# 13 Freshwater Ecology

## 13.1 Introduction

Ecology may be broadly defined as the relationship between organisms and their natural environment. The quality of water is generally reflected in the variety and numbers of plants and animals living in it. Through their various functions, organisms modify their aquatic environment by gaseous exchange and by taking up nutrients and other organisms. An understanding of the ecology of the freshwater environment of the lakes, rivers, and wetlands within the Tarawera River catchment is essential in determining how the water resources and their immediate environment will be managed in a sustainable manner.

As indicated in Chapter 7 – *Community Attitudes and Perceptions*, Environment Bay of Plenty proposes that those matters highlighted in section 5(a-c) be tests, all of which must be met in order for an activity to be considered as sustainable. Section 6(a) of the Resource Management Act 1991 specifically charges people to recognise and provide for the preservation of the natural character of wetlands, lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use and development. Section 6(c) of the Act specifically identifies the protection of areas of significant indigenous vegetation and significant habitat of indigenous fauna, to be recognised and provided for as a matter of national importance. Sections 7(d) and 7(h) of the Act require that particular regard be had to the intrinsic values of ecosystems, and the protection of the habitat of trout and salmon.

This chapter outlines those aspects of the freshwater ecology of the rivers, and wetlands within the Tarawera River catchment which has a bearing on the objectives, policies and methods of implementation adopted elsewhere in this regional plan. These are present most notably in the *Surface Water Quantity, Surface Water Quality*, and *River and Lake Beds* chapters. Supporting documents for this chapter are as follows:

Donald, R: 1994 (19 July); <u>Tarawera River Regional Plan Technical Investigations – Freshwater Ecology Component</u>, Environment Bay of Plenty, Whakatane.

McIntosh, J: 1994; <u>Tarawera River Regional Plan Technical Investigations – Water Quality Component</u>, Environment Bay of Plenty, Whakatane.

## 13.2 Historical and Cultural Context

Before the 1900s the Tarawera and Rangitaiki Rivers drained extensive wetlands which are now the Rangitaiki Plains. The ecology, value and subsequent loss of this wetland system has been highlighted in a statement by Tuwharetoa ki Kawerau to the Tarawera River Liaison Group[49];

> *Many pa tuna (eel weirs) were situated in the swamp and river. Koura, inanga and other kai was to be found in the whole of the surrounding area. The diversity of life found in the swamp is gone, hemmed into the few remaining wetlands and in some cases has disappeared altogether.*

Well-known sites for the collection of tuna (eel) were at Parawai (Tumurau Lagoon) and Tamurenui Lake[50]. The name of a pa situated on the old riverbank at Onepu,

[49] Te Runanga o Tuwharetoa ki Kawerau, 1994.
[50] BOPCC, 1985(a).

Te Ahi Inanga, suggests that this is near a site where inanga (whitebait) were collected. While there is less information on the gathering of kai in the upper river catchment it is known that Mangate (or Mangati) Stream was considered a place for eeling. A Maori eeling reserve is present below the Tarawera Falls (Te Tatau a Hape) and large specimens are occasionally collected there to this day.

## 13.3 Freshwater Ecology in the Water Bodies of the Catchment

For the purposes of this chapter the freshwater ecology of the Tarawera River catchment is discussed in three parts. These cover the Upper Reach of the Tarawera River (upstream of Kawerau Bridge, including the upper tributaries), and the wetlands in the lower catchment.

The ecological information described in this chapter has been collected by Environment Bay of Plenty, external research agencies, and consultants working for industry. Specific environmental investigations, designed to contribute to this regional plan, were carried out by Environment Bay of Plenty between 1991 and 1994. These surveys have concentrated on a number of aspects of the freshwater ecology: undesirable biological growths, macro-invertebrates and fish.

### 13.3.1 The Upper Reach of the Tarawera River

The water in the Upper Reach of the Tarawera River is generally of a high quality, well oxygenated and of a high visual clarity. Of all the water bodies in the Tarawera River catchment, this can be expected to be the closest to its 'natural' state.

In the Upper Reach of the Tarawera River there is a diverse and abundant aquatic plant community. In 1984 two bryophytes, one fern and eight species of macrophytes were identified[51]. Submerged species (mainly 'oxygen weeds') covered 10-20% of the river bed between the Tarawera Forest and Kawerau. In the same survey a site in the Tarawera Forest was found to support an abundant algal flora. These microscopic plants (mainly diatoms) colonise rocks and plants on the river bed and, where present, form an almost continuous film. A summary of the aquatic plant species found in the Tarawera River is presented in Appendix 13.

The Upper Reach of the Tarawera River supports a diverse and abundant invertebrate community. Invertebrates include the familiar trout nymphs along with other small animals such as snails and worms. Species of mayfly and caddisfly which filter food from the water are the most abundant in the Upper Reach of the Tarawera River while midge-fly larvae (chironomids) make up a small proportion. The mayfly and caddisfly species decline in abundance between the Tarawera Forest and Kawerau. Over this reach the river bed changes from boulders and cobbles to smaller pumice stones and sand which naturally support fewer invertebrates. Koura are present throughout the upper catchment and are particularly abundant in the Lake Tarawera outlet.

The Lake Tarawera outlet if gazetted as a trout-spawning area and plays an important role in the management of the Rotorua District trout fishery. Other fish species which are present at the Lake Tarawera outlet and in the lake are common bully and common smelt. Longfinned eel are present in the lake and are, therefore, likely to be found in the outlet. These eels may have been liberated to the lake or, alternatively, have ascended in the Tarawera Falls as elvers (juveniles). A landlocked population of koaro is present in Lake Tarawera and may also occur in the outlet. This species is assumed to have been liberated to the lake in pre-European times.

---

51 Bioresearches, 1987(a).

The Tarawera Falls represent a significant physical barrier to the upstream migration of fish. Longfinned eel, common bully and banded kokopu were found at the base of the falls in 1983[52]. Banded kokopu were not found in a Environment Bay of Plenty survey of 1993 although common bully were recorded along with longfinned eel and abundant elvers. As noted above, it is possible that elvers may negotiate the Tarawera Falls.

