WATER

Physical Stock Accounts for the June years 1995 to 2001

Inaugural Report

Environmental Accounts Series

Prepared by Statistics New Zealand

Published July 2004
Updated December 2004

Contents

Figures

Tables

Acknowledgements

This report was prepared by the Geography, Regional and Environment Division and published by the Product Development and Publishing Services Division of Statistics New Zealand. It is based on studies commissioned by the Ministry for the Environment (MfE) and Statistics New Zealand.

Statistics New Zealand would like to thank many organisations for providing data, advice and assistance for this study. Among those who contributed are:

- District councils
- Hydropower companies: Meridian Energy, Contact Energy, Mighty River Power, Bay of Plenty Electricity, Todd Energy
- Institute of Environmental Science and Research Ltd (ESR)
- Institute of Geological & Nuclear Sciences Ltd (GNS)
- Lincoln Environmental (LE)
- Metrowater
- Ministry for the Environment (MfE)
- Ministry of Agriculture and Forestry (MAF)
- National Institute of Water & Atmospheric Research Ltd (NIWA)
- Opus International Consultants
- Regional councils
- United Water
- Watercare Services Ltd

Further information

For further information on the statistics in this report, or on other reports or products, contact our Information Centre.

Visit our website: http://www.stats.govt.nz
or email us at: info@stats.govt.nz
or phone toll free: 0508 525 525

Auckland	**Wellington**	**Christchurch**
Private Bag 92003	PO Box 2922	Private Bag 4741
Phone 09 920 9100	Phone 04 931 4600	Phone 03 964 8700
Fax 09 920 9198	Fax 04 931 4610	Fax 03 964 8964

Information Centre

Your gateway to Statistics New Zealand

Each year, we collect over 60 million pieces of information. New Zealanders tell us how and where they live; about their work, spending and recreation. We also collect a complete picture of business in New Zealand. This valuable resource is yours to use. But with all the sophisticated options available, finding exactly what you need can sometimes be a problem.

Giving you the answers

Our customer services staff provide the answer. They are the people who know what information is available, and how it can be used to your best advantage. Think of them as your guides to Statistics New Zealand. They operate a free enquiry service where answers can be quickly provided from published material. More extensive answers and customised solutions will incur costs, but we always give you a free no-obligation quote before going ahead.

1 Introduction

Statistics New Zealand is developing a set of natural resource accounts for freshwater. The first accounts to be published are the physical stock accounts for water quantity. These accounts are at the national and regional levels for the June years 1995 to 2001. A summary of the account tables and links to further tables and reports are in chapter 3.

The physical stock accounts for water deal with quantities of water in the inland part of the hydrological system. Inflow of water to the system is by way of precipitation, while the main outflows are via rivers to the sea and evapotranspiration to the atmosphere. Outflows equal inflows when changes in storage are taken into account.

There is limited data for water abstraction in the tables. Abstractions and discharges for irrigation are not available. Volumes for livestock usage are not measured but are calculated from livestock numbers and standard consumption per head. Abstractions for private domestic supply have been estimated according to regional water usage in municipal reticulation networks but there is insufficient information to enable reliable estimation of private industrial abstraction volumes.

- The accounts can assist in assessing water usage, availability and effects of climate change.
- The West Coast is the wettest region and Otago the driest.
- Annual precipitation per person in the West Coast region, at 2.2 million cubic metres, is 430 times higher than in the Auckland region.
- Hydroelectricity generation uses about 140 cubic metres of water per person per day.
- Municipal and domestic abstraction is only 0.2 percent of annual precipitation.

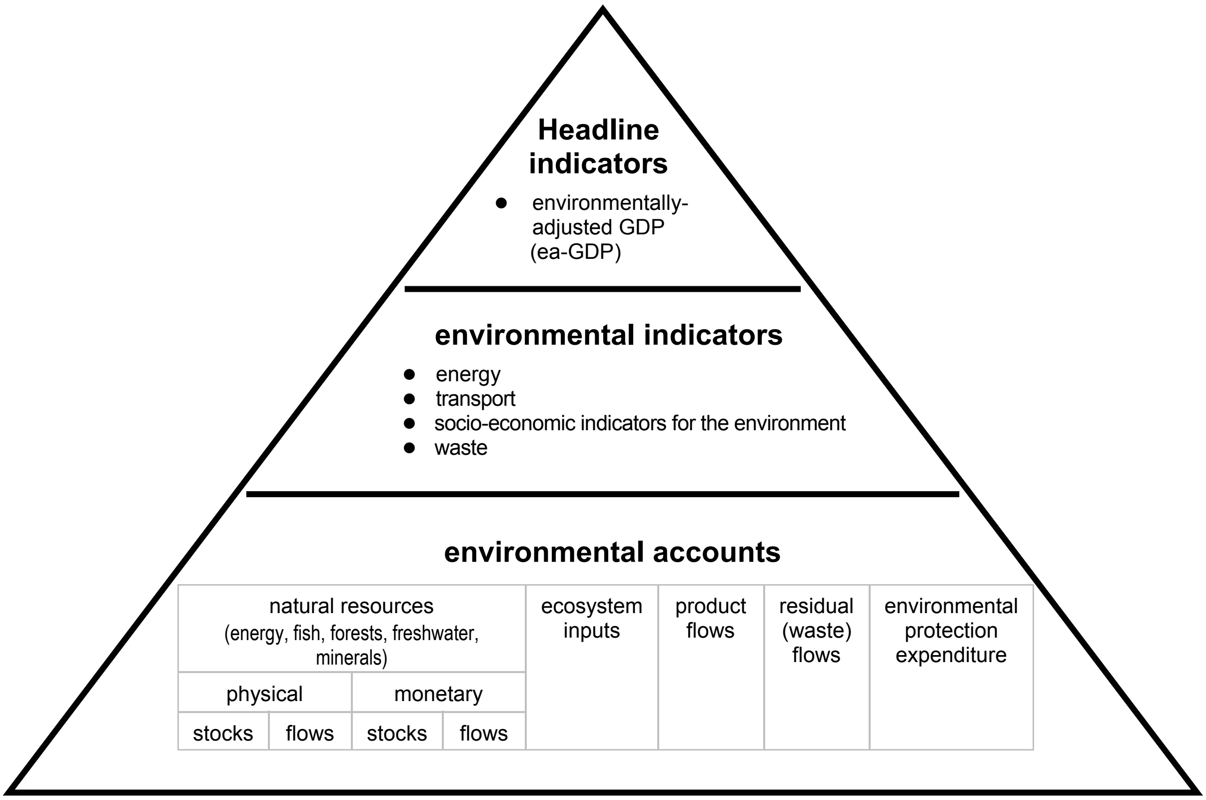
Feedback on this report and accounts is welcome. Content and presentation of the accounts may evolve as data sources and methods change and develop.

2 Background

2.1 Environmental accounting

Statistics New Zealand is working with a number of government and other agencies to produce a range of statistical measures regarding the natural environment and the impact of economic and social activities on the environment. Among the statistical measures, Statistics New Zealand is developing environmental accounts for several natural resources: fisheries, forestry, minerals and energy, and freshwater. Environmental accounts consist of physical and monetary stock and flow accounts. The physical stock and flow accounts are referred to as natural resource accounts. They measure the physical stocks (assets) and flows of natural resources in units such as tonnes and cubic metres. These quantities are then valued, resulting in monetary figures that will form the environmental accounts and be linked to economic statistics such as the Gross Domestic Product (GDP). Refer to figure 1 below.

Figure 1. Statistics New Zealand's Environment Statistics Framework



Further information on the environment statistics framework and strategy is available on the Statistics New Zealand website.[1]

The physical stock accounts are the first accounts to be developed for freshwater. They describe how the stocks of freshwater are affected by water flows within the hydrological system during accounting periods. The general structure of the accounts is defined by the United Nations handbook *Integrated Environmental and Economic Accounting* (commonly referred to as SEEA).[2] In the SEEA, stock accounts are called asset accounts. They deal with opening and closing stocks of water resources and the flows that affect these stocks. In the New Zealand stock

1 http://www.stats.govt.nz
2 The handbook can be downloaded from website http://unstats.un.org/unsd/envAccounting/seea.htm

accounts, total opening and closing stocks are not quantified. Instead, the accounts are presented in terms of inflows, outflows and changes in stock levels. There are gaps in the New Zealand stock accounts concerning water use (abstraction and discharge) by people and livestock. These gaps will be filled when comprehensive data becomes available or suitable estimation methods are developed.

The water and energy physical stock accounts are currently the only New Zealand resource accounts developed at the regional level. Monetary stock accounts for water will follow if suitable valuation methods are developed. There is insufficient data on industry usage at this time to develop flow accounts for water. Stock accounts deal with components of the hydrological cycle relating to freshwater supplies in New Zealand. Flow accounts, if produced, would show exchanges of water between the environment and the economy (at an industry level). Refer to sub-chapters 6.3 and 6.4 for further information.

