2 ML/day.	A minimum flow of 0.2 ML/day is required to maintain pressure in the two 25 mm diameter pipelines. The panel thought that a daily extraction of 0.2 ML was reasonable to supply 44 properties.
Mid Bega River Sands	The Mid Bega Sands will be included in Cl 77 (Part 11, Division 5) of the plan that stipulates access conditions for access licences which nominate water supply works approvals used to take water from the alluvial sediments in the mentioned water sources.	If the Mid Bega Sands was not included licence holders who are on an aquifer drawdown rule would also need to observe a visible flow rule and this was not the intention of the rules as discussed during targeted consultations.
Mid Bega River Sands	The TDEL for town water supply when extracting from very low flows from the Mid Bega Sands should be averaged over four weeks during January, and over two weeks for all other months.	Assuming very low flow conditions for January, BVSC's maximum extraction limit for the month would be about 145 ML, which is 7 to 8% of the estimated available aquifer capacity. The panel concluded that the proposed averaging of TDELs would allow operational flexibility for council without compromising access for other water users.
Upper Bega / Bemboka Rivers	The TDEL for the Bemboka township during periods of very low flow, has been set at 0.1 ML/day during periods when the Cochrane Dam drought reserve is being accessed, and 0.2 ML/day when the drought reserve is not being accessed.	The panel recommended these TDELs in order to strike a balance between water users along the Bemboka River, and water users in Bemboka township.
Lower Bega / Brogo Rivers regulated	The possibility of increasing the storage capacity of Brogo Dam was raised. The water sharing plan will guide investment in, and the development of, future water infrastructure in the Bega and Brogo Valleys while protecting BLRs and the environment. The plan allows for an additional 15,000 ML/yr to be extracted from the Bega and Brogo Valleys during high flows, but does not specify the means of how this water will be extracted. Additional high flow extractions could be pumped from streams into off river storages, harvested as run off by on-river storages or captured by the enlargement of existing dams such as Brogo Dam. Individual assessments will be required to determine the preferable means of utilising the allowed increase in high flow entitlement. The costs and benefits of the various options may change over time and under different conditions.	

Water Source	Change to water source rules	Justification
Mid Bega River Sands	Part 16, 98 sub clause 4 will be removed from the plan	This clause has fundamental impacts on the accreditation scheme. It could theoretically override the scheme making it irrelevant. Irrigators will invest significant resources into meeting the requirements to ensure access to very low flows, but this clause will determine if the town water utilities cannot be met then top of very low flow will be increased to 5 ML from 2 ML.
Bega-Bemboka River	Licences on the Bega-Bemboka trunk stream will be normalised. Those licence holders whose licence conditions fall between the new flow classes, will be given the choice of: • a reduced CTP with a reduced entitlement (and reduced DEL) • an increased CTP with an increased entitlement (and increased DEL) • a maintained level of entitlement split across A class and B class flows. For licences in other water sources, the access rules defined in the plan are minimum compliance levels which do not supersede current licence conditions that are stricter than those in the plan.	

Adaptive management

Adaptive management is an important part of a water sharing plan. Adaptive management refers to the process of ongoing data collection monitoring, evaluation and review during the life of the plan that either enables plan amendment or remaking of a better plan after 10 years. Adaptive management is a requirement of both the WMA 2000 and the National Water Initiative, and has been allowed for during the life of the plan through amending provisions and establishment of 'limits of change' to the plan.

Where adaptive management is identified further studies may be undertaken within agencies or by external organisations which may assist in informing the review of plan provisions.

Monitoring of plan performance

The Office of Water is also developing a Monitoring, Evaluation and Reporting (MER) Framework. This framework will be developed in collaboration with key stakeholders and will be consistent with the MER needs of the Natural Resources Commission and the National Water Commission. The intention is that the framework can be applied to existing plans and macro plans to enable the development of a specific MER plan.

Performance indicators

The plan includes a number of performance indicators that will be monitored over the 10 year life of the plan.

The plan includes a number of performance indicators. These are:

- change in low, moderate and high flows
- change in volumetric entitlement to extract water from low flows
- extent to which local water utility requirements have been met
- change to the ecological values and condition of the water sources and their dependent ecosystems including the Bega estuary
- extent to which access to riparian rights have been improved
- extent to which Native Title Rights have been met
- improvement of water quality to support the environmental values of this water source.

It is not practicable to monitor all issues in all water sources. The performance indicators identify that monitoring will be undertaken for specific issues in key water sources. The actual procedure for monitoring each indicator may change over the period of the plan as improved methods are developed.

Plan review

The Natural Resources Commission will undertake a review of this plan prior to any decision to extend its term or to make a new plan.

The MER framework developed will consider the statutory requirements for the different types of monitoring of plan implementation and effectiveness and to inform the NRC review, specifically:

- the application of information from the relevant monitoring and evaluation programs to inform progress against the relevant statewide targets and requirements of the National Water Commission under the National Water Initiative.

The *Water Management Act 2000* states that water sharing plans will be audited at intervals of no more than five years, for the purpose of ascertaining whether its provisions have been given effect to, that is, are being implemented. This audit is to be carried out by an audit panel appointed by the Minister for Water.

There are also some amending provisions that may be triggered as a result of a mid-term review of the plan itself. This review will consider correlations between flow measurements taken during field verification and data from river gauges at nominated reference points, in order to recommend refinements to the specified flow reference points for each water source.

The year five review of this plan will also consider:

- correlations between flow measurements taken during field verification and data from river gauges at nominated reference points, in order to recommend refinements to the specified flow reference points for each water source
- the need for TDELs on unregulated rivers other than the Bemboka-Bega
- the release of stage 2 high flow water
- the effectiveness of Bega Shire Council's demand management strategy.

