December 2007

# RESPONSE TO REQUEST FOR FURTHER INFORMATION REGARDING ECOLOGICAL EFFECTS

## Central Plains Water Scheme

**Submitted to:**
URS New Zealand Ltd

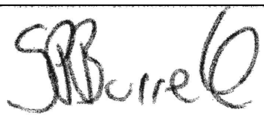
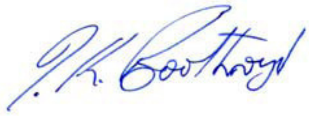
REPORT

A world of capabilities delivered locally

Golder Associates

# Table of Contents

# Quality Assurance

| | Name | Signature |
|---|---|---|
| Project Manager | GREG BURRELL |  |
| Approved Reviewer(s) | IAN BOOTHROYD |  |

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# 1.0 INTRODUCTION

## 1.1 Background

The Central Plains Water Enhancement Scheme (CPW) has applied to Environment Canterbury (ECan) to abstract up to 40 $m^3/s$ of water from each of the Waimakariri and Rakaia Rivers for irrigation of up to 60,000 hectares of land between the two rivers. The scheme also includes the creation of a water storage reservoir in the Waianiwaniwa River valley, to increase the reliability of water supply when minimum river flows restrict water abstraction. A level headrace will run between the two rivers and carry water from the rivers and reservoir to a network of water races that scheme shareholders can draw water from.

Central Plains Water Limited (CPW Ltd) lodged resource consent applications with ECan for the water takes in late 2001, and further consents were lodged in late 2005 and 2006. Kingett Mitchell Ltd (now Golder Associates NZ Ltd) provided assessments of environmental effects in 2006 following lodgement of consents for water use, discharge and construction in late 2005 (e.g., Kingett Mitchell 2006a). Additional Golder/Kingett Mitchell reports include a report on effects of the proposed water take on the Waimakariri River (Kingett Mitchell 2006b), a Section 92 report (Golder Kingett Mitchell 2007a), and an IFIM modelling report for the Waimakariri River (Golder Kingett Mitchell 2007b).

Environment Canterbury requested further information (pursuant to Section 92 of the Resource Management Act) from CPW Ltd in a letter dated 2 November 2007. The purpose of this report is to provide information relating to several technical issues raised in the November 2007 Section 92 letter.

## 1.2 Report Scope

This report focuses on the following issues raised in the 2007 Section 92 letter:

- Effects of the proposed water take on the Waimakariri and Rakaia Rivers. Specifically, effects on:
  - Flood frequency.
  - Habitat availability.
  - Wetland habitat.
  - Water quality.
- Construction effects and mitigation.
- Effects of water use on wetlands (including lakes and streams) and dryland ecosystems.

Other issues raised in the Section 92 letter are being addressed separately by URS and its consultants. Proposed mitigation for effects of the CPW scheme on the nationally endangered Canterbury mudfish are also presented in a separate mitigation plan that is currently being finalised and will be presented separately.

It is noted that a number of the issues raised in the November 2007 Section 92 letter have been covered to varying degrees in previous reports. Therefore, to avoid unnecessary repetition, this report refers the reader to the earlier reports when necessary.

# 2.0 EFFECTS OF WATER ABSTRACTION

## 2.1 Introduction

Water abstraction has the potential to affect river and wetland communities through reduced habitat availability, reduced flood frequency and reduced water quality. These effects have been assessed previously for the Rakaia River by Golder Kingett Mitchell (2007a) and no adverse effects were anticipated due to the rate of take being low relative to flows in the Rakaia River. This assessment remains unchanged and the reader is referred to Golder Kingett Mitchell (2007a) for further details.

Effects of water abstraction on the Waimakariri River were assessed previously by Kingett Mitchell (2006b) and effects were assessed as being minor. However, since completion of the 2006 report, new flow series data have been provided by URS for the period 1967 to 2001 (data valid as at December 2007). Therefore, this report assesses effects of the CPW water take on Waimakariri River ecosystems, using the revised flow data from URS.

## 2.2 Effects on River Flows

The revised flow series provided by URS comprises the following three calculated flows at the Old Highway Bridge site for the period 1967-2001:

- **No abstraction**. River flow with all known water takes removed.
- **Before CPW**. River flow with all existing permitted water takes added in.
- **After CPW**. River flow with all permitted water takes and the CPW take.

It should be noted that the likely maximum rate of take from the Waimakariri River is now 25 $m^3/s$, which is less than the 40 $m^3/s$ originally applied for. Therefore the modelling data provided by URS and presented in this report assumes a maximum rate of take of 25 $m^3/s$ from the Waimakariri River.

The difference between the Before CPW and After CPW flow scenarios is used to assess effects of the CPW take on river flows, while comparison of the After CPW flow with the no abstraction scenario may be used to assess cumulative water take effects.

Modelled daily rates of abstraction for the 1967-2001 period indicate that the maximum rate of take of 25 $m^3/s$ for CPW will occur 24% of the time (Figure 1). During the summer period (November to April[1]), when irrigation demand is highest, the median rate of take for CPW is 8.4

[1] Summer is defined in this report as November to April inclusive; this is the timing of the salmon angling season, and also the period when irrigation demand is greatest.

m³/s. The median rate of take is low compared to the maximum sought due to restrictions on abstraction rates caused by minimum flow rules.

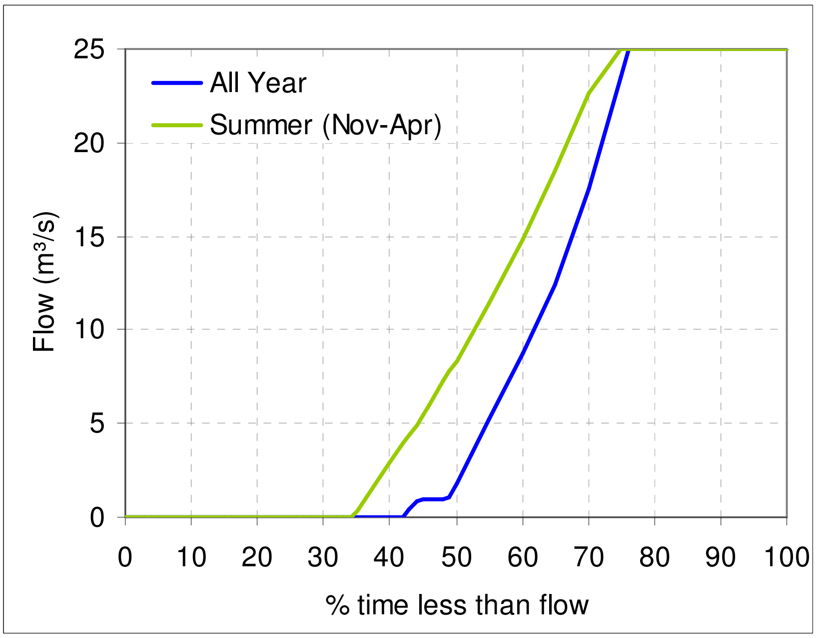


**Figure 1: Cumulative frequency plot of the rate of the CPW take from the Waimakariri River during summer (November to April) and throughout the year (including summer). Data from URS.**

Comparison of flow duration curves for Waimakariri River flows before and after the modelled CPW water take (Figure 2 and Figure 3) reveals the following:

- Median flow will be reduced:
  - From 75 $m^3/s$ before CPW to 63 $m^3/s$ after CPW (a 16% reduction).
  - In summer from 66 $m^3/s$ before CPW to 44 $m^3/s$ after CPW (a 33% reduction).
- River flow will be at the minimum flow of 41 $m^3/s$ for longer:
  - Increasing from 15% of the time at 41 $m^3/s$ before CPW to 33% after CPW.
  - In summer increasing from 26% before CPW to 48% of the time after CPW.

