Wonderful Wai

Education resource kit for Taupo District schools

MARCH 2007

Department of Conservation
Te Papa Atawhai

Tongariro National Trout Centre Society

Taupo District Council

genesis ENERGY

Acknowledgements

The education programme at the Tongariro National Trout Centre, *Taupo for Tomorrow*, has arisen through a partnership between Genesis Energy, the Department of Conservation and the Tongariro National Trout Centre Society. By using the Taupo trout fishery and freshwater environment as teaching mediums the programme aims to:

1. Raise awareness of the importance, value and management of the Taupo fishery.
2. Encourage freshwater conservation.
3. Examine the concept of sustainability in reference to some of the region's renewable resources.

Funding from Taupo District Council (TDC) in conjunction with *Taupo for Tomorrow* has resulted in the development of a freshwater education programme specifically designed for primary schools within the district. The programme is split into two separate learning programmes which are delivered in alternative years.

Much of the material in this kit has been compiled from other educational resources. I would like to thank the following organisations for use of their material:

- Department of Conservation - West Coast Conservancy.
- Enviroschools Foundation.
- Environment Waikato.
- Hydrological Society of New Zealand.
- Ministry for the Environment.
- National Institute of Water and Atmospheric Research
- United States Geological Society

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The resources

The learning programme, **Wonderful Wai**, is designed for the district's Year 3/4 students to explore the key themes of resource use, the water cycle, and cultural uses of water. This programme will enable students to investigate the ways in which the lake and surrounding tributaries were used by people in the past and today.

The second programme, **Human Impacts upon Freshwater**, is for the district's Year 5/6 students. This programme will revisit the cultural uses of water in our community, and then examine how human impacts affect this resource and the ways to minimize these detrimental effects. The overall aim of both these programmes is to help students gain an appreciation of the Taupo freshwater environment and to minimize their impacts on the resource, specifically through wasting and polluting.

Each programme includes educational resource material, a fully funded field trip for each class to the Tongariro National Trout Centre for participation in a Taupo for Tomorrow education programme, and an end of year competition with prizes for winning classes.

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Using the Wonderful Wai resource

This resource kit is designed around the following five focusing ideas:

1. Earth's water.
2. The importance of freshwater.
3. Taupo's freshwater environment.
4. How water is used in Taupo.
5. Why we should value and conserve water.

Included in the resource are teacher information sheets, suggested lesson plans and ideas, and student activity sheets.

A fully funded field trip (including transport costs) to the Tongariro National Trout Centre for a Taupo for Tomorrow education programme for each Year 3 / 4 class in the district is also part of the initiative. As each school has its own curriculum and timetable requirements, the timing of the field trip (whether at the start, middle or end of this unit) is up to individual teachers. Field trips can be booked through the Taupo for Tomorrow educator (phone 07 386 9246 or email: tdepetris@doc.govt.nz).

As highlighted in the environmental education guidelines (see curriculum links section below), it is important that students not only learn about the environment but also participate in projects that work for the environment. Therefore, it is highly recommended that teachers provide students with an opportunity to participate in a student-lead action project related to the conservation of Taupo's freshwater environment. Ideas for action-based projects are given in the lesson plan (under Focusing Idea 4).

Curriculum links & learning outcomes

The following curriculum objectives and learning outcomes are suggestions only, not a comprehensive list. As the programme is specifically designed for years 3 and 4 students, the objectives are largely derived from Level 2. Some objectives relate to specific activities while others will be met during the course of the unit as a result of a well integrated programme. It is not intended that every objective be taught and assessed. Teachers will need to decide which objectives are relevant for their programme.

Science: Making Sense of the Living World – Level 2

Achievement Objectives	Specific Learning Outcomes
AO2. Students can investigate and understand the general functions of the main parts of the animals and plants.	Students will be able to tell how trout spawn, breath and eat.
AO3. Students can investigate and understand the changes that take place in animals and plants during their life cycles.	Students will investigate the trout's life cycle and talk about the different stages.

Science: Making Sense of Planet Earth and Beyond – Level 2

Achievement Objectives	Specific Learning Outcomes
A1/4. Students can investigate observable physical features and patterns and consider how the features are affected by people.	• Students will demonstrate an understanding of the water cycle. • Students will be able to identify at least three local waterways in the Taupo District. • Students will be able to identify ways to conserve water in the school environment.

Social Studies – Place and Environment – Level 2

Achievement Objectives	Specific Learning Outcomes
AO1. Students can investigate how people's activities influence places and the environment and are influenced by them.	Students will show how people's activities in Taupo are influenced by its waterways.

Social Studies – Resources and Economic Activities – Level 3

Achievement Objectives	Specific Learning Outcomes
AO1. Students can investigate how and why people manage resources.	Students will show how trout are an important resource to Taupo and why they are managed.

Technology – Strand A: Technological Knowledge – Level 2

Achievement Objectives	Specific Learning Outcomes
AO1. Students can explore and discuss the use and operation of technologies in everyday use.	Students will explain where and how water comes from and leaves our homes.

Health and Physical Education / Strand D:

Healthy Communities and Environments - Level 2

Achievement Objectives	Specific Learning Outcomes
AO1. Students can examine how people's attitudes, values and actions contribute to healthy physical and social environments.	Students will explain the different types of water in the Maori culture and how this helps to protect the resource.
AO2. Students can identify and use local community resources and explain how these contribute to a healthy community.	• Students will be able to catch and trout and use it for a food source. • Students will determine the factors that make high quality waterways.
AO4. Students can share ideas and beliefs about ways in which the environment contributes to well-being and work with other people to make improvements.	Students will take action to conserve water in their school environment.

The Arts: Learning the Language of Visual Arts - Level 2

Achievement Objectives	Specific Learning Outcomes
Students will identify and explore the elements of the visual arts, using a variety of techniques, tools and processes, materials and media.	Students will develop their ability to use different techniques, tools, processes, materials and media using freshwater resources.

English: Oral Language - Level 2

Achievement Objectives	Specific Learning Outcomes
Interpersonal listening Students can listen to and interact with others in a group. **Interpersonal speaking** Students can converse, ask questions, and talk about events and personal experiences in a group. **Thinking critically** Students should identify, clarify and question meanings in spoken texts, drawing on personal background, knowledge and experience.	While exploring information about waterways (streams, rivers and lakes) students will listen to other student's ideas, ask relevant questions about water and be able to share their experiences of freshwater.

English: Written Language - Level 2

Achievement Objectives	Specific Learning Outcomes
Close reading Students should respond to language, meanings, and ideas in different texts, relating them to personal experiences. Transactional writing Students should write instructions and explanations, state facts and opinions, and recount events in a range of authentic material. Thinking critically Students should identify and express meanings in written texts, drawing on personal background, knowledge and experience.	• Students will read appropriate material related to freshwater, to help clarify understandings about how water resources are used. • Students will be able to write relevant information related to their growing knowledge about rivers, streams and lakes, e.g. recounts of field experiences, diagrams of catchments etc. • Students will show a growing ability to respond to written texts and write information demonstrating understanding of freshwater resources and peoples interaction with them.

English: Visual Language - Level 2

Achievement Objectives	Specific Learning Outcomes
Viewing Reading visual and dramatic texts, including static and moving images, students should respond to meanings and ideas, identifying and describing the verbal and visual features.	Students will view photographs of fishery management and develop their ability to respond to visual images about how people help conserve resources in freshwater environments like trout.

Mathematics: Measurement - Level 2

Achievement Objectives	Specific Learning Outcomes
Within a range of meaningful contexts, students should be able to carry out practical measuring tasks using appropriate metric units, length, mass and capacity.	• Using the water quality monitoring equipment, students should be able to measure the clarity, velocity, and depth and width of stream. • Students will measure amount of water being used in different areas of school environment and compare against school's water meter.

Mathematics: Geometry - Level 2

Achievement Objectives	Specific Learning Outcomes
Within a range of meaningful contexts, students should be able to: Describe and interpret, position, using the language of direction and distance.	Students will look at maps of the area and observe the approximate distances of different waterways and treatment stations in the area. They will describe the paths that waterways in the District take identifying north, south, east and west.

Mathematics: Algebra - Level 2

Achievement Objectives	Specific Learning Outcomes
Within a range of meaningful contexts, students should be able to use graphs to illustrate relationships.	Students will create appropriate graphs to show how people use water resources.

Mathematics: Statistics - Level 2

Achievement Objectives	Specific Learning Outcomes
Within a range of meaningful contexts, students should be able to: Collect and display category data and whole numbers data in pictograms, tally charts and bar charts as appropriate.	Students will use graphs created from data collected from water quality testing and then talk about the information that they have depicted.

Environmental Education

Also in this programme are the elements of the key dimensions of environmental education:

- **Education in the environment** – using the field trip and other outdoor activities for increasing knowledge and skill development.
- **Education about the environment** – by providing information about environmental phenomena and processes.
- **Education for the environment** – action project directed at influencing environmental outcomes.

Integrated throughout the programme are also the five key aims of environmental education:

- **Awareness and sensitivity** to the environment and related issues.
- **Knowledge and understanding** of the environment and the impact of people on it.
- **Attitudes and values** that reflect feelings of concern for the environment.
- **Skills** involved in identifying, investigation and problem solving associated with environmental issues.
- A sense of **participation and actions** as individuals, or members of groups, whanau, or iwi, in addressing environmental issues.

Background Information for teachers

The water cycle

The study of water is called hydrology and its foundation is the water cycle. The water cycle shows how water is always moving around the Earth, continually changing forms from liquid to solid, and back again. Because the cycle is continuous, it does not really have a beginning or an end. However, the best place to start understanding the water cycle is with **precipitation** (rain, snow, sleet and hail).

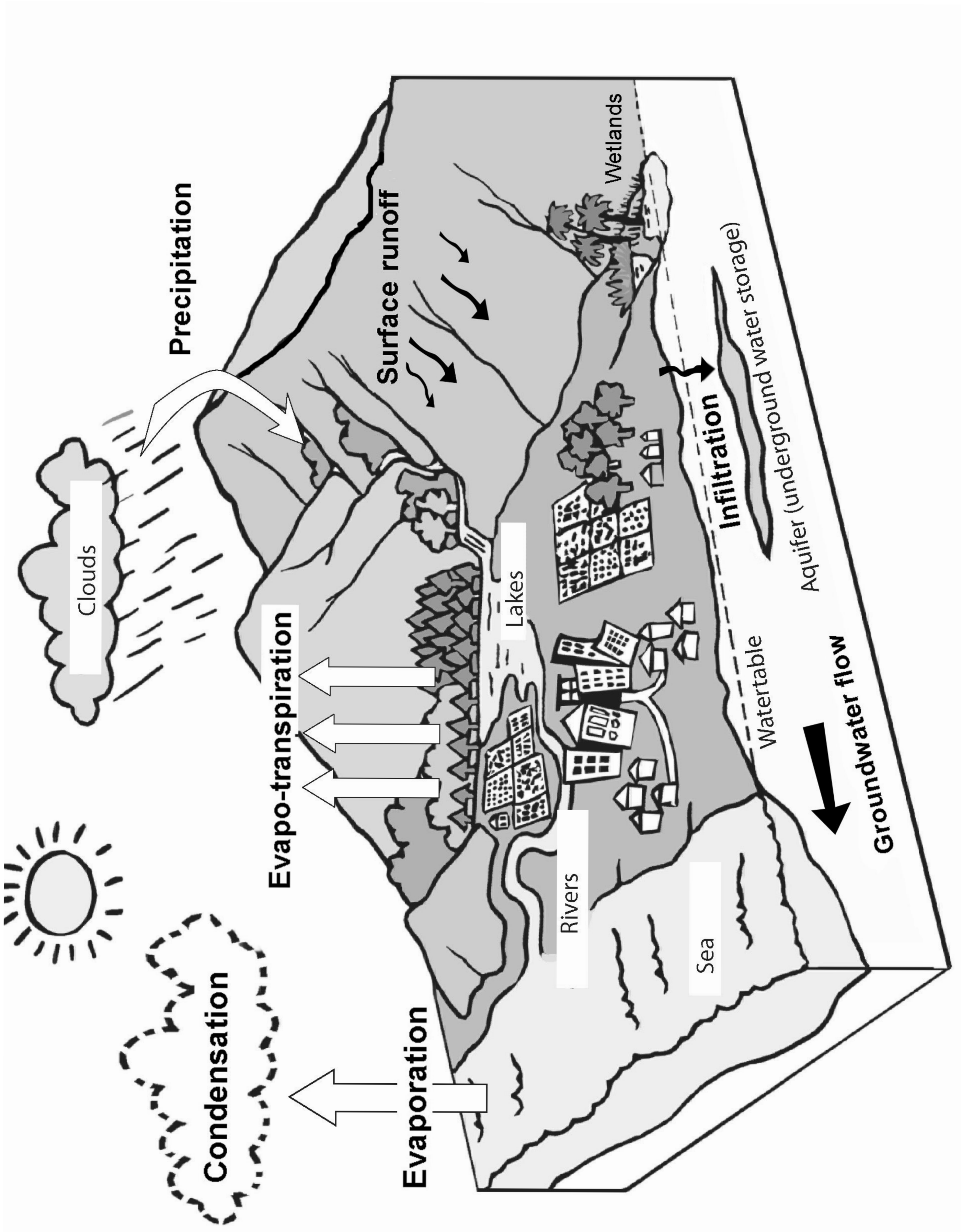
When precipitation falls over an area, several things can happen.

- Precipitation can be absorbed into the soil, a process called **infiltration**. Infiltration allows water to seep into the ground and into the water table. In some areas, the water is stored in natural underground reservoirs called **aquifers**. All this water eventually flows to other areas as **groundwater** flow and/or discharges at the land surface as springs or wetlands.
- Precipitation that is not absorbed into the soil can become **surface runoff**, which flows into rivers and streams. Water that runs along the land's surface in this manner acts as a powerful solvent, picking up minerals, chemicals and sediment from the **substrate** over which it flows.
- Water can evaporate a process which turns water into vapour and returns it to the atmosphere. It can also return to the atmosphere by transpiration through plants. Since it is difficult to separate these two processes, they often are lumped together and called **evapotranspiration**.
- Precipitation can also be stored on the surface of the land. Water stored in depressions such as puddles, ponds and lakes will eventually evaporate from the surface and/or infiltrate into the ground below. In cold climates, precipitation can also be stored in solid form as ice and snow. When the temperature warms, the ice and snow will melt and flow to recharge surface water features such as lakes, rivers and streams, and/or groundwater resources.

This cycling of water is continuous but the rate at which it moves through the different components varies. The time it takes for water to travel through the cycle's components is called the residence time. For example, water cycling through the atmosphere can take one to four weeks; water cycling through a wetland can take one to ten years; and water cycling through as groundwater can take as little as two weeks but as long as 25,000 years.

A number of factors determine the length of residence time and path of water. Soil type, the slope of land, soil and atmospheric moisture conditions, and the intensity and amount of precipitation are all such factors. For example, if rain lands on soil that is comprised of mainly clay or well-packed sediments, or if the soil is already wet and saturated, then the majority of water will travel as surface runoff. However, if the soil has a high proportion of sand or gravel, or has low moisture content, then much more infiltration will occur.

SOURCE: adapted from www.hydrologynz.org.nz – Water resources educational teachers kit.



