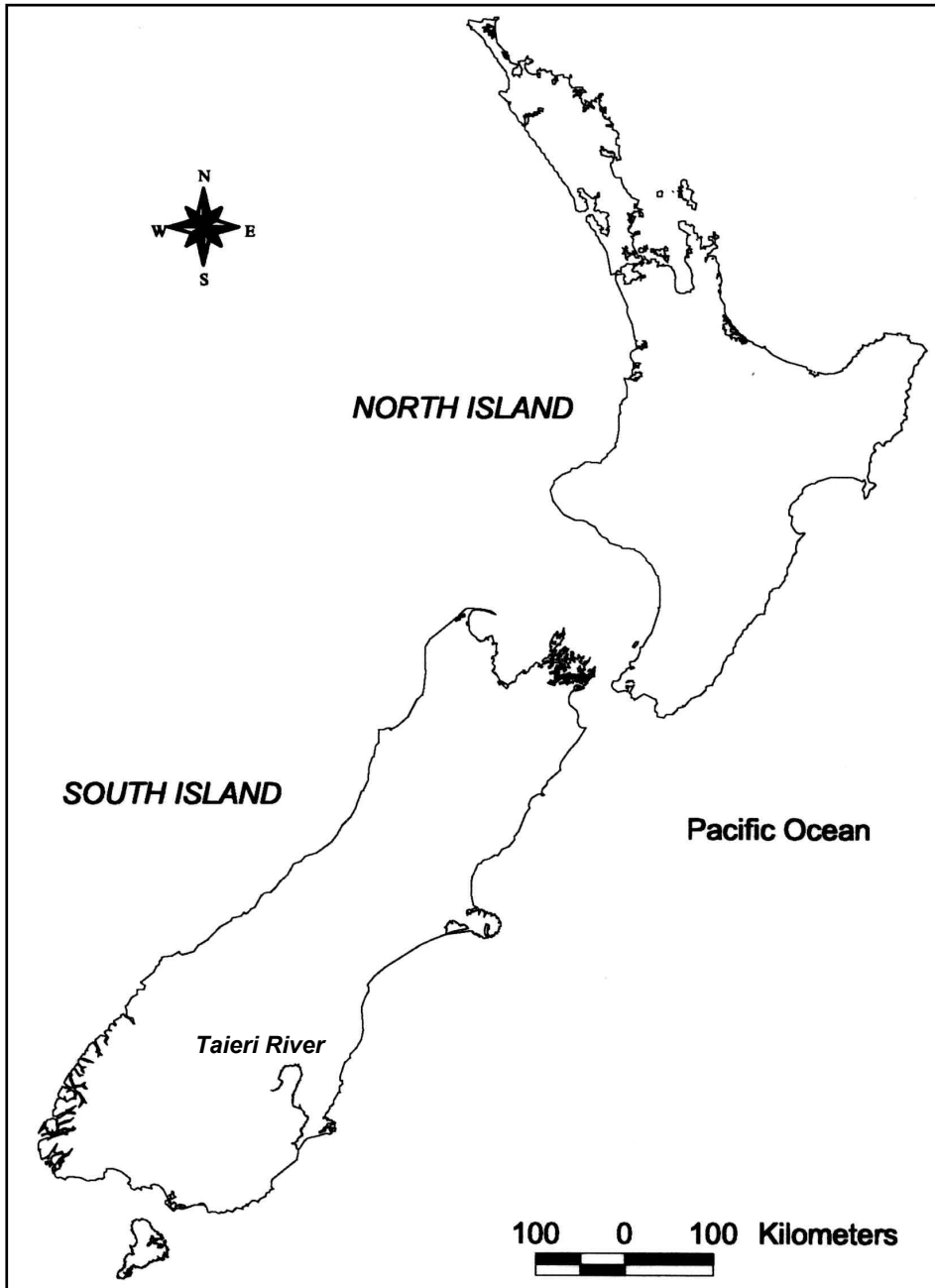


New Zealand

New Zealand-4: Taieri River



Introduction

New Zealand lies in the Southwest Pacific Ocean, and consists of two main and a number of smaller islands, with a combined area of 271 000 km². The islands extend over 1 500 km between the latitudinal range of 33° to 53°S, with a width of around 250 km. The highest mountains exceed 3 700 m in elevation, with short, steep rivers and high sediment loads. The climate is temperate, with a winter precipitation maximum in the north, and a summer-autumn maximum in the far south. The heaviest precipitation is estimated to exceed 15 000 mm/year in the Southern Alps, which are transverse to the rain-bearing westerly winds, with precipitation falling below 400 mm/year in the rain shadow area of central Otago. The population of New Zealand is about 3.7 million, of whom over 80 % reside in urban areas – nearly 1 million in the Auckland region alone. On the other hand, 51 % of the land is pasture and arable land, and 28 % is forest.

The New Zealand river catalogued in this volume is the Taieri River, in the central Otago region of the South Island. The catchment is pastoral in nature, with only 16 000 people, and represents the lightly populated, predominantly native grassland landscape of 1 000 years ago. It is in some respects unusual, because the topography is very much older and more subdued than the characteristically youthful New Zealand landscape, and it has a markedly dry and drought-prone climate. The mean annual runoff for the catchment is only 240 mm (35.8 m³/s), reflecting precipitation totals in some places below 400 mm/year, and high evaporation rates associated with a generally windy and sunny climate. The water resources have been developed for irrigation, water supply (for the nearby city of Dunedin), and also for hydro-electricity generation. A flood control scheme has been installed on the lower 20 km of the river, and this, together with land drainage, has dramatically reduced the frequency of flooding on the Taieri Plain.

Acknowledgements

The report was prepared by Paul Mosley (Secretary of the New Zealand National Committee for the IHP) and Alexander Kleinhaus, with the assistance of Steph Brown and Kathy Walter. Precipitation, river flow, and water quality data were supplied by the National Institute of Water & Atmospheric Research Ltd. The report has drawn heavily on published and unpublished material provided by the Otago Regional Council.

