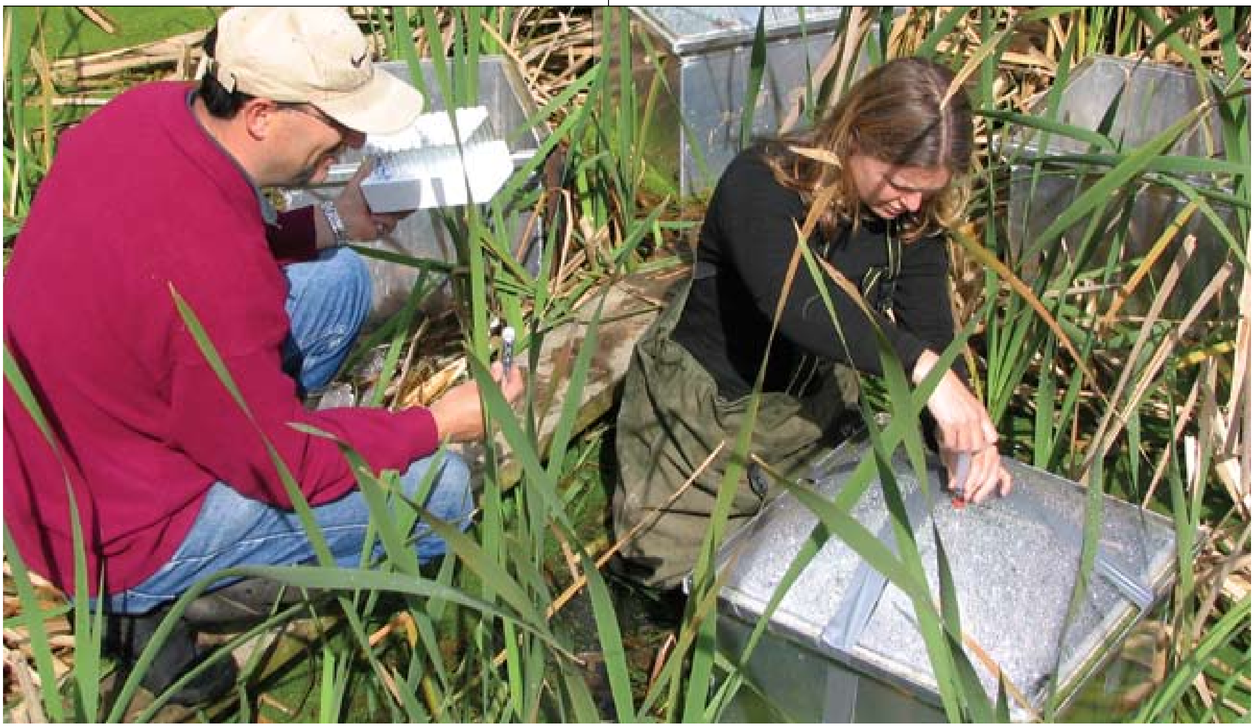
# Freshwater



Chris Tanner, NIWA

*James Sukias and Dr Fleur Matheson take samples in NIWA's constructed wetland at Toenepi, Waikato. They are conducting stable isotope studies to identify the key ways the wetland removes nitrogen and to measure emissions of nitrous oxide and nitrogen gas.*

## Constructed wetlands: sustained research leads to practical advice

By creating wetlands, farmers can reduce sediment and nitrogen in pasture runoff, reinforcing other best management practices.

NIWA operates five 'research' wetlands, from Titoki in Northland to Bog Burn in Southland, with funding from the Foundation for Research, Science & Technology and Dairy Insight. The wetlands are paddock-scale, except at Te Hoe, Waikato, where we use 16 experimental plots to conduct replicated studies on aspects of wetland design and performance.

Most of these wetlands are only now starting to mature, after 3–5 years. Wetland plants establish rapidly and play a key role in taking up nutrients early on, but over the long term wetlands primarily remove nitrates through bacteria feeding on rotting plant litter and converting nitrate to nitrogen gas.

Preliminary NIWA guidelines for the design and construction of wetlands, and general indications of the results farmers can expect, were incorporated into new Environmental Farm Management Guidelines published in 2006. The research to date suggests that a wetland comprising 1% of the drained catchment can remove 20–35% of annual nitrate and total nitrogen runoff. Different plant species have shown variable performance and woodchip filters show early promise.

www.dexcel.co.nz/data/usr/ACF790.pdf

## Accounting for all the water

Elliot Tuck, NIWA

Scientific advances at NIWA are making a difference in the country's natural resource accounting. The ultimate goal of such accounts, being developed by Statistics New Zealand, is to examine links between economic activity and the state of our natural resources.

