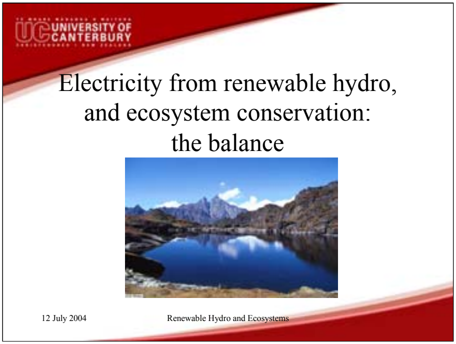
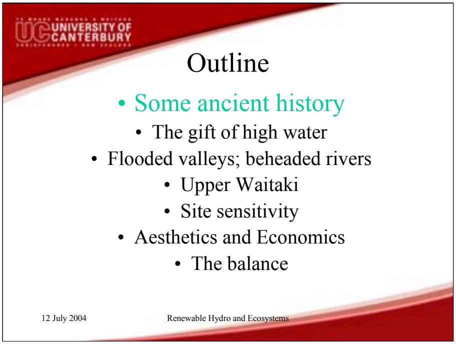


Slides for a talk presented to the University of the Third Age [U3A] in Christchurch, 12 July 2004.

Outline

- Some ancient history
- The gift of high water
- Flooded valleys; beheaded rivers
- Upper Waitaki
- Site sensitivity
- Aesthetics and Economics
- The balance



The understanding we have today of the ‘hydrological cycle’ is quite recent in history. It was not understood by the classical Greek philosophers.

“The safest general characterization of the European philosophical tradition is that it consists of a series of footnotes to Plato ”

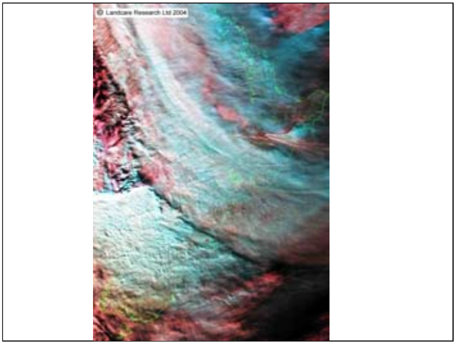
Plato

"The land had great depth of soil and gathered the
water into itself and stored it up into the soil . . . as
though it were a natural water jar; it drew down into the
natural hollow the water which it had absorbed from the
high ground and so afforded in all districts of the country
liberal sources of springs and rivers."

Critias, Plato (427-346 BC)

Aristotle

"Just as above the earth, small drops form and these
join others, till finally water descends in a body of rain,
so too we must suppose that in the earth the water at
first trickles together little by little, and that the sources of
rivers drip, as it were , out of the earth and then unite."
Meterologicia, Aristotle (384-322 BC)



New Zealand, Aotearoa, is a long land of cloudy skies athwart the prevailing westerly winds.

The Southern Alps provide the uplift of moisture-laden air which cools it and drops the contents on the West Coast, or spilling over into the headwaters of eastern alpine catchments, like the Waitaki.

Vitruvius

Vitruvius recognized that rivers and springs were the

result of melting snow in the mountains percolating into

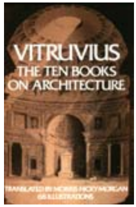
the soil and then coming to the surface in the valleys

below the mountains.

While Vitruvius was correct, his theory was not widely adopted.

Architectura Libri Decem

Vitruvius (27 – 17 BC)



Leonardo da Vinci

Even the great Leonardo da Vinci maintained the concept of a hydrologic cycle in which underground veins of water rose from the sea to the mountains, where they issued forth as rivers.

- During this underground passage the salt was filtered out.
- This concept was identical to some of the concepts put forth by Greeks such as Plato.

Leonardo da Vinci (1452 - 1519)

Leonardo da Vinci
(1452-1519)

Palissy

- **The first person to provide a correct written explanation of the origin of rivers and springs and the hydrologic cycle was a Frenchman, Bernard Palissy**
- **“ rain water that falls in the winter goes up in summer, to come again in winter. . . And when the winds push these vapors the waters fall on all parts of the land, and when it pleases God that these clouds (which are nothing more than a mass of water) should dissolve, these vapors are turned to into rain that falls on the ground.”**

Bernard Palissy (1510? - 1590)

Palissy

"And these waters, falling on these mountains through
the ground and cracks, always descend and do not stop
until they find some region blocked by stones or rock
very close set and condensed. And they rest on such a
bottom and having found some channel or other
opening, they flow out as fountains or brooks or rivers
according to the size of the opening and receptacles…"

Discourse admirables, Palissy , 1580

An 'admirable discourse' indeed!