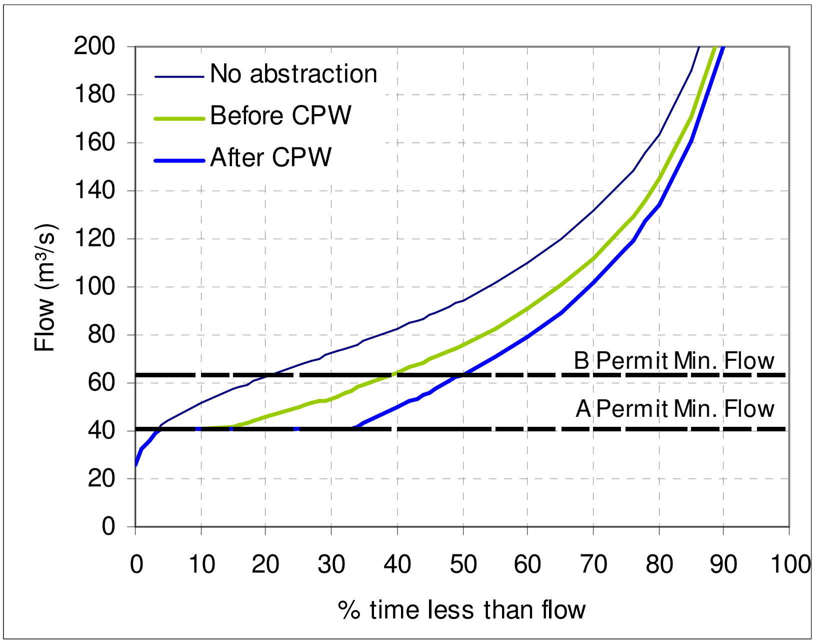


**Figure 2: Flow duration curves for the Waimakariri River.**

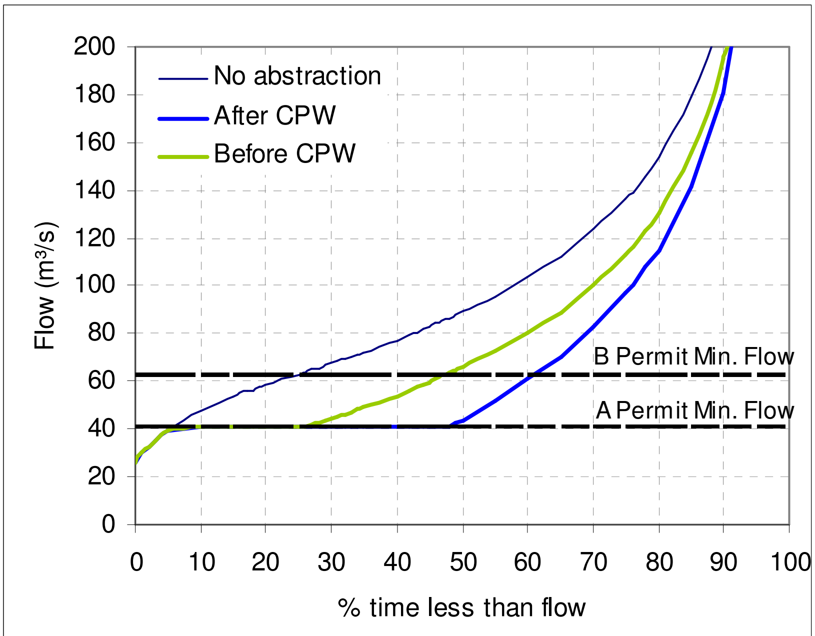


**Figure 3: Flow duration curves for the Waimakariri River in summer (November to April data).**

Flood frequency and duration of low flows are important factors influencing both physical river processes and biological communities. The length of time between flood events is referred to as an accrual period, as it is the length of time that biological communities (e.g., algae and invertebrates) can recover and increase in biomass. Long accrual periods may result in algal proliferations. In a study of 83 New Zealand rivers, Clausen & Biggs (1997) found that the annual frequency of floods of a magnitude of at least three times the median flow (FRE3) was the best hydrological predictor of responses in biological communities, with periphyton biomass and invertebrate abundance decreasing as FRE3 increases. In a more in-depth study of nine Canterbury rivers, including the Waimakariri River, it was found that flows of at least 1.4 times the preceding base flow were sufficient to scour periphyton communities with a high biomass (Biggs & Close 1989).

The effect of the CPW take on the frequency and duration of floods and accrual periods was calculated using two measures of flood disturbance:

- FRE3: Three times the "no abstraction" median flow (284 $m^3/s$); and
- MIN3: Three times the A Permit minimum flow of 41 $m^3/s$ (123 $m^3/s$).

Both of the above hydrological statistics were chosen for their relevance as potential measures of disturbance to biological communities. The FRE3 statistic provides a value that can be compared against rivers at a national scale (e.g., Clausen & Biggs 1997). The MIN3 statistic was adapted from the results of Biggs & Close (1989); the A Permit minimum flow will be the most common summer baseflow following the CPW take, and three times the minimum flow is considered a conservative estimate of the flow required to remove high biomass periphyton communities (i.e., those likely to constitute "nuisance growths").

Comparison of flows before and after the CPW take indicates that the CPW take will have negligible (<10%) effect on the annual frequency of FRE3 and MIN3 flood events (Figure 4). The cumulative effect of the CPW take and existing takes (i.e., "After CPW" vs "no abstraction" in Figure 4) is slightly greater, with a 14% reduction in FRE3, while the effect on MIN3 is still negligible. A similar pattern is seen with summer data (data not shown, but available on request). Overall, Figure 4 shows that the CPW take will have negligible effect on the frequency of biologically important flood events, and that the river will remain highly flood-disturbed.

Comparison of summer flows before and after the CPW take indicates that the CPW take will result in a 14% increase in the average length of FRE3 accruals and a 12% increase in the length MIN3 accruals (Figure 5); a minor increase. The cumulative effect of the CPW take and existing takes is greater, with a 21% increase in FRE3 accrual length and a 31% increase in MIN3 accrual length. However, it should be noted that the cumulative increase in accrual length is still relatively small, with the mean FRE3 accrual length increasing by 9 days, and the MIN3 accrual length increasing by only 4 days (Figure 6). It is worth pointing out here that the mean FRE3 accrual period length is strongly influenced by data from 1971 and 1992, when there were exceptionally long accrual periods. When the 1971 and 1992 data is excluded, mean FRE3 accrual length declines from 43 to 34 days for the no abstraction scenario, from 45 to 37 days for the Before CPW scenario, and from 52 to 43 days for the After CPW scenario.

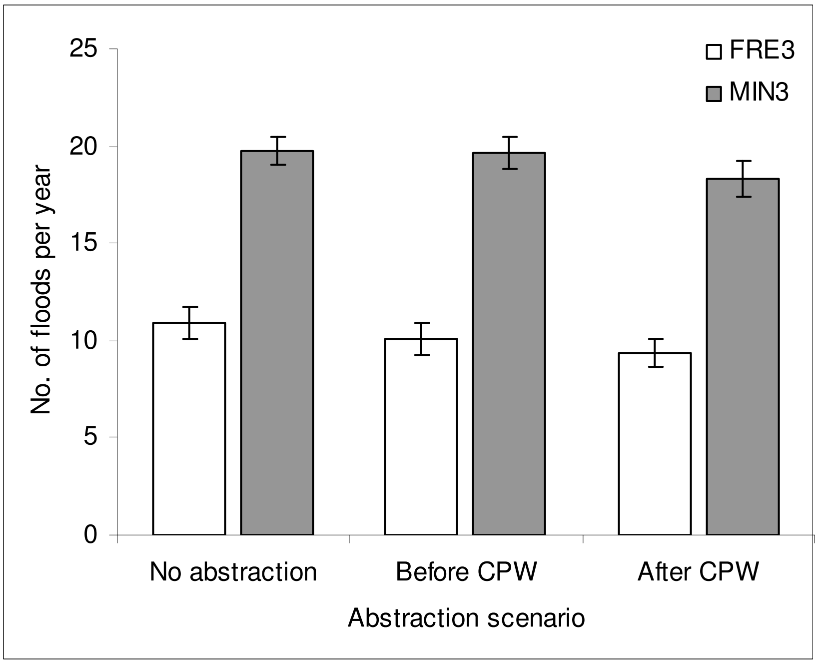


**Figure 4: Effect of the CPW water take on the mean (± 1 SE) annual frequency of floods of a magnitude of at least 3 x median flow (FRE3) and 3 x minimum flow (MIN3). Based on data from URS.**

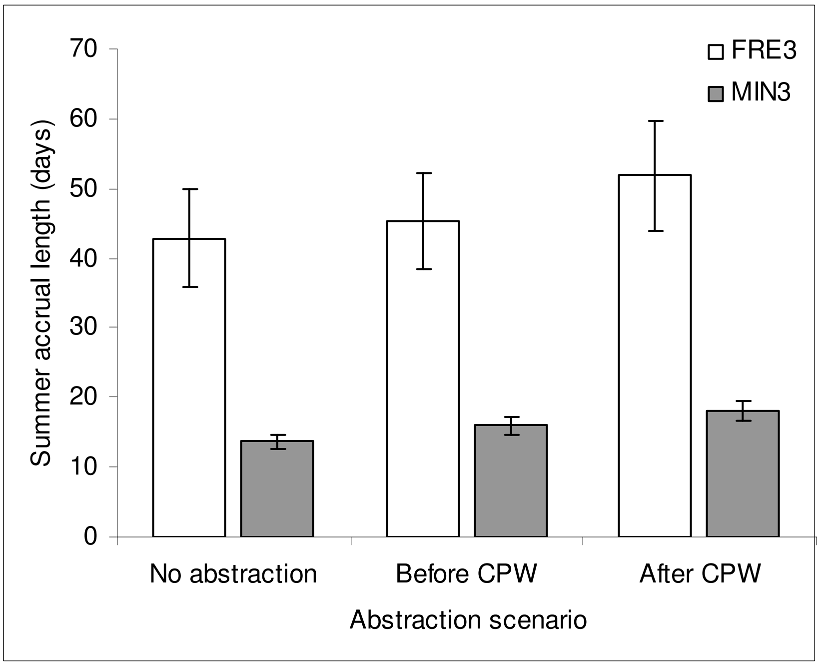


**Figure 5: Effect of the CPW take on mean (± 1 SE) accrual length during summer (November-April), based on floods of a magnitude of at least 3 x median flow (FRE3) and 3 x minimum flow (MIN3).**

## 2.3 Biological Effects of Reduced Flood Frequency

In a previous assessment, Kingett Mitchell (2006b) found a negative relationship between the QMCI index of macroinvertebrate health and accrual period length in the Waimakariri River. Kingett Mitchell (2006b) predicted that an average increase in accrual period of 10 days would correspond to a reduction in QMCI score in the order of 0.5 QMCI units. The greatest change in accrual period assessed in the present report was 9 days, when comparing the cumulative effect of the CPW take on FRE3 accruals. Based on the previous study of Kingett Mitchell (2006b), an increase in accrual period in the order of 9 days may result in a minor reduction in QMCI scores.

A reduction in QMCI scores would be caused by a minor shift in invertebrate community composition, with fewer mayflies and more chironomids, although it is expected that the invertebrate community will still be dominated by "clean water" taxa, with QMCI scores >5 or 6 (Kingett Mitchell 2006b). The slight shift in invertebrate community composition is unlikely to significantly affect feeding of native fish, which are generalist invertebrate feeders (Sagar & Glova 1994). Because the predicted shift in the invertebrate community is slight any effects on salmonid feeding are also expected to be minor. Furthermore, the minor shift in invertebrate community composition will be offset by a minor increase in benthic invertebrate productivity, due to greater flow stability (Kingett Mitchell 2006b).

It is concluded that the change in invertebrate community composition is considered minor and would be offset by increased invertebrate abundance and biomass overall, due to the greater stability afforded by longer inter-flood accrual periods. Thus, increased accrual period is not predicted to result in an adverse effect on invertebrate communities in the Waimakariri River, or the fish that feed on them. This assessment is similar to that of Kingett Mitchell (2006b), derived using a different set of modelled river flow data.

Although it is concluded that effects of increased accrual period length will be minor, it is acknowledged that there are inherent uncertainties to hydrological modelling, and therefore there can be uncertain outcomes for biological communities. Therefore, CPW has offered mitigation for this potential effect (Tipler 2007). It is envisaged that the exact details of the mitigation approach will be determined following feedback from ECan and interested parties. However, an example of the approach would be that following sustained periods at the minimum flow in summer (e.g., >3 weeks at 41 $m^3/s$), CPW would cease taking water during any minor freshes or floods. The purpose of this action would be to maximise the potential flushing or scouring of fine sediments and periphyton that may build up during sustained low flows.

