
and

in the matter of: an application for resource consent CRC071029 by the South Canterbury Irrigation Trust and Meridian Energy Limited to take and use water from the Waitaki River

BRIEF OF EVIDENCE OF DIANA ROBERTSON
Terrestrial Ecology and Wetlands

November 2007
1.0 INTRODUCTION

Qualifications and experience

1.1 My name is Diana Margaret Robertson and I am an ecologist with Boffa Miskell Limited, a national consultancy company specialising in planning, landscape design and ecology. I am based in the Christchurch office, where I am a Principal Ecologist.

1.2 I have the qualifications of Bachelor of Horticultural Science Honours in Ecology from Lincoln University (1988) and Masters of Horticultural Science Honours in Ecology from Massey University (1990). I have been practising as a professional ecologist since 1990 and have been a member of the New Zealand Ecological Society for that period.

1.3 The majority of my professional work has been in the South Island focusing on assessments of ecological significance, assessment of ecological effects of proposed developments, sustainable land management and management for biodiversity values. I have been involved in investigations of the terrestrial ecological values of the lower Waitaki River from March 2001 to the present for the Project Aqua proposal, for Waitaki Regional Plan investigations, North Bank Tunnel Concept (NBTC) investigations and for this Hunter Downs Irrigation (HDI) water consents application. Other recent jobs include ecological assessment, mitigation and monitoring design for White Hill wind farm in Southland and for Canterbury Waste Services’ application for the landfill at Kate Valley.

1.4 Over the past six years I have spent more than 45 days in the lower Waitaki River valley, in many separate visits, investigating wetland and terrestrial ecology values and the potential effects associated with different projects, as well as two hikoi and several site visits for consultation. I have also spent 3 days at Wainono Lagoon and in the surrounding area.

1.5 In preparing my evidence I have reviewed:

- The Code of Conduct for Expert Witnesses (Rule 330A, High Court Rules and Environment Court Practice Note) and agree to comply with it.
- The joint South Canterbury Irrigation Trust and Meridian’s resource consent application for water-only consents for a Hunter Downs Irrigation (HDI);
- The Assessment of Environmental Effects for this application;
- Relevant parts of the Waitaki Catchment Water Allocation Regional Plan;
- Other HDI technical reports and evidence of Mr Brian Ellwood, Mr Walter Lewthwaite, Mr Roddy Henderson, Mr Ian Jowett, Dr Murray Hicks, Dr John Stark, Dr Don Jellyman, Mr Eric Graynoth, Mr Ian Fraser, Mr Ned Norton, Mr. Rob Potts, Mr Victor Mthamo, Mr Rob Greenaway and Ms Claire Mulcock.
- Relevant submissions of others.
- The Officer’s Report and Technical Appendix 8, the review of wetlands and terrestrial ecology by Dr Philip Grove of ECan and Dr Rob Jessop of Golder Associates.

**Scope of evidence**

1.6 I have been asked by the applicants to prepare evidence in relation to terrestrial ecology and wetlands. This evidence is concerned only with the take, use and discharge of the water required for the HDI scheme.

1.7 I have separated my evidence into five main sections:

- The values of, and effects of the proposed irrigation flow regime on:
  - riverbed vegetation between Stonewall and the sea (Section 2)
  - braided river birds between Stonewall and the sea (Section 3)
  - wetlands between Stonewall and the sea (Section 4)
- The values of, and effects of the proposed irrigation take on, wetlands and terrestrial ecological values at the location of the take (Section 5); and
- The values of, and effects of the proposed irrigation on, the wetland and terrestrial ecology of Wainono Lagoon and lowland streams (Section 6).

1.8 In Section 7, I summarise the recommended mitigation and monitoring.
Investigations and Methodology

Waitaki River

1.9 The assessments carried out for Project Aqua in 2001-2003 form the basis of the HDI assessment on terrestrial ecology and wetlands below Stonewall, with additional information from NBTC assessments and specific work undertaken for HDI.

Vegetation

1.10 Changes in types and extent of vegetation in the lower Waitaki riverbed were analysed by NIWA using aerial photos from 1936 to 2001. Current vegetation was surveyed during the Project Aqua, WRP, NBTC and HDI field surveys.

Braided River Birds

1.11 Five repeat surveys of braided riverbed birds were undertaken in spring 2001 and spring 2005 from Waitaki Dam to the mouth. The methodology was designed, in consultation with the Department of Conservation, to allow some comparison to surveys undertaken in the last 30 years\(^1\) and to provide a solid baseline for future surveys. The river was divided into 11 sections, surveyed using 6 personnel by jet boat and on foot and all wetland and river bird species were counted and recorded. Predator trapping was also undertaken after the bird surveys in 2001 to determine the suite of predators present in the lower Waitaki and their potential to access breeding bird islands. Dr Sanders in his evidence for NBTC, described further work that was undertaken in 2006/2007. In summary this investigated the relationship between flow around islands and breeding success of black-fronted terns, and tested the effectiveness of short-term, localised predator control around tern colonies. The trial was conducted on braided rivers of the upper Waitaki catchment. Egg and chick survival was monitored at ten colonies, including four on islands surrounded by flows of between 0.059 and 3.13 \(m^3/s\).

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Wetlands

1.12 NIWA and Boffa Miskell worked together to assess the aquatic and terrestrial values of wetlands in the lower Waitaki Valley during the Project Aqua investigations. The wetlands were located using previous survey reports\(^2\), aerial photos, classified satellite imagery, topographical maps and aerial and ground surveys. All the wetlands listed in Table 1 (Appendix 1) were field surveyed in 2001 and 2002 for area, condition, vegetation and birds and a representative sample of these were surveyed for macrophytes, macroinvertebrates and fish in 2002. A comprehensive database was built up, and linked to a GIS mapping system, with historic and current data for each wetland including ecological values, location, area, land uses, hydrology and recorded recreational or cultural uses. All wetlands were classified firstly as riparian, terrace and estuarine wetlands, which I will define further in section 4 of my evidence, and secondly by the wetland national classification framework classes\(^3\) of hydro-system, sub-system, structural class and dominant species.\(^4\)\(^5\)

1.13 Most wetlands below Stonewall were field checked in 2007 for general current condition and extent.

1.14 Accurate measurements and survey of all riparian wetlands were not made due to the dense gorse shrublands that limit access in much of the riparian area, and the willow canopy which limits the ability to measure all areas by aerial photos or other remote sensing methods. Estimate of area and values of these wetlands were therefore made by combining information from the Landcover Database\(^6\), transects and examination of aerial photos, oblique

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\(^4\) The wetland condition recording sheet derived for MfE(5) and used in the proposed NRRP had not been derived at the time for these surveys. However the information collected at the time would allow completion of most of the new recording sheets. Maps not released as they were done for area estimation and analysis, but not considered accurate enough yet for the basis of future monitoring.


aerial photos, aerial assessments (plane and helicopter) and ground and river surveys.

1.15 Wetlands within some of the mahika kai sites below Stonewall were visited with representatives from Te Runanga o Arowhenua, Te Runanga o Waihao and Te Runanga o Moeraki and Te Runanga o Ngai Tahu in 2002. The ecological values were recorded for these sites as well as the historic and contemporary cultural values. Mapping and further cultural values were obtained from a cultural report prepared for Project Aqua.

Waitaki Irrigation Flow Regime Assessments

1.16 The likely effects of 5 proposed Irrigation Flow Regimes were assessed using flow modelling work provided by Meridian Energy, analysis undertaken by Dr Hicks, Mr Jowett, Mr Henderson and Mr Fraser and analysis of high quality aerial and oblique aerial photographs taken during the low flow trial of 2001.

1.17 The assessments were concerned with determining the differences in the terrestrial ecological and wetland values below Stonewall with the proposed Hunter Downs irrigation abstraction (up to 20.5 m$^3$/s), utilising either a 150 m$^3$/s or a 100 m$^3$/s minimum flow at the sea, and the current flow regime. The differences, with respect to terrestrial ecology and wetlands, between the existing with HDI (i.e. up to 76.5 m$^3$/s), described by Mr Henderson as “HDI 150 Existing + HDI” and “HDI 100 Existing +HDI”, and the full 90 m$^3$/s abstraction are not considered to be sufficient to analyse separately. Therefore the effects analysis for HDI is based on a full 90 m$^3$/s allocation, other than where I make specific comment. In addition the full 90 m$^3$/s allows for assessment of the likely cumulative abstraction effects.

1.18 I have therefore used the following 3 flow regimes for my assessments, as described by Mr Henderson in his evidence. Each of these are modelled to show the predicted flows given specified irrigation takes and minimum flows and using historic flow data from 1931 to 2004:

- **HDI Status Quo (HDI Status Quo, existing irrigation).** This regime approximates the current situation with up to 56 m$^3$/s of irrigation takes,
with effectively 150 m<sup>3</sup>/s minimum at Waitaki Dam (120 m<sup>3</sup>/s consented minimum with a 30 m<sup>3</sup>/s operational buffer) and a 80 m<sup>3</sup>/s minimum for irrigation takes.

- **HDI150Full (Full WRP abstraction with 150 m<sup>3</sup>/s minimum flow).** This flow regime assumes up to 90 m<sup>3</sup>/s is abstracted for irrigation and other uses with a 150 m<sup>3</sup>/s minimum flow below the most downstream abstraction (effectively Bell’s Pond). The irrigation takes are assumed to vary throughout the irrigation season, and include the existing consented 56 m<sup>3</sup>/s, the proposed HDI (20.5 m<sup>3</sup>/s) and the additional potential 13.5 m<sup>3</sup>/s that is allowed for in the WRP allocation.

- **HDI100Full (Full WRP abstraction with 100 m<sup>3</sup>/s minimum flow).** This flow regime assumes up to 90 m<sup>3</sup>/s is abstracted for irrigation (including the proposed HDI take of 20.5 m<sup>3</sup>/s) and other uses and a 100 m<sup>3</sup>/s minimum flow below the most downstream abstraction take (effectively Bell’s Pond). The abstraction assumptions are the same as outlined above for HDI150Full.

Wainono and lowland streams

1.19 I undertook a review of existing information<sup>8</sup> and a site visit in June 2007 to assess values and I used the analysis of effects from URS and NIWA, as described by Mr Fraser, Mr Norton and Dr Jellyman in their evidence to assess potential effects.

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2.0 RIVERBED VEGETATION

2.1 In this part of my evidence I will describe the riverbed vegetation values in the lower Waitaki and assess the effects of the irrigation flow regimes on those values.

2.2 The riverbed vegetation in the lower Waitaki is largely driven by exotic plant invasion, vegetation management works (willow control, planting and layering), grazing patterns and river flows. This has resulted in a diverse pattern of braided river vegetation. Willows and shrublands of gorse and broom dominate the river margin, with smaller areas of native as well as exotic herbaceous vegetation. Crack willow trees are extensive along both banks and are scattered over the riverbed, between braids and on old river courses. Gorse and broom shrublands also occupy large areas of the stable riverbed and are not specifically controlled under the current vegetation management programme. Between the adjacent developed pasture on both riverbanks, the riverbed width varies between approximately 300 metres and 2 km. On average, a transect across the river has approximately 200 metres of willows and 300 metres of gorse and broom shrubland.

2.3 The native vegetation on the Lower Waitaki River has decreased and is continuing to decrease as a result of invasion of exotic species. Throughout the vegetation, bird and wetland surveys I noted that native vegetation in the braided river system is very limited. Native wetland species occur occasionally under the willows on the riverbanks. I will discuss this riparian vegetation further in section 4 of my evidence. Other native vegetation comprises mainly small mat and herb species sparsely distributed on relatively bare islands.

2.4 The overall trend in vegetation pattern over the last 70 years has been of increasing tall and shrubby exotic vegetation (mainly willows, gorse and broom) and decreasing gravels. Based on analysis from aerial photos, the amount of low and tall vegetation has increased since 1936 from an average of 112 to 655 metres width across the floodplain, while bare gravel has decreased from an average width of 380 to 133 metres. This pattern has continued despite the vegetation management work carried out by Environment Canterbury. With similar vegetation and river flow...
management, vegetation is likely to continue to encroach onto bare or sparsely vegetated gravels, further decreasing these areas.

Effects of Irrigation Flow Regimes on Riverbed Vegetation

2.5 A change in flow regime in the river has the potential to affect riverbed vegetation if there are changes in the flooding size, frequency and duration or flow variability.

2.6 Floods currently have some role in clearing vegetation in the river flood plain. In his evidence Dr Hicks shows that flooding incidence is independent of irrigation extraction and that there is no significant difference in flood size with the different irrigation based flow regimes. Consequently the vegetation composition and disturbance that is driven by floods in the river is not anticipated to change with any of the proposed abstraction or minimum flow changes. As discussed by Mr Jowett in his evidence flow variability is also expected to be similar under the irrigation flow regimes.

2.7 Floods do not maintain a fairway clear of woody vegetation. In spite of the current occurrence and magnitude of floods, vegetation encroaches into the river fairway. The vegetation control undertaken by ECan currently limits the extent of willow encroachment but woody weeds and herbaceous vegetation extend across large areas. The extent of this encroachment is limited by, in addition to the flooding regime, the amount of predominantly exposed gravels available for vegetation establishment. The modal flow of a regime (the most commonly occurring flow) is an indicator of relative exposed gravel extent. Comparing modal flows is therefore a guide to the potential difference in vegetation encroachment that would be expected under the different flow regimes. Dr Hicks’ analysis predicts the relevant width of exposed gravel, which is therefore vulnerable to vegetation encroachment, would increase from 325 m under the Status Quo up to 345 m for both the modelled HDI150Full and HDI100Full abstractions. This is a 6% increase. The different minimum flows are not anticipated to affect vegetation encroachment. Dr. Hicks predicts the HDI takes alone (modelled as HDI 150 Existing+HDI and HDI 100 Existing+HDI) would result in a 4% increase in
vegetation encroachment over the HDI Status Quo, in other words a slightly lower increase than the full 90 m$^3$/s modelled abstraction.