Most of the tributary streams of the Upper Reach of the Tarawera River have high water quality and provide ideal fish habitat. Fish species which would be expected to occur in these streams include longfinned eel, rainbow trout, common bully, banded kokopu, koaro, torrentfish and possibly shortjawed kokopu. Of these, only longfinned eel, common bully, a single banded kokopu and rainbow trout have been found.

It is likely that the migration of juvenile native fish to the upper tributaries is hampered by the poorer water quality in the lower river. Iwi have knowledge that since the water quality in the lower river has deteriorated there have been changes to the migration patterns of native fish. Unfortunately the impact of industrial effluent on migration patterns is difficult to assess because there is little information on the tolerances of these species. Other factors such as land use changes (forestry, agriculture and wetland drainage), overfishing (whitebaiting), channelisation and exotic fish introduction may also contribute to the distribution patterns. Research to investigate the health and distribution of native fish is planned.

Between the Tarawera Falls and Kawerau the river supports a regionally important trout fishery. The yield of this fishery is maintained by the high quality of the tributary streams. Of these, Otuhangu (Buddles Creek) is an important spawning stream while the Kaipara Stream appears to be a significant juvenile rearing area.

The 10 kilometres of river downstream of the Tarawera Falls is notable in that it provides habitat for a river resident breeding population of New Zealand Scaup. This is unusual as most scaup populations require a lake habitat for breeding. Other bird species using the river include pukeko, grey and mallard ducks, shags, kingfishers and spotless crake in the swampy areas.

## 13.3.2 The Lower Reach of the Tarawera River

The Lower Reach of the Tarawera River may be divided into sections upstream and downstream of the Tasman Pulp and Paper Company Limited oxidation pond discharge. Upstream of the discharge area there is a high diversity and cover of aquatic plants. The highest diversity of submerged species has been found just upstream of the Tasman Pulp and Paper Company Limited discharge where they covered up to 35% of the river bed.

Downstream of the Tasman Pulp and Paper Company Limited discharge the aquatic plant communities are significantly altered. The rooted species present in this lower section of the river tend to be those that have the main part of their foliage out of the water. While these ‘emergent’ species cover up to 25% of the river bed the submerged species cover less than 5%. The algal flora supported downstream of the Tasman Pulp and Paper Company Limited effluent discharge is sparse to absent.

In 1993 a survey[53] documented that undesirable biological growths,[54] composed predominantly of *Ulothrix* and *Thiothrix* species, were identified in the Tarawera

---

52 Bioresearches, 1987(b).

53 Donald, R 1994 (May) Tarawera River Regional Plan Technical Investigations – Freshwater Ecology Component, Environment Bay of Plenty, Environmental Report 94/1. 121pp.

54 “Undesirable biological growths” are covered in detail in the Ministry for the Environment publication Guidelines for the control of undesirable biological growths in water (June 1992).

River downstream from the Caxton Paper Limited effluent outfall. From 1995 to July 2001 these species have not been noted.

Industrial discharges have a major impact on the invertebrate communities supported in the Lower Reach of the Tarawera River. An increase in the abundance of pollution-tolerant species between the Tarawera Forest and Kawerau is thought to be due to diffuse stormwater inputs from Kawerau township. Despite this, the communities recorded at Kawerau are typical of clean water conditions, being dominated by species of mayfly, caddisfly and midge larvae. Between the Kawerau Bridge and the Carter Holt Harvey Tissue effluent outfall, a further small increase in the abundance of pollution tolerant midge larvae and worms occurs. Although the groundwater flow into the river contains discharges from the RIB's, the treatment capability of the RIB's has ensured that no significant impact on the river has yet been measured.

Downstream of the industrial discharges, sensitive invertebrate species reduce, being replaced by large numbers of midge larvae, worms and snails. Similar communities are supported down the remaining length of the Tarawera River with little return of the sensitive species. Even if the industrial discharges were not present, the changes in habitat of the Lower Reach of the Tarawera River resulting from the straightening and diverting carried out in the early 1900s, make it less suited to supporting large numbers of the sensitive invertebrate species that occur above Kawerau Bridge.

Freshwater fish communities in the Lower Reach of the Tarawera River have been affected by the drainage and consequential loss of wetlands, the straightening of the river, flood protection works and industrial discharges. Indigenous fish communities may have been affected by the introduction of trout. There is anecdotal evidence that before the construction of the Tasman Pulp and Paper mill in the 1950s the lower river supported a trout fishery along with significant numbers of common smelt and inanga (whitebait). Common smelt have returned and are present in high numbers. Inanga and trout stocks are present. No inanga were recorded during several days of seine nettings in the lower river in 1994. However, adult inanga have been recorded at the Tumurau Lagoon weir and at Kawerau Bridge. Thus it is likely that inanga are using the main river as a migration route to the tributary streams rather than as habitat.

The western tributary streams of the Lower Reach of the Tarawera River have high water quality and provide ideal fish habitat. These streams have been identified as particularly important for the conservation of native fish values in the catchment. As an example, the Mangaone Stream holds nine species of native fish including the only known stream population of koaro in the Tarawera River catchment. It has been suggested that spawning trout in the Mangaone Stream have migrated upstream from the Lower Reach of the Tarawera River. Whether or not this is the case, it is likely that the tributary streams will play an important part in the re-establishment of a trout fishery in the lower river.

Despite major eel kills in the 1970s, the lower river now supports a large population of these tolerant fish, due in part to the reluctance of eel fishers, particularly traditional harvesters Tuwharetoa ki Kawerau, taking eel due to the degraded mauri of the river. Shortfinned eels are known to be ten times more abundant below the Tasman Pulp and Paper Company Limited oxidation pond discharge than in the Kawerau area. These eels appear healthy but those exposed to effluent show a number of stress responses. These include changes in liver structure (enlargement, tissue die-off, fatty changes) and changes in blood chemistry and cell counts.

The productivity of common smelt in the Lower Reach of the Tarawera River appears to be enhanced by the industrial discharges. Compared to smelt in the nearby Rangitaiki River, the Tarawera Smelt are larger and produce more eggs. Diet analysis suggests that these differences are related to food supply. Small crustaceans, the dominant smelt food in the Tarawera River, would be expected to feed on the high concentrations of bacteria present in and encouraged by the major discharges. Support for this conclusion has come from studies on freshwater mussels and finger-nail clams. These studies have concluded that the growth and reproduction of these animals is increased by inputs of food present in the Tasman Pulp and Paper Company Limited effluent.

