REPORT

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Subject: Water use efficiency

1. Précis

As requested by the Policy Committee on 21 November 2002, this report deals with water use efficiency. The report considered issues, policies and regulations on water use efficiency in the Otago Region. It was demonstrated that a large proportion of water abstracted is used for irrigation purposes in Otago and a small gain in water use efficiency could provide large quantities of water for further irrigation or other uses. The report recommends council workshop approaches to improving efficiency of water use under its policies and rules.

2. Background

On 21 November 2002 a report on fully allocated catchments was submitted to the Policy Committee. That report indicated that a large proportion of the Otago catchments had been fully allocated according to the Water Plan's surface water allocation policy. The Committee discussed that the lack of water availability may be an impediment to further economic growth in the Region and if any wastage of water could be avoided through efficient use of water this would release water for the Region's growing water demand. Consequently, the Committee requested a report on efficient use of water. The committee also requested information on ground water availability.

3. Objective of the report

The objective of this report is to review water use efficiency issues, policies and rules for surface water. Future reports will address groundwater resources and actions Council may initiate to improve water use efficiency.

4. Water take in the national context

According to the Council database, there are 1551 surface water takes (311 deemed permits) and 419 ground water takes consents. A study commissioned by the Ministry for the Environment (MfE) in April 2000 indicates that of the total national consented weekly allocation of 428.9 m^3/s, Otago granted 90.1 m^3/s take (21% of national take) of which 85% is for irrigation, 10% for industrial use and 5% for public water supply.

About 85% of Otago's water take is derived from surface water, 9% from storage and 6% from ground water. About 91% of the irrigation water is used for pasture irrigation of which 24% is used for dairy pasture and 67% for sheep and beef pasture. Being the largest water user in the country, Canterbury Region allocated 249.8 m^3/s (58% of national take) of which 67% is derived from surface water and 33% from ground water aquifers.

Otago Region is the second largest water user in New Zealand followed by Hawkes Bay Region (16.8 m^3/s). When combined, Otago and Canterbury use 79% of water allocated in New Zealand and the South Island uses 83%. With additional large irrigation schemes being proposed in Otago and Canterbury, the South Island take is likely to reach 90% of the water taken nationally.

The above water take statistics for Otago must not be construed out of context. They are statistics largely based on the face value of the various forms of consent, including mining privileges, as recorded in Council's register of authorised takes. Some of these takes cannot be fully exercised, and many can only be partially exercised in most seasons.

Partial exercise is compelled in two different ways. Firstly because of limitations that apply most of the time such as equipment limits, water availability limits or crop and land area limits. Secondly because of seasonal limits such as reducing water availability and changing crop or industry demands.

5. Permitted water takes

In addition to consented takes there are unaccounted or unknown permitted activity takes. The following rules in the Water Plan provide for permitted takes.

General permitted activity surface/ground takes

A general rule in the Water Plan to take water for domestic and stock watering needs has been derived from s14 of the Resource Management Act (RMA). According to rules 12.1.2.1 and 12.2.2.1,

" ...The taking or use of ground/surface water for an individual's reasonable domestic needs or the reasonable needs of an individual's animals for drinking water is a permitted activity providing the taking or use does not or is not likely to have an adverse effects on the environment..."

There is no limit set on the takes in this rule and this may become a concern in catchments where water availability is low. The water requirement for stock watering needs is relatively large. For example with increasing herd sizes some are now in excess of 1000 cows. Such farms will require in excess of 100 m^3/d of water based on 100 1/cow daily water requirement. Although this rule has a caveat of "*...providing that taking or use does not, or is not likely to have an adverse effect on the environment…"* strict interpretation of the rule may mean permitted activity takes should not be allowed during water shortage periods when minimum flows are breached.

Specific permitted surface water takes

1.Takes from Clutha main stem and lakes (Rule 12.1.2.2): The taking of surface water is permitted from the main stem of the Clutha and Kawarau Rivers and Lakes Wanaka, Hawea, Wakatipu, Dunstan and Roxburgh under the following conditions:

- <100 L s"^{1} and <1000 m^3 d^{-1}
- one take per landholding
- no backflow
- intake structure to prevent fish entry

2. Takes from small dams (Rule 12.1.2.3): Takes from dams with <50 ha catchment and <20,000 m^3 storage are permitted. Construction of such dams is also permitted therefore it is difficult to know the cumulative effects of such takes.

