Snowy River below Lake Jindabyne

Map of River

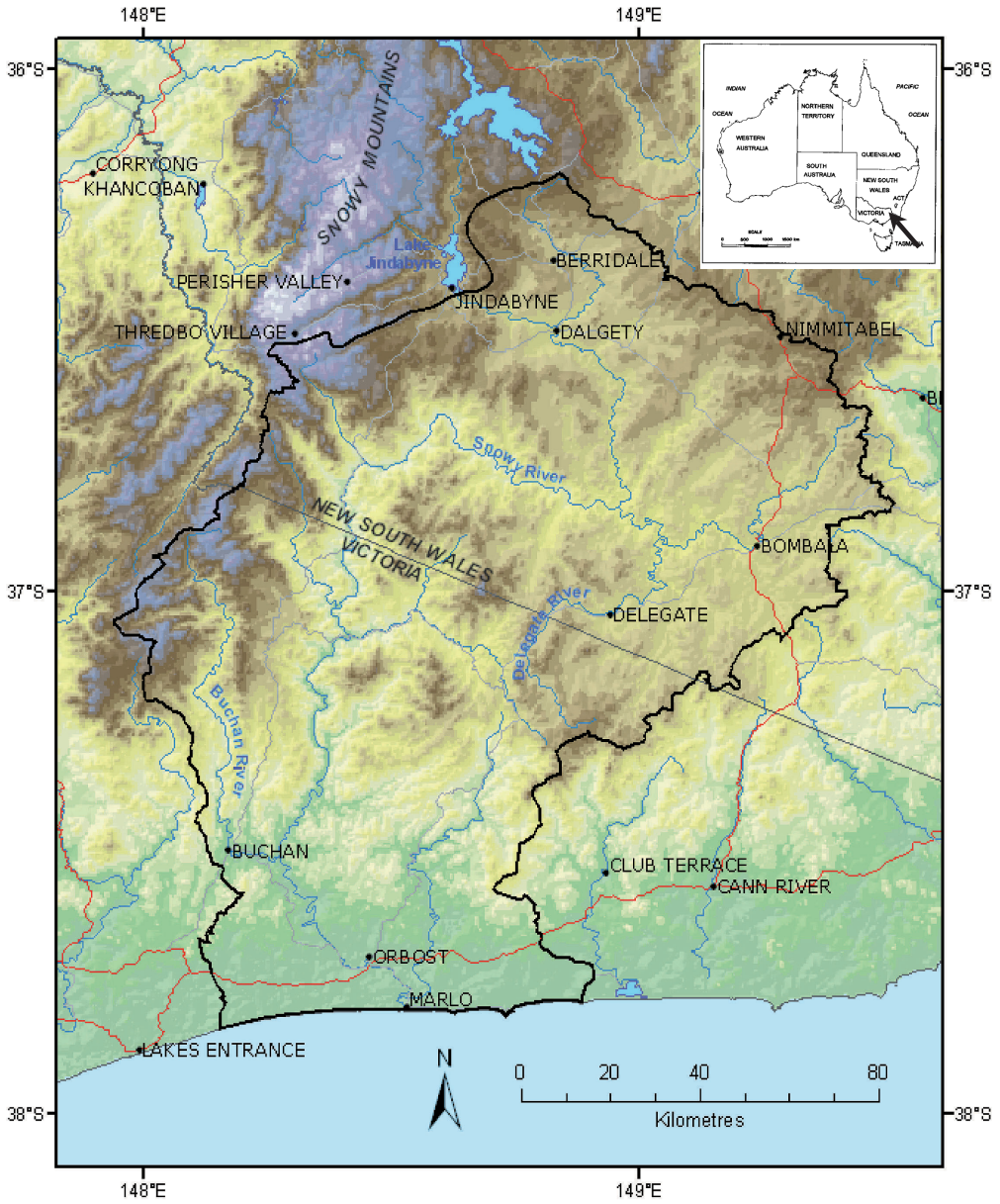


Table of Basic Data

Name(s): Snowy River below Lake Jindabyne		**Serial No. :** Australia-7
Location: Southeastern Australia	N 36° 27' ~ 37° 50'	E 148° ~ 149° 30'
Area: 11,720 km^2 below Lake Jindabyne	**Length of main stream:** 350 km	
Origin: Lake Jindabyne	**Highest point:** Mt Cobberas, 1,833 m	
Outlet: Tasman Sea	**Lowest point:** River mouth at sea level	
Main geological features: Low grade metamorphic and granitic rocks		
Main tributaries: Maclaughlin, Delegate, Deddick and Buchan rivers		
Main lakes: None		
Main reservoirs: Jindabyne Dam (most upstream point of the catchment)		
Mean annual precipitation: 500 mm in the coastal region to 3,800 mm in the upper central region		
Mean annual runoff: 43.1 m^3/s post Jindabyne Dam construction		
Population: approx 12,000 (2001)	**Main cities:** Orbost	
Land use: Grazing, National Park, forestry, intensive cropping in lower reaches		

1. General Description

The Snowy River catchment extends from Kiandra in the Snowy Mountains to the river mouth at Marlo where it flows into the Tasman Sea. The total catchment area is 13,570 km^2 with the area below Lake Jindabyne being 11,720 km^2. The annual precipitation ranges from 500 mm to 3,800 mm with the highest precipitation occurring on the mountain peaks in the form of winter snow. Precipitation in the upper Snowy catchment is highest during late autumn and lowest during summer and is increased by orographic effects. The central portion of the catchment (below Lake Jindabyne) is in a rainshadow and experiences mean annual rainfall of about 500 mm. The mean annual precipitation then increases moving south to the coast where it is about 800 mm.