The physical stock accounts for water cover the June years 1995 to 2001. Each accounting period represents the 12 months from 1 July to 30 June inclusive. The 1995 June year, for example, ends on 30 June 1995. The unit of measurement is millions of cubic metres (billions of litres).

2.2 Broad perspective

Most of the world's water is seawater. Only about 2.5 percent of water is freshwater. Ice-caps and glaciers account for about 70 to 80 percent of freshwater, depending on the source of information, while groundwater accounts for about 20 to 30 percent. Lakes, soil moisture, atmospheric water vapour, rivers, and water within living organisms account for the remainder, which is about one percent.

Figure 2. World Water Distribution[3]

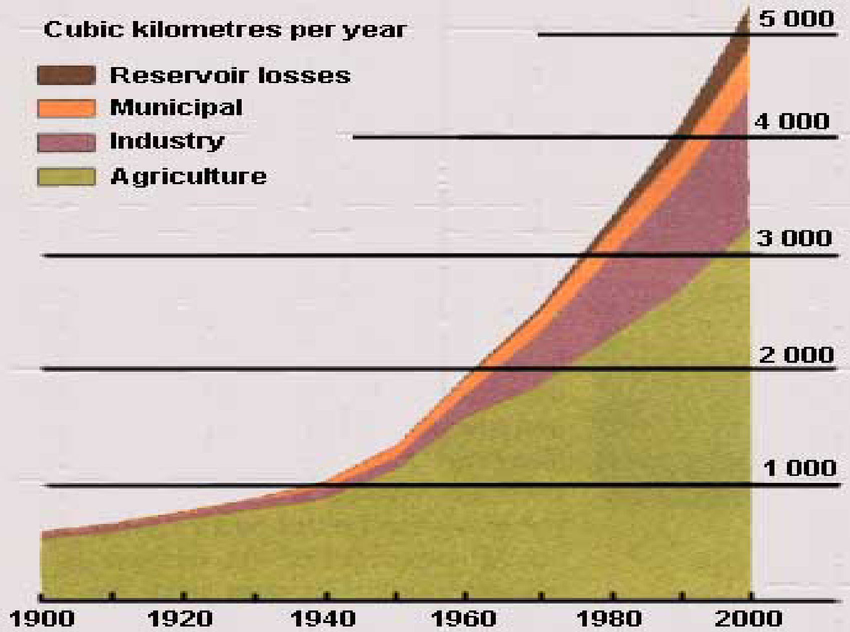
	Water volume km^3 (million)	Percent of total water	Percent of freshwater
Total water	1,386	100.00	…
Saline water	1,351	97.47	…
Freshwater	35	2.53	100.0
- ice-caps and glaciers	24.4	1.76	69.7
- groundwater	10.5	0.76	30.0
- lakes, rivers, atmosphere	0.1	0.01	0.3

Symbol: … not applicable

"Over the last 50 years, global water withdrawal has quadrupled while world population doubled."[4] The heaviest water user globally is agriculture, which is responsible for about 69 percent of total freshwater abstraction. Industry accounts for 23 percent and households for 8 percent. While per capita water consumption has decreased since 1980 in OECD countries, the net population growth has meant that water consumption overall has increased. Industrial use in the OECD countries, with the exception of New Zealand, is now higher than agricultural use.

3 *World water resources,* Food and Agriculture Organization of the United Nations (FAO).
4 *Water Crisis?* Rory Clarke, OECD Observer (19 March 2003).

Figure 3. Estimated Annual World Water Use[5]



Relative to most other countries, New Zealand has abundant freshwater. The total annual amount of precipitation in New Zealand varies between 300,000 million and 600,000 million cubic metres. However, the availability of New Zealand's freshwater varies significantly between regions, with the amount of annual rainfall generally decreasing as one moves east.[6] This is largely due to New Zealand's mountainous topography where one third of the land area is above 1,000 metres. The mountains largely control the distribution of rainfall due to their orientation to the predominant west-southwest wind flows. Rainfall in most areas is higher during winter and spring than during summer and autumn.

The availability of water also varies between the rural and urban environments. The sustainable management of water in urban environments is becomingly increasingly important as the urban population increases, particularly with the added pressures of higher drinking-water standards and stricter discharge conditions. New Zealand's rainfall also varies markedly over periods of time. "Shifts in rainfall patterns indicate greater variability of supply in the future, and our per capita demands tend to still be rising, stressing supply and delivery systems, and taxing treatment capacity."[7]

"New Zealand's rivers and lakes provide about 60 percent of the water we consume (the other 40 percent comes from underground). They also provide 75 percent of our electric power."[8]

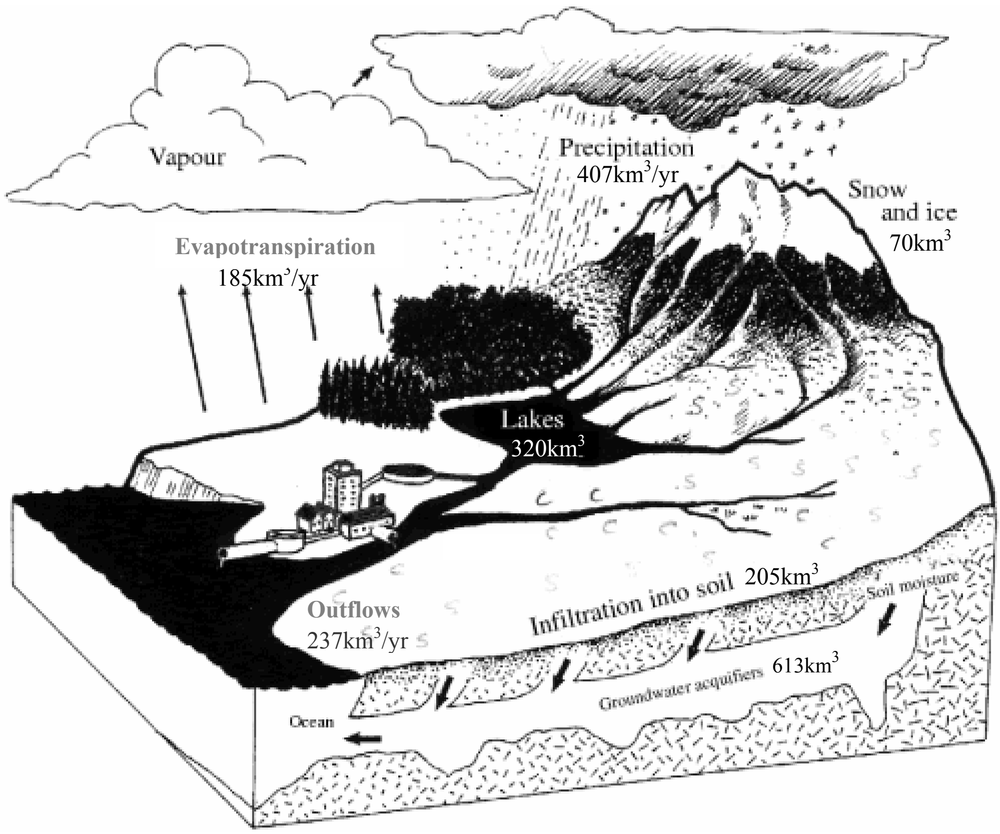
2.3 The hydrological cycle

Water has a number of properties that set it apart from other natural resources. Water is constantly moving and transforming into different states over time. Water is also constantly being renewed, but its availability fluctuates over time for different regions, depending on the hydrological cycle, human use of water, and other factors.

---

5 *Water: a finite resource,* Food and Agriculture Organization of the United Nations (FAO), http://www.fao.org/docrep/U8480E/U8480E0c.htm [5 July 2004]
6 *Waters of New Zealand,* M P Mosley [editor] (1992).
The New Zealand Hydrological Society. ISBN 0-473-01667-2 (out of print).
7 *Whose Water Is It?,* Parliamentary Commissioner for the Environment (2001).
8 *The State of New Zealand's Environment,* chapter 7.6, MfE (1997).