3. Three-day takes (Rule 12.1.2.4): Provided the following key conditions are met, takes are permitted 3 days per month:

- water not used for irrigation purpose
- not taken from wetlands
- < 10 Ls^{-1} <100 m^3 d^{-1}
- taken outside the water suspension period

4. Daily takes from watercourses (12.1.2.5): Provided following key conditions are met daily takes from watercourses are permitted:

- <25 m^3 d^{-1}
- <0.5 L s^{-1} in North Otago, Maniototo or Central Otago sub-regions
- <1 L s^{-1} elsewhere in Otago

6. Water takes and uses authorised by the RMA

S14 of the RMA requires no person to take, use, dam and divert any water unless

(a) The taking, use, damming or diversion is expressly allowed by a rule in a regional plan and in any relevant proposed regional plan or a resource consent; or

(b) In the case of fresh water, the water, heat, or energy is required to be taken or used for-

(i) An individual's reasonable domestic needs; or

(ii) The reasonable needs of an individual's animals for drinking water, -and the taking or use does not, or is not likely to, have an adverse effect on the environment;...

(e) The water is required to be taken or used for fire-fighting purposes.

According to the above provision, unless permitted by a plan, *'use'* of water requires resource consent. The only use of water that is permitted in the Water Plan is in Rules 12.1.2.1 and 12.2.2.1 where water take and use for domestic and stock watering are permitted provided there are no adverse effects on the environment. The only take and use of water that is exclusively allowed by the RMA without giving regard to adverse effects on the environment is for fire-fighting purpose.

Currently, when granting water take application the rights for *'use'* of water are also granted with appropriate conditions and for new irrigation schemes the water use application is processed separately.

7. Water use types, policies and regulations

Water taken from surface or ground water is used for a range of purposes:

- Irrigation
- Hydro-power generation
- Domestic/community needs
- Industrial
- Stock watering and farm dairy
- Frost fighting

With the exception of water use for fire-fighting purposes, the RMA does not prioritise the use of water. In addition, the purpose of the Act does not differentiate between public health and safety and economy. For example, s5 requires the use, development and protection of natural resources in a way and at a rate, which enable people and communities to provide for their social, economic and cultural wellbeing and for their health and safety. Nevertheless, the Act (s14) recognises and provides for individuals' and animals' water needs provided there is no adverse effect on the environment.

Some regional councils in New Zealand give higher priority to community water takes in their water allocation policy. Although our Council's Water Plan does not prioritise water allocation, it recognises community water supplies by processing consent applications on a non-notified basis provided special circumstances do not apply.

The objectives and policies in the **Regional Policy Statement** (RPS) do not appear to give higher status for community water supply, e.g.

Objective 6.4.1 To allocate Otago's water resources in a sustainable manner which meets the present and reasonably foreseeable needs of Otago's people and community.

Policy 6.5.2 To allocate water in areas of Otago where there is or potentially will be insufficient water supplies through:

- ***a) Considering the need to protect instream amenity and habitat values; and***
- ***b) Considering the needs of primary and secondary industry; and***
- ***c) Considering Kai Tahu cultural and spiritual values; and***
- ***d) Considering the extent to which adverse effects can be avoided, remedied or mitigated.***

Method 6.6.11 Establish systems for the allocation of surface water and ground water while considering:

- ***a) The need to protect instream amenity and habitat values; and***
- ***b) The needs of primary and secondary industry.***

There are three **Water Plan** Objectives that are relevant to water use. These three objectives do not appear to differentiate between community water needs and primary industry water needs.

6.3.2 To Provide for the water needs of Otago's primary and secondary industries, and community domestic water supplies.
The objective is to ensure continued access for the taking of water for consumptive use and primary and secondary industry use.

6.3.3 To minimise conflict among those taking water.
This objective gives higher priority to existing lawful water users over new users by ensuring continuous access to water.