Precipitation
Clouds
Surface runoff
Wetlands
Evapo-transpiration
Lakes
Infiltration
Aquifer (underground water storage)
Watertable
Groundwater flow
Rivers
Sea
Condensation
Evaporation

Freshwater supply

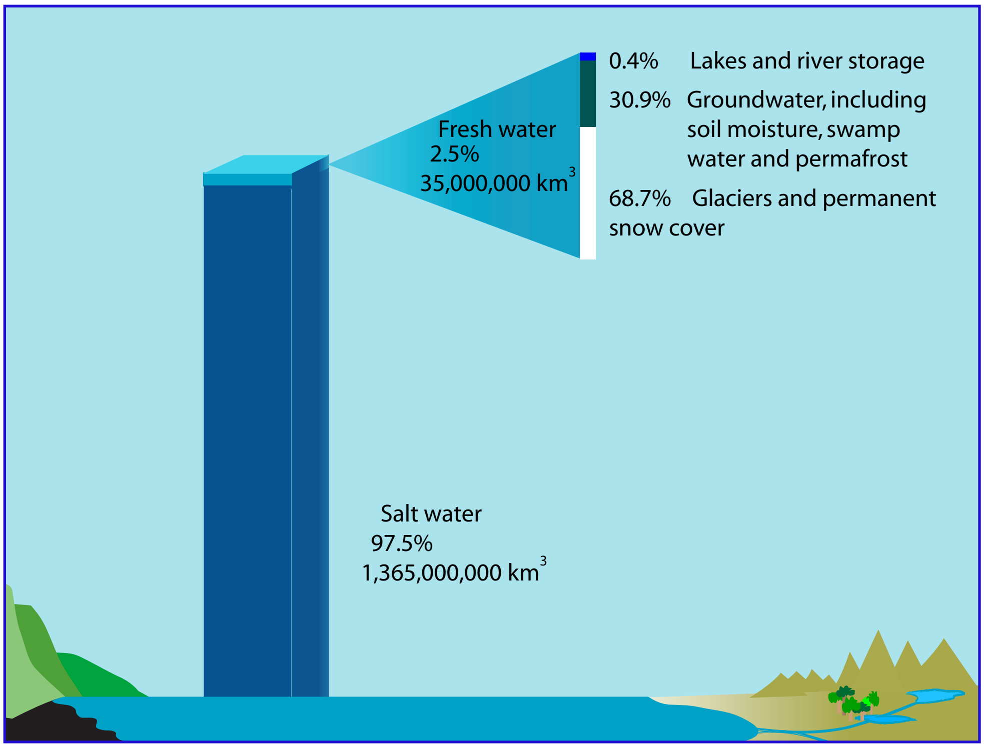
As shown by the water cycle, water exists on Earth and in its atmosphere as a solid (ice), liquid or gas (water vapour). Water contained in oceans, rivers, clouds and rain is continually changing forms (surface water evaporates, cloud water precipitates, etc). Although the distribution of water in its different forms on our planet is variable, the total amount of the Earth's water does not change. **Therefore, water is neither gained nor lost as it moves through the water cycle.**

Water covers **three-quarters** of the Earth's surface. While this seems like an inexhaustible supply of water, in reality the majority of the world's water resource is made up of saltwater, and a very small proportion is freshwater. Approximately **97.5%** of the Earth's water is **saline** (salt water) and is contained in the oceans. Only **2.5%** is freshwater, for example the water in rivers, lakes, ground water and ice.

Of the freshwater on Earth, much more is stored in the ground than is present in **lakes and rivers**. More than 8,400,000 km^3 of freshwater is stored **beneath the ground**, most within one kilometre of the surface. Contrast that with the 250,000 km^3 of water stored as freshwater in lakes and rivers. But the largest store of freshwater is the 29,200,000 km^3 found in **glaciers and icecaps**, mainly in the polar regions and in Greenland.

Freshwater is a vital resource that provides people (and all life) with most of the water they need everyday to live. Therefore it is important to note that not all of the 2.5% of Earth's freshwater supply is useable as some of it is polluted, or is inaccessible because it is located too deep beneath the ground, or is frozen in icecaps. It is estimated that only a small fraction of the world's freshwater supply **(0.7% of 2.5%)** is readily available for use by humans. Another way to look at this is: of the 1.4 billion cubic kilometres of water on Earth, only 200,000 cubic kilometres or **0.014%** of it is useable without modification.

Figure 1: Distribution of water on the Earth



Globally, clean drinkable freshwater is **a precious resource**. The state (or condition) of freshwater resources, both in terms of quantity (how much is available) and quality (how good is it), is very important. If not monitored and managed properly, the availability of freshwater resources can be significantly altered through our use and impacts upon the resource. Over-extraction of water for one purpose such as irrigation can lead to a depleted resource. That is it is not available to use for other purposes. The quality of freshwater can also become degraded through poor management of land use activities like farming, forestry and manufacturing.

Note: This resource kit (for Taupo District's Year 3/4 students) is primarily focused upon the supply and use of freshwater sources, and next year's resource (for Taupo District's Year 5/6 students) will focus upon water quality issues.

It is estimated that already one third of the world's population (two billion of its six billion people) are affected by water shortages; 1.1 billion do not have sufficient drinking water; and a total of 2.4 billion lack adequate sanitation systems.

In places like southern California and the Middle East, where large populations of people live in dry, arid climates, water supplies are scarce. In New Zealand, we are fortunate to have relatively abundant amount of useable freshwater due to our high rainfall and relatively small population. However, in parts of the country, like the east coast of both islands, droughts are occurring more frequently and sometimes summer water restrictions must be put in place. There is concern that too much water is being extracted from some of New Zealand's groundwater aquifers, like those beneath the ground in the Canterbury region, especially for domestic supply and irrigation. Across the country the amount of land requiring irrigation doubles about every ten years. Without careful monitoring and management of our freshwater supply, New Zealand could end up with a lot less water in our surface and groundwater systems.

Saline water – is it useable?

Water that is saline contains significant amounts (referred to as "concentrations") of dissolved salts. The concentration is the amount (by weight) of salt in water, expressed as 'parts per million' (ppm). If water has a concentration of 10,000 ppm of dissolved salts, then one percent (10,000 divided by 1,000,000) of the weight of the water comes from dissolved salts.

The parameters for saline water are:

- Freshwater – less than 1,000ppm of salt.
- Slightly saline water – from 1,000ppm to 3,000ppm.
- Moderately saline – from 3,000ppm to 10,000ppm.
- Highly saline – from 10,000ppm to 35,000ppm.

The ocean has about 35,000ppm of salt.

Students commonly ask **why the ocean is salty**. There are two parts to the answer:

First, 'fresh' water is not entirely free of dissolved salt. Even rainwater has traces of dissolved substances picked up during passage through the atmosphere. Much of this material that 'washes out' of the atmosphere today is pollution, but there are also natural substances present. Once on the ground, water seeps through mineral-rich soils and rocks. As it travels it dissolves some of the minerals - a process called **weathering**. This is the water we drink, and of course, we cannot taste the salt because its concentration is too low. Eventually, this water with its small load of dissolved minerals or salts reaches a stream and flows into lakes and eventually the ocean. The addition of dissolved salts by rivers every year is only a tiny fraction of the total salt in the ocean.

A second clue to how the sea became salty is the presence of salt lakes such as the Great Salt Lake and the Dead Sea. Both are about ten times saltier than sea water. Why are these lakes salty while most of the world's lakes are not? Lakes are temporary storage areas for water. Rivers and streams bring water to the lakes, and other rivers carry water out of lakes. Thus, lakes are really only wide depressions in a river channel that have filled with water. Water flows in one end and out the other. But the Great Salt Lake, Dead Sea, and other salt lakes have no outlets. All the water that flows into these lakes escapes only by evaporation. When water evaporates, the dissolved salts are left behind. So a few lakes are salty because rivers carried salts to the lakes, the water in the lakes evaporated and the salts were left behind. After years and years of river inflow and evaporation, the salt content of the lake water built up to the present levels.

The same process made the seas salty. Rivers carry dissolved salts to the ocean. Water evaporates from the oceans to fall again as rain and to feed the rivers, but the salts remain in the ocean. Because of the huge volume of the oceans, hundreds of millions of years of river input were required for the salt content to build to its present level.

- Rivers are not the only source of dissolved salts. About 20 years ago, features on the crest of oceanic ridges were discovered that modified our view on how the sea became salty. These features, known as hydrothermal vents, are like escape tunnels for sea water that has seeped into the rocks of the oceanic crust become hotter, and dissolved some of the minerals from the crust. The hot, mineral-rich water then rises back up to the ocean floor and escapes out these vents. With the hot water comes large amounts of dissolved minerals. This process has a very important effect on salinity. However, the reaction between sea water and oceanic basalt (the rock of ocean crust) is not a one-way process, some of the dissolved salts react with the rock and are removed from the water to become part of the sea bed.
- A final process that provides salts to the oceans is submarine volcanism, the eruption of volcanoes under water. This is similar to the previous process in that sea water reacts with hot rock dissolving some of the mineral constituents.

Source: adapted from www.utdallas.edu/~pujana/oceans/why

Will the oceans continue to become saltier?

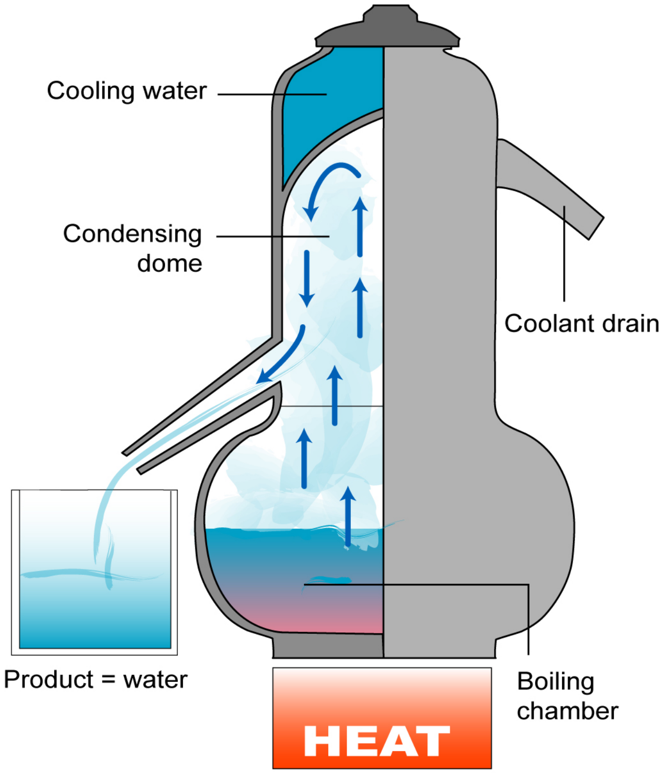
Not likely. In fact the sea has had about the same salt content for many hundred of millions if not billions of years. The salt content has reached a steady state. Dissolved salts are being removed from sea water to form new minerals at the bottom of the ocean as fast as rivers and hydrothermal processes are providing new salts.

Since most of the world's water resource is saline, are there **ways in which humans can use it**? Humans can use slightly saline water for purposes like irrigating crops or cooling electricity generating equipment in power plants. But moderate to high saline water, like that in our oceans, cannot normally be used in these types of industries as the salt cause's machinery, to corrode. However, saline water of all concentrations can be made into freshwater. The process is called desalination and it is one of mankind's earliest forms of water treatment. In ancient times, many civilizations used this process on their ships to convert sea water into drinking water. Today, **desalination plants** are used to convert sea water to drinking water on ships and in many arid regions of the world, and to treat water in other areas that is fouled by natural and unnatural contaminants.

The distillation process

In nature, this basic process is responsible for the hydrologic cycle. The sun causes water to evaporate from surface sources such as lakes, oceans, and streams leaving behind any dissolved solids. The water vapour eventually comes in contact with cooler air, where it re-condenses to form dew or rain. This process can be imitated artificially, and more rapidly than in nature, using alternative sources of heating and cooling.

Figure 2
Distillation of freshwater from salt water



Presently, the high cost of desalinisation has kept it from being used more often. For example in the United States it can cost over $1,000 (US) per acre-foot to desalinate sea water as compared to $200 (US) per acre-foot for obtaining water from a freshwater supply source. As the world's population grows, shortages of freshwater will occur more often, and desalination is expected to be used more frequently, if only in certain locations.

Source: adapted from www.ga.water.usgs.gov/edu

Focusing Idea Two – The importance of freshwater

Essential for life

Water is a basic requirement for all living things. It was not until water appeared on Earth that life began. According to geologists, our planet formed 4.5 billion years ago. Water appeared some time later, around **3.8 billion years ago,** and the first life evolved in the water. It was much later that terrestrial forms of life arose.

Oceans are important to all life, they:

- Play a major role in the water cycle,
- Influence the absorption of carbon dioxide and release of oxygen,
- Influence the climate, and
- Are home to a huge variety of life, providing oxygen and food for organisms.

Freshwater environments like streams, rivers and lakes:

- Provide habitat for different life forms, including certain types of aquatic plants, fish, insects and birds. Some of these organisms need very pure freshwater quality, while others will survive in dirty water.
- Are also important for life on the land. Almost all organisms on Earth today contain at least 50 percent water in their bodies. Most of this water is contained in cells and between cells. Living things use water to transport nutrients, hormones and oxygen to their cells, cleanse waste from their systems and cool their bodies. Animals drink water, while plants take it up through their roots and transport it to the atmosphere through their leaves.

Source: adapted from Enviroschools Foundation educational resource kit.

Human use

Humans have many uses for freshwater. The way we use freshwater is commonly divided into three sectors: agriculture, industrial and domestic.

Agriculture

Agricultural purposes, like irrigating crops and managing livestock, account for nearly **70%** of all freshwater use world wide. Throughout the world, **irrigation** (water for agriculture or growing crops) is probably the most important use of water. Almost 60 percent of the world's freshwater withdrawals go towards irrigation uses, from simple procedures like emptying a bucket of water over a garden to mechanised systems using advanced centre-pivot irrigation systems with spray guns pivoting around a central water source. Large-scale farming could not provide food for the world's large populations without the use of such irrigation systems, nor could crops be grown in the deserts of places like California or Israel.

Water is also needed to raise **livestock** like cows, chickens, horses, fish, or rabbits. Livestock water use is associated with the production of meats, poultry, eggs and milk. For example, it is estimated that the production of one litre of milk requires approximately 20 litres of water.

Industrial

Approximately 20% of freshwater withdrawal is used for industrial processes. The **industries** that produce metals, wood, paper products, chemicals, petrol and oil are all major water users. Industry needs water for purposes like fabricating, processing, washing, diluting, cooling, transporting products, incorporating water into products, or for sanitation needs within the manufacturing facility. It is likely that water is used during some part of the production of every single manufactured product. For example, it takes about 50,000 litres of water to make a car and about 200 litres to make one newspaper.

Elecricity Generation. The **electricity generation industry** is one of the larger water users worldwide. Water is used either as the fuel source (hydro power) or for cooling equipment (thermal generation producing electricity by burning coal, natural gas, and/or oil). The water used in thermal power stations to cool the equipment must also be cooled before it can be released back into the environment. This is because the hot water can negatively affect aquatic habitats. To do this the hot water is sent to cooling towers where it is sprayed with more water, causing evaporation and cooling. The necessity for large volumes of water is the reason why thermal power stations are located near rivers, lakes and the ocean (i.e. Huntly Power Station).

Domestic. The remaining **10%** is used domestically. Domestic water is used for indoor and outdoor **household purposes** – all the things we do at home like drinking, cooking, cleaning, and watering the garden. Water generally comes to our homes in one of two ways. Either a city or regional council delivers it from a **public water supply**, or people supply their own water. Normally private supplies are from a tank that collects rainwater or a bore that taps into an underground water source.

In developed countries water is treated before it is used for public supply. There are very few areas left where water is safe to drink directly from its source without first being treated. The treatment process involves several stages and is costly. The more treatment required, the greater the cost.

Domestic and industrial **wastewater treatment** should also be considered as it interconnected with water use. Wastewater is 'used' water from homes, industries, and businesses. It includes substances such as human sewage, food scraps, oils, soaps and chemicals from sinks, showers, bathtubs, toilets, washing machines and dishwashers.

Wastewater must be treated / cleaned before it is released back into the environment. This is a matter of caring for our environment and for our own health. Nature has an amazing ability to cope with small amounts of water wastes and pollution, but it would be overwhelmed if we didn't treat the billions of litres of wastewater and sewage produced every day before releasing it back to the environment.

So, all wastewater leaves houses, schools and businesses through pipes that lead to either a **wastewater (sewage) plant** or, in rural areas, **septic tanks**. A small percentage of people have composting toilets and alternative grey water systems. Wastewater treatment plants reduce pollutants in wastewater to a level nature can handle by removing solids as much as possible before the remaining water, called **effluent**, is discharged back to the environment. Solid material needs to be removed because when it decays, it uses up the oxygen needed by plants and animals living in the water. 'Primary treatment' removes about 60% of suspended solids from wastewater and aerates it (stirs it up) to replace the oxygen. 'Secondary treatment' removes more than 90% of the remaining suspended solids.