Between years 5 and 10 of the term of the plan, the Natural Resource Commission of NSW (NRC) will assess the extent to which the water sharing provisions have contributed to the relevant state wide targets, and natural resource standards and targets in the Southern Rivers Catchment Action Plan and the State Plan, Priority E4. The NRC will call for public submissions when undertaking its review. The review will consider the environmental merits and likely socio-economic impacts of an adjustment of the water sharing rules. Information from the relevant monitoring and evaluation programs, the review of Implementation Programs and the mid-term review of implementation should inform progress against the relevant state wide targets and ultimately the review of the plan itself towards the end of its 10-year term.

This review will also consider the effectiveness of water users' adoption of the Bega River Health Agreement, in regard to achievement of improvements to farm water application efficiency, riparian habitat, river channel recovery and opportunities for fish movement.

Implementation

Making and commencement

Once the plan is made, a period will be allowed before the plan commences. The period between gazettal and commencement allows the Office of Water to undertake the following:

- Amend existing licence conditions to reflect new flow classes;
- Ensure there are works approvals where the current WA 1912 licence does not cover works.

When the plan commences, the licensing provisions of the WMA 2000 come into effect in the plan area. This means that existing WA 1912 licences will be converted to WMA 2000 water access licences, and water supply works and use approvals.

Implementation programs

An Implementation Program may be established that sets out the means by which the objectives of the plan are to be achieved. The Office of Water will establish compliance measures for assessing whether extractors and State Water have complied with cease to pump rules and end of system flow target rules. In undertaking this, the Office of Water understands the practical issues in meeting these flow targets each day and will set tolerance ranges and seven day rolling average accounting. For example, in meeting the 2 ML/day flow rule at Kanoona the flow may vary down to 1 ML/day but over any 7 day period 14 ML will need to have past Kanoona. Therefore, if the river reaches 1 ML/day on a particular day then the deficit will need to be made up with an additional 1 ML/d flow above the 2 ML/d target over the following six day period. This keeps the rolling seven day average at 2 ML/d.

An annual review of the Implementation Program will be conducted to determine whether the Implementation Program is being effective in implementing the water sharing provisions. The results of this review will be included in the Office of Water's annual report.

Monitoring water extractions

Each water sharing plan establishes the relevant mandatory conditions for extraction, including that all licences undertake measurement of extraction. The Office of Water will develop a measurement of extractions strategy to meet the objectives of the NSW Water Extraction Monitoring Policy.

Measurement of extractions may be via meters or other forms of monitoring devices fitted to approved works, or via alternate monitoring systems, in order to provide water extraction estimates. Different types of devices will be required depending on the nature of the water supply work installation, the size of the work, and the affect that the operation of the work may have on the water source and other water users.

Under the Water Use Monitoring Program assessment of water sources is being undertaken across the State to identify priority areas of measurement of extractions and to determine the most suitable measurement options. It is likely that this will be implemented in high priority areas initially, with roll out to all water sources over time, as appropriate.
Note: Decisions regarding the timetable for introduction of measurement of extractions are still under consideration. In the interim, water users are encouraged to use other forms of self-measurement to assist them to extract water in compliance with their licence conditions, which will be developed from the relevant plan provisions. Water users may install flow meters of their own volition. Meters need to meet new national water meter standards and be installed in accordance with the manufacturer's specifications

Compliance

The Office of Water will undertake compliance activities as necessary to enforce each individual's licence conditions, which are developed based on the provisions of the plan once it is implemented. Some reliance is placed on local water users to identify inappropriate or unlawful behaviour and report this to the Office of Water. Reports may be made by calling 1800 633 362 or emailing watercompliance@water.nsw.gov.au (refer to the Office of Water website www.water.nsw.gov.au)

Assigning risk from climate change

Under clause 48 of the National Water Initiative, water access entitlement holders are to bear the risk of any reduction in the availability of water as a result of climate change, or less reliable water allocation, under their water access entitlements unless a different risk-sharing formula is negotiated between water access entitlement holders, environmental stakeholders and the NSW Government. In the plan, the manner in which the access rules are constructed, determine how the risk of climate change is apportioned.

In the plan the cease to pump rules are based on a fixed flow rate (e.g. 3 ML/day). This means that any reduced flows due to climate change that may occur during the life of this plan would result in statistically increased triggering of the cease-to-pump rule and therefore reduced opportunities for licence holders to extract water. In effect this will therefore apportion all the risk of climate change to extractors.

The 50 per cent rule where a percentage of a flow is available for extraction (high flow and BVSC extraction from Tantawangalo) will equally distribute the risk of reduced flow between users and the environment.

The total daily extraction limits (TDELs) in the plan are based on percentile flows determined from past streamflow records and hydrological modelling using recorded (past) rainfall. The flow ranges as presented in the plan, if fixed, would not allow for a downward shift in percentile flows that might occur through climate change. Since extraction takes the first percentage of each flow class the risk is assigned to the environment and downstream users. During consultation BVSC requested that the flow classes be reviewed and reset periodically to protect the volume of water entering the Bega Sands Water Source during periods of lower flows. The plan allows for the flow class ranges to be reviewed yet the ratio of extraction to environmental water is to remain the same. For example modelling estimated that at Kanoona a flow of 65 ML/d has occurred 80 per cent of the time. If this was to be reduced by say 20 per cent the TDEL for all users upstream of Kanoona would also be reduced by 20 per cent.

In the regulated river the annual allocation is based on local water utility access licences having 100 per cent of share component through a repeat of the worst period of low flows in the water source. The available water determination (AWD) to high security and general security are also based on minimum inflows. If during the period of the plan's operation a new worst period of inflow is recorded then that will be adopted for all subsequent determinations with the risk apportioned to the high security and general security users.