6.3.4 To maximise the opportunity for diverse consumptive uses of water which is available for taking.
This objective recognises a diverse use of water by the community and does not want to restrict certain uses over others.

8. The significance of water use efficiency, policies and regulations
S7 of the RMA requires the Council among other things ***to have particular regard to the efficient use and development of natural and physical resources.*** As discussed before, s14 requires the control of water use. The control of water use through consent or permitted activity should consider any adverse effects of water use. This is not different from considerations to water take effects.

The **RPS** identifies and recognises water use efficiency in the following manner:
Issue 6.3.3 Inefficient uses of water and wastage of water can occur.
This issue recognises that large quantities of water wastage can occur through inefficient irrigation, industrial and domestic use and losses from reticulation supplies.

Policy 6.5.3 To promote efficient consumptive water use through:

- ***a) Promoting water use practices which minimise losses of water before, during and after application; and***
- ***b) Promoting water use practices which require less water; and***
- ***c) Promoting incentives for water users to use less water.***

In the principal reason for adopting, the above policy emphasises that "*...traditional management techniques and methods of irrigation or reticulation including urban and rural domestic uses may not provide the most efficient method of water use. Casual attitudes towards water conservation may not encourage efficient use of water, further reducing the amount of available water among competing users. Attitudes towards water usage will eventually impact on the ability of Otago's water supplies to meet the needs of future generations…"*

Method 6.6.12 Establish and implement programmes to monitor water yield, water usage and the quality of water in Otago.

Method 6.6.16 Take enforcement action to address unauthorised water use activities.

Method 6.6.32 Promote and educate about mechanisms available to reduce or prevent inefficiencies in water use.

The **Water Plan** also identifies and recognises water use efficiency as follows:
Issue 6.2.3. Opportunities for the wider use of available water resources are constrained by inefficient water use practices.
Explanation: " ...wider use of water is constrained by water shortages. Such shortages can arise for either of two reasons: the natural limits of water resource or the inefficient water use practices. The latter can result in the waste of water, particularly through the following:
(a) Water being lost through leakage from distribution systems;
(b) Not utilising the most efficient means of taking or using the water; and
(c) Taking more water than is needed.."

Policy 6.4.15 To ensure that the quantity of water granted under a resource consent for the taking of water is no more than that required for the intended use of that water having regard to the local conditions.

Policy 6.4.16 In granting resource consents to take water, or in any review of the conditions of a resource consent to take water, to require the volume and rate of take to be measured in a manner satisfactory to the Council unless it is impractical or unnecessary to do so.
Principal reasons for adopting:
The policy is adopted to provide measurement of water takes in a manner suitable to the needs of the council and the environment. The policy will assist to identify actual demand for water, and thus may provide for more efficient allocation and use of water.
The reasons for requiring the measuring of takes as a result of a catchment wide review of consent conditions under Policy 6.4.5 (b), (c) and (d), include:

- *Better information on the volumes and rates taken will assist in establishing the influence of abstractions, if any, on the incidence and duration of minimum flow breaches, and also assist with water balance equations, allowing improved water management generally;*
- *Better information will assist water allocation committees to more effectively manage the rationing of takes during times of low flows to prevent minimum flows from being breached; and*
- *Better take information may enable supplementary allocation to be granted, ensuring instream values and flow variation are appropriately provided for and to prevent supplementary minimum flows from being breached.*

Policy 6.4.18 Where a resource consent for the taking of water has not been exercised for a continuous period of 2 years or more, disregarding years of seasonal extremes, the Otago Regional Council may cancel the consent.

In short, the RMA, RPS and Water Plan recognise the significance of water use efficiency. Efficiency is promoted to ensure water abstracted is not wasted and is available for wider consumptive, primary and secondary industry needs. In regions such as Otago where there is increasing demand for water, and water availability for abstraction is low, it is vital to promote water use efficiency through regulation and education.

9. Water wastage

There is a high potential for water wastage across a range of water users. Table 1 illustrates a range of pathways for water wastage/loss.