Taiari River

Map of the River

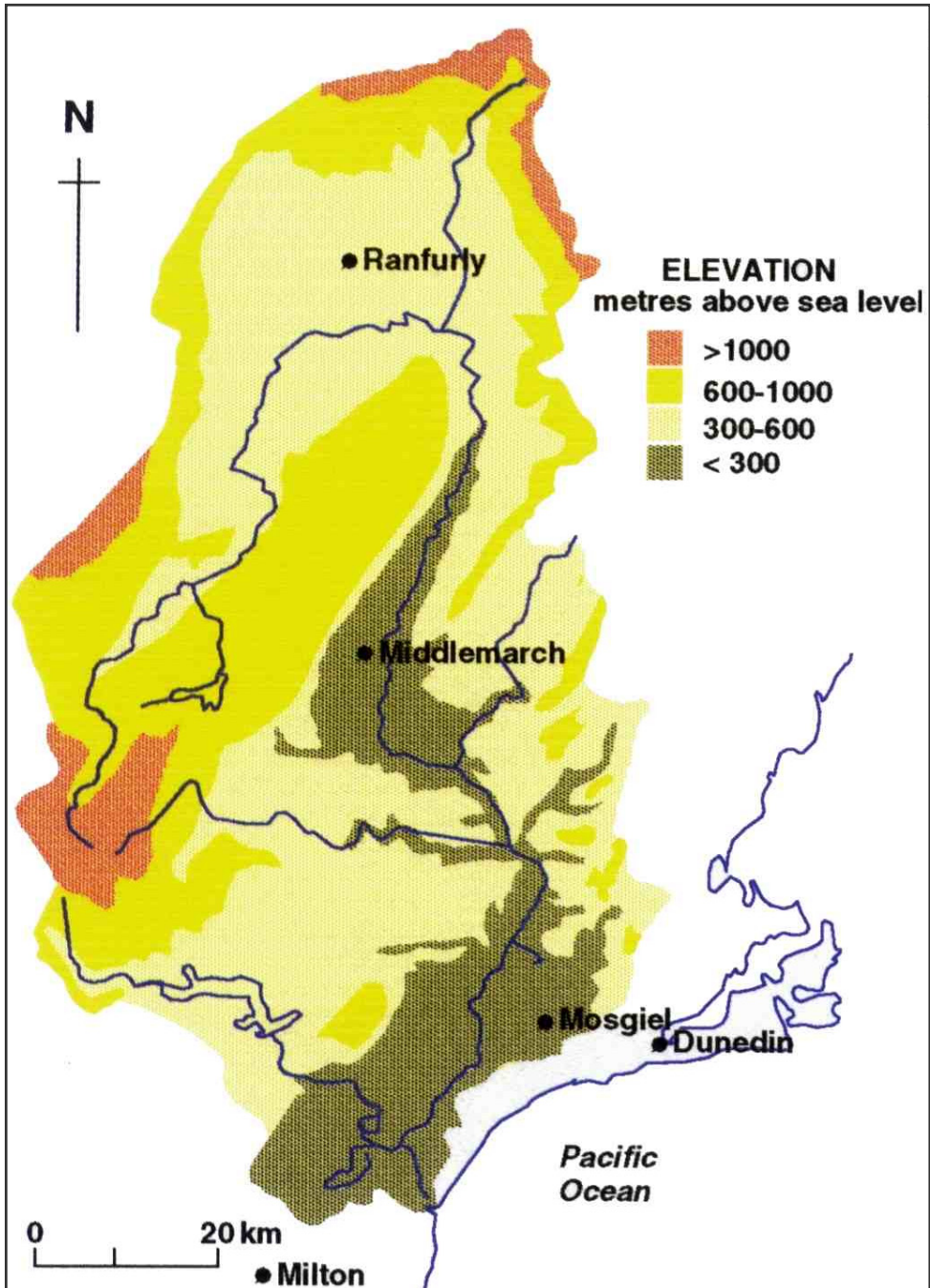


Table of Basic Data

Name: Taieri River		Serial No.: New Zealand-4
Location: Central Otago region, South Island	S 44° 55' ~ 46° 5'	E 169° 40' ~ 170° 30'
Area: 5 650 km ²	Length of main stream: 320 km	
Origin: Lammerlaw Range, Otago region	Highest point: Mt Ida (1 692 m)	
Outlet: Pacific Ocean	Lowest point: River mouth (0 m)	
Main geological features: Predominantly Paleozoic schists, with intrusions of Tertiary volcanic rocks. The topography is generally subdued, with extensive remnants of a Tertiary peneplain, and the overall tectonic structure is of basins and ranges. The ranges are low mountains up to around 1 500 m above sea level, and the basins have an infilling of Tertiary and Quaternary fluvio-glacial gravels and sands		
Main tributaries: Waipori River, Deep Stream, Kyeburn		
Main lakes: Lake Waiholo, Lake Waipori		
Main reservoirs: Lake Mahinerangi		
Mean annual precipitation: 900~1 000 mm estimated		
Mean annual runoff: 240 mm		
Population: 16 000	Main settlements: Mosgiel, Middlemarch, Ranfurly	
Land use: Predominantly unimproved and improved pasture, with small areas of plantation forest, alpine grassland and herbfield, horticulture.		

1. General Description

The Taieri River is located in the Otago region of the South Island, New Zealand. Its course is 320 km long, and it drains an area of 5 650 km². The catchment is lightly populated, with a population of only 16 000 persons, 9 000 of whom live in the largest town, Mosgiel. Land use in the catchment is predominantly pastoral, with both native tussock grassland and introduced pasture grasses equally represented. There are small percentages in exotic coniferous forest, regenerating shrubland, alpine grasslands and herb fields, and wetlands.

The river rises on the Lammerlaw Range, at around 1 150 m, then its course follows a large loop which is guided by geological structure. It eventually reaches the Pacific Ocean about 30 km south of the city of Dunedin, less than 50 km from its source. The landscape is one of the most ancient in New Zealand, and the topography is relatively subdued, featuring an extensive peneplain which was created during the Tertiary. It is dominated by schist block mountains arranged in a series of subparallel ranges trending northeast-southwest, and several intermontane basins and plains which are covered with Quaternary gravels. The largest of these, the Maniototo Plain, has been developed for irrigation, largely of pasture.