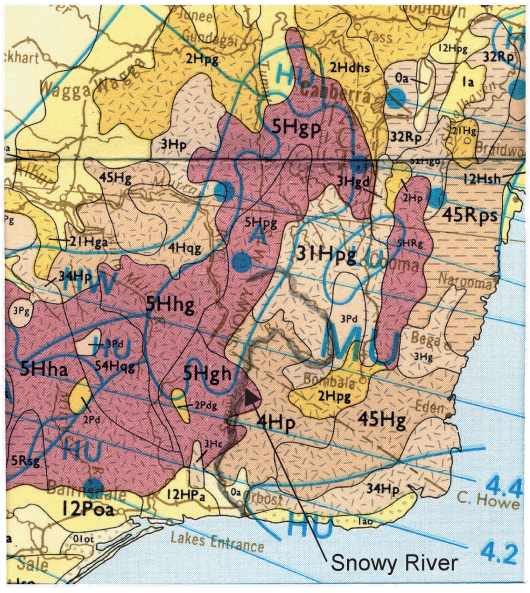
Construction of the Snowy Mountains Hydro-electric Scheme has reduced annual average natural flows in the Snowy River immediately below Jindabyne Dam by 99 percent. Two tributaries below the dam, Mowamba River and Cobbin Creek are substantially diverted into the dam. The Delegate River is the first substantial river to contribute to the Snowy below Lake Jindabyne. Flow releases from Jindabyne Dam range from a ‘visible’ flow to 50 ML/d to satisfy riparian users. Under natural conditions the Snowy River exhibited a strong seasonal pattern characterized by low summer flows and high persistent spring flows due to snowmelt. The elimination of the high spring flows is evident even at the river mouth.

Moving downstream from Jindabyne Dam, tributary inflows substantially increase the flow of the Snowy River. The Delegate River contributes approximately 30% of the post-Scheme mean annual flow of the Snowy River. At Jarrahmond the Snowy flows are approximately 53 percent of pre-Scheme flows. The catchment from the Buchan River and below generates low summer flows with the highest flows occurring in autumn. The lower reaches of the Snowy (below the Buchan River) change from riverine to estuarine.

Under natural conditions the Snowy River experienced a number of floods each year that could occur at any time but particularly in spring when rainfall coincided with snowmelt. Under existing conditions there are no floods immediately downstream of Jindabyne. Even at the coast, the frequency and magnitude of floods have been reduced.

2. Geographical Information

2.1 Landform and Geological Map



Lands of Low Relief (100-300 ft)
- 2P Dissected plateaux
- 2R Escarpments and ridges
- 2H Hills

Lands of Moderate Relief (300-600 ft)
- 3P Dissected plateaux
- 3R Escarpments and ridges
- 3H Hills

Lands of High Relief (600-1200 ft)
- 4P Dissected plateaux
- 4R Mountain ridges
- 4H Mountains

Lands of Very High Relief (over 1200 ft)
- 5P Dissected plateaux
- 5R Mountain ridges
- 5H Mountains

Unconsolidated superficial sediments

o Well-sorted sand
b Alluvium, dark cracking clay
a Alluvium, undifferentiated
e Evaporites, mainly saline lake deposits
w Swampy alluvial-flat deposits, including peat

Consolidated rocks

Sedimentary

s Sandstone and conglomerate

Carbonates

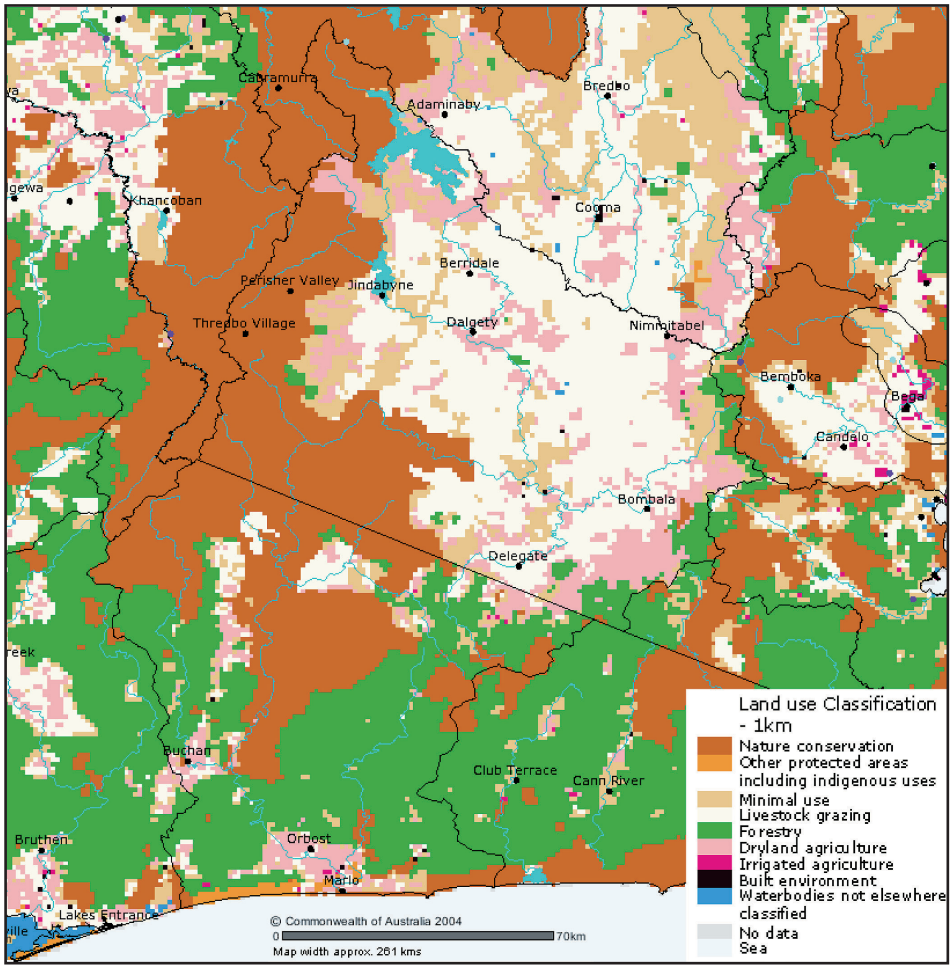
l Porous limestone, mainly Cainozoic
c Limestone and dolomite, mainly Palaeozoic & older