Like water treatment for public water supply, this process has a cost, and the more water we use in our houses, the more water there is to treat. Although the treated water is considered 'safe' as bacteria levels have been greatly reduced, it is still considerably altered. The additional nutrients that are not filtered out (such as phosphate in faeces and detergents, and nitrogen in urine) may increase the growth of plants in waterways and this can lead to eutrophication. *Note: More about the detrimental effects of eutrophication process in next year's Year 5/6 resource kit.*

Recreational use

Water is a great playground for everyone. The scenic and recreational values of our waters are the reason many people choose to live by water. Visitors are drawn to areas that can provide water-based activities such as swimming, fishing, boating and picnicking. Clean water is critical to plant and animal habitat, which is important for the fishing industry and sport fishing enthusiasts. Keeping our freshwater resource clean and healthy also ensures it will be available for future generations.

Source: adapted from www.ga.water.usgs.gov/edu/wateruse

Cultural importance

The importance of water to all people is reflected by the many different cultural and religious **traditions, values and meanings** surrounding water. Often, these refer to the scarcity or abundance of water, its importance for cleansing and value as a food source, or its destructive power.

Maori have strong cultural, traditional and historic links with water. Freshwater sources are spiritually significant and closely linked to the identity of the tangata whenua (people of the land). Before Europeans arrived, major settlements were sited beside waterways, as they were the principal means of transport as well as contributing significantly to the Maori diet. This is reflected in the well-known Waikato whakatauaki about the many chiefs living along the river:

Waikato taniwharau, He piko, he taniwha, He piko, he taniwha.

(Waikato of the hundred taniwha, at every bend a taniwha).

Maori recognise many different types of water (momo wai), and each has different values and uses. Every body of water has a mauri and so should not be mixed with water from another source. Mauri is often translated as the 'life force'- the essence of a being, the power that makes it what it is. It is considered that all natural things, and some things humans build, have mauri. Land, plants, rivers and buildings all have their own mauri, which must be respected and protected.

Tikanga (correct practises) involving water reflects the need of the water resource to be protected. For example, separate facilities are used for cooking and for washing the body; these waters should not be mixed. Different water sources may be used for different purposes, such as a spring for ritual purposes and a river for ordinary washing. In some places, distinct parts of the same river would be identified as sources for ritual, for drinking water and for washing. Alternatively, a different time of the day could be set aside for using a river for various purposes. When water is properly cared for it can be used for purifying and cleansing, both in a physical sense (washing ourselves) and in a ritual sense. For example, water is used to sprinkle in a house whose occupier has died and for washing hands after being in an urupa (cemetery), or after being with a dead person at a tangi.

Source: adapted from Enviroschool Foundation educational resource kit and Environment Waikato – Rivers and Us resource kit.

Focusing Idea Three – Taupo's freshwater environments

Physical geography

The rivers, lakes and wetlands give the Taupo District much of its distinctive character. The district's freshwater resource is comprised of:

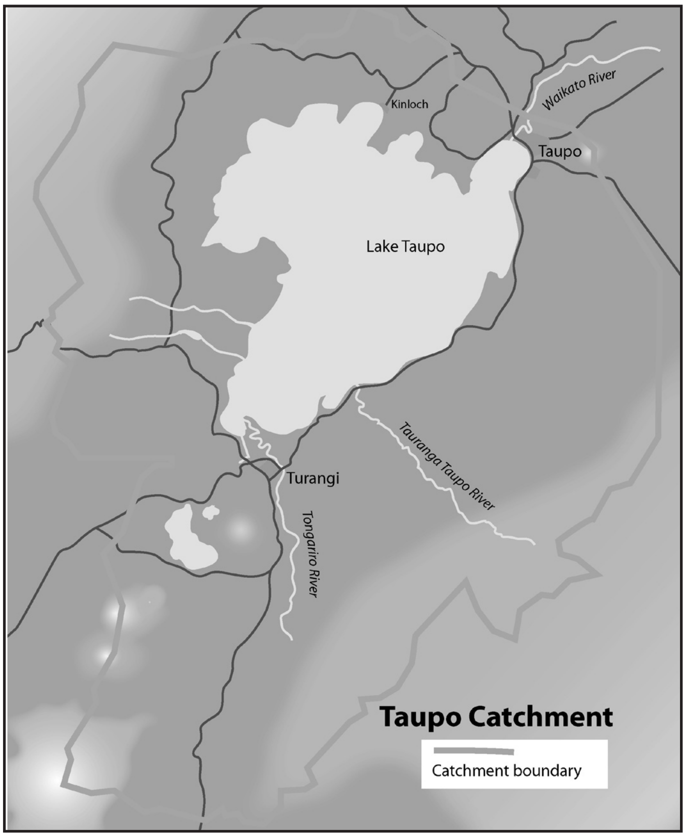
- Mountain and lowland streams.
- Wild and scenic rivers like the Tongariro.
- The Waikato River (425 km) is the country's longest river.
- Lake Taupo (Taupo-nui-a-Tia) (622 km^2) is the largest body of freshwater in Australasia
- South Taupo Wetlands.
- Groundwater – constituting 90% of the Waikato region's freshwater supply.

The natural and physical environment is strongly centred around **Lake Taupo**. The lake's 616 square kilometres covers about 10% of the total Taupo District (6,970 km^2 or 697,000 hectares).

The Taupo **catchment** encompasses all the land and water courses which ultimately drain into the lake. A catchment can be defined as an area of land, bounded by hills or mountains which all drains in the same direction to a common point. A good simile is to visualise a droplet of falling water on the leaf of a tree and running down the branches (streams), which join to become bigger branches (rivers) to the base of the trunk (river mouth).

About **40 streams and rivers** flow into Lake Taupo. The largest are the Tongariro, the Waitahanui, the Hinemaiaia, Tauranga-Taupo, Waimarino and Waiotaka. Freshwater leaves the Taupo catchment via the Waikato River and flows into the Tasman Sea.

Figure 3
Example of a catchment area



In addition to Lake Taupo and its tributaries, there are a number of smaller lakes, for example Rotoaira and Rotopounamu in the southwest and the sulphurous Lake Rotokawa in the north. Like Lake Taupo they were all formed by past volcanic upheavals.

Undoubtedly, Lake Taupo is the main landscape feature of the district. It is of significant visual and conservational value due to its size, high water clarity and attractive blue colour. The lake is New Zealand's largest and one of the country's clearest with more than 15 metres of visibility. It currently has low levels of plant nutrients which limits algal growth. If these were to increase the water's clarity would probably lessen and it could become unsuitable fore recreational use at times. Preservation of the lake's water quality is seen as the most significant resource management issue for the district.

Also of great importance are the **South Taupo wetlands.** To most people wetlands aren't the most favoured place for recreation as they are often seen as a muddy and smelly 'wasteland'. However, wetlands are not wastelands. In fact they are quite the opposite: they are full of fascinating plants and animals and provide important ecosystem functions. Wetlands are like big sponges that filter water, retain soil in floods and stop nitrogen and other pollutants from entering waterways. This helps to prevent the eutrophication of rivers and lakes. In shallow wetlands much of the accumulated nitrogen returns to the atmosphere as it is used and released by aquatic bacteria. This is one of the reasons why artificial wetlands are the most advanced method for treating urban sewage. Wetlands soak up water during floods and slowly release it back to streams during dry periods. They are nurseries for many species of plants, insects, fish and aquatic birds.

Formation of Lake Taupo

Lake Taupo's current form has been defined by **volcanic activity** from **vents** beneath the lake bed. Such activity has occurred on and off over a period of 50,000 years. The most violent event occurred 26,500 years ago. This eruption was one of the **world's largest** in the past 75,000 years and destroyed the lake that previously extended between Kuratau and Reporoa. After this eruption, Lake Taupo initially filled to a level 140 m above where it sits now but then was slightly lowered due to an overflow at Waihora.

The present day **Waikato River outlet was formed** a few thousand years later when a catastrophic flood lowered the lake by 80 m. The peak of this flood was equivalent to the flow of the Amazon River and would have filled the Westpac Trust Stadium in Wellington in three seconds. The lake then remained more or less stable until 1800 years ago when another large **eruption** from the Taupo volcano occurred. After this eruption, the lake quickly refilled to 34 m above its modern level a pumice and ash dam failed causing another flood and lowering the lake to a level similar to what we see today.

Lake Taupo's web of life

In any ecosystem, lake, forest or field, organisms depend on each other for survival. Water, soil, insects, plants and animals – including humans – rely on each other for food.

Plants capture the sun's energy (through a process called photosynthesis) but since animals cannot capture the sun's energy in this way they must obtain their energy by eating plants or by eating other animals. The plant eaters **(herbivores)** get their energy directly from the plant, while the meat eaters **(carnivores)** get theirs by eating the plant eaters. Larger meat eaters in turn get their energy by eating from plant eaters or smaller meat eaters. Some animals, such as humans, eat both plants and animals **(omnivores)**.

Because of their unique ability to produce energy-laden substances, green plants are called **producers**. All other living things are **consumers**; they consume the energy from plants or other animals. Fungi and bacteria are classed as **decomposers** as they break down and release the nutrients contained in organic matter such as leaves.

A simple **food chain** can show the flow of energy from one group of organisms to the next. This is an example of a simple food chain of a lake in the north island.

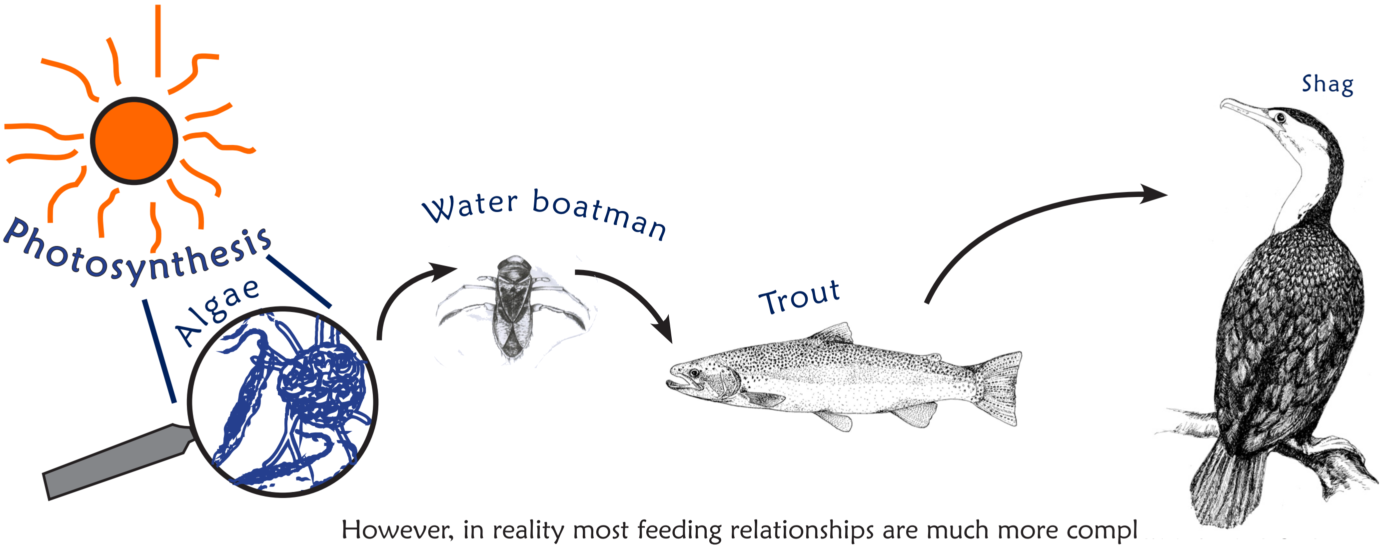


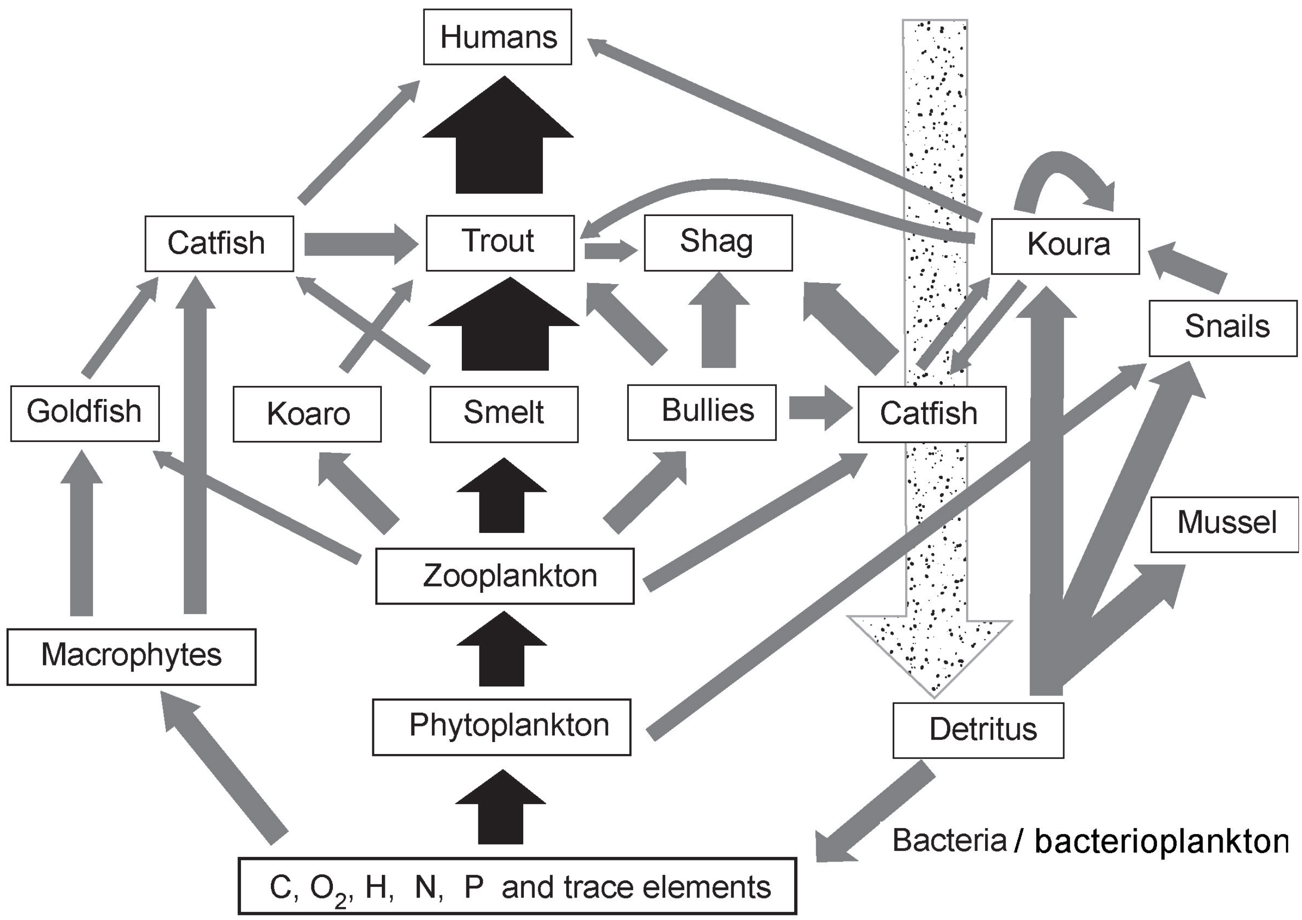
Figure 4:
Example of a basic foodweb

However, in reality most feeding relationships are much more compl shown above. These complex relationships are best described as a **food web**. Food webs include many organisms, each in turn a consumer and then a food source. This complex web is not just about having a varied diet, but it is important for survival; if one food source disappears then another will be selected. By drawing links between those living things that eat (or are eaten by) each other, a maze of interconnecting lines appears. Lines run from every plant (the smallest bacterium to the largest tree) and every animal (the one-celled animals to the largest meat eaters).

Source: adapted from Wetlands for Education resource kit.

Figure 5:
Lake Taupo foodweb

Lake Taupo's food web looks like this:



This example of Lake Taupo's food web shows the interactions that occur most frequently between the most prevalent organisms.