The long-term average annual extraction limit (LTAAEL) for the Bega Valley was based on an environmental share and a reasonable expectation of supply. This means that although the percentage of extraction relative to annual flow may vary over time, the access rules are considered sufficient for environmental protection. In other words the environment is not dependent on the residual (water left in the river after extraction) for survival. A reduction in flow will result in water users tending to change their pumping behaviour and become more dependent on extractions in the higher flow range, within the access rules in the plan to maintain their required level of extraction volume to meet crop demands.

Conversion of licences with CTP into flow classes

There are a number of licences along the length of the Bemboka River and upper Bega River that have different cease to pump conditions. These conditions were placed on licences to protect the water access of existing downstream licence holders and basic rights users. These conditions vary between the water sharing plan CTP of 2 ML/day and the top of A Class flows (also the bottom of B Class flows) of 65 ML/day. Many of these conditions refer to flows at the Morans Crossing Gauge rather than the flow at the Kanoona Gauge as in the plan.

It is possible that these conditions could be maintained by placing them on a works approval (approval for the pump) and prohibiting licences from being linked to any other works, which would in effect stop the entitlement from being sold or moved. This is undesirable as it is contrary to allowing trading in the Bega Valley within the trading rules.

The panel's preferred option is to allow the licence holders to convert their entitlement to the Unregulated Category entitlement with access to all flow classes (A, B and C Class flows), or to an entitlement with access to B and C Class flows only. If a licence holder selects to convert to the Unregulated Category, reducing the CTP to 2 ML/day, their annual entitlement would be reduced. Alternatively, if they selected to convert to High Flow, increasing their CTP, then their annual entitlement would be increased. The conversion rate would be pro-rata between a conversion rate of 1 if the CTP was 2 ML/day and 3 if the CTP was 160 ML/day.

The other step is to change the reference point for CTP rules from Morans Crossing to Kanoona. This is best done by ensuring the frequency of the flow at Kanoona is the same as the current frequency of flow for the CTPs at Morans Crossing.

Glossary

Many of the terms in this document are defined in the WMA 2000 and are therefore not redefined here. However, there are some terms that are not and have therefore been defined below to assist with understanding the water sharing plan.

Account water: The balance in an access licence water allocation account at a particular time. An access licence water allocation account records water allocations accrued under the licence as well as water allocations taken, assigned or re-credited. The operation of the account is also governed by rules for the carrying over of credits from one accounting period to the next and rules for the maximum credit that may be allowed to accumulate in the account as established in a water sharing plan.

Alluvial, alluvium: Sediment deposited by a stream of running water, in particular along river beds or flood plains.

Aquifer: An underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt or clay) from which groundwater can be usefully extracted. The volume of water stored in an aquifer, the rate at which water can recharge, the volume of water extracted from it, and the rate at which water can move through the aquifer are all controlled by the geologic nature of the aquifer.

Connectivity: The capacity of in-stream biota to move longitudinally in a river system and not be impeded by barriers (e.g. weirs, dams, culverts). Connectivity is important for in-stream aquatic processes and biota and the conservation of natural riverine systems.

Conversion factor: The adjustment factor that is to be applied to share components when they are cancelled and reissued in a different water source and vice versa, or as a different category. It is designed to allow movement of water from one water source to another or from one licence category to another while minimising the impacts on third parties of such movements. These impacts result in that the value of a unit of share component (in terms of the average water allocations) that result from it may vary from one water source to another or from one licence category to another.

Critical habitat: Areas of habitat (land or water) that are crucial to the survival of particular threatened species, populations or communities.

Cumulative impact: The combined impact of all surface water extraction.

Ecological values: The intrinsic or core attributes associated with naturalness, diversity, rarity and special features, but excluding representativeness used to classify water sources for apportioning water management rules.

Endangered ecological communities: Ecological communities listed in Schedule 1 of the *Threatened Species Conservation Act 1995* or Schedule 4 of the *Fisheries Management Act 1994*.

Environmental contingency allowance (ECA): A volume of water held in storage from which releases are made for particular environmental purposes or in response to particular environmental circumstances.

Ephemeral: Temporary or intermittent; for instance, a creek or wetland which dries up periodically.

Extraction of water: Removal of water from a river for off-stream storage or consumptive use.

Extraction management unit (EMU): A group of water sources; defined for the purpose of managing long-term annual average extraction.

Flow classes: The range of daily flow rates in a river which provides the framework for sharing water on a daily basis.

Flow duration curve: A plot that shows the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest.

Flow gauging station: A device used to measure the height of a river, from which the flow in the river can be calculated.

Flow reference point (FRP): The site from which the flow data is calculated to determine the rates associated with a flow class and then to implement the daily access rules during the life of the plan.

Groundwater: The water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated.

Groundwater dependent ecosystems (GDEs): Ecosystems that rely on groundwater for their species composition and their natural ecological processes.

Individual daily extraction limit (IDEL): The daily volume limit that may apply for a particular licence holder for each flow class. The IDEL will be specified as part of the extraction component on the access licence. It establishes a share of the TDEL for that flow class.

In-stream refuge habitat: Stream habitat containing pools that retain water for longer periods of time during drought and low flow. In-stream biota will migrate to these more permanent habitats to survive.

Integrated Quantity/Quality Model (IQQM): A numerical hydrologic computer model that simulates a river basin's behaviour on a daily time step, based on inflows to the system, configuration of the major infrastructure, routing and losses of flows through the system and irrigation extractions to meet crop water requirements. It also models the processes of available water determinations, uncontrolled flow and supplementary water announcements and irrigator planting decisions. This model is used to analyse and compare the outcomes of proposed water sharing options or assess potential growth-in-use over long-term climatic sequences (> 100 years).