Metamorphic

p Low-grade (metasediments, metavolcanics, schists of greenschist facies)
q High-grade (schist, greenstone, amphibolite etc)

Igneous

2.2 Land Use Map

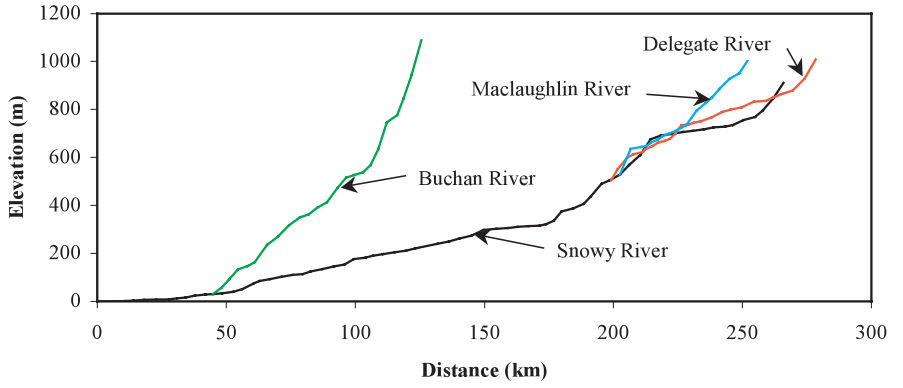


2.3 Characteristics of River and Main Tributaries

No.	Name of river	Length [km] Catchment area [km^2]	Highest peak [m] Lowest point [m]	Cities Population (2001)	Land use[1)]
1	**Snowy** (below L Jindabyne) (Main river)	350 11,720	1,833 0	Orbost Approx. 3,000	A G N
2	**Maclaughlin** (Tributary)	57 459	1,018 528		
3	**Delegate** (Tributary)	79 2,687	1,308 515		
4	**Buchan** (Tributary)	81 1,214	1,566 30		

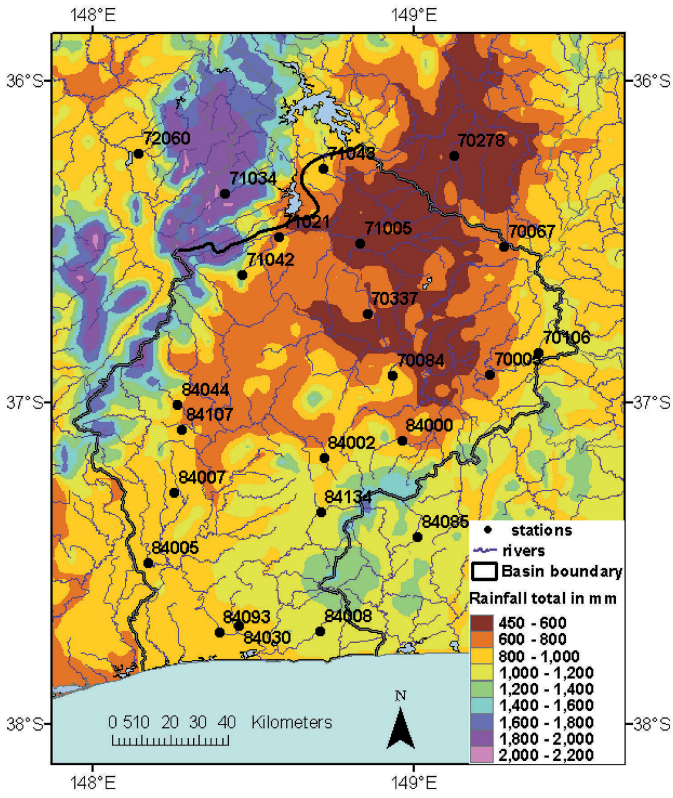
1) A: Agricultural G: Stock grazing N: National Park

2.4 Longitudinal Profiles



3. Climatological Information

3.1 Annual Isohyetal Map and Observation Stations



Based on thin plate spline analysis of all available rainfall stations.