## 2.4 Effects on Habitat Availability

Effects of the CPW take on habitat availability in the Rakaia River was assessed as being minor or less than minor by Golder Kingett Mitchell (2007a), and this assessment remains unchanged. Therefore this assessment focuses on effects of the CPW take on habitat availability in the Waimakariri River.

The relationship between river flow and potential habitat availability at a heavily braided reach of the Waimakariri River at Crossbank was modelled by Duncan (2001) and described for a wide range of species/life stages by Golder Kingett Mitchell (2007b). The reader is directed to the Golder Kingett Mitchell (2007b) for details of the habitat modelling methods and results. This section focuses on some of the key results of the Golder Kingett Mitchell report in relation to effects of the CPW take on instream habitat.

Waimakariri River instream habitat (depth, width, and velocity) was modelled by Duncan (2001) for the following river flows: 41, 52, 63, 67.5, 74, 79.5, and 85 $m^3/s$. Median summer flows have been compared between the three different flow scenarios to assess effects of the CPW take on instream habitat availability. Because the exact summer median flows have not been modelled by Duncan (2001), the following flows have been assumed for comparing habitat availability:

- No abstraction summer median: 85 $m^3/s$ (actual median is 89 $m^3/s$).
- Before CPW summer median: 67.5 $m^3/s$ (actual median is 66 $m^3/s$).
- After CPW summer median: 41 $m^3/s$ (actual median is 44 $m^3/s$).

The following is a summary of the findings of Golder Kingett Mitchell (2007b). The following is observed with increasing flow:

- **Habitat.** Mean depth and width change little with increasing flow, but large increases in total wetted width occur.
- **Periphyton.** Habitat (as weighted usable area, WUA) for diatoms and short filamentous periphyton increases and long filamentous algae decreases as flow increases. Habitat availability for long filamentous algae increases rapidly at flows <52 $m^3/s$.
- **Invertebrates.** Two of the three invertebrate taxa and the food producing curve all showed a linear increase in WUA with increasing flow. The rate of WUA increase was lower for *Deleatidium* mayflies at flows <53 $m^3/s$, but the gradient increased at higher flows. In contrast, there was little change in habitat quality (expressed as the habitat suitability index, HSI) with flow for any of the groups.
- **Native fish.** Of the native fish species examined, torrentfish and bluegill bully showed the steepest, linear increase in WUA with flow. Shortfin eel also showed a steep increase in WUA at flows >53 $m^3/s$, but showed a steep decline in WUA as flows increased from 41 to 53 $m^3/s$. Common bully, upland bully, and small longfin eels (<300 mm long) all showed a decline in WUA as flow increased from 41 to 53 $m^3/s$, followed by a gradual increase in WUA at higher flows. Large longfin eels showed no change in WUA at flows <53 $m^3/s$, after which there was a gradual increase in WUA. For five of the seven native fish species/life stages examined, there was a steep decline in HSI as flows increased from 41 to 53 $m^3/s$, followed by a more gradual decline in HSI. Torrentfish and bluegill bully are the two species that showed virtually no change in HSI with flow.
- **Salmonids.** Juvenile Chinook salmon (<55 mm) showed a gradual increase in WUA as flows increased from 41 to 63 $m^3/s$; WUA increased at a greater rate at flows above 63 $m^3/s$. Adult brown trout WUA habitat increased more gradually, but linearly with flow, while salmon juveniles (>55 mm), brown trout spawning and trout fry (<15 cm) follow a near-identical very gradual increase in WUA with flow. HSI declined with increasing flow for all five salmonid species/life stages, with the rate of decline being greatest for salmon fry (<55 mm) at flows between 41 and 68.5 $m^3/s$.
- **Angling.** Two of the angling suitability curves (Rangitata (suitability) and Waitaki) showed a steep linear increase in WUA with increasing flow, while there was very little change in WUA with flow for the Rakaia or Rangitata (weighted) salmon angling curves or for adult salmon holding water. HSI increased with flow for all five of the salmon angling curves and the adult salmon holding water curves

- **Native birds.** The Waimakariri black-fronted tern curve showed a steep decline in WUA as flow increased from 41 to 52 m³/s, followed by a more gradual decline to 63 m³/s, then a gradual increase at higher flows. In contrast, the Rangitata black-fronted tern curve showed a nearly linear increase in WUA with flow. Wrybill plover feeding habitat showed virtually no change in WUA or HSI with flow. The Rangitata black-fronted turn curve also showed virtually no change in HSI with flow, while the Waimakariri curve showed a steep decline in HSI as flows increased from 41 to 63 m³/s, followed by a gradual decline.

In the heavily braided Crossbank reach of the Waimakariri River studied, a halving of flow from 85 to 41 m³/s resulted in a relatively small reduction in mean depth of 0.07 m (ca 17% reduction), but a relatively large decrease in total wetted channel width of around 90 m (ca 28% reduction). Recent habitat modelling studies in braided reaches of the Waitaki River (Jowett 2002, 2006), showed that a seven-fold decrease in flow from 350 to 50 m³/s resulted in a 2.5-fold decrease in the wetted width, but mean depth decreased by only around 0.14 m (a 21% decrease). In a similar study in the Rangitata River, Duncan & Hicks (2001) found that a nearly six-fold decrease in flow from 80 to 15 m³/s decreased mean water depth in the order of 0.25 m, a halving of mean depth. In the Rakaia River, a near halving of river flow from about 132 to 70 m³/s resulted in an approximately 25% decrease in wetted area, and no appreciable change in mean depth (Glova & Duncan 1985). These studies in braided reaches of the Waitaki, Rangitata, Rakaia, and Waimakariri Rivers indicate that due to the relatively wide and shallow nature of minor and major braided channels, flow changes result in a large change in wetted width, but little change in depth in braided rivers. This small reduction in mean depth with reduced river flow is the reason why instream habitat for many species changes little with flow in the Waimakariri River, at least over the range of flows modelled.

Salmon angling showed the greatest increase in WUA with flow of the 27 different species/life stages examined by Golder Kingett Mitchell (2007b). The reason for this is that each of the different salmon angling suitability curves all have optima at depths >1 m and velocities >1 m/s and these physical conditions are restricted to major braids and higher flows in the Waimakariri River. However, as pointed out by Duncan & Hicks (2001), some caution needs to be exercised when interpreting WUA vs flow curves, as they do not take into account the effect of water clarity on angling suitability. Thus, optimal angling in the Rangitata River occurs when water clarity is reduced, but not muddy-looking, at around 70-80 m³/s in spring and 50-60 m³/s in summer; considerably lower than the WUA vs flow plots would suggest (Duncan & Hicks 2001).

In the Rakaia River, optimal fishing conditions occur on the receding limb of a fresh, when clarity (measured using a black disk) is in the order of 0.5 to 1.0 m (Glova 1987, 1988). Similarly, rule-of-thumb optimal angling conditions in the Rangitata River (elucidated at the Water Conservation Order hearing) occur when an angler can see the toe of their gumboot in knee-deep water, which is roughly equivalent to black disk clarity of around 0.4-0.5 m. In the Waimakariri River, water clarity of 0.4 to 1.0 m occurs on average at flows of around 50 to 85 m³/s (Kingett Mitchell 2006b). Based on observations in the Rakaia and Rangitata Rivers, and correlations between flow and water clarity in the Waimakariri River, optimal water clarity for fishing may occur as waters clear after a recent fresh, at flows of around 50 to 85 m³/s. Thus, optimal angling conditions in the Waimakariri River based on the relationship between flow and water clarity occur at lower flows than would be predicted by the habitat modelling results presented above.

As stated in the previous section, CPW have offered mitigation that may include not taking water during any minor freshes or floods following periods of sustained low flow. This mitigation measure would also help protect optimal angling conditions during antecedent river flow conditions.

## 2.5 Effects on Wetland Habitats

In the November 2007 Section 92 letter, ECan requested further information concerning effects of the CPW water takes on wetlands. As discussed above, the proposed CPW take will have no appreciable impact on existing flows in the Rakaia River, due to minimum flow restrictions and flow sharing rules. This, combined with the fact that CPW will be taking water at flows considerably higher than mean low flows or even median flows, suggest that the CPW take will have no significant effect on riparian groundwater levels and associated wetland habitats (Golder Kingett Mitchell 2007a). This section therefore focuses on effects of the CPW take on riparian wetlands of the Waimakariri River.

Riparian wetland habitats adjacent to the Waimakariri River were previously described by Kingett Mitchell (2006b). In addition, Grove (2006) recently described the ecological values of Sanctuary Swamp, a significant wetland habitat bound by stopbanks near Coutts Island.

The following paragraph describes the relationship between Waimakariri River flows and shallow groundwater levels, and is taken directly from Kingett Mitchell (2006b):

> *Brown (2001) reported that between 5 – 8 $m^3/s$ of surface water is lost to groundwater from the Waimakariri River downstream of Halkett, and shallow groundwater that feeds orthofluvial [riparian tributary streams outside the active fairway] spring-fed streams is most likely sourced from the river. Interactions between the Waimakariri River and shallow groundwater have been studied extensively using two arrays of shallow wells adjacent to the river's south bank in the vicinity of Halkett and further downstream at Crossbank (White et al 2001). Following high river flow events (in the order of 400 $m^3/s$), groundwater levels in wells located closest to the river increased by around 0.02 to 0.03 m. Recent research undertaken by Meridian in the lower Waitaki River (downstream of Waitaki Dam) indicates that a reduction in median flow from 369 to 140 $m^3/s$ (a nearly 230 $m^3/s$ reduction) will result in an average reduction in shallow groundwater levels of approximately 0.5 m (unpublished data). Thus, reduced river flow has the potential to reduce flows and water levels in riparian wetlands and orthofluvial spring-fed streams adjacent to the Waimakariri River.*

Effects of the CPW take on riparian and wetland vegetation was assessed by Kingett Mitchell (2006b) as follows:

> *The proposed scheme has the potential to affect riparian and wetland vegetation through an altered flow regime and through altered groundwater levels affecting wetland hydrology. Riparian vegetation in large braided rivers is controlled by large bed moving flood events. Because the proposed scheme will not affect the frequency or size of large bed moving flood events any effects on riparian vegetation are expected to be minor.*
>
> *Studies in the Waitaki, Waimakariri and Wairau Rivers which have assessed the effects of reduced river flows on wetland water levels have generally shown that the effects of reducing river flows on wetland water levels is small. Based on studies within the Waitaki and Waimakariri River catchments the water take for the proposed scheme may result in a small decrease in water levels in wetlands. Wetland vegetation within the potentially affected portion of the catchment is dominated by species that are relatively tolerant of fluctuations in water level and the effects of the scheme on wetland vegetation is expected to be minor.*

The above assessment remains unchanged with the new flow series data provided by URS. Further to the above assessment, recent groundwater modelling by Aqualinc (Weir 2007) also indicates that effects of the take on riparian groundwater levels will be moderated by a general increase in groundwater levels in the Central Plains area. This effect is discussed in greater detail in Section 3 below. In addition, based on a recent review of the ecologically significant Sanctuary Swamp (Grove 2006), management issues of potentially greater concern to biodiversity and ecological functioning of riparian wetlands of the Waimakariri River include control of exotic plants (including willow, gorse and broom), animal pests, and manipulation of water levels caused by river engineering works, such as stopbanking.