Lake Taupo's food chain is based on the **elements** and their associated compounds (more than one element) in the water. The elements like nitrogen, carbon and oxygen are derived from weathering of surrounding rocks, soils, and vegetation, as well as from the air and rain. Air passing over the lake dissolves in the water so all the gases found in the air are also found in the lake water. These elements and their compounds are important nutrients for plant life. Of particular importance is oxygen and carbon. Oxygen is necessary for plants and animals to respire and carbon dioxide is the basic requirement for green plants to make carbohydrates by photosynthesis.

The next **trophic** (energy) level contains rooted plant life **(macrophytes)**, found mainly in shallow water around the lake edge (known as the **littoral zone).** The depth at which macrophytes will grow is largely dependant upon **water clarity,** as adequate light is required for growth. In each litre of lake water there are also thousands of microscopic plant and animals collectively called **plankton** (a Greek word meaning to passively wander and drift). Most of these simple organisms are invisible to the naked eye, yet they are a very important link in the food chain. Many of the types of plankton in Lake Taupo, including several of the plant types, can swim, but mostly they travel passively in the circulating lake currents. The microscopic plants or algae are called **phytoplankton.** In Lake Taupo there can be more than 25 species of algae at some times of the year. After an extensive period of settled weather large colonies of phytoplankton may accumulate in the bays and can be seen with the naked eye.

The next link in the food chain consists of another type of plankton called **zooplankton** (microscopic animals). Zooplankton species are not strong enough to swim very far against turbulence in the open waters; nevertheless they do show independent movement, changing their horizontal position and depth through the day and night.

Bacterioplankton are the third type of phytoplankton. These tiny, colourless cells are even smaller than phytoplankton, and are found in concentrations of 100 billion per litre of lake water. Although these cells are bacteria, they are not the disease-producing forms which trouble humans. They are natural inhabitants of the waters and their role in the lake is vital. Bacterioplankton have special enzymes to decompose the organic debris floating in the water; during this process nutrients are released which can then be used by the phytoplankton for growth. Another group of **bacteria** are simultaneously at work in the sediments regenerating **detritus** (organic nutrients) from the dead alga, plants and animals which have fallen to the lake floor as indicated by the dotted arrow. The bacteria in the lake are therefore nature's recycling agents, ensuring that life-supporting substances remain in continuous supply.

The main types of **benthic** (bottom dwelling) invertebrates of Lake Taupo include the freshwater crayfish **(koura)**, snail and mussel **(kakahi)**. The main ecological role for these organisms is in recycling detritus on the lake bed by scavenging, breaking down and consuming organic material.

In the two remaining trophic levels, there are six types of **fish**, all described in the next section, and two types of **shag**, the black shag and the little shag; both widely distributed around the lake. Another type of shag, the little black shag, which is abundant at Rotorua, is sometimes observed at Taupo but it is not known to breed in the district. Lastly, **humans** are located at the top as the ultimate consumer of the organisms in the lake's food web.

The **most dominant food chain** of the lake is indicated by the bold, black arrows. It begins with phytoplankton (algae), which are eaten by zooplankton, in turn which are eaten by smelt. Trout prey on smelt and in turn are caught and eaten by us.

Source: adapted from Forsyth D.J. and Howard-Williams, C. 1983. Lake Taupo. P.D. Hasselberg, Government Printer, Wellington.

Fish species of Lake Taupo

History

Before the arrival of Europeans, there were only **two species** of small fish found in the lake. These were the **koaro** - a member of the whitebait family- and the common bully or **toitoi**. The koaro was the dominant species in Lake Taupo and were an important food source for Maori. Other food sources included the **koura** (freshwater crayfish) and the **kakahi** (freshwater mussel) which were the only two large aquatic invertebrates. It is likely that all these species were brought to Lake Taupo by early Maori after the last eruption in 181 AD. Today, all four of these species are still found in the lake.

Other freshwater fish commonly found in New Zealand's waterways, like eels and whitebait, **do not naturally occur** in Lake Taupo. This is because these species are **diadromous**, meaning that they spend part of their life at sea to **spawn** (breed). Physical barriers like Huka Falls and the eight hydro dams along the Waikato River, and the long distance they must travel, prevent new generations getting as far as the lake after hatching at sea or in tidal estuaries.

In the 19th century, European settlement in the Taupo region brought many changes, including the introduction of new species of fish to the lake. The first fish introduced was the **goldfish** in 1873. Local Maori know the goldfish as **morihana,** after sub-inspector Morrison of the armed constabulary who first released these fish. Small numbers of goldfish are still found in Lake Taupo but tend to only occur in weedy areas in southern parts of the lake.

Trout were introduced soon afterwards in the hope that a sports fishery could become established in Taupo's waterways. **Brown trout,** originally from Britain but imported via Tasmania, were released into the lake in 1887. These grew to a very large size but proved difficult to catch and as a consequence, **rainbow trout** originating from California were introduced in 1898. The lack of competition from native species and the habitat of Lake Taupo and its tributaries proved ideal for rainbow trout, so the quantity and quality of the fish caught was initially high.

However, the trout population grew so rapidly that it started to **overwhelm its food source** of koaro, bully and koura. Trout condition deteriorated as starvation set it. As a result, 208 tonnes of trout were netted between 1914 and 1920 to **reduce the population.** In the 1930s, **common smelt** were introduced into Lake Taupo from the Waikato River as an alternative food source. Smelt fared very well in the lake as they breed in sufficient numbers to withstand trout predation. Today, when trout are living in the lake, smelt comprise up **90%** of their diet.

Other introduced species include two tropical aquarium fish: the **sail fin molly and the swordtail.** These fish require warm water and have found suitable conditions in some of the small, thermal streams entering the lake. In the mid-1980s **brown bullhead catfish** were illegally released into Lake Taupo, either accidentally or deliberately. Catfish are classified as a pest fish in New Zealand waterways and the population is carefully monitored to ensure that they do not pose a threat to the trout in the Taupo Fishery. Population numbers appear to have stabilised in recent years.

Taupo is free from other pest fish species such as koi carp, gambusia and rudd. If these species were to get into the lake it would have dire consequences for the things we value about the lake, such as its trout population and clear water. Eradication of pest fish and plants is simply not an option due to the size do the lake and control can be very difficult. Therefore the only solution is to keep them out. In practise it's not hard. It simply requires all of us, whenever we go to a new lake or river, to always practise the following procedure to ensure our gear is clean.

Check: Check and remove any fragments of weed or fish eggs from any gear (i.e. fishing rods, waders, togs, boats) used in the water.

Clean: Saturate our gear for one minute with a five percent detergent or two percent bleach solution.

Dry: Once dry, leave for another 48 hours.

Characteristics

Koaro

This fish is part of Galaxiidae family, the largest family of freshwater fishes in New Zealand with about 26 different species. The koaro has a distinct elongated, slender shape, almost tube-like. Its sides and back are covered in a variable pattern of golden botches and bands that gleam and glitter in the sun. Most adult koaro are 80 -120 mm long, but they can grow up to 270 mm in lakes. Koaro can live up to ten years.

Rocky, tumbling streams are the preferred habitat of koaro. When possible koaro will migrate to sea to spawn, and their young are one of the five key whitebait species. Koaro are highly skilled climbers and can penetrate well inland in many river systems. As a consequence they have the most widespread distribution of the whitebait species. Koaro also form land-locked, non-migrating populations in river systems associated with large lakes like Taupo.

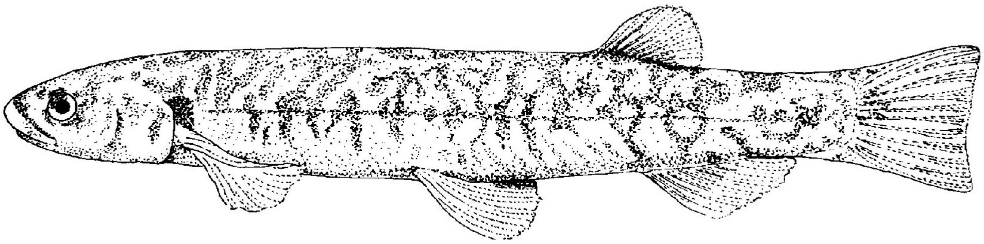


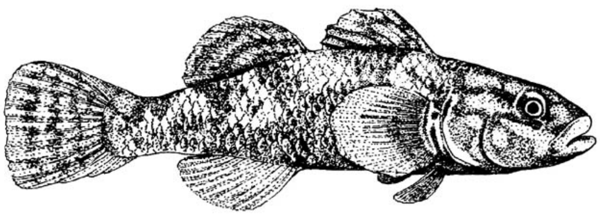
Figure 6: Koaro

Around Taupo koaro spawn mainly over summer in the inlet streams of lakes. Eggs are laid between the interstices of cobbles on the streambeds. The juveniles live in the lake before most migrate into the rivers to complete their lifecycle. Koaro feed on of a wide range of invertebrates like mayfly, stonefly, caddisfly, and chironomid (snails or midges) larvae and fish eggs. The largest feed on bullies.

Toitoi (common bully)

There are seven species of bullies in New Zealand and only four of these species are known to be land-locked. The common bully is the most wide spread, and there are few lakes where it is not present.

Figure 7: Toitoi



The Bully's body is speckled brown, tan and white that helps them blend in with gravel and stone surroundings. They live up to five years and generally grow to 30 – 60 mm long, but some older and hence larger fish (up to 100 mm long) have been recorded.

Bullies deposit eggs in nests on hard substrates such as rocks, old weed stalks and mussel shells, mainly in the littoral zone around lakes during spring and summer. These nests are fanned and guarded by males.

After hatching the 3-4 mm long larvae become **plantivorous** (feed on plankton) and by depth congregate in a discrete layer some 5-20 m below the lake surface. At night they migrate to surface waters. At about 15- 18 mm long the larvae settle on the lake bottom, usually in spring, and become **benthic** (bottom dwelling). They mature around the age of two. In the summer time adult bullies can be seen in the shallow (0 – 5 m) of the lakes quite frequently, presumably because of the warmer waters and increased food supply. During other times of the year there is an inshore/offshore movement of bullies from depths of around 10-12 m to these shallows between dusk and dawn. However, small populations are known to occur to at least 80 m.

Larval bullies feed mainly on zooplankton, whereas the adults feed primarily on benthic invertebrates such as chironomids, larvae and mayfly nymphs and snails.

Common smelt

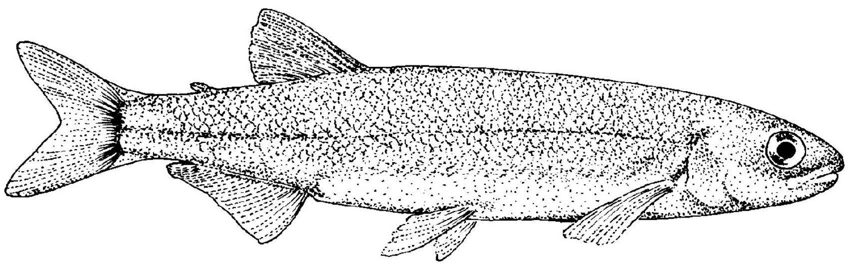
The common smelt is wide spread throughout New Zealand and is the only type of smelt species found in New Zealand lakes. Smelt can be distinguished from other fish species by their easily dislodged scales, and by the presence of the adipose fin, a small fleshy lobe on their back between the dorsal fin and the tail. They also have a distinctly forked tail and a peculiar, strong cucumber smell. The common smelt is a shiny white-silvery colour.

They live in flowing and still water, and there are both **diadromous** (sea-going) and non-diadromous (land-locked) populations, although humans have established many of the latter. Although they are not a climbing species like the koaro, smelt are good swimmers and will penetrate well inland in river systems that are not too steep (e.g. the Wanganui River).

Smelt are a **pelagic** species, which means they swim in mid water rather than resting or hiding on the substrate like bullies and koaro. Thus, they are often seen out in the open in streams and lakes as they feed on drifting food organisms. Smelt are commonly seen in schools during the spring and summer months in the shallows around the lake shore and stream mouths where they come to reproduce. Here they scatter their eggs over clean, sandy substrates in the shallows (for example, 0.5 - 2.5 m in Lake Taupo). The eggs hatch relatively quickly (in about ten days) into 8 -10 mm long transparent larvae.

The larvae feed on phytoplankton as well as some micro-zooplankton, and the juveniles and adults are mainly plankitvorous. Of the freshwater fish that live in New Zealand, smelt are one of the most sensitive to poor water quality like high water temperatures or pollutants making them a good indicator species for determining freshwater quality.

Figure 8: Smelt



Trout – Rainbow and Brown

Trout occur in most North and South Island lakes, with brown trout generally predominating in the South Island and rainbow trout in the North. There are also very small populations of lake trout and brook trout in some lakes but these are scarce. In the Taupo region, the percentage of rainbows and browns is about **90%** and **10%,** respectively. However several, very small populations of brook trout are located in areas that are inaccessible to anglers.

Rainbow trout are a silvery colour with black speckles, whereas the brown trout's coloration is more greenish brown with black speckles. Both types of trout have a faint red streak which runs along the middle of their body and intensifies to a much darker red colour during spawning.

In the Taupo region, the trout populations are totally **wild** and there is no stocking of trout from the Tongariro National Trout Centre hatchery. Adult trout spawn during the winter months in the rivers and streams that surround Lake Taupo. In the river bed gravels the **hen** (female trout) builds a **redd** (nest) to deposit her eggs in by excavating a hole with her tail and then covering the eggs with gravel .The eggs are fertilised once a **jack** (male trout) releases his **milt** (sperm) on the redd. After approximately 30 days, small trout know as **alevins** start to emerge from the eggs. At this stage the alevins have an attached yolk sac which they feed off, and remain hidden in the gravels. When the yolk sac is completely digested, the trout emerge as free-swimming **fry** and begin foraging for their food in the river. 18 months after hatching, these young trout enter Lake Taupo as **fingerlings** which are approximately 100-200 mm long. Most trout grow in the lake until they are approximately three years (450 – 550 mm) before beginning their journey to rivers and streams in order to repeat the lifecycle.

Growth rates of trout are strongly influenced by water temperatures and food supply. Across the country, growth is fastest in central North Island lakes, which combines optimal thermal habitat and abundant food sources. Rainbow trout can spawn once a year for up to four to five years and brown trout are known to usually live a few years longer than this. The post-spawning mortality rate for trout is higher for males than for females due to all the fighting they do for the females, so the older age classes become progressively dominated by females.

As juveniles in the river environment, trout tend to feed mainly on larvae of mayflys, stoneflies, caddis and chironomids. As adults, trout are opportunistic carnivores, feeding on whatever suitable prey is most abundant. Once mature the habitat of brown trout differs from that of rainbows, thus their diet differs as well. In Taupo, rainbow trout spend the majority of their adult lifecycle in the open waters of the lake preying on smelt, which makes up approximately 90% of their diet. On the other hand, brown trout are benthic, usually living amongst weeds and other debris on the lake and river bottoms and adopting a much more sedentary approach to life. Their prey includes snails, aquatic and terrestrial insect larvae, small fish and koura.