Figure 4. New Zealand Water Cycle



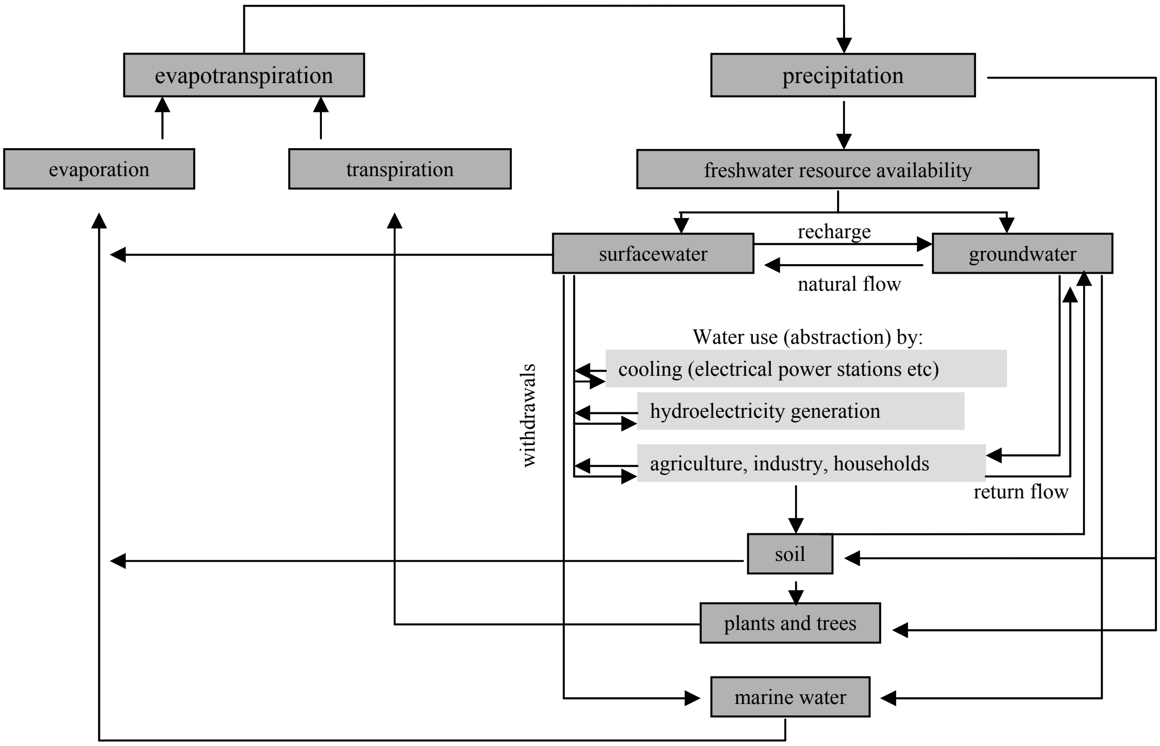
Source: Based on MfE, adapted fom Mosley (1993)

In the above figure, one cubic kilometre (km^3) equals 1,000 million cubic metres. Annual flows (km^3/yr) are for the June year 2001. Storage volumes (km^3) for snow and ice and groundwater aquifers are estimates as at 30 June 2001.

Water use is dependent on its quality. Humans rely on clean water for drinking while other uses, such as hydropower generation, do not require the same standards of purity. As a result, there may be a plentiful supply of water but it may still be a scarce resource, depending on the planned use of that water.

Water accounting, using the SEEA handbook, is based on the hydrological cycle (see figure 4), which tracks the movement of water through the hydrosphere (the region containing all the water in the oceans, atmosphere and land). In the cycle, water evaporates from oceans and the vapour is carried in air currents. As the vapour cools, it condenses and forms clouds or fog which, with further cooling, may fall on land as precipitation (either rain or snow). This precipitation can then follow a number of pathways. It may be evaporated immediately, be absorbed by plants and vegetation which then release the water back to the atmosphere through transpiration, or drain into surfacewater and groundwater systems which eventually drain into the sea.

Figure 5. Interaction between the Hydrological Cycle and the Economy[9]



"The hydrological cycle is driven by radiation reaching the earth's surface. This radiation increases as greenhouse gas concentrations rise. The incoming radiation strongly influences both the surface temperature and the rate at which water evaporates from land and sea. In turn, the temperature determines the moisture-carrying capacity of the air, and the melt rate of polar ice and alpine snow. Temperature differences also create air pressure differences that give rise to the world's winds. Climate scientists therefore expect significant changes in climate patterns if greenhouse gas pollution continues to force up surface radiation and global temperatures, and these changes would have very significant flow-on effects for water resources."[10]

The natural cycle is also modified more directly through human activities, such as abstractions, discharges, construction of dams, and changes in land use including urbanisation, forest planting and land drainage.

2.4 Water management

In New Zealand, a number of different agencies are involved in the management of water. Regional councils are responsible for the management of natural water (ie, freshwater, groundwater, geothermal water and coastal water). They are required to safeguard the life-supporting capacity of waters and to ensure that water users avoid, remedy or mitigate any adverse effects on the environment from their use of water. Territorial authorities are generally responsible for the management of the municipal and community water supplies in their district (sometimes these community water supplies are privately owned). Crown research institutes, in particular the National Institute of Water & Atmospheric Research Ltd (NIWA), and the Institute of Geological & Nuclear Sciences Ltd (GNS), through their research and scientific monitoring roles, also contribute to the management of surfacewater and groundwater resources.

9 Based on *Environmental Indicators for Agriculture, Volume 3, Methods and Results,* OECD (2001). http://www1.oecd.org/publications/e-book/5101011E.PDF [6 July 2004]
10 National Institute of Water & Atmospheric Research Ltd, NIWA, (2004).

Unless expressly allowed by a rule in a regional plan, the Resource Management Act 1991 (RMA) requires approval, in the form of a resource consent from a regional council, for the abstraction of water, except for an individual's reasonable domestic use, livestock use or for fire-fighting purposes. Regional councils keep records of the water permits granted, including the allocated maximum volumes, as well as monitoring records, such as the actual volumes abstracted, when this information is available. Allocated volumes are maximums and tend to overestimate the amount of water actually abstracted. The reasons for this are:

- allocations are based on peak or near-peak demand
- different uses require peak volumes at different times
- not all of the allocated volume is required every year
- some water is not used but reserved for future use
- variation in weather.

As a result, allocated maximum volumes are generally not a good proxy for actual water abstraction. The degree to which actual abstraction is monitored varies greatly between regional councils and there is insufficient coverage for compilation of national aggregates.

In New Zealand, households obtain their water either through a piped community water supply that is usually managed by the local authority (but in some cases is privately owned), or by directly connecting to their own water source through private wells or pumping from streams. Some houses also have rainwater tanks. An estimated 87.5 percent of New Zealand's population was connected to a registered drinking-water supply in 2002.[11]

Territorial authorities, to varying degrees, collect data on water abstraction by category of user, for the municipal and community water supplies they manage. Good information is generally available for large urban water supplies because these supplies are usually metered. The smaller the population served by a water supply, the less likely it is that data is available, because of limited resources for metering and monitoring. Private abstraction of water for reasonable domestic or livestock use is a permitted activity that does not require resource consents. There is no comprehensive data for such abstractions.

Territorial authorities also monitor water quality and administer rules concerning dairy shed effluent, sewage and other discharges of contaminants to water. In addition, regional councils, NIWA and GNS all have water quality monitoring networks. The RMA which replaced more than 20 major statutes, including the Town and Country Planning Act 1997, has changed the focus of water resource management from multiple-use management to environmentally-sustainable management.

2.5 Scope of the water accounts

2.5.1 Inclusions

The water accounts deal with the inland water component of the hydrological system. The scope is broad and includes all freshwater (as opposed to seawater) resources, whether above, on or below ground, that provide both direct use and non-use benefits. Direct use benefits include water that can be extracted in the current period as well as water that may be of use in the future. Non-use benefits (such as kayaking) arise simply by having the resource exist.

The stock classification for freshwater resources reflects those components of the hydrological system that are available for water abstraction and that provide direct inputs into the economy.

Soil moisture, glaciers and permanent snow are not specifically classified as a 'stock' as water is not abstracted directly from these sources. However, they are important components of the hydrological system and are included in the accounts.

---

11 *Annual Review of the Microbiological and Chemical Quality of Drinking-Water in New Zealand 2002*, Ministry of Health (December 2003).

The water stock accounts are compiled on a regional basis as well as a national basis. Although New Zealand is a relatively small country, there is considerable variation in precipitation and water availability from one region to another. For example, droughts can occur in Canterbury at the same time as heavy rainfall occurs on the West Coast. Such extremes tend to average out at the national level. Accounts at the regional level are necessary for meaningful analysis.

2.5.2 Exclusions

Opening and closing stocks are excluded because of difficulties in measuring volumes, particularly for rivers. The SEEA handbook includes opening and closing stocks in the water asset or stock account and suggests that the stock of water in a river can be measured by the volume of the riverbed. However, many South Island rivers are braided and have riverbeds that are constantly shifting. Data is not available for the riverbed volumes in New Zealand. The absence of opening and closing stocks for rivers means that total opening and closing stocks cannot be calculated. The water stock accounts are therefore in the form of a water balance, where inflows equal outflows plus changes in stored volumes.

Water in oceans and seas is not included in the accounts because the volumes of water involved are so large that a stock measure would be meaningless and such water is rarely abstracted for direct use.

Some flows, such as discharges of abstracted water and outflows to sea from groundwater, are not individually included in the accounts. They are included only indirectly or as part of other components.

Water quality is outside the scope of the current water accounts, but could in principle be included in the future.

The water stock accounts are the first attempt at water accounting in New Zealand. Data limitations have made it necessary to adopt a broad approach.

2.5.3 Uses

The physical stock accounts for water bring together abstraction and discharge information with a variety of hydrological data, including precipitation, evapotranspiration, outflows and changes in stored water. The tables in the stock accounts can assist in assessing:

- regional and national availability and scarcity of the resource
- effects of El Niño/Southern Oscillation (ENSO) and Interdecadal Pacific Oscillation (IPO) cycles
- regional and national water usage
- interactions between the environment and the economy
- effects on the water resource of structural and policy change in other sectors

2.5.4 Water accounting year

The period 1 July – 30 June has been selected as the water accounting year because:

- each June year contains a whole irrigation season
- periods of low flows or drought are of interest for analysis and usually fit well with (ie occur entirely within) individual June years
- June/July is generally a period when storage has been replenished and water levels are stable.

2.5.5 Sources of data

Water is probably the most monitored feature of the New Zealand environment. Even so, national data is rather limited. Information on the quantity and quality of groundwater, surfacewater and coastal water is collected by a diverse range of organisations, headed by regional councils and local territorial authorities (ie district and city councils), NIWA and GNS.

The State of New Zealand's Environment 1997, prepared by the Ministry for the Environment (MfE), compiles the available water data for New Zealand, to provide a general overview of the state and pressures on the water resource. Many regional councils also publish *State of the Environment* reports containing information on water quality and flows, and ESR, a Crown research institute, manages a drinking-water database for the Ministry of Health.

"From 1983 through to 1988, the Ministry of Agriculture and Fisheries summarised much of the existing information on a region by region basis in a series of reports entitled "Regional modifications to waterways" in the now defunct journal, *Freshwater Catch*. … Apart from this, there have been few attempts to provide a systematic overview of the state of our waters, particularly at the national level. No repetitions of the 1980s baseline surveys have been undertaken to report on trends."[12]

2.5.6 Abstraction data

The physical stock accounts for water measure inflows, outflows and changes in storage between years for inland water (freshwater, as compared to seawater). The accounts also measure, where possible, interactions between the hydrological cycle and the economy. The exchange of water between the environment and the economy is partly represented by net abstraction in the 'outflows to sea and net abstraction' component of the stock accounts and by additional, but incomplete, supplementary tables included with the annual stock accounts. Abstraction, and discharge, of water for hydroelectricity generation involve very large volumes of water and are presented as separate components in the accounts.

For the purposes of the New Zealand accounts, all water abstracted from the environment for human and economic use is considered to enter the economy. It encompasses domestic, commercial and industrial supplies, including water used for electricity generation, irrigation and livestock. Abstraction figures include water that is abstracted more than once. For example, water abstracted for irrigating pasture can seep down into an aquifer and be available for re-abstraction.

Where abstraction volumes are unavailable, plant outflow volumes may be used as a close approximation. Passive uses of water, such as for recreation and transport, are not included in the accounts. The collection of rainwater is also not considered to be water 'abstraction'.

In the SEEA handbook, abstraction is disaggregated into abstraction that is at a 'sustainable' level and abstraction that is considered to be 'depletion'. The distinction between sustainable and depletion is not made in the accounts, primarily due to the complexity in assessing the local levels at which abstraction becomes unsustainable.

The SEEA handbook also makes a distinction between the different sources of water from which water is abstracted, namely surfacewater (rivers, lakes and reservoirs) and groundwater (from aquifers). A supplementary table for stocks of groundwater is included with the annual stock accounts.

Ideally, separate abstraction and discharge volumes for all major abstractive water uses would be detailed in the accounts. In practice, however, comprehensive data is not always available. A model is being investigated for estimating abstraction for irrigation, and estimates were needed for quantifying private domestic abstraction and livestock usage. Private industrial abstraction and abstraction for geothermal electricity generation are presently out of scope of the accounts.

12 *The State of New Zealand's Environment,* chapter 7.5, MfE (1997).

Comprehensive data is not readily available for discharges of abstracted water back into the environment.

3 Physical stock accounts

3.1 Tables and reports

Tables for this report, together with other associated reports, can be accessed from the Statistics New Zealand webpage:

http://www.stats.govt.nz/analytical-reports/natural-resource-accounts/water-natural-resource-accounts.htm

- water physical stock accounts – report.pdf (ie this report)
- water physical stock accounts – annual tables.xls
- water physical stock accounts – regional tables.xls
- surfacewater components.pdf report by National Institute of Water & Atmospheric Research Ltd (NIWA)
- groundwater.pdf report by Institute of Geological & Nuclear Sciences Ltd (GNS)
- snow.pdf report by Otago University, commissioned by NIWA
- glaciers.pdf report by NIWA, with Otago University

3.2 Analysis of data

The tables reflect climatic conditions in New Zealand. The June years 1995 and 1996 show precipitation volumes that are above the average for the June years 1995 to 2001. The increased precipitation led to higher than average outflows and also increases in storage. Conversely, the June year 1998 was an El Niño drought year with below average precipitation and outflows. The La Nina drought in the South Island in the June year 2001 affected soil moisture, lake and snow volumes.

Components of the hydrological cycle are subject to seasonal change. For example, evapotranspiration is higher in summer than in winter and precipitation can change throughout the year. Seasonal details, such as a dry spring and wet summer, are aggregated and difficult to analyse in annual accounts. Ideally, some components of the water stock account will be updated on a quarterly basis in future, as outlined in sub-chapter 6.1.

Average precipitation across New Zealand was 1.5 metres per year for the seven June years 1995 to 2001. The West Coast (an average of 3.0 metres) is the wettest region while Otago (1.0 metre) is the driest. Average precipitation per person is highest in the West Coast region and lowest in the Auckland region (which has the highest population density). Annual precipitation per person in the West Coast region, at 2.2 million cubic metres, is 430 times higher than in the Auckland region.

Outflows to the sea and net abstraction (abstraction less discharges) accounted for 58 percent of total outflows, on average, in the seven June years 1995 to 2001. Evapotranspiration accounted for the remaining 42 percent. The volume of water abstracted for hydroelectricity generation averaged 87 percent of the volume for outflows to seas and net abstraction, but includes water that was abstracted several times (because power stations are often built in chains along rivers).

Changes in storage of freshwater amounted to 4.2 percent, at most, of the volume of precipitation falling on New Zealand.

Net abstraction totals are unavailable so are included with outflows to sea as a residual volume. Municipal and domestic abstraction on a gross basis (which excludes discharges back into the environment) amounted to only 0.2 percent of the annual precipitation volume. Almost two-thirds of water abstracted for municipal and domestic uses is obtained from surfacewater, with the remainder being obtained from groundwater. Rainwater is not regarded as abstracted water. Total volumes are not available or collected for irrigation abstraction, private industrial abstraction or geothermal electricity generation.

3.3 Summary of volumes

The following tables are accessible via the hyperlink in sub-chapter 3.1. Table 1 gives national totals while tables 2 and 4 are sample tables for a single year and a single region.

Table 1 Water Stock Account: June years 1995 to 2001

New Zealand(1)	Year ended June						
	1995	1996	1997	1998	1999	2000	2001
	millions of cubic metres						
Inflows							
Precipitation	429,593	440,889	370,354	371,857	409,927	380,922	406,696
Total inflows	*429,593*	*440,889*	*370,354*	*371,857*	*409,927*	*380,922*	*406,696*
Outflows							
Evapotranspiration	163,099	174,949	168,049	167,432	161,174	166,600	184,609
Abstraction for hydroelectricity generation	222,579	225,950	196,020	195,256	200,170	183,310	192,772
Discharge from hydroelectricity generation(2)	222,579	225,950	196,020	195,256	200,170	183,310	192,772
Outflows to sea and net abstraction(3)	259,220	263,268	214,179	199,978	258,699	198,200	236,982
Total outflows	*422,319*	*438,217*	*382,228*	*367,410*	*419,873*	*364,800*	*421,591*
Change in storage(4)							
Soil moisture(5)	7,371	1,402	-1,958	-2,257	572	5,387	-10,519
Lakes and reservoirs(6)	-428	392	-2,222	2,322	-1,271	3,176	-4,382
Groundwater	4,220	-1,220	-2,480	-830	-1,810	820	290
Snow(7)	-6,819	3,098	-7,685	5,131	-5,998	7,778	-2,725
Ice(8)	2,930	-1,000	2,470	80	-1,440	-1,040	2,440
Total change in storage	*7,274*	*2,672*	*-11,874*	*4,447*	*-9,946*	*16,122*	*-14,895*

Source: based on data from NIWA and GNS

(1) Sum of the 16 areas administered by regional councils and unitary authorities. Excludes the Chatham Islands and other outlying islands.

(2) Water used in hydroelectricity generation is returned to the hydrological system. Discharges match abstraction, meaning that 'net' abstraction is zero.

(3) This is a residual volume and is calculated as the inflow less other outflow and change in storage. It is the volume of water leaving the New Zealand water system, other than by evapotranspiration.

Net abstraction is the difference between abstraction and discharges. It is not specifically calculated because there is insufficient data on:

- abstraction of water for irrigation, livestock use, private domestic use, private industrial use, and geothermal electricity generation
- discharges of water back into the environment

(4) The change from the end of the previous June year to the end of the current June year.

(5) Changes in soil moisture average zero in the long-term, as represented by the average of the June years 1995 to 2001.

(6) These volumes include an estimate for unavailable data.

(7) These volumes are for water stored as seasonal snow at an altitude of 900m to 2,000m. Transient snow (below 900m) and perennial snow (above 2,000m) are excluded.

(8) These volumes are for water stored in glaciers. Snow above 2,000m will largely be included here.

Table 2 Water Stock Account: June year 2001 by region

Hydrological cycle components, land area and population	Region																
	North-land	Auckland	Waikato	Bay of Plenty	Gisborne	Hawke's Bay	Taranaki	Manawatu-Wanganui	Well-ington	Tasman	Nelson	Marl-borough	West Coast	Canterbury	Otago	South-land	New Zealand[1]
	millions of cubic metres of water																
Inflows																	
Precipitation	15,961	5,105	36,690	16,342	10,359	15,037	13,322	31,566	9,376	21,048	495	12,292	70,964	58,315	32,196	57,627	406,696
Inflow from other regions[2]	0	0	171	1,166	0	284	0	0	0	0	0	0	4,013	2,233	0	0	0
Total inflows	*15,961*	*5,105*	*36,861*	*17,508*	*10,359*	*15,321*	*13,322*	*31,566*	*9,376*	*21,048*	*495*	*12,292*	*74,977*	*60,548*	*32,196*	*57,627*	*406,696*
Outflows																	
Evapotranspiration	7,558	3,981	16,651	5,673	4,983	11,345	7,008	17,857	3,591	6,244	202	4,888	24,495	26,565	19,903	23,666	184,609
Outflow to other regions[2]	0	171	0	0	1,451	0	0	0	0	4,013	0	2,183	0	0	50	0	0
Outflow to sea and net abstraction[3]	10,470	1,453	19,994	12,234	4,243	5,082	6,626	14,833	7,388	10,166	297	6,524	47,990	38,332	16,423	34,930	236,982
Total outflows	*18,028*	*5,605*	*36,645*	*17,907*	*10,677*	*16,427*	*13,634*	*32,690*	*10,979*	*20,423*	*499*	*13,595*	*72,485*	*64,897*	*36,376*	*58,596*	*421,591*
Change in storage[4]																	
Soil moisture[5]	-2,067	-500	-287	-441	-318	-1,096	-184	-1,123	-1,343	1,057	-4	-1,411	1,965	-2,892	-2,106	234	-10,519
Lakes and reservoirs[6]	0	0	-192	-18	0	0	0	0	0	0	0	0	-3	-1,706	-1,738	-725	-4,382
Groundwater	0	0	690	60	0	-10	-130	-10	-260	-520	0	-30	90	-840	630	610	290
Snow[7]	0	0	4	0	0	0	2	7	0	88	0	138	-541	-172	-1,122	-1,129	-2,725
Ice[8]	0	0	1	0	0	0	0	2	0	0	0	0	981	1,261	156	40	2,440
Total change in storage	*-2,067*	*-500*	*216*	*-399*	*-318*	*-1,106*	*-312*	*-1,124*	*-1,603*	*625*	*-4*	*-1,303*	*2,492*	*-4,349*	*-4,180*	*-969*	*-14,895*
	square kilometres																
Land area[9]	12,500	4,955	24,532	12,215	8,296	14,160	7,264	22,209	8,119	9,517	434	10,565	23,418	44,890	31,835	30,053	264,961
	estimated resident population																
Population[10]	144,400	1,216,900	369,800	246,900	45,500	147,300	105,700	227,500	440,200	42,400	42,900	40,700	31,100	496,700	188,300	93,300	3,880,500

Source: based on data from NIWA and GNS

Footnotes:

(1) Sum of the 16 areas administered by regional councils and unitary authorities. Excludes the Chatham Islands and other outlying islands.

(2) Inflows and outflows across regional boundaries sum to 7,868 million cubic metres, but have been removed from the New Zealand column because they net to zero.

(3) This is a residual volume and is calculated as the inflow less other outflow and change in storage. It is the volume of water leaving the New Zealand water system, other than by evapotranspiration. Water used in hydroelectricity generation is returned to the hydrological system, so has a net abstraction volume of zero. Net abstraction is the difference between abstraction and discharges.

(4) The change from 30 June 2000 to 30 June 2001.

(5) Changes in soil moisture average zero in the long-term, as represented by the average of the June years 1995 to 2001.

(6) These volumes include an estimate for unavailable data. The estimate is prorated by volume across all regions.

(7) These volumes are for water stored as seasonal snow at an altitude of 900m to 2,000m. Transient snow (below 900m) and perennial snow (above 2,000m) are excluded.

(8) These volumes are for water stored in glaciers. Snow above 2,000m will largely be included here.

(9) Further information on land areas is available at http://www2.stats.govt.nz/domino/external/web/prod_serv.nsf/Response/Geography+and+mapping

(10) As at 30 June, from webpage http://www.stats.govt.nz/NR/rdonlyres/9CB8B16E-CF9F-4C11-8B21-7C533ED79BFB/0/SubPopEstJune96alltabls.xls

Table 3 Municipal and Domestic Abstraction[1]

Region	Year ended June																	
	1996			1997			1998			1999			2000			2001		
	surface water	ground water	total	surface water	ground water	total	surface water	ground water	total	surface water	ground water	total	surface water	ground water	total	surface water	ground water	total
	millions of cubic metres[2]																	
Northland	..	..	..	..	..	..	..	..	..	19	4	23	20	3	23	19	3	22
Auckland	..	..	..	115	6	121	117	7	123	120	6	126	121	7	129	119	9	128
Waikato	..	..	..	..	..	..	51	17	67	55	17	73	52	17	70	51	17	69
Bay of Plenty	23	15	38	22	16	38	23	17	39	24	17	41	23	16	39	22	16	39
Gisborne	6	0	6	6	0	6	6	0	7	6	0	6	5	0	6	5	0	6
Hawke's Bay	3	29	32	3	29	32	3	33	36	3	31	33	3	31	34	3	32	34
Taranaki	..	..	..	..	..	..	21	0	21	24	0	24	24	0	25	25	1	25
Manawatu-Wanganui	..	..	..	18	17	35	19	17	36	20	18	38	19	18	36	20	18	38
Wellington	..	..	..	48	22	71	51	21	72	50	25	74	47	24	72	48	26	75
North Island	..	..	..	..	..	..	..	..	..	*320*	*118*	*438*	*315*	*118*	*433*	*312*	*122*	*435*
Tasman[3]	1	6	7	1	7	8	1	7	8	1	8	9	1	8	9	1	8	10
Nelson	8	-	8	9	-	9	10	-	10	10	-	10	8	-	8	8	-	8
Marlborough	0	7	8	1	10	10	1	9	10	1	9	10	0	9	10	0	10	11
West Coast	7	1	8	8	1	9	7	1	8	7	1	8	8	1	9	8	1	9
Canterbury	..	..	..	..	..	..	..	..	..	..	..	..	14	82	96	15	92	107
Otago	..	..	..	34	2	36	37	2	39	39	2	41	37	2	39	38	3	41
Southland	..	..	..	..	..	..	..	..	..	15	3	18	14	3	17	15	3	18
South Island	..	..	..	..	..	..	..	..	..	..	..	..	*82*	*106*	*188*	*85*	*118*	*203*
New Zealand	..	..	..	..	..	..	..	..	..	..	..	..	397	223	620	397	240	637

Footnotes:

(1) Includes municipal supply to domestic, commercial and industrial users plus private abstraction for domestic use. Excludes irrigation, private industrial abstraction, and livestock use.

(2) Volumes may not sum to stated totals because of rounding.

(3) Volumes for the Tasman region were not available so were imputed. The imputation calculations used Statistics New Zealand population figures and water usage volumes per person for appropriately sized (and stratified) water supply systems in adjacent regions (Marlborough and West Coast).