## 2.6 Effects on Water Quality

### 2.6.1 Introduction

In the Section 92 letter, ECan asked for information regarding effects of the CPW take on water quality in the Waimakariri River, particularly effects of reduced assimilation capacity on diffuse pollution and point source discharges, principally the PPCS discharge in the lower Waimakariri River. These effects were assessed previously by Kingett Mitchell (2006b) and effects were assessed as being minor. This section re-evaluates the earlier assessment of Kingett Mitchell (2006b) using the new Waimakariri River flow data (described in Section 2.2 above). The focus here is on effects of the take on diffuse pollution, focusing on dissolved nutrients), and on point source pollution from the PPCS discharge. Effects of the CPW take on water temperature and clarity are considered minor, based on the analyses presented in Sections 4.3.2 and 4.3.3 of Kingett Mitchell (2006b); this is due to the poor relationship between temperature and flow, and the relative contribution of higher clarity spring-fed tributaries in the lower reaches of the Waimakariri River, particularly during periods of low mainstem flow.

### 2.6.2 Effects on Diffuse Pollution

Kingett Mitchell (2006b) assessed effects of the CPW take on diffuse pollution using a load-based mass balance approach. The updated URS river flow data was used on the same water quality data previously used, to assess effects of the CPW take on dissolved nutrients at the National River Water Quality Network site near State Highway One (SH1) and immediately upstream of the Otukaikino Creek confluence. The predicted changes in water quality in the Waimakariri River between the Gorge and SH1 sites are shown in Figures 6 and 7 as cumulative frequency plots, where water quality before and after the CPW take are compared

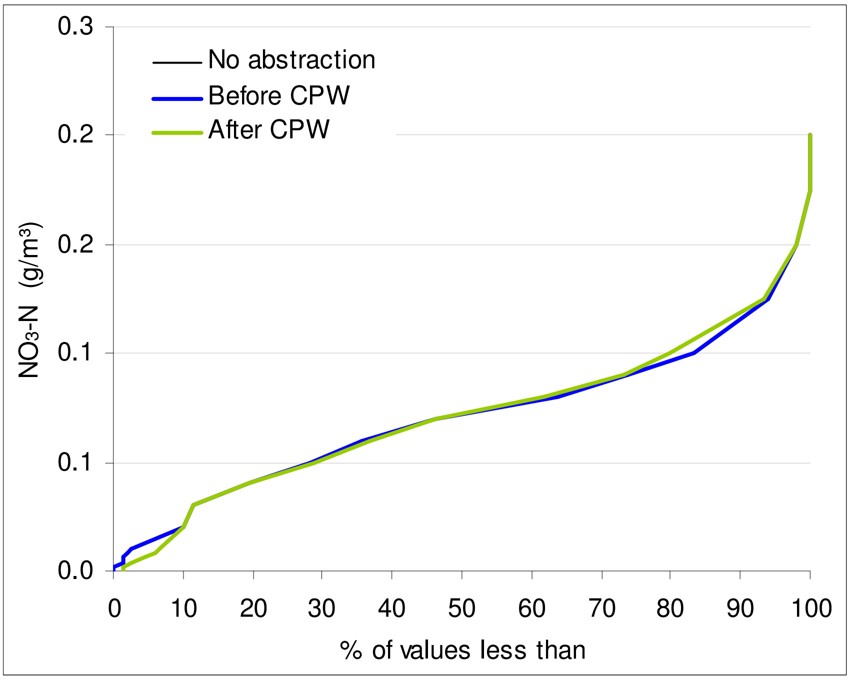


**Figure 6: Frequency of nitrate-N ($NO_3$-N) concentrations in the Waimakariri River immediately upstream of Otukaikino Creek, near SH1. Data are based on modelled flows from URS.**

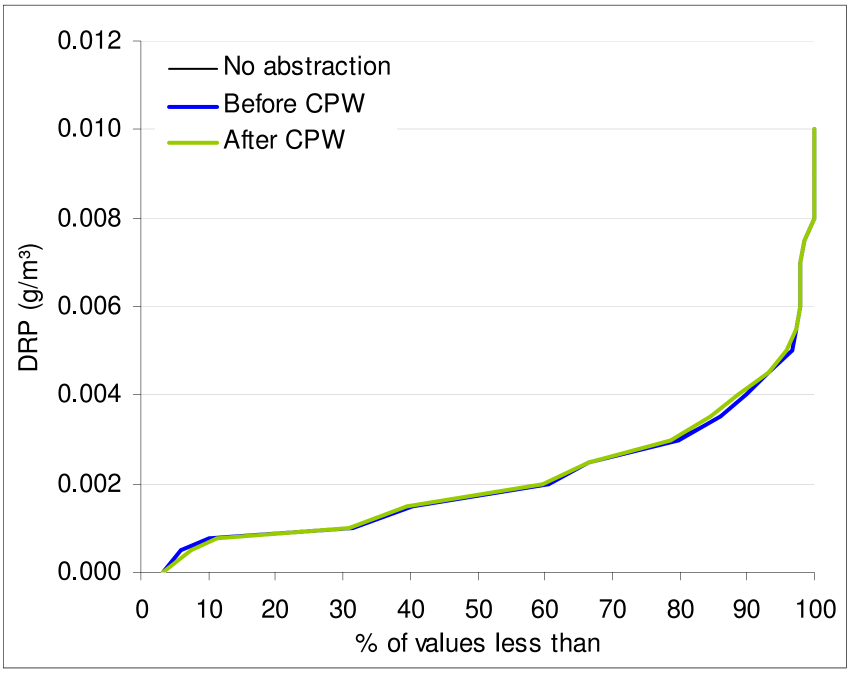


**Figure 7: Frequency of dissolved reactive phosphorus (DRP) concentrations in the Waimakariri River immediately upstream of Otukaikino Creek, near SH1. Data are based on modelled flows from URS.**

Based on the revised river flow modelling data provided by URS, the CPW take is predicted to have a negligible effect on nitrate nitrogen and dissolved reactive phosphorus concentrations upstream of the Otukaikino Creek confluence (Figures 6 and 7). This suggests that the CPW water take will not exacerbate the effects of diffuse sources of pollution on nutrients. Periphyton biomass is affected by both nutrient supply and flood disturbance frequency. These data indicate that the take should not affect periphyton nutrient supply upstream of the Otukaikino Creek confluence. Effects on water quality downstream of the Otukaikino Creek confluence and the PPCS discharge are discussed below.

### 2.6.3 Effects on Point Source Discharge Contaminants

The model used to assess the effects of the PPCS discharge on water quality in the lower Waimakariri River is described in Kingett Mitchell (2006b). Given that the PPCS discharge rate is governed by river flows at the Old Highway Bridge flow recorder, the maximum consented discharge rate was assessed against the modelled river flows to determine whether the discharge rate was likely to be compromised by reduced river flows. This was re-assessed using the updated URS river flow data. When river flows are below 23 $m^3/s$, PPCS are not able to discharge at a maximum rate of 0.23 $m^3/s$ (equating to the consent limit of 20,000 $m^3/day$). Under the Before CPW scenario (described in Section 2.2 above), this would occur on 14 days of the 34 year record or 0.11% of the time. The ability to discharge at the full rate was not compromised further by the After CPW flow scenario. Under the no abstraction scenario, PPCS could discharge at their maximum consented rate all of the time.

The assessment of effects on consent limited parameters in the PPCS discharge, described in Kingett Mitchell (2006b), was used to predict any changes in water quality in the lower Waimakariri River, as a result of the PPCS discharge and reduced flows from the CPW take. While this assessment predicted a negligible to minor change in various contaminant concentrations, it did not take into account background concentrations of contaminants already in the river. This was difficult due to disparity between the PPCS consent limited parameters and parameters measured in the National River Water Quality Network (NRWQN) data set.

The only parameter common to both datasets, that could be modelled to assess a maximum load in the PPCS discharge combined with the background in-river concentration at SH1, is ammoniacal-nitrogen ($NH_4$-N). The resultant data set predicts that in-river $NH_4$-N concentrations downstream of the PPCS discharge may increase slightly, as shown in Figure 8. The model predicts that in-river $NH_4$-N concentrations may increase by a median of 0.03 $g/m^3$ and a maximum of 0.13 $g/m^3$. Any resulting increase in $NH_4$-N in the lower Waimakariri River are considered to be minor and are well below USEPA (1999) toxicity criteria for ammonia. Compliance with in-river consent limits is not predicted to change as a result of the CPW take.