3.2 List of Meteorological Observation Stations[1)]

No.	Station	Elevation [m]	Location	Observation period	Mean annual precipitation[2)] [mm]	Mean annual evaporation [mm]	Observation items[3)]
070005	**Bombala PO**	705	S 36° 54' 41" E 149°14' 16"	1912 - 2003	646		P, T
070067	**Nimmitabel PO**	1,075	S 36° 30' 44" E 149° 17' 06"	1911 - 2003	695		P, T
070084	**Tombong** (Hilcrest)	800	S 36° 55' 57" E 148° 56' 21"	1908 - 2003	593		P
070106	**Cathcart**	803	S 36° 50" 42" E 149° 23' 18"	1899 - 2003	801		P
070278	**Cooma** (Visitor Centre)	778	S 36° 13' 54" E 149° 07' 27"	1973 - 2003	537		P, T
070337	**Dalgety** (Jimenbuen)	790	S 36° 43' 30" E 148° 51' 17"	1993 - 2003	643		P
071005	**Dalgety** (Hamilton St)	765	S 36° 30' 15" E 148° 50' 02"	1896 - 2003	481		P
071021	**Jindabyne** (Lynwood)	1,030	S 36° 29' 14" E 148° 34' 56"	1906 - 2002	623		P
071034	**Guthega Power Station**	1,340	S 36° 21' 06" E 148° 24' 45"	1952 - 1994	1,780		P
071042	**Ingebyra** (Grosses Plains)	1,240	S 36° 36' 08" E 148° 28' 04"	1971 - 2003	857		P, TB
071043	**Berridale** (Eucumbene Trout Farm)	1,050	S 36° 16' 27 E 148° 43' 06"	1973 - 2002	627		P
072060	**Khancoban SMHEA**	337	S 36° 13' 31" E 148° 08' 35"	1961 - 2003	981	1,193	P, T, W, E
084000	**Bendoc Park**	790	S 37° 07' 07" E 148° 57' 48"	1887 - 2003	696		P
084002	**Bonang**	675	S 37° 10' 23" E 148° 43' 16"	1887 - 2003	916		P
084005	**Buchan**	90	S 37° 29' 55" E 148° 10' 23"	1883 - 2003	817		P, TB
084007	**Butchers Ridge**	670	S 37° 16' 52" E 148° 15' 14"	1933 - 2003	970		P
084008	**Cabbage Tree Creek**	51	S 37° 42' 36" E 148° 42' 29"	1946 - 2003	1,084		P
084030	**Orbost**	41	S 37° 41' 30" E 148° 27' 32"	1883 - 2003	850	1,073	P, TB, T, E
084044	**Black Mountain**	915	S 37° 00' 31" E 148° 15' 52"	1920 - 2003	726		P
084085	**Combienbar**	213	S 37° 24' 59" E 149° 00' 44"	1967 - 2003	987		P, TB
084093	**Orbost** (Bete Bolong)	20	S 37° 42' 54" E 148° 23' 38"	1968 - 2003	845		P

No.	Station	Elevation [m]	Location	Observation period	Mean annual precipitation[2)] [mm]	Mean annual evaporation [mm]	Observation items[3)]
084107	**Wulgulmerang**	914	S 37° 05' 03" E 148° 16' 40"	1970 - 2003	699	989	P, E
084134	**Goongerah**	235	S 37° 20' 28" E 148° 42' 38"	1980 - 2003	961	-	P

1) Only a representative sub-set of stations available in the basin are presented.
2) For period of observation.
3) P: Precipitation. TB: Tipping bucket with recording chart or logger. T: Temperature E: Evaporation W: Wind

3.3 Monthly Climate Data

Observing station: 072060 Khancoban

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	21.2	21.4	18.4	14.1	9.9	6.7	6.2	7.8	10.3	13.5	16.3	19.1	13.7	1962 - 1994
Precipitation [mm]	63.0	47.8	57.9	63.6	87.5	84.7	101.7	114.4	99.4	101.5	80.6	73.8	981.0	1961 - 2003
Number of rain days	7	6	7	9	12	14	16	16	14	13	11	9	134	1961 - 2003
Evaporation [mm]	205.1	171.0	135.9	70.7	36.3	20.7	22.4	35.9	65.4	106.3	144.4	187.3	1,193.0	1966 - 2003
Duration of sunshine [hr]	9.9	9.5	8.3	7.0	4.7	3.3	3.5	4.4	5.8	7.5	8.7	8.7	6.7	1962 - 1994

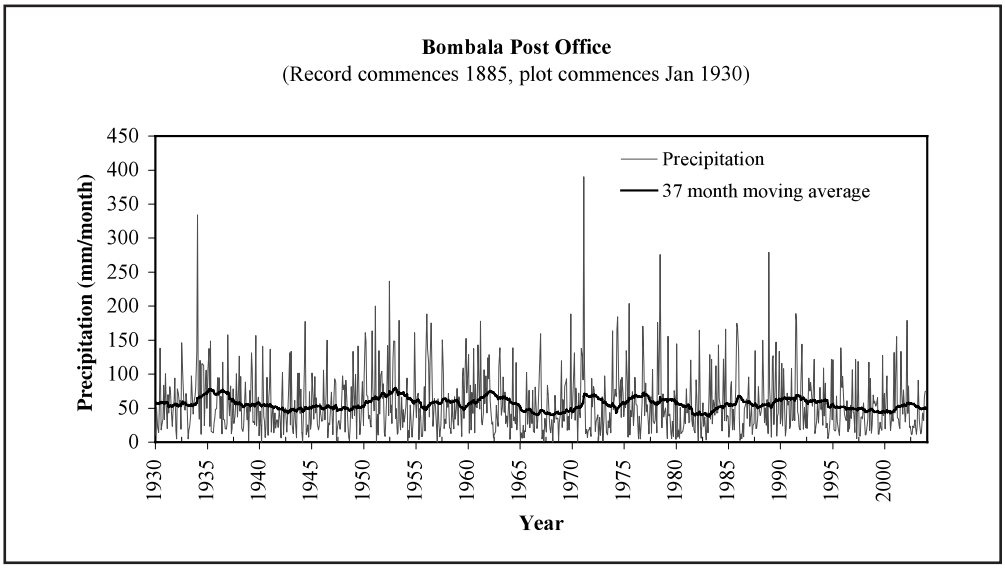
Observing station: 084030 Orbost

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	19.2	19.4	17.9	15.0	12.4	10.2	9.5	10.4	12.0	14.0	15.8	17.6	14.5	1938 - 2003
Precipitation [mm]	68.1	58.2	67.5	74.8	70.9	85.0	67.1	58.9	71.4	78.0	71.7	78.2	849.5	1883 - 2003
Number of rain days	8	7	8	9	10	11	11	11	12	12	10	9	117	1883 - 2003
Evaporation [mm]	152.7	135.4	107.5	66.7	49.0	36.6	40.3	61.4	81.6	103.9	120.0	136.4	1,073.0	1994 - 2003