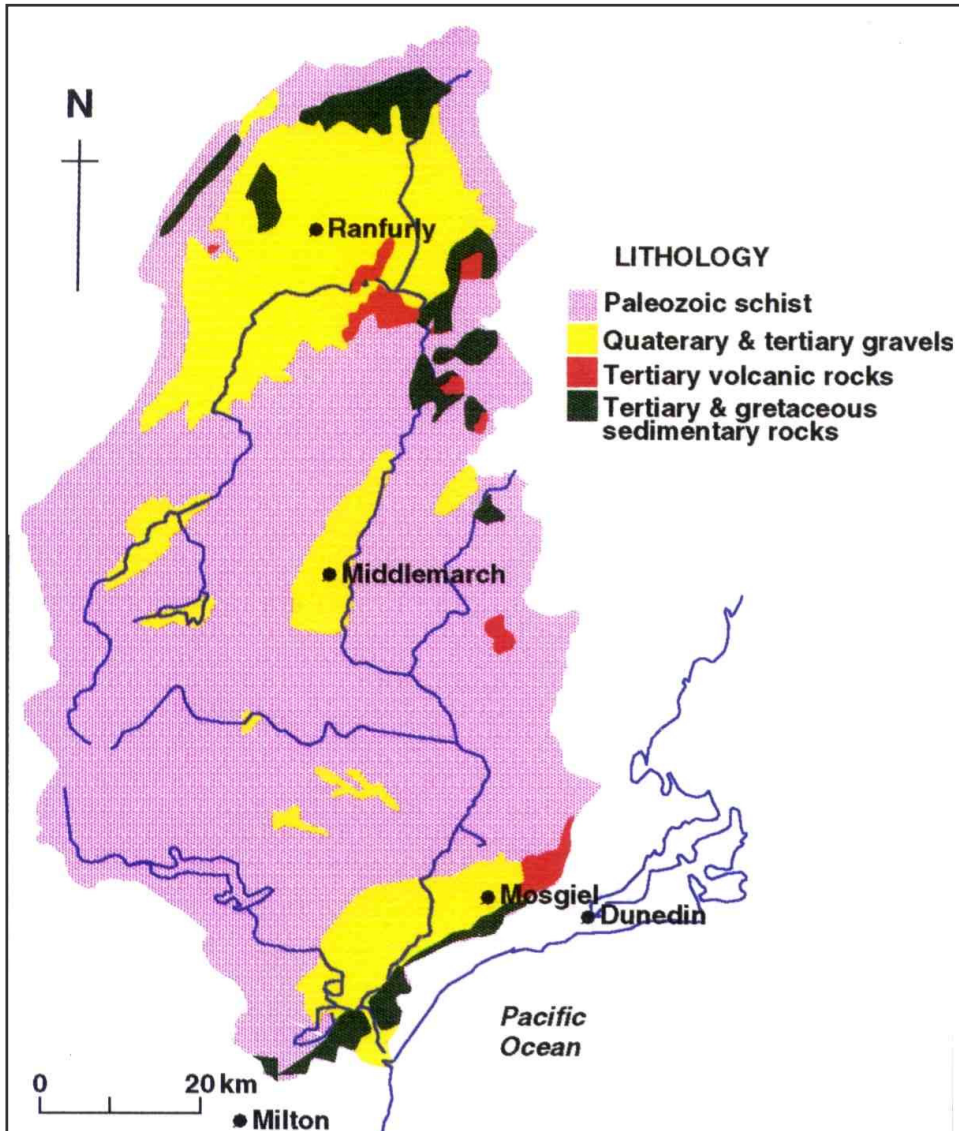
The highest point in the catchment is Mt Ida (1 692 m). Only 3 % of the catchment lies above 1 000 m, although 84 % is above 300 m. Where the river flows across the intermontane basins, its course has a low gradient and meanders intensely, but where it passes from the inland peneplain to the coastal plain, it has created the Taieri Gorge, an important tourist attraction.

The Taieri River and some of its tributaries have been developed for hydroelectricity generation, irrigation, and urban water supply. Because the catchment is drought prone, and these uses compete for water, an important water resource management issue is allocation of flows. The catchment features

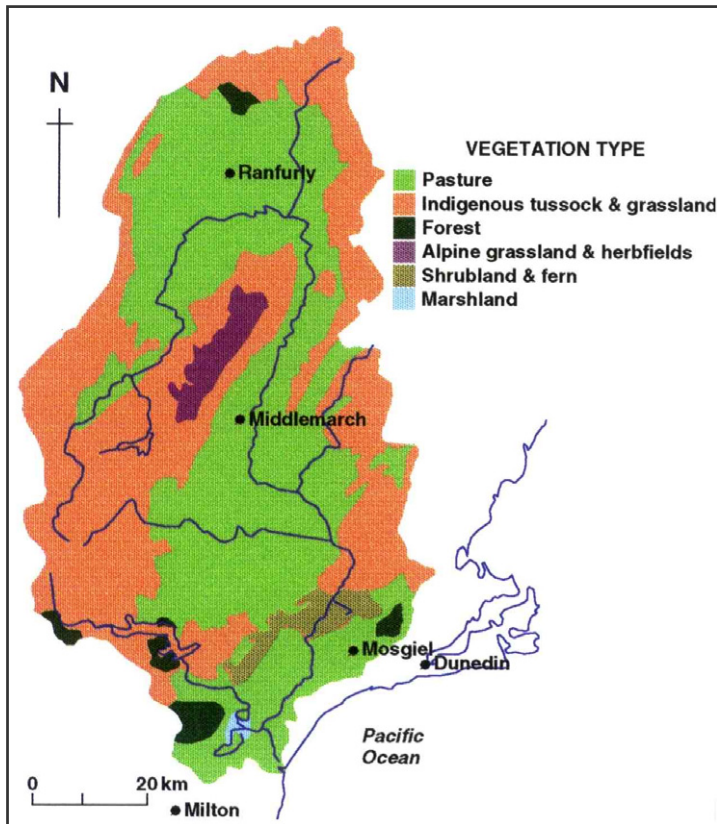
nationally important freshwater ecosystems, particularly wetlands and the highly sinuous meandering course of the upper river, which are sensitive to human activity. The river is dealt with as part of the *Draft Regional Plan: Water for Otago*, which has been prepared by the local resource management agency, the Otago Regional Council.