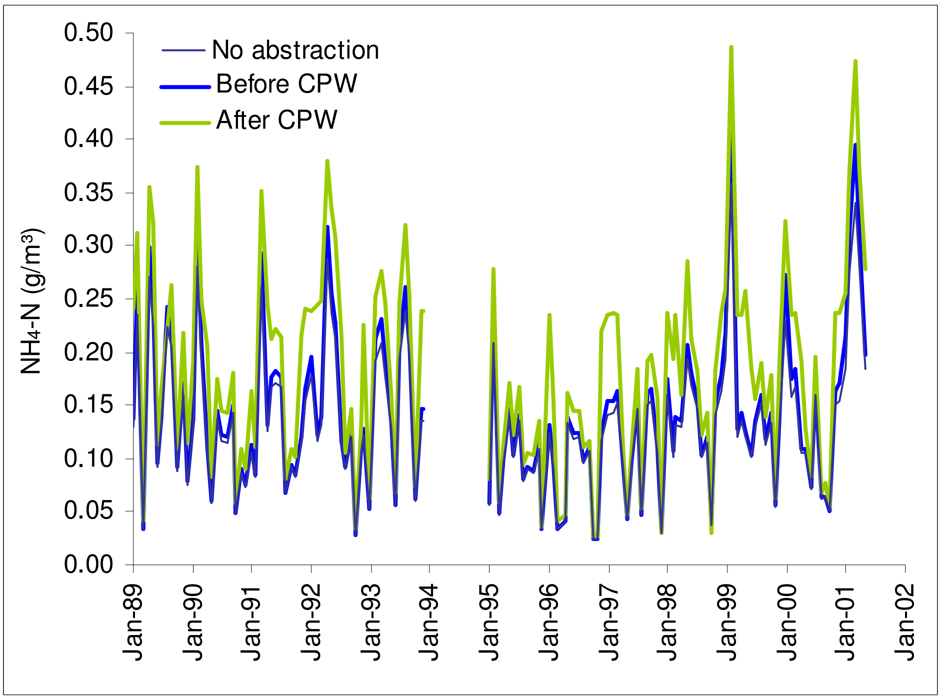


**Figure 8: Predicted ammoniacal nitrogen ($NH_4$-N) concentrations in the Waimakariri River downstream of the PPCS discharge, near State Highway One. Data are based on modelled flows from URS.**

# 3.0 CONSTRUCTION EFFECTS AND MITIGATION

Questions were raised by ECan in the Section 92 letter concerning effects of works in the bed of the Rakaia and Waimakariri Rivers on terrestrial ecology and wetlands. Construction effects were addressed in an earlier assessment (Kingett Mitchell 2006c), and are outlined in greater detail here. Furthermore, draft management have been developed by URS, and these include management plans for construction, site rehabilitation, and control of weeds and animal pests.

The CPW intakes and associated infrastructure (e.g., sediment settling ponds) will be located in or adjacent to the bed of the Waimakariri and Rakaia Rivers. These two rivers are well recognised iconic braided rivers, that support a diverse range of natural and other values (e.g., recreation and cultural).

General areas of concern during construction identified by Kingett Mitchell 2006c include:

- Permanent loss of habitat where structures are established.
- Temporary habitat disturbance or loss due to construction processes (e.g., vehicle tracking, spoil stock piling, amenities area establishment).
- Physical gravel movements.
- Loss of topsoil and dust generation.
- Ground exposure leading to sediment mobilisation and possible weed invasion.

- Weed introductions on vehicles and in construction materials.
- Animal pest/predator introductions which may threaten bird species.
- Vegetation disturbance/loss.
- Bird breeding habitat disturbance/loss.

Particular habitats or species of concern known to occur or potentially occurring in the vicinity of the intake locations include:

- Braided river bird habitat, especially for black-fronted tern (nationally endangered) and waybill (nationally vulnerable).
- Dry shrubland in the vicinity of the Waimakariri Gorge Bridge.
- Spring and associated floodplain wetland downstream of the Waimakariri Gorge Bridge.
- The upper Waimakariri River intake crosses or is in the vicinity of Hacketts Creek, which provides valued salmonid spawning habitat.

Impacts on braided river bird habitat will be localised and are not considered significant, given the abundance of other available habitat present in each of the rivers and the temporary nature of the disturbance. However, effects on other habitats present may be more significant, depending on the exact location and final design of the intakes. Mitigation is therefore considered necessary and further details of this mitigation is now available than was available at the time of the earlier assessment (Kingett Mitchell 2006c).

URS have drafted a number of management plans as part of a comprehensive Environmental Construction Management Plan (ECMP) for the CPW development, and these plans will be further refined closer to the consent hearing in early 2008. The overarching objective of the ECMP is to avoid, remedy or mitigate the potential adverse effects of the construction activities on ecosystems, people and communities, natural and physical resources, amenity values and the social, economic, aesthetic and cultural conditions that pertain to the CPW development area. Destruction of significant vegetation and ecosystems will be avoided as far as is practical, and measures put in place to mitigate effects. Of particular relevance to construction effects is the draft site rehabilitation plan.

Relevant mitigation measures outlined in the draft site rehabilitation plan (at the time of writing) are as follows:

**Management Objective:** To ensure that all construction areas not subject to operational buildings, permanent structures and access roads are rehabilitated as far as is practicable to a natural state, taking into account the time it takes for rehabilitation to occur.

- All practicable measures shall be undertaken to restore the construction site to a “natural” environment using locally sourced native species.
- Development of a rehabilitation plan including plant species list, landscaping plan and maintenance schedule.
- All plants to be eco-sourced from the area or propagated from seeds collected prior to felling.

- Regular maintenance (monthly) of rehabilitated areas to ensure plants become well established.
- Annual weed survey to be carried out (detailed in the Weed Management Plan)
- Control of animal pests (detailed in the Pest Management Plan)
- On completion of work at any location, all plant, equipment, fuels, hazardous substances, temporary buildings, fencing, signage, debris, rubbish and any other materials brought onto site shall be removed, and the site left clean.
- All areas disturbed by spoil disposal, vegetation clearance, and soil disturbance shall be rehabilitated with all rehabilitation and restoration activities will be undertaken in close consultation with DOC.
- A Stormwater Management Plan will remain in place until cover has established on exposed surfaces.

# 4.0 EFFECTS OF WATER USE

## 4.1 Introduction

In the Section 92 letter, ECan made a number of enquires related to effects of landuse intensification and increased drainage from the CPW scheme on groundwater levels, lowland stream flows and surface water quality. These issues were addressed in earlier assessments of effects (e.g., Kingett Mitchell 2006a), however since that time the groundwater modelling has been revised by Weir (2007) and URS (2007). This section briefly summarises the key findings of the additional modelling, then discusses the implications of the modelling for aquatic and terrestrial ecosystems in the Central Plains area.

## 4.2 Effects on Groundwater Levels

Effects of increased drainage from the CPW irrigation area on groundwater levels have been assessed by Aqualinc (Weir 2007). The Aqualinc model predicted groundwater levels for a dry year (1969), wet year (1978) and an average year (average of all years modelled) before (i.e., the "status quo") and after irrigation with CPW water. The general findings of the modelling are similar to those assessed previously by Aqualinc (2006). Key findings of the more recent Aqualinc modelling (Weir 2007) are as follows:

- CPW will increase groundwater levels and lowland stream flows.
- The maximum increase in groundwater level (so-called "mounding") is in the order of 3, 8, and 16 m for wet, average and dry years, respectively. However, this mounding is most pronounced in locations where the current depth to groundwater is 10, 25, and 30 m below ground level, respectively.
- There is predicted to be a minor (~3.6-6.5%) increase in the total area between the Waimakariri and Rakaia Rivers where groundwater is present at (or near) the groundwater surface under the CPW scheme compared with the status quo. However, this increase in area occurs in areas where groundwater is naturally shallow under the current status quo scenario.

- The general direction of groundwater flow will be unaltered by the CPW scheme. Thus, groundwater flow pathways and hence contaminant transport will remain unchanged.

## 4.3 Effects on Stream Flows

Effects of increased drainage from the CPW irrigation area on river flows have been modelled by Weir (2007). Figure 9 shows the increase in stream flows immediately downgradient of the CPW irrigation area in an average year following CPW, as predicted by Weir (2007). Key findings of the Aqualinc (Weir 2007) modelling are as follows:

- Lowland stream flows will increase following CPW, with the magnitude of increase greatest in the Selwyn and Irwell Rivers (a doubling of base flow), immediately downgradient of the irrigation area.
- The general spatial pattern of flow intermittency in streams such as the Selwyn River and headwaters of Doyleston Drain will remain the same following CPW. However, during average to dry years the river will begin to flow at a location further upstream than under the current situation and the flows will be greater. Thus, CPW will decrease the longitudinal length of dry river bed and increase flows.
- Increased groundwater levels buffer the effect of flows abstracted from the Rakaia and Waimakariri Rivers, resulting in a smaller reduction in river flow than what would occur by the diversion alone.