Observing station: 084107 Wulgulmerang

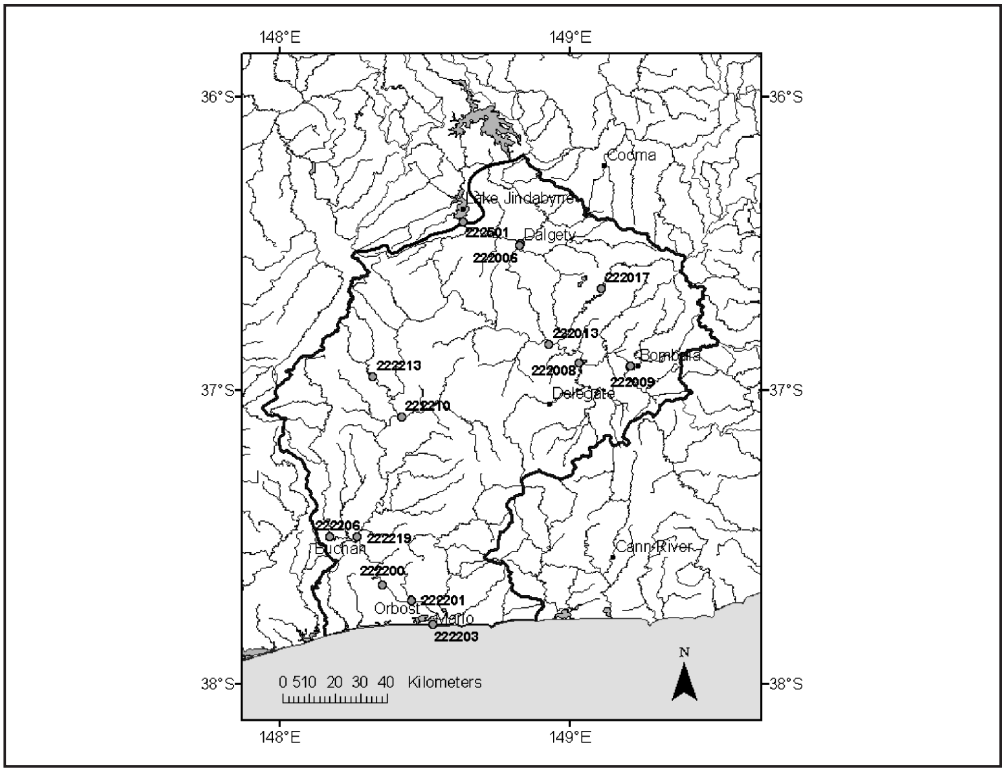
Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Precipitation [mm]	57.9	60.2	63.3	47.2	45.6	53.5	44.3	47.5	60.7	68.9	86.2	64.1	699.4	1970 - 2003
Number of rain days	9	8	9	9	10	10	10	11	11	12	12	9	121	1970 - 2003
Evaporation [mm]	156.6	123.5	99.5	64.9	44.5	30.3	36.6	52.7	72.6	92.7	107.7	157.8	988.6	1972 - 1982

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Hydrological Observation Stations



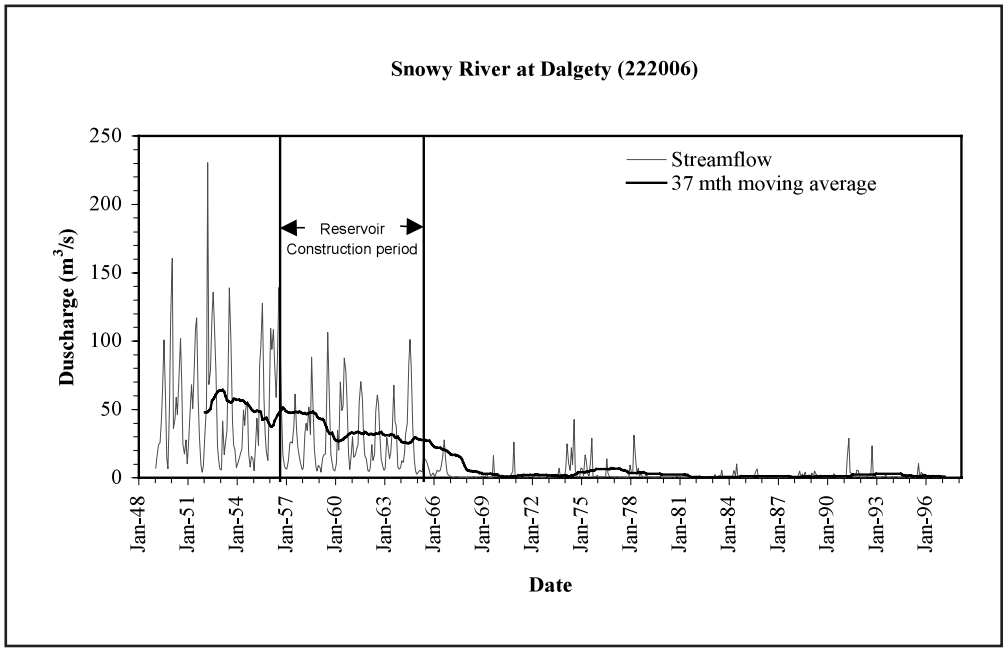
4.2 List of Hydrological Observation Stations