Long-term average annual extraction limit (LTAAEL): The target for total extractions (under all water access licences plus an estimate of basic landholder rights within an EMU) which is used to assess whether growth-in-use has occurred. The actual annual extractions (metered plus estimated) are averaged over a fixed period of time defined by the water sharing plan when comparing with the LTAAEL. If the fixed period of time is greater than one water year, then in any one water year, extractions can exceed the LTAAEL without triggering a growth-in-use response.

Macro water sharing plans: Plans which apply to a number of water sources across catchments or different types of aquifers. The macro planning process is designed to develop broader-scale plans covering most of the remaining water sources in NSW.

Management zone (MZ): An area within a water source used for defining the location of applicability of water sharing rules, but secondary to the water source. A management zone (MZ) is more likely to be designated where local dealing restrictions are in place or where 'Cease to Pump' (CtP) rules for works approvals apply.

Regulated river: A river that is declared by the Ministerial, by order published in the Gazette, to be a regulated river. Typically rivers where state owned storages catch water during wetter periods and the river is used to supply stored water to meet downstream users' orders during dry times are regulated rivers.

Reliability: The frequency with which water allocated under a water access entitlement is able to be supplied in full (referred to in some jurisdictions as 'high security' and 'general security'). Alternately, reliability can also sometimes be measured in terms of long-term average water availability relative to entitlement.

Riparian: Relating to or living or located on the bank of a natural watercourse, such as a river or stream.

Security: The legal status and tenure of a right to access water. This includes the level and assurance that a water access entitlement will provide that which it specifies. Security thus includes the reliability of supply. The range of water access entitlement characteristics detailed in the NWI contributes to the security of a water access entitlement.

Schedule 2: Refers to those licence holders, as identified in Schedule 2 of the plan, that may continue to access water during periods of very low flows for fruit washing, cleaning of dairy plant and equipment for the purposes of hygiene, poultry watering and misting or cleaning of enclosures used for intensive animal production for of hygiene.

Supplementary water event: A continuous period during which the taking of water from uncontrolled flows under supplementary water access licences or as no-debit access under a Regulated River (general security) access licence is permitted in all or part of a River Water source

Sustainable yield: That percentage which is allowed to be extracted from groundwater after considering the aquifer's ability to recharge and the needs of the environment.

Total daily extraction limit (TDEL): The total limit on the daily volume of water that access licence holders in a particular category can take from a flow class. It is the sum of all the IDELs in that flow class.

Uncontrolled flow: is flow, in excess of that needed to meet the environmental provisions of the plan, basic landholder rights and water orders placed by Regulated River (general security) access licences and higher priority access licences in a water source. These flows originate from tributary inflows or dam spills.

Visible flow: The continuous downstream movement of water that is perceptible to the eye.

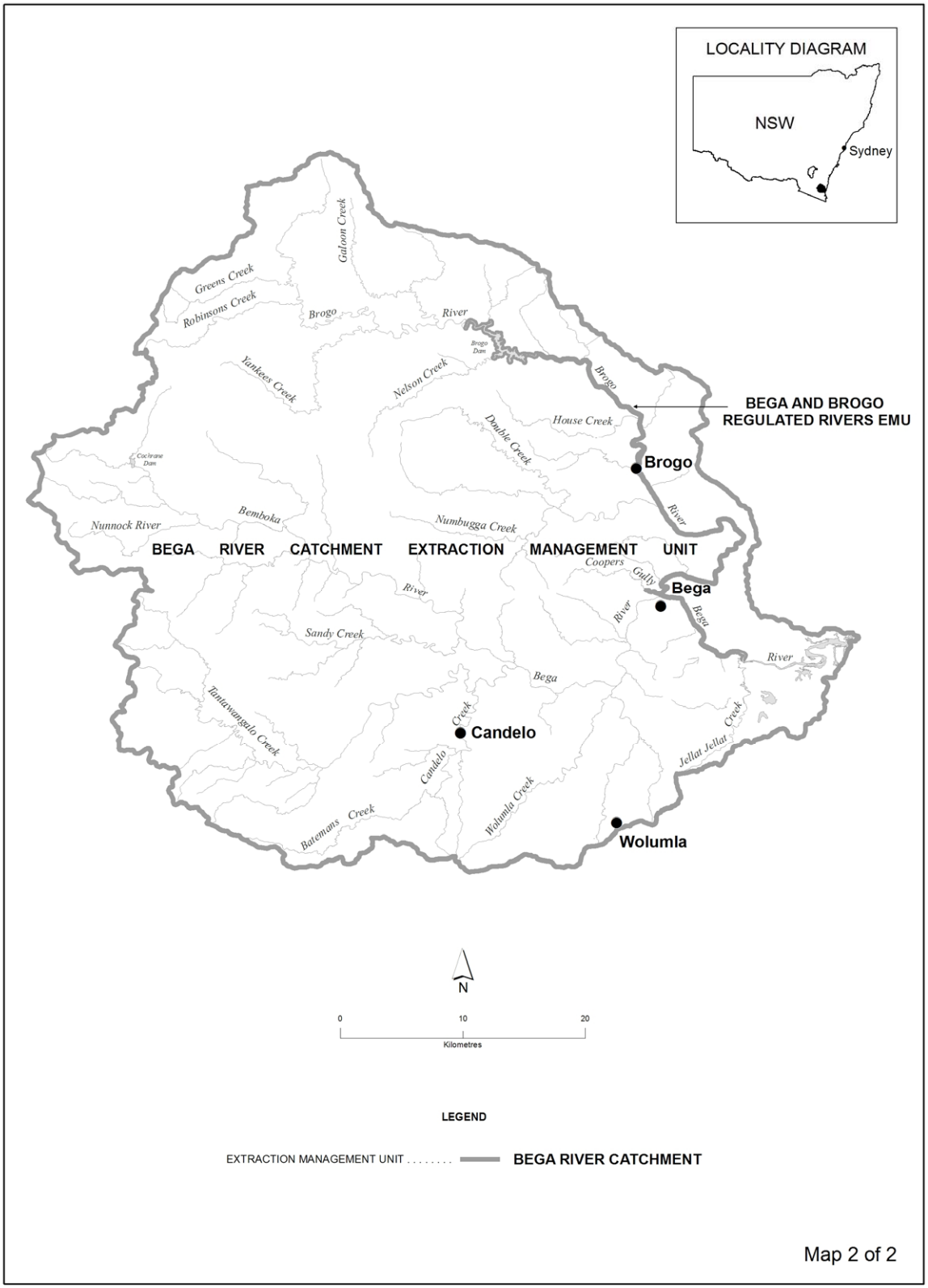
Water sharing plan (plan): A plan made under the WMA 2000, which sets out the rules for sharing water between the environment and water users within whole or part of a water management area or water source.