Table 1. Water wastage across a range of water users

Water use	**Typical estimated water need**	**Potential loss/wastage pathways**
Irrigation (pasture and crops in general regardless of soil types)	50 m^3/day	• Leaky pipes, storage and races • Wind drift and evaporation • Runoff • Infiltration beyond root zone • Plant interception • Application to non-target areas • Inefficient irrigation system
Hydro-power generation	various	• Evaporative loss of water • Flow of water is altered.
Domestic/community use	200 1/person/day	• Leaky taps • Large toilet flushing systems • Water use for recreation such as home swimming pools • Inefficient shower heads • Bathing versus shower • Long showers • Inefficient hot water mix • Excess garden watering with inefficient water applicators • Inefficient use of water (e.g. running tap while brushing teeth) • Washing cars, windows etc.
Industrial	various	• Leaky taps and systems • Excessive use for washing
Stock watering	Up to 100 L/cow/day	• Leaky/overflowing water troughs
Farm dairy	50 L/cow/day	• Leaky tap and systems • Running hose • Yard wetting
Frost fighting	various	• Inefficient and excess use

As provided in the Background section of this report a high proportion of abstracted water is used for irrigation (85%) and relatively smaller proportion for industrial (10%) and public water supply (5%).

Therefore, in theory, a significant gain in water availability could be made if water use efficiency is improved in irrigation. A 10% gain in efficiency means 10% of the water being used is available for other purposes.

10. Irrigation and water use efficiency

In the process of irrigation, water use efficiency should be considered once the water is abstracted for the purpose. Such a process will involve abstraction, storage, conveying to application area and application.

(a) Storage

Storage is used for harvesting water during wet times (generally supplementary take) or used as a contingency during water short periods or in cases where a large rate of take is not possible. The critical factors for surface water take are the rate and duration of take. Where surface water is in high demand farmers could take water at low rate on a 24-hour basis to fill their storage. The stored water could be used at a higher pumping rate to irrigate the paddocks. Smaller more uniform takes of water are much more efficiently rostered for the purpose of gaining maximum economic benefit from available stream flows.

While storage is an excellent method of efficient water management, poorly constructed storage could lose a substantial amount of water. Storage occupies a large area, would incur high capital cost, and allows increased evaporative loss. For example, to store 75,000 m^3 of water to irrigate 50 ha pasture for a month would require 5 m x 100 m x 150 m storage (i.e. a total area of 1.5 ha). During summer, evaporation loss from such a storage would be 75 m^3/day.

Depending on the nature of the geological material on site, in-stream and off-stream dams could also leak water. In most cases leaked water is not lost from the catchment.

(b) Leaky water races

Leaking water distribution systems have been specifically mentioned in the Water Plan Issues 6.2.3. Large irrigation schemes rely on large takes that are conveyed through water races for irrigation. Typically, the network of water races could range from several hundred metres to many tens of kilometres. Water lost by evaporation from water races is very minor compared to the loss sustained through leakage. For example, a 2 m wide 5 km long race may lose 50 m^3/day by evaporation. The same race when carrying 250 1/s water might lose more than 10% to seepage, that is more than 2000 m^3/day.

The worst known cases of race leakage are up to 30% of water loss. Our discussions with several irrigation companies indicated that on average 20% of water is lost through water race seepage in the major irrigation networks in Otago. In the past attempts have been made to line races with clay, however, since excavators are used to remove weeds, clay lining was damaged by weed removal activity. Irrigation schemes also rely on natural silt in water that could reduce seepage.

Many years of water seepage from leaky races have also created ‘new’ habitats (e.g. wetlands, springs etc.) particularly in the Central Otago area. For example, Lindis Irrigation Co measured water flow from the Cluden swamp when the race was empty and when it was full and noticed the swamp doubled its flow (i.e. flow increased from 14 1/s to 28 1/s) when the race was full. The significance and contribution of irrigation seepage water to ‘new’ habitats is unknown. Through consent applications it is known that several farms also rely on seepage water and associated springs to irrigate their farms. Typically such springs flow during summer and will be dry during winter.