2. Geographical Information

2.1. Geological Map



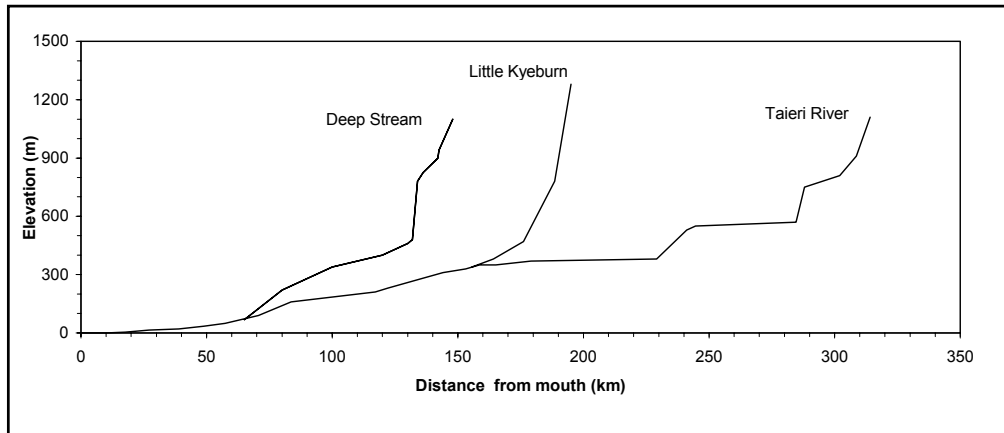
2.2. Land Use Map



2.3. Characteristics of River and Main Tributaries

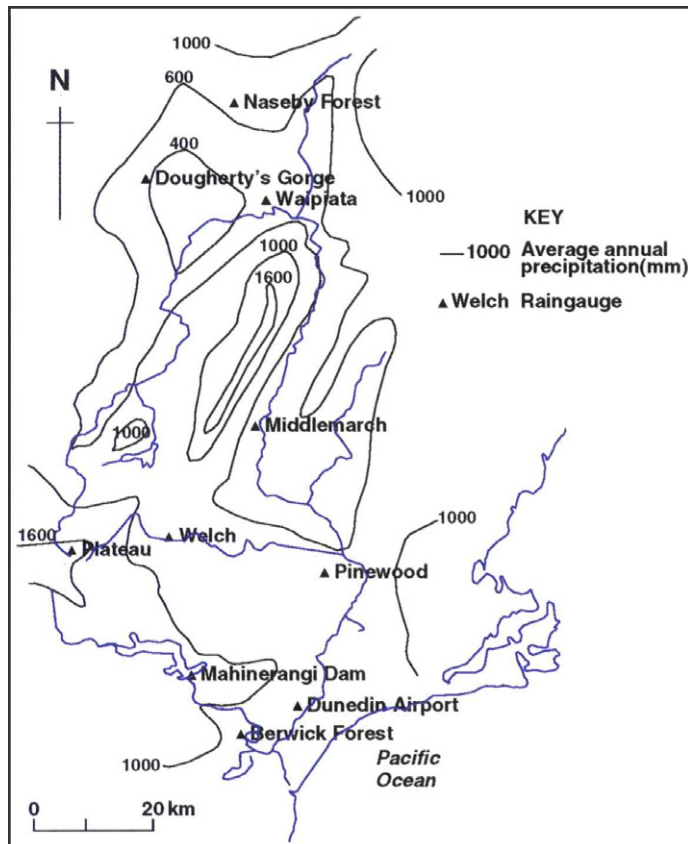
No.	Name of river	Catchment area [km ²]	Highest peak [m] Lowest point [m]	Settlements Population in 1991	Land use [%] (1991)
1	Taieri River (Main river)	5 650	Mt Ida (1 692) Pacific Ocean (0)	Mosgiel, 9 000 Ranfurly, 2 000	Forest (2) Alpine (2) Shrubland (2) Marshland (<1) Pasture (50) Native tussock grassland (44)
2	Waipori River (Tributary)	138	Lammermore (1 159) Taieri River (20)	No settlements	Forest (13) Shrubland (1) Pasture (3) Native tussock grassland (83)
3	Deep Stream (Tributary)	155	Lammermore (1 159) Taieri River (95)	No settlements	Pasture (100)
4	Kye Burn (Tributary)	135	Mt Kyeburn (1 636) Taieri River (350)	No settlements	Pasture (100)

2.4. Longitudinal Profiles



3. Climatological Information

3.1. Annual Isohyetal Map and Observation Stations



3.2. List of Meteorological Observation Stations

No. ¹⁾	Observation station	Elevation [m]	Location	Observation period	Mean annual precipitation [mm]	Observation items ²⁾
159234	Alexandra ³⁾	141	S 45° 56' E 170° 12'	1922~1980	343	Climate station
150921	Dunedin Airport	1	S 45° 01' E 170° 06'	1961~1990	661	Climate station
150012	Naseby Forest	610	S 45° 16' E 169° 23'	1923~1980	611	Climate station
150111	Ranfurlly	424	S 45° 07' E 170° 06'	1961~1990	417	Climate station
150853	Berwick Forest	18	S 45° 58' E 170° 04'	1961~1990	747	Rainfall
1591912	Dougherty's Gorge	480	S 45° 08' E 169° 55'	1969~1993	441	Rainfall
159891	Mahinerangi Dam	396	S 45° 53' E 169° 58'	1961~1990	972	Rainfall
150512	Middlemarch	198	S 45° 31' E 170° 08'	1961~1990	498	Rainfall
150722	Pinewood	351	S 45° 44' E 170° 15'	1961~1990	717	Rainfall
150112	Waipiata	360	S 45° 10' E 170° 09'	1961~1990	383	Rainfall
1596910	Welch	380	S 45° 41' E 169° 59'	1968~1985	596	Rainfall

1) Meteorological Service of New Zealand code number.

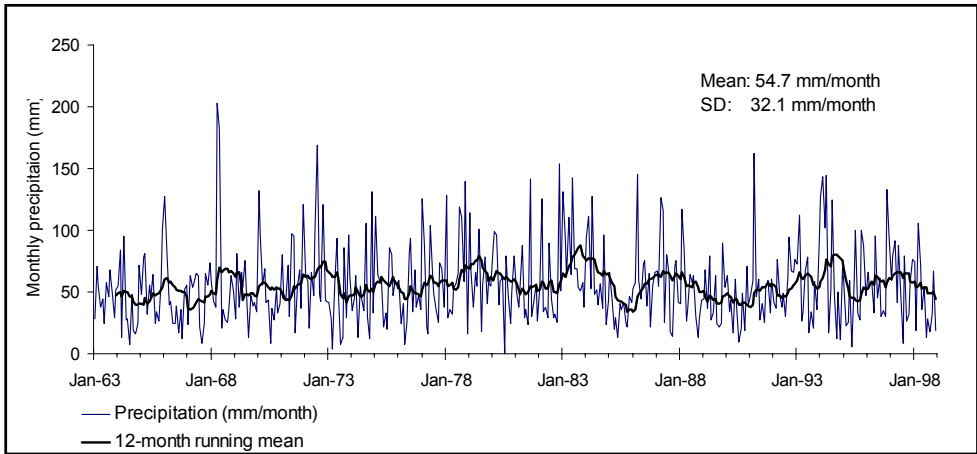
2) All observing stations had daily observations at 0900 hours.