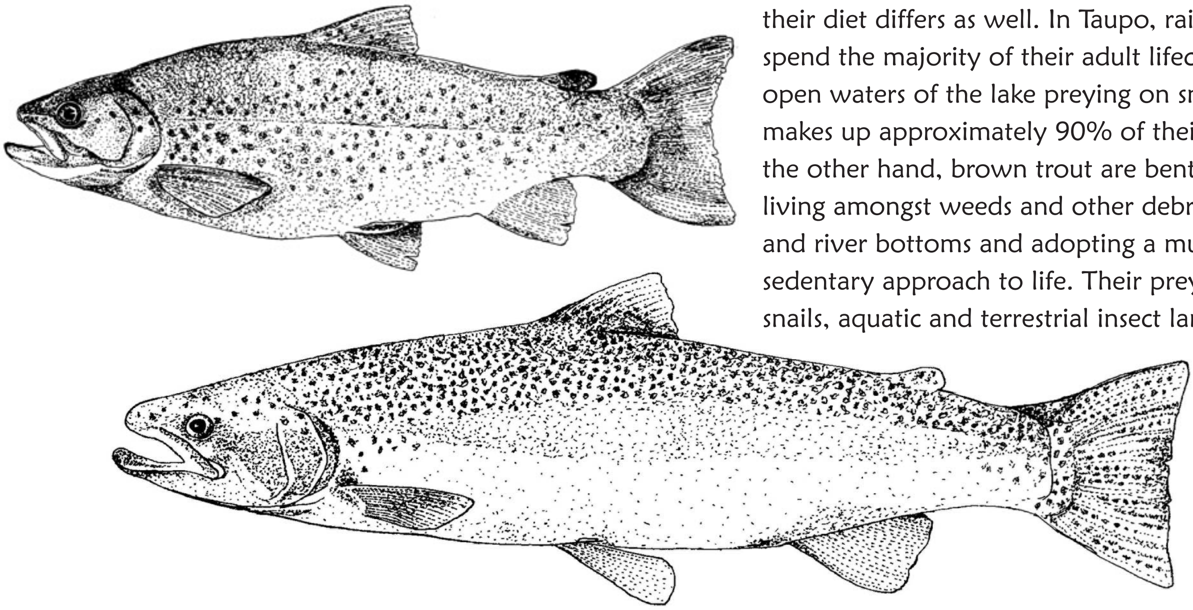
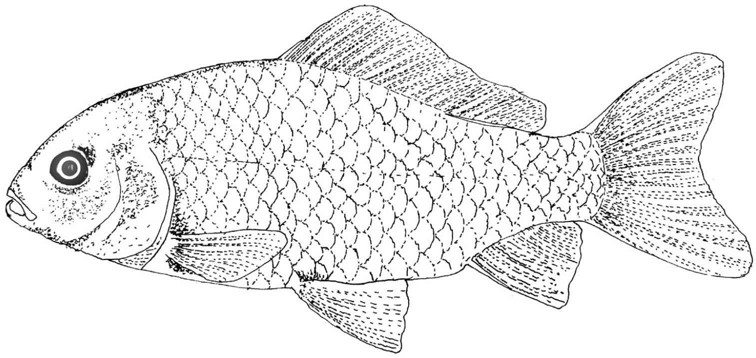


Figure 9: Brown trout (top) and rainbow trout (below)

Goldfish

Most North Island lakes and some rivers such as the Waikato River contain feral (wild) populations of goldfish, but they have been reported from only a few South Island lakes. Goldfish are rarely abundant in New Zealand lakes although thousands have been reported in Lake Rotoehu near Rotorua. Usually they occur in low numbers associated with shallow weedy areas where they can grow up to lengths of 200 to 300 mm. Wild goldfish populations rarely have the bright colours or unusual fins associated with fish kept in an aquarium, but are more of a dull yellowish brown colour. Being brightly coloured is not a good strategy when you are trying to hide from predators like shags. Goldfish will spawn several times a year (in spring, summer and autumn). Plants are the preferred spawning substrate, but goldfish will also deposit eggs on wood and rocks when plant material is scarce. There are no known studies of their feeding habits in New Zealand. Most of those examined have contained detritus (rotting organic material) in their gut, indicating that while mainly herbivorous, adults may also feed on material off the bottom. Juveniles can be expected to be omnivorous.

Figure 10: Goldfish

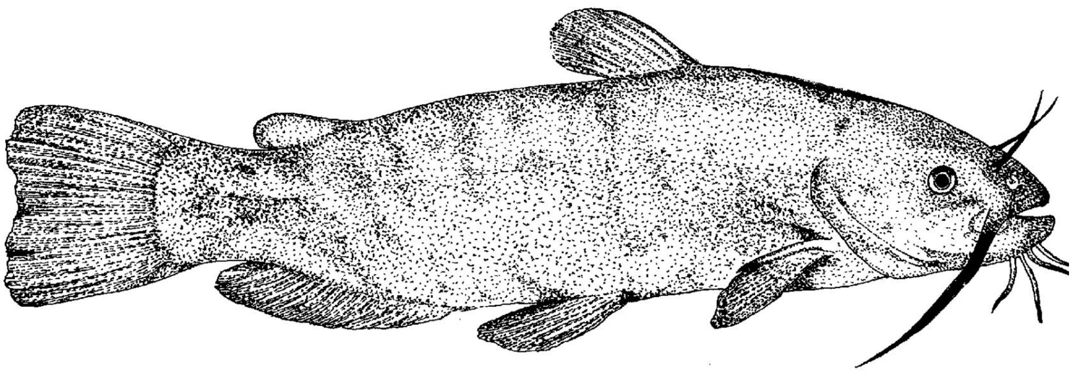


Brown bullhead catfish

The catfish is a member of the Ictaluridae family which are characterised by having barbels around the mouth – these look rather like whiskers and hence the common name catfish. They are dark brown to olive green colour with paler sides and bellies. In addition to the distinctive barbels around their mouth they also have relatively small eyes and smooth skin. The leading edge on their dorsal and pectoral fins has a sharp toxic spine, and thus catfish should be handled very carefully to avoid your hand getting speared by one of these spines.

Like goldfish, catfish are found mostly in the North Island living in the shallow, weedy areas of lakes. Breeding occurs during summer in small, guarded depressions. The male guards and fans the eggs during development, and also guards the larvae for about a week after hatching. They commonly grow to 200-300 mm in length.

Figure 11: Brown bukllhead catfish



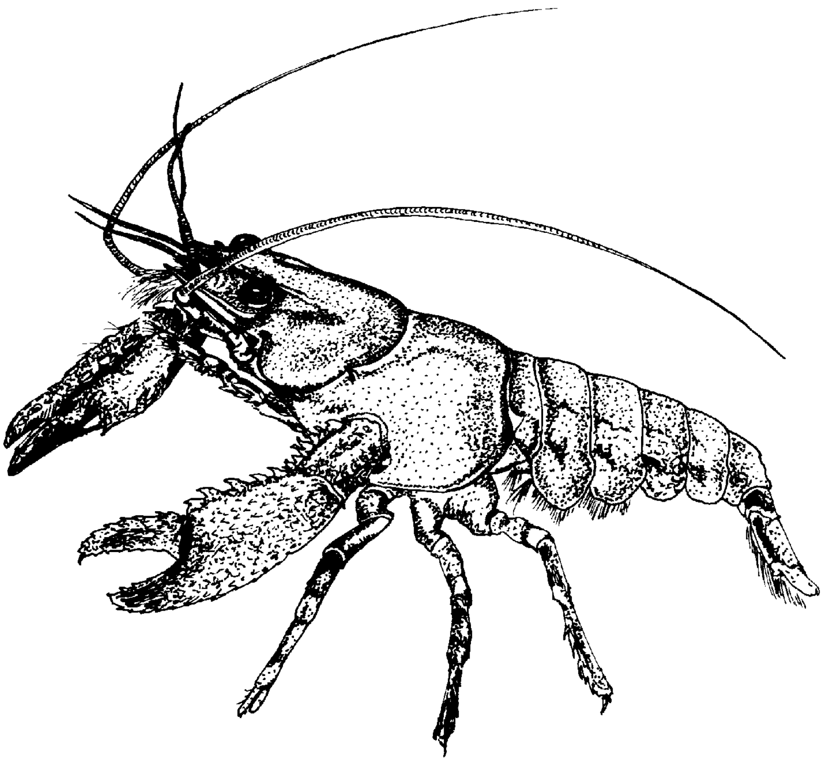
Catfish are mainly benthic scavengers such that they will prey on whatever is available on the lake bed. They waggle their sensitive barbels along the substrate to locate insects, koura, molluscs and small fish.

Koura (freshwater crayfish)

Another important species that is not strictly a fish but rather a crustacean is the koura. The koura is **endemic** (found only here) to New Zealand. Although genetic research is still ongoing, there are currently two recognised species of koura. The larger species (80 mm long) has very hairy pincers and is found in the east and south of the South Island and on Stewart Island. Koura in the rest of the west and north of the South Island and the North Island are slightly smaller (70 mm long) and have less hairy pincers.

Koura live on the lake bed during the day and migrate into the shallows in the dark to scavenge on dead fish and other organic material. They tend to inhabit spaces between rocks, stones, stumps and other debris for shelter. As with all crustaceans, they have a hard, shell-like covering. This covering eventually gets too small for the koura, and the animal must then shed the old layer in a process called moulting. The old shell and skin splits and is left behind, while the new skin underneath hardens. During moulting, crayfish are very vulnerable to predators.

Figure 12: Koura



They are highly prized by local Maori for food. By law only tribal member of Ngati Tuwharetoa may collect koura in the Taupo region.

Source: adapted from freshwater fish catalogue www,niwa.co.nz, and Rowe D.K and Graynoth E. 2002. Lake Managers Handbook – Fish in New Zealand Lakes, Ministry of the Environment, Wellington – this report is available at www.mfe.govt.nz.

Focusing Question Four – Ways water is used in Taupo

Early Maori and European settlement

Legend has that it began a long, long time ago, when Ruapehu, the first mountain of Te Ika o Maui (the North Island of New Zealand) was lonely. Ranginui, the sky father, had placed Ruapehu on the new island to bring calm and peace to the land. Ruapehu grew lonely and single teardrops flowed across the land to form the Whanganui River to the south and the Waikato to the north. His loneliness brought water to the new land. With water came life.

In time, other mountains joined Ruapehu and as the land heaved and tilted, rivers formed to carry away the rains that swept the North Island of New Zealand. Forests grew lush and green and birds twirled and sang through the canopy while others, less flighty, crunched their way through the undergrowth below.

1800 years ago the world changed. After a period of violent ash eruptions that blanketed much of the North Island, water found its way into the magma chamber. Superheated water and gas ripped the earth apart in an eruption that hurled pumice, ash and rock up to 50 kilometres into the atmosphere. Gravity took over and a searing, hot pumice laden wave of material buried everything in its path. Eventually rains washed into gullies and gullies became rivers, flowing into the vast cavity left in the earth to create Lake Taupo, the heart of the central North Island.

During the time of this eruption, the Taupo Pumice eruption of 186 A.D., there is no evidence of human settlement in New Zealand. In fact not until hundreds of years after this event, around the eleventh and twelfth century, does archaeological opinion suggest Maori settlement of the country. At this time the main sources of food for these earliest arrivals were the moa and from the sea. Compared with coastal areas, the Taupo region must have seemed an unattractive place to live. The climate was cold and food was scarce. While the coastal lowlands provided for the needs of the Maori people, there was little motive to settle the volcanic plateau of the central North Island.

But by the fourteenth and fifteenth centuries, circumstances had changed. The larger species of moa were approaching extinction, and with the disappearance of this ready source of protein, pressure on food resources grew. The widespread burning of forests, whether by accident or design, had reduced other traditional food supplies, and people were becoming increasingly dependent on agriculture. This led to competition for the best garden land, and conflict soon followed. Besides this, the population of the coastal areas was increasing. The area around Lake Taupo was one of the regions settled as a result of this pressure to move inland, this settlement occurring about 700 years ago.

For these early inhabitants the lake and its surroundings was not an easy place to live. The great ash eruptions of the past had resulted in poor soil, and the winters were cold and long. The lake itself was almost certainly lifeless after the 186 AD eruption. Even after regeneration of life in these waters, either naturally and/or by man, it was no comparison with the sea as a food source. Apart from what they could eat from the lake (koaro, bullies, kakahi and koura), people hunted bush birds extensively and used many edible plants and roots. Survival in this region must have been a great struggle. Yet Maori persevered and adapted to their environment, so that by the mid-eighteenth century a powerful people, known as Ngati Tuwharetoa, were established, largely to the south of the lake.

The Tongariro River, the largest river feeding into the lake, had built a large delta. Here important pas were built and the largest concentration of Maori lived. The average level of the lake was about one metre lower than at present – the control gates built near the township of Taupo in 1941 altered that- and so the delta was less flooded and more easily cultivated than it is now. Fertile soil was scarce, and often gardens were cultivated in the bush to take advantage of natural humus of the forest floor. The species living in the wetlands around the Tongariro delta helped provide a steady food supply.

Another area of settlements was a line of Maori establishments along the east coast of the lake. These early Maori inhabitants used Lake Taupo as a means of **transport, a food supply, and as a focus for their community life**. During this time, very little settlement occurred on the lake's northern and western shores.

Against this background the **first European travellers and settlers** arrived in the early to mid 1800s. The visitors comprised of travellers, missionaries, and settlers who used the lake itself and the beaches for transport. In these early days canoes were built from hollowed out of logs. Later, European-style boats (nine metre whaleboats) arrived on the lake which was operated by the Armed Constabulary for communication around the lake shore. In 1870 The "Taupo Hotel" was established on the corner of what is now Tongariro Street and Lake Terrace in Taupo, and in 1878 was joined by the "Lake Hotel". Slowly the essential services of a small back country travellers' way post were established. Travel overland from Putaruru, Rotorua, Napier or Waiouru was by coach, but the only link from one end of the lake to the other was by walking, horseback along the beaches of the eastern coastline or by boat.

For the first half of the twentieth century a few small industries existed in the region, such as a timber milling operation in Mokai and a butter factory in Waihi. But at this time Taupo was really only known for tourism, particularly for fishing. The entire district lacked a strong economic base meaning that no large centres of urban populations were established and the lake remained largely untouched.

However the seeds of change were germinating in the 1920s and 1930s as agricultural researchers discovered that the problem with Taupo soils was **trace-element deficiencies**, notably the lack of magnesium, potassium, cobalt and selenium. These deficiencies had previously limited use of the land. Thereafter, extensive forests of exotic pines were planted and farming ventures pursued. Also of significance to the growth of this region was the survey of the Waikato River for its hydro-electric potential. Lake Taupo was soon identified as a valuable reservoir to feed a chain hydro-electric stations, leading to the construction of control gates. These events led the transformation of Taupo from a remote, world-renowned fishing area to a farming, forestry, tourist, and power generation centre.

Source: adapted from *Tongariro Journal, It began with a teardrop*. March 2005. Vol 13 p 3, and Forsyth D.J. and Howard-Williams, C. 1983. Lake Taupo. P.D. Hasselberg, Government Printer, Wellington.

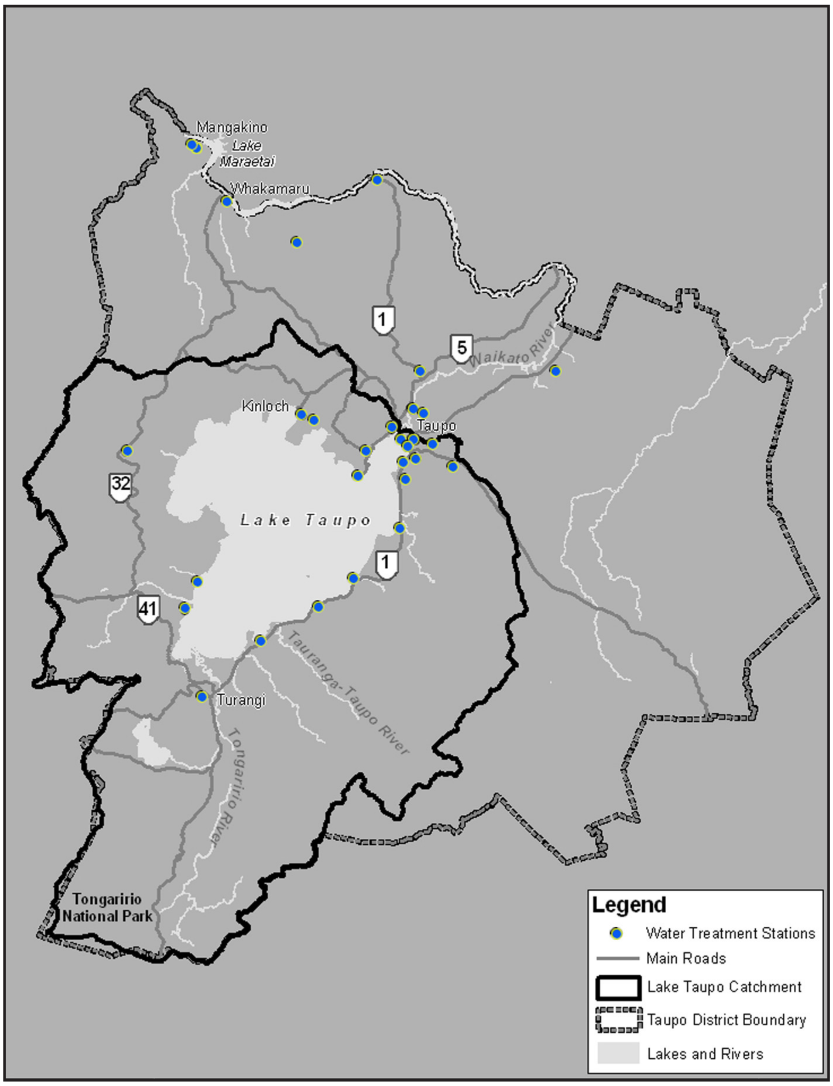
Present day uses

Domestic

Public water supply

Taupo District Council sources, treats and distributes water at a number of different sites throughout the district. The extent of treatment and quantity of water supplied varies between sites. There are 21 water supply schemes in total -ten are located in Taupo/Kaingaroa, six in Turangi/Tongariro and five in Mangakino/Pouakani. Approximately half of these collect water from intakes in the lake, and the other half source water from groundwater.