The Lower Reach of the Tarawera River is used by a variety of birds including grey and mallard ducks, pukeko, shags, fantail, welcome swallow, kingfisher, gulls, pied stilt, white-faced and white heron. It is not known if these species are affected by the poor water quality, although diving species would have difficulty in obtaining food downstream of the Tasman Pulp and Paper Company Limited discharge due to the discoloured water. No investigations have been undertaken on waterbirds to determine their health in this environment.

Relatively little is known of the ecology of the drainage canals which enter the Lower Reach of the Tarawera River. The Awaiti Canal and the Old Rangitaiki Channel drain immediately upstream of the river mouth and form part of the Rangitaiki Plains drainage system. Water quality in the canals is poor, reflecting the intensive agriculture in their catchments. In particular, dissolved oxygen concentrations and light penetration are low while nutrient concentrations are high. Species of fish tolerant of these conditions include shortfinned eels, goldfish and mosquito fish and these are abundant in both canals. Yelloweyed mullet are known to enter the canals from the sea to feed while inanga and smelt have also been recorded. Hornwort is the dominant aquatic plant forming dense beds in shallow areas where light penetration is adequate for growth.

### 13.3.3 Wetlands in the catchment of the Lower Reach of the Tarawera River

Wetlands are important due to:

- Their biological productivity;
- The habitat they provide for many species;
- Their role in flood control;
- The recreational opportunities they give;
- Their role in protecting species diversity;
- Their importance as a food source for tangata whenua;
- Their cultural and historical values.

Intentional and inadvertent destruction of many freshwater and coastal wetland systems has occurred throughout New Zealand and is still continuing in some areas today. Recently, the ecological and physical importance of these environments as wildlife habitats, botanical communities, water purification sites and areas for flood control, has been recognised. This has highlighted the significant adverse effects that will result from a failure to preserve and effectively manage remaining wetlands areas.

Plants growing in a wetland habitat are specially adapted to living in wet conditions. Usually there is a gradual transition in plant types, changing from dryland species bordering the wetland fringe, to those which exist completely underwater. Wetlands often form zones of natural succession and ecosystem change (ecoclines) eventually leading to the creation of drylands. The resulting diversity in physical conditions such as water depth, fertility, substrate and temperature ensure the formation of complex and unique plant communities.

These original communities tend to be made up of native species with relatively narrow ecological habitats and specific physical requirements. As a result they are sensitive and vulnerable to long-term environmental changes, particularly to reduced water levels. When put under stress, wetland vegetation communities become susceptible to invasion by introduced plants and usually lose species diversity.

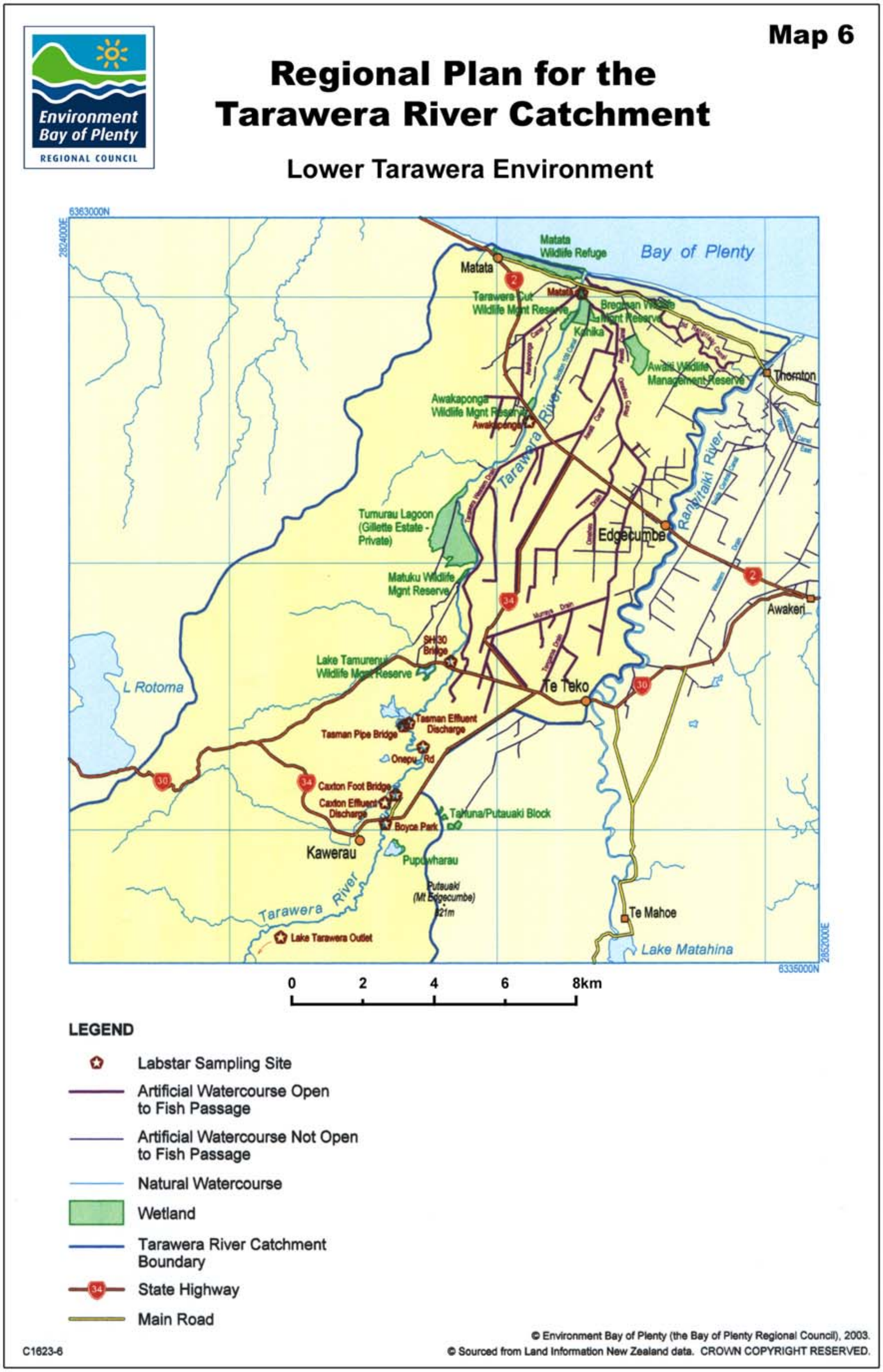
The wetland areas connected to the Lower Reach of the Tarawera River comprise some of the most important wildlife habitat remaining in the lower catchment (Map 6). These wetlands are remnants of the original vegetation which once extensively covered floodplains of the Tarawera and Rangitaiki Rivers. Subsequent river straightening and drainage of the land for agriculture and urbanisation have resulted in a significant loss of wetland habitat leaving only small, relatively isolated patches totalling approximately 1.7% of the original wetlands. Many of these areas of significant indigenous vegetation and provide a significant habitat for indigenous fauna. Thus their protection is to be provided for as required under section 6(c) of the Resource Management Act.