2.8 There is therefore a potential for a slight increase in vegetation encroachment with increased abstractions irrespective of minimum flows. Dr Hicks suggests a small increase in the existing vegetation control works may therefore be required under the HDI150Full or HDI100Full flow regimes, or HDI 150 Existing+HDI and HDI 100 Existing+HDI, to maintain the current level of cleared fairway.

2.9 I have also considered any cumulative effects that there might be on the river below Stonewall if the NBTC proposal was to proceed. However the NBTC would not significantly alter the flow regime below Stonewall, and therefore would not affect issues such as vegetation growth and control, braiding intensity, and flood management in that reach. Consequently it would not compound any of the effects discussed above.
3.0 BRAIDED RIVER BIRDS

3.1 In this part of my evidence I will describe the braided river bird values in the lower Waitaki and assess the effects of the irrigation flow regimes on those values.

3.2 The 2001 and 2005 surveys, between the Waitaki dam and the mouth, recorded 28 and 26 braided river bird species respectively, including three types of shag, heron, swan, two species of geese, six species of duck, two types of oystercatcher, two species of stilt (and a hybrid), four types of plover, three types of gull, three types of tern, godwit and a spoonbill. The most numerous species (counted during the surveys) were black-backed gull followed by white-fronted tern, back-billed gull and black-fronted tern.

3.3 The reach from the Waitaki Dam to the bridge at Kurow has a low number of species, with gulls that tend to roost at the base of the dam being the most numerous. The reach between Kurow and Stonewall has the highest numbers of black-fronted tern, black-billed gulls, banded dotterels and paradise shelduck. The river below Stonewall has the highest numbers of black-backed gulls, white-fronted terns, red-billed gulls, feral geese, spotted shags and white-faced herons. Other species do not show such clear distinctions in distributions down the river. These distributions are based on breeding season counts.

3.4 Threatened braided river bird species below Stonewall included black-fronted tern, black-billed gull, white-fronted tern, wrybill and black stilt.

- The Waitaki River is important breeding habitat for the black-fronted tern (more than 650 birds counted in surveys), which has a threat rank of nationally endangered. Most of the breeding colonies are upstream of Stonewall, with no colonies below Stonewall in 2001 and 4 colonies below Stonewall (25% of colonies) in 2005.

- Two and three breeding colonies of black-billed gulls (threat status of serious decline) were recorded in 2001 and 2005 respectively with one of these being downstream of Stonewall both years.
• One large colony of more than 1300 white-fronted terns (threat status gradual decline) was present in 2001 and 2005. In both years the colony was below Stonewall.

• Six and four wrybills (threat status nationally vulnerable) were recorded on the whole river in 2001 and 2005 and were found above and below Stonewall. The Waitaki is not currently an important breeding site for wrybill.

• Three juvenile black stilt (threat status nationally critical), which had been captive reared and released from the upper Waitaki, were observed in 2001. While the lower Waitaki is not currently known to be a breeding site for black stilt it is possible that their numbers will increase with ongoing success in the upper Waitaki programme and the lower Waitaki could become an important breeding site in the future.

Significance

3.5 The lower Waitaki River, including the reach from Stonewall to the sea, is ecologically significant for its range of braided river bird species, including threatened species, and their habitats.

Threats

3.6 Of the key threats to braided river birds those that relate to flow regimes are predators, vegetation encroachment, feeding habitat and floods during the breeding season.

Predators

3.7 Birds that nest on islands in braided rivers appear to have increased breeding productivity, in comparison to mainland sites, probably because the islands are less accessible to mammalian predators. The Waitaki River,


with its many braids and wide fairway, has numerous islands. This “natural” protection on islands may have been an important factor to date in sustaining black-fronted tern numbers, and potentially other braided river specialists, in the lower Waitaki River. River flows are therefore considered to have an effect on braided river bird productivity, but the relationship between flow and island accessibility by predators is only understood at a very coarse level. In his evidence for NBTC Dr Sanders reported on recent work in the upper Waitaki, where even at very low flows (0.059 and 3.13 m$^3$/s) strong protective effects of predators not accessing the islands were shown. Predation events have however also been recorded across large flows$^{11}$ and predation risk is generally believed to increase with decreasing flows.

Vegetation encroachment

3.8 Braided river bird specialists appear to have a strong preference for clear gravels for breeding, which may make the birds less vulnerable to predators as they can see them approaching$^{12}$. Vegetation has encroached into the Waitaki riverbed since at least 1936. Vegetation encroachment reduces suitable bird nesting sites, as well as contributing to the trend of decreased braiding, which further reduces breeding, roosting and feeding sites for braided river specialists in particular.

Feeding Habitat

3.9 Braided river bird species rely on the presence of an appropriate and sufficient food source (aquatic invertebrates and fish) as well as their preferred velocities and depths of water for feeding. The current flow regime supports braided riverbed specialists, generalists and wetland bird species. It provides the range of water depths and velocities for feeding, and gravels and vegetated areas for breeding and roosting. Food (invertebrates and fish)

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does not appear to be a limitation for the braided river bird specialists in the Lower Waitaki. 13

Floods during Breeding Season

3.10 In natural braided river systems on the east of the South Island, high spring and summer flows are common with rapid and frequent flooding. Some of the braided river bird species have adapted to these conditions with ability to lay repeat clutches if early nesting fails.

3.11 Floods do occur during the breeding season in the Lower Waitaki River. Flows of near 500 m$^3$/s flooded some nesting sites in 2005. Flows of this magnitude or greater have occurred in 17 of the last 27 breeding seasons. In 5 of these breeding seasons flows were greater than 900 m$^3$/s, when major losses would have occurred. These flow records indicate therefore, that in at least half of the recent years, there is likely to have been some loss of breeding productivity as a result of high flows. The combination of floods with other pressures from predators and vegetation encroachment compounds low breeding productivity.

Effects of Irrigation Flow Regimes on Braided Riverbed Birds

3.12 Any effects on braided river birds of the irrigation flow regimes relate to effects on predators, vegetation, feeding habitat and flooding of breeding birds.

Predators

3.13 As I have discussed islands appear to provide some protection to breeding birds in the lower Waitaki River from predation, with quite small flows appearing to deter predators. There is little evidence of the quantitative relationship between predation events and flows. I have therefore assessed the potential effects of the flow regimes in terms of predation risk where I have assumed that with lower flows, where islands become part of the mainland or are surrounded by only small flows, the predation risk increases.

3.14 The bird breeding season overlaps with the irrigation season and therefore additional irrigation abstraction from the river has the potential to reduce flows around islands with breeding birds. The minimum flow also has the potential to affect predation as some islands may be more accessible at 100 m$^3$/s than 150 m$^3$/s. I have therefore assessed:

- Whether there are still islands present at 150 m$^3$/s and 100 m$^3$/s; and
- The occurrence of flows at or below 150 m$^3$/s (and 100 m$^3$/s) under the different irrigation scenarios.

**Presence of islands at lower flows**

3.15 Analysis of the 2001 aerial photos shows there are still numerous islands at 150 m$^3$/s and 100 m$^3$/s including islands with fast flowing water around them. However some of the islands present at higher flows (350 m$^3$/s) are part of the mainland at the lower flows, and some of those that remain as islands are surrounded by only small flows.

3.16 For example the photos show that the site used in 2005 by a large (1500+) white-fronted tern colony and small black-fronted tern colony (near Ferry Road) was surrounded by fast flowing water at 350 m$^3$/s. At 150 m$^3$/s the flows on one end of the island had reduced but were still present, and at 90 m$^3$/s there was no apparent flow separating this island from the mainland on one corner (Figure 1).

3.17 Another island, downstream of Borton’s Pond, had a large colony of black-billed gulls and small colony of black-fronted tern in 2005. The photos show that it still retained some flowing water between it and the mainland at 90 m$^3$/s, but it had become part of a much larger island and some of the surrounding flows were quite small (Figure 2).

**Occurrence of low flows under irrigation scenarios**

3.18 In order to assess any potential differences between the flow regimes I compared the number of days, within the susceptible part of the breeding season, with flows at or below 150 m$^3$/s, using the 73 years of modelled data (Table 3.1). I used the months of October to December as this is the period when a predation event is most likely to affect breeding success. (I note 150 m$^3$/s was chosen simply because we have low flow photo coverage at that
flow and because it is the minimum flow set in the WRP. A flow of 150 m$^3$/s does not represent any particular shift in the relationship of islands and their surrounding flows).

All years

3.19 The HDI Status Quo had an average of 8 days (of the 92 day breeding season) at or below 150 m$^3$/s, while the HDI100Full (and HDI150Full) had 12 days at or below 150 m$^3$/s (Table 3.1). The HDI Status Quo had an average of 2 days at or below 100 m$^3$/s while the HDI100Full had 6.

Table 3.1. Average and median number of days per "breeding season" (October-December incl), using 73 years of mean daily flows, and number of days in dry year 1977 that the river is at or below 150 m$^3$/s or 100 m$^3$/s under HDI Status Quo, HDI100Full and HDI150Full.

<table>
<thead>
<tr>
<th>Days in susceptible breeding season</th>
<th>At or below 150 m$^3$/s with HDI Status Quo</th>
<th>At or below 100 m$^3$/s with HDI Status Quo</th>
<th>At or below 150 m$^3$/s with HDI100Full</th>
<th>At 100 m$^3$/s with HDI100Full</th>
<th>At 150 m$^3$/s with HDI150Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average days per breeding season</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Median days per breeding season</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Number of days per breeding season in 1977 - dry year example</td>
<td>50</td>
<td>6</td>
<td>58</td>
<td>30</td>
<td>58</td>
</tr>
</tbody>
</table>

3.20 While this represents an average 50% increase in number of days per breeding season with the lower flows, from the HDI Status Quo to the HDI100Full, the actual number of days per season with low flows is still small. Predation risk, with respect to its relationship to flows, is therefore still likely to be low.

3.21 In an average, or wetter, year there is therefore likely to be little difference in risk between the HDI Status Quo and the HDI100Full for predators accessing islands at times of low flows.

Dry years

3.22 I have considered drier years separately as it is these years that predator risk is likely to be highest. In drier years the river will be at or near the minimum flows more frequently and for longer periods under all scenarios. I have chosen 1977 as an example of a dry year, as it is the same dry year

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example used by Mr Jowett and other witnesses, is one of the 10 dry years identified by Mr Henderson in his evidence and is also one of the 10 driest bird breeding seasons. In 1977 the HDI Status Quo had 50 days (of the 92 days in the breeding season) with mean daily flows at or below 150 m$^3$/s, compared with the average of 8 days, and median of 2 days at or below 150 m$^3$/s for the full 73 years (Table 3.1). Therefore in this example of a dry year, the river would be at or below 150 m$^3$/s for more than half the susceptible breeding season, indicating the risk of predation is likely to be higher compared with wetter years.

3.23 In 1977 the HDI Status Quo had 6 days in the breeding season at or below 100 m$^3$/s, while the HDI100Full had 30 days at 100 m$^3$/s. The HDI Status Quo flow was less than 130 m$^3$/s on all days that the HDI100Full was at 100 m$^3$/s, and on average 110 m$^3$/s. The increase in number of days of the lowest flows (100 m$^3$/s) therefore indicates an increase in predation risk in dry years with the HDI100Full in comparison with the HDI Status Quo but this difference in predation risk between the two scenarios is relatively small.

3.24 The higher minimum flow in the HDI150Full would decrease the risk compared with the HDI100Full. In the 1977 example there would be up to 58 days when the river would be lower under the HDI100Full than the HDI150Full, with approximately half of these days 50 m$^3$/s lower, that is the river at 100 m$^3$/s rather than 150 m$^3$/s.

3.25 Mr Jowett states that an extreme dry year such as 1977 is a 1 in 15 year event. This fits with my analysis as 1977 is the 5th driest breeding season in the 73 year record, based on number of days with flows at or below 150 m$^3$/s, under the 3 scenarios.

3.26 In summary the HDI100Full had more days at lower flows than the HDI Status Quo and this may slightly increase the risk of predation in drier years. The HDI150Full is less likely to increase predation risk over the HDI Status Quo, although there is still obviously predation risk under both these latter scenarios.

Affected species

3.27 The degree to which different species are potentially affected by changes in predation risk associated with flow changes depends on their distribution
along the river. Of the threatened bird species the white-fronted tern nests only below Stonewall and is therefore the most at risk from the proposed HDI100Full. While the black-billed gulls and black-fronted terns also breed in this reach they also breed upstream of Stonewall, with most of the black-fronted tern breeding colonies recorded upstream of Stonewall.

3.28 The increased risk of predation associated with HDI100Full over the HDI HDI Status Quo, therefore relates particularly to the white-fronted tern. It also relates to a lesser extent to the black-billed gull and black-fronted tern and to the more common braided river species that depend on flows to provide some protection from predators during the breeding season.

Summary and mitigation

3.29 In summary in average and wetter years there is unlikely to be any significant difference in the risk of island predation between the HDI Status Quo or HDI Full scenarios. In dry years (estimated at 1 in 15 years), all scenarios (including the HDI Status Quo) have a higher risk of island predation, than in wetter years, as a result of frequent persistent low flows in the breeding season. There is little difference in risk between the HDI Status Quo and HDI150Full but the lower minimum flow in the HDI100Full regime increases its risk relative to the HDI150Full regime (as well as the Status Quo). Of the threatened species the risk relates mainly to the white-fronted tern and to a lesser extent to the black-billed gull and black-fronted tern.

3.30 This risk cannot be quantified, given the lack of quantitative information regarding the specific relationship between flows and predation. The lower flows associated with HDI100Full could cause increase predation in occasional dry years and therefore could reduce breeding productivity, in those years, of white-fronted tern, black-billed gull and black-fronted tern. It would be very difficult to measure any changes in breeding productivity associated with a change in abstraction and minimum flow, given the unpredictable nature of predation events, and given the large variation in flows within and between seasons and the impacts of floods on these species under all scenarios.

3.31 I therefore do not recommend monitoring to specifically attempt to measure for effects. It is very unlikely that such monitoring could ascribe any changes
in breeding productivity overtime to flow changes associated with the irrigation abstractions. I therefore recommend that habitat enhancement is undertaken as mitigation for this potential effect. I recommend that 2 or 3 islands that are used by white fronted tern, black-billed gull and black-fronted tern, and that have protective flows around them, be enhanced using vegetation clearance to improve the potential breeding productivity in all years.