No.	Station	Location	Catchment area (A) [km^2]	Observation period	Observation items[1)]
222009	**The Falls** (Bombala River)	S 36° 55' 00" E 149° 12' 36"	559	1951 - 2003	H, Q
222206	**Buchan** (Buchan River)	S 37° 30' 00" E 148° 10' 30"	822	1926 - 2003	H, Q, W Q
222210	**Deddick (Caseys)** (Deddick River)	S 37° 05' 30" E 148° 25' 30"	857	1964 - 2003	H, Q, WQ
222008	**Quidong** (Delegate River)	S 36° 54' 24" E 149° 02' 00"	1,127	1951 - 2003	H, Q
222017	**The Hut** (Maclaughlin River)	S 36° 39' 18" E 149° 06' 06"	313	1978 - 2003	H, Q
222213	**Suggan Buggan** (Suggan Buggan River)	S 36° 57' 12" E 148° 19' 30"	357	1957 - 2003	H, Q, WQ
222501	**Jindabyne** (Snowy River)	S 36° 25' 24" E 148° 38' 00"	1,850	1902 - 1957	H, Q
222006	**Dalgety** (Snowy River)	S 36° 30' 00" E 148° 50' 00"	3,040	1949 - 1997	H, Q
222013	**Burnt Hut Crossing** (Snowy River)	S 36° 50' 30" E 148° 55' 54"	7,081	1975 - 2003	H, Q
222219	**D/S of Basin Creek** (Snowy River)	S 37° 30' 00" E 148° 16' 12"	11,964	1978 - 2003	H, Q, WQ
222200	**Jarrahmond** (Snowy River)	S 37° 39' 42" E 148° 21' 30"	13,421	1937 - 2003	H, Q, WQ
222201	**Orbost** (Snowy River)	S 37° 43' 00" E 148° 27' 30"	13,570	1907 - 2003	H, WQ
222203	**Marlo Jetty** (Snowy River)	S 37° 47' 54" E 148° 31' 42"	NA	1934 - 1998	H

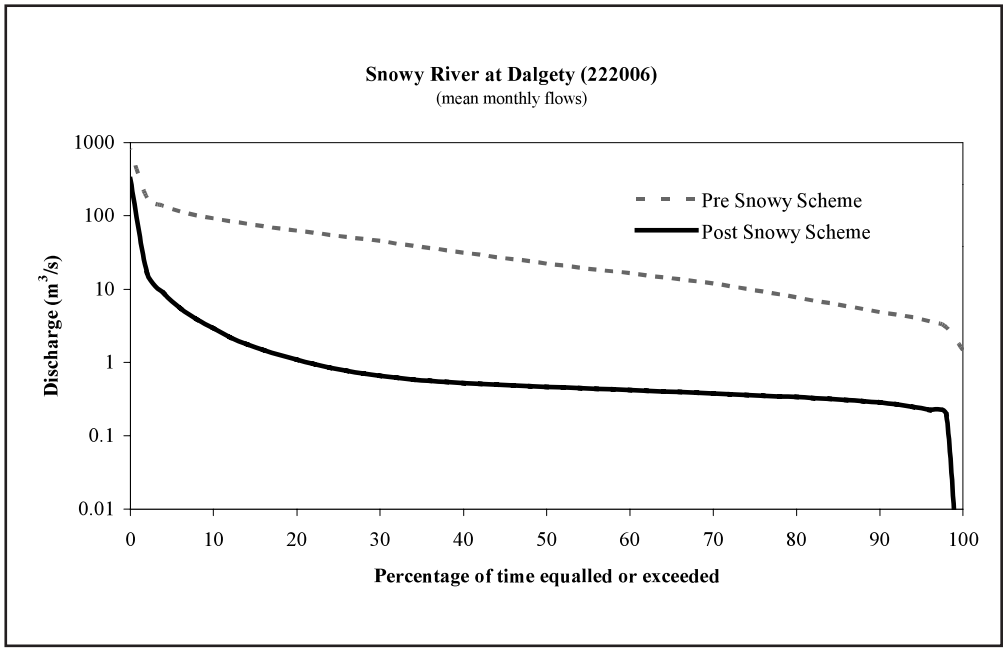
No.	$\overline{Q}$[2)] [m^3/s]	Qmax[3)] [m^3/s]	$\overline{Q}$max[4)] [m^3/s]	$\overline{Q}$min[5)] [m^3/s]	$\overline{Q}$/A [m^3/s/100km^2]	Qmax/A [m^3/s/100km^2]	Period of statistics
222009	4.47	1,670	65.3	0.66	0.80	298	1951 - 1995
222206	3.81	409	19.0	1.45	0.46	49.8	1975 - 2003
222210	1.98	389	14.25	0.64	0.23	45.4	1975 - 2003
222008	5.18	1,967	28.6	2.48	0.46	174	1951 - 2003
222017	0.73	789	15.5	0.18	0.23	252	1978 - 2003
222213	1.51	151	6.36	0.64	0.42	42.3	1975 - 2002
222006	39.5 2.16	1,216 501	156 24.1	15.9 0.510	1.30 0.18	40.0 42.1	1949 - 1965[6)] 1966 - 1997[7)]
222013	12.5	3,597	94.5	3.93	0.18	50.8	1975 - 2003
222219	22.4	3,378	123	7.96	0.19	28.2	1979 - 2003
222200	30.6	5,433	166	11.1	0.23	40.5	1975 - 2003

1) H: Water Level
Q: Discharge
WQ: Water Quality
2) Mean annual discharge
3) Maximum instantaneous discharge
4) Mean monthly instantaneous maximum discharge
5) Mean monthly instantaneous minimum discharge
6) Pre Snowy Scheme construction
7) Post Snowy Scheme construction

4.3 Long-term Variation of Monthly Discharge



4.4 Annual Pattern of Discharge



4.5 Unique Hydrological Features

Four hundred million years ago the Snowy region was a deep marine basin near the edge of a continent and prone to submarine volcanoes. Later, about three hundred and fifty million years ago, the area had risen above the ocean. Although the terrain was volcanic the mountains are believed to have been pushed up as fold mountains when Australia and New Zealand geologically separated. During the next two hundred and fifty to three hundred million years the region was gradually eroded, with the more resilient rock types forming the mountain ranges which have remained much the same for the past sixty million years to the present.

