WAIKATO CONSERVANCY

Lower Waikato River and Estuary (10)

Location: Rangiriri, 37°26'S, 175°08'E; centre of delta, 37°21'S, 174°46'E. The Lower Waikato River is approximately 34 km southwest of the city of Auckland at Port Waikato and 72 km south of the city of Auckland at Rangiriri, North Island.
Area: Lower Waikato River, c.3,500 ha (56 km from Rangiriri to Port Waikato); estuary c.588 ha.
Altitude: Sea level to 10 m at Rangiriri.
Overview: The Waikato River, between Rangiriri and Port Waikato, passes through large areas of mineralised swamp and shallow lakes, and finally discharges through a diverse delta habitat to the sea. It provides habitat for a range of threatened bird species, and supports New Zealand's largest eel fishery.
Physical features: The site comprises the Lower Waikato River from Rangiriri downstream for about 56 km to Port Waikato at its mouth. The basement rocks of the Waikato Region are comprised of Mesozoic "greywacke-type" rocks that have undergone extensive alteration to form dissected fault blocks around the perimeter of the Waikato catchment. During the early Tertiary, coal measures with associated freshwater and shallow marine sediments were laid down, although today many have been removed by erosion. Following this period, a series of several different phases of volcanism occurred. As a result of extensive sediment deposition at this time, the Waikato River, which previously flowed out to the Firth of Thames, changed course to flow out into the Hamilton Basin, bringing much sediment with it and causing extensive deposition and creating small lakes and swamps. The soils in this area are primarily brown granular loams and clays, gley and yellow brown earths.
The entire Waikato River is 425 km long with its source in the central North Island volcanoes from where it flows north into Lake Taupo and out through the plateau lands in an incised channel. Eight hydro-electric dams occur along this stretch of river, after which the river flows on to flat swampy lowlands and out to a wide delta before reaching the sea. Here the river is made up of sandbars, islets and broad braided channels. From Mercer to Port Waikato, the river is generally broad and meandering, with elongated low-lying islands in its lower reaches. The last 5 km of the river are typically deeper than the rest of the channel, and are confined by a large sandspit at Port Waikato which extends some 3 km northwards from the southern head.
Flows in the Lower Waikato are largely influenced by upstