Water Physical Stock Account

1995–2005

Environmental Accounts

Information

This report was prepared by the Geography, Regional and Environment business unit and published by the Product Development and Publishing business unit of Statistics New Zealand on 22 June 2007: ISBN 978-0-478-26948-2 (internet). We acknowledge the use of data supplied by National Institute of Water & Atmospheric Research Ltd (NIWA) and Institute of Geological & Nuclear Sciences Ltd (GNS). Statistics New Zealand would also like to thank many organisations for providing information, advice and support. Among those who contributed are:

- Auckland Regional Council
- District councils
- Institute of Geological & Nuclear Sciences Ltd (GNS)
- Metrowater
- Ministry for the Environment (MfE)
- Ministry of Agriculture and Forestry (MAF)
- National Institute of Water & Atmospheric Research Ltd (NIWA)
- Regional councils
- Watercare Services Ltd

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(www.stats.govt.nz/analytical reports/ water physical/stock account 1995-2005)

Standards

Abbreviations

GNS Institute of Geological & Nuclear Sciences Ltd

MfE Ministry for the Environment

NIWA National Institute of Water & Atmospheric Research Ltd

SEEA system of integrated environmental and economic accounting

SEEAW system of integrated environmental and economic accounting for water resources

SNA system of national accounts

Rounding procedures

Figures have been rounded, and discrepancies may occur between sums of component items and totals. All percentages have been calculated using un-rounded figures.

Source

Data has been provided by National Institute of Water & Atmospheric Research Ltd (NIWA) and Institute of Geological & Nuclear Sciences Ltd (GNS), except where otherwise stated.

Symbols

.. figures not available

…not applicable

Values

All values are shown in New Zealand currency, except where otherwise stated.

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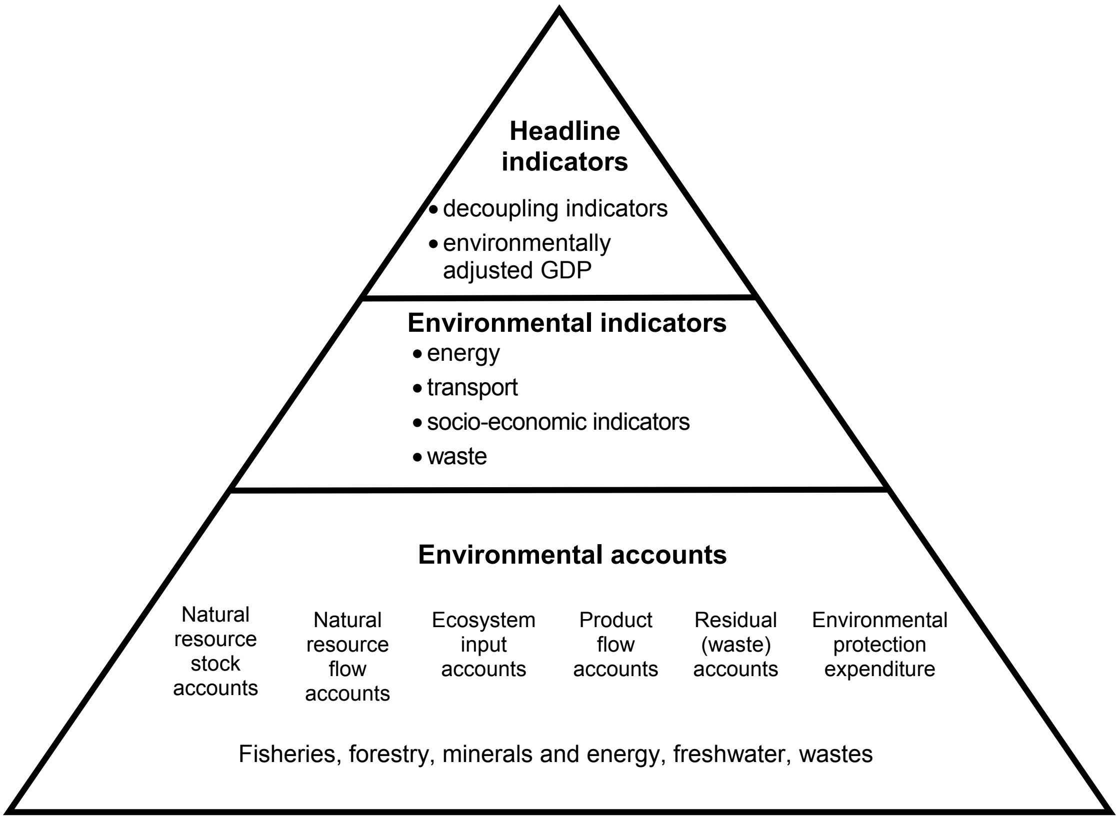
1. Environmental accounts

Statistics New Zealand is working with a number of government and other agencies to produce a range of environmental statistics about the natural environment, its contribution to the economy and the impact of the economy and social activities on the environment. As part of this work, Statistics NZ has developed environmental accounts for several natural resources: forestry, energy, fisheries, minerals, 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 and flows of natural resources in units such as tonnes and joules. These quantities are valued, resulting in monetary figures that form environmental accounts and can be linked to economic statistics such as the gross domestic product (GDP).

Statistics New Zealand's Environmental Statistics Framework



The release of natural resource and environmental accounts reflects an international movement towards compiling information beyond the traditional measures of economic activity. The accounts reflect the view that the environment has a finite capacity to supply materials and absorb waste. The development of the water physical stock account is part of a wider programme of natural resource accounts produced by Statistics NZ. These series of natural resource accounts can be used to assess trends over time as well as to gauge whether New Zealand's resources are being utilised in a sustainable manner.

For more information on the uses of natural resource and environmental accounts see *Natural Resource Accounts for New Zealand: Overview Document* (Statistics New Zealand, 2002) or Chapter 11 of the *Handbook for Integrated Environmental and Economic Accounting* (SEEA)[1] (United Nations et al, 2003). For more information on Statistics NZ's Environment Statistics Programme, refer to the Statistics NZ website at:
http://www.stats.govt.nz/environment/default.htm.

1 The handbook can be downloaded from the website at:
http://unstats.un.org/unsd/envAccounting/seea.htm

2. Concepts and conventions

Information included in this report is calculated using the international statistical standard for environmental accounting. Statistics New Zealand produces environmental accounts using the framework recommended in the *Handbook for Integrated Environmental and Economic Accounting* (SEEA) (United Nations et al, 2003) and *Integrated Environmental and Economic Accounting for Water Resources* (United Nations, 2006).

The physical stock account describes how the stocks of freshwater are affected by water flows within the hydrological system during accounting periods. The general structure of the account is defined by the United Nations *Handbook for Integrated Environmental and Economic Accounting* (SEEA) (United Nations et al, 2003) and *Integrated Environmental and Economic Accounting for Water Resources* (United Nations, 2006). The handbook describes a system of stock or asset accounts with opening and closing stocks of water resources and the flows that affect these stocks. In the New Zealand stock account, 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.

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).

The water physical stock account covers the June years 1995 to 2005. 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 (1 million cubic metres equals 1 gigalitre)

Revision to *Water Physical Stock Account: 1995–2001*

Results contained in this report are revised from the *Water Physical Stock Account: 1995–2001*. The results have been revised due to improvements made by the National Institute of Water & Atmospheric Research (NIWA) to the national hydrological model. In particular, the accuracy of the estimation of rainfall across New Zealand is significantly improved as a result of new research conducted since the last accounts, and published in 2006 (Tait et al. 2006). The accuracy of the region boundaries used in the hydrological model has also been improved over those used in the first edition of the water account. Further explanation of the methodology used in estimating the components of the national and regional water balance can be found in Henderson, Woods and Tait, (2007).

The groundwater volume figures have been provided by the Institute of Geological & Nuclear Sciences Ltd (GNS), these figures are unrevised, but updated, and no change has been made to the methodology used in estimating them.

Future developments

Statistics NZ welcomes feedback on this report and its future direction. For any questions, comments or responses please contact:

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3. Introduction

The physical stock account for water provides information on 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. This report is at the national and regional levels for the June years 1995 to 2005. A summary of the account tables and links to further tables and reports can be found in section six of this report.

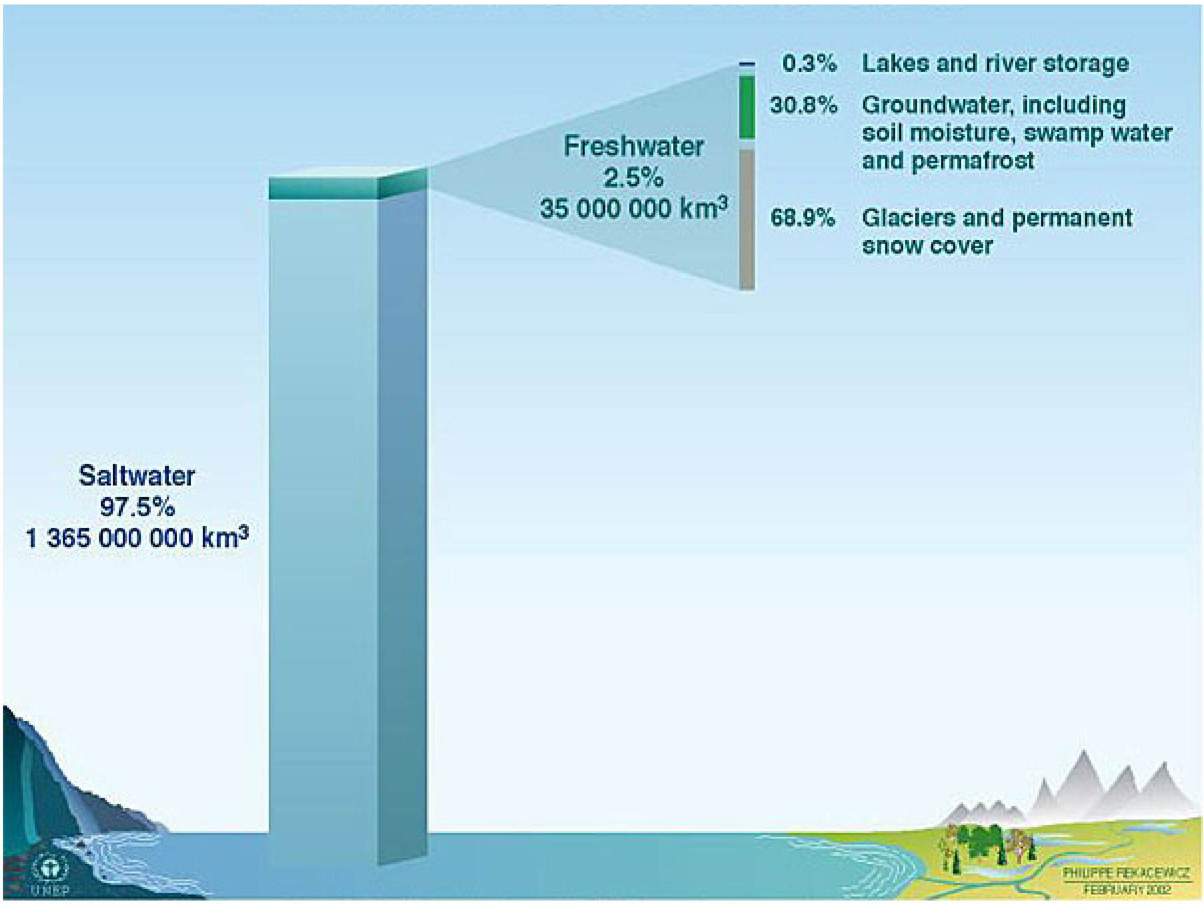
There is limited data for water abstraction in the tables. Abstractions and discharges for irrigation are not available. Volumes for livestock usage are not measured but are calculated from livestock numbers and standard consumption per head. There is insufficient information available to enable reliable estimation of private industrial abstraction volumes. Previously (*Water Physical Stock Account: 1995–2001)* abstractions for private domestic supply have been estimated according to regional water usage in municipal reticulation networks. This work has not been repeated. For further information on the estimates for municipal and private domestic supply please see section six of this report.

A case study on water abstraction and use volumes within the Auckland region with limited by use type breakdown, can be found in section nine.

Broad perspective

Most of the world's water is seawater, and only about 2.5 percent of water is freshwater. Ice-caps and glaciers account for about for about 70 percent of freshwater, depending on the information source, while groundwater accounts for about 30 percent. Lakes, soil moisture, atmospheric water vapour, rivers, and water within living organisms account for the remainder, which is about 1 percent.

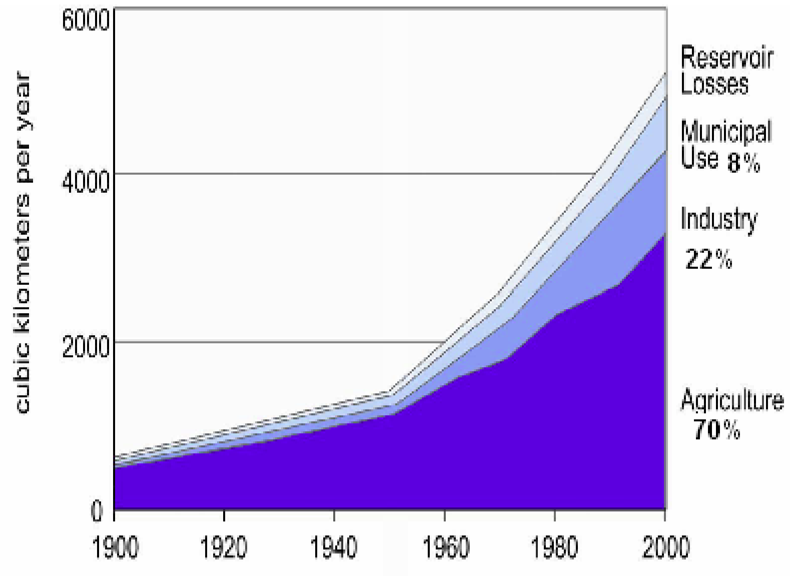
Figure 1 **Total Global Saltwater and Freshwater Estimates**



Source: Shiklomanov (1999) in United Nations Environment Programme (2002).

"Over the last 50 years, global water withdrawal has quadrupled while world population doubled" (Clarke, 2003). 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 (Clarke, 2003).

Figure 2 **Estimated Annual World Water Use**



Source: Postel (1992) in OECD (2005).

The hydrological cycle

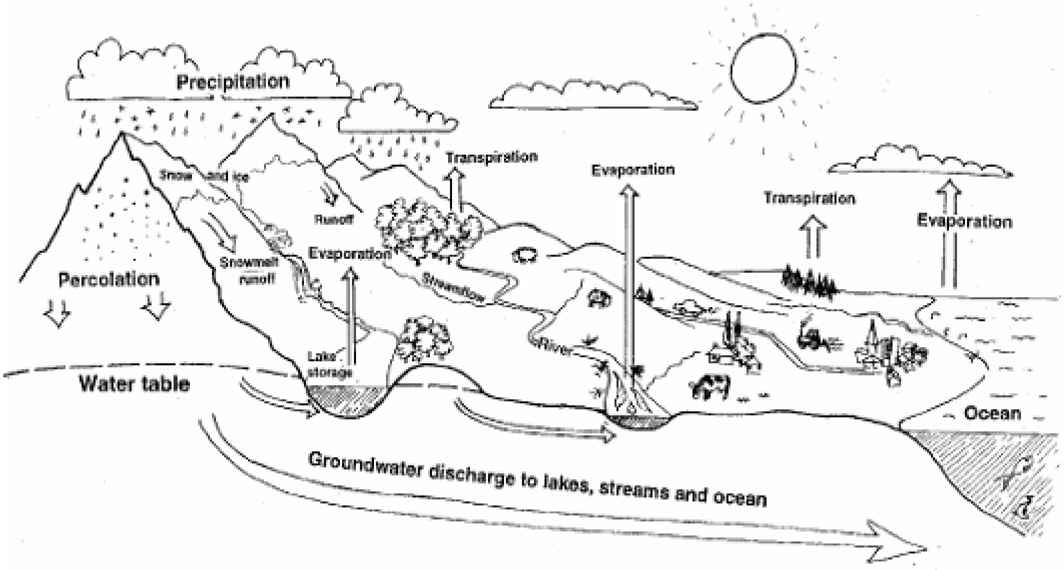
Water has a number of properties that set it apart from other natural resources. Water is constantly moving and transforming into different states over time. Water is also constantly being renewed, but its availability fluctuates over time for different regions, depending on the hydrological cycle, human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

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 framework, is based on the hydrological cycle (see figure 3), 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.

Relative to many other countries, New Zealand has abundant freshwater. Over the period 1995–2005, the total annual amount of precipitation in New Zealand varied between 485,487 million cubic metres in 2001 and 639,692 million cubic metres in 1996. However, the availability of New Zealand's freshwater varies significantly both geographically and seasonally. The amount of rainfall received generally decreases as one moves further east. 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.

Figure 3 **New Zealand Hydrologic Cycle**

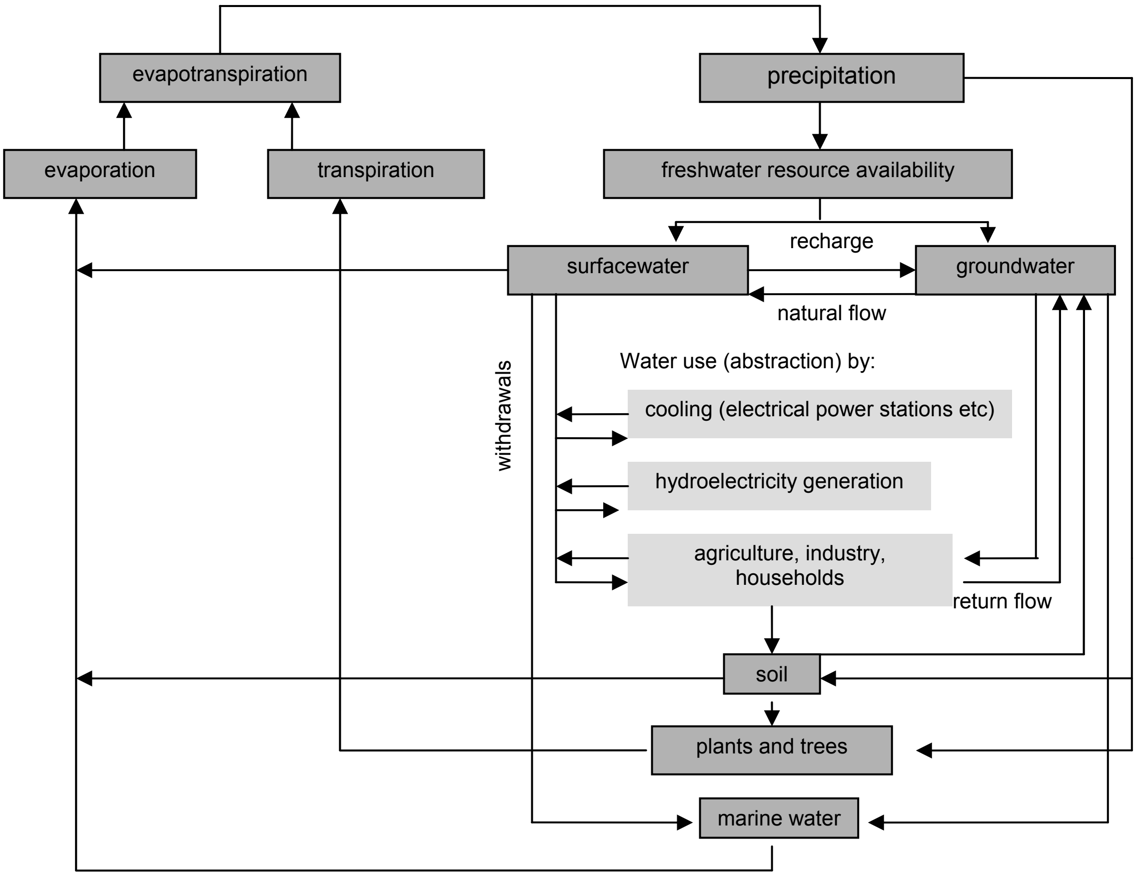


Source: Biggs, B.J.F., Kilroy, C., Mulcock, C.M., Scarsbrook, M.R. (2002)

The hydrological cycle is driven by radiation reaching the Earth's surface and this radiation increases as greenhouse gas concentrations rise. "The greenhouse effect is a warming of the earth's surface and lower atmosphere caused by substances such as carbon dioxide and water vapour which let the sun's energy through to the ground but impede the passage of energy from the earth back into space. As the temperature of the earth's surface increases more water vapour is evaporated. Since water vapour is itself a strong greenhouse gas this is a positive feedback which will tend to amplify the warming effect of (for example) carbon dioxide emissions" (NIWA, 1998). Climate scientists expect that there will be significant changes to available water resources if greenhouse gases continue to accumulate in the atmosphere. While it is expected that drought affected areas will increase in extent, heavy precipitation events are very likely to increase in frequency, and will increase flood risk (IPCC, 2007).

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.

Figure 4 Interaction between the Hydrological Cycle and the Economy



Source: Based on "Environmental Indicators for agriculture", volume 3, methods and results, OECD (2001)

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 (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[2] 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.

Unless expressly allowed by a rule in a regional plan, the Resource Management Act 1991 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.

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2 . "Community drinking-water supplies" means all drinking-water supplies serving more than 25 people for at least 60 days a year (Ministry of Health, 2006)http://www.moh.govt.nz/moh.nsf/pagesmh/4996. Register of Community Drinking-Water Supplies in New Zealand, 2006 Edition

Allocated volumes are maximums and tend to overestimate the amount of water actually abstracted. The reasons for this 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
- 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. However, maximum allocation volumes do provide an insight into the maximum permitted volume of water that may be abstracted in any one year, and it is useful to monitor the growth of the maximum permitted volumes over time. The Ministry for the Environment (2006) produced a report on water allocation in New Zealand in 2006. This report stated that total annual allocation in 2006 was close to 10 cubic kilometres per year (km^3/yr) and that the total national water allocation has increased by approximately 50 percent between 1999 and 2006.

In New Zealand, households obtain their water through a piped community water supply that is 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 89 percent of New Zealand's population was connected to a registered drinking-water supply in 2005 (Ministry of Health, 2005).

Territorial authorities, to varying degrees, collect data on water abstraction by category of users, for the municipal and community water supplies they manage. 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 consent. There is no comprehensive data for such abstractions. An estimate of water use by livestock based on livestock numbers is provided in table 15.

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 Resource Management Act 1991, 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.

Future developments in water management

The government has embarked on a Sustainable Water Programme of Action[3], coordinated by MfE and the Ministry of Agriculture and Forestry. The strategy focuses on three national outcomes for freshwater:

- Improve the quality and efficient use of freshwater by building and enhancing partnerships with local government, industry, Māori, science agencies and providers in rural and urban communities
- Improve the management of the undesirable effects of land use on water quality through increased national direction and partnerships with communities and resource users
- Provide for growing demands on water resources and encourage efficient water management through increased national direction, working with local government to identify options for supporting and enhancing local decision making, and developing best practice.

The Sustainable Water Programme of Action is a comprehensive programme to improve and strengthen freshwater management. One of the initiatives developed under the programme is the draft National Environmental Standard for water measuring devices[4]. The objective of the proposed

3 Further information about the Sustainable Water Programme of Action can be found at: http://www.mfe.govt.nz/issues/water/prog-action/
4 Further information about the proposed National Environmental Standard on water measuring devices can be found at: http://www.mfe.govt.nz/publications/water/proposed-nes-water-measuring-devices-nov06/html/index.html

National Environmental Standard is to facilitate the sustainable management of New Zealand's water resource by ensuring accurate and comprehensive measurement of water-takes.

A National Environmental Standard on water measuring devices would provide, over time, the necessary tools to collect a consistent and comprehensive dataset on water abstraction. It is anticipated that this information would enable improved estimates of water use to be included within the water physical stock account.

4. Scope of the water account

Inclusions

The water physical stock account deals 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 recreational) arise simply by having the resource in existence.

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' because water is not abstracted directly from these sources. However, they are important components of the hydrological system and are included in this account.

The water stock account is compiled on a regional as well as a national basis. Although New Zealand is a relatively small country, there is considerable variation in precipitation and water availability amongst regions. For example, a drought 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 allow more meaningful analysis. However, there remain large variations across regions especially in the South Island.

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 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 presented 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 account. They are included only indirectly or as part of other components.

Water quality is outside the scope of the current water account.

Uses of the Account

The physical stock account for water brings together a variety of hydrological data, including precipitation, evapotranspiration, outflows and changes in stored water. In addition the account presents limited information on water abstraction.

The tables in the stock accounts can assist in assessing:

- availability and scarcity of the resource on a regional and national basis
- 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.

Over the longer term the water account can also be used to asses the impact of climate change on water resources.

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 and usually occur entirely within June years
- June/July is generally a period when storage has been replenished and water levels are stable.

Sources of data

Water is valuable for many reasons – drinking, irrigation, energy, and recreation and tourism. Water has cultural values and is essential for the health of the natural environment. Even so, national data on water abstraction and use is 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 (district and city councils), NIWA and GNS.

The State of New Zealand's Environment 1997, prepared by the 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 the institute of environmental Science and Research Limited (ESR), a Crown research institute, manages a drinking-water database for the Ministry of Health.

Abstraction data

The water physical stock account measures inflows, outflows and changes in storage between years for inland water. 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 account and by additional, but incomplete, supplementary tables included in the annual stock account.

Abstraction and discharge of water for hydroelectricity generation involve very large volumes of water and are presented as separate components in the accounts. It should be noted that New Zealand has several chains of power stations (for example along the Waikato River). Adding the flows through all power stations in these accounts means that the same water is counted as being abstracted and discharged several times in the water account.

For the purposes of the New Zealand account, 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 account. 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 use 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 from which water is abstracted, namely surfacewater (rivers, lakes and reservoirs) and groundwater (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 readily available for discharges of abstracted water back into the environment.

5. 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 directly from NIWA and GNS.

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 a detailed national rainfall dataset was developed using spatial interpolation modelling. Rain gauges have a typical measurement uncertainty of 10 percent and are sparse in remote areas, including some that may have high, changeable rainfall. The rainfall dataset obtained has been calibrated against measured river flows to reduce the effects of rain measurement error. The derived rainfall dataset is used as input into a hydrological model and compiled into regional volumes.

Inflow from other regions

In general, regions in New Zealand are bounded by catchment boundaries. Most rivers do not flow from one region to another, however there are exceptions. The major transfers between regions and the rivers are shown below.

Table 1 Surfacewater Transfers Between Regions

Name of river(s)	From this region	To this region
Motu, Waioeka (and others)	Gisborne	Bay of Plenty
Wairoa (and others)	Gisborne	Hawke's Bay
Whanganui (and others)	Manawatu-Wanganui	Waikato (by diversion)
Clarence	Marlborough	Canterbury
Wairoa	Nelson	Tasman
Waitaki (south bank)	Otago	Canterbury
Mokoreta	Otago	Southland
Kaiwera stream	Southland	Otago
Buller	Tasman	West Coast
Mangatawhiri (and others)	Auckland	Waikato

Source: Henderson, Woods and Tait (2007)

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.

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 20 percent of outflows at the national level.

Evapotranspiration is calculated by the Topnet[5] hydrological model which calculates daily actual evapotranspiration using data for latitude, air temperature, vegetation type and modelled soil moisture content. The model reports daily values and annual summaries for each catchment, and catchment volumes are then summed into regional and national totals.

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.

Abstraction for hydroelectricity generation

Volumes 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. The volume abstracted during the year ended June 2005 amounts to an estimated 114 cubic metres per person per day. Most abstraction by volume occurs in Canterbury, Waikato and Otago. Water that is stored behind hydro dams is accounted for in ‘Changes in lakes and reservoirs’, see below.

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.

5 For further information on the Topnet hydrological model see Henderson, Woods and Tait (2007).

Outflow to sea and net abstraction

Outflow to sea and net abstraction makes up about 80 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. It is anticipated that methods for estimating abstraction and discharge volumes for irrigation will improve over time if the proposed National Environmental Standard on water measuring devices is implemented. 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.

Total outflows

Total outflows 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, detailed below.

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 will in turn vary 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.

Changes in soil moisture are calculated by the Topnet hydrological model. At the national scale, changes in soil moisture fluctuate around zero with a range of around 10mm either side of zero.

Changes in lakes and reservoirs

New Zealand has more than 50,000 lakes (Henderson, Woods, Tait, 2007). Of these 3,820 are over one hectare in size and less than 40 are greater than 1,000 hectares in size (MfE, 2006).

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 The South Island's Lake Benmore, at 7,500 hectares, is the largest of these lakes (MfE, 1997).

The lakes and reservoirs that are monitored and for which data is available are mostly hydroelectricity reservoirs and major lakes. These monitored lakes are very large, and consequently the monitored lake level data covers approximately 80 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 change in storage for each measured lake is the difference in level between the start and end of each accounting period, multiplied by the area of the lake. 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.

Changes in groundwater

Data for groundwater volumes was provided by the Institute of 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 612 billion cubic metres as at 30 June 2005.

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 97 percent of the liquid freshwater[6] on Earth (UNEP, 2002). It is important for irrigation, municipal and private supply and constitutes 33 percent of New Zealand's total allocation volume (MfE, 2006).

Changes in snow

The current snow model standard for New Zealand is SnowSim, developed by Fitzharris, Garr, McAlevey and others at the University of Otago. The model produces daily estimates of snow water equivalent (mm) on a 1 km grid scale for the South Island (Fitzharris and Garr 1995, Kerr 2005, McAlevey 1998 cited in Henderson Woods and Tait, 2007). In order to produce regional and national information on net changes in snow storage, NIWA have modified the SnowSim model to calculate daily snow water equivalent from interpolated daily rainfall and temperature data. The rainfall dataset is the same as that used for the analysis of precipitation (Henderson Woods and Tait 2007).

The SnowSim model produced a map of snow water equivalent for each day in the period 1995 to 2005. The change in snow storage for each year at each grid point was calculated as the difference between snow maps on 30 June in each successive year.

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.

Changes in ice

Ice storage is measured indirectly in New Zealand, through annual monitoring of the areas and altitudes of 49 index glaciers. This permits the estimation of changes in mass of the index glaciers, and a spatial mapping technique is then used to extend this to the 3,144 glaciers in the New Zealand inventory.

A glacier is a body of ice at least 1 ha in area, which has persisted over the last two decades (Chinn, 2001 cited in Henderson, Woods and Tait, 2007). The data reported in the account is for changes in glacier volume over a glacier accounting year, which ends at the end of summer (March or April). The glacier accounting year ends at the end of summer so that glaciers can be observed separately from temporary snow.

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).

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6 The freshwater that is potentially available for human use.

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 2005, averaged less than 1 percent of precipitation.

6. Physical stock account

Highlights

In the June 2005 year:

- The total volume of precipitation falling in New Zealand was 505,194 million cubic metres
- Hydroelectricity generation uses about 114 cubic metres of water per person per day.

For the 1995 to 2005 June years:

- A yearly average of 2.1 metres (depth) of precipitation fell in New Zealand.
- Annual precipitation per person in the West Coast region, at 4 million cubic metres, was 705 times higher than in the Auckland region.

Summary of results

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 2005, the increased precipitation lead to higher than average outflows and also increases in storage. Conversely the lower than average national values for precipitation and outflow to sea in 1997, 2001, 2003, and 2005 were all caused by low precipitation in the South Island and Taranaki. Consistent impacts of El Niño/Southern Oscillation (ENSO) events on precipitation are not necessarily visible at the national scale, because ENSO impacts vary by region (Gordon, 1986, Salinger and Mullan, 1999, cited in Henderson, Woods and Tait, 2007). A severe El Niño event occurred in 1997-98, and weak events in 2002-03 and 2004-05, while weak La Niña conditions occurred over late 1998 to 2000 (Henderson, Woods and Tait, 2007). A summary of annual results at the national level is provided in table 2 below.

The total volume of precipitation, which includes rainfall, snow, sleet, and hail, falling in New Zealand in 2005 was 505,194 Million cubic metres. This is equivalent to the amount of water needed to fill Lake Taupo eight times over. The average precipitation depth across New Zealand was 2.1 metres per year for the 11 June years 1995 to 2005. The West Coast (an average of 5.5 metres) was the wettest region while Otago (1.2 metres) was the driest. Average precipitation per person was 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 3.97 million cubic metres, was 705 times higher than in the Auckland region.

Outflows to the sea and net abstraction (abstraction less discharges) accounted for 80 percent of total outflows, on average, in the 11 June years 1995 to 2005. Evapotranspiration accounted for the remaining 20 percent. The volume of water abstracted for hydroelectricity generation averaged 37 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 1 percent, at most, of the volume of precipitation falling on New Zealand.

Net abstraction totals are unavailable and thus 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) was estimated for the *Water Physical Stock Account 1995–2001* and amounted to only 0.2 percent of the annual precipitation volume. Estimates for Municipal and domestic abstraction are not included in the *Water Physical Stock Account 1995–2005* for reasons outlined below.

- Previously this information was collected by requesting the information directly from district and city councils. However, some councils have resource constraints making it difficult for them to supply the information
- Apart from hydroelectricity generation, irrigation is the main use of abstracted water in New Zealand. Priority should be given to developing national and regional estimates for abstraction and discharge for irrigation

- Private industrial abstraction is also largely unmeasured and may be comparable to water abstracted for municipal and domestic use.

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 updates of the water physical stock account

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 account – (xls 187Kb) – annual tables
- Water physical stock account – (xls 146Kb) – regional tables
- *Surfacewater components of New Zealand's National Water Accounts, 1995–2005* (pdf 1.2Mb) – report by National Institute of Water & Atmospheric Research Ltd (NIWA)

  http://www.stats.govt.nz/analytical-reports/water-physical-stock-account-1995-2005.htm

- *Surfacewater components of New Zealand's National Water Accounts, 1995–200*1 (pdf 862Kb) – report by National Institute of Water & Atmospheric Research Ltd (NIWA)
- *The volume of groundwater in New Zealand 1994 to 2001 (pdf 173Kb)* – report by Institute of Geological & Nuclear Sciences Ltd (GNS)

  http://www.stats.govt.nz/environment/environmental-accounts/water.htm

Summary of volumes

The following tables are also accessible via the hyperlinks above. Table 2 below gives national totals while table 3 is for a single region – Northland. Tables 4 and 5 are for a single year for the North and South islands respectively.

Table 2 Water Stock Account: June years 1995 to 2005

Water Physical Stock Account
1995-2005 June years

New Zealand[1]	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Million cubic metres											
Inflows											
Precipitation	617,117	639,692	531,168	556,863	578,304	554,396	485,487	556,297	517,188	597,497	505,194
Total inflows	617,117	639,692	531,168	556,863	578,304	554,396	485,487	556,297	517,188	597,497	505,194
Outflows											
Evapotranspiration	112,451	117,443	113,151	112,128	112,911	111,805	109,593	113,672	111,420	116,294	113,275
Abstraction for hydroelectricity generation	181,776	184,534	159,474	159,035	164,312	151,510	159,327	139,830	160,562	166,575	169,851
Discharge from hydroelectricity generation[2]	-181,776	-184,534	-159,474	-159,035	-164,312	-151,510	-159,327	-139,830	-160,562	-166,575	-169,851
Outflows to sea and net abstraction[3]	492,955	507,770	417,774	444,685	470,709	440,203	376,039	433,711	407,757	466,027	392,390
Total outflows	605,406	625,213	530,925	556,813	583,620	552,008	485,631	547,384	519,177	582,321	505,665
Change in storage[4]											
Soil moisture	-328	1601	2063	-1727	316	-694	264	-1206	579	-1444	2071
Lakes and reservoirs	-289	264	-1,676	1,714	-763	2,357	-3,338	2,124	-761	1,968	-3,348
Groundwater	4,220	-1,220	-2,480	-830	-1,810	820	290	2,750	-4,480	3,060	-3,130
Snow[5]	6,219	13,746	770	2,543	1,346	3,822	1,633	8,361	1,535	10,626	2,751
Ice[6]	1,890	89	1,565	-1,651	-4,405	-3,917	1,007	-3,115	1,139	965	1,185
Total change in storage	11,711	14,479	243	49	-5,315	2,388	-144	8,913	-1,988	15,176	-471

(1) Sum of the 16 areas administered by regional councils and unitary authorities.

(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 that leaves the hydrological 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) 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.

Table 3 Water Stock Account: Northland region – June years 1995 to 2005

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Million cubic metres										
Inflows											
Precipitation	20,280	18,463	22,918	17,801	26,351	18,945	20,186	23,296	20,422	20,733	13,102
Inflow from other regions	0	0	0	0	0	0	0	0	0	0	0
Total inflows	*20,280*	*18,463*	*22,918*	*17,801*	*26,351*	*18,945*	*20,186*	*23,296*	*20,422*	*20,733*	*13,102*
Outflows											
Evapotranspiration	6,481	6,716	6,643	6,029	6,582	6,676	6,597	6,905	6,489	6,273	6,128
Outflow to other regions	0	0	0	0	0	0	0	0	0	0	0
Outflow to sea and net abstraction(1)	13,626	11,850	16,390	11,499	19,950	12,309	13,467	16,397	13,880	14,565	7,143
Total outflows	*20,107*	*18,566*	*23,033*	*17,528*	*26,531*	*18,984*	*20,063*	*23,302*	*20,369*	*20,838*	*13,272*
Change in storage(2)											
Soil moisture	63	-43	-155	203	-100	-49	123	14	-17	-65	0
Lakes and reservoirs	0	0	0	0	0	0	0	0	0	0	0
Groundwater	110	-60	40	70	-80	10	0	-20	70	-40	-170
Snow(3)	0	0	0	0	0	0	0	0	0	0	0
Ice(4)	0	0	0	0	0	0	0	0	0	0	0
Total change in storage	*173*	*-103*	*-115*	*273*	*-180*	*-39*	*123*	*-6*	*53*	*-105*	*-170*
	Square kilometres										
Land area	11,840										
	Estimated resident population										
Population(5)	..	140,700	142,100	143,300	143,900	144,400	144,400	145,400	146,600	147,600	148,600

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) 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.

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

(5) As at 30 June, from Statistics NZ population estimates. Due to rounding, individual figures may not always sum to the stated totals.

Symbol:

.. not available

Table 4 **Water Stock Account: North Island – June year 2005**

	Northland	Auckland	Waikato	Bay of Plenty	Gisborne	Hawke's Bay	Taranaki	Manawatu-Wanganui	Wellington	North Island Total(1)
Million cubic metres										
Inflows										
Precipitation	13,102	5,243	36,218	24,521	15,509	21,665	13,259	35,098	16,207	180,822
Inflow from other regions(2)	0	0	1,093	1,925	1,201	1,672	0	20	42	0
Total inflows	*13,102*	*5,243*	*37,311*	*26,445*	*16,710*	*23,337*	*13,259*	*35,118*	*16,249*	186,774
Outflows										
Evapotranspiration	6,128	2,177	11,214	7,382	3,563	6,152	1,754	9,824	3,044	51,239
Outflow to other regions(2)	0	117	23	992	3,558	242	0	1,019	0	0
Outflow to sea and net abstraction(3)	7,143	2,965	27,581	18,076	9,407	16,842	11,587	24,353	13,019	130,972
Total outflows	*13,272*	*5,259*	*38,817*	*26,450*	*16,528*	*23,236*	*13,342*	*35,196*	*16,063*	188,162
Change in storage(4)										
Soil moisture	0	-16	-30	103	182	126	67	-14	134	553
Lakes and reservoirs	0	0	-407	-7	0	-36	0	-26	-2	-478
Groundwater	-170	0	-1,080	-100	0	10	-150	-100	-40	-1,630
Snow(5)	0	0	10	0	0	1	0	55	94	160
Ice(6)	0	0	1	0	0	0	0	6	0	7
Total change in storage	*-170*	*-16*	*-1,506*	*-4*	*182*	*101*	*-83*	*-78*	*186*	-1,388
Square kilometres										
Land area(7)	11,840	4,476	24,195	12,108	8,335	14,051	7,069	22,167	7,984	112,224
Estimated resident population										
Population(7)	148,600	1,337,200	384,700	260,300	44,700	149,500	105,000	226,200	460,400	3,116,600

Source: based on data from NIWA and GNS

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

(2) Inflows and outflows across regional boundaries have been removed from the total North Island 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 2004 to 30 June 2005.

(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) As at 30 June, from Statistics NZ population estimates. Due to rounding, individual figures may not always sum to the stated totals.

Table 5 Water Stock Account: South Island – June year 2005

	Tasman	Nelson	Marlborough	West Coast	Canterbury	Otago	Southland	South Island Total[1]
Million cubic metres								
Inflows								
Precipitation	23,876	637	14,476	109,675	58,872	36,164	80,672	324,372
Inflow from other regions[2]	1,184	0	1,071	6,356	2,035	111	202	0
Total inflows	*25,060*	*637*	*15,547*	*116,031*	*60,907*	*36,275*	*80,874*	*335,331*
Outflows								
Evapotranspiration	4,913	185	4,028	13,369	14,432	11,731	13,378	62,036
Outflow to other regions[2]	6,356	69	1,991	1,115	1,071	246	111	0
Outflow to sea and net abstraction[3]	14,763	378	9,375	99,043	45,757	24,569	67,524	261,408
Total outflows	*26,031*	*631*	*15,394*	*113,528*	*61,260*	*36,546*	*81,014*	*334,404*
Change in storage[4]								
Soil moisture	187	6	133	327	483	265	117	1,518
Lakes and reservoirs	0	0	0	-39	-1,029	-1,105	-697	-2,870
Groundwater	-1,180	0	10	40	-580	-30	250	-1,490
Snow[5]	22	0	6	1,196	839	433	95	2,591
Ice[6]	0	0	3	979	-66	167	95	1,178
Total change in storage	*-970*	*6*	*152*	*2,503*	*-353*	*-270*	*-140*	*928*
Square kilometres								
Land area[7]	9,516	412	10,124	23,238	45,039	31,710	31,093	151,133
Estimated resident population								
Population[7]	46,600	45,700	42,700	30,500	526,400	196,600	93,000	981,500

Source: based on data from NIWA and GNS

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

(2) Inflows and outflows across regional boundaries have been removed from the total South Island 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 2004 to 30 June 2005

(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) As at 30 June, from Statistics NZ population estimates. Due to rounding, individual figures may not always sum to the stated totals.

7. 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:

- irrigation
- livestock use
- private domestic use
- private industrial use
- geothermal electricity generation

More detailed information about the limitations on quantifying the abstraction of water for these purposes is provided below.

Irrigation

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

Irrigation accounted for 78 percent of the total number of national allocation consents in 2006, and 51 percent of total annual allocations by volume (MfE, 2006). The maximum annual volume of water consented for irrigation was just over 5 km^3.

Where actual water use has been measured, the volumes taken over a season were between 20 to 80 percent of the allocated volumes (MfE, 2006). 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.

Livestock use

Estimated volumes for consumptive water usage by livestock have been included in the physical stock account for water.

The estimates are calculated from livestock numbers and average water usage per head for different types of livestock. The livestock numbers are from Statistics NZ's agriculture censuses, while the usage per head figures are from the 1987 draft *Farm Water Supply Design Manual* by MAFtech.[7] 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 thus could not be used as a data source.

Private industrial use

Industry is a major user of water, however 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 may vary. Only a small proportion of resource consents are monitored.

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

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

Private domestic use

Private domestic use includes 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 was estimated (for the 1995–2001 years) as part of a broader category called 'municipal and domestic abstraction'. This work has not been repeated for the revised *Water Physical Stock Account 1995–2005* (see section 6 above). The estimation method assumed that domestic use per person for private domestic abstraction is the same as for households connected to reticulation networks in rural communities. However as noted in section 6 above, the estimates for municipal (or reticulated) abstraction have not been updated from the *Water Physical Stock Account 1995–2001* and therefore neither have the estimates for private domestic abstraction.

The 1995–2001 estimates for Municipal and domestic abstraction are found in Table 16 of water physical stock accounts – annual tables.xls. It should be noted that the category 'municipal and domestic abstraction' also includes supply to domestic, commercial and industrial users where they were connected to municipal reticulation networks.

Geothermal electricity generation

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

8. Future developments

As noted above it is expected that over time initiatives, such as those to be implemented under the Sustainable Water Programme of Action - particularly the National Environmental Standard for water measuring devices - will provide the necessary tools to collect a consistent and comprehensive dataset on water abstraction. It is anticipated that this information would enable improved estimates of water use to be included within the Water Physical Stock Account.

At this stage there are no plans for the development of a physical flow account for water due to a lack of available data. A physical flow account for water, if developed, would provide information on the flows of the water resource through the economy. The account would show the volumes of water supplied and used by the various industries in the economy. Flow accounts for natural resources can be used to identify how dependent the New Zealand economy is on those natural resources. The reliance of individual industries can be linked to their contribution to GDP. This concept is known as decoupling, where the more that resource use is decoupled from GDP the better.

Ideally the physical flow account would include information on the volumes for discharge (residual flows) as well as for abstraction or supply, however, it is unlikely that the account could include this level of detail due to the difficulties inherent in measurement of these aspects of the supply and use of the water resource. The physical flow account for the water resource would provide part of the 'outflow to sea and net abstraction' component of the water physical stock account.

In order to produce a physical flow account for the water resource, information would need to be collected for all water supplied from the environment and abstracted either for reticulated supply or as private abstraction. It would also be necessary to have information on who is using the water resource in the economy and it would also be necessary to be able to disaggregate this information to standard industrial classification (Australia New Zealand Standard Industry Classification 1996).

It is likely that any future water physical flow account would initially be developed by regions where the issue of water resource management would result in the development of comprehensive water metering and recording systems.

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 may also be possible.

9. Auckland water supply and use case study

Nearly 150 million cubic metres of water is abstracted from the environment in the Auckland region.

Background

This case study presents water supply and use tables for the Auckland region for the period ending 30 June 2005. It has been possible to construct water supply and use tables for the Auckland region because water-takes by consent holders are required to be metered and recorded, and end users are metered. However, current data limitations do not enable the supply and use tables to be produced at the industry level. In order to produce a full physical flow account for water, more detailed breakdowns of water use by industry type would be necessary.

The purpose of this case study is to give an indication of what can be produced with available data within a region where water use is monitored and recorded. The data that is available shows the volume of water that is being used, and gives some categories for the types of users and the volumes of water they are using. Some of these categories are quite broad, but still give an indication as to where water is being used within the Auckland region.

Data coverage:

The water supply and use described here is for the Auckland region. It does however include some water originating from outside the region. Some reticulated water used in Auckland is sourced from the Waikato River. Also, the Franklin District Council, whose territory is split between the Auckland Regional Council and Environment Waikato regions, uses a small proportion of its reticulated water within the Waikato region boundaries, as well as discharging treated wastewater to the Waikato River. For the purpose of the tables below, this water supply and use is considered as part of the Auckland region.

Data sources:

For the reticulated water supply and use, most of the data used has been taken from the *Auckland Water Industry Annual Performance Review 2004/05* (Auckland Water Industry, 2006). This report covered reticulated water supplied and treated by both Watercare Services Ltd and Rodney District Council. The data also includes totals for water supplied, water used, waste-water treated, trade waste treated, the volume of sewerage overflow events, and amount of water lost before delivery to users.

Franklin was excluded from the Auckland Water Industry (AWI) 2004/05 report, but was included in the 2005/06 report. Consequently figures for Franklin have been taken from the AWI 2005/06 report, except for the total reticulated water use figures, which have been taken from information about the Franklin District Council water status, supplied by Mr Daryl Henehan, that covers the volume of reticulated water used in Franklin.

Data on the amount of consented non-reticulated water used is from the *Auckland Water Quantity Statement July 2004-May 2005,* (ARC, 2006) and information supplied by Henehan. The statement also includes figures for total reticulated water supply, however the figures given for reticulated water in the AWI report have been used as their coverage matches more closely the coverage of the case study.

The MfE report gives total allocation of 152.3 million cubic metres for the Auckland Regional Council area, of which 78 percent is used. It is useful to compare the total allocation volume to recorded use volume in order to determine what proportion of total allocation is being used. However, the allocation and use volumes presented in the MfE report are not entirely comparable with this case study. The region in this case study differs from that in the MfE report, because the data sources used for compiling this study include water taken from the Waikato River, and also because part of the Franklin area lies within Environment Waikato boundaries.

Auckland Region Supply and Use Tables

Year ended June 2006

Supply table

Categories supplied from	Self-extracted	Mains water	Regulated discharge	Other discharge	Total
	Million cubic metres(1)				
Environment	148				148
Water Companies(2)					
Distribution company		136			136
Wastewater company(3)			126	2	128
Reticulated Water					
Households					
Industry, schools, offices, hospitals, etc					
Agriculture, irrigation					
Reticulation maintenance, fire fighting					
Non-reticulated water(4)					
Industry				6	6
Irrigation				4	4
Community				1	1
Other				1	1
Total	148	136	126	14	

Use table

Categories used by	Self-extracted	Mains water	Regulated discharge	Other discharge	Total
	Million cubic metres(1)				
Environment(5)		14	126	14	154
Water Companies					
Distribution company	136				136
Wastewater company					
Reticulated Water(6)					
Households		73			73
Industry, schools, offices, hospitals, etc(7)		30			30
Agriculture, irrigation		4			4
Reticulation maintenance, fire fighting		15			15
Non-reticulated water					
Industry	6				6
Irrigation	4				4
Community	1				1
Other	1				1
Total	148	136	126	14	

(1) All figures rounded to the nearest million

(2) This category is comprised of Watercare Services Limited, Rodney District Council, and Franklin District Council, which both supply reticulated water and treat wastewater.

(3) Other discharge supplied by the wastewater operators is the volume of sewerage overflow events. Data used for Franklin may be incomplete, as overflow from combined and separate sewerage networks was not reported for Franklin in 2005/06, only overflow from pump stations. However any missing data is likely to be only a small proportion of the total.

(4) The amount of water discharged by non-reticulated water users has been assumed here to be equal to the amount used. This will however include irrigation water absorbed by soil and plants.

(5) Other discharge to the environment as recorded here is made up of the amount of non-reticulated water used, and also the volume of sewerage overflow events.

(6) The volumes of reticulated water used by these different categories has been estimated from proportions given on the Watercare Services Ltd website, which do not necessarily apply to the water supplied by Franklin and Rodney District Councils. However these councils supply only a very small amount of water compared to Watercare, so any differneces would not greatly affect the figures given.

(7) This category includes commerce

Results

For the year to 30 June 2005, 148 million cubic metres of water was abstracted for use in the Auckland region. Of this, 136 million cubic metres, or about 90 percent, was abstracted for the reticulated supply. 122 million cubic metres of reticulated water was used, the difference being water lost from pipes in transport before reaching users. Households used 73 million cubic metres, or about 60 percent, of the total reticulated water used; 30 million cubic metres, or 25 percent, was used by industry, schools, offices, and hospitals; 4 million cubic metres, or 3 percent, was used for agriculture and irrigation; and the remainder, about 12 percent, was used for reticulation maintenance and emergency use, such as fire fighting.

About 126 million cubic metres of wastewater was treated. The volume of wastewater treated was higher than the volume of reticulated water used because of stormwater entering the sewerage system. However, the volume of stormwater included in the treated wastewater was likely to be higher than 4 million cubic metres, because some reticulated water would not have made it into the sewerage network. For example, water used for gardens and lawns would have been lost to evapotranspiration, and some water would have gone straight to stormwater and out to sea. The volume of sewerage overflow was 2 million cubic metres.

About 12 million cubic metres was abstracted for non-reticulation supply. Of this, about 6 million cubic metres was used for industry; about 4 million cubic was metres used for irrigation; and the remainder, about 2 million cubic metres, was used by community facilities such as golf courses and bowling greens, and used for other activities such as monitoring and emergency use. No data was available on how this non-reticulated water was discharged after use, although much of it, particularly the water used for irrigation, would be absorbed by plants and soil.

Summary

The purpose of this case study was to give an indication of what can be produced with available data within a region where water use is monitored and recorded. This case study provides a more complete depiction of water-use information than is presented for the rest of New Zealand in the main body of the *Water Physical Stock Account 1995–2005*.

Present data limitations mean it is not possible to produce information at this level for other regions or nationally. The value of producing supply and use tables is that they can be used to compare total abstraction with available water resources, total abstraction with maximum allocated volumes, and uses of water within a regional or national economy. The Auckland region includes the country’s largest urban area, but has a relatively small amount of agriculture. If the water metering and monitoring becomes more prevalent on a national basis it will be interesting to compare total abstraction figure from regions where irrigation is important for regional production.

Sources:

Auckland Water Industry Annual Performance Review 2004/05, Auckland Water Industry, 2006, pp.6,7,23,25.

Auckland Water Industry Annual Performance Review 2005/06, Auckland Water Industry, 2007, pp.6,7,24,26.

Auckland Water Quantity Statement June 2004 – May 2005, Auckland Regional Council, 2006.

10. 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.

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) that 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.

References

Auckland Water Industry (2006). "Auckland Water Industry Annual Performance Review 2004/05", http://www.watercare.co.nz/assets/Publications/AWI06Final.pdf, [20 April 2007].

Auckland Water Industry (2007). "Auckland Water Industry Annual Performance Review 2005/06: Part One", http://www.watercare.co.nz/assets/Publications/industry_review/AWI2005_06_sml_p1.pdf, [20 April 2007].

Auckland Water Industry (2007). "Auckland Water Industry Annual Performance Review 2005/06 Part Two", http://www.watercare.co.nz/assets/Publications/industry_review/AWI2005_06_sml_p2.pdf, [20 April 2007].

Biggs BJF, Kilroy C, Mulcock CM., Scarsbrook MR. (2002). "New Zealand stream health monitoring and assessment kit." Stream monitoring manual, version 2. NIWA technical report 111.

Chin (2001). "Distribution of the glacial water resources of New Zealand" *Journal of Hydrology (NZ)* 40(2).

Clarke (2003). "Water crisis?", OECD Observer, http://www.oecdobserver.org/news/fullstory.php/aid/935/Water_crisis_.html [24/05/07].

Fitzharris and Garr (1995). "Simulation of past variability in seasonal snow in the Southern Alps, New Zealand", *Annals of Glaciology* 21:377-382.

Gordon (1986). "The southern oscillation and New Zealand weather", *Monthly Weather Review* 144:371-387.

Henehan, D. (2007). Letter to author, 16 May 2007.

IPCC (2007), "Climate change 2007: Impacts, adaptation and vulnerability", summary for policymakers, intergovernmental panel on climate change www.ipcc.ch/SPM13apr07.pdf [10/06/07].

Henderson, Woods and Tait, (2007). "Surface water components of New Zealand's national water accounts, 1995–2005", NIWA Client Report: CHC2007-046 http://www.stats.govt.nz/environment/environmental-accounts/water.htm.

Kerr (2005). "Snow storage modelling in the Lake Pukaki catchment, New Zealand: An investigation of enhancements to the Snowsim model", unpublished MSc thesis. University of Canterbury, Christchurch.

McAlevey (1998). "A distributed seasonal snow model for New Zealand", unpublished MSc thesis. University of Otago, Dunedin.

Ministry for the Environment (1997), "The State of New Zealand's Environment 1997" http://www.mfe.govt.nz/publications/ser/ser1997/ [26/05/07].

Ministry for the Environment (2006), "Snapshot of lake water quality in New Zealand" http://www.mfe.govt.nz/publications/ser/snapshot-lake-water-quality-nov06/html [26/05/07].

Ministry for the Environment (2006), "Snapshot of water allocation in New Zealand," http://www.mfe.govt.nz/publications/water/water-allocation-snapshot-nov06/index.html [27/02/07].

Ministry of Health (2006), "Register of Community Drinking-Water Supplies in New Zealand", http://www.moh.govt.nz/moh.nsf/pagesmh/4996 [27/05/07].

(NIWA, 1998), "Climate variability and change", http://www.niwascience.co.nz/ncc/clivar/greenhouse [10/06/07].

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

Salinger and Mullan (1999). “New Zealand climate: temperature and precipitation variations and their links with atmospheric circulation 1930–1994”, *International Journal of Climatology* 19:1049-1071.

Statistics New Zealand (2002). “Natural resource accounts for New Zealand: Overview document”, http://www.stats.govt.nz/environment/environmental-statistics/publications/2002.htm [12/06/07].

Tait A, Henderson RD, Turner R, and Zheng X (2006). “Spatial interpolation of daily rainfall for New Zealand”, *International Journal of Climatology* 26(14):2097-2115.

United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2003). *Integrated Environmental and Economic Accounting 2003*,
http://unstats.un.org/unsd/envAccounting/seea.htm [12/10/06].

United Nations Statistics Division (2006). “Integrated environmental and economic accounting for water resources”, draft for discussion (SEEAW) [20/04/2007]
http://unstats.un.org/unsd/envaccounting/ceea/PImeetings/Handbook_Voorburg.pdf

United Nations Environment Programme (UNEP) (2002). “Freshwater resources”
http://www.unep.org/vitalwater/01.htm [24/05/07].

Watercare Services Limited, “Water Supply", http://www.watercare.co.nz/default,water-supply.sm [20 April 2007].