Perrault

Pierre Perrault made a study of the upper reaches of the Seine River. He measured the average annual rainfall over a

small part of the upper the Seine basin well as the annual discharge of the river from that catchment. He found that rainfall was six

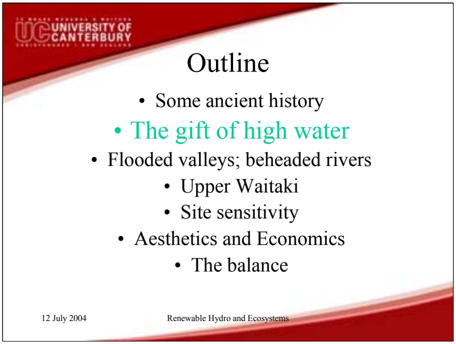
times the amount that flowed in the Seine, thus proving that precipitation was more than enough to supply the water in the Seine and:

"to cause this River to flow for one year, from its source to the place designated, and which must serve also to supply all of the losses,

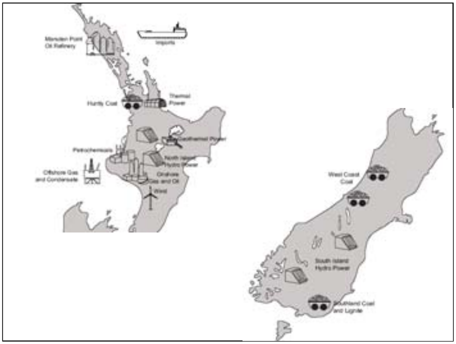
such as the feeding of trees, plants, grasses, evaporation…."

De l'origine des fontaines, 1674

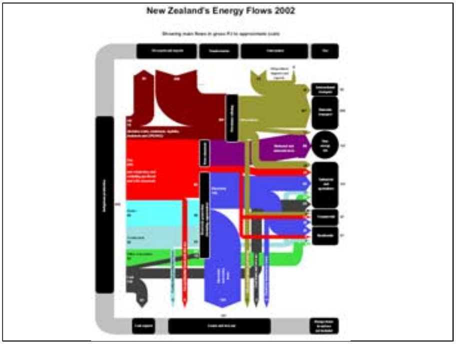
Pierre Perrault, 1608-1680



New Zealand is not only long, narrow and wet, it is ‘a land uplifted high’. Given gravity, and a downhill route towards the sea, water up high is a gift for an energy-hungry society.



Fossil oil and gas are past their peak; coal has environmental downsides. New Zealand is very fortunate to have excellent renewable energy resources: solar, wind, geothermal, tidal, wave and, pre-eminently, hydro.



Industrial, commercial and residential non-transport energy supply is predominantly sourced from hydro [renewable] and LPG [non-renewable fossil].

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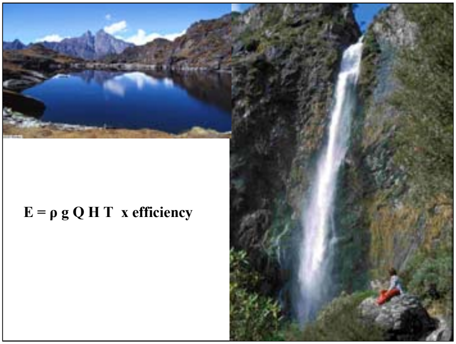
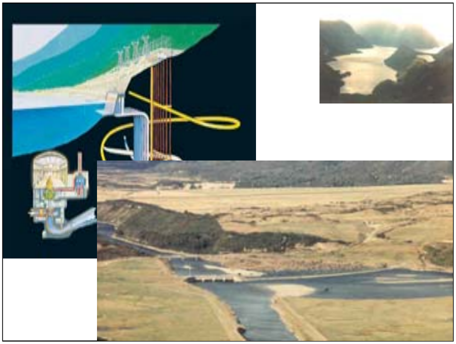


Water density [ρ] and the acceleration of gravity [g] are not things we can alter. So the energy we can extract from high water depends on what flow rate [Q] we can have fall through a height [H] during a time period [T] with a high turbine efficiency. Large flows falling through small heights [Arapuni] are useful, as are small flows falling through large heights [Highbank]; large flows falling through large heights [Manapouri] are best.