3.32 I also note that both the proposed future abstractions as well as the existing abstractions (which are included in the HDI Status Quo) have the same effect of increasing predation risk. There is no particular abstraction which in itself has a higher risk of affecting predation.

Vegetation encroachment and bird habitat

3.33 As I have already discussed some minor additional vegetation encroachment is anticipated with the proposed HDI irrigation take. Without additional vegetation control works this may result in a reduction of available breeding habitat for braided river bird specialists. Below Stonewall such habitat is particularly important for the threatened white-fronted tern and black-billed gull. I therefore support Dr Hicks’ recommendation to increase vegetation control works to mitigate for this increased encroachment. The additional vegetation control works required relates to the size of the irrigation abstractions. There would be more vegetation encroachment if the full 90 m$^3$/s is abstracted, as allocated for in the WRP, than if just this proposed HDI take is added to the current abstractions.

Food availability

3.34 Food is not currently considered to be a limiting factor for braided river bird species and the flow regimes associated with the different irrigation abstractions are not expected to cause it to become limiting.

Floods during breeding season

3.35 Above average flows in the bird breeding season have the potential to flood nests and reduce breeding productivity. As the breeding season coincides with the irrigation season the flows below Stonewall will be less during the breeding season under the range of irrigation scenarios than would occur
without irrigation takes. The reduction in flow magnitude will however be relatively small, up to 34 m$^3$/s for the HDI Full scenarios, which would be less than 7% of any flooding flows (flow greater than 500 m$^3$/s). This is unlikely to cause any notable reduction in flooding of breeding colonies or have any noticeable positive effect on breeding productivity.

Summary of HDI Effects on Braided River birds.

3.36 The HDI100Full scenario is not expected to change the braided river bird habitat with regard to feeding habitat and flooding of breeding birds. There is likely to be a marginal increase in vegetation encroachment and I support Dr Hicks' recommendation for additional works to control the additional vegetation in the fairway. The HDI100Full scenario may increase the risk of predation of breeding birds on islands particularly in dry years. This is of most relevance for the threatened species white-fronted tern, black-fronted tern and black-billed gull. For mitigation I recommend enhancement of 2 or 3 islands that are used by white-fronted tern, black-billed gull and black-fronted tern.
4.0 WETLANDS

4.1 “Wetland” is defined as “any permanently or intermittently wet areas, shallow water and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions” (RMA 1991, Environment Canterbury Regional Policy Statement). This definition is adopted in the Waitaki Regional Plan (WRP).

4.2 There is a history of vegetation change in the Lower Waitaki Valley driven largely by fire, agricultural development, drainage and the introduction of willows to the river margins.

4.3 In undertaking my assessment I have identified 3 distinct wetland types within the study area namely riparian wetlands, river terrace wetlands and estuarine wetlands:

- **Riparian wetlands** are adjacent to the Waitaki River, between the cleared fairway and intensively managed farmland, and have at least periodic surface inflows from the river.

- **Terrace wetlands** are away from the river edge and do not have surface water inflows from the Waitaki.

- **Estuarine wetlands** are those adjacent to the mouth of the river and are influenced by coastal processes and, in this case, low salinity conditions.

4.4 Most of the riparian and terrace wetlands are palustrine wetlands, that is, freshwater wetlands with emergent vegetation. Some of the larger open water wetlands can be classified as lacustrine as they have large areas of standing open freshwater and little if any emergent vegetation.

4.5 Wetlands in the Lower Waitaki Valley are extremely varied, and provide habitat for a diverse range of native and exotic plants (such as macrophytes, sedges, willows and reeds) and animals (fish, macroinvertebrates, terrestrial invertebrates and birds). They also act to varying degrees as a sink for nutrients and suspended sediment, with the result that waters flowing out of wetlands are generally of higher quality than those flowing in.

4.6 The wetlands of the Lower Waitaki Valley have a range of water sources. Wetlands on the flood plain of the river and underlain by the recent post
glacial gravels have the potential to be directly affected by the river flows in the Waitaki River as the groundwater levels are related to the river levels (as described by Mr Fraser in his evidence). However this relationship can be less direct, or wetlands can be fully independent of the river, where wetlands also receive water from springs from higher terraces, river tributaries, and irrigation channels. Most of the wetlands in the study area exist under conditions of highly fluctuating water supply due both to the large variability in flow in the Waitaki River and variability in irrigation/spring flows within and between seasons. I will discuss this further shortly.

4.7 Figure 3, shows the location of wetlands throughout the valley that have been assessed for values. Table 1, Appendix 1, lists the wetlands between Stonewall and the sea and summarises their values. I will now describe the main wetland types of all wetlands in the Waitaki Valley and summarise their ecological values.

Riparian Wetlands

4.8 The riparian areas of the Waitaki River are highly modified predominantly through:

- invasion by exotic trees and shrubs since the late 1800’s,
- agricultural development since the late 1800’s (I have noted further extensive agricultural development into the riparian areas in the 6 years that I have been working in the valley),
- altered and managed river flows for hydroelectricity since the 1930’s, and
- Active vegetation management in the river fairway and margins and river control works since the 1950’s.

4.9 This has resulted in a river fairway and riparian margins contained in a narrower width than would have occurred without these interventions and modifications. The width of the riparian area varies greatly. In places a main braid of the river immediately abuts farmland with no intermediate riparian vegetation or habitat. Conversely at its widest the riparian area between Stonewall and the sea is approximately 700 metres on any one bank.
4.10 There are approximately 2,890 ha of riparian area in the Lower Waitaki, with approximately 1,650 ha between Stonewall and the sea (I note this is based on 2001 aerial photos and is likely to be less now with interim agricultural development of these areas).

4.11 I estimate wetlands cover less than 100 hectares of this 1650 ha riparian area below Stonewall. The remainder of the riparian area is dominated by dryland ecosystems, of predominantly gorse and broom scrub and open willow forest.

Hydrology

4.12 The riparian wetlands consist of generally slow flowing channels, pools and swamps. Small side braids also occasionally flow through the riparian area. Most of the channels originate from springs sourced from adjacent floodplains, terraces and hills, which meander through farmland and then through the riparian area and into one of the braids of the river.

4.13 Water levels in the riparian wetlands are affected by the flow in the Waitaki River and to varying extents from springs, terrace seepages, irrigation and tributary rivers and streams. Field observations indicate that some of the riparian wetlands below Stonewall maintain more stable water levels than those observed and measured upstream of Stonewall for NBTC investigations. Mr. Fraser notes in his evidence that the border dyke irrigation systems elevate ground water levels and are likely to assist in maintaining spring flows and therefore wetland water levels.

4.14 The substrate of the wetlands is recent and dominated by gravels, sand and silt which are very porous allowing for easy flow between and within the groundwater.

4.15 As discussed by Mr Jowett and others the current flow regime of the Lower Waitaki River is one that varies greatly. The average daily fluctuation in the period 1996-2000, as described by Mr Jowett in his evidence, was about 80 m$^3$/s and the average 30-day fluctuation in the same period was about 300 m$^3$/s, which equate to average stage height fluctuations of approximately 15cm and 55 cm respectively (100 m$^3$/s change in river flow represents a stage height difference of approximately 18.5 cm, as described by Mr Fraser in his evidence). Such variation leads to variability in connectedness of the
riparian wetlands to the main braids of the river as well as variability in the
depth of water in the wetlands through changing (and interrupted) surface
water inflow and groundwater levels. At higher than average flows (400 m$^3$/s
plus) there will be increased surface water flow into the riparian areas
(limited though by natural river braid dynamics, river control works and
vegetation management) and higher groundwater levels leading to an
increase in connection between, backwaters, side braids and wetlands. As
the flow decreases the connections will also generally decrease with
interruption of surface flow potentially occurring depending on depth of water
bodies (the underlying contour of the substrate) relative to the surface and
groundwater flow. Different areas are therefore dewatered at different
Waitaki River flow levels.

4.16 The flow in the river and the connectivity of riparian wetlands is not however
a direct relationship as the wetlands and groundwater system is also
influenced by the springs, terrace seepages, irrigation and tributary rivers
and streams. The water level in a particular wetland in the riparian area is
therefore determined by a complex relationship between the underlying
contour of the substrate, the flow in the Waitaki River and to a lesser extent
the relative contribution of other sources of water.

Vegetation and habitats

4.17 The riparian area is dominated by exotic trees and shrubs, mainly crack
willow, gorse and broom and within the willow forests are areas of open
water, wetland vegetation, exotic shrublands and grasslands.

4.18 Native and exotic rushes and sedges are found amongst the grasses and a
range of plant species is found along the margins – almost totally comprised
of introduced species of herbs and grasses. Small monocultures of raupo
are also found along the margins and generally extend into open water.
Native ferns are also present along shaded permanent streams and
channels.

4.19 Anchored below permanent water level and floating on the surface of slow-
moving water in pools is a range of native and introduced macrophytes (for
example Potamogeton species and Myriophyllum species).
4.20 The flowing channels and swamps in the riparian areas provide habitat for short and long-finned eels. As discussed by Dr Jellyman in his evidence, the willow lined side braids of the river provide important daytime cover for adult long-finned eels. These are often braids in the fairway adjacent to the riparian area, as well as occasional places where they flow through the willow dominated riparian areas. Bully also utilise the riparian waterways.

4.21 The threatened Canterbury mudfish is present in riparian wetlands in the vicinity of Welcome Stream, near the State Highway 1 bridge (Figure 5). This is the southern most recorded site for the mudfish and they are present in a series of pools and spring fed channels in the riparian area.

4.22 With respect to wetland birds, the network of wetlands in the riparian areas (and adjacent river terraces) provide additional habitat for many of the braided river birds, as well as for birds preferring wetland habitats such as white-faced heron and black and little shag and the waterfowl, mallards, scaup and shoveler. The Waitaki River has been particularly recorded as providing primary habitat for swamp rails, which include bittern and marsh crake. These species however have been only infrequently recorded and the lack of native wetland vegetation or exotic tall wetland herbs is likely to limit the potential habitat.

Role of riparian area in water quality

4.23 The riparian area of rivers and lakes, with their associated wetlands, can play an important role in improving water quality through sediment filtration and retention, nutrient transformation and contaminant retention. In the lower Waitaki it is likely that the willows are playing the major role in any water quality improvement through their extensive root network. The occasional stands of raupo are also likely to be having role in the water quality of the surface and groundwater that flows around them. Previous NIWA studies on willow and raupo vegetation adjacent to Lake Okareka have demonstrated how important this vegetation is in reducing nitrogen run-off from catchments to water bodies.

Summary of riparian wetlands

4.24 While the riparian area is a substantial part of the lower Waitaki River the riparian wetlands are a relatively minor spatial component of this area. The
water levels in the wetlands are influenced largely by the Waitaki River but also by adjacent irrigation, tributaries and springs. The vegetation in the wetlands is generally species adapted to fluctuating water levels and dominated by exotic species. Native species include occasional stands of raupo, sedges and rushes on wetland margins and macrophytes. The riparian areas also provide habitat for eel, mudfish and bully and wetland bird species.

**Terrace Wetlands**

4.25 Terrace wetlands are made up of discrete wetlands and wetland complexes, found on the river floodplain and higher river terraces of the north and south banks of the Lower Waitaki River. These river terrace wetlands are away from the direct surface water overland influences of the river itself and are supplied with water from a range of sources including springs, groundwater and small streams. Some wetlands have been artificially created or enhanced, but most are formed by water collecting in natural landforms such as at the base of terraces or old braids of the Waitaki River. These wetlands are usually discrete entities, but are linked by natural watercourses, or watercourses that have been cleared and re-aligned as water races for agricultural use.

4.26 There are approximately 190 ha of discrete wetlands on the river terraces in the Lower Waitaki Valley, from Waitaki Dam to the Coast, ranging in size from less than one hectare to the large open water wetlands such as Bortons Pond (37ha).

*Note that Bortons Pond has been considered a terrace wetland as, while it is clearly directly fed by the river, the inflow channel is managed by gates and the wetland characteristics are more typical of a terrace wetland.*

**Hydrology**

4.27 Water level monitoring of wetlands for the assessment of NBTC has greatly increased our understanding of the hydrology of terrace wetlands and their different relationships with the flow in the Waitaki River. With distance from the river the response in groundwater levels to the river is more subdued...
and delayed, and irrigation on the terraces tends to be the key driver of water levels in wetlands at the base of the terraces.

4.28 Consequently the connectedness of different terrace wetlands, with adjacent wetlands and the river, also responds differently to changes in river flows. Those wetlands with direct relationships to the river respond as generally described for riparian wetlands where a decrease in river flow will decrease connectivity with different wetlands, and different parts of the same wetlands will lose surface water connection at different river flows. Other wetlands’ connectivity is driven by irrigation supply or takes, terrace seepages or a combination of these and the river levels.

Vegetation and habitats

4.29 A range of types of terrace wetlands, based on dominant vegetation, occur between Stonewall and the sea.

4.30 Just as in riparian wetlands adjacent to the Lower Waitaki River, the exotic tree and shrub species willow, gorse and broom are the most frequently occurring vegetation cover in discrete terrace wetlands. However, these species are not as dominant in individual terrace wetlands as they are in riparian wetlands.

4.31 Raupō occurs occasionally in pools, channels or swamps.

4.32 Carex secta occurs in many wetlands, but it is only abundant in two terrace wetlands both upstream of Stonewall.

4.33 Flax occurs infrequently in the Lower Waitaki Valley but is abundant in three wetlands. The largest intact flax dominated wetland is at Te Hua Taki. This is a largely spring fed wetland at the toe of a terrace, with some additional irrigation channel flushing. Other native species here include Carex secta, raupō, bracken, Coprosma propinqua and C. rigidula and the fern Blechnum novae zelandiae. Willows occur at the wetland edge. The other two wetlands with abundant flax are upstream of Stonewall.

4.34 There are a few lacustrine (lake) wetlands in the Lower Waitaki Valley. Most are artificially created or enhanced as a result of either irrigation schemes (Bortons Pond, Bells Pond) or for wildlife habitat (Eckhold’s Pond). Some of
the marginal areas around these lakes have either been planted in or have been allowed to develop into wetland vegetation.