Figure 13: Taupo's water treatment sites



In order to comply with the new national drinking water standards a new water treatment plant in Taupo township needs to be built. Because of the additional treatment processes involved treatment costs will rise. This new plant will increase the safety of Taupo's public water supply by controlling protozoa and algal bloom toxins as well keeping pace with growth in the Taupo township.

Council allocated $2 million dollars in 2006, $8 million dollars in 2007, $14 million in 2008 and $1 million in 2009 to upgrade the Taupo Water Treatment Plant. The project strategy study has shown that a single treatment plant inland from the lake is the best option to service the Taupo central, west, south, and Acacia Bay. The treatment plant may include new processes such as flocculation, filtration, clarification and UV disinfection. The water treatment plant is due for completion in 2010.

The council also intends to have all 21 of Taupo District Council's water supply schemes compliant with the new standards by 2018.

Households in rural areas of Taupo obtain their water through private means, either via a bore that taps into a groundwater reservoir or from rainwater stored in a tank.

Wastewater treatment

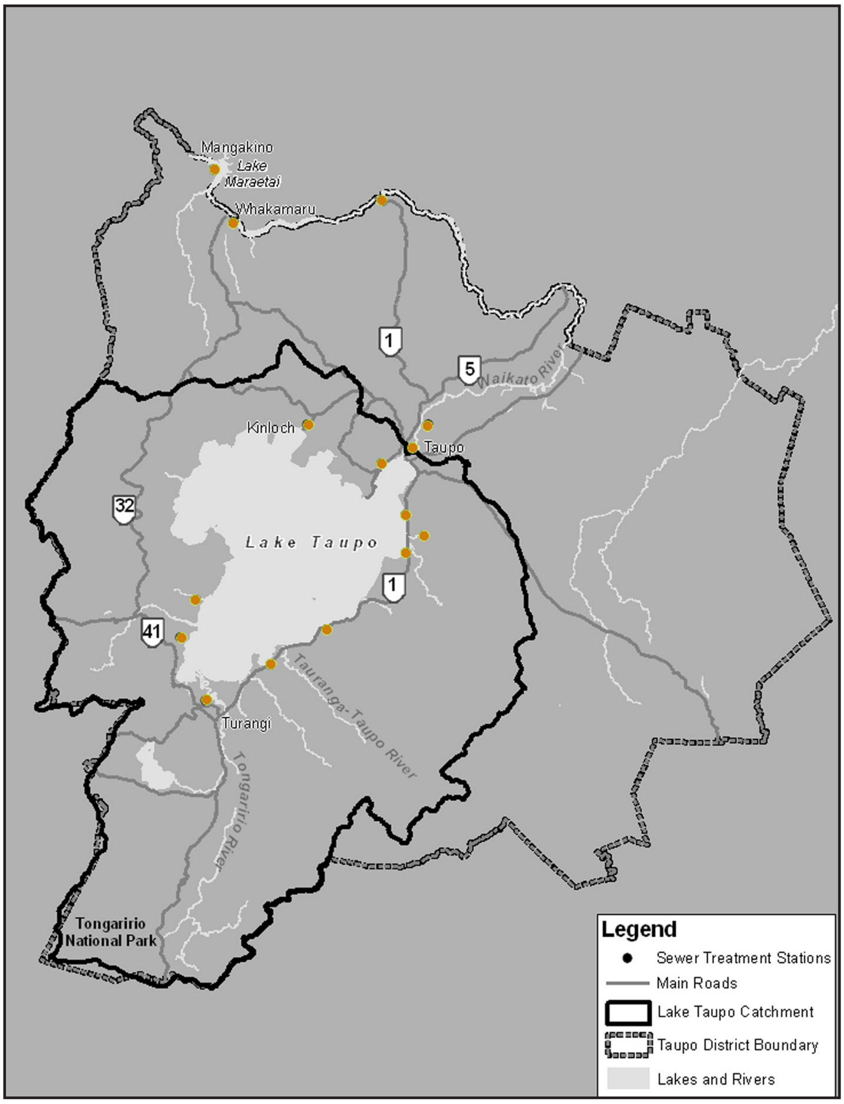
Council collects and treats wastewater by way of various treatment systems at a number of different sites throughout the district. There are 14 sewerage schemes situated throughout the district - five in Taupo/Kaingaroa, six in Turangi/Tongariro and three in Mangakino/Pouakani.

There are several different types of treatment systems used in the Taupo District. For example in Turangi, a Membrane Biological Reactor (MBR) system removes solids as well as nutrients (like nitrogen and phosphorous) from wastewater before discharging it into the wetlands at Tokaanu. Currently in Taupo township wastewater treatment occurs at the Pollution Control Plant along side the Waikato River. This system differs from the MBR systems as it does not remove any nutrients from effluent. Instead the effluent is irrigated on to the land, and the grass is then harvested and taken out of the catchment, thereby removing the nutrients in this way.

In order to cope with a growing urban population, the council has allocated $5 million in the 2006 - 2007 period to purchase an additional 350 hectares of land for spray irrigation of wastewater from Taupo township's sewage treatment system.

Currently a structure plan for Taupo's wastewater treatment is being drawn up as alternative methods of treatment and disposal have to be investigated for the long term protection of Lake Taupo.

Figure 14: Taupo's wastewater treatment sites



As with the public water supply system, people who live in rural areas are also not connected to any wastewater treatment systems. Alternatively, septic tanks are used as an on-site wastewater system. Septic tanks are very basic and do not really do a lot to treat wastewater. After going through the tank where the solids settle out, the effluent usually discharges to a simple trench or soakhole system where some further treatment will occur via the filtration process through the soil. Therefore, households with septic tanks need to be extra cautious about what they allow to go into their system.

For clarification sake, there are two main types of drainage systems beneath Taupo's urban areas. One set of pipes are **sanitary sewers** which collect wastewater to be transported to and from treatment plants. The other set of pipes are used to carry water from **stormwater drains**. These drains collect and transport rainwater away from buildings and sealed surfaces such as roads, to empty into natural waterways or land-based disposal fields. This water is not treated and any chemicals, dirt, oil, detergents, litter, and animal faeces that are on the surface can pollute stormwater. *More information about stormwater to be given in the Year 5/6 resource kit.*

Industry

Economic activity in the district centres around four key industries:

- Pastoral farming,
- Forestry,
- Electricity generation (geothermal and hydro); and
- Tourism.

Forestry

Of the total land area in the Taupo District (6,790 km^2), 1,890 km^2 is in planted plantation forest and approximately 448 km^2 is unplanted forestry land. The Taupo District holds the largest **forestry** resource for any district in New Zealand. Radiata pine is the main species and accounts for over 92% of forest area; douglas fir 4.0%; hardwood (principally eucalypts) around 3.0%; and other softwoods account 1.0%.

In relation to water use, the forestry industry, specifically the growing and logging of trees, requires no irrigation so the amount of freshwater used is minimal. In the district, Tenon is the only major processing mill, supplying appearance grade timber for the North American market. Again minimal amounts of water are used in this factory as water is only required for domestic purposes and to fill tanks for fire fighting.

Agriculture

Farmland in the Central Volcanic Plateau was among the last land of the country to be broken in for large scale farming. This late development has been attributed to factors such as trace mineral deficiencies in the pumice soils and poor access to the coast.

However once phosphatic fertilisers were developed and applied, pastoral farming became an important industry for the district. Pastoral farming land use accounts for 1,879 km^2 of total land area. Of this area, approximately 90.7% is used for sheep and beef, 4.1% for dairy, 2.0% for deer/horse/poultry and the remaining 2.2% is classified as other farm types.

Farms require water in order to keep their stock hydrated, to irrigate fields for adequate grass growth and for washing down facilities. The average sheep and beef farm requires 12,000 – 14,000 litres per day. In Taupo, about 50% of sheep and beef farms take groundwater and the other half take surface water from streams and rivers. Dairy farms require approximately seven times as much water as sheep and beef - i.e. 84 - 98,000 litres per day. The majority of dairy farms in Taupo use ground water sources.

Electricity

A further major component of the Taupo District economy is the energy sector. Three of the major electricity generating companies (Contact Energy, Genesis Energy and Mighty River Power) have facilities in the district. Genesis Energy is the owner of the Rangipo and Tokaanu stations of the Tongariro hydro scheme at the southern end of the lake. Water is diverted to these two hydro power stations through a series of rivers, lakes, canal and tunnels before discharging into Lake Taupo. The scheme diverts an additional 23.7% more water into Lake Taupo than would naturally flow there, which in turn increases the generation capabilities of the nine power stations located along the Waikato River (owned by Mighty River Power). Contact Energy has geothermal generation capacity at Wairakei, Mokai and Rotokawa while new stations are being planned for Poihipi and Tauhara.

Water and steam is a clean, renewable energy source when used for hydro and geothermal generation as it flows back into the environment or ground just as clean and fresh as it was at the start. However there can be other adverse environmental and ecological effects to these surface and groundwater resources if its use is not monitored and managed properly.

Tourism

Taupo now is a thriving tourist town. It has been estimated that tourism is worth at least $222 million to the local economy. Lake Taupo is one of New Zealand's largest visitor destinations, attracting over 726,000 visitors annually, including 582,000 domestic and 143,000 international visitors. Our freshwater resource underpins this successful tourist industry. The list of activities in the Taupo region is seemingly endless and many of these activities like jetboating, white water rafting, kayaking, bungy jumping, fishing and parasailing are set in or amongst a backdrop of water.

Since brown and rainbow trout were released, the Taupo Fishery has been a major contributor to Taupo's appeal as a tourist destination. On the world stage, Lake Taupo and its rivers is seen as a holy grail of freshwater fishing. The Taupo trout fishery is a wild fishery, which sets it apart from many other freshwater fisheries around the world. As a wild fishery, it is with careful management that it remains self-sustaining, and does not require hatchery reared fish to be released in order to provide enough trout for anglers to catch. The environment at Taupo has all the necessary elements for wild trout to thrive - cool, clear water, plenty of food and an abundance of spawning and rearing habitat. This environment produces outstanding specimens, and the opportunity of catching a wild, perfectly formed Taupo trout is valued by many overseas anglers.

The Taupo Fishery is a valuable asset to our region for many reasons. Excellent winter fishing on the rivers, combined with summer fishing on Lake Taupo, provides a year-round recreational choice for visitors to the area. In fact 40% of all freshwater fishing done in New Zealand takes place in the Taupo Fishery. This also means that the fishery contributes economically to the region all through the year. The fishery is estimated to generate more than 80 million dollars per annum to the local and regional economy and provides important business and employment opportunities in the area.

Taupo trout have become interwoven with the culture of the local Maori. In fact a trout features prominently on the crest of the Tuwharetoa Maori Trust Board. The importance of the fishery is also borne out through the 1926 Maori Land Amendment and Maori Land Claims Adjustment Act. This historic agreement provides foot access for all licensed anglers along the rivers of Taupo and access for the general public to Lake Taupo. It also requires the Crown to be responsible for management of the Taupo fishery and that a payment equivalent to half of the annual proceeds from fishing licences, mooring and boat berth fees is paid to Ngati Tuwharetoa in recognition for the rights of access across private Maori land. Over the years, Ngati Tuwharetoa has made very clear the value they place on this relationship with the Crown.

Recreational

Competing with all of these water uses is our desire to protect freshwater environments purely so we can enjoy it for its recreational and aesthetic values. For many people living in Taupo, being able to look out over the water from one's home or while driving to work is highly rewarding. Water can also be used for all sorts of activities like swimming, boating, sailing and fishing – all which are a means of exercise and challenge. The lake and its associated tributaries offer habitat for a wide range of aquatic organisms. These organisms all have value; whether it is for conservation, recreation (i.e. sport fishing or social enjoyment) or scientific and ecological importance in maintaining healthy aquatic ecosystems.

Cultural

Ngati Tuwharetoa are the iwi with mana whenua in the Lake Taupo catchment. Generations of Ngati Tuwharetoa have lived within the Taupo rohe (territory), and as a result, have developed tikanaga and kawa (protocol) that reflect a special and unique relationship with this environment. Taupo nui-a-Tia, 'the great cloak of Tia,' is their taonga (treasure). Ngati Tuwharetoa are Treaty partners with the Crown and hold legal title to the bed of the lake and its tributaries. Accordingly, Ngati Tuwharetoa are the kaitiaki (caretakers) of the lake.

Focusing Idea Five – Why we should value & conserve water

Up until now, most New Zealanders have taken water for granted. It is true that we have an abundance of freshwater in some parts of New Zealand, but we are finally reaching the point where pressure to satisfy our different values and needs for freshwater is pushing the resource to its limits in some places. Therefore, it is important that everyone recognises that water is not an unlimited resource. It is one of the country's most valuable assets, and we must manage it efficiently and sustainably.

In the Taupo District there is a significant water issue concerning Lake Taupo's water quality. In February of this year a major step towards protecting the water quality of Lake Taupo happened with the signing of the Lake Taupo Protection Project. This $81.5 million initiative, described as the largest environmental project in New Zealand, aims to improve water quality of the lake by reducing the amount of nitrogen entering it by some 20% over the next 14 years.

In relation to quantity, although there is no shortage of freshwater in the district it costs money to treat and distribute the water for domestic consumption, as well as for treating wastewater before it can be put back into the environment. The less water that households use for things like clothes and dish washing, baths and showers, toilet flushing and gardening, then the less money Taupo District Council and taxpayers must spend treating water.

Conservation measures

It's easy to conserve water. Here are some tips for inside, outside and around your home.

Lawns

A lawn can use more water per square metre than any other area in your garden.

- Water your lawn only when it needs it. A good way to test this is to step on the grass. If it springs back up when you move it doesn't need watering. .
- Deep soak your lawn. While giving the lawn a quick drink every night may be good therapy for you, it makes the grass shallow rooted and dependent on the meagre amount of water that you provide. Water a maximum of twice a week, but for a longer period and this enables the roots to become deeper rooted. This enables it to go deeper to seek out any moisture which in turn makes the grass hardier.
- Reduce the lawn area. This has the additional benefit of reducing your mowing.
- Check your local nursery for a suitable drought tolerant lawn grass for your area.
- Let the lawn go brown during very dry times. When the rain comes the transformation from brown to green will be dramatic.
- Give the lawn a feed but do not over fertilise.
- Aerate the soil to allow water to be absorbed more easily.
- Do not mow to a height of less than 2 cm. Taller grass holds water better.
- Use a timer with your sprinkler. A forgotten sprinkler wastes more than a 1000 litres per hour. A timer will allow you to use as much water as is needed without the threat of wastage.