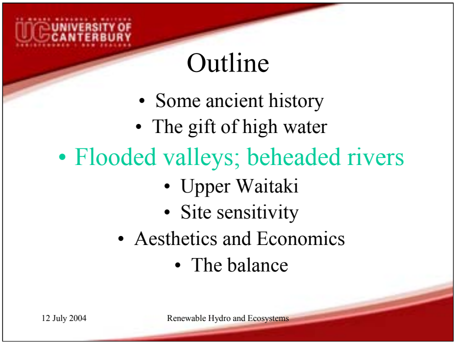
Highbank

Arapuni

West Arm, Lake Manapouri.

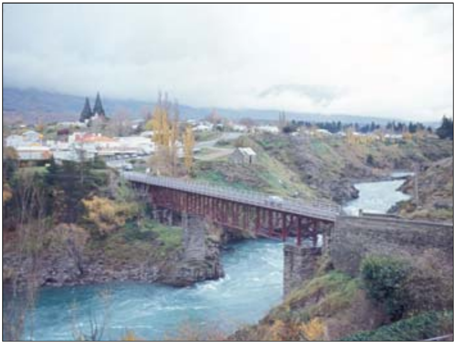


Lake Manapouri underground power station.



The price paid for convenient, renewable hydro-electricity is flooded valleys and beheaded rivers.

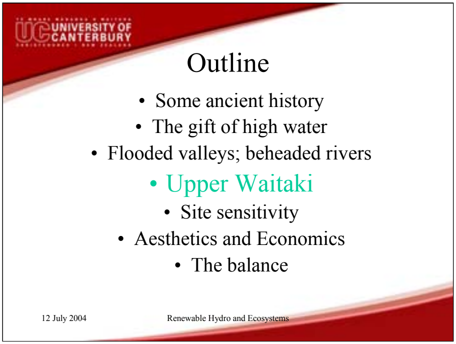
Sometimes that means flooding valleys with unique characteristics, like sacrificing the frost-free fruit-growing available in the Cromwell Gorge, and creating new potential hazards, like the risk of major landslide into Lake Dunstan causing a damaging tsunami.



Sometimes it means submerging historic and beautiful structures, like the old Cromwell bridge across the Clutha River.

Often it means controlling, usually raising, the level of an existing lake, as happened first to Lake Pukaki in the late 1940s, and again in the early 1970s.

Raising a lake such as Pukaki affects not only the lake and its ecosystem, but associated landscapes and features – in this case Aoraki Mt Cook.



The Upper Waitaki catchment and Mackenzie Basin are an example of both significant development for hydro-electric generation and significant change to ecosystems and landscapes as a result.

The Ohau canal [with the Ohau C power station at left] travels parallel to the beheaded Ohau River. The Pukaki and Tekapo Rivers now carry much less flow as the Tekapo and Pukaki canals divert as much flow [Q] as possible and allowed through the greatest height [H] for the longest time [T], so that the Upper Waitaki system is the major hydro-electric resource for the whole country.

There are other benefits, like the salmon farms in the canals.

Minimum flows for ecosystem and environmental reasons are mandated [as here by an ‘invert siphon’ at the outlet of Lake Ohau.

The upper reaches of Lake Tekapo surrounded by snow are beautiful in their raised state, as they were before raising, and new wetlands have developed on the shores.

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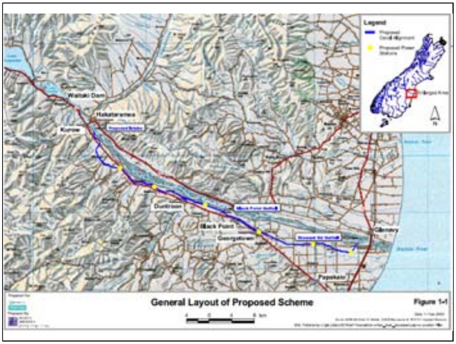
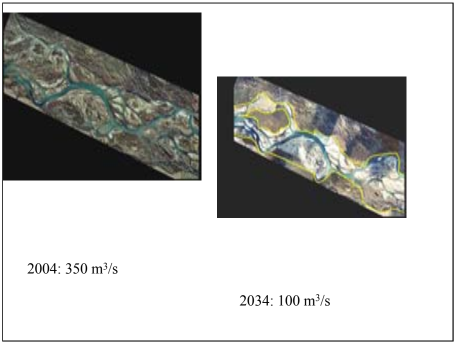