Symbols:

- nil or zero

.. not available

Table 4 Water Stock Account: Canterbury region

	Year ended June						
	1995	1996	1997	1998	1999	2000	2001
	millions of cubic metres of water						
Inflows							
Precipitation	52,664	53,883	45,570	39,244	46,138	49,809	58,315
Inflow from other regions	2,091	1,946	1,713	1,052	1,884	1,562	2,233
Total inflows	*54,755*	*55,829*	*47,283*	*40,296*	*48,022*	*51,371*	*60,548*
Outflows							
Evapotranspiration	22,019	23,858	23,488	21,259	20,811	23,371	26,565
Outflow to other regions	-	-	-	-	-	-	-
Outflow to sea and net abstraction(1)	28,025	32,049	25,489	18,489	29,664	26,194	38,332
Total outflows	*50,044*	*55,907*	*48,977*	*39,748*	*50,475*	*49,565*	*64,897*
Change in storage(2)							
Soil moisture(3)	1,241	1,039	298	-262	-335	912	-2,892
Lakes and reservoirs(4)	182	61	-1,103	846	-139	622	-1,706
Groundwater	2,270	-260	-830	-1,270	230	-80	-840
Snow(5)	-495	-401	-1,335	1,194	-1,465	889	-172
Ice(6)	1,514	-517	1,276	41	-744	-537	1,261
Total change in storage	*4,711*	*-78*	*-1,694*	*548*	*-2,453*	*1,806*	*-4,349*
	square kilometres						
Land area(7)	44,890						
	estimated resident population						
Population(8)	..	480,400	485,400	488,800	491,200	493,600	496,700

Source: based on data from NIWA and GNS

(1) This is a residual volume and is calculated as the inflow less other outflow and change in storage. It is the volume of water leaving the New Zealand water system, other than by evapotranspiration.
Water used in hydroelectricity generation is returned to the hydrological system, so has a net abstraction volume of zero.

(2) The change from the end of the previous June year to the end of the current June year.

(3) Changes in soil moisture average zero in the long-term, as represented by the average of the June years 1995 to 2001.

(4) These volumes include an estimate for unavailable data. The estimate is prorated by volume across all regions.

(5) These volumes are for water stored as seasonal snow at an altitude of 900m to 2,000m. Transient snow (below 900m) and perennial snow (above 2,000m) are excluded.

(6) These volumes are for water stored in glaciers. Snow above 2,000m will largely be included here.

(7) Further information on land areas is available at:
http://www2.stats.govt.nz/domino/external/web/prod_serv.nsf/Response/Geography+and+mapping

(8) As at 30 June, from webpage:
http://www.stats.govt.nz/NR/rdonlyres/9CB8B16E-CF9F-4C11-8B21-7C533ED79BFB/0/SubPopEstJune96alltabls.xls

Symbols:

- nil or zero

.. not available

4 Components of the accounts

The accounts are in the form of a water balance, where inflows equal outflows plus changes in stored volumes. Components of the accounts are based on the hydrological cycle.

1. Precipitation
2. Inflow from other regions
3. *Total inflows*
4. Evapotranspiration
5. Outflow to other regions
6. Abstraction for hydroelectricity generation
7. Discharge from hydroelectricity generation
8. Outflow to sea and net abstraction
9. *Total outflows*
10. Changes in soil moisture
11. Changes in lakes and reservoirs
12. Changes in groundwater
13. Changes in snow
14. Changes in ice
15. *Total change in storage*

Unless otherwise indicated, volumes for all components were obtained either directly or indirectly from NIWA. Volumes from NIWA were adjusted in some cases when national coverage was incomplete. Further information about the components and measurement methods is available in the reports listed in sub-chapter 3.1.

4.1 Precipitation

Precipitation is any form of water that falls to the planet's surface and includes rain, snow, sleet and hail. It is the source of all inflows to the inland part of the hydrological system at the national level.

Daily measurements are obtained from nationwide rain gauges and are converted to a detailed geographic grid using spatial interpolation modelling. The data is used as input into a hydrological model and compiled into regional volumes. Rain gauges have a typical measurement uncertainty of 10 percent and are sparse in remote areas that have high, changeable rainfall.

4.2 Inflow from other regions

Regions in New Zealand are usually bounded by catchment boundaries. Most rivers do not flow from one region to another, the main exceptions being:

- Tasman to West Coast (Buller River)
- Marlborough to Canterbury (Clarence River)
- Gisborne to Bay of Plenty (Motu, Waioeka and other rivers).

4.3 *Total inflows*

This is the sum of precipitation and inflow from other regions. At the national level there is no inflow from other regions or countries. Regional inflows and outflows, when summed across all regions, balance each other out.

4.4 Evapotranspiration

Evapotranspiration is loss of water by evaporation from the soil and transpiration from plants. It is one of the main freshwater components of the hydrological system in New Zealand, accounting for about 42 percent of outflows at the national level.

Evapotranspiration is calculated by the Topnet hydrological model and is based on estimates of daily maximum or 'potential' volume for each catchment, according to air temperature and day-length. These volumes are then adjusted for increases in evaporation created by tall vegetation and decreases caused by soil moisture being below field capacity. Catchment volumes are summed into regional and national totals.

4.5 Outflow to other regions

The volume of outflow to other regions is calculated on the basis that no abstraction is occurring. At the national level, the outflow across regional boundaries balances the inflow.

4.6 Abstraction for hydroelectricity generation

Volumes include an estimate for missing data and are presented in the accounts at the national level only. Figures are additive, meaning that water abstracted for use in a power station is often abstracted (and counted) several more times by downstream power stations. Water that is stored behind hydro dams is accounted for in sub-chapter 4.11 below.

The volume abstracted during the year ended June 2001 amounts to an estimated 137 cubic metres per person per day. Most abstraction occurs in Canterbury, Waikato and Otago.

4.7 Discharge from hydroelectricity generation

Water that is abstracted for hydroelectricity generation is also discharged back into the hydrological system. It is a non-consumptive use of water.

4.8 Outflow to sea and net abstraction

This component accounts for about 58 percent of outflows of freshwater from New Zealand. It is calculated as a residual and is the volume of water that leaves the inland part of the hydrological system, other than by evapotranspiration.

Detailed breakdowns for this component are not available because there is insufficient data for net abstraction volumes. Most abstraction data is for gross volumes rather than net volumes as there are difficulties obtaining comprehensive data on discharges of water back into the environment. There is also a lack of data for non-municipal water abstraction. Private domestic abstraction volumes have been estimated and included with municipal abstraction. Consumptive water use by livestock has also been estimated but the volume of water abstracted for supplying livestock is unknown. Estimating abstraction and discharges for irrigation is being investigated but there is little data or estimation methodology suitable for measuring volumes for private industrial abstraction.

Outflow of water to the sea includes groundwater as well as surfacewater. Groundwater is slow-moving whereas surfacewater may spend just a day or two in New Zealand's network of small catchments and fast-flowing rivers before reaching the sea.

4.9 *Total outflows*

This is the sum of evapotranspiration, outflow to other regions, and outflow to sea and net abstraction. At the national level there is no outflow to other regions or countries. Regional inflows and outflows, when summed across all regions, balance each other out. Water that enters New Zealand's inland part of the hydrological system and has not left by the end of the June year is dealt with in the storage components below.

4.10 Changes in soil moisture

Soil moisture refers to water stored in land and soil, in the rooting zone (typically the top one metre, depending on soil and vegetation type). The amount of moisture varies according to rainfall, soil type, land use and evapotranspiration (which in turn varies according to air temperature, day-length and vegetation). Soil moisture can vary markedly during the year with summer levels often being low while winter levels are high. The change in soil moisture from one year to another in the water stock account is a point-to-point movement and can be significantly influenced by rainfall in the last few days of June each year.

Changes in soil moisture are calculated by the Topnet hydrological model, which appears to show a small upward bias when accounting for changes in this component. To compensate for this, it was decided to adjust the soil change figures on a regional basis so that the annual changes are zero when calculated as averages for the seven available June years, 1995 to 2001. In the long-term, annual changes can be expected to fluctuate around an average of zero.

4.11 Changes in lakes and reservoirs

New Zealand has more than 50,000 lakes but only 40 are larger than 900 hectares. The total surface area is an estimated 380,000 hectares.[13] Lakes and reservoirs provide storage for irrigation, town supply and hydroelectricity generation; as well as having uses for flood control, wildlife, recreation and transportation. "At least 16 artificial lakes have been created for hydro power stations."[14] The South Island's Lake Benmore, at 7,500 hectares, is the largest of these lakes.

The lakes and reservoirs that are monitored and for which data is available are mostly hydroelectricity reservoirs and major lakes and account for 72 percent of the surface area of all lakes and reservoirs in New Zealand. It is assumed for the water stock accounts that lakes and reservoirs for which data is unavailable will have the same changes in levels as other lakes and reservoirs. The missing data has been imputed across regions on a pro rata basis.

Changes in lake and reservoir levels in the water stock accounts are point to point movements from the end of one June year to another and can depend on rainfall in the last few days or weeks of each June.