4.35 Lacustrine environments, especially irrigation ponds, are often surrounded by a developed agricultural environment with pasture and grazing directly to the water edge.

Habitats

4.36 The network of terrace wetlands, as well as wetlands in the riparian area, provide additional habitat for many of the braided river birds as well as for birds preferring wetland habitats.

4.37 Similar fish species as those found in riparian wetlands are found in the terrace wetlands with species occurrence affected by connectivity to the river and habitat within the wetlands.

Estuarine Wetlands

4.38 At the mouth of the Waitaki River a large and dynamic estuary has formed. The mouth moves regularly and the river shifts within the estuary. The effects of salinity on the wetlands around the margin appear to be diluted by the large volumes of fresh water in the river. Despite this, a few coastal wetland plant species occur in the estuary, such as oioi, sea rush and glasswort which are not found elsewhere within the Lower Waitaki River system.

Current Threats and Trends in Wetlands

4.39 The extent and number of riparian and terrace wetlands in the Waitaki are following a national trend of decline. Much of this decrease has come about through the continuing development of land for agricultural production and the intensification of land use in already developed land.

4.40 The increasing invasion of exotic species into wetlands, particularly the more natural wetlands with high indigenous biodiversity values, is a high threat. Crack willow is the biggest problem as it establishes in and dominates wetlands by shading and out-competing other species. Willows are regarded as particularly problematic invaders in wetlands, as they are ‘transformer’ weeds that can alter hydrology, increase siltation, and reduce habitat
availability for many plants and animals. Crack willow has already established as the dominant species in wetlands adjoining the Waitaki River, and it is likely to do so in terrace wetlands.

**Significance of Wetlands**

4.41 The ecological significance of wetlands in the study area was assessed using the general methodology and associated guidance in the ECAn Proposed Natural Resources Regional Plan, Chapter 7, Appendix WTL1. Each wetland listed in Table 1, Appendix 1, was classified using the national wetland classification system of wetland system, subsystem, class and form, referenced in section 1.12 of my evidence. It was then assessed for ecological significance using the four criteria of representativeness, rarity and distinctiveness, ecological context and sustainability. The application of the criteria was slightly amended from that stated in the PNRRP. In Chapter 7, Appendix WTL1 the wetlands are determined as significant or not. However the Objectives and Policies of the PNRRP and WRP refer to wetlands of “moderate or higher significance”. I have therefore applied the criteria to classify wetlands to be of low, moderate or high significance as opposed to simply whether they are significant or not. The analysis for assessing significance was not undertaken to the extent necessary if any assessment under the NRRP was required. However, as I will explain later in my evidence, I do not consider there will be any effect on these wetlands and I therefore consider the level of assessment undertaken to be satisfactory.

4.42 I have included examples of species, communities and functionality from the wetlands in the lower Waitaki that contribute to high values in each criterion.

4.43 Representativeness – the extent to which an area represents an indigenous vegetation type, habitat or process typical of the ecological district. Raupo reedland and flax wetlands are the most representative of indigenous vegetation type and general habitat between Stonewall and the sea. The least modified wetlands at the base of terraces and spring fed wetlands with at least intermittent connectivity to the river, fish passage and macrophytes are also representative of habitat.
4.44 Rarity and Distinctiveness – the presence of rare or distinctive species, groups of species or habitats in a site. Threatened species that have been recorded in wetlands between Stonewall and the sea include Canterbury mudfish, long-finned eel, bittern and marsh crake.

4.45 Ecological Context – importance of the role played by the area in the health of the wider ecosystems in the district. In the context of the lower Waitaki Valley, the connectivity of wetlands is an important feature. Historically many of the areas now developed for agriculture would have been a series of wetlands interconnected by groundwater, streams, Waitaki River flows and springs. Now they have become discrete and isolated units. Movement of fish and macroinvertebrates between and within wetlands, as well as to and from the main river is limited. The areas of open water habitat in the Valley, many artificially created, recreate the connections for some river and wetland birds and macroinvertebrates.

4.46 Sustainability – the ability of the area to remain viable, or potential to become viable and the need and type of management required. Very few of the wetlands in the lower Waitaki Valley have formal legal protection, and factors which lower their sustainability rating include potential weed invasion, lack of guaranteed water supply, potential for high inputs of high fertility, lack of management of ecological values, and heavy grazing. All of these factors can however be managed in active wetland restoration.

4.47 Based on these criteria, 9 of the 18 terrace wetlands below Stonewall are of moderate or higher significance.

4.48 I have not individually assessed all of the riparian wetlands or wetland complexes, due to inaccessibility. Of the riparian wetlands I have surveyed on the ground and through aerial survey (flights and photos), I assess some to be of moderate or higher significance, where native plants dominate or there is high habitat value for indigenous fauna. This includes habitat for mudfish, eel, marsh crake and bittern.

Mahika kai sites

4.49 While the whole of the lower Waitaki River system is important for mahika kai, specific sites were identified in the Cultural Impact Assessment for Project Aqua for their particular importance and use historically and today.
4.50 Most of the wetlands in identified mahika kai sites are riparian wetlands along channels and braids in the riparian area of the Lower Waitaki River. The wetland values associated with these sites were documented through discussions with the author and contributors of the Project Aqua Cultural Impact Assessment, through hikoi with Ngai Tahu and through separate site visits. The key values are recorded in Table 2 of Appendix 1 and their locations are shown in Figure 4.

**Waterfowl hunting**

4.51 Waterfowl hunting occurs in a range of locations on the river and in riparian and terrace wetlands. The highest concentrations of waterfowl seasonally in wetlands are found on Bortons, Eckhold’s and Bells Ponds. Waterfowl hunting occurs as described by Mr Greenaway in his evidence.

**Summary of Wetland Values**

4.52 In summary the wetlands of the lower Waitaki Valley range in size, type, naturalness and hence ecological value. Generally the least modified wetlands, mostly terrace wetlands, have the highest ecological value and due largely to the paucity of wetlands in the Lower Waitaki Valley, many of these and some of the riparian wetlands are considered to be of moderate or higher ecological significance. The highest value wetlands are those with abundant wetland plants, which provide physical habitat diversity for periphyton, macro-invertebrates, birds and fish, and those with at least intermittent connectivity to the river.

4.53 Many biological components of the wetlands are exotic species. However, in those wetlands where native species are dominant, the species are generally common and widely occurring in New Zealand. There are a small number of exceptions to this general rule; Canterbury mudfish (nationally endangered) in waterways and ponds on the north bank below Stonewall, as described by Dr Jellyman in his evidence, and on the south bank near State Highway 1, in the vicinity of Welcome Stream, and a small number of bittern (nationally endangered) previously recorded in a range of wetlands in the valley.

4.54 Wetlands act as an important sink for nutrients and suspended sediment, with the result that waters flowing out of wetlands are generally of higher
quality than those flowing in, particularly in relatively still ponds with raupo, tall sedges and willows. Such wetlands are limited in the riparian area.

4.55 The total extent of wetlands and associated plant communities in the Lower Waitaki Valley is low relative to the riverine and terrestrial ecosystems. However, the wetlands have a disproportionately large contribution to the biodiversity of the area.

4.56 The flow in the mainstem is not necessarily determinative of water levels in all wetlands. Many of the terrace wetlands are dominated by groundwater inflows from sources other than the Waitaki River. For the riparian wetlands the relationship is generally closer but even here the relationship is complex. Connectivity generally reduces as the river flow decreases. However different wetlands lose surface connectivity at different flows.

EFFECTS OF FLOW REGIMES

4.57 Wetlands in the vicinity of the Waitaki River are affected to different degrees by the flows in the river.

4.58 I have separated the specific attributes of the flow regime that have the potential to influence wetland hydrology as:

- flooding frequency or intensity,
- flow variability,
- median flows,
- Minimum flows, and the duration of minimum or lower flows.

4.59 These hydrological factors affect wetland extent and connectivity (both within wetlands and between wetlands and the river). They therefore affect available habitat in different parts of the wetlands, the aquatic fauna composition and the plant species composition. The extent that these aspects of the flow regime drive a wetland’s hydrology varies with the wetland’s proximity to the river and the relative influence of other sources of water on the wetland’s hydrology.
4.60 I will examine these factors shortly. However in summary I note that the overall changes in wetland hydrology associated with the irrigation flow regime scenarios would be minor. I do not expect these minor changes to affect the total area that would be classified as wetland, or overall condition or significance of these wetlands. While there may be some minor temporary reduction in available habitat area or connectivity for some species, in dry years and within the peak irrigation season, I do not expect this to affect the population of any species.

4.61 I will now examine the specific attributes of the flow regime that influence wetland hydrology separately.

Flooding

4.62 In his evidence Dr Hicks shows that flooding incidence is independent of irrigation abstraction and that there is no significant difference in flood size with the different irrigation based flow regimes. The role of the Waitaki flood flows in flushing wetlands or providing temporary connectivity is therefore not expected to change.

Flow variability

4.63 As I discussed in paragraph 4.15 flow variability in the lower Waitaki is high and the wetlands with strong hydrological connection with the river therefore also experience high variability in water level and potentially connectivity. This variability would continue to be high under any of the irrigation flow regimes, as described by Mr Jowett in his evidence.

Median flows

4.64 The HDI100Full and HDI150Full would decrease the median flow, from the HDI Status Quo, from 320 m$^3$/s to 303 m$^3$/s (Table 4.1). This represents a median reduction in stage height of less than 3 cm. Such a difference in median flows and corresponding stage height is not anticipated to be a driver of wetland condition.
Table 4.1: Mean, median, mean annual 7 day low flow and maximum and minimum flows under the HDI Status Quo, HDI100Full and HDI150Full scenarios. Stage height difference from HDI Status Quo is given in brackets.

<table>
<thead>
<tr>
<th></th>
<th>HDI Status Quo</th>
<th>HDI100Full</th>
<th>HDI150Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Flows (Stage height difference from HDI Status Quo)</td>
<td>332 m³/s</td>
<td>314 m³/s (-2.9 cm)</td>
<td>316 m³/s (-3.3 cm)</td>
</tr>
<tr>
<td>Median Flows (Stage height difference from HDI Status Quo)</td>
<td>320 m³/s</td>
<td>303 m³/s (-3.3 cm)</td>
<td>303 m³/s (-3.1 cm)</td>
</tr>
<tr>
<td>Mean Annual 7 day Low Flows</td>
<td>147 m³/s</td>
<td>131 m³/s (-3.3 cm)</td>
<td>160 m³/s (+2.4 cm)</td>
</tr>
<tr>
<td>Maximum Flows</td>
<td>1929 m³/s</td>
<td>1898 m³/s</td>
<td>1898 m³/s</td>
</tr>
<tr>
<td>Minimum Flows</td>
<td>97 m³/s</td>
<td>100 m³/s</td>
<td>150 m³/s</td>
</tr>
</tbody>
</table>

Minimum flows and frequency and duration of minimum and low flows

HDI100Full compared with HDI Status Quo

4.65 Flows of approximately 100 m³/s are predicted under both these scenarios. The lowest levels the wetlands would experience under HDI100Full are therefore not any lower than HDI Status Quo.

4.66 However the frequency and duration of low flows would increase under the HDI100Full. The increase in number of low flows would occur during the peak irrigation season with the most notable differences between the scenarios occurring in the driest years. I will now present the data that shows these changes.

4.67 The differences between the scenarios have been presented by Mr Henderson, and I have included these in Table 4.2. The modelling shows that the HDI100Full would have on average 28 days per year with flows less than or equal to 150 m³/s, with 11 of those days at 100 m³/s. The HDI Status Quo would have an average of 18 days per season when the flows would be at or below 150 m³/s, with 4 of those days at or below 100 m³/s. So while the minimum flow would be similar between these two scenarios, the irrigation takes under HDI100Full would mean the flows would be at lower flows (lower water levels in wetlands) more frequently and for longer.
Table 4.2. Average number of days per year and number of days and continuous days in 1977 that the river is at or below 150 m$^3$/s or 100 m$^3$/s under HDI Status Quo, HDI100Full and HDI150Full.

<table>
<thead>
<tr>
<th></th>
<th>At or below 150 m$^3$/s with HDI Status Quo</th>
<th>At or below 100 m$^3$/s with HDI Status Quo</th>
<th>At or below 150 m$^3$/s with HDI100Full</th>
<th>At 100 m$^3$/s with HDI100Full</th>
<th>At 150 m$^3$/s with HDI150Full</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average days per year</strong></td>
<td>18</td>
<td>4</td>
<td>28</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td><strong>1977/78 (dry year). Number of days</strong></td>
<td>96</td>
<td>21</td>
<td>121</td>
<td>58</td>
<td>121</td>
</tr>
<tr>
<td><strong>1977/78 (dry year). Maximum continuous days</strong></td>
<td>14</td>
<td>14</td>
<td>23</td>
<td>14</td>
<td>23</td>
</tr>
</tbody>
</table>

In the driest of years, such as 1977/1978, the HDI100Full would have on average 121 days per water year with flows less than or equal to 150 m$^3$/s, with 58 of those days at 100 m$^3$/s. The HDI Status Quo would have 96 days when the flows would be at or below 150 m$^3$/s, with 21 of those days at or below 100 m$^3$/s. Such dry years are expected to occur once every 15 years (as described by Mr. Jowett). As I noted in paragraph 3.22 I chose 1977 as an example of a dry year, as it is the same dry year example used by Mr Jowett and other witnesses and is one of the 10 dry years identified by Mr Henderson in his evidence. I also assessed the other dry years and my findings, with respect to effects on wetlands, are the same as I outline here.

The 1977 data shows that under the HDI Status Quo there will be summers with extended periods of low flows, and that their duration would increase under the HDI100Full.

I have assessed the potential effects of these changes in low flow frequency and duration on the wetlands.

Wetlands will be affected differently in relation to their depths. Some wetlands, or parts of wetlands, will still be deep (for example greater than 1 metre) at 150 m$^3$/s and 100 m$^3$/s, while others will be shallow and some will be dry. The dry conditions under the HDI100Full will be the same as currently occurs but will last for longer and be more frequent.