Water year: The 12 months running from 1 July to 30 June.

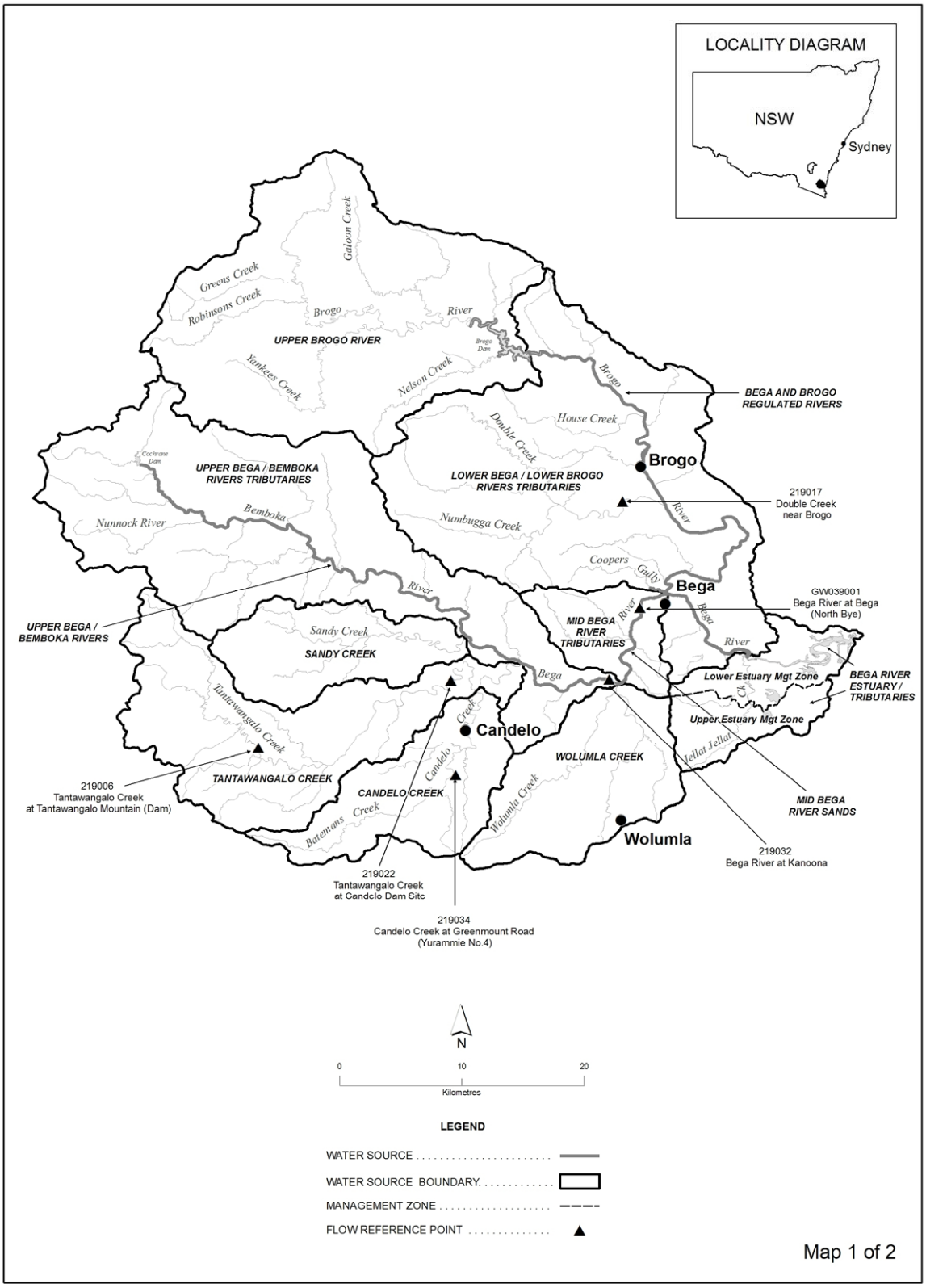
Appendix 1: Water sharing plan maps

The Bega Valley

Extraction management units (EMUs) of the Bega Valley



Water sources of the Bega Valley



Appendix 2: Identified threatened species

It is important to note that the macro water sharing plan process is concerned with protecting in stream water values that relate to extraction. Therefore, only threatened species that are likely to be sensitive to extraction have been considered when assessing the water source values.

It should also be noted that some threatened species are highly sensitive to low flow extraction, while other threatened species, such as plants that occur in the riparian zone, are less sensitive. Accordingly, threatened species considered to be highly sensitive to low flows are given a highly priority for protection.