3) Alexandra is outside the Taieri catchment, 25 km west of the western boundary.

3.3. Monthly Climate Data

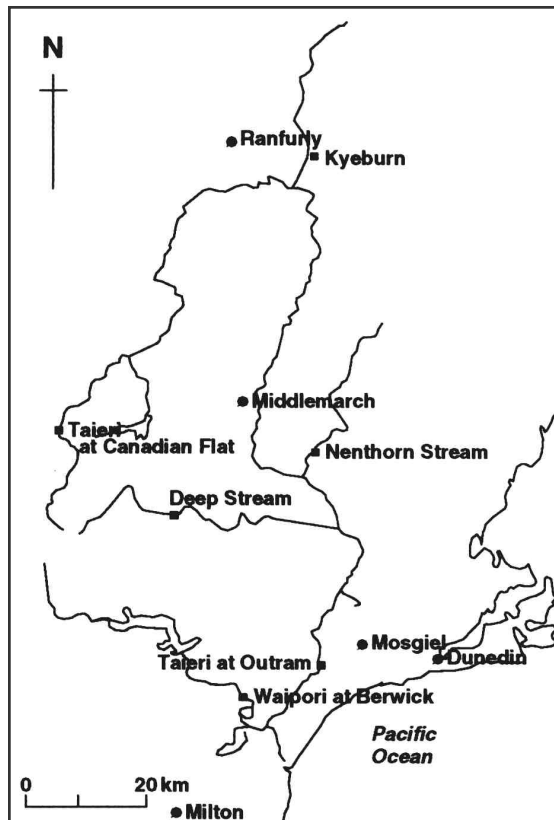
Observation item	Observation station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period for the mean
Temperature [°C]	Dunedin Airport	14.7	14.7	13.4	10.7	7.6	4.9	4.8	6.5	8.6	10.5	11.9	13.8	10.2	1962~80
Precipitation [mm]	Dunedin Airport	70	41	61	54	59	48	45	50	47	57	57	70	659	1962~80
Solar radiation [MJ/m ² /d]	Dunedin Airport	20.2	17.5	12.7	8.4	5.1	4.0	4.5	7.2	11.6	15.8	20.1	21.5	12.4	1962~80
Duration of sunshine [hr]	Dunedin Airport	174	165	143	128	99	98	100	122	134	162	169	182	1 676	1962~80
Temperature [°C]	Ranfurlly	14	12	11	8	4	2	2	3	6	9	10	12	8	1975~89
Precipitation [mm]	Ranfurlly	43	34	45	32	31	23	23	32	24	42	36	58	439	1975~89
Duration of sunshine [hr]	Ranfurlly	197	183	158	135	100	83	84	117	137	161	183	177	1 715	1975~89

3.4. Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1. Map of Streamflow Observation Stations



4.2. List of Hydrological Observation Stations

No. ¹⁾	Station	Location ²⁾	Catchment area (A) [km ²]	Observation period	Observation items (frequency) ³⁾
74308	Taieri at Outram	I44:958810	4 705	1958 ~ present	Q (15 min), S (periodic), WQ(m)
74311	Taieri at Tiroiti	I42:959466	2 468	1968 ~ present	Q (15 min), S (periodic)
74318	Taieri at Canadian Flat	H43:551135	158	1982 ~ present	Q (15 min), S (periodic)
74321	Waipori at Berwick	H45:851696	400	1986~1993	Q (15 min), S (periodic)
74331	Nenthorn at Mt Stoker Rd	H43:879157	213	1982 ~ 1996	Q (15 min), S (periodic)
74337	Kyeburn at SH 85	I42:946585	376	1986 ~ present	Q (15 min), S (periodic)
74353	Gimmerburn at Rough Ridge	H42:667589	23.7	1971 ~ 1994	Q (15 min), S (periodic)
74368	Elbow Creek at Muster Huts	H44:558969	1.24	1979 ~ present	Q (15 min), S (periodic)

1) National Institute of Water and Atmospheric Research code number.

2) New Zealand metric map reference.

3) Periodic measurements are taken irregularly, commonly during flood events.

Q(15 min): discharge recorded at 15 minute intervals; S: Sediment concentration; WQ(m): monthly water quality.

No. ¹⁾	Q [m ³ /s]	Q _{sd} [m ³ /s]	Q _{ma} [m ³ /s]	Q _{max} [m ³ /s]	Q _{min} [m ³ /s]	Q _{mi} [m ³ /s]	Q/A [m ³ /s/100km ²]	Q _{max} /A [m ³ /s/100 km ²]	Period
74308	35.8	53.2	653	2,526	1.67	4.55	0.76	53.7	1968~1998
74311	14.9	18.7	167	495	0.9	1.45	0.60	20.1	1986~1998
74318	4.9	7.02	104	162	1.9	0.85	3.10	102	1982~1998
74321	11.0	11.4	90.8	265	0	0.7	2.75	66.4	1968~1993
74331	1.0	4.68	111	364	0	0.07	0.47	171	1982~1998
74337	3.0	5.94	70.7	406	0	0.16	0.80	108	1986~1996
74353	0.07	0.18	3.42	23.8	0.0001	0.002	0.29	100	1971~1994
74368	0.03	0.08	1.36	6.47	0.001	0.006	2.81	522	1979~1998

1) National Institute of Water and Atmospheric Research code number.