These temporal changes in wetland depth however are not expected to affect the overall condition, composition and functioning of wetlands. The plant species present are species that tolerate fluctuating water levels, are dominated by willows, and are expected to remain under the overall slightly
lower water levels. The increase in frequency and duration of dry conditions may stress plants at their hydrological limit but I do not expect this to cause a change in the wetland composition.

4.73 Fauna in the wetlands, such as bully, eel and waterfowl will survive provided they find suitable alternative temporary habitat when conditions become too dry. Such movement between areas is likely to occur with the current flow regime. Dr. Jellyman noted in his evidence, that there is still plenty of habitat available for eels during such low flows.

4.74 Dr. Jellyman also expects the Canterbury mudfish in the vicinity of Welcome Stream to tolerate the slightly more frequent and longer duration low flow periods. The wetlands with mudfish appear to be at least partially fed by spring water and not entirely driven by water level changes in the Waitaki River and therefore may still retain water at low flows. If the sites became dewatered Dr Jellyman notes that the mudfish can withstand this by burrowing into the substrate where they can survive as long as they are kept moist.

4.75 Riparian wetlands with the most direct hydrological relationship to the river would be the most affected, as they would be less buffered by other water sources.

4.76 The terrace wetlands are not expected to be adversely affected by the HDI100Full because their hydrology is driven more by springs and irrigation. The changes in the river flows therefore have a lesser effect on these wetlands’ hydrology than the riparian wetlands.

4.77 Springs, irrigation water and tides also contribute to the hydrology of estuary wetlands thereby tempering any effects of changes in the river’s flow regime.

4.78 Wetlands in mahika kai sites, and mahika kai species generally, would be affected as I have described for riparian and terrace wetlands. While there will be occasional differences in species availability at specific sites, between the HDI100Full and the HDI Status Quo, in general the same species would be present at the same sites under the two regimes.

4.79 Game bird hunting is unlikely to be affected by the proposed flow regime with gamebird hunting occurring in winter, when there will be no changes in
the flow regime. The proposed irrigation takes and minimum flow are not expected to affect gamebird populations.

HDI100Full compared with HDI150Full

4.80 The HDI100Full and HDI150Full regimes differ only in their minimum flows and therefore the frequency and duration of flows less than 150 m$^3$/s. The modelling shows that the HDI150Full would experience the same number of days per year with flows at 150 m$^3$/s, as the HDI100Full would have at or below 150 m$^3$/s (that is on average 28 days per year). Under HDI100Full, on average 11 of the 28 days would be at the 100 m$^3$/s minimum. (As I have discussed this minimum is not lower than the HDI Status Quo minimum but would occur more often and for longer duration under the HDI100Full regime). The HDI150Full would therefore effectively increase the minimum flow by up to 50 m$^3$/s on 28 days on average per year, with 11 of these days being the full 50 m$^3$/s difference. An increase of 50 m$^3$/s represents a water level increase of approximately 9 cm in wetlands directly hydrologically linked to the river.

4.81 Therefore the water level in wetlands with direct hydrological links to the river would be the same under HDI100Full as HDI150Full on all but 28 days of the year (on average). On these 28 days the water levels would be at their lowest under both regimes but up to 9cm higher under the HDI150Full.

4.82 In extreme dry years such as 1977/78 the water levels would at their lowest for 121 days under both regimes, but up to 9cm higher under HDI150Full (with the full 9cm on 58 of these 121 days). Such dry years are considered a 1 in 15 year event.

4.83 There is unlikely to be a detectable difference in wetland composition and function as a result of a flow regime that increases the minimum water level in wetlands by up to 9cm on up to 28 days in a year (average). The higher minimum may allow some aquatic plant species to establish slightly higher in the wetland profile as they would not experience the same dry conditions that currently occur or would occur under HDI100Full, i.e. flows less than 150 m$^3$/s. This is likely to be only a small area in wetlands and the plants still need to be able to survive the fluctuating and high flows.
4.84 The differences are unlikely to affect populations of species including threatened species given their adaptation to the existing dynamics of the system (with average daily fluctuations of approximately 15 cm and average monthly fluctuations of 55 cm for wetlands with a direct river water level relationship). The higher minimum flow may allow for some more sustained connectivity in some wetlands, but the 150 m$^3$/s is not a particular determinant of connectivity.

4.85 Again some riparian wetlands and terrace and estuary wetlands will be buffered from flow regime differences by irrigation, spring water and tides and are therefore less affected by differences between regimes.

Summary of Wetland Effects and Proposed Mitigation

4.86 In summary, no wetlands would be lost, or wetland area reduced, as a result of the HDIFull flow irrigation regimes. The flooding intensity and frequency, the flow variability and the median flows will effectively be the same in terms of wetland function, values and conditions. The only changes that may occur are a result of the duration of low flows. Minor effects may occur where wetlands sit at low levels for long periods, especially in drier years, and some plants may suffer higher drought stress. This is only expected to be a very minor effect given the highly fluctuating environment that these wetlands currently exist under, the adaptation of the plant species present to a range of water levels, the periods of low water levels that currently occur and the river water level minimums being tempered by spring and irrigation water supplies into wetlands.

4.87 While there may be some minor temporary reduction in available habitat area or connectivity for some species, in dry years and within the peak irrigation season, I do not expect this to affect the population of any fauna. The HDI150Full would increase the minimum water level in directly affected wetlands from the HDI100Full and HDI Status Quo. This may provide for slightly different location of some wetland plants and provide slightly more habitat for fish and waterfowl during low flow periods. However the differences are not expected to be discernible at the population and plant species composition level give the continued highly dynamic flow regime.
4.88 I have considered whether it is necessary to monitor for effects of the proposed flow regime on wetland ecology if HDI were to proceed. I conclude that greater benefits would accrue from implementing good wetland management techniques than from attempting to detect adverse effects and subsequently mitigate them, should they be detected. The reasons for my conclusion are:

- First, any effects on wetland area, species composition, habitat and / or “quality” are likely to be small because the changes to the flow regime are relatively small. Such small changes would be difficult to detect against the ‘background’ of a dynamic hydrological system and the inherent variability of ecological systems.

- Second, even if changes are detected, it would be difficult to know whether they were caused by the changed flow regime.

- Third, there are clear potential benefits from good wetland management practices that, if implemented, would greatly outweigh any potential adverse effects of the HDI.

4.89 The wetland species that is most vulnerable to changes in wetland hydrology, due to its rarity, is the Canterbury mudfish. While it is well adapted to variable water levels it is a nationally endangered species and any changes to populations are therefore significant. I therefore recommend the applicant, and other abstractors, investigate and undertake options for protecting and enhancing the mudfish habitat in the vicinity of Welcome Stream as the most apparent threats to mudfish in this area are associated with stock trampling and vegetation clearance.
5.0 LOCATION OF TAKE

5.1 Upstream of the proposed intake and diversion channel, and the current Morven Glenavy Irrigation intake, there is a 200-400m wide area of willow-dominated vegetation between the road and the main braid of the river. Crack willow dominates the canopy effectively creating a willow forest. Gorse and broom dominate where the willows are sparse, or underneath areas of open willow canopy. Other exotic species are also common, such as blackberry, and exotic grasses, such as cocksfoot and yorkshire fog.

5.2 While this riparian forest is strongly exotic in its composition, there are small areas of native ferns, trees and shrubs dominating the understorey of the dense willow canopy adjacent to the existing irrigation diversion channel. The consistently higher water table associated with the irrigation channel, the proximity of hillside native shrublands and the relative stability of this riparian area appear to favour these species. Such an assemblage of native species is uncommon in the riparian areas of the lower Waitaki. These areas are well upstream of the proposed intake and associated construction activities.

5.3 A wetland has developed in an old braid channel near the intake pond with some native wetland plants, such as a small patch of raupo, and Carex and Juncus species (Figure 6). Upland bullies and short-finned eel were found in the wetland in 2006 during a survey for mudfish. No mudfish were found. There is a bird hide in the wetland with evidence it had been used in the 2007 duck shooting season. This wetland area has developed since 1966 (as Figure 7 shows).

5.4 Aerial photographs show part of the area immediately upstream of the diversion channel and intake pond to be open river braids and gravels in 1966. Woody vegetation had started establishing by 1985 and the area is now almost completely vegetated.

5.5 The area where future construction may be undertaken is predominantly within exotic riparian vegetation, which has established over the last 40 years. As described above, most of this is open and dominated by exotic grasses, gorse and broom. Willow dominates in some areas but again with an exotic understorey.
Significance

5.6 The intake site is part of the “Waitaki River” Site of Natural Significance in the Waimate District Plan. This site covers the full length of the Waitaki River from the Waitaki Dam to the mouth and is noted in the Plan for its bird and fish values. I do not consider the wetland, which I discussed in paragraph 5.3, is significant based on the criteria in the PNRRP. It does have value for waterfowl and native fish in association with the wider existing irrigation intake channels and head pond, but given its recent formation, predominance of exotic vegetation, lack of rare species and presence of similar habitat in the vicinity I do not consider it significant.

5.7 Several mahika kai sites are recorded in the vicinity of Stonewall for several kilometres along the north bank of the Waitaki River, as shown in Figure 4 and documented in Table 2 of Appendix 1). The intake is within a mahika kai site called Rakaitu – Stonewall. The historical values of Rakaitu – Stonewall include a settlement and gathering of birds and eel.

EFFECTS OF PROPOSED TAKE

5.8 As I have discussed the vegetation in the general vicinity of the proposed take is predominantly exotic and relatively recent. The intake works are therefore unlikely to have an adverse effect on native vegetation. I have discussed the proposed intake works with Mr Lewthwaite and there is sufficient flexibility in the engineering design to avoid the wetland with the bird hide. While I do not consider this wetland ecologically significant there are ecological (and recreational) values present and I have therefore recommended avoiding the site.

5.9 There would also be some potential to enhance wetland values in the area at the time of any intake construction works and this should be considered during the detailed design and consenting stage for the take.

5.10 The vicinity of the proposed take is within a mahika kai site and any construction works may be considered a further adverse effect on an already highly modified area. I recommend further discussions with the local runanga if the proposal proceeds. There would be potential to improve access to the area and to improve the habitat for mahika kai species in association with construction works.
6.0 IRRIGATION SCHEME AREA

6.1 In this section of my evidence I describe the values and predicted effects of the use of water for irrigation in the scheme area, as described by Mr Potts, on the wetland and terrestrial ecological values associated with Wainono Lagoon and lowland streams.

Wainono Lagoon

Physical Environment

6.2 Wainono Lagoon is a large shallow brackish coastal lagoon with water levels usually less than 1 metre deep. Water levels vary significantly however, with high monthly variations of up to 1 metre. Storm or flood events can raise lagoon levels by up to 1.5 metres. Droughts can result in substantial decreases in water level. High sea conditions cause water levels and salinity to rise fairly frequently (at least annually). Whilst water levels drop relatively quickly, salinity can remain elevated for several months as described by Mr Fraser in his evidence. Water levels are controlled by the operation of the Waihao Box (location shown in Figure 8) which is influenced by sea conditions, lagoon inflows and engineering works. Salt water feeds the lagoon through waves overtopping the barrier, salt spray and salt water seepage through the barrier and tidal flow up the dead arm (depending on the water level of the lagoon and dead arm relative to the sea).

6.3 Water levels are often especially low in late summer with low inflows and high evaporation.

6.4 The waters of the lagoon are highly turbid much of the time because of fine bed sediments held in suspension by wind-generated wave action and phytoplankton. The visual quality of the lagoon varied considerably during NIWA's 2006/07 investigation. Despite the high turbidity of the lagoon, NIWA's investigations suggest that periphyton are not strictly light-limited but that nitrogen is a limiting nutrient much of the time, as described by Mr Norton in his evidence.

Significance

6.5 Wainono Lagoon is identified as a Site of Natural Significance in the Waimate District Plan because of its wetland plant communities, including ‘flax swamp, rush and sedge swamp, succulent herb swamp and mudflat’, and its value as an important habitat for many species of water birds. The lagoon is also listed as a Special Site of Wildlife Interest (SSWI)\textsuperscript{16}, Wetland of Ecological and Representative Importance (WERI)\textsuperscript{17}, and is listed by the Department of Conservation\textsuperscript{18} as a wetland of international importance under the RAMSAR Wetland Convention, although it has not been designated as such.

6.6 Wainono is a mahika kai area of significance to Ngai Tahu. Ms Dawson will describe the cultural significance in more detail in her evidence.

Vegetation at Wainono Lagoon.

6.7 Wainono Lagoon has a range of wetland vegetation along its margins including salt marsh communities (turflands), sedgelands and willow wetlands. Another vegetation community occurs on the gravel / stony beach barrier (Figure 9).

6.8 The immediate shores on the eastern side of the lagoon consist of large mudflats, with diverse native dominated salt marsh communities (estimated at approximately 150 hectares\textsuperscript{19} (exposed) at the water level during a site visit in June 2007). The species composition appears to vary with subtle changes in ground height, reflecting differences in frequency and duration of inundation, with other contributing factors likely to be salinity or salt spray, nutrients, substrate drainage and grazing by ducks and geese. While the conditions obviously fluctuate there are clear zones of species dominance (and areas of co-dominance) from:

- \textit{Lilaeopsis} on large areas (mudflats) immediately north and south of open water on the east side of the lagoon (i.e. coastal side);


\textsuperscript{17} Department of Conservation 1986. Wetlands of Ecological and Representative Importance (WERI) database. Department of Conservation, Wellington.


\textsuperscript{19} Area updated from that in Boffa Miskell 2007: Hunter Downs Irrigation Terrestrial Ecology, Wetlands and Mudfish Ecological Assessment.
- Sea spurrey-dominated on slightly higher ground within the \textit{Lilaeopsis} areas;
- Glasswort and bachelor's buttons and shore cotula often occur together, again on slightly higher ground;
- NZ musk was also dominant over large areas;
- \textit{Selliera radicans}-dominated in small areas; and
- Mudwort dominated a small turfland area on the west side of the lagoon. Figure 10 has photos of these species and other turfland species are listed in Table 3 of Appendix 1.