13.3.3(a) Sites of International Botanical Importance

None of the Tarawera wetlands are known to contain any endemic plant species classed as endangered and therefore they cannot be classified as sites of international botanical importance.

13.3.3(b) Sites of National Botanical Importance

Five of the ten wetlands are known to contain colonies of swamp fern (*Thelypteris confluens*). This species has been variously described as vulnerable, threatened and rare. Colonies of *Cyclosorus interruptus*, another species of fern, are also found in seven of the wetland areas. This species also has a status of rare. *Juncus holoschoenus*, recently reclassified from indeterminant to rare, is found at Lake Tamurenui. This reclassification allows Lake Tamurenui to be classified as a wetland of national botanical importance.


Environment Bay of Plenty
REGIONAL COUNCIL
Map 6
Regional Plan for the
Tarawera River Catchment
Lower Tarawera Environment
6363000N
2824000E
Bay of Plenty
Matata
Matata Wildlife Refuge
Tarawera Cut Wildlife Mgmt Reserve
Kohika
Awaiti Wildlife Management Reserve
Thornton
Awakaponga Wildlife Mgmt Reserve
Awakaponga
Tarawera River
Rangitaiki River
Tumurau Lagoon (Gillette Estate - Private)
Edgecumbe
Matuku Wildlife Mgmt Reserve
Awakeri
SH30 Bridge
Lake Tamurenui Wildlife Mgmt Reserve
L Rotoma
Te Teko
Tasman Effluent Discharge
Tasman Pipe Bridge
Onepu Rd
Caxton Foot Bridge
Caxton Effluent Discharge
Boyce Park
Tahuna/Putauaki Block
Kawerau
Pupuwharau
Putauaki (Mt Edgecumbe) 821m
Tarawera River
Lake Tarawera Outlet
Te Mahoe
Lake Matahina
2852000E
6335000N
0 2 4 6 8km
LEGEND
Labstar Sampling Site
Artificial Watercourse Open to Fish Passage
Artificial Watercourse Not Open to Fish Passage
Natural Watercourse
Wetland
Tarawera River Catchment Boundary
State Highway
Main Road
© Environment Bay of Plenty (the Bay of Plenty Regional Council), 2003.
© Sourced from Land Information New Zealand data. CROWN COPYRIGHT RESERVED.
C1623-6

Altogether ten sites are known to contain one or several of the above species and so can be classified as wetlands of national botanical importance. These are shown on Table 6.

13.3.3(c) Sites of Regional Botanical Importance

The remaining wetlands in the Tarawera River catchment which are not known to contain threatened plant species are significant as remnants of the original vegetation. Several of these contain species that are uncommon in the area. These features enable all of the remaining wetlands of the Lower Tarawera to be classified as having botanical importance on a regional scale.

13.3.3(d) Botanical Conservation Value

Wetlands can be ranked according to their botanical conservation values. These rankings are arrived at using a set of criteria based on sound conservation values and scientific principles[55]. The criteria include the presence of threatened species but also require judgements on the representativeness of the vegetation on a national and ecological district basis, its degree of modification, the presence of rare communities and the presence or absence of introduced plants. It is, therefore, a more inclusive assessment of the specific botanical importance of a site. Tables 6 and 7 contains a summary of the botanical conservation and protection status values for wetlands in the catchment of the Lower Reach of the Tarawera River.

## Table 6

## BOTANICAL CONSERVATION VALUES OF WETLANDS IN THE CATCHMENT OF THE LOWER REACH OF THE TARAWERA RIVER

| Wetland | Exceptional | Very High | High | Moderate | Low |
|---|---|---|---|---|---|
| Lake Pupuwharau | | x | x | | x |
| Tahuna-Putanaki | | x | x | | x |
| Lake Tamurenui | | | x | **x** | x |
| Tumurau Lagoon | x | x | | | |
| Awakaponga Wetlands | | | x | x | x |
| Awaiti Wetlands | | x | x | | x |
| Tarawera Cut | | x | x | | x |
| Matata Lagoon | x | x | | | x |
| Bregman Lagoon | | | x | x | x |
| Matuku Wetlands | | | | | x |

Matata Lagoon and Tumurau Lagoon[56] have plant communities with exceptional and very high botanical conservation value. This corresponds to Matata Lagoon as one of the best examples of saline wetlands with contiguous freshwater wetland in the Te Teko Ecological District and Tumurau Lagoon as the best example of primary wetland vegetation in the District.

Vegetation of very-high botanical conservation value is also present in the Tahuna-Putanaki Block, Awaiti Wetlands, and Tarawera Cut Wildlife Management Reserve. A very-high botanical conservation value is applied to those wetland sites containing vegetation types which represent the remaining natural vegetation in an ecological district.

Lake Pupuwharau, Awakaponga Wetlands, Lake Tamurenui and Bregman Lagoon all contain vegetation with a high botanical value. This high value applies because

55 Shaw, 1988

56 Also known as Braemar and Gillette Lagoons.

of the presence of secondary vegetation which has developed after disturbance. In ecological districts where there are very few remaining examples of natural vegetation, this secondary vegetation becomes representative of the habitat still remaining.

The following order of comparative wetland value has been established from the information in Table 6:

Highest Value:

- Matata Lagoon
- Tumurau Lagoon
- Lake Pupuwharau, Tarawera Cut, Tahuna-Putanaki Block and Awaiti Wetlands
- Bregman Lagoon and Lake Tamurenui
- Awakaponga Wetlands

Lowest Value:

- Matuku Wetlands

Such a ranking system may be useful when considering conservation priorities. Thus, the highest value sites should have the highest priority for botanical conservation efforts.

13.3.3(e) Wildlife Values

Those wetlands which provide fish access to the Lower Reach of the Tarawera River can be expected to contain a variety of fish species. For example, the Matata Lagoon contains an abundant shortfinned eel population with high numbers of common bully and mosquitofish. A number of species, including inanga, common smelt, banded kokopu and common bully, are thought to spawn in the Lagoon. Estuarine/lowland species which live in the lower Lagoon include giant bully, parore, grey mullet and yelloweyed mullet.

Nearly forty species of waterbirds use the wetlands of the catchment of the Lower Reach of the Tarawera River. Threatened species include New Zealand dabchick and North Island brown kiwi. Both have been reported at Tumurau Lagoon and dabchick have been observed at Matata Lagoon and Lake Tamurenui. Other threatened species include banded dotterel, white heron, reef heron, banded rail, Australasian bittern, and North Island fernbird. The presence of these threatened wildlife species adds to the national and regional importance of the Tarawera wetlands.

The presence of rare waterbirds, common waterfowl and upland game is significant to statutory organisations such as the Eastern Region Fish and Game Council and the Department of Conservation. Wetlands may be used for recreational purposes including bird watching and duck shooting. These pursuits are allowed in some wildlife management reserves such as Lake Tamurenui and Bregman Lagoon.

Unfortunately, recreation and conservation do not always go hand in hand. The Awaiti Wetland has been substantially altered and disturbed by activities such as artificial pond construction, grazing to maintain low vegetation and development of vehicular tracks to allow access. These activities were largely designed to encourage game birds and provide access for hunters. Approximately a third of the Awaiti Wildlife Management Reserve is currently administered on a day to day basis by the Eastern Region Fish and Game Council who encourage development of maimai within the reserve area. It is important to ensure that the recreational use of the wetlands does not unduly compromise their conservation.

## Table 7

## PROTECTION STATUS, AREA, NUMBER OF THREATENED PLANT SPECIES, AND BOTANICAL IMPORTANCE FOR WETLANDS ASSOCIATED WITH THE LOWER REACH OF THE TARAWERA RIVER

| Site | Protection | Area (Ha) | Vulnerable | Rare | Local | Uncommon * | Importance |
|---|---|---|---|---|---|---|---|
| Lake Pupuwharau | N.F.P. | 40 | | 1 | | 6 | National |
| Tahuna-Putanaki Block | N.F.P | ? | 1 | | | | National |
| Lake Tamurenui | W.M.R. | 17 | | | | | Regional |
| Tumurau Lagoon | C.C. | 140 | | 2 | | 1 | National |
| Awakaponga Wetlands | W.M.R. | 8.1 | | 1 | | | National |
| Awaiti Wetlands | W.M.R. | 80 | | 2 | | | National |
| Tarawera Cut | W.M.R. | 14 | | 2 | | | National |
| Matata Lagoon | W.R.R. | 110 | | 1 | 1 | 4 | National |
| Bregman Lagoon | W.M.R. | 8.6 | | 2 | | | National |
| Matuku Wetlands | W.M.R. | 11 | | 1 | | | National |

* Number of species present which are uncommon in the Ecological District
N.F.P. = No Formal Protection
W.M.R. = Wildlife Management Reserve
C.C. = Conservation Covenant under the Reserves Act 1977
W.R.R. = Wildlife Refuge Reserve

## 13.4 Sustaining Life Supporting Capacity

Aquatic ecosystems often cope with brief environmental changes. However, the ability of organisms to tolerate prolonged changes in factors such as dissolved oxygen, light intensity, toxicity, temperature, pH and obstructions to migration is often limited.

In this section the threats to freshwater ecosystems in the Tarawera River catchment are reviewed. Many of the policies and methods which are expected to mitigate these threats are presented in Chapter 15 – *Surface Water Quality*. They reflect the intimate link between water quality and aquatic ecology. Where appropriate, these policies and methods are cross-referenced and briefly discussed here.

### 13.4.1 Dissolved Oxygen Content

Environment Bay of Plenty has identified the dissolved oxygen content of the Tarawera River to be a central issue in the preparation of this regional plan. The lower river is unusual in that at least 90% of the present dissolved oxygen depletion is due to oxygen uptake by bacterial communities present in the sediment. The river bed comprises moving dunes composed of porous pumice sediment. This provides an ideal habitat for oxygen-consuming bacteria which primarily feed on the industrial effluent. Thus, the physical nature and the sediment ecology of the river limit its ability to assimilate effluent without significant depression of oxygen levels.

The oxygen requirements of aquatic organisms have been extensively studied. The United States Environmental Protection Agency[57] stated:

> *There is apparently no concentration level to which the oxygen level of natural waters can be reduced without causing or risking some adverse effect on the reproduction, growth and consequently the production of fishes inhabiting those waters.*

There is relatively little information on the dissolved oxygen requirements of New Zealand's indigenous fish. Generally those species that would be expected to be present in the main stem of the Lower Reach of the Tarawera River tolerate lowered oxygen levels. These species include eels, bullies, smelt and inanga. Dissolved oxygen levels are likely to be most critical to native fish during the upstream and downstream migration of juveniles.

The concept of using a Fish Purpose classification is not on the basis of recreational fishing but on the basis of developing a viable trout fishery that is indicative of a healthy sustainable environment.