Q: Mean annual discharge

Q_{ma}: Mean annual flood

Q_{min}: Minimum instantaneous discharge

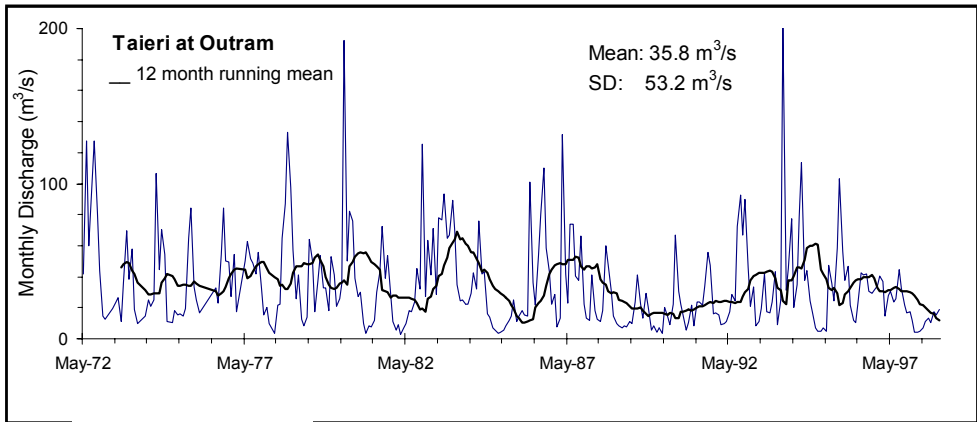
A: Catchment area

Q_{sd}: standard deviation of 15-minute discharges

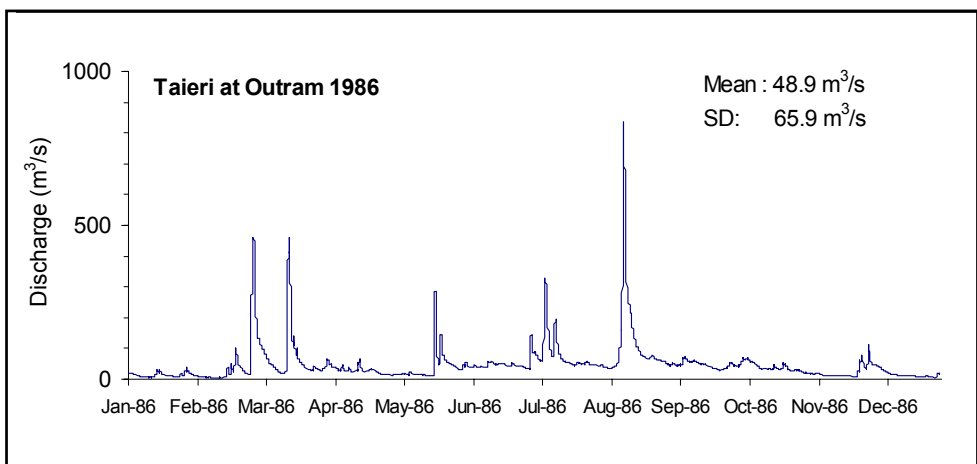
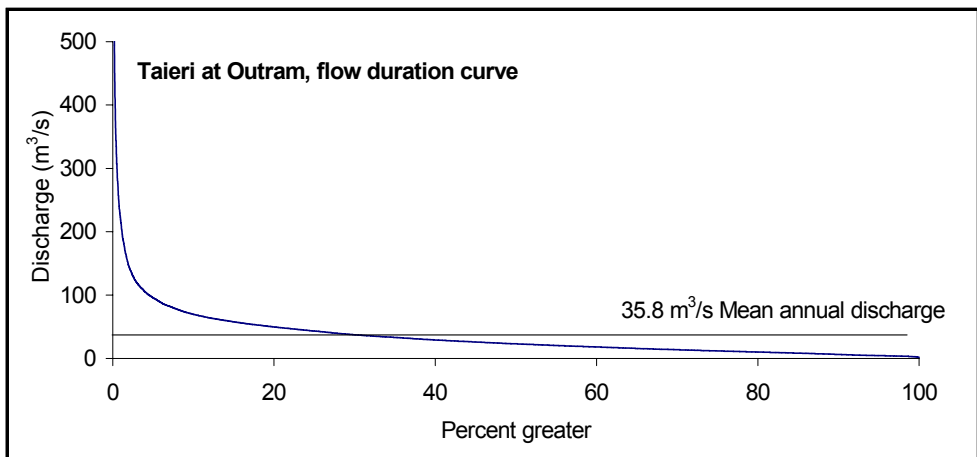
Q_{max}: Maximum instantaneous discharge

Q_{mi}: Mean minimum instantaneous discharge

4.3. Long-term Variation of Monthly Discharge



4.4. Annual Pattern of Discharge



4.5. Unique Hydrological Features

The Taieri River is very distinctive for its intensely meandering channel in a number of the basins, a result of the “basin and range” tectonic structure, and infilling of the basins by fluvio-glacial alluvium. In such places, the riparian areas are flood prone, but only in the downstream-most basin, the Taieri Plain, is the value of economic activity sufficient to warrant any significant flood mitigation. Here are located Dunedin airport and Mosgiel, the largest settlement in the catchment, and the recently completed Lower Taieri Flood Control and Drainage Scheme provides protection against a 1 in 100 year flood. Flood mitigation in other parts of the catchment consists of telemetered flood warning systems, channel straightening, and clearance of willow trees to improve channel conveyance.

The catchment also is distinctive, though not unique, for its dry, drought-prone climate. Cycles of wet and dry years have been recognized for many years, with periods of below average precipitation lasting as long as ten years. Such climatic variability is now commonly associated with the El Niño-Southern Oscillation phenomenon; whatever its cause, it has a major effect on agriculture in the alluvial basins of the catchment, and has prompted the development of the water resource for irrigation. The effect of climatic variability can be seen by comparing annual maximum and minimum discharges at the most downstream observation station, Outram. Maximum discharges range more than tenfold, from 201 m³/s to 2 526 m³/s, and minimum discharges from 1.67 m³/s to 12.1 m³/s.

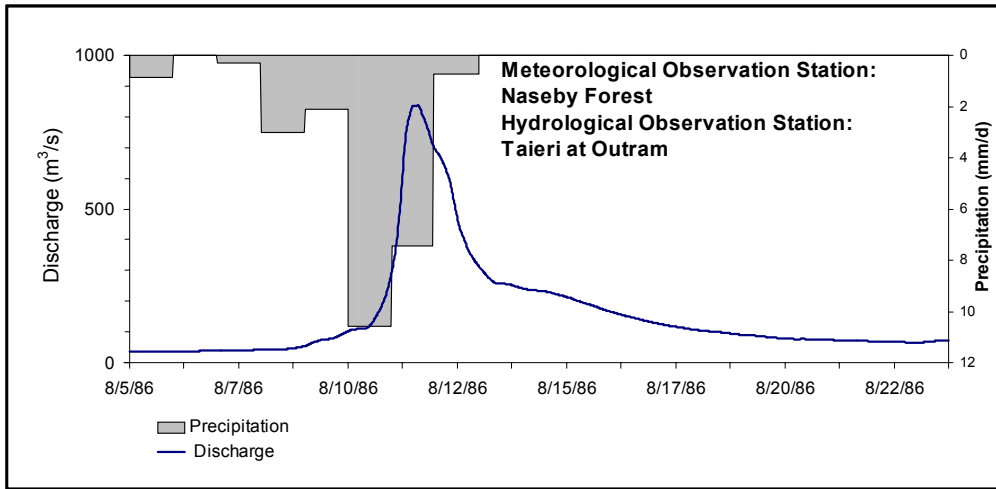
4.6. Annual Maximum and Minimum Discharges