Seepage from earthen channels is also a major issue in Australia. Australian National Committee of Irrigation and Drainage (ANCID) and Murray Darling Basin Commission (MDBC) had

commissioned a project to investigate channel seepage remediation techniques. The extensive study thoroughly assessed most available techniques (including cost) and recommended earth liners, hard surface and flexible membrane liners as options. Such liners could be used on a case by case basis provided the long term financial return from conserved water is high.

(c) Irrigator efficiency

Irrigator efficiency could be defined as the percentage of water delivered to the field that is used beneficially. This means water losses following abstraction to final delivery should be considered. Table 2 provides information on typical water losses sustained in a sprinkler system. It must be cautioned that the typical values reported in the Table can vary significantly over different studies performed in New Zealand.

Table 2. Water losses from spray irrigation systems

Source of loss	Range	Typical
Losses from open races	0-30%	10%
Leaking pipes	0-10%	<1%
Evaporation in the air	0-10%	<3%
Blown away by wind	0-20%	<5%
Watering non-target areas	0-5%	<2%
Interception by plants	0-3%	<2%
Surface runoff	0-10%	<5%
Uneven application	5-30%	15%
Excessive application depth	0-50%	10%

Adopted from "Efficient and Reasonable Use of Water for Irrigation", Report No.U01/69, May 2002, Environment Canterbury.

As illustrated in Table 2, a high proportion of water loss is sustained from races and uneven and excessive application of water. Uneven and excessive application depends on irrigator type and prolonged irrigation. There is a wide range of irrigation systems used in New Zealand (e.g. border-dyke, wild flooding, contour irrigation, rotary booms, fixed boom, centre-pivots, travelling guns, side-rolls, K-lines, drips). Table 3 provides information on irrigator efficiency of several irrigation systems.

Table 3. Application efficiencies of irrigation systems

Irrigation system	Range
Border dykes	31-61%
Rotary boom	48-90%
Centre-pivot	85-94%
Side roll	86-92%
Travelling gun	60-70%
Drips	75-90%

Compiled from "Efficient and Reasonable Use of Water for Irrigation", Report No.U01/69, May2002, Environment Canterbury.

It must be emphasised that most systems can achieve up to 90% efficiency, provided they are well managed and designed on the basis of factors such as soil and crop types, topography and climatic conditions. For example, border dyke systems perform poorly in light (porous) soils compared to

heavier (high water holding capacity) soils. Free draining soils would require more frequent applications compared to heavy soils. Farmers use soil as a reservoir to hold water but excessive water is wasted if it is drained below the root zone. Water wastage is minimised by applying smaller quantities of water with higher frequency. In practice this objective is difficult to achieve where farmers rely on roster systems or schemes that restrict the timing of application. Increasingly farmers are using soil moisture devices to plan irrigation.

Numerous studies have demonstrated that excessive water application in agricultural and horticultural soils can cause excessive nutrient leaching, particularly, nitrate nitrogen. Typically, irrigated soils have high soil nitrogen turn-over, hence nitrate leaching potential in irrigated soils is greater than that from non-irrigated soil.

It must also be noted that border-dyke systems generally demand high instantaneous takes compared with spray and drip systems. Typically, on average, large spray systems require 25 1/s takes while more than double the take is required for border-dykes. Rate of take is critical in sustaining surface water flows in the source streams.

(d) Other loss pathways

Irrigation during heavy winds can sustain more water loss than through evaporative losses (see Table 2). Loss by wind is important in spray systems and low to negligible in border dyke and drip systems.

Crops can also intercept water during irrigation and this depends on crop foliage size and shape. Crop interception is nil in drip irrigation.

Irrigation application rate should match soil infiltration rate, otherwise loss by surface runoff will result.

11. Conclusions

It is clear that a small improvement in water use efficiency in irrigation will provide a large return of water because of the large amount of water used for irrigation in Otago. Therefore, it is worthwhile exploring options to improve water use efficiency in irrigation.

The current council policy and plan framework sufficiently provides for water use efficiency and Council now needs to give regard to practical measures to promote and implement these policies. Systematic application of the policies will be necessary.

12. Recommendation

1. That the Committee note the report.
2. That Council workshop approaches to improving efficiency of water use under its policies and rules.

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