The table below shows threatened species that are known (K) or expected (E) to occur in each water source:

	Mid Bega River	Brogo River	Wolumula Creek	Candelo Creek	Tantawangalo Creek	Sandy Creek	Bemboka River	Upper Brogo River	Bega Estuary
Fish species	2	2	1	1	2	2	2	0	2
Australian grayling									
Frog species									
Alpine tree frog	1	1	1	1	1	1	1	1	1
Giant burrowing frog	2	2	2	2	2	2	2	2	2
Green and golden bell frog	2	2	2	2	2	2	2	2	2
Littlejohn's tree frog	2	2	2	2	2	2	2	2	2
Southern bell frog	0	0	0	0	2	0	2	0	0
Stuttering barred frog	2	2	2	2	2	2	2	2	2
Macroinvertebrate Species									
Giant Dragonfly	0	0	0	0	0	0	0	0	0
Bird Species									
Australasian bittern	2	2	2	2	2	2	2	2	2
Black bittern	2	2	2	2	2	2	2	2	2
Black-tailed godwit	2	2	2	0	2	2	2	0	2
Comb-crested jacana	2	2	2	0	2	2	2	0	2
Freckled duck	0	0	0	0	0	0	0	0	0
Great knot	0	0	0	0	0	0	0	0	0
Greater sand-plover	0	0	0	0	0	0	0	0	0
Lesser sand-plover	0	0	0	0	0	0	0	0	0
Little tern	2	2	2	0	2	2	2	0	2
Osprey	2	2	2	0	2	2	2	0	2
Regent honeyeater	2	2	2	2	2	2	2	2	2
Sanderling	2	2	2	0	2	2	2	0	2
Terek sandpiper	0	0	0	0	0	0	0	0	0

	Mid Bega River	Brogo River	Wolumula Creek	Candelo Creek	Tantawangalo Creek	Sandy Creek	Bemboka River	Upper Brogo River	Bega Estuary
Other fauna									
Greater broad-nosed bat	2	2	2	2	2	2	2	2	2
Large footed myotis	2	2	2	2	2	2	2	2	2
Wet flora species									
Waterwheel plant	2	2	0	0	0	0	0	0	0
Threatened populations									
Coastal salt marsh in south-east corner bioregions	2	2	2	0	2	2	2	0	2
Freshwater wetlands on coastal floodplains	2	2	2	0	2	2	2	0	2

Explanation of scoring

If the species is:

- likely to be sensitive to low flow extraction and is known to occur within a subregion that is located within the Catchment Management Unit (CMU), the CMU scores a '2' for that species value
- likely to be sensitive to low flow extraction and is predicted to occur within a sub-region that is located within the CMU, the CMU scores a '1' for that species value
- not known or predicted to occur within a sub-region, the CMU scores a '0'.

Disclaimer

The Department of Environment Climate Change and Water (DECCW) has provided assessments on the presence of threatened species and their sensitivity to extraction to inform the classification of water sources through the macro water sharing planning process. The assessments were undertaken for the specific purpose of developing an initial classification of water sources. They were based on the most accurate and relevant data/ information sourced and analysed at the time.

Initial classifications were a first step to inform panel deliberations. Panels considered a range of information and used local knowledge in determining a final classification. The assessments are not absolute – for example the absence of threatened species for an assessment does not necessarily mean the threatened species are not present.

These assessments should not be used for any purpose other than classification of catchment management units as part of the macro water sharing planning process.

Appendix 3: Committee members

Bega Valley Water Management Committee

Name	Agency/role
Community representatives	
Mr Don Patterson	Chair
Mr Bill Caldicott	Far South Coast Community Representative
Mr Jim Collins	Far South Coast Catchment Management Committee (FSCCMC)
Mr Frank Foster	Bega Valley Water Users Association
Mr Mick Harewood	Bega Environment Network / SE Forests Conservation Council
Industry	
Mr Bob Burns	Pacific Power
Mr Lew Brown	Manager Brown Mountain Power Station
Local and State Government	
Mr Harry Kemp	NSW Agriculture
Mr Doug Mein	Bega Valley Shire Council
Mr Andrew Philippa	Department of Land and Water Conservation (DLWC)
Mr Bruce Watt	DLWC Regional Licensing Officer
Mark Conlon	DLWC
Observers	
Mr John Hukins	Secretary, Bega Valley Water Users Association
Mr Kerry Pfeiffer	Far South Coast Catchment Management Committee Chair
Ex-officio and support staff	
Mr Paul Corbett	DLWC Hydrographer, Bega
Mr Don McPhee	DLWC Executive Officer, Water Management Committees
Ms Carole Williams	DLWC Hydrologist, Sydney South Coast Region
Mr Peter Clemson	Manager Brogo Dam (State Water)

South Coast Water Management Committee

Name	Agency/role
Community representatives	
Mr Don Patterson	Chair
Fergus Thomson	Acting Chair/Catchment Management Committee Representative
Mick Harewood	Far South Coast Conservation
Lynda Allen	South Coast Water Management Committee (SCWMC)
Dinesh Moylan	Riparian Water User (RWU) alternate
Garry Leighton	Commercial Estuary User
Mark Bice	Lower South Coast Water Users (LSCWU)
Jenny Edwards	Lower South Coast Conservation (LSCC)
Jim Collins	Far South Coast Water Users
Local and State Government	
Pam Green	Local Government, Eurobodalla
Doug Mein	Local Government, Bega Valley
Noel Kesby	DLWC
Ken McLeod	BVSC
John O'Connor	NSW Agriculture alternate
Jim Walker	Recreation and Tourism
Peter Simpson	NSW Agriculture
Andy Spate	National Parks and Wildlife Service (NPWS)
Craig Lamberton	Environmental Protection Agency (EPA)
Rodney James	NSW Fisheries
Craige Brown	State Forests
Roger Good	NPWS
Ex-officio and support staff	
Don McPhee	Executive Officer
Paul Corbett	DLWC

South Coast Interagency Regional Panel

Name	Agency	Role	Expertise
Interagency Regional Panel members			
Eddie Harris	The Office of Water	Agency representative (Nov 2006 to present)	River operations, aquatic ecology and interpretation of the national agreements.
John O'Connor	SRCMA / I&I NSW	SRCMA observer (June 2008 to present); DII rep (June 2005 to present)	Catchment management, local knowledge of catchments, agricultural issues.
Allan Lugg	I&I NSW - Fisheries	Agency representative (June 2005 to present)	Fisheries management and conservations issues, threatened species, local knowledge of catchments.
Anne Muir	I&I NSW - Agriculture	Agency representative (June 2005 to present)	DII regional input to water reforms, agriculture, catchment management and land use/strategic planning.
John Patten	DECCW	Agency representative (May 2008 to March 2009)	DECCW regional input to water reforms, conservation issues.