While it has been suggested that adult trout are present in the Lower Reach of the Tarawera River, it is considered that dissolved oxygen levels will need to be improved to become consistent with Fish Purpose standards which indicate a health river environment[58]. Environment Bay of Plenty has adopted the approach of the USEPA[59] in setting dissolved oxygen standards for the main stem of the Lower Reach of the Tarawera River. These are intended to provide protection for cold-water fisheries values (e.g. trout) using a staged approach as outlined in Table 8 below (Rule 15.8.4(h)(i)).

## Table 8

## OXYGEN CLASSIFICATION – FISH PURPOSES LOWER TARAWERA RIVER

| Period | Mean of any consecutive 30 days | Mean minimum of any consecutive 7 days | Absolute Minimum |
|---|---|---|---|
| To 31 December 2002 | 5.0 $g/m^3$ | 4.0 $g/m^3$ | 3.5 $g/m^3$ |
| From 1 January 2003 | 6.0 $g/m^3$ | 5.0$g/m^3$ | 4.5 $g/m^3$ |

Environment Bay of Plenty believes that these standards will provide adequate protection for aquatic life which would normally be expected in the main stem of the Lower Reach of the Tarawera River. The standards for the catchment of the Upper Reach of the Tarawera River and all tributaries of the Tarawera River excluding the drains of the Rangitaiki Plains specify that the dissolved oxygen concentration shall exceed 80% of the saturation concentration (see Chapter 15 – *Surface Water Quality*).

57 Cited in NWASCO, 1979.

58 The Tarawera River Liaison Group were in general agreement that the re-establishment of a trout fishery was a reasonable restoration goal for the Lower Tarawera River.

59 USEPA, 1986.

### 13.4.2 Light Penetration (Colour and Clarity)

The major ecological impact of reduced water clarity in the Lower Reach of the Tarawera River is the reduction of submerged aquatic plant communities. Inputs of colour from Tasman Pulp and Paper Company Limited discharge clearly reduce light penetration to the river bed. As a result, the potential habitat available for aquatic plants has been reduced by the Tasman Pulp and Paper Company Limited discharge. Similar lowland systems with adequate light penetration (e.g. the Kaituna and Rangitaiki Rivers) are known to support large areas of aquatic plants. However, there is uncertainty as to whether the mobile bed of the Lower Reach of the Tarawera River would support similarly abundant communities and associated biota.

The feeling of predatory fish which visually search for prey is likely to be affected downstream of the Tasman Pulp and Paper Company Limited outfalls. In particular, the feeding of trout could be impaired because of reductions in the distance at which the prey can be seen. As discussed in section 13.3.2, the ability of smelt to collect food in the lower river does not appear to be significantly impaired. Because of the lower visual clarity it might be expected that these fish are themselves less vulnerable to predation by other fish and waterbirds.

Rules relating to the maintenance of colour and clarity standards in the water bodies of the Tarawera River catchment are given in Chapter 15 – *Surface Water Quality*. With regard to the Lower Reach of the Tarawera River, Rule 15.8.4(h)(ii) states (in part) that there shall be no decrease in visual clarity of the surrounding water upstream of any discharge that would (or may) reduce clarity, in this case water at the Kawerau Bridge monitoring site. In the long-term, this rule is expected to provide an improvement in the visual appearance of the river and enhance aquatic habitat.

### 13.4.3 Toxicity and Instream Impact

Toxicity testing has been carried out on Tarawera River water and on the major industrial effluents. Tests on a number of organisms showed that toxicity was found to be moderate in undiluted geothermal effluence, slight for the Carter Holt Harvey Tissue CTMP effluent and minimal for the Tasman Pulp and Paper Company Limited[60]. In contrast, the hatching of eggs and larval survival of zebra fish have been found to be severely affected by undiluted Carter Holt Harvey Tissue effluent, indicating high toxicity[61]. Standard toxicity tests have revealed no toxicity in river water collected downstream of the mixing zone[62] of any of the major discharges. This is due to the generally high dilution rates of the toxic effluents, including geothermal discharges and Carter Holt Harvey Tissue CTMP effluent discharges, in the river water.

Environment Bay of Plenty has used aquatic invertebrate communities to assess trends in the water quality and hence the life supporting capacity of the Tarawera River. Invertebrate species vary widely in their tolerance to pollution. For this reason the occurrence of sensitive or tolerant species can be used as an ecological indicator of water quality. Established impact assessment protocols[63] have been applied to the Tarawera River invertebrate data sets. This has allowed the level of industrial impact on the invertebrate communities to be expressed within a scale ranging from no impact to severe impact.

---

60 Hickey, 1994.

61 Beresford, 1993.

62 The setting of mixing zones is discussed in the *Surface Water Quality* Chapter.

63 USEPA, 1989.

Since 1983 the ability of the Lower Reach of the Tarawera River to support balanced invertebrate communities has been significantly reduced. In 1983 the Kawerau sewage and Tasman Pulp and Paper Company Limited oxidation pond outfalls caused a moderate level of impact. There was no apparent impact from the Carter Holt Harvey Tissue outfall which at that time discharged clarifier effluent only. By 1991 the impact attributed to the Carter Holt Harvey Tissue effluent had increased to moderate, with a gradual downstream increase leading to severe impact upstream of the Tasman Pulp and Paper Company Limited outfalls. This severe impact caused the near complete loss of sensitive species and a marked increase in the abundance of pollution-tolerant species.

The increase in impact since 1983 is due to the discharge from the Carter Holt Harvey Tissue anaerobic effluent treatment plant which began operation in the early 1990s. As a result the sensitive, and important, mayfly and caddisfly species are not present to colonise in significant numbers downstream of the Carter Holt Harvey Tissue outfall. It is clear that the chemical inputs from the Tasman Pulp and Paper Company Limited and Works Geothermal effluents have been measurably reduced over the past decade. Unfortunately, any reduction in the impact of these effluents is difficult to assess because of the large increase in the impact of the Carter Holt Harvey Tissue effluent.

Within the toxicity literature there is uncertainty regarding the ability of laboratory toxicity tests to predict instream ecological impact. For this reason Environment Bay of Plenty intends to use a number of methods to monitor trends in the environmental performance of industry. Thus, assessments of instream community impact will be carried out in tandem with laboratory toxicity testing procedures (see Chapter 19 – Monitoring and Review). This monitoring may reveal whether instream exposure leads to actual mortality, or if in fact the observed invertebrate impact is due to avoidance of poor water quality or degraded substrate.