NIWA worked on the national water accounts, estimating ten components of the annual national and regional water balance. These covered inflows (e.g., rain, snow, sleet, and hail), storage changes (e.g., water held in soil, lakes, glaciers, and hydro dams), and outflows (e.g., river flows or evaporation).

As part of this, we developed a national streamflow model to estimate some components for which very few measurements are available. This takes advantage of significant redevelopment of NIWA's Topnet modelling system since the first edition of the accounts (2003). NIWA research on better methods for mapping rainfall also substantially improved the new accounts, especially for catchments draining the Southern Alps.

Residents of the South Island's west coast may not be surprised to learn that their region has by far the largest water resource per unit of area. There is more work to be done to improve the accuracy of the accounts, but already they provide detailed information on year-to-year variation.

The National Water Accounts are online at www.stats.govt.nz/environment

## Hyporheic magic: how an ecosystem cleans Canterbury's water

Most Canterbury residents drink water which has not been treated at all. The water is drawn pure from aquifers below the central plains. It's pure largely because river water soaking through the river beds, and groundwater seeping to the surface, flows down, up, over, under, and around millions of grains of gravel. Here, in the 'hyporheic' zone, where surface water and groundwater mix, tiny animals and microbes purify the water.

NIWA's extensive research programme on the Selwyn River, however, has found that the hyporheic organisms here are not particularly effective at removing nitrate. Though the water remains safe to drink, it prompted us to explore possible causes of poor nitrate removal.

In an innovative series of field experiments, the research team created artificial gravel bars (in PVC pipes), ran unfiltered river water through them, and monitored the effects of adding more organic carbon and/or phosphorus. It appears that bacteria in the Selwyn hyporheic zone are starved of both nutrients. The next step is a long-term nutrient enrichment experiment in natural hyporheic ecosystems.

This research is funded by the Foundation for Research, Science & Technology.

*Top right: Dr Scott Larned adds a non-toxic dye to the hyporheic zone of the Selwyn River to trace the water flow underground.*

Thibault Datry, CEMAGREF

## Lake Taupo: how much nitrogen?

Concentrations of nitrogen entering Lake Taupo have been rising for decades. Now we are seeing algal blooms and fluctuating water clarity.

NIWA, Lincoln Ventures, AgResearch, and GNS Science are collaborating to develop a catchment planning tool which will help predict the effects of land-use changes and mitigation measures on nitrogen delivery to the lake. It will also assist research on nutrient trading led by Motu. A moderately complex GIS-based model developed by NIWA for Rotorua is a prototype for the simpler tool and can be readily adapted to catchments elsewhere in New Zealand.

The model development is underpinned by extensive fieldwork. This year, NIWA established that about 30% of all streamflow in the Tutaeuaua catchment, on the lake's northwest side, passes through wetlands which take up nitrogen. This is a big step forward, putting us in a position to develop catchment budgets for water and nitrate and to quantify the effectiveness of such streambank bogs at catchment scale.

NIWA also collaborated with Dr Jennifer Tank of the University of Notre Dame to quantify the nitrate uptake in 13 streams feeding the lake.

The research is funded by the Foundation for Research, Science & Technology, with assistance from Environment Waikato and Environment Bay of Plenty.

Dirk Schroer (German student)

*James Sukias and Kit Rutherford install a weir at Tutaeuaua, near Lake Taupo.*

Case study: water resources (under fold)

### National Centre for Water Resources

*making every drop count*

*providing tools & information for the sustainable use of water:*

- water allocation
- water quality
- environmental monitoring & modelling
- pollution control & prediction
- lake, wetland, & river restoration
- flow forecasting
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# Case study: water resources

# We have enough water –
## but not in the right place at the right time

Around the world, climate change is expected to dramatically alter water availability, pitting people against each other and the environment in regions short of water.

Even in water-rich New Zealand, debates and legal battles over water are intensifying, particularly in drier parts of the country, where increasing demands and predicted effects of climate change are creating complex and far-reaching water management issues.

"So far we have tapped the easy water," says NIWA's General Manager, Freshwater, Dr Clive Howard-Williams. "The financial and environmental cost of using water is already rising. Much of the debate is about where these costs should fall, and the best balance between uses."

In water allocation, decision-makers often face conflicting interests, incomplete knowledge, and patchy datasets. NIWA is contributing to a clearer understanding of patterns in water availability and use, associated environmental effects, and more effective planning and management processes.