4.12 Changes in groundwater

Data for groundwater volumes was provided by the GNS. The volumes are for water that is contained in aquifers and is currently used or potentially available for use. The total volume for New Zealand is estimated at 613 cubic kilometres (613 thousand million cubic metres) as at 30 June 2001. This is about twice the estimated volume of water in New Zealand lakes.

---

13 From database of lakes supplied by Land Information New Zealand to NIWA (2004).
14 *The State of New Zealand's Environment,* chapter *7.6,* MfE (1997).

Aquifers are underground rock layers that yield water in usable quantities to wells or springs. Water enters aquifers from rainfall or by seepage from lakes and rivers and provides a store of water for meeting high demand in summers or dry years. Most replenishment occurs between autumn and spring when evapotranspiration is low, and soils are moist and unable to absorb much additional water. Aquifers can be classified as unconfined, semi-confined or confined. Unconfined aquifers are estimated to contain 96 percent of New Zealand's groundwater and are located mainly in Canterbury.

Groundwater comprises approximately 91 percent of the liquid freshwater on Earth. It is important for irrigation, municipal and private supply and constitutes about 40 percent of New Zealand's freshwater usage. Considerable use is made of groundwater in many regions, particularly Canterbury and Hawke's Bay.

"Groundwater levels have fallen in most of New Zealand's flood plains through a prolonged programme of unchecked land drainage. … Lowered aquifer levels have led to sea water intrusion in a number of places, including quite extensive aquifers on the Heretaunga and Waimea Plains, and small aquifers situated beneath rural seaside communities such as those on the Coromandel Peninsula."[15]

4.13 Changes in snow

Changes in volumes of water stored as snow were provided via NIWA from Professor Blair Fitzharris of the University of Otago.

The volumes contained in the tables in sub-chapters 3.1 and 3.3 are for changes in water stored as seasonal snow at an altitude of 900m to 2,000m. Transient snow (below 900m) and perennial snow (above 2,000m) are excluded from the snow component of the water stock accounts. The changes in volume are as at 30 June each year. This is midway between 15 March and 15 October, which are the approximate dates when snow storage volumes are at their minimum and maximum each year. Sub-chapter 3.1 has a link to the snow report which contains detailed methodology.

Mountain-fed rivers in the South Island usually have their lowest flows in winter, due to snow pack accumulation in the mountains. Melting snow in spring and summer raises river flows and, if stored in lakes, this water can be used later in the year to generate electricity for meeting winter demand.

As at 30 June 2001, an estimated 11 cubic kilometres (11,000 million cubic metres) of water was stored as transient snow.

4.14 Changes in ice

This component does not measure the volume of ice itself, but the volume of water stored as ice or perennial snow in glaciers. Snow above 2,000 metres will largely be included in this component of the water stock accounts.

The volume of water stored as perennial snow and ice in New Zealand glaciers is estimated to be nearly 60 cubic kilometres (60,000 million cubic metres), with a surface area of over a thousand square kilometres. Glaciers in the Southern Alps lost 25 percent of their surface area during the last century.[16] They have grown slightly bigger in the past year, however, according

---

15 *Water Resources,* M P Mosley (1993), unpublished draft report prepared for MfE, Wellington, quoted in The State of New Zealand's Environment, chapter 7.8, MfE (1997).

16 *New Zealand Glacier Responses to Climate Change of the Past Century,* T J Chinn (1996).

to a March 2003 aerial survey by NIWA. A wet winter in 2002, followed by a cool summer, contributed to the above-average snowfall and reduced snowmelt.[17]

4.15 *Total change in storage*

Storage can be viewed as a balancing set of components. If inflows of water to the inland part of the hydrological system exceed outflows then the excess must be going into storage. Conversely, if the total storage volume reduces from one year to the next, then outflows will be higher than inflows. Volumes of water held in storage can fluctuate throughout the year but it is the volumes at the end of each June year that affect the water stock accounts. Storage levels are point-to-point movements and are influenced by short-term changes in weather, such as storms, as well as by longer-term weather cycles including El Niño/Southern Oscillation (ENSO) and Interdecadal Pacific Oscillation (IPO).

Changes in storage are a relatively minor part of the water stock accounts. The total volume of water stored in aquifers, lakes and reservoirs and as soil moisture, snow and ice is large but the annual changes are much smaller. Annual absolute changes in storage, for the June years 1995 to 2001, averaged only 2.4 percent of precipitation.

17 *Southern Alps glaciers growing,* The New Zealand Herald (27 May 2003). http://www.nzherald.co.nz/storydisplay.cfm?storyID=3504064 [5 July 2004]

5 Gaps in measurement of abstraction

There is insufficient data for the current stock accounts to quantify the volumes of water abstracted for the following purposes:

1. Irrigation
2. Livestock use
3. Private domestic use
4. Private industrial use
5. Geothermal electricity generation.

5.1 Irrigation

Water abstracted for irrigation is not included in the inaugural physical stock accounts for water because of insufficient data being available.

"Every year, pastoral farmers, orchardists and market gardeners remove (or abstract) approximately 1,500 million cubic metres of water from surface waters and groundwater. This is an estimate, as no national statistics exist on water abstraction."[18]

Irrigation is a large use of water and accounts for an estimated 77 percent of all water allocated for consumptive use in New Zealand.[19] There is a difference, however, between the volumes that are allocated and the volumes that are actually abstracted and used. Where actual water use has been measured, the volumes taken over a season are 20 to 65 percent of the allocated volumes. Reasons for the differences between allocated volumes and actual use include:

- allocations are based on peak or near-peak demand
- different uses require peak volumes at different times
- not all of the allocated volume is required every year
- some water is not used but reserved for future use
- year-to-year variation in climate.

Statistics New Zealand and Lincoln Environmental have investigated estimating the volumes of water abstracted for irrigation. The approach taken was the development of a model that simulates the day-to-day operation of irrigation systems on representative farms in each region. The model allows for the effects of soil type, climate variability, farm type, irrigation method and management, and area irrigated. Many of these characteristics vary spatially. Data for the model is available from nationwide surveys conducted by Statistics New Zealand and MAF, as well as from resource consent and NIWA climate data.

Test results from monitored irrigation networks show that modelled water volumes can differ considerably from volumes actually used. This suggests that some farmers may not be applying optimal water volumes, which makes it difficult to accurately model actual water use. Options to be considered by Statistics New Zealand include refining the modelling approach, or adopting alternative measurement or estimation methods.

---

18 *The State of New Zealand's Environment,* chapter 7*.7,* MfE (1997).

19 *Information on Water Allocation in New Zealand,* Lincoln Environmental (2000), prepared for MfE.
http://www.maf.govt.nz/mafnet/publications/rmupdate/rm5/rm5001.html (summary) [6 July 2004]
http://www.mfe.govt.nz/publications/water/water-allocation-apr00.pdf (full report) [6 July 2004]
The uses of allocated water do not include non-consumptive uses such as hydroelectricity generation or cooling water.

5.2 Livestock use

Estimated volumes for consumptive water usage by livestock have been added to the inaugural physical stock accounts for water.

The estimates are calculated from livestock numbers and average water usage per head for different types of livestock. The livestock numbers are mostly from Statistics New Zealand's Agriculture Censuses, while the usage per head figures are from the 1987 draft *Farm Water Supply Design Manual* by MAFtech.[20] The volumes are for consumptive use, not volumes abstracted or discharged, and are calculated on a regional basis.

Resource consents are not required for livestock water use and so could not be used as a data source.

5.3 Private industrial use

Industry is a major user of water but data is lacking on the volumes supplied, either from municipal reticulation networks or from private abstraction. Resource consents are required for private industrial abstraction but the degree of monitoring by regional councils can vary. Only a small proportion of resource consents are monitored.

Estimates of private industrial use will be included in future water stock and flow accounts if comprehensive, detailed data becomes available.

5.4 Private domestic use

This category applies to households and communities that abstract water themselves instead of, or in addition to, using water from municipal reticulation supplies. Data is not available for this type of abstraction but it has been estimated as part of a broader category called 'municipal and domestic abstraction'. The estimation method assumes that domestic use per person within each region is the same for private domestic abstraction as for households connected to reticulation networks in rural communities. (Refer table 10 of "water physical stock accounts – annual tables.xls" in sub-chapter 3.1.) The category 'municipal and domestic abstraction' also includes supply to domestic, commercial and industrial users connected to municipal reticulation networks.

Estimates for municipal and domestic abstraction require detailed population mapping and considerable information from district councils, and are unlikely to be included in future stock accounts.

5.5 Geothermal electricity generation

There are no plans, at present, to collect data for this type of water abstraction and discharge.

20 MAFtech (MAF Technology) was part of the former Ministry of Agriculture and Fisheries until 1992.

6 Future developments

6.1 Quarterly updates

Water availability can vary drastically from one part of the year to another. If a summer drought is followed by high rainfall in autumn, it may not be apparent from annual figures that a drought even occurred. To assist with interpretation of figures in the water stock accounts, it would be helpful to have sub-annual tables as well as regional tables. Consideration will therefore be given to the development of quarterly, regional updates for the following components of the water stock accounts:

- precipitation
- evapotranspiration
- soil moisture change
- outflows to sea
- outflows/inflows across regional boundaries.