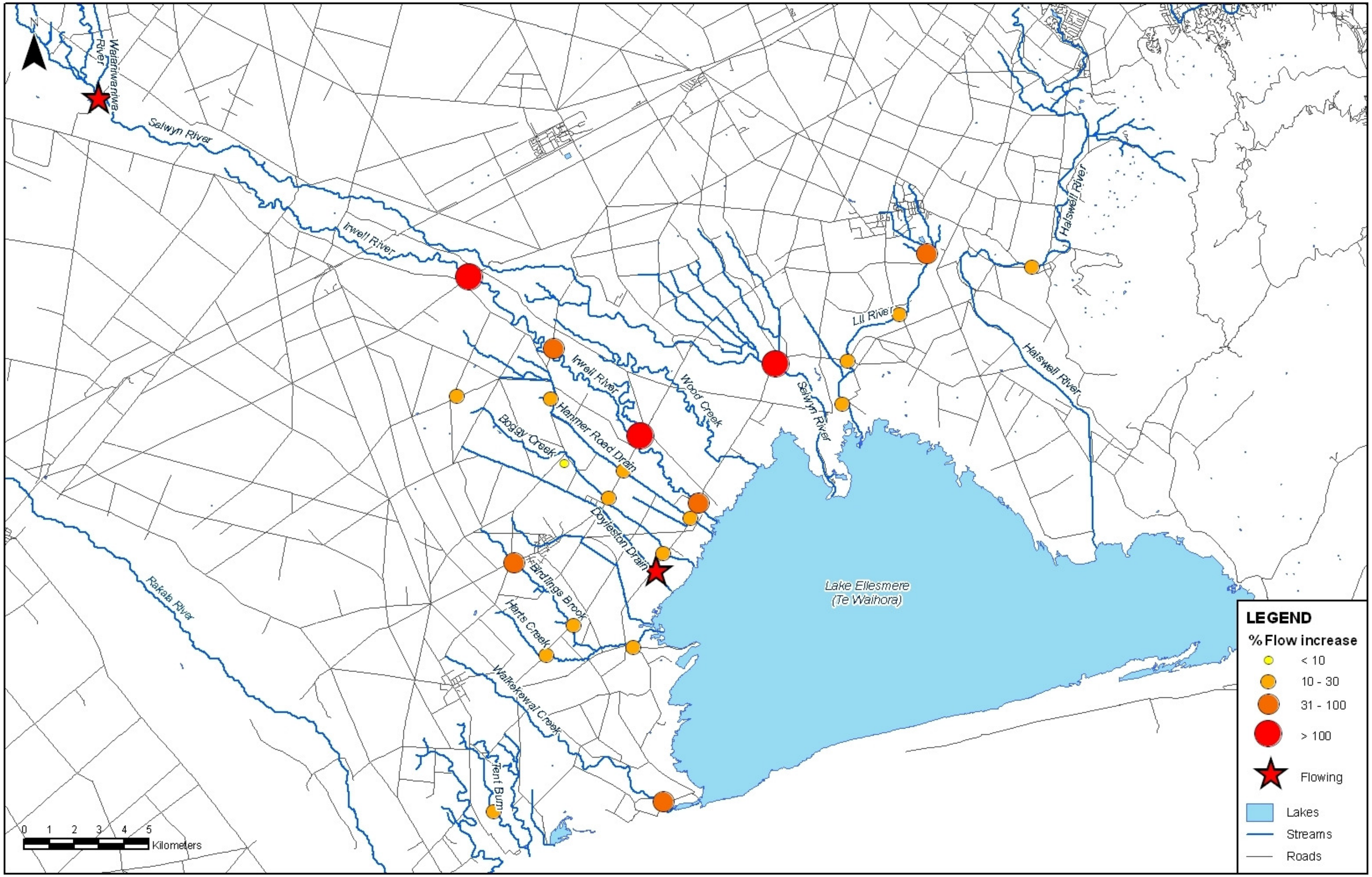


**Figure 9:** **Predicted effect of the CPW scheme on average flows in lowland streams. Stream flow data are from Weir (2007). Star symbols indicate sites that are currently dry that would be flowing following the CPW scheme.**

## 4.4 Effects on Lake Ellesmere Levels and Opening

Freshwater inputs to Lake Ellesmere come from tributary rivers and streams, groundwater, and rainfall, however tributaries provide by far the greatest proportion of freshwater inflows into the lake (Taylor 1996). Thus, increased flows in tributary streams may increase lake levels and overall lake area. Furthermore, because lake levels are artificially controlled, any increased inflows may require the lake to be opened more frequently to the sea, to maintain the desired lake levels.

Effects of the CPW scheme on lake opening frequency was recently assessed by ECan hydrologist Graeme Horrell for the period 1970-1991 using the Lake Ellesmere water balance model (Taylor 1996) and predicted groundwater and surface water inputs from the Aqualinc groundwater model (Weir 2007). Key findings of the lake water balance model area as follows (pers. Comm. Mark Mabin, URS):

- Mean annual level of Lake Ellesmere increased from 782 mm before CPW and 840 mm after the scheme, an increase of 58 mm or 7.4 %.
- The highest increase in level was in August (+150 mm) and the lowest was in June (-5 mm). Significantly the months that in pre-CPW conditions had the highest levels (June and July) showed no change or a slight fall in level under the post-CPW scenario.
- Mean lake area will increase from 191 km² pre-CPW to 194 km² post-CPW. This 2 % increase in area is slight, and would be well within the natural range of variability of lake area.
  - The pre-CPW lake area has varied from 150-217 km² (1994-2007 data).
- Increased freshwater inflows and slightly higher average water levels in the lake will increase the number of lake openings required by on average one opening per year.
  - Thus, the average frequency of land openings following CPW increases from 3.6 to 4.6 openings per year. CPW Ltd propose to fund the costs of these extra openings.

It is noted here that the revised model predictions for lake opening frequency are similar to the increase of one or two lake openings per year assessed by Kingett Mitchell (2006a, c). Figure 10 shows ECan data for the number of lake openings per year, overlain with the modelled changes in mean opening frequency predicted by the water balance model.

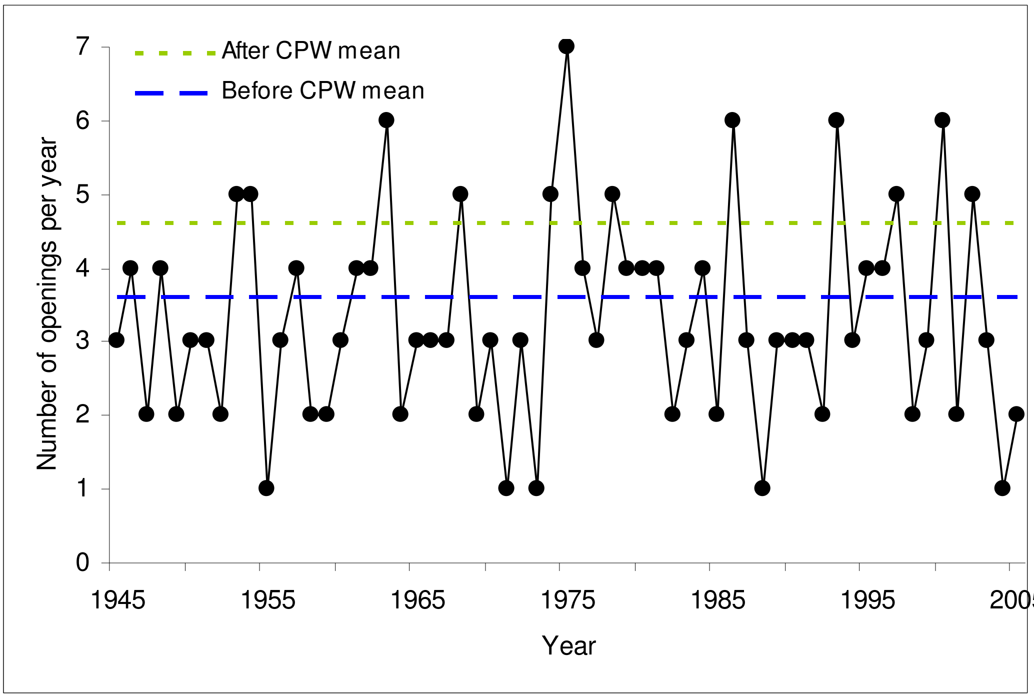


**Figure 10: Number of Lake Ellesmere openings per year compared with modelled means before and after CPW. Mean data are from URS.**

## 4.5 Effects on Nitrate Loading and Concentrations

Effects of CPW on nitrate concentrations in groundwater were originally assessed by Aqualinc (2006), and predictions have recently been revised by URS (2007). The conclusions of the revised modelling, which excluded any specific mitigation measures being assumed for the CPW landuse scenario, are as follows (URS 2007):

- Landuse intensification under CPW will increase the median loading of nitrate-nitrogen to groundwater from the CPW irrigation area by 81%.
- The nitrate loading to Lake Ellesmere will also increase, but to a lesser extent, as the CPW irrigation area represents only a part of the entire lake catchment and not all of the CPW irrigation area will drain directly into Lake Ellesmere.
- CPW will not have a significant adverse impact on groundwater nitrate concentrations. This is because the increased nitrate loading will be diluted by the additional irrigation drainage water and losses to groundwater of river water from the headrace canal and distribution network.
- Water quality of the lowland springs and streams is geochemically similar to that of the shallow groundwater. As there is expected to be no significant change to shallow groundwater quality, it is expected that there will be no change to the water quality in lowland springs and streams.

Thus, the revised modelling predicts no adverse effects on water quality in lowland stream tributaries to Lake Ellesmere. However, there will be an increase in the total annual loading of nitrate to the groundwater system, and Lake Ellesmere, associated with landuse intensification and increased irrigation drainage to ground.

## 4.6 General Ecosystem Implications

The combination of landuse intensification, increased nutrient loading to freshwater systems and increased groundwater levels and lowland stream flows could result in a number of possible outcomes for aquatic and terrestrial ecosystems downgradient.

Based on the groundwater quantity assessment of Weir (2007), nitrate model results of URS (2007), and original assessment work of Kingett Mitchell (2006c) the following potential issues and generalisations may be derived:

- Increased groundwater levels could adversely affect dryland vegetation communities but benefit freshwater wetland ecosystems.
  - Effects on dryland vegetation communities are discussed further below (Section 4.7).
- Increased stream flows and greater flow permanence will generally increase habitat available for aquatic species.
- Increased freshwater inflows into Lake Ellesmere will not greatly increase wetland area, but will necessitate more frequent artificial openings to the sea. Increased overall lake salinity may be the result, although water may become more freshwater dominated around tributary inflows.
  - This may favour more saltmarsh-type brackish water plant communities over freshwater vegetation overall. However, the area favourable for freshwater wetland communities may increase around the mouths of tributary inflows.
  - Based on recent surveys of the lake, saltmarsh vegetation is likely to be dominated by native species. However, any increase in freshwater wetland habitat will be tempered by the threat of invasion by exotic crack willow.
- Increased frequency of lake openings will generally provide greater opportunities for migratory freshwater fish species (e.g., eels and sea run brown trout) to migrate between the sea, lake and its tributaries.
  - Timing of openings is important (e.g., spring lake openings are optimal for eel migration).
- Increased nitrogen loading into Lake Ellesmere is unlikely to result in significant increases in phytoplankton productivity, toxic algal blooms or anoxia because:
  - Phytoplankton in the lake are limited by light, not nutrients (Larned & Schallenberg 2006);
  - The lake is shallow and well mixed, so issues associated with stratification, anoxia and blue-green algal blooms (associated with deeper eutrophic lakes) are unlikely.
  - Nutrient concentrations will not be significantly affected by the increased loading, due to dilution with increased freshwater inflows.