The Snowy River catchment (including the area above Jindabyne) can be broadly divided into four parts: the mountain rivers above Jindabyne Dam; the Monaro reach between Jindabyne Dam and the Delegate River; the Escarpment, a large tract of steeply dissected land stretching between the Delegate River and to upstream of the junction of the Buchan and Snowy rivers; and the lower Snowy floodplain, centred on the town of Orbost close to the river mouth. The Monaro reach of the river is in a rain shadow and experiences a mean annual rainfall of 500 mm while the mean annual rainfall increases to 800 mm at the coast. The Escarpment reach is thinly populated, mainly covered in forest reserves and National Parks and is difficult to access. Major floods in the lower Snowy are generated in the escarpment zone.

Under natural conditions the Snowy River experienced a number of floods each year that could occur at any time, although they were more frequent in the spring when rainfall coincided with snowmelt. Under existing conditions, after the construction of the Snowy Scheme, there are no floods immediately downstream of Jindabyne. Even at the coast, where there is a significant residual catchment unaffected by the Scheme the frequency and magnitude of floods have been reduced.

4.6 Annual Maximum and Minimum Discharges

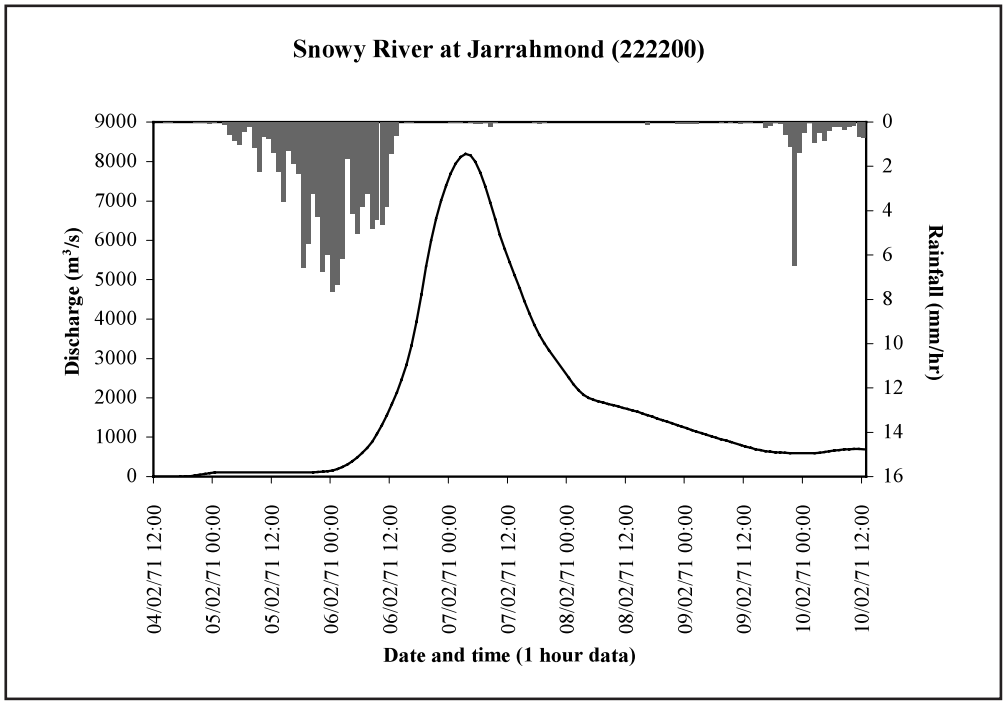
At Dalgety [3,040 km^2]

Year	Maximum[1)]		Minimum[2)]		Year	Maximum[1)]		Minimum[2)]	
	Month	[m^3/s]	Month	[m^3/s]		Month	[m^3/s]	Month	[m^3/s]
1949	10	289			**1973**	11	198	1	0.07
1950	3	790	1	2.79	**1974**	8	466	1	0.24
1951	10	477	2	3.93	**1975**	6	186	2	0.32
1952	6	1,216	2	2.04	**1976**	10	190	12	0.35
1953	10	382	4	2.80	**1977**	3	4.78	11	0.22
1954	8	592	4	2.96	**1978**	6	279	2	0.32
1955	10	669	1	2.10	**1979**	3	51.9	11	0.18
1956	5	531	2	6.10	**1980**	1	40.4	12	0.15
1957	10	339	4	1.54	**1981**	1	145	10	0.17
1958	6	536	3	1.95	**1982**	12	72.9	12	0.20
1959	10	498	4	1.76	**1983**	3	68.7	9	0.09
1960	7	408	3	1.37	**1984**	9	113	2	0.12
1961	11	340	2	1.39	**1985**	11	107	4	0.17
1962	11	198	4	1.92	**1986**	11	16.9	1	0.14
1963	11	275	3	2.32	**1987**	11	46.4	8	0.14
1964	10	248	3	1.83	**1988**	11	174	2	0.10
1965	8	171	12	1.14	**1989**	6	70.2	12	0.27
1966	11	156	4	0.04	**1990**	4	48.9	1	0.25

Year	Maximum[1)]		Minimum[2)]		Year	Maximum[1)]		Minimum[2)]	
	Month	[m^3/s]	Month	[m^3/s]		Month	[m^3/s]	Month	[m^3/s]
1967	1	24.9	9	0.013	**1991**	7	502	3	0.18
1968	10	5.48	3	0.0	**1992**	12	493	2	0.36
1969	11	201	1	0.16	**1993**	10	57.6	12	0.04
1970	12	53.1	7	0.12	**1994**	10	5.97	3	0.29
1971	2	372	10	0.13	**1995**	10	216	12	0.25
1972	1	49.5	12	0.02	**1996**	1	70.2	3	0.22