The Waitaki dam near Kurow was built during 1928-34 [by my father, among many others] and commissioned in 1935. The Upper Waitaki was developed starting in the 1930s, but especially in the 1970s. But there was still a tempting amount of fall [H] to the sea available in the Lower Waitaki valley! It had been considered before and the Project Aqua proposal was no surprise to those knowledgable about hydro development. But public attitudes towards river ecosystem disruption, recreational river pursuits like fishing and kayaking and landscape change are very different in the nid-2000s from what they had been in the 1930s, even the 1970s.

The Lower Waitaki River is a significant example of a large, braided, gravel-bed river.



The diversion of significant flow out of the river to provide Q and H for electricity generation would undoubtedly have considerable effects on the river.

Marckolsheim [Rhine]

High-flow, low-head turbine installations on the canals would minimise out-of-river landscape values, but effects on the river itself would be significant.

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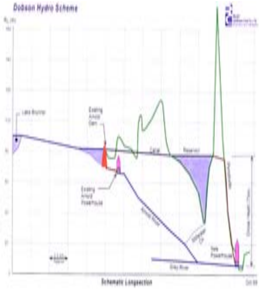
Water diversion
Canal
Storage lake
Conveyance tunnel
Penstocks
Power station

The proposed Dobson scheme is a current example of where additional generation potential needs to be considered in the light of ecosystem effects. There is a proposal to 'trade' land to be flooded, which is presently under Department of Conservation authority, for other land nearby claimed to have better conservation value. If this were so, perhaps it could be a 'win-win' example for both development and conservation.

Lake Arnold is at present controlled for a very small hydro scheme.



Dam/Storage lake

Height 50 m

Surface area 5 km^2

Storage 50 million m^3

Generation

Gross head 75m

Capacity 60 MW

Generation 270 GWhrs

Flow statistics

Av flow 66.8 m3/sec

Mean diverted flow 46.0 m3/sec

Mean flow below existing station 20.8 m3/sec

Lake Rotoiti has a natural outlet control on the Buller River. A 2001 Water Conservation Order maintains and protects the lake, headwaters and river in its natural state. A 2008 Amended Order changes some aspects related to the Gowan and Matiri catchments. There is considerable hydro potential [Q and H] foregone in favour of retaining these natural values. There are currently [2004] ten such orders in place in New Zealand.

Sometimes it is the hydro-power infrastructure, rather than the natural environment, which is conserved. The Lake Coleridge power station, opened in 1914 to supply power to Christchurch, is a registered IPENZ Engineering Heritage site.

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Figure S- 1: Potential Impact on LRMC Prices

This demonstrates that the wholesale electricity prices could be lower, on average, over the period 2009 to 2015 in particular, if Project Aqua proceeds.

[Concept Consulting for MED: Project Aqua; an Evaluation of the Economic Impact 2004]

Hydropower proposals are justified in terms of economics: national, regional and company economics. Ecosystem values are not usually amenable to presentation in terms of economics alone.

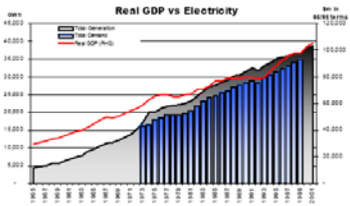

Figure 2-1 Real GDP vs Electricity

Due to technology advances New Zealand, like many developed nations, has become a very immediate society where the instantaneous provision of electricity has become a necessity.

Meridian Energy: Project Aqua AEE 2003

Project Aqua, or alternative generation projects being considered, have potential economic benefits and potential environmental costs. Aye, there's the rub.

NZ Government Policy

- Sustainable Development for New Zealand:
  Programme of Action January 2003.
- National Energy Efficiency and Conservation Strategy (NEECS)
- Climate change policy package
  [Kyoto Protocol ratified December 2002]

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One of the best ways of satisfying demand for electricity in New Zealand is to reduce demand! Energy saving appliances and technology are to be encouraged. After that, there are trade-offs and compromises to be made. High water in New Zealand is a gift. So is our natural environment. 'No more hydro' would not be a good slogan if it led to more coal-thermal or unsustainable-waste nuclear! A careful balance with proper public participation is required.

UNIVERSITY OF CANTERBURY

Thank you for listening!