- Nitrate concentrations in Lake Ellesmere will also be moderated by more frequent openings to the sea and dilution with sea water.

The following section provides a more detailed assessment of effects on dryland plant communities, due to their potential susceptibility to groundwater increases. The subsequent section focuses on Lake Ellesmere, as it is the largest and most ecologically significant wetland in the Central Plains area.

## 4.7 Effects on Dryland Vegetation and Habitats

The Section 92 letter requested further information regarding the potential effects of increased groundwater levels on remnant indigenous dryland vegetation and habitats. Significant remnants of terrestrial native vegetation are very uncommon on the Canterbury Plains, due to the long history of land clearance for farming. Because of their relative rarity, any remnants of indigenous vegetation are potentially significant in the Central Plains area. Kingett Mitchell (2006c) provided a map (Figure 3.1) and a list (Appendix 3) of areas of significant conservation interest to the Department of Conservation. The following dryland sites of significance are worthy of particular mention:

- **Rakaia Terrace Dry Shrublands.** Numerous narrow threads and patches of dry shrubland on terrace risers along the north bank of the Rakaia River. These shrublands extend for about 5 km along high terraces on the north bank of the Rakaia River, extending downstream from about 3 km downstream of the Rakaia Gorge. Characteristic species include matagouri (*Discaria toumatou*), porcupine shrub (*Melicytus alpinus*), silver tussock (*Poa cita*), kowhai (*Sophora* sp.) and broadleaf (*Griselinia littoralis*).
- **Bankside Kanuka Shrublands.** Considered by DOC as the best examples of kanuka shrubland between the Rakaia and Waimakariri rivers. Includes dry kanuka shrubland with native broom and matagouri. Includes the DOC-administered Bankside Scenic Reserve
- **Waimakariri Dry Remnants.** Numerous small remnants of cabbage tree and kowhai treeland, and scattered matagouri and kanuka shrubland. Between the Waimakariri and State Highway One, from around Courtenay to just northeast of Yaldhurst.
- **Waimakariri Gorge Bridge Dry Shrubland.** Located around the rocky south bank wall at the Waimakariri Gorge Bridge. A diverse shrubland with many species typical of desiccated thin soils, including prostrate kowhai, kohuhu, poroporo, and tutu. Considered by DOC as the largest and least modified site of this type in the area.

Increased groundwater levels caused by the CPW scheme have the potential to affect areas of significant dryland vegetation. This is because dryland plant communities are characterised by hardy, drought-tolerant species, and increased groundwater levels and soil moisture may favour more vigorous drought-sensitive species. To assess this potential effect, groundwater level data provided by Weir (2007) were overlain with the location of known significant dryland vegetation sites, to compare where groundwater levels would change the most and hence identify the potential threat to dryland plant communities. It is recognised that there will be other as yet unidentified areas of significant dryland vegetation in the area; however, the sites chosen for assessment are of particularly high value and cover a wide geographical range of the Central Plains area. Furthermore, it is not feasible to survey the entire Central Plains area for areas of significant vegetation, particularly given that much of the land is privately owned.

- Figure 11 shows that groundwater levels in the vicinity of the Bankside and Rakaia Terrace shrublands generally occur tens of metres below ground surface, and are therefore unlikely to be affected by increased groundwater levels.

- Figure 12 shows modelled shallow groundwater levels in an average year (average of all years modelled) before and after irrigation with CPW water.

- Figure 12 shows that groundwater levels in the vicinity of the Bankside and Rakaia Terrace shrublands generally occur tens of metres below ground surface, and that this will remain the case following the CPW scheme. The Waimakariri Dry Remnants and Gorge shrubland occur in areas where groundwater levels are relatively shallow and are therefore potentially more susceptible to groundwater level changes. However,

Figure 12 shows that groundwater levels are predicted to change very little in these locations. This is because the greatest groundwater level changes are generally experienced immediately downgradient of the CPW irrigation area, and effects in the vicinity of the Waimakariri River are considered to be negligible.

It is therefore concluded that, based on the groundwater modelling results provided by Aqualinc, areas of significant dryland vegetation will not be adversely affected by increased groundwater levels as a result of the CPW scheme. Based on the low risk of potential effects, no mitigation is considered necessary.

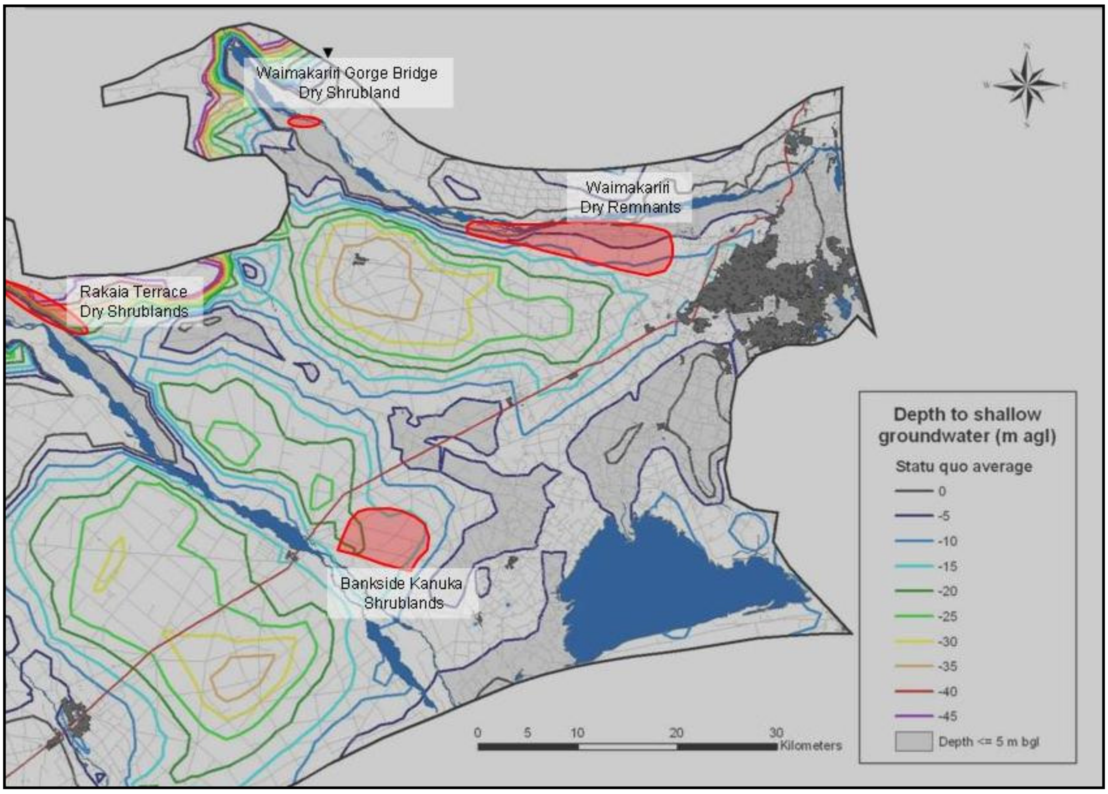


**Figure 11: Location of significant dryland vegetation (in red) in relation to modelled existing groundwater levels for an average year. Groundwater data are from Weir (2007).**

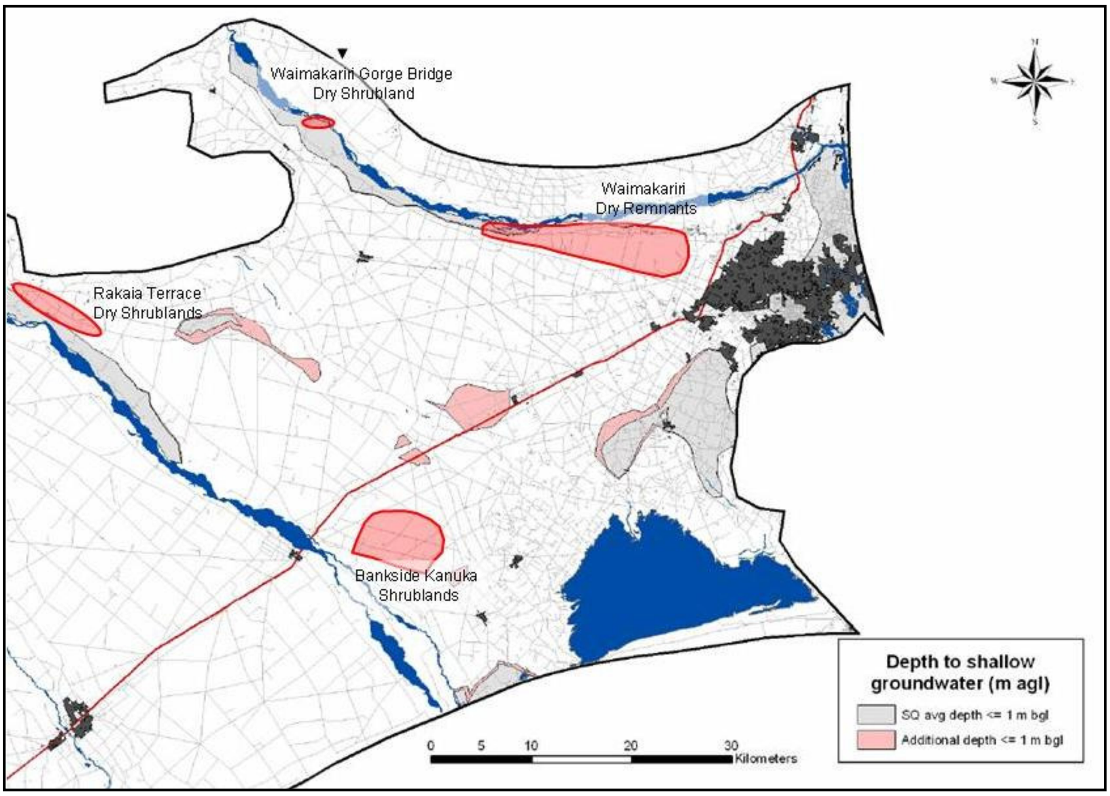


**Figure 12: Modelled distribution of shallow groundwater under existing conditions (grey) and following CPW (pink) in an average year in relation to areas of significant dryland vegetation (red). Groundwater data are from Weir (2007).**

## 4.8 Effects on Lake Ellesmere

The Section 92 letter requested the following information in relation to Lake Ellesmere:

- Effects of increased freshwater inflows on Lake Ellesmere salinity and consequences for lake shore vegetation and wildlife habitat.
- Effects of increased freshwater inflows and nutrients on lake shore vegetation and wildlife habitat.
- Effects on changes to quality and quantity freshwater inflows on the balance of indigenous vs exotic vegetation.