Support staff			
Andrew Craig	The Office of Water	SRCMA observer (2006 to 2008); panel Co-ordinator (June 2008 to present)	Local knowledge, facilitation & consultation.
Don McPhee	SRCMA	SRCMA (June 2005 to March 2006)	Facilitation and consultation.
Paul Corbett	The Office of Water	Hydrometric and unregulated rivers operational support	Development and operation of the Flow Plan. Hydrometric analysis.
Jon Sayers and Simon Morton	The Office of Water	Hydrologists	Flow data analysis, flow behaviour of catchments, development of IQQM model.
Maree Abood	The Office of Water	Panel Co-ordinator (Nov 2006 to May 2008)	Natural Resource Planning.
Louise Whiting	The Office of Water	Legal and technical support	Environmental Law.
Ken Harris, Ashleigh Jones & Mark Harris	The Office of Water	Plan Writers, legal and planning support	Environmental Planning and Management.
Kimberley Dale, Linden Bird & Danielle Doughty	The Office of Water	Preparation of support documents	
Wayne Ryan	The Office of Water	Licensing Officer, Nowra	Licensing support, local knowledge.
Bob Britten	The Office of Water	Hydrogeologist, Bega	Groundwater analysis and hydrology.
Michael Healey & Simon Williams	The Office of Water	Ecological analysis	Aquatic ecologist, knowledge of flow requirements for freshwater biota.
Paul Lee	The Office of Water	Technical support	Urban water supply requirements and local knowledge.
Greg Hillis	State Water	Technical Support	State-wide water policy, plan development.
Peter Clemson and Garry Hunt	State Water	Technical support – Brogo Dam officer in charge	Brogo dam operations, local knowledge, flow requirements for irrigators, history of use.

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- Geoff Johnston Bega Valley Water Users
- Richard Parbery Bega Cheese
- Ken Garner Bega Cheese
- Stephen Guthrey Brogo Water Users
- Guy Lucas Brogo River irrigator
- Mick Harewood Environmental Representative
- Jim Collins Bega Valley Shire Council
- Ken McLeod Bega Valley Shire Council
- Mark Hankinson Eurobodalla Shire Council
- John Kennedy Eraring Energy
- Doug Payne Eraring Energy
- Warwick Wilton Eraring Energy

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Appendix 5: Schematic of IQQM models