Rules relevant to toxicity in the water bodies of the Tarawera River catchment are given in Chapter 15 – *Surface Water Quality*. Environment Bay of Plenty proposes that there shall be no detectable increase in acute and chronic toxicity using a number of defined testing protocols (see section 15.8.4).

### 13.4.4 Water Temperature

As discussed in the Chapter 15 – *Surface Water Quality*, fish and invertebrates are generally considered to become stressed at temperatures above 25°C. Elevated temperatures are known to increase the amount of oxygen required by fish. Furthermore, the combined effects of heat stress and contamination also appears to increase fish mortality rates[64].

### 13.4.5 pH

No specific ecological issues have been identified in the Tarawera River catchment as a result of changes in pH. Most of the water bodies in the Tarawera River catchment have pH levels near neutrality (pH 7-8). It is generally accepted that pH levels of 5-9 will not unduly impact on aquatic communities. Environment Bay of Plenty proposes that the sustainable pH in the Lower Reach of the Tarawera River be between 6.5 and 8.5 (Rule 15.8.4(h)(v)). This more restrictive range is appropriate because of the potential for changes in the toxicity of ammonia and hydrogen sulphide with changes in pH.

---

[64] NWASCO, 1979.

## 13.4.6 Biological Growths

In December 1993, Environment Bay of Plenty carried out a survey[65] of biological growths in the Tarawera River. The survey found undesirable biological growth of genus *Ulothrix* and Thiothrix in parts of the lower river. The impact of these growths on the ecology and water quality of the river is difficult to determine. Generally, New Zealand rivers with similar growths have tolerant invertebrate faunas dominated by snails, worms and midge larvae. Such communities have been recorded below the Carter Holt Harvey Tissue outfall where they replace the more sensitive mayfly and caddisfly species[66].

Rules relating to the restriction of undesirable biological growths in the water bodies of the Tarawera River catchment are given in Chapter 15 – *Surface Water Quality*.

## 13.4.7 Physical Restrictions to Migration

Flow and flood control structures in the Lower Reach of the Tarawera River system have been identified as the main impediment to fish migration. Most free-swimming species have both seasonal and lifecycle movement patterns, and in some instances are restricted by the physical aperture of flow control structures, or more usually by the fall and velocity of flow across the structure. Map 6 identifies the main known obstructions to fish passage identified in the Lower Tarawera catchment. Most of these are positioned at the ends of drainage systems to prevent the backflow of floodwater, and to maintain water levels during times of low rainfall.

## 13.4.8 Wetlands in the catchment of the Lower Reach of the Tarawera River

The following are considered to be the major threats to the wetlands of the catchment of the Lower Reach of the Tarawera River.

### 13.4.8(a) Wetland Desiccation and Lowering of Water Levels

Many of the remaining wetlands are threatened by continued drainage of the surrounding land and steadily dropping water table levels. In certain places weirs have been built (Tumurau Lagoon, Matata Lagoon) and ponds excavated (Awaiti Wetland) to maintain water levels. Despite these measures there are still areas where dryland plants are taking over wetlands.

### 13.4.8(b) Grazing and Trampling by Livestock

Many of the wetlands are subjected to grazing and trampling damage by livestock. For example, trampling damage to rare swamp ferns (*Thelypteris confluens* and *Cyclosorus interruptus*) has been identified in the Bregman Wildlife Reserve. The trampling of dense vegetation may also reduce the available habitat for secretive waterbirds such as spotless crake and bittern.

---

65 Donald, R 1994 (May) Tarawera River Regional Plan Technical Investigations – Freshwater Ecology Component, Environment Bay of Plenty, Environmental Report 84/1. 121pp.

66 "Undesirable biological growths" are covered in detail in the Ministry for the Environment publication Guidelines for the control of undesirable biological growths in water (June 1992).

13.4.8(c) Vehicle Damage and Human Activities

During the duck shooting season, raupo clearance by herbicide spraying and vegetation cutting to clear tracks is carried out at selected sites (Tumurau Lagoon, Tahuna-Putanaki Block). Areas of wetland vegetation around the privately-owned Lake Pupuwharau have been extensively damaged by vehicle tracks.

13.4.8(d) Industrial Contamination

Significant contamination from the pulp and paper industry has been found in sediments from the lower eastern part of the Matata Lagoon. DHAA (dehydroabietic acid) and other resin acids are present at concentrations 10-15 times higher than background levels[67].

13.4.8(e) Agricultural Nutrient Pollution

The Awaiti Wetland is fed by water flowing via the Awaiti Canal. This water can be nutrient rich, due largely to discharge of dairy shed effluent into the canal. The high nutrient load is a cause for concern as it increases the risk of infestation by water net and other aquatic weeds. Aquatic animals and plant life tend to suffocate under these conditions, resulting in less species and invasion by introduced plants.

13.4.8(f) Invasion by Introduced Plants

Declining water levels tend to result in increasing numbers of introduced plants into areas formerly dominated by flax and sedges. A large introduced fern, *Osmundo regalis*, was found in the Bregman Wildlife Reserve in 1983. This plant has the potential to exclude threatened and local wetland plants. Problem plants in many of the wetlands include grey willow, privet, pampas, radiata pine, reed sweetgrass and raupo.

13.4.8(g) Sedimentation and Infilling

Over the past few decades infilling and sedimentation have lowered the depth of water in the Matata Lagoon. This has encouraged invasion by marginal vegetation, particularly raupo. Wood fibre from the pulp and paper mills upstream was deposited during the 1960s when high tides raised the level of the Tarawera River which subsequently flowed into the Lagoon. This formed a deep layer of dark-coloured organic sediments.

13.4.8(h) Lack of Protected Area Status

Lake Pupuwharau and the Tahuna-Putanaki Block are among the most valuable wetlands that are not legally protected. This leaves them vulnerable to private land uses.

## 13.5 Issues, Objectives, Policies, Methods of Implementation, Principal Reasons and Anticipated Environmental Results

### 13.5.1 Issues

The following are considered by Environment Bay of Plenty to be the important ecological issues affecting the water bodies of the Tarawera River catchment (excluding the Tarawera Lakes):

67 Wilkins and others, 1992.

13.5.1(a) Dissolved oxygen depletion is high in the Lower Reach of the Tarawera River.