Lake Ellesmere is a complex environment, with its ecology strongly influenced by its artificial opening regime and windswept, turbid nature. Increased frequency and/or duration of lake openings will increase lake salinity, favouring saltmarsh-type vegetation communities and (depending on timing) migration of migratory freshwater fish species (e.g., eels and sea-run brown trout). Less frequent lake openings and higher lake levels would greatly increase wetland habitat and favour freshwater vegetation, but would reduce opportunities for freshwater fish migration and be done at the expense of productive farmland.

Kingett Mitchell (2006c) assessed effects of CPW on Lake Ellesmere as follows:

- Changes in salinity, determined both by mixing of seawater with freshwater surface flows and groundwater seepage, will have a role in determining local wetland species and distributions around river inflows.
  - The frequently submerged aquatic and wetland vegetation (e.g., macrophytes, rushes, reeds and sedges) would benefit slightly from any local reductions in salinity and increased frequency of water level fluctuations, which reduces periods of exposure.
  - Halophytic (saltmarsh) species/communities (e.g., glasswort (*Sarcocornia quinqueflora*) and sea primrose (*Samolus repens*)) would be noticeably disadvantaged by any significant reduction in salinity and in the length of aerial exposure, especially around river inlet channels.
- Agricultural pasture immediately adjacent to the lake may be harmed by increased lake salinity.
  - However, it is noted that lake edge soils are saline at present, and this is unlikely to change appreciably.
- A major aereal increase in wetland vegetation is unlikely.
- Nutrients are currently non-limiting in Lake Ellesmere (Taylor 1996) and therefore wetland vegetation growth is unlikely to change significantly with the input of additional nutrients transported in surface-flows.
  - Taylor (1996) lists lake salinity, lake openings, lake levels, temperature, turbidity and oxygen levels as more important factors affecting wetland plants than nutrient concentrations (in addition to human modification effects).

This assessment remains largely unchanged with the revised lake opening and groundwater quality data. However, recent vegetation survey data from ECan highlights the uncertainty inherent in predicting effects of changing water levels on lake ecosystems. In a comparison of wetland vegetation patterns observed in 2007 with those of 1983, Grove (2007) concluded that an overall (albeit very small) decrease in brackish wetland and increase in freshwater wetland areas over the last 25 years was probably a response to lower average lake levels and reduced frequency of lake openings. Spread of willows was the major cause of increased extent of wetland vegetation, at the expense of native vegetation. This recent work suggests that increased freshwater inflows and an associated increase in lake openings would in fact favour a greater predominance of brackish or saltmarsh wetland at the expense of freshwater vegetation. However, greater inflows into the lake from major tributaries such as the Selwyn River would also be expected to favour freshwater wetland species in the vicinity of the lake inflows.

Overall, it is difficult to predict with great certainty the effects of the CPW scheme on the relative balance of brackish vs freshwater ecosystems in Lake Ellesmere. This is because any effects of increased groundwater levels or nutrient loading will likely be masked by the frequency and duration of lake openings. Freshwater and brackish wetland communities both have inherent ecological value, and their relative contribution to the total wetland community will have changed over time as the lake makes the gradual transition from an open estuary to an enclosed barrier lake.

Of greater potential concern is the relative dominance of indigenous and exotic vegetation around the lake. Grove (2007) noted that native-dominated vegetation cover declined from 54% in 1983 to 35% in 2007, with spread of willows being the main reason. Hughey & O'Donnell (2007) also recently highlighted the importance of willow control for protecting bird habitat, due to willow invasion of raupo swamp areas that provide important bird habitat. Protection of native wetland habitat is also a priority for protection of native fisheries (Jellyman & Smith 2007) and sea-run brown trout fisheries (Holland 2007).

It is recommended that CPW Ltd contribute to protection of Lake Ellesmere ecosystems through the use of its proposed Environmental Management Fund (EMF). A tangible benefit the EMF could make is in contributing towards control of crack willow. Willow control would stand to benefit indigenous plant communities and improve habitat for native birds, and possibly also benefit native fisheries and the sea-run brown trout fishery.

## 4.9 Mitigating Effects of Landuse Intensification

As mentioned above, CPW have prepared a number of draft environmental management plans and consent conditions, to avoid and mitigate adverse effects of landuse intensification. Of particular importance in avoiding effects on water quality are robust farm management plans. The following lists the draft consent conditions relating to farm management plans that users of CPW will be required to adhere to.

**Farm Management Plans (draft from URS)**

- The use of water from the CPWES for irrigation shall be undertaken in accordance with an individual Farm Management Plan.
- A template is to be used as a basis for the individual Farm Management Plans. The Farm Management Plan shall cover the following management areas:
  - Irrigation;
  - Soils;
  - Nutrients;
  - Collected animal effluent;
  - Biodiversity & ecosystems;
  - Waterways and riparian zones;
  - Agrichemicals;
  - Energy.
- The Farm Management Plans shall include the following requirements:

  (a) That all new irrigation infrastructure is designed and accredited by a qualified professional, and installed in accordance with the accredited design. The design shall take into account the specific requirements of any individual fragic pallic soils on the property.

(b) That, for any property receiving water from the Scheme that is currently using existing irrigation infrastructure that has not received design approval from an accredited designer, the consent holder is provided with an evaluation report prepared by a certified irrigation evaluator within 12 months of the property first receiving water from the Scheme, and any upgrades identified in the report are implemented within the following 12 months, in order to achieve efficient water use.

(c) That a nutrient budget is prepared and implemented for all properties receiving water from the Scheme.

(d) That mechanisms are implemented to ensure that cattle, pigs, and deer are excluded from Rivers and Wetlands (as defined in the Resource Management Act 1991) and their margins adjoining land being irrigated.

(e) That any potential mudfish sites, from which cattle, pigs, and deer are not otherwise excluded in terms of (d) above, are surveyed by an appropriately qualified person and, if found to be actual mudfish habitat, then mechanisms are implemented to ensure that cattle, pigs, and deer are excluded from such sites in accordance with (d) above, or an equivalent habitat is provided and the mudfish relocated to the alternative habitat.

(f) That, for each property, for each 12 month period ending 30 June:

(i) Either, it is demonstrated, via the nutrient budget required in (c) above, that the average total nitrogen (fertiliser and effluent) application has been less than 200 kgN/ha/yr; or

(ii) Approved methods are used to undertake calculations or measurements of the average annual concentration of nitrate nitrogen in the soil drainage below the plant root zone and the actions in (iii), (iv) or (v) below are implemented depending on the calculated or measured nitrate concentration. For the purposes of this rule, approved methods shall be:

- Calculations using either the most recent version of the OVERSEER® model or the most recent version of the Soil Plant Atmosphere Model (SPASMO); or
- Any other method of calculation or measurement approved by the Canterbury Regional Council.

(iii) Where the average annual concentration of nitrate nitrogen in the soil drainage water below the plant root zone as calculated in accordance with clause (ii) or measured, for the property exceeds 8 grams per cubic metre, management practices are implemented to reduce the loss of nitrate nitrogen to soil drainage water. These may include but not be limited to:

- Split applications of fertiliser.
- Timing of fertiliser application to plant growth.
- Avoiding application of fertiliser to saturated soil.
- Avoiding applying fertiliser when the soil temperature at 10 cm depth is less than 10°C.

(iv) Where the average annual concentration of nitrate nitrogen in the soil drainage water below the plant root zone calculated in accordance with clause (ii) exceeds 12 grams per cubic metre of nitrate nitrogen:

- Nitrification inhibitors, winter cover crops, or appropriate technology or management practice, implemented to reduce the loss of nitrate nitrogen to soil drainage water.

(v) Where the average annual concentration of nitrate nitrogen in the soil drainage water below the plant root zone calculated in accordance with clause (ii) or measured, exceeds 16 grams per cubic metre of nitrate nitrogen:

- The average total nitrogen (fertiliser and effluent) application to that property is limited to 200 kgN/ha/yr.

(g) That the following records are kept for each property and made available to the consent holder, in a form that is suitable to be made available to Canterbury Regional Council on request:

(i) Timing and rate of inorganic fertiliser applications;

(ii) Timing and rate of nitrification inhibitor applications;

(iii) Stocking rates (number and type of animals) on an annual basis; and

(iv) Land uses, including timing and type of cultivation activities.

- The farm management plans will be audited by an independent assessor. For the first two years of receiving scheme water each farm plan will be audited annually. After that time each plan will be independently audited at least once every 5 years. A programme of incentives will be developed, and those achieving full compliance will have longer periods between audits than those who do not. Following each independent audit the water user will receive an audit report and will be required to remedy any problems that are identified.

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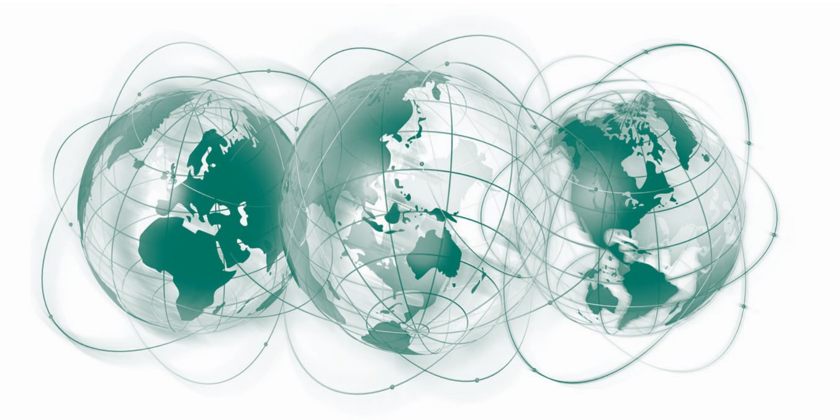

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