Figure 22: Upper reaches of the Bemboka unregulated model

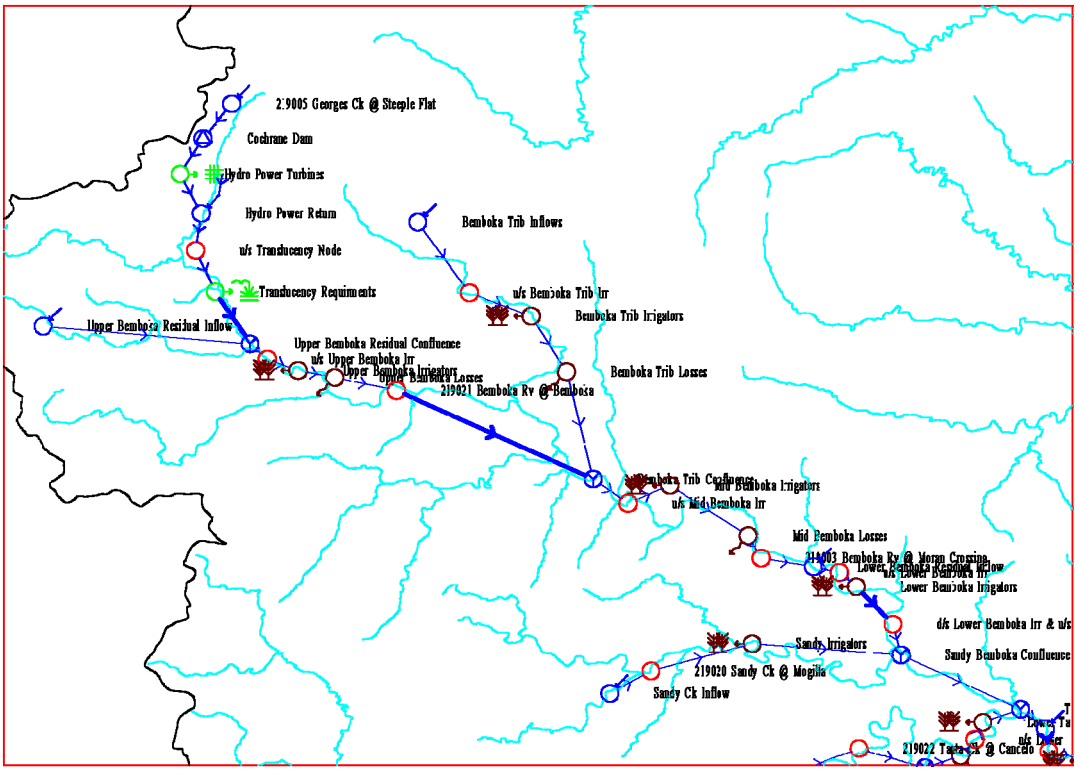

Figure 23: Lower reaches of the Bemboka unregulated model

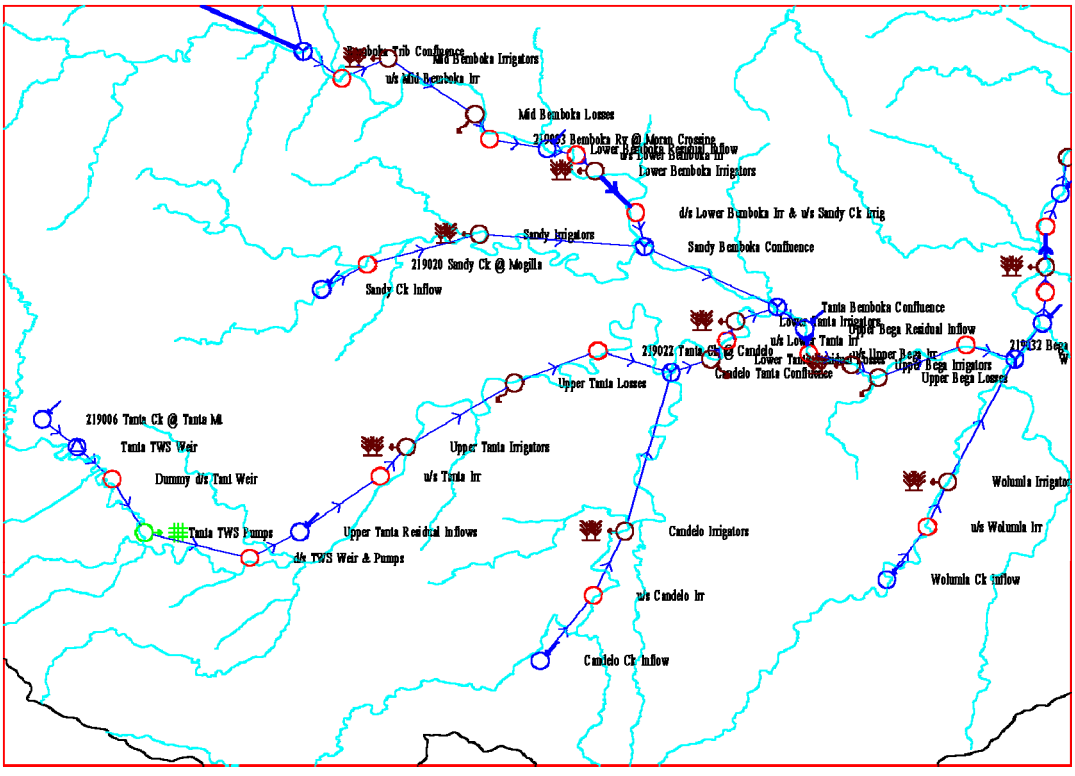

Figure 24: Upper reaches of the Brogo regulated model

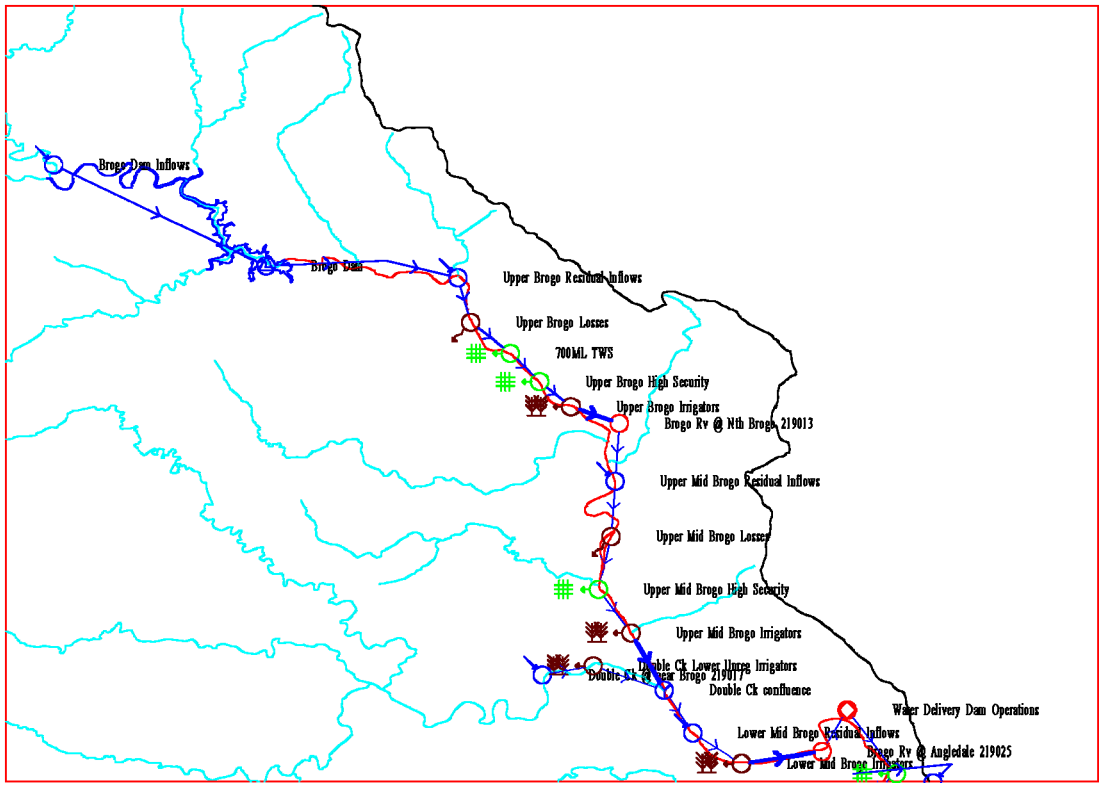

Figure 25: Lower reaches of the Brogo regulated model