Alan Blacklock, NIWA

### How much water is available?

NIWA has built a hydrological model of all New Zealand river catchments, in a major step towards understanding the country's water resources.

Most previous methods for estimating how much water is available have been "disturbingly rough", says NIWA hydrologist Dr Ross Woods. "Where a flow recorder has been in a river for decades you get good information, but where there isn't a flow recorder or the record is very short, you get low accuracy and high uncertainty."

In essence, Ross and his colleagues have completely redeveloped NIWA's Topnet model for the hydrology of all New Zealand's rivers. Topnet is a good example of the integration of climate science and hydrology at NIWA, with better river flow estimation arising from improvements in rainfall forecasting and in estimating precipitation.

"We are using Topnet to investigate the impact of land-use changes, such as cutting down or planting forests, and to explore the likely effects of climate variability and change on hydroelectricity generation and water resource availability," says Ross.

For situations where less complex approaches than a Topnet model are appropriate, the same research team assembled simple methods to estimate the hydrological properties of ungauged catchments. This year, NIWA ran a training course for council hydrologists and consultants on these methods and highlighted new national datasets.

### Irrigation modernisation

Once an irrigation scheme gets the go-ahead, there's increasing need to deliver the water in a way that closely matches on-farm needs. "Water users are introducing sophisticated water monitoring, control, and communications technology where they see it's cost-effective and brings real benefits," says NIWA's Dennis Jamieson. "We're working with irrigation scheme managers and consultants to provide water and climate monitoring, flow measurement and control equipment, data management, and advice on irrigation modernisation."

### Injecting evidence: science in complex situations

Nowhere are claims and counter-claims about water louder than in Canterbury. Here the Selwyn River is the focus of multidisciplinary research. Like many gravel-bed rivers of the Canterbury Plains, flows in the Selwyn are a product of runoff from the hills and interactions with groundwater aquifers on the plains. NIWA scientists have reconstructed a long-term record of the day-to-day flow along 60 km of the river. "Now we are in a better position to predict the river's future under different conditions, such as climate change," says hydrologist Dr David Rupp. In related research, Drs Alistair McKerchar and Jochen Schmidt found climate variability cannot fully explain decreasing summer flows in the river, and concluded that increased take of groundwater for irrigation is a likely explanation.

The Selwyn provides a valuable illustration of the interactions between groundwater and surface water. “The bottom line is that groundwater and surface water are a single resource and have to be managed as such”, says leader of the National Centre for Water Resources, Dr Mike Scarsbrook. “Many regional plans still portray surface and groundwater as separate entities.”

## Dealing with dams

As well as working with irrigators, NIWA provides extensive expert advice on dams to the hydro-electricity sector, consenting authorities, and the Environment Court. Issues vary from project to project but include specifying minimum and maximum flows, estimating design floods, evaluating likely sediment and ecological effects, and recommending mitigation methods.

At the Opuha Dam in South Canterbury, NIWA is working with the dam operators, researching the effectiveness of releasing water to clear the riverbed downstream. Such ‘flushing flows’ cost money in lost power or irrigation potential; the key is to design them with the right water volume, duration, frequency, and timing to get the required ecological benefit at the lowest cost.

Tens of thousands of small dams ‘harvest’ floodwaters for irrigation or stockwater around New Zealand. Where water is in short supply, and as fears grow that climate change means less reliable rainfall, there’s increasing pressure to develop more water storage as insurance against dry spells.

Estimating the cumulative effect of many small dams is complex, and an on-going research area, but NIWA has already established that more than 25% of the annual runoff is intercepted in some streams, notably around Auckland, Moutere, and Central Otago. “Ultimately, we will develop tools to help decide how much water harvesting is sustainable before you irreversibly change a river,” says Dr Murray Hicks, an expert in sediment processes.

These processes, of course, don’t stop at the river mouth. NIWA is developing computer models to predict how reduced river sediment supply affects coastal erosion.

## A national debate

In June 2007, NIWA’s national centres for water resources and for climate hosted a two day workshop for over 100 water resources stakeholders. “Too often stakeholders are pitted against each other in the media or adversarial legal proceedings”, says Clive Howard-Williams. “The workshop was an opportunity to discuss solutions in a more open, constructive forum.” NIWA plans to hold another workshop in the coming year.

Mike Scarsbrook says people naturally start with the low hanging fruit, the easy solutions to water resource issues. “Science is a ladder. We are providing knowledge, technologies, and tools to help people reach the more difficult fruit.”

In a world of heightened conflict over water, perhaps science can be not only a ladder but also a bridge to greater sustainability.

Nelson Boustead, NIWA