Taieri River at Outram [4 705 km²]

Year	Maximum		Minimum		Year	Maximum		Minimum	
	[m ³ /s]	Date	[m ³ /s]	Date		[m ³ /s]	Date	[m ³ /s]	Date
1971*	458	71.06.08	48.0	71.06.06	1985	66	85.07.14	2.98	85.03.22
1972*	979	72.09.09	9.82	72.12.13	1986*	837	86.08.11	5.45	86.02.11
1973*	203	73.09.02	6.70	73.04.22	1987	770	87.03.11	3.93	87.01.22
1974*	944	74.07.31	6.44	74.12.07	1988	419	88.01.20	1.94	88.12.28
1975*	348	75.08.20	3.06	75.12.24	1989	93	89.06.26	1.71	89.01.03
1976*	478	76.08.27	13.6	76.12.14	1990*	696	90.08.25	2.23	90.02.08
1977*	337	77.05.04	7.71	77.04.03	1991*	326	91.02.18	3.49	91.02.11
1978*	1 070	78.08.25	1.67	78.03.31	1992*	305	92.09.10	4.09	92.02.27
1979	427	79.05.16	3.90	79.03.10	1993	1 467	93.12.23	5.00	93.11.19
1980	2 526	80.06.05	9.42	80.12.30	1994	1 066	94.07.28	6.26	94.12.31
1981	280	81.08.01	2.42	82.02.17	1995*	276	95.09.29	2.67	95.03.10
1982	672	82.10.26	1.68	82.03.21	1996	172	96.10.14	7.14	96.04.08
1983*	927	83.03.10	12.1	83.12.02	1997	327	97.01.12	6.95	97.12.20
1984	201	84.09.30	5.85	84.12.31	1998*	74	98.09.06	1.87	98.02.23

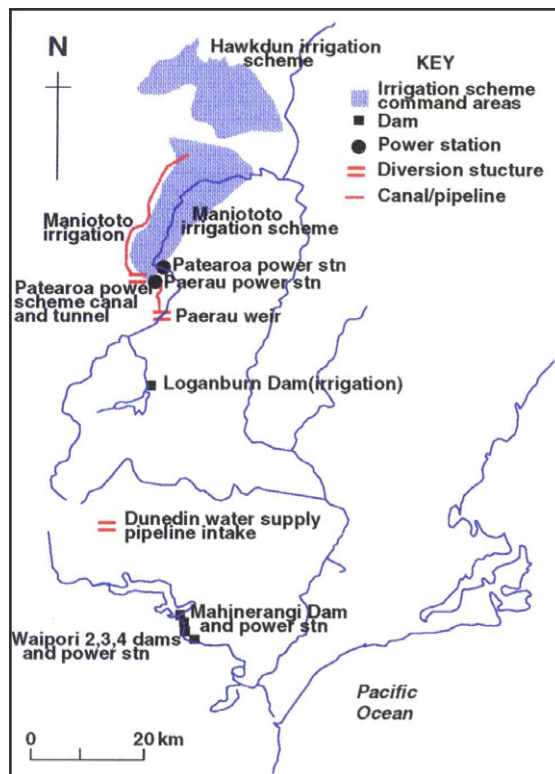
* denotes years in which there was missing record.

4.7. Hyetographs and Hydrographs of Major Floods



5. Water Resources

5.1. Map of Water Resources Systems



5.2. General Description

The Taieri River, with a catchment area of 5 650 km², is located in the southeastern part of the South Island. Because it is in the rainshadow of the Southern Alps, much of the catchment has one of the driest climates in New Zealand, with Waipiata receiving only 383 mm/year average precipitation (1961~1990). The western and central mountains receive 1 200~1 800 mm/year, the eastern uplands receive 750~1 000 mm/year, and the basins and plains receive 400~750 mm/year. The highest mean annual precipitation, about 1 800 mm/year, is experienced along the axis of the Rock and Pillar Range, in the center of the catchment. Precipitation is generally evenly distributed throughout the year, and is associated with the passage of frontal systems and the moisture-bearing southerly air flows that they bring. There is a tendency for a summer maximum inland, under the influence of convectional rainfall, and for a winter maximum in coastal areas, under the influence of southerly air flows. High summer temperatures, low humidity, and consistently high wind speeds encourage high rates of evaporation, particularly inland. Estimated annual evaporation is in the range of 400~500 mm/year, with monthly values ranging from 20 mm/month in winter to 110 mm/month in summer. Periodic droughts are a significant feature of the climate.

River flows at the most downstream observing station, Taieri at Outram (site 74308, with a catchment area of 4 705 km²), range between 1.7 m³/s and 2 530 m³/s (1968~98). Mean discharge is 35.8 m³/s and mean annual flood is 603 m³/s. The risk of flooding, particularly on the Taieri Plain where the river becomes tidal, has led to installation of a flood control scheme that is designed to provide protection against the “100 year flood”.

There are two natural lakes in the catchment, Lakes Waihola and Waipori, and two reservoirs, Lake Mahinerangi (hydro-electricity) and Logan Burn (which serves the Maniototo combined irrigation and hydro-electricity scheme). Water from the Taieri and its tributaries feed seven small rural water supply schemes, three small urban supply schemes, and the nearby Dunedin city, which is the second largest population centre in the South Island. The Taieri River catchment is regarded as having nationally significant ecological values. In particular, Lakes Waipori and Waihola and their adjacent wetlands provide outstanding wildlife habitat, and the upper Taieri is highly regarded for fishing. The flood plain of the upper Taieri, which features an intensely meandering channel, oxbow lakes and wetlands, is the best example of a “scroll plain” in New Zealand.