The Garden

- Use a good mulch. Mulches can prevent up to 73% evaporation loss. Mulches can prevent excessive runoff, restrict weed growth, improve soil structure and help put valuable nutrients back into the soil.
- Group plants according to how much water they require. By grouping plants by water usage you can avoid waste on plants that don't need a lot of water.
- Toughen up the plants. Too many plants are pampered to the point where they are so dependent on water that they do not go out of their way to find any water themselves. Wait until the soil dries out before watering and use a plant such as bamboo as an indicator. When the leaves start to droop, then water.
  Water the highest parts of the garden first. This ensures that any runoff water soaks into lower dry areas rather than being wasted.
- Remove weeds. Weeds compete for water and nutrients.
- Dig a small trench around the trees. This will give the water a chance to soak in and reduces water lost as runoff.
- Water your pot plants by dunking them in a bucket of water. Wait a few seconds, when the bubbles disappear, do the next pot. This saves water and ensures pot plants get a thorough drink. Water during cooler parts of the day.
- Avoid watering on windy days.
- Water the roots not the leaves. If you water the leaves water is lost through evaporation, and any chlorine in the water could damage the leaves.
- Don't water the road or pathways. Position your sprinklers so water lands on the lawn or garden, not on paved areas.
- Plant drought resistant native trees and plants. Many natives are both attractive and suited to gardens, and thrive with far less watering than do other species.
- Water wisely to avoid runoff. Soil and dissolved nutrients are carried away with runoff, increasing the need for expensive fertiliser and polluting nearby streams.
- Use a trigger hose. This allows you to be in control and water is not wasted when moving the hose around. Always remember to turn the tap off when finished in case the pressure build-up causes the nozzle to pop off.

The Yard

- Discourage games with the hose and sprinklers. Squirting water around can waste up to 1000 litres per hour.
- Use a broom not a hose to clean driveways and footpaths. Cleaning a path with a broom is quicker and more efficient than using a hose, which can waste up to 1000 litres per hour.
- Every home should have a compost bin. Compost improves the structure of your soil. This increases the moisture holding capacity of sandy soils and allows better penetration of water into heavy clay soils.

Swimming Pool

- Cover your pool to reduce evaporation, retain warmth and keep out leaves and dirt. Up to 200 litres of water per day can be lost because of evaporation from a typical ground pool. Accept some fluctuation in pool level due to evaporation and rainfall. They will often compensate for each other, meaning topping up with the hose can be avoided.
- Check the pool for leaks

Washing the Car, Boat or Caravan

- Use a bucket and sponge to wash the car, boat or caravan. Use the hose only for rinsing and turn it off between rinses.
- Wash the car, boat or caravan on the lawn instead of on the driveway.

In the bathroom

- Install a dual flush toilet. Modern toilets give the option to flush either half or all the cistern's water. Traditional toilets can usually be converted to dual flush.
- Take shorter showers. Limit showers to the time it takes to soap up, wash down, and rinse off. Remember that shorter showers also save on hot water costs.
- Install a water-saving shower rose. Many showers put out 20 litres of water per minute, however, 10 litres is enough for a refreshing, cleansing shower.
- There is no need to run water down the plughole while brushing your teeth. Just wet your brush and fill a glass for rinsing.
- Don't rinse your razor under a running tap. Fill the sink with a little warm water for rinsing. This is just as effective as running water and far less wasteful.

In the Laundry

- Make sure the washing machine's load adjustment is right for the load. If there's no load adjustment, wait until you have enough clothes for a full load. Washing machines use 100 - 200 litres of water per load.
- Front loading machines are generally more efficient than top loaders, saving water and power. Also use the suds-saver option when several loads have to be washed.

In the Kitchen

- When washing dishes by hand, don't rinse them under a running tap. If you have two sinks, fill the second one with rinsing water. If you have only one sink, stack washed dishes in a dish rack and rinse them with a pan of hot water.
- Don't run the automatic dishwasher until you have a full load.
- Don't let the tap run when cleaning vegetables. Just rinse them in a plugged sink or a pan of clean water.
- Keep a bottle of drinking water in the refrigerator. Running the tap until the water is cool enough to drink is wasteful. Aerating taps are inexpensive and can reduce water flow by 50 per cent.
- When cooking, use only a little water in the saucepan and keep the lid on.
- Garbage disposal units use about 30 litres of water per day and send a lot of extra rubbish into the sewers. This places an additional load on the sewage treatment plants. Perhaps some of your food scraps could be used in the garden.
- When buying a new appliance that uses water, be sure it has a high water conservation rating.

Hot Water Pipes and Systems

- Insulate hot water pipes. This avoids wasting water while waiting for hot water to flow through and saves power.
- Make sure your hot water system thermostat is not set too high. Adding cold water to cool too hot water is wasteful.
- If you have a spa, ensure it is well insulated to keep water warm for longer. Reheating the water during the reticulation/spa process reduces water wastage.

No Leaks

- If you have a water meter, turn all taps off before you go to bed one night and take a meter reading. Check the meter the next morning before any water is used. If the meter reading has advanced, and no-one used any water during the night, you may have a leaking pipe, tap or toilet cistern. Locate the problem and repair it.
- A slow drip from a tap can waste more than 200 litres of water per day. Turn taps off properly and check washers for wear.
- A continuously running toilet can waste more than 16,000 litres of water per year. To check for leaks put a little food colouring in the tank. If without flushing, the colouring begins to appear in the bowl, the cistern should be repaired immediately.

Lesson plans

Lesson Plan for Focusing Idea One – Earth's Water

Aim

To explore the water cycle

Activity sheet 1: Get into the flow

Prior to completing this sheet, get students thinking about water by asking them where rain comes from and where it goes once it hits the earth's surface. Or look at a globe or a map of the world and discuss where most of the water is and the difference between salt and freshwater.

Activity idea: Make a rainstorm

Source: Enviroschools Foundations education resource kit

Actions

1. Get the class in a circle.
2. Using fingers and hands, the class is led to tap and clap the actions, to illustrate the effects of rain.
3. Students imitate the teacher in a series of actions, joining in one-by-one. The teacher makes eye contact with the first student, who begins to make the first action (rubbing hands). The teacher slowly goes around the circle, bringing in each student by making eye contact. Each student who has been brought in continues with the actions while the teacher brings in all the other students in the circle, one by one. The teacher then changes to the next action and once again makes eye contact with each student one by one. The students continue with the first action until the teacher comes around to them again, at which point they change to the second action. The teacher keeps going round the circle, introducing a different action with each circuit (as listed below). This creates a steady progression from one sound to the next, simulating how a rainstorm builds and then fades as it passes by.
   - Rub hands together (to illustrate a gentle breeze)
   - Snap fingers (to illustrate rain falling gently)
   - Clap hands together irregularly (rain getting harder)
   - Slap hands on legs (torrential rain)
   - Stomp feet
   - Slap hands on legs and stomp feet (the height of the rainstorm)
   - Ease the rainstorm off by reversing the actions
   - Stomp feed
   - Slap hands on legs
   - Clap hands
   - Snap fingers
   - Rub hands
   - Open palms (quiet)
   - Remain silent for one minute to think about the activity and to catch your breath.

Activity sheet 2 – Where does all that water come from

This activity introduces students to the concept of the water cycle. Have students follow the arrows on the water cycle diagram as they read the Info to know box. There is no correct answer for the order for the cards. However, students should be able to give reasons to support their decision about how they ordered the cards.

Activity sheet 3 – Model that water cycle

This activity uses simple equipment to demonstrate evaporation, condensation and precipitation. Evaporation will occur once the jug boils and steam is produced. Condensation will form on the outside of the glass container holding the ice. This liquid can be collected in a second container as it forms and drips off (precipitation). After this activity, go back to the water cycle diagram and discuss how these processes occur in nature. You may also want to discuss the process of transpiration whereby plants breathe out moisture into the atmosphere.

Activity idea: Model that catchment

Source – Wai Korero resource kit

This activity is used to illustrate how water in a catchment flows from high ground (mountains and hills) to low areas (valleys, plains and wetlands) and eventually to the sea. Refer to a topographic map of the Taupo District to illustrate our local catchment.

Equipment:

- Sheet of polythene or a tarpaulin to create a catchment with small streams feeding into the river. The model can be supported with boxes, blocks, or crates.
- Watering can or bucket for pouring "rainfall" in the hills.
- Ice cream container or bucket for catching water at the "river mouth".

Actions

1. Assemble tarpaulin so that one end is high representing the hills and the other end of the sheet is at ground level representing the floodplains. There should be creases/folds in the tarpaulin - these resemble the riverbeds and associated tributaries.
2. Sprinkle water over the landscape to simulate rain falling.
3. Collect the water at the 'mouth'.
4. Observe how the water behaves on the different terrain.
5. You could also put some 'absorbers' (e.g. sponges) to represent the work that vegetation and wetlands do to help the water infiltrate into the ground. Discuss what happens if there are not many absorbers in the catchment.
6. You may also want to pour "pollutants" (e.g. coloured water made with food dye or Raro or a handful of dirt) into the catchment. Discuss how this might affect waterways downstream.

Interactive computer activity idea – Make a water cycle wheel

Visit www.epa.state.il.us/kids/fun-stuff/water-cycle/

Activity sheet 4 – Water cycle discussion

Tasks 1 and 2 are good for assessing student learning about the water cycle

Task 3 questions will start to get students thinking about where our water comes from.

Activity sheet 5 – Follow that drop

This activity can be used to further review the stages of the water cycle or to discuss the water cycle in relation to human use.

Lesson Plan for Focusing Idea Two – Freshwater supply.

Aim

To investigate the amount of freshwater on earth and how it is used by people.

Starter activity idea: Water use collage

Equipment

- Old newspapers and magazines,
- Scissors, glue and paper.

Actions

Brainstorm how we use water and make a list on the whiteboard. Then create a collage of pictures (or a mobile) of all the different uses people have for water. Once completed see if students can put the different uses in groups.

Starter activity idea: Water tasting

Source: adapted from Envrioschools Enviroschools Foundation education resource kit

Equipment

- Four containers per group labelled A, B, C, and D.
- Source of tap water, bottled water, filtered water (or from a cooler), and saltwater (about one tablespoon salt to one cup of water).
- Empty cups (enough for each person)

Actions

1. Pour tap water in to the container labelled A, bottled water into container labelled B, filtered water into container labelled C and saltwater into D.
2. Invite students to use their senses – sight, smell, and taste, to sample the water from each labelled container.
3. Each group or individual guesses what each type of water is and states which one they would prefer to drink and why.
4. Discuss the following:
    - Which type of water does your family prefer to drink and why?
    - Are all types of water good for people and nature?
    - Can humans and animals drink saltwater?
    - Does the type of water humans choose to drink impact anything else (e.g. bottled water uses plastic bottles – creates more rubbish)?
    - Should all humans have the right to clean, free water or should we have to purchase it?

Activity sheet 6 – Where is our water?

This activity illustrates the small amount of freshwater on earth compared to the large amount of saltwater, and the different places that water can be found (Prior to completing this sheet, have students look on the globe and world map to see where the majority of earth's water is located -ocean. Also locate the world's icecaps in the North and South Poles as well as some large freshwater lakes and rivers). Have students describe the different types and forms of water and their locations.

Activity idea: How much water is there? Source: Wai Korero education kit

Equipment

- Bucket
- Cup
- Eyedropper

Actions

1. Fill the bucket with 4L of water. This represents all the water on earth.
2. Measure out ½ cup of the water. This represents all the freshwater on earth – this includes all the ice, rivers, lakes, groundwater/underground stream, and the water found in the living things.
3. Use the eyedropper to collect one drop of the freshwater supply – this represents all of the freshwater available for our use. About 2/3 of the water left in the cup is bound up in ice, and most of the rest is unavailable as it is too deep underground or polluted to use, or it is in the soil, living things or the atmosphere.

Activity sheet 7 – The beginning of life

This story is a good lead in to discussing why water is essential for life. After reading the story, discuss questions listed on activity sheet.

Activity idea: How much water is in us?

Source – Enviroschools Foundations education resource kit

Equipment

- Large sticks of chalk or crayons and paper.
- Outside area.
- Banana

Actions

1. In pairs, using chalk outside or crayons on large paper, take turns to lie down while your partner traces around your body shape.
2. Discuss with your partner where water can be found in the body. Shade in how much water you think there is in your body (e.g. ½, 1/3 etc).
3. You might think that most of the water in your body is in your blood. In fact, only eight percent is in the blood, 25 percent is located between the cells and 67 percent of water in the human body is located in the cells. To demonstrate that water is contained in cells, cut a banana (which contains 74 percent of water) and consider why water doesn't gush out.
4. To make a water content guessing game, draw the shapes of the following organisms – human, whale, cactus, carrot. Rank the one that has the most water in it as #1 and the one with the least amount of water in it #4.
5. Compare your guesses with the following figures: the cactus has the most with 90 percent, carrots 88 percent; whales 75 percent and people have 67 percent.
6. Are you surprised by any of the answers? Do you think every living thing contains water and how much? Why do you think it is so important to drink at least eight glasses of water per day? Can we get water from the food we eat?

Activity sheet 8 – How freshwater is used by people

Aim

To illustrate the three main uses of freshwater by people.

Activity idea: Reduce Reuse Recycle

Source Waki Korero educational resource kit

Equipment:

- A big clear container
- Four sponges cut into eight pieces
- Water and a bowl or bucket
- Marker or tape
- Paper towels

Actions

1. Put about four cups of water in the container. Ask the students to pretend the container represents the earth and the water represents all that is available freshwater to use.
2. With a marker or tape, mark the water level on the container.
3. Ask a student to name one way that water is used by either themselves or others and get them to drop a sponge into the container. Remove the wet sponge and wring it into the bucket. Check the water level and mark (probably changed very little).
4. Repeat this procedure with more students; naming different demands, extracting their sponges and marking changing water level.
5. Ask: What happened to the water level as we each used the water?
6. What will happen if we all keep using water at this rate?
7. What can we do about this situation?
8. How can we give water back to the environment?
9. Student that come up with ideas about reducing, reusing and recycling get to come up and squeeze a sponge back into the clear container.
10. Ask: Why doesn't the water level return to the original level? (Even when the water is recycled in the water cycle – some is still used up by becoming polluted or infiltrating too deep into the ground to be used for a long time).
11. Discuss why it is important to make careful demands on water and to reduce, reuse, recycle whenever possible.

Activity sheet 9 – Tama board game

Have students make their own game pieces before starting. Game pieces might be something that relate to water, like a raindrop or body of a fish.

Activity sheet 10 – Freshwater words

A review of some of words used in this resource.

Activity sheet 11 – Maori types of water

This story shows the importance of water to the Maori culture. Students can be set a homework task to ask parents about ways that other cultures or religions use and value water, which can be discussed the next day in class.

Lesson Plan for Focusing Idea Three – Taupo's freshwater environment

Aim

To identify some of Taupo's freshwater environments and explore the ecology of Lake Taupo.

Starter activity idea: Things to Brainstorm

- Brainstorm the names of streams, rivers and lakes in the Taupo District.
- Locate these waterways on a topographic map of the Taupo District. Ask students whether these contain saltwater or freshwater.
- Brainstorm the names of living plants, fish and birds that use these aquatic environments.
- Ask students to identify which are native and which are introduced to New Zealand.
- Discuss where freshwater is located other than in our lakes and rivers. Is there water under our feed or above our heads in the atmosphere?
- If there is a local stream or lake near your school, you may want to visit it when discussing the above questions.

Activity sheet 12 – Taupo's watery world

Use a map like the Holiday Maker Information Map (#336-06) or topographic maps for students to label their maps. When using the map discuss the different parts of the map (like the north arrow, key, and symbols) and their purpose.

Alternatively, an overhead with the labels already written on it could be shown for the students to copy from.

Ask students whether or not they think there are more small streams (tributaries) than shown that run into the lake. (only a few of the tributaries are shown). Ask them why they think towns like Turangi and Taupo are built close to the lake's edge.

Interactive computer idea – Up the creek

Visit www.upthecreek.org.nz

A game that shows how freshwater environments support different kinds of life. There is both an English and Te Reo version

Activity sheet 13 – Living in our water

Before completing this activity, teachers should show students the photos of the different fish species in Lake Taupo (located in teacher information section). Students could make a list of each fish type, identifying whether or not it is a native species and some basic information about its habitat and/or diet.

Activity sheet 14 – Taupo trout

About Rainbow trout lifecycle.

Activity sheet 15- Cool trout ecology

Ask students what they think the words ‘ecology’ and habitat means. (ecology refers to the study of living things in their habitat or environment that they live in)

Activity sheet 16 – Macro-invertebrates

Activity sheet 17 – Lake Taupo food chain

Interactive computer idea – On-line quizzes about Taupo trout

Visit www.taupofortomorrow.co.nz (quizzes are located under fishery facts section).