1), 2) Instantaneous observation

4.7 Hyetographs and Hydrographs of Major Floods



5. Water Resources

5.1 General Description

Australian rivers have some of the most variable flow regimes in the world, with long periods of drought induced low flows followed by flooding in wetter periods. A key feature of the Snowy Scheme is to provide greater security, by large long-term storage capability, to allow for electricity production and water releases for irrigation to continue at close to average output during long droughts. The design dry sequence taken from the historical record commenced in December 1936 and extended 5 years and 4 months on the Snowy-Murray, and 9 years and 7 months on the Snowy-Tumut

On average 1,140 Gl/year (1.14×10^9 m^3/year) of the southern flowing Snowy River flows above

Jindabyne are diverted to the other side of the Snowy Mountains to the northern flowing Murrumbidgee and Tumut rivers and the western flowing Murray River. These diverted flows are primarily released for electricity production in times of greatest demand. This has been primarily for winter heating but is increasingly being used for summer cooling through increased use of air conditioners. Releases are also provided for irrigation purposes. As a result of the diversions, flow in the Snowy River immediately below Jindabyne dam has been reduced to 1 percent and end of river flows have been reduced to 55 percent of pre-Snowy Scheme annual average natural flows.

Below Jindabyne there are no significant water impounding structures. There are some minor diversions of flow for stock and domestic and horticultural purposes.

5.2 List of Major Water Resources Facilities

Major Reservoirs

Name of river	Name of dam (reservoir)	Catchment area [km^2]	Gross capacity [$10^6 m^3$]	Effective capacity [$10^6 m^3$]	Purposes[1)]	Year of completion
Snowy River	**Jindabyne[2)]**	1850[2)]	688.3	N/A	P	1967

1) P: Hydro-power 2) The reservoir is the upstream extremity of the basin being described.

5.3 Major Floods and Droughts

Floods			Droughts
Date	**Station (River)**	**Peak Discharge (m^3/s)**	**Date**
Jul 1922	Jarrahmond (Snowy)	3,290	**1888**
Jan 1934	Jarrahmond (Snowy)	7,680	**1914/15**
Feb 1971	Jarrahmond (Snowy)	7,790	**1940**
Jun 1978	Jarrahmond (Snowy)	5,440	**1944**
Jul 1991	Jarrahmond (Snowy)	2,600	**1967**
Jun 1998	Jarrahmond (Snowy)	2,640	**1972/73**
Apr 1950	Buchan (Buchan)	330	**1979/80**
Feb 1971	Buchan (Buchan)	280	**1982/83**
Jun 1978	Buchan (Buchan)	410	**1987/88**
Jul 1984	Buchan (Buchan)	220	
Nov 1988	Buchan (Buchan)	280	
Jun 1998	Buchan (Buchan)	300	

5.4 Groundwater and Water Quality

A shallow aquifer system exists in the Snowy River basin that comprises four rock types. A strip approximately 20 km in width runs along the southern portion of the basin and consists of a gravelly aquifer overlain by Quaternary alluvial aquifers. An aquifer of dune sand occurs along the coast. The remainder of the basin is composed of a Palaeozoic basement of folded sediment, metamorphic and granite that act as minor erratic aquifers. Outcrops of Tertiary basalt and Devonian granite are scattered throughout the region. These rocks form local minor fractured rock aquifers. There is no deep aquifer system in the Snowy River basin. The groundwater resource is generally fresh declining to marginal in the south-western corner of the basin.

River Water Quality[1)] at Jarrahmond in 2003

Date	8/1	12/2	5/3	2/4	7/5	4/6	2/7	6/8	3/9	8/10	12/11	3/12
pH	7	7	8	8	7.3	7.6	7.3	7.4	6.8	7	7.3	7.4
DO [mg/l]	9.2	7.4	10.9	9.7	10.7	10.4	10.7	12.5	10.8	9.7	9.9	8.3
SS [mg/l]	1	1	3	1	3	3	5	3	14	2	2	3
Elect conductivity uS/cm	130	140	160	200	190	150	130	110	94	78	89	95
Discharge[2)] [m^3/s]	21.7	0.47	2.99	7.14	3.37	5.42	9.05	7.64	17.8	15.1	15.9	20.5

1) Observed once a month on a dry day normally several days after rainfall.
2) Discharge on the water quality observation date.

6. Socio-cultural Characteristics

Humans first moved into the mountains about twenty thousand years ago. Evidence in one cave near the Buchan River traces seventeen thousand years of almost constant occupancy, right up to the 1830s and 1860s when the Aborigines were annihilated by conflict and disease brought by white settlers. Cave art along the Snowy River dates back twenty thousand years, older than the famous paintings of the Lascaux bison hunters in Southern France and Spain. The Snowy Mountains played a profound spiritual and material role in the lives of Aborigines in the region.

Cooma and the Monaro district were the scene of brisk settlement in the 1820s and early 1830s as the pioneer stockman settled the grassy downs of the Snowy and upper Murrumbidgee catchments. By the 1840s all of the great grazing properties of the area were occupied and were supporting a population of 600. Consolidation of the grazing industry was punctuated by timber logging and the gold rush.

The 25 year construction period of the Snowy Scheme commencing in 1949 had a major impact on the social structure of the region. A country founded almost entirely by settlers from Britain almost overnight became one of the world's great pancultures. Tens of thousands of workers from more than 30 lands poured into what was an undisturbed pastoral realm. Following the completion of the Snowy Scheme the construction workers have dispersed throughout the country and their settlements have disappeared.

Orbost, the largest town in the catchment is a service centre for the local timber logging and saw milling industry and for the surrounding agricultural industry that raises beef and dairy cattle and grows beans and maize. The Snowy area below Jindabyne is an increasingly popular tourist destination featuring a range of outdoors and nature activities. A number of ski resorts are located in mountains above Jindabyne.

7. References, Databooks and Bibliography

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