5.3. 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]	Purpose ¹⁾	Year of completion
Waipori River	Lake Mahinerangi	319	244.5	166.7	F, P	1946
Logan Burn	Logan Burn Dam	95	84	nd	A	1984

1) A: Agricultural irrigation; F: Flood control; P: Hydropower

Major Water Transfer

Name of transfer line	Name of rivers and places connected		Estimated annual quantity [10^3 m^3]	Purpose ¹⁾
	From	To		
Hawkdun Irrigation Scheme supply	Manuherikia River	Taieri River	4 800	A
Mahinerangi inflow	Beaumont River	Lake Mahinerangi	1 700	P
Dunedin City water supply	Silverstream	Dunedin City	3 700	W
Dunedin City water supply	Deep Stream	Dunedin City	15 300 max	W
Dunedin City water supply	Deep Creek	Dunedin City	2 500	W
Dunedin City water supply	Taieri Plain infiltration gallery	Dunedin City	12 000 max	W

1) A: Agricultural irrigation; P: hydroelectricity power generation; W: Municipal water supply

5.4. Major Floods and Droughts

The Taieri has a long history (in New Zealand terms) of river control works, principally by planting of willow trees to prevent bank erosion and channel realignment to improve flood runoff and drainage. Willow plantings in many places have had a negative effect, by spreading into the river channel and drastically reducing channel capacity. There also has been extensive land drainage, particularly on the Taieri Plain, where a flood control scheme using flood banks was initiated in 1921. Data have not been collected which enable preparation of a summary of the flood history of the catchment.

The Lower Taieri Flood Control Scheme now provides protection for the Taieri Plains up to the “1 in 100 year flood”, in conjunction with two subsidiary schemes, and appropriate operation of the Lake Mahinerangi hydroelectric power scheme. In the Upper Taieri, clearance of willows from the river channel, together with some channel realignment, are reducing flood-related problems, to the extent that can be justified in an economically undeveloped catchment.

As already noted, the upper Taieri catchment is dry and inherently drought-prone, and has experienced periodic droughts since active settlement and agricultural development began in the nineteenth century. Data are not available to summarize the attributes and consequences of such droughts, but construction of the Maniototo and Hawkdun Irrigation Schemes, as well as numerous farm-scale irrigation schemes, is an obvious major response to drought risk in the upper catchment.

5.5. River Water Quality

Observations of river water quality have been made at numerous locations in the Taieri catchment, and data are available from the Otago Regional Council. The Outram gauging station is one of the sites in the National Water Quality Network at which monthly observations have been made since 1988, and the table below presents some of the data for Outram, for 1997.

Because of the small population and low density of grazing animals, water quality in the Taieri catchment is generally high. Monthly observations at the Outram station indicate that dissolved oxygen and BOD₅ levels in the water flowing from the upper catchment are very satisfactory. Sewage has been discharged to the river from the small settlements of Ranfurly and Middlemarch, but volumes have been small relative to river flows. The greatest water quality concerns have been contamination of the lower Taieri River by discharge of contaminants, including sewage effluent from the treatment plant at Mosgiel, and reduced levels of dissolved oxygen and elevated temperatures during particularly low

flows, exacerbated by water abstraction in several locations. Eutrophication of Lakes Waihola and Waipori has been a concern for some years, because, even though they are partially flushed by tidal inflows, they receive runoff water from the agriculturally developed Taieri Plain. Water quality issues are all being actively addressed by setting minimum flow regimes and appropriate conditions on consents to abstract from or discharge to the river, and installing improved water treatment infrastructure. The Otago Regional Council considers that water quality has been improving in the lower Taieri over recent years. With the rapid growth of the dairy industry in New Zealand, the effect of contaminated runoff from dairy farms and milking facilities, particularly on the Taieri Plain, can be expected to present increasing problems for maintaining water quality in the lower river and Lakes Waipori and Waihola.

River Water Quality, Taieri River at Outram in 1997

Date	Jan 16	Feb 13	Mar 13	Apr 10	May 15	Jun 12	Jul 10	Aug 14	Sep 11	Oct 21	Nov 13	Dec 11
pH	7.48	7.33	7.78	7.14	7.45	7.32	7.34	7.27	7.77	7.49	7.11	7.60
BOD ₅ [ppm]	0.80	0.90	0.15	1.30	1.40	0.55	0.85	2.20	1.05	0.80	0.90	0.50
Conductivity [µS/cm]	64	58	87	64	77	59	73	64	75	79	40	73
Turbidity [NTU]	30.0	12.0	2.1	11.0	15.0	4.2	15.1	71.0	4.2	7.6	4.2	3.5
Total N [ppb]	559	596	225	588	579	395	518	814	254	393	319	319
Total P [ppb]	93	66	24	63	90	30	86	224	24	59	41	43
Discharge [m ³ /s]	53.3	86.9	10.8	52.1	48.8	27.6	27.8	91.8	22.8	16.9	39.6	15.6

6. Socio-cultural Characteristics

Much of the catchment is very lightly populated, and the principal land use is extensive, light grazing which supports scattered farms and a few small settlements. This type of development is typical of those parts of rural New Zealand which have been settled during the last 150 years by British and Australian colonists. Two large (for New Zealand) irrigation schemes, the Hawkdun and Maniototo Irrigation Schemes, have enabled intensification of land use in the area around Ranfurly, but even so, the population of the upper catchment (that is, excluding the Taieri Plain) is less than 6 000 persons (about 1.5 persons/km²), half of whom live in the settlements of Ranfurly, Middlemarch, and Naseby..

The principal area of settlement is the Taieri Plain, which contains Mosgiel (with a population of 9 000) and a number of smaller settlements, and the airport which serves the nearby city of Dunedin. Mosgiel and surrounding areas have experienced a certain amount of commercial and industrial development. The Taieri Plain is more intensively developed for a wider range of agricultural activities than the upper catchment, including dairying and horticulture. Because of its proximity to Dunedin, which is the second largest city in the South Island, it has also become a popular residential area – although, nevertheless, the total population is still only approximately 10 000 persons. The agricultural, residential and industrial developments have placed stresses on the water resource, particularly from a water quality perspective. This is of some importance, because the lower river and Lakes Waipori and Waihola have significant ecological and recreational value, and active management of the water resource is aiming to improve water quality, to safeguard such instream values.

The environment and natural resources in the Taieri River catchment are managed by the Otago Regional Council, within the provisions of the Resource Management Act. In practice, of course, the ultimate managers of the water resource are landowners, irrigators, and other users of the river system, with the Otago Regional Council exercising an “oversight” role. Management is carried out within the

framework of a Regional Policy Statement and a system of issuing “resource consents” to abstract or divert water, discharge effluents, and so on. A Regional Plan for Water is currently (1999) being prepared and debated within the community, which will provide more specific guidance for decision makers and resource owners/users.

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