At this point, further research could be done to investigate any species of insect or fish in more detail. It may be possible to arrange a visit from a scientist from the Department of Conservation to talk to the class about one or more of these living organisms. Alternatively students could email the Taupo for Tomorrow educator with queries about the species that they are most interested in. Contact Educator by calling 386-9246 or emailing tdepetris@doc.govt.nz

Lesson Plan for Focusing Idea Four – How water is used in Taupo

Aim

To investigate different ways that water is used in Taupo.

Starter activity idea – Things to brainstorm

Set students a homework task to ask parents where all the water comes from that we use in our homes, schools and businesses and what the water is used for.

On the following day, collate a list on the whiteboard.

Ask students for ideas about what happens to the water that flows down our sink drains and our toilets.

Activity sheet 18 – Lake users

- The teacher information section in this resource kit contains specific information about early Maori and European settlement in the district. You may wish to share some of this information with your students.
- A trip to the Taupo museum would complement this activity as they have an excellent scavenger hunt activity that illustrates how humans have used Lake Taupo in the past. Ask to speak to the museum's educator.
- Ask students whether or not they think how we use the lake will change in the future. For example, presently the major industries in our region are farming, forestry, electricity generation and tourism. Will there be new industries that use freshwater more than these current ones?

Activity sheet 19 – Water in our homes

- It is important students are introduced to the idea of public water supply and water treatment (also in teacher info). The distinction between these two supplies will help students when they participate in the Year 5/6 Human Impacts programme.

Activity idea – Make a water bracelet

Source: Enviroschools Foundation education resource kit

- This activity is a great introduction to the water audit action project for lesson plan #5. Before you start, make a class list of all the ways water is used in the school and guess which uses take the most water. Then make a water bracelet to record how frequently you use water at school for different purposes.

Equipment

- Thick cardboard
- String or ribbon
- Pens

Actions

1. Each child makes a thick cardboard strip about five centimetres wide, long enough to go around the wrist and attached with a ribbon or string.
2. Draw horizontal lines around the bracelet and create a letter or symbol to illustrate each typical use of water, e.g. FT for flush toilet, DF for drinking from a fountain, WH for washing hands, GW for drinking a glass of water, etc.

3. Students will need to carry a pen to mark a cross on the bracelet in the appropriate row each time water use occurs.
4. Combine your results and make a class bar graph of frequency of different water uses. Keep this information for your water audit (see lesson plan #5).

You may also want students to determine which uses of water on their bracelet use water from water supply treatment station (e.g. water from fountains or from taps) and which uses send water to the water treatment station (e.g. water flushed down toilets or drains). This can be colour coded or the bar graph made above can be split into two.

Activity sheet 20 – The human continuum

This activity is best done by having students do the activity sheet individually, then having them form a human continuum in the classroom or outside. Once students move to the area that represents their own opinion, have a few students justify their thoughts.

Lesson Plan for Focusing Idea Five – Valuing and conserving water

Aim

To complete an audit of school water use and take action steps to conserve it.

Why take Action?

Taking action for the environment is one of the key dimensions identified in the Guidelines for Environmental Education in New Zealand. As stated in this document:

"Education for the environment seeks ways in which people can minimise their impact on the environment. In a society that values freedom and choice and where resources are finite, it is important to develop a sense of responsibility about the social and natural environments of local, national and international communities. Environmental education promotes informed, concern citizens, enabings individuals and groups to take effective action on environmental issues."

In other words, learning about the environment is a start but by having students work for the environment teachers are giving students a sense of empowerment and responsibility.

What kind of action project?

A Water Audit with an associated action project has been designed for this resource kit. However, there are many different action projects that students could do in order to help increase awareness of the value of the freshwater resource and/or to conserve it. Teachers and students should design a project that best fits in with what they are interested in and what they are keen to change. A good template for designing and implementing an action project can be found in the Enviroschools Foundation educational resource kit or contact the Taupo for Tomorrow educator for help.

Water Audit Action Project.

Source – adapted from Enviroschools Foundation educational resource kit

Part One – Our school's total water use

1. Locate the school's water meter. If it is not clear how to read the meter, contact the Taupo District Council and they will be able to help you out.
2. Take readings at the same time everyday over a period of weeks. Calculate how much water is used by the school per day/per month/per year.

Part Two – How much water does each activity use?

<u>Equipment</u>

- Bucket with litres marked on the side
- Measuring cup
- Watch with second hand

<u>Actions</u>

- Placing a bucket under a tap, turning it on, miming the activity (e.g. hand washing) and then measuring how much water is in the bucket.
- Using a container to empty the toilet cistern into a bucket.

- Timing how long the average student drinks from a drinking fountain, and then running the fountain into the container for the same amount of time and measuring the water.
- Measuring any other typical water use activities.

Part Three – How much water do children use at school?

- Return to your class tally from your water bracelet activity (See lesson plan 4).
- Multiply the frequency of different uses with the amount of water used each time (from your measuring activities above).
- Total use = frequency X amount per use
- Graph the total class water use for each activity and compare with your frequency graph. This may show that though some actions are less frequent, they use more water than others in total, because they require more water per use.
- Multiply your class totals by the number of classes in the school to get a total of water use estimate by children in the school. Compare your total use by children with total water use off the school meter. Is there a big difference? What other uses might account for this difference?

Part Four – What other things is water used for at school?

- Carry out investigations to see who else might use water, for what purposes, and how much. You will need to do some groundwork with others in the school to prepare them for investigations. You could:
  - ~ Interview caretakers and cleaning staff.
  - ~ Ask teachers to monitor their water use in the staff room.
  - ~ Estimate how much water it takes each time to water the lawn- turn on the sprinkler and watch the meter for precisely one minute, multiply the result by 60 to calculate the quantity used per hour, and then find out from the caretaker or observe how long the sprinkler is used for.
- Calculate the percentage of total water used for each purpose. Show this as a pie graph. You may have some water use that is still unexplained, e.g. from leaks. Find out the biggest water uses at the school.

Part Five – Checking for leaks

Sometimes, there are water uses that are not obvious, but they can still waste a lot of water.

- Make sure all taps, hoses, etc. are turned off. After a while, if the numbers on your meter have change then you have a leak!
- If you have a leak, calculate how much water is being lost per hour/wee/per day. What percentage of the total is it?

Part Six- Costing your water

Unlike most New Zealand homes, school water supply is usually metered and charged for in urban areas.

- Find out what your school pays for water. Use a bill or ask administration staff.
- Find out if this varies much at different times of the year.
- Consider what else the school could do with the money it currently spends on excessive water use, e.g. more computers or play equipment.

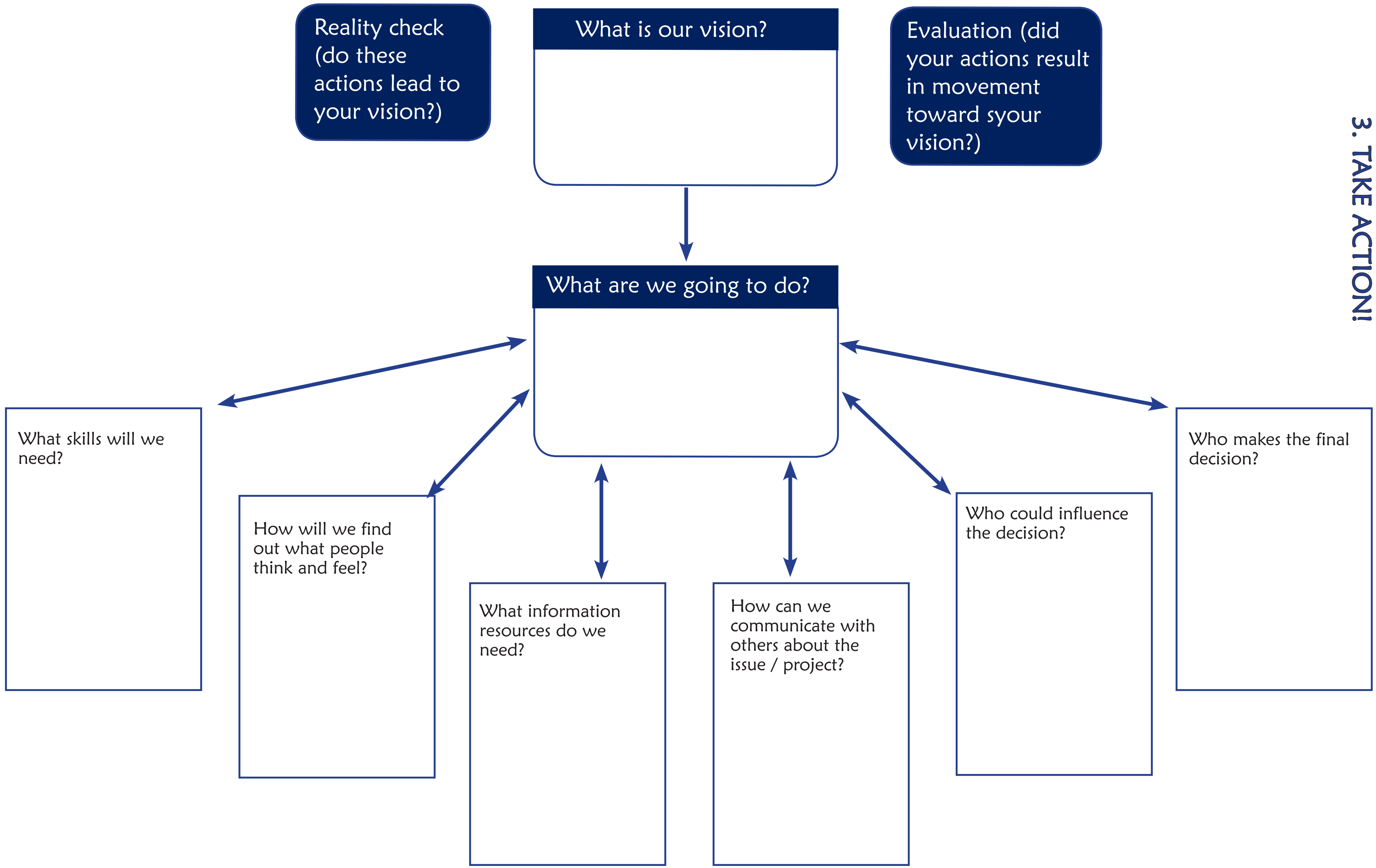
Part Seven – Save water

- Use the action planner template (next page) to design a project that will help your school minimize the amount of water used
- Once a project is decided upon, a task programmer like below will help your class organize what needs to be done.

Our action is to…..

Task	Person responsible	Key dates	Resources, people and budget required

Action Planner



Additional resources

Guest speakers/Contacts

Taupo for Tomorrow educator

Contact the Taupo for Tomorrow educator with questions about anything related to freshwater environments or if you would like a name of a contact person for any of the guest speakers below. Email tdepetris@doc.govt.nz

Fishery/freshwater scientist from Department of Conservation

Invite someone from DOC to talk about the importance of freshwater environments and/or the species that live in these places.

Freshwater Technician/engineer from Taupo District Council or Environment Waikato

Invite someone from either of these agencies to discuss their job.

Plumber or school caretaker

Invite someone who can talk to the class about the difference between sanitary sewers and stormwater systems. Ask them to show students where the systems are obvious within the school grounds.

School journals

Topic	Year	Part	Type
Rivers			
Gunboats on the Waikato	1983	4.2	Article 1-13
River story (Waipa)	1983	4.2	Poem
Waikato Canoe Chant	1983	4.2	Poem
Highway on the Whanganui	1983	4.2	Article 9-10
Friday of no Mercy	1986	3.1	Article 8-9
Gisborne Floods	1990	YPW	Poem
Rains on the Hills	1990	1.1	Article
Big Grey	1991	4.1	Poem
After the Storm	1992	2.2	Story 9-10
The River Crossing	1995	4.1	Story 11-13
Water and Use			
Water Supply	1978	4.3	Article
The Water we Breathe	1978	3.2	Article
Water Mad	1979	4.1	Poem
Turning on the Power	1981	4.3	Article 9-10
Laying the Drains	1981	3.3	Article 9.5 – 10.5
Water	1984	2.4	Poem
Waiere	1987	4.2	Poem
The Old Water Wheel	1989	1.2	Article 9-10
Make a Water Wheel	1989	1.2	Article 9-10

Power Crisis- Where Now?	1993	4.2	Article 10-11
Shapes of Water	1995	1.4	Article 10-12
White knuckle territory	1996	SJ	Story Library
Water	1997	2.3	Poem
Don't Waste the Water	1999	3.3	Article
Easy as Child's Play	2002	Connected #2	Article
The Water Cycle	2002	Connected #2	Article
Drought	2002	3.3	Poem

Water Conservation

Water Supply	1978	4.3	Article 8-9
Using Water	1979	4.1	Article 10-12
Rain in the Hills	1990	1.1	Article 8-9
Don't Waste the Water!	1999	3.3	Article 8.5-9.5

Fishy Tales

Eels have Feelings Too!	1978	1.6	Story <8
The Eel Business	1980	4.1	Story
Hopu Koura	1981	2.4	Article
Nanny's Whitebait	1981	2.3	Story
Whitebaiting	1981	2.3	Article
A Fishy Question	1985	3.3	Article 12-14
Our Tame Eels	1997	YPW	Article
Eeling	1988	YPW	Story
Eel	1989	3.3	Poem
Catching the Big One	1994	4.3	Article
The Whitebait Game	1996	2.3	Story
Bait	1998	4.2	Story
Queen of the River	1999	1.1	Story
Hinaki	2000	SL	Story

Related Topics'

The water we breathe	1978	3.2	Article 10-12
Diane Oud – Nursery Worker	1979	1.2	Article 9-10
Windows made of Water	1982	1.2	Article 8.5-9.5
Salt from the Sea	1982	1.4	Article 8.5-9.5
How we came to have Town Belts	1983	3.1	Article 9-10
Branches	1988	1.1	Article 7-8
Landscapes by the Foot	1989	2.1	Article 9-10
Building a House in India	1993	2.1	Articles 9.5-10.5
It's all Happening	1996	2.3	Story
The Shapes of Water	1998	2.3	Photo-Article
Making Puddles	2000	Connected #1	Article
An Interview with a Glass of Water	2002	Connected #2	Story

Internet sites

- Auckland Regional Council Education Homepage: www.arc.govt.nz/arc/education/schools/
- Department of Conservation ; www.doc.govt.nz
- Environment Canterbury's Environmental Education Homepage: www.ecan.govt.nz/education/ee-homepage
- NZ's Association for Environmental Education directory: www.eedz.org.nz/
- Guide to groundwater education links: www.eelink.net/
- Enviroschools : www.enviroschools.org.nz
- Environment Waikato's Environmental Education Homepage: www.ew.govt.nz/forschools/teachers/classroomunits/rivers.htm
- Fish and Game: www.fishandgame.org.nz
- The Environmental Monitoring and Action Project (EMAP) website which combines the delivery of the National Waterways Project and the GLOBE programme: www.emap.rsnz.org/
- Interactvie Websit: www.upthecreek.org.nz/
- Horizons Regional Council Environmental Education Homepage http://www.horizons.govt.nz/default.asp?pageid=12
- Ministry for the Environment: www.mfe.govt.nz
- Ministry of Agriculture and Fisheries: www.maf.govt.nz
- National Institute of water and Atmospheric Research – great info on N.Z.'s freshwater resource and fisheries – including an excellent information resource on fish and educational resources: www.niwascience.co.nz/
- Taranaki Regional Council: Education Homepage : www.trc.govt.nz/environment/education.htm
- Taupo for Tomorrow Education: www.taupofortomorrow.co.nz
- Waterwatch: communities caring for catchments in Australia: www.waterwatch.org.au
- Wellington Regional Council: Take Action for Water: www.gw.govt.nz/section44.cfm
- Wild About New Zealand – a hands-on biodiversity investigation and action programme: www.wildaboutnz.co.nz
- World Wildlife Fund Environmental Education homepage: www.wwf.org.nz/env_education/env_education.cfm

Videos

- Contact Taupo for Tomorrow educator to borrow any of these videos.
- Waitakere's Underwater Life- Focus on Bugs
- The Guardians of the Mauri – an animated underwater adventure in a stream
- Environment Waikato's – Stream Sense (how to monitor for stream health)

Activity sheets