6.9 Exotic grasses and herbs are uncommon amongst the turfs on the mudflats but increase at higher ground levels.

6.10 The turf communities are grazed by ducks and geese. Landcare Research have a trial at Wainono to investigate the role of waterfowl grazing in maintaining these short-stature communities. Stock also graze the turflands in places.

6.11 With higher elevation and moving up onto the beach barrier the vegetation changes, with the native species salt marsh ribbonwood common and frequent occurrences of the leafless pohuehue (a threatened species with ranking "sparse") on the gravels (Figure 11). Other native species here include the shore bindweed, harakeke and creeping and scrub pohuehue. The exotic tree lupin, pampas grass and gorse are common. Reed canary grass, which is also an exotic weed, is dominant along the track and ditch at the north end of the lagoon.

6.12 On the northwest edge of the lagoon (shown in Figure 9), from where the Hook River flows into the lagoon and to the south, is a wetland that grades from a sedgeland to a willow wetland (estimated at approximately 120 hectares). The dominant native species are purei, salt marsh ribbonwood, harakeke, \textit{Coprosma propinqua}, and \textit{Juncus edgariae} (Figure 12). Swamp nettle (threatened species rank gradual decline) has also been reported\textsuperscript{20}.

The exotic weeds willows and reed canary grass have decreased the values in, and continue to threaten, this wetland area. Crack and grey willows extend from the Hook River into the wetland with decreasing density heading south. A more recent invasion is reed canary grass, a perennial rhizomatous species which covers a wide band adjacent to the lagoon and is spreading across the wetland. In extensive areas it completely dominates the groundcover and is smothering other species including overtopping the salt marsh ribbonwood and *Coprosma propinqua* shrubs (Figure 12). It is likely to be restricting the regeneration of native species and is a major threat to the whole wetland. While control is possible for willows, control methods for the reed canary grass are still under investigation in the North Island. Tall fescue is the other common exotic species although this has largely been replaced by the canary grass.

Other parts of the lagoon edge are dominated by agricultural land use and therefore dominated by exotic grasses and herbs.

**Birds**

Wainono Lagoon is the largest coastal lagoon between Karitane and Lake Ellesmere (Waihora), and provides valuable feeding and roosting habitat for large numbers of coastal species. It is also an important 'staging site' before and after the breeding season, for migratory birds that breed inland.

At least 90 bird species have been recorded at Wainono Lagoon (in Pierce 1980, and other more recent records). Threatened bird species that have been commonly recorded at the site include white heron, Australasian bittern, grey duck, banded dotterel, wrybill, black-billed gull, black-fronted tern, Caspian tern and white-fronted tern. Species recorded also include northern hemisphere migratory waders whose habitats elsewhere in the world are severely threatened.

Wainono Lagoon is highly valued as a game bird hunting site because of the large numbers of waterfowl it supports.

**Fish**

Long-finned eel, short-finned eel, common smelt, yellow-eyed mullet, common bully, inanga and brown trout have been recorded in Wainono
Lagoon (in the Freshwater Fish Database). Canterbury mudfish have been recorded in the freshwater wetland on the western shores of the lagoon\textsuperscript{21}.

Current limitations and threats at Wainono Lagoon

6.19 Inappropriate water level controls are identified as a key threat to the ecological values at Wainono Lagoon\textsuperscript{22} and low levels are likely to be adversely affecting the freshwater wetland communities. Elevating groundwater levels above present levels is likely to be crucial to maintain the wetland system and to enhance the ecology of the lagoon\textsuperscript{23}.

6.20 Willows and reed canary grass also seriously threaten the ecological values of the sedgeland and are still spreading.

Lowland streams in or adjacent to irrigation area

6.21 The vegetation and bird fauna associated with the rivers and streams of the HDI area have not been formally surveyed. However, from site observations and knowledge of similar systems elsewhere in Canterbury and Otago I would expect only a sparse bird fauna in the riparian margins, comprising common introduced species and some of the more widespread native passerines (e.g. fantail, silvereye, grey warbler). Native vegetation is also likely to be limited to occasional rushes, sedges and cabbage trees. The beds of larger rivers such as the Waihao and Pareora support a range of braided river birds and waterfowl, and riparian vegetation may support marsh crane, pukeko and game birds (e.g. California quail, pheasant).

Canterbury mudfish

6.22 The HDI Scheme Area is an important area for Canterbury mudfish and their distribution has been described by Dr Jellyman in his evidence.

Effects if HDI Irrigation Scheme on Wainono Lagoon and lowland streams

6.23 Mr Fraser predicts that, if the HDI Scheme were implemented without mitigation, inorganic nitrogen and phosphorus concentrations in surface
waters would approximately double. On the basis of these predictions, and field trials over the 2006/2007 summer, Mr Norton identified three potential ecological effects on aquatic ecosystems:

- Increased periods of time when aquatic invertebrate populations of rivers and streams may be limited because of smothering of habitat by filamentous growths of periphyton.

- Possibly, increased periods of time when dissolved oxygen and pH, in rivers, streams, and Wainono Lagoon, fluctuate diurnally to an extent that is harmful to aquatic invertebrates and fish.

- A shift to conditions in Wainono Lagoon that are more favourable for phytoplankton, and less favourable for macrophytes than current conditions.

6.24 As discussed by Mr Fraser in his evidence, even with efficient irrigation, the HDI proposal is predicted to result in increased surface water drainage to groundwater and subsurface runoff and flow to surface water bodies. This may cause increased flows in springs and more consistent flows in lowland streams. Streams that are currently intermittent may flow for longer periods. In lowland areas that already have high groundwater levels, irrigation may increase water inputs to wetlands, raising their levels and/or reducing the likelihood that these would become dry.

6.25 The proposed scheme would generally increase the frequency of run-off events (not flooding) in the area, because soil moisture would generally be closer to field capacity than it is now, as described by Mr Mthamo in his evidence. Flood events are not expected to increase in frequency as they are associated with fully saturated soil conditions throughout the catchment requiring significant amounts of rainfall over and above the influence of irrigation.

6.26 Mr Fraser predicts increases in inflows of freshwater into Wainono Lagoon, mainly because of a 26% increase in average flow in the Hook River, but also from an increase in groundwater inputs through springs. Water outflow from Wainono Lagoon to the sea is also expected to increase proportionally. The effects of these changes in flow on water levels and salinity in the lagoon are likely to be small in comparison to existing variation in these
factors, although this has not been quantitatively modelled. The upper and lower extremes of the range of salinities and water levels are likely to be dictated by weather events such as storms, floods, and droughts, rather than changes in inflows.

**Wainono Lagoon**

6.27 It is difficult to predict the effects of increased water flows into the lagoon on the wetland ecosystems. The communities that are present are adapted to the currently wide ranging water levels and variable salinity, as well as the effects of wind and storm events and adjacent land management. The change in water inflows is predicted to have a relatively minor effect on actual lagoon water levels as the operation of the Waihao Box, combined with evaporation, tend to dominate and restrict the water levels. It does seem likely that higher inflows may reduce the frequency and duration of low water level events (particularly in summer).

6.28 I have also considered any potential changes in salinity of Wainono Lagoon as the distribution and composition of the salt marsh communities are likely to be driven by salinity, as well as inundation, grazing and nutrients. The salinity levels in the lagoon appear to be driven largely by seawater overtopping the beach barrier, flooding the lagoon at least on an annual basis as described by Mr Fraser in his evidence. Although the water levels drop quickly the salinity (measured as conductivity) can take several months to return to background levels. The HDI inflows are not expected to change the impact of the seawater overtopping events on the lagoon flooding and salinity.

6.29 The salinity levels associated with the coastal marsh communities, on the coastal side of the lagoon, may also be influenced by a freshwater - seawater interface in the groundwater. Sustained changes in water level in the lagoon would be required to alter the nature of this interface. Such a change is not predicted under HDI with the ongoing operation of the Waihao Box effectively regulating water levels.

**Vegetation communities**

6.30 As I have already described, the turfland distribution and composition is likely to be influenced by frequency and duration of inundation, nutrients,
salinity and grazing.

6.31 The water level changes have the potential to affect turflands’ species composition and extent. While the upper limit of inundation is not predicted to change with HDI, the periods when the lagoon is at lower levels may decrease, because the increased water supply from irrigation will fill the lagoon more quickly. Those communities at the lowest ground level (i.e. only currently exposed when lagoon levels are low) may be exposed less often and for shorter duration which may limit the survival of some species and favour different species. Similarly if there is an overall change in the frequency and duration of inundation at a range of heights, then this may change the existing species relative dominance.

6.32 The increased nitrogen and phosphorus levels in the lagoon (as described by Mr Fraser and Mr Norton) are not anticipated to have a major effect on the plant species composition, given the high nutrient status of the lagoon already from the ground and surface water, and the likely high nutrient input from waterfowl.

6.33 As I have discussed, it appears unlikely that there would be any gross changes in salinity concentrations or fluctuations with HDI, because the process is driven by storm events at sea and coastal freshwater – seawater interactions. Salinity does however appear to be one of the drivers of turfland communities’ composition and distribution and it is possible that subtle changes in salinity could affect the relative location and species dominance in these communities.

6.34 However, provided the lagoon continues to be brackish, be influenced by salt spray, have fluctuating water levels and be grazed by waterfowl then the turflands are expected to continue to dominate on the extensive mudflats on the eastern end of the lagoon under the HDI proposal. There may be minor changes in relative dominance and distribution of species.

6.35 However I support mitigation measures that reduce nutrient level input into the lagoon. While the additional nutrient inputs from HDI are not predicted to have detectable effects on the wetland and terrestrial ecological values of the lagoon, minimising the additional stress on the system will minimise any
current effects and support any improvements of the lagoon’s ecology in the future.

6.36 I do not expect the changes in water quantity and quality input to Wainono Lagoon from the HDI scheme to affect the vegetation community and associated ecosystem on the shingle beach barrier as they are above the lagoon water levels and more driven by ocean conditions.

6.37 The changes in water levels and nutrients are not anticipated to drive changes in the sedge and willow wetland composition. These communities are also already adapted to high nutrient levels and changing ground and surface water levels. The willow and reed canary grass weeds are likely to thrive in higher nutrient systems but it appears unlikely that increasing nutrient levels will alter their already strong influence on, and ongoing threat to, these wetlands. However, once again I support mitigation measures that reduce nutrient level input into the lagoon. Such measures will minimise the likelihood of any further adverse effects on this wetland area.

Wetland Birds

6.38 Wetland birds are not expected to be affected by the water level or nutrient changes. Changes in salinity and nutrients have the potential to affect water birds by changing the community composition of the aquatic and mud-burrowing invertebrates on which some species of birds feed. However, given the prediction of no or very small changes in salinity and the range of food items that the water birds prey on, it is unlikely that there will be any adverse effect.

Streams and Wetlands

6.39 Increased nutrient levels may lead to nuisance-growth of filamentous algae as described by Mr Norton in his evidence, which may cause reductions in the availability of aquatic invertebrates and fish as food for water birds. However, such effects, if they do occur, are likely to be partly or completely offset by beneficial effects: more consistent flows in small streams and a reduced likelihood of wetlands drying out is likely to benefit water birds by providing a greater area of, and more reliable, feeding, roosting, and breeding habitat.
6.40 Increased surface water levels and flows may support increased populations of aquatic invertebrates, and their terrestrial (adult) stages (e.g. damselflies, dragonflies, caddisflies, mayflies), which in turn may provide food for some bird species.

6.41 Increased flow may also advantage both native (sedges and rushes) and exotic riparian (willows and wetland grass and herb) species, with longer periods of surface water.

6.42 Dr Jellyman discussed the potential effects on mudfish and that there is good scope to ensure a net benefit to mudfish by maintaining or enhancing important mudfish habitats.

Potential mitigation options

Wainono Lagoon

6.43 The mitigation options that I will identify shortly for streams and wetlands would also reduce the effects of increased freshwater and nutrient inputs to Wainono.

6.44 As noted in Mr Norton’s evidence, there is good scope for beneficial enhancement of native vegetation around the margins of Wainono Lagoon, and such revegetation is proposed in the Department of Conservation’s Canterbury Conservation Management Strategy. Weed management is also an important issue at Wainono lagoon to avoid the loss of wetland values.

Streams and wetlands

6.45 Our analysis suggests that the terrestrial flora or fauna associated with streams and wetlands will not be significantly adversely affected by the HDI Scheme. Nevertheless, there are various options for mitigation of adverse effects that are identified, or become apparent, as a result of HDI. These include:

- best management practices for farming (as proposed in consent application), in particular to reduce nutrient inputs and sedimentation of surface waters;
- physical protection of riparian margins and wetlands (e.g. fencing);
- wetland enhancement and wetland creation where appropriate;
• riparian planting and weed control. Riparian planting is particularly beneficial to provide shade and minimise periphyton blooms, reduce the nutrient levels in the ground and surface water, provide additional native biodiversity in an area with few native species (other than at Wainono), to favour native species over nuisance exotic weeds and to provide food and roosts for native aquatic and terrestrial fauna. A riparian revegetation / restoration project at Buchanan’s Creek exhibits some of the species that are well suited to the local conditions. Restoration works should include sedges, rushes and harakeke within or at the water’s edge and taller species such as cabbage trees, kowhai, and other native trees up the banks. Willows and reed canary grass are two current weed species which are becoming increasingly dominant and their management is therefore recommended.

6.46 All of these practices would benefit the existing mudfish populations, particularly if key mudfish sites were identified and protected or enhanced. Dr Jellyman has discussed this further.

Summary of Irrigation Area Effects.

6.47 Wainono Lagoon has high ecological values particularly for its wetland vegetation, birdlife and fish species. The lagoon is a physically dynamic system with varying water levels and salinity and high nutrient enrichment and sedimentation. Ecological values are limited by these factors as well as weed invasion. Given the existing dynamic system and limitations the changes in water quality and quantity associated with the HDI proposal are not expected to cause significant adverse effects on the wetland vegetation, birds or fish. The increased water flow into the lagoon may reduce the time that the lagoon is at low levels in summer which would benefit the lagoon’s ecology. To minimise any potential adverse effects, mitigation to minimise the nutrient input are supported as well as any enhancement works to improve the values of the lagoon, such as native planting and protection from stock grazing.

6.48 While there are not anticipated to be any adverse effects on the lowland streams’ terrestrial values, I support mitigation that has been recommended for HDI of best management practices for farming, fencing of wetlands and waterways and native riparian planting to minimise any chance of effects and to provide some environmental enhancements.
7.0 SUMMARY OF MITIGATION AND MONITORING

7.1 In this final section of my evidence I will summarise the mitigation and monitoring that I am recommending.

7.2 In the Waitaki River I recommend contributions to:

- Specific vegetation clearance on 2 or 3 islands with protective flows around them, to enhance the habitat for white-fronted tern, black-billed gull and black-fronted tern breeding colonies;

- Investigating options and undertaking works to protect and enhance the mudfish habitat in the vicinity of Welcome Stream; and

- Monitoring water levels in the mudfish wetlands, as recommended by Dr Jellyman.

7.3 In the Hunter Downs Command Area I recommend:

- Physical protection of, and stock exclusion from, riparian margins and wetlands;

- Riparian planting along lowland streams and Wainono Lagoon;

- Contributing to weed management at Wainono Lagoon and co-ordinating with other parties to improve the ecological conditions at Wainono Lagoon:

- Promotion of the farm management and scheme management plans to minimise nutrient input to waterways and to protect and enhance existing biodiversity values as described by Ms Mulcock in her evidence;

- Monitoring wetland condition\textsuperscript{24} of the sedgelands and turflands at Wainono Lagoon, for 3 years prior to irrigation commencement, then annually for 3 years after commencement and 5 yearly thereafter.

- Monitoring riparian vegetation and habitat prior to, and after commencement of irrigation.

# APPENDIX 1

## Table 1: Wetlands Surveyed and Summary of Wetland Values (locations of wetlands shown in Figure 3)

<table>
<thead>
<tr>
<th>Wetland Site No and Approx Size</th>
<th>Wetland Type and Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Below proposed take</strong></td>
<td></td>
</tr>
<tr>
<td>Area 21 (above Bortons Pond) 30</td>
<td>6ha</td>
</tr>
<tr>
<td>Bortons Pond 29</td>
<td>37ha</td>
</tr>
<tr>
<td>Area 19 (below Bortons Pond) 28</td>
<td>10ha</td>
</tr>
<tr>
<td>Area 18 (wetland 28 cont.) 27</td>
<td></td>
</tr>
<tr>
<td>Goulding Road 102</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Jardines Road Wetland 26</td>
<td></td>
</tr>
<tr>
<td>Te Hua Taki 108</td>
<td>7ha</td>
</tr>
<tr>
<td>Eckhold’s Pond 6</td>
<td>7ha</td>
</tr>
<tr>
<td>Ferry Road Stream 24 and 100</td>
<td>8.5ha in 2 (connected)</td>
</tr>
<tr>
<td>Ferry Rd/Seven Mile Rd wetland 99</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Welcome Creek 12 and 23</td>
<td>10ha</td>
</tr>
<tr>
<td>Welcome Creek Ponds 10</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Waitaki Bridge 22</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Te Korotuaheka Waitaki Mouth (S) 149</td>
<td>5.5ha</td>
</tr>
<tr>
<td>Trig D Channel 123 Elephant Hill Stm 141</td>
<td>20ha in a series of channels</td>
</tr>
<tr>
<td>Ikawai Wetland 110 and 122</td>
<td>1ha</td>
</tr>
<tr>
<td>Wetland Site No</td>
<td>Approx Size</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Bells Pond 48, 85</td>
<td>25ha in 2 wetlands</td>
</tr>
<tr>
<td>Longlea Wetland 121</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Punakawa 21</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Redcliff Gardens 97</td>
<td>2ha</td>
</tr>
<tr>
<td>Waikakahi Stream 96</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Puna Kia Toa 11</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Waitaki Mouth 101</td>
<td>0.5ha</td>
</tr>
<tr>
<td>Awakokomuka (Whitneys Creek) 1</td>
<td>1.4ha</td>
</tr>
</tbody>
</table>

**Above proposed take**

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurow Holiday Park Channels 139</td>
<td>≈ 1.5ha</td>
<td>R Riparian willow forest lining Waitaki-River-fed (artificial) creek. Some indigenous vegetation, native fish and trout.</td>
</tr>
<tr>
<td>Kurow River Terrace Wetlands 2,34,136,120 and 140</td>
<td>5ha in 5 linked wetlands</td>
<td>T Complex of linked spring- and stream-fed wetlands dominated by raupo, gorse, Juncus, bog rush and Carex. Native fish habitat.</td>
</tr>
<tr>
<td>Kurow Creek – Otiake River 33</td>
<td>0.5ha</td>
<td>R Large riparian willow channel and wetland complex from Kurow Creek to Otiake River.</td>
</tr>
<tr>
<td>Riverside Flats 93</td>
<td>5ha</td>
<td>T Long, narrow raupo wetland at terrace edge. Rarely wet, but dominated by indigenous wetland vegetation. Unlikely to support fish populations.</td>
</tr>
<tr>
<td>Grants Rd Wetland 119</td>
<td>0.5ha</td>
<td>T Stream- and Waitaki-River-fed old channel of the Waitaki River. Raupo and willow dominant. Potential fish and waterfowl, pukeko, crake and bittern habitat.</td>
</tr>
<tr>
<td>Strachan's Wetland 118</td>
<td>1.5ha</td>
<td>T Spring (and possibly stream) fed old Waitaki River channel. Recently (within last three years) connected to Waitaki River. Raupo and low mound community, native fish and trout.</td>
</tr>
<tr>
<td>Otiake East Wetland</td>
<td>1.5ha</td>
<td>T Spring-fed willow dominated wetland with patches of raupo, Carex secta and toetoe. Waterfowl habitat and potential crane and bittern and fish.</td>
</tr>
<tr>
<td>Otekaike Wetland I 3</td>
<td>3ha</td>
<td>T Complex of connected channels and open water wetlands (gorse, willow, rushes and puruei). One large open water wetland, with deep silt, little macrophyte and bisected by raised track, and one semi-connected shallow raupo wetland. Numerous waterfowl. Uncertain connection to Waitaki River.</td>
</tr>
<tr>
<td>Otekaike Wetland II 4</td>
<td>0.5ha</td>
<td>T Possibly artificial regular shaped pond with steep sides.</td>
</tr>
<tr>
<td>Tewatapoki Wetland 105</td>
<td>10ha</td>
<td>T Spring- and stream-fed raupo, purei, flax, bog rush and carex. Linked to Waikaura Creek (wetland 60). Eels present.</td>
</tr>
<tr>
<td>Waikaura Creek Wetland 60</td>
<td>1.5ha</td>
<td>T Spring- and stream-fed raupo reedland on river terrace. Native fish present. Linked to Tewatapoki (wetland 105).</td>
</tr>
<tr>
<td>Priest Rd II Wetland 98</td>
<td>1ha</td>
<td>T Artificially created (for irrigation) gorse-dominated wetland fed by groundwater. Low natural values except as open water potential for waterfowl.</td>
</tr>
<tr>
<td>Wetland Site No and Wetland Type and Values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fielding’s Swamp 9</td>
<td><strong>Wetland Type and Values</strong></td>
<td></td>
</tr>
<tr>
<td>Cairns Flax Wetland 94</td>
<td>Extensive, dense and relatively unmodified raupo wetland on high river terrace. Fed by springs, but no open water, moist anoxic soils. No connection or fish values noted.</td>
<td></td>
</tr>
<tr>
<td>Dunroon Wetland 70</td>
<td>Spring-fed raupo reedland on river terrace. Source of Dunroon Creek – supplies wetlands 59 and 143.</td>
<td></td>
</tr>
<tr>
<td>Maerewhenua Wetland 143</td>
<td>Gorse and willow forest wetland with deep open water (waterfowl habitat) on river terrace fed by Dunroon Creek; itself spring-fed. Connected to river.</td>
<td></td>
</tr>
<tr>
<td>Hakataramea/Waitaki confluence 5</td>
<td>Willow and grass riparian wetland fed by Waitaki River flow and groundwater.</td>
<td></td>
</tr>
<tr>
<td>Fettercairn II Wetland 39</td>
<td>Old Hakataramea River channel fed by (Hakataramea) groundwater and flood flows. Area to west of stopbank connected to the Waitaki River. To east of stop bank is string of relatively isolated pools with strong native vegetation (especially raupo). At eastern end wetlands also connected to Waitaki braid.</td>
<td></td>
</tr>
<tr>
<td>Fettercairn Wetland 116</td>
<td>Raupo and willow lined channels, part of irrigation supply?</td>
<td></td>
</tr>
<tr>
<td>Northbank purei swamp</td>
<td>Purei-dominated swamp on river terrace fed by groundwater and stream from Campbell Hills.</td>
<td></td>
</tr>
<tr>
<td>Clarksfield Wetland 109</td>
<td>Pond (possibly artificial) in pasture fed by groundwater. Dominated by willow and rank grass – minimal ecological values.</td>
<td></td>
</tr>
<tr>
<td>Penticotico Wetland I 41</td>
<td>Riparian willow on low terrace adjacent to Waitaki River. Strong braids on margin, channels and ponds on terrace.</td>
<td></td>
</tr>
<tr>
<td>Penticotico Wetland II 42</td>
<td>Willow-dominated ponds on upper terrace near Penticotico Stream outlet to Waitaki River.</td>
<td></td>
</tr>
<tr>
<td>Grassly Hills Road Wetland 43</td>
<td>Old channel now riparian willow wetland fed by groundwater and springs.</td>
<td></td>
</tr>
<tr>
<td>Stonewall 44, 45, 46 and 72</td>
<td>Riparian willow-dominated channels and wetlands complex on margin of Waitaki River from Grassly Hills area to Ikawai and beyond.</td>
<td></td>
</tr>
<tr>
<td>Browns Corner Wetland 112</td>
<td>Spring- and stream-fed raupo and Carex wetlands in old channels in pastureland, native fish present. Partially fenced to exclude stock.</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Wetland values in identified mahika kai sites. Refer to Cultural Impact Assessment Report for Project Aqua for traditional names of mahika kai sites. Fig 5.1 shows locations

<table>
<thead>
<tr>
<th>Mahika kai site (settlement &amp; location)</th>
<th>Wetland ref</th>
<th>Historical values from CIA &amp; other info[ ]</th>
<th>Current condition and threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>At or below proposed take</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awakokomoku gully N of Waitaki River Mouth. Whitneys Creek donga.</td>
<td>1</td>
<td>1Mahika kai site, 1868 fishing easement. [Apparently once a large lagoon joined to Waitaki River estuary, nearby terraces were traditional campsites.]</td>
<td>No access, private property. Wetlands in this old Waitaki River channel now developed for agriculture. Modifications include; flow variability in Whitney’s Creek (depends on irrigation regime), wetland weed dominance, gully is unfenced and gravel beach now covers the lagoon. Nearby Maori reserve is 500m from gully.</td>
</tr>
<tr>
<td>Oteheni terrace edge on N of Waitaki River Mouth (Waitaki Huts).</td>
<td>2</td>
<td>101Mahika kai, including inanga.</td>
<td>Good access – part of site is DoC administered. Steep terrace riser with gorse and broom, narrow and dense willow forest in riparian wetlands. Fish values high (see native fish report). Inanga spawning is generally poor due to limited suitable habitat.</td>
</tr>
<tr>
<td>Puna (Pura) kia toa N bank, E of SH 1 Bridge.</td>
<td>3</td>
<td>11Mahika kai site including inanga spawning and juvenile eel habitat.</td>
<td>Good physical access, legal access rights unknown. Inanga spawning is generally poor due to limited suitable habitat. Ponds on terrace are only infrequently connected to river. No fish in upper ponds during 2003.</td>
</tr>
<tr>
<td>Tauhinu (Te Awa Te Mahiaroa) N bank between Ikawai &amp; Bells Pond.</td>
<td>4</td>
<td>123 &amp; 141Waka landing, Fenton Reserve.</td>
<td>Private property, heavily modified by, and potential for more, dairy conversion. Includes some of a string of wetlands along Elephant Hill Stream.</td>
</tr>
<tr>
<td>Punakawa North bank between SH 1 bridge and Ferry Road.</td>
<td>5</td>
<td>21Mahika kai, eel habitat, egg gathering, flappers [young waterfowl]. Springs present.</td>
<td>Riparian wetlands with heavy willow cover. Fed by a strong Waitaki River braid. Some land has AMF rights, some is administered by DoC.</td>
</tr>
<tr>
<td>Pai whetau and Te Manu N bank below Ikawai.</td>
<td>67</td>
<td>122 &amp; 110Mahika kai, eel habitat, egg gathering, flappers [young waterfowl]. Springs present.</td>
<td>Lower river terrace, now highly modified by dairy farming. Only isolated, unprotected wetlands remain with low ecological values and no open water.</td>
</tr>
<tr>
<td>Hakuwai Browns Corner. Te Ruawai Browns Corner</td>
<td>89</td>
<td>112, 44, 45 &amp; 46Mahika kai, springs, large braid. Large hole with eels</td>
<td>Dominated by dairy farming and riparian willow wetlands. Braids and springs feeding wetlands are strong. Isolated wetlands on river terraces are on private property. AMF rights east of Stonewall corner. Some DoC administered land at west end of mahika kai site. Physical access is difficult due to dense vegetation and large braids.</td>
</tr>
<tr>
<td>Rakaitu Stonewall</td>
<td>10</td>
<td>Settlement, eels &amp; birds taken.</td>
<td>Access difficult. Irrigation race, strong braid and dense willow forest limits access.</td>
</tr>
<tr>
<td>Potiki tautahi/poua Stonewall</td>
<td>11</td>
<td>44, 45 &amp; 46Mahika kai, settlement, eels</td>
<td>Private property. Access is physically difficult due to dense willow forests and a strong Waitaki River braid nearby.</td>
</tr>
<tr>
<td>Te Poua Stonewall</td>
<td>12</td>
<td>Mahika kai, eels, creek outlet [Grassy Hills Stream?].</td>
<td>Access difficult. Dense willow and large braid prevents access.</td>
</tr>
<tr>
<td>Mahika kai site (settlement &amp; location)</td>
<td>Wetland ref</td>
<td>Historical values from CIA &amp; other info[ ]</td>
<td>Current condition and threats</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-------------</td>
<td>--------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Te Korotuaheka &amp; Puna Kotuku S of Waitaki River Mouth east of SH 1. Part of Whakapapapariki</td>
<td>20 21 22</td>
<td>10, 22 &amp;149</td>
<td>Significant historical site, (nohoanga, Fenton reserve). Inanga spawning, patiki, eel, mullet, kanakana. Kotuku sighted. Dense riparian willow forest between river and farms. Flax and raupo near estuary. Physical access difficult due to dense willow. Irrigation and drainage has altered water regime. Some DoC administered and some Maori land, most is private. Inanga values low due to lack of suitable habitat. Good indigenous biodiversity, especially Korotuaheka (wetland no. 149).</td>
</tr>
<tr>
<td>Whakapapariki S bank near SH 1 Bridge.</td>
<td>22</td>
<td>10 &amp; 12</td>
<td>Contemporary mahika kai site. Dense willow forest; difficult access. Some DoC administered land. Isolated ponds west of bridge include Canterbury mudfish.</td>
</tr>
<tr>
<td>Punatutae S bank around Welcome Creek.</td>
<td>23</td>
<td>23</td>
<td>Mahika kai site, especially eels. [Place where blessings were performed. Also a wāhi tapu site]. Spring fed, 4km long creek, willow lined with willow-dominated wetlands. Variable fish populations. Access is physically difficult, but one paper road exists. LINZ grazing lease over part. Surrounded by unfenced pasture (dairy).</td>
</tr>
<tr>
<td>Moepuku Orakeikoroheo S bank from Ferry – Jardines Rds</td>
<td>24 25 100</td>
<td>24, 25 &amp; 100</td>
<td>Significant mahika kai site, especially eels. Wāhi tapu. Dense willow forest wetlands along braids and backwaters. Difficult access to river due to dense willow. Access road between wetlands and farms is reasonable. Good fish populations in large backwaters. Much of this mahika kai site is administered by DoC.</td>
</tr>
<tr>
<td>Puna Maru, East of Bortons Pond.</td>
<td>26 27</td>
<td></td>
<td>Wāhi tapu, Fenton Reserve1868, Urupa, Mahika kai sites. Little remains. Inland are developed farms, riparian area is dominated by willow and gorse with side braids. Backwater with similar fish to Waitaki River. Part private property, part administered by DoC. Legal road access to river but physical access limited by dense willow.</td>
</tr>
<tr>
<td>Waikakahi Stream Outlet</td>
<td>nil</td>
<td></td>
<td>No details provided by Kai Tahu. Poor water quality, access difficult – private property. Some DoC administered lands.</td>
</tr>
<tr>
<td>Bortons Pond</td>
<td>29</td>
<td></td>
<td>Contemporary mahika kai site. DOC administered. Open water wetland, shelving margins. Biota high. Overflow on eastern side to willow wetlands (wetland no. 28).</td>
</tr>
<tr>
<td>Above proposed take</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kai Patu Grassy Hills Road</td>
<td>13 43, 72 &amp; 103</td>
<td></td>
<td>Eel habitat. Strong braid nearby. Good eel populations. Dense willow forest. Access on angler’s access tracks is good. Un-developed areas appear to be DoC administered land, elsewhere is private land.</td>
</tr>
<tr>
<td>Puna Tamakotore Clarkefield flats &amp; Penticotico Stream.</td>
<td>14 41, 42 &amp; 109</td>
<td></td>
<td>Mahika kai, spring flowing into Waitaki River. Eels &amp; kokopu. AMF rights &amp; LINZ grazing lease. Private property, developed for dairy. Access difficult. Willow forest and gorse / broom scrub in riparian zone. Irrigation take in Penticotico Stream may impact on flow regime, despite minimum flow levels set in consent.</td>
</tr>
<tr>
<td>Puna Kotuku North Bank.</td>
<td>15</td>
<td></td>
<td>Mahika kai site. Heavily developed to Waitaki River edge. Few wetlands remain. No site marked on map of mahika kai site boundaries provided by Kai Tahu, interpretation difficult.</td>
</tr>
<tr>
<td>Korapa Station Peak Wetlands.</td>
<td>16</td>
<td></td>
<td>Mahika kai site. String of wetlands on private property. Good eel populations, native vegetation (raupo) in areas. Access difficult, water supply for irrigation.</td>
</tr>
<tr>
<td>Mahika kai site (settlement &amp; location)</td>
<td>Wetland ref</td>
<td>Historical values from CIA &amp; other info</td>
<td>Current condition and threats</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------</td>
<td>------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Te Uku, Porohio &amp; Taramea, Old Hakataramea River.</td>
<td>17, 18, 19, 39 &amp; 116</td>
<td>Mahika kai site.</td>
<td>Old Hakataramea River channel fed by (Hakataramea) groundwater and flood flows. West of stopbank connected to the Waitaki. East is string of relatively isolated pools with native vegetation (esp. raupo). Eastern most wetland also connected to Waitaki. Dairy conversion on adjacent land, water abstraction from wetland. Some is DoC land. Also AMF rights here.</td>
</tr>
<tr>
<td>Maerewhenua, Duntroon vicinity.</td>
<td>27, 59, 70 &amp; 143</td>
<td>Mahika kai, settlement, eels, kanakana, ducks, birds eggs. Two mahika kai sites; near Takiroa and at Duntroon.</td>
<td>Generally developed farms, but some discrete and linked, wetlands on private property - mostly low ecological value. Access to some difficult due to dense vegetation. Modification to some channels and wetlands. Some connection between rock art, wetlands &amp; river at Takiroa.</td>
</tr>
<tr>
<td>Otekaieke, Otekaieke River delta and backwaters.</td>
<td>28, 3 and 4</td>
<td>Mahika kai site.</td>
<td>Willow and raupo wetlands. Access is moderate, but private land. Waterfowl values moderate.</td>
</tr>
<tr>
<td>Oteake Between Gards &amp; Grants Rds, around Otiake River.</td>
<td>29, 118 &amp; 119</td>
<td>Mahika kai, eels, birds &amp; eggs.</td>
<td>Wetlands present and valuable includes eels. Good connection to river. Dense gorse and broom scrublands hinder access to wetlands and river.</td>
</tr>
<tr>
<td>Te Kohurau, Kurow to Riverside Flats, incl Kurow Creek.</td>
<td>30, 2, 33, 34, 120, 136 &amp; 140</td>
<td>Significant mahika kai site.</td>
<td>A few fragmented and isolated river terrace wetlands on private property. Extensive riparian willow wetlands administered by DoC. LINZ grazing licence over one portion.</td>
</tr>
<tr>
<td>South back opposite Kokoamu</td>
<td>No details provided by Kai Tahu.</td>
<td></td>
<td>Dominated by pasture and scrub with small willow backwater.</td>
</tr>
</tbody>
</table>
Table 3: Species List from Wainono Lagoon survey 20 June 2007.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>English Name</th>
<th>Native</th>
<th>Maori</th>
<th>Latin</th>
<th>Main ecosystem/location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td>S - Sedgeland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td></td>
<td></td>
<td>T - Turfland</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - Barrier</td>
</tr>
<tr>
<td>bachelor's buttons</td>
<td>N</td>
<td></td>
<td></td>
<td>Atriplex prostrata</td>
<td>T</td>
</tr>
<tr>
<td>broom</td>
<td>E</td>
<td></td>
<td></td>
<td>Cotula coronopifolia</td>
<td>T</td>
</tr>
<tr>
<td>browntop</td>
<td>E</td>
<td></td>
<td></td>
<td>Cytisus scoparius</td>
<td>B</td>
</tr>
<tr>
<td>cleavers</td>
<td>E</td>
<td></td>
<td></td>
<td>Agrostis capillaris</td>
<td>S, B</td>
</tr>
<tr>
<td>couch</td>
<td>E</td>
<td></td>
<td></td>
<td>Galium aparine</td>
<td>B</td>
</tr>
<tr>
<td>creeping bent</td>
<td>E</td>
<td></td>
<td></td>
<td>Agrostis stolonifera</td>
<td>S, T</td>
</tr>
<tr>
<td>creeping pohuehue</td>
<td>N</td>
<td></td>
<td></td>
<td>Muehlenbeckia axillaris</td>
<td>B</td>
</tr>
<tr>
<td>curled dock</td>
<td>E</td>
<td></td>
<td></td>
<td>Rumex crispus</td>
<td>T, S</td>
</tr>
<tr>
<td>dock</td>
<td>E</td>
<td></td>
<td></td>
<td>Rumex obtusata</td>
<td>T</td>
</tr>
<tr>
<td>fireweed</td>
<td>N</td>
<td></td>
<td>pukatea</td>
<td>Senecio glomeratus</td>
<td>B</td>
</tr>
<tr>
<td>glasswort</td>
<td>N</td>
<td></td>
<td>ureure</td>
<td>Sarcocornia quinqueflora</td>
<td>T</td>
</tr>
<tr>
<td>gorse</td>
<td>E</td>
<td></td>
<td></td>
<td>Ulex europaeus</td>
<td>B</td>
</tr>
<tr>
<td>kentucky bluegrass</td>
<td>E</td>
<td></td>
<td></td>
<td>Poa pratensis</td>
<td>B</td>
</tr>
<tr>
<td>leafless pohuehue</td>
<td>N</td>
<td>(endemic)</td>
<td></td>
<td>Muehlenbeckia ephedroides</td>
<td>B</td>
</tr>
<tr>
<td>narrow leaved plantain</td>
<td>E</td>
<td></td>
<td></td>
<td>Plantago lanceolata</td>
<td>T</td>
</tr>
<tr>
<td>native sea spurrey</td>
<td>N</td>
<td></td>
<td></td>
<td>Spergularia media</td>
<td>T</td>
</tr>
<tr>
<td>New Zealand musk</td>
<td>N</td>
<td></td>
<td></td>
<td>Mimulus repens</td>
<td>T</td>
</tr>
<tr>
<td>NZ wind grass</td>
<td>N</td>
<td></td>
<td>perehia, purei, repoheina, toheraoa, turnkoka</td>
<td>Lachnagrostis filiformis</td>
<td>T</td>
</tr>
<tr>
<td>reed canary grass</td>
<td>E</td>
<td></td>
<td></td>
<td>Phalaris arundinacea</td>
<td>S, T (edge)</td>
</tr>
<tr>
<td>salt-marsh ribbonwood</td>
<td>N</td>
<td>(endemic)</td>
<td>houi, makaka, runa</td>
<td>Plagianthus divaricatus</td>
<td>S, T, B</td>
</tr>
<tr>
<td>scotch thistle</td>
<td>E</td>
<td></td>
<td></td>
<td>Cirsium vulgare</td>
<td>T</td>
</tr>
<tr>
<td>scrub pohuehue</td>
<td>N</td>
<td></td>
<td></td>
<td>Muehlenbeckia complexa</td>
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<td>Blechnum minus</td>
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Evidence of Diana Robertson

Figure 1
Figure 2
Figure 3
Figure 4
Figure 5a
Figure 5b
Figure 6
Figure 7a
Figure 7b
Figure 7c
Figure 8
Figure 9
Figure 10a
Figure 10b
Figure 10c
Figure 11
Figure 12a
Figure 12b
FIGURE 1
Island with White-Fronted Tern Colony
Evidence of Diana Robertson

Flow – 350m$^3$/s
2001 Aerial Photo

Flow – 150m$^3$/s
2001 Aerial Photo

Flow – 90m$^3$/s
2001 Aerial Photo
FIGURE 2
Island with Black-Billed Gull Colony
Evidence of Diana Robertson

Flow – 350m$^3$/s
2001 Aerial Photo

Flow – 150m$^3$/s
2001 Aerial Photo

Flow – 90m$^3$/s
2001 Aerial Photo
FIGURE 3
Lower Waitaki River: Wetlands study area
Evidence of Diana Robertson
FIGURE 4
Lower Waitaki River: Identified Mahika Kai Sites
Evidence of Diana Robertson

Legend
- Contemporary sites
- Traditional sites
- Maori rock art

HDI Intake
FIGURE 5a
Mudfish Location at Welcome Stream
Evidence of Diana Robertson
FIGURE 5b
Mudfish Habitat Photographs
Evidence of Diana Robertson

November 2007
FIGURE 6
Approximate Intake Location – 2005 Aerial
Evidence of Diana Robertson

November 2007
FIGURE 7a
Approximate Intake Location – 1966 Aerial
Evidence of Diana Robertson

November 2007
FIGURE 7b
Approximate Intake Location – 1985 Aerial
Evidence of Diana Robertson
FIGURE 7c
Approximate Intake Location – 2005 Aerial
Evidence of Diana Robertson

November 2007
FIGURE 8
Location of Wainono Lagoon and Waihao Box
Evidence of Diana Robertson

November 2007
FIGURE 9
Broad Vegetation Types at Wainono Lagoon
Evidence of Diana Robertson
Turfland at northern end of lagoon, dominated by *Lilaeopsis*

Turfland at southern end of lagoon, dominated by *Lilaeopsis*
Turfland at southern end of lagoon, dominated by NZ musk with glasswort, bachelors buttons and shore cotula.
FIGURE 10c
Photographs - Main Turfland Species at Wainono Lagoon
Evidence of Diana Robertson

Lilaeposis
Sea spurrey on higher ground beside Lilaeposis
NZ musk with glasswort and mudwort

Shore cotula
Selliera radicans
Bachelor’s buttons
Beach barrier with leafless pohuehue mid-ground and harakeke, gorse and salt-marsh ribbonwood beyond
Sedgeland at west side of lagoon with *Carex secta*, harakeke, mikimiki and grey willow

Reed canary grass invading sedgeland and willow wetland

FIGURE 12a
Photographs – Freshwater Wetland at Wainono Lagoon
Evidence of Diana Robertson

November 2007
Reed canary grass overtopping 2 metre high salt marsh ribbonwood

FIGURE 12b
Photograph – Freshwater Wetland at Wainono Lagoon
Evidence of Diana Robertson

November 2007