13.5.1(b) The discharge of coloured effluent decreases light penetration which in turn can limit the growth of aquatic plants.

13.5.1(c) In 1993 undesirable biological growths were recorded in the Tarawera River downstream from the Carter Holt Harvey Tissue discharge.

13.5.1(d) The ecological impact caused by changes in the technology of industrial discharge treatment cannot be predicted with certainty.

13.5.1(e) Poor water quality in the lower river may be reducing the success of juvenile fish migration to the upper tributaries.

13.5.1(f) Dissolved oxygen concentrations are occasionally too low to sustain a viable trout habitat in the reach of the Tarawera River between Braemar and the river mouth.

13.5.1(g) Dissolved oxygen concentrations are occasionally too low to allow the full life cycle of all native fish in the lower reach of the Tarawera River to be completed without effects.

13.5.1(h) Eels in the lower river are showing minor stress symptoms attributed to pulp and paper contaminants.

13.5.1(i) Smelt growth appears to be indirectly enhanced by the industrial inputs.

13.5.1(j) The wetlands of the lower catchment represent 1.7% of those which once covered floodplains of the Tarawera and Rangitaiki Rivers.

13.5.1(k) The botanical and wildlife values of catchment habitats including wetlands and lakes are threatened.

13.5.1(l) Wetlands and lakes are variously threatened by nutrient and contaminant inputs, exotic plant infestation, over drainage, siltation and direct physical damage.

13.5.1(m) Historical pulp and paper industry contaminants in sediments in the eastern part of Matata Lagoon are a concern.

## 13.5.2 Objectives

13.5.2(a) Protection, maintenance and enhancement of the life supporting capacity of surface water bodies in the Tarawera River catchment.

13.5.2(b) Protection, maintenance and enhancement of the indigenous vegetation, habitat and migration pathways of the remnant wetlands, lakes, rivers and their margins in the Tarawera River catchment.

## 13.5.3 Policies

*Note:* *Policies relevant to Objective 13.5.2(a) (life supporting capacity of all surface water bodies) are given in Chapter 15 – Surface Water Quality.*

*Policies relevant to Objective 13.5.2(b) (wetlands in the lower catchment) are given below and in Chapter 14 – Surface Water Quantity.*

13.5.3(a) To ensure that the natural character of wetlands, lakes, rivers and their margins is not further degraded but is enhanced or protected from inappropriate subdivision, use and development.

13.5.3(b) To ensure that wetland, river and riparian values are provided for when maintaining and establishing drainage systems.

13.5.3(c) To discourage subdivision and development that results in the drainage, fragmentation or destruction of wetlands, riverine and riparian habitats.

13.5.3(d) To discourage the access of stock into wetlands and riparian margins and promote the effective fencing of wetlands and riparian margins.

13.5.3(e) To promote the restoration and enhancement of wetlands, lakes and riverine habitats; and their riparian margins.

13.5.3(f) To promote the creation of new wetlands.

13.5.3(g) To ensure that the existing wetland habitats are preserved and the creation and development of new wetland habitats encouraged.

13.5.3(h) To ensure that wetland and river habitats and migration pathways are conserved and, as appropriate, enhanced.

## 13.5.4 Methods of Implementation

*Note: Methods of Implementation, Principal Reasons and the Anticipated Environmental Results relevant to Objective 13.5.2(a) are given in Chapter 15 – Surface Water Quality.*

*Methods of Implementation relevant to Objective 13.5.2(b) (wetlands in the lower catchment) are given below and in Chapter 14 – Surface Water Quantity).*

**Environment Bay of Plenty will:**

13.5.4(a) Make appropriate submissions to district councils through the statutory consents process, to discourage the subdivision (resulting in fragmentation), drainage and development of wetlands.

13.5.4(b) Cooperate with relevant organisations and individuals to determine the most appropriate methods for the protection and enhancement of wetlands, river and lake habitats, and their riparian margins.

13.5.4(c) Promote the maintenance of water levels in wetlands within the minimum and maximum levels specified in Rule 14.4.5(a) (Chapter 14 – *Surface Water Quantity*).

13.5.4(d) Research, in conjunction with district councils, tangata whenua, the Department of Conservation, Eastern Region Fish and Game Council, and other relevant organisations and individuals, the importance of the natural values of the wetlands, lake and riverine habitats and riparian margins in sustaining natural habitats and communities.

13.5.4(e) Promote, in conjunction with district councils, the Department of Conservation, Eastern Region Fish and Game Council, and other relevant organisations and individuals, research into the location and significance of the wetland and river habitat and migration pathways of aquatic life, particularly native fish species, and fish food species.

13.5.4(f) Manage its flood control and drainage activities to minimise adverse effects on aquatic habitat and where practicable enhance the natural character and ecological values of the Tarawera River catchment.

## 13.5.5 Principal Reasons

Much of the lowland Tarawera River has been realigned and channelled for flood control and drainage purposes and there are conflicts between the management of the wetlands and the drained land. Less than 2% of the original Tarawera River catchment wetlands and the habitat they provide remain. These wetlands are important representative remnants of lowland ecosystems and their retention and rehabilitation requires interventional management, including ensuring minimum water levels and reliable water supply. Policy requiring the careful management of drainage and flood control systems is necessary to ensure that the remnant wetlands are not deprived of an adequate water supply. This should ensure that their viability is not placed at risk and their natural values are not damaged.

Subject to the efficient performance of their drainage function, policy is also necessary for the appropriate management of drains and canals to ensure the protection of the natural values they provide. This includes providing for whitebait spawning habitat and migration routes for the native fish.

## 13.5.6 Anticipated Environmental Results

13.5.6(a) Remaining wetlands are identified and protected.

13.5.6(b) Wetlands, lakes and riverine habitats, and riparian margins are protected and enhanced.

13.5.6(c) The natural values of wetlands, riverine and lake habitats riparian margins are recognised and provided for.

13.5.6(d) Additional wetlands may be identified, created and maintained.