Measurement difficulties will probably preclude the inclusion of quarterly updates for the other components.

6.2 Seasonal adjustment

Some form of seasonal adjustment of quarterly water account volumes is a further possible development. It would probably be implemented only for precipitation and evapotranspiration components, as in 6.1 above.

6.3 Physical flow accounts

If development proceeds, the physical flow accounts would provide information on the exchange of water between the economy and the environment. The accounts would show the volumes of water supplied and used by the various industries in the economy. Volumes would ideally be for discharge as well as for abstraction or supply, but measurement difficulties would militate against this.

The physical flow accounts would provide detail for part of the 'outflow to sea and net abstraction' component of the physical stock accounts.

6.4 Monetary stock and flow accounts

If a system is developed for valuing water, then monetary versions of the physical stock accounts and physical flow accounts will be considered. Difficulties with valuing water are that it occurs in several forms, and when it enters the economy there are seldom market prices available. Water that falls as precipitation obviously has some value but until it is abstracted it is outside the economy. Even when it is abstracted, it is usually treated as being free.

Market prices, if they existed for water, would likely exhibit regional and seasonal differences, depending on such factors as type of use, quality, scarcity, and cost of abstraction and reticulation.

Statistics New Zealand intends to produce a report on monetary stocks of water. However, it is likely that the report will be a review of background and methodology and will not contain tables.

6.5 Gaps in coverage

Depending on availability and suitability of data, gaps in coverage (as outlined in chapter 5) may be addressed in future years. At present, much water abstraction in New Zealand is unmetered and there is not always sufficient information to enable reliable estimation.

6.6 Structure of accounts

The structure of all proposed and developed water accounts is relatively flexible at this stage and may alter according to data availability, developments in component modelling, and feedback from users. Incorporation of a formalised classification for water components and sub-components is also possible.

7 Glossary

Abstraction (of water): The taking of water from groundwater or surfacewater sources.

Aquifer: Permeable water-bearing geologic formation capable of yielding exploitable quantities of water.

Catchment: The area from which rainwater flows into a particular river or lake.

Conservation: The management of resources such as water so as to eliminate waste or maximise efficiency of use. See also 'sustainability'.

Ecosystem: A system, such as a wetland or forest, in which the interaction between different organisms and their environment generates a cyclic interchange of materials and energy.

El Niño–Southern Oscillation (ENSO): A 2–4 year major climate cycle with warm (El Niño) and cool (La Niña) fluctuations in sea surface temperatures in the central and eastern tropical Pacific and associated air pressure changes in the Pacific–Asia region (Southern Oscillation). See also 'Interdecadal Pacific Oscillation (IPO)'.

Environment: External conditions affecting organisms and social groups. It includes the natural environment (air, water, soil, plants, animals, fungi and micro-organisms), the built environment (buildings, roads, housing and recreation facilities) and social and cultural aspects of our surroundings.

Environmental accounts: Quantitative information linking environmental and economic performance.

- *natural resource accounts* provide information on usage and depletion of natural resources and complement economic measures such as GDP
- *ecosystem input accounts* show flows of substances absorbed from the environment for consumption and production processes, including oxygen for combustion and air, water and nutrients for biomass growth
- *product flow accounts* trace the movement of products or product groups (such as timber and packaging) through the economy
- *residual flow accounts* show volumes of waste (whether solid, liquid or gaseous) discharged from the economy into the environment
- *environmental protection expenditure* is the amount spent on maintaining or restoring the environment.

Environmentally-adjusted GDP: This is also known as 'green GDP' or 'ea-GDP'. The original GDP figure, which measures economic activity, is adjusted to take into account the cost of natural resource depletion and environmental degradation.

Evapotranspiration: Transfer of water from the Earth's surface to the atmosphere by evaporation of liquid or solid water plus transpiration from plants and animals.

Freshwater: Naturally-occurring water having a low concentration of salts.

Gross domestic product (GDP): This is a measure of economic activity. It is *gross* in that depreciation is not deducted and *domestic* in that it covers only national territory. There are no deductions for natural resource depletion and environmental degradation. The output-based version is the sum of the gross value-added of all resident producers at basic prices, plus all taxes (less subsidies) on imports.

Groundwater: Subsurface water occupying the saturated zone (in which all voids, large and small, are filled with water). Excludes soil moisture.

***In-situ* freshwater:** Freshwater that has not been removed from the lake, river, aquifer or other water body. *In situ* uses include recreation, tourism, hydroelectricity generation, fish farming and waste disposal.

Interdecadal Pacific Oscillation (IPO): A long timescale oscillation in the ocean–atmosphere system that shifts climate in the greater Pacific region every one to three decades. In the negative IPO phase, New Zealand generally experiences higher sea-levels, and more storm surges and floods in eastern areas. See also 'El Niño–Southern Oscillation (ENSO)'.

Irrigation: Artificial application of water to lands for agricultural purposes.

Natural resources: Natural assets (raw materials) occurring in nature that can be used for economic production or consumption.

Orographic rainfall: Enhanced rainfall as a result of moist air cooling when it rises to cross a mountain range.

Precipitation: Water in any form (including rain, snow, hail, sleet and mist) that leaves the atmosphere and reaches the Earth's surface.

Soil moisture: Moisture contained in the portion of the soil that is above the water table. Includes water vapour, which is present in the soil pores.

Supply and use tables: Matrix tables showing commodity quantities (or values) categorised by supplier (domestic industries and imports) and by user (domestic industries, households and exports). Supply and use tables are collectively known as 'flow' tables or accounts.

Surfacewater: Water that flows over or is stored on the ground surface.

System of integrated Environmental and Economic Accounting (SEEA): SEEA measures the contribution of the environment to the economy and the impact of the economy on the environment and was developed by the United Nations Statistical Division as an extension to the world-wide System of National Accounts (SNA).

System of National Accounts (SNA): The international standard framework for compiling macro-economic accounts.

Unitary authority: A territorial authority (city or district council) which also has the responsibilities, powers and duties of a regional council.

Water cycle (hydrological cycle): The paths that water takes through its various states (liquid, vapour, solid) as it circulates among the ocean, atmosphere and land.

Water table: The top of the water surface in the saturated part of an aquifer.

Wetland: Semi-aquatic land that is either inundated or saturated by water for varying periods of time during each year, and that supports aquatic vegetation which is specifically adapted for saturated soil conditions.

8 Bibliography

Chinn T J (1996). "New Zealand glacier responses to climate change of the past century", *New Zealand Journal of Geology and Geophysics,* 1996, Vol. 39, 415-428.

Drinking Water for New Zealand,
http://www.drinkingwater.co.nz [5 July 2004]

Food and Agriculture Organization of the United Nations (FAO),
http://www.fao.org/ag/agl/aglw/prtwat.stm [5 July 2004]

Institute of Geological & Nuclear Sciences Ltd (GNS),
http://www.gns.cri.nz/search/search.asp?q=water&Submit=Search [5 July 2004]

Lowe D J and Green J D (1987). "Inland waters of New Zealand",
DSIR Bulletin 241, Wellington.

Ministry for the Environment (MfE),
http://www.mfe.govt.nz/publications/ser/ser1997/chapter7.1.html [5 July 2004]

Ministry of Agriculture and Forestry (MAF),
http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/water-efficiency/index.htm
[5 July 2004]

National Institute of Water & Atmospheric Research Ltd (NIWA),
http://www.niwa.cri.nz [5 July 2004]

OECD Observer,
http://www.oecdobserver.org/news/categoryfront.php/id/1165/Water.html [5 July 2004]

Organisation for Economic Co-operation and Development (OECD),
http://www.oecd.org/topic/0,2686,en_2649_37465_1_1_1_1_37465,00.html [5 July 2004]

Parliamentary Commissioner for the Environment (PCE),
http://www.pce.govt.nz/reports/pce_reports_subject.shtml#waters [5 July 2004]

Statistics New Zealand,
http://www.stats.govt.nz/environment/default.htm [7 December 2004]

The New Zealand Hydrological Society,
http://www.hydrologynz.org.nz [5 July 2004]

United Nations (UN). "United Nations Statistics Division environment page",
http://unstats.un.org/unsd/environment/default.htm [5 July 2004]

United Nations (2003). "Handbook of Integrated Environmental and Economic Accounting 2003 (SEEA 2003)",
http://unstats.un.org/unsd/envAccounting/seea2003.pdf [5 July 2004]

United Nations Educational, Scientific and Cultural Organization (UNESCO),
"The UN World Water Development Report",
http://www.unesco.org/water/wwap/wwdr/index.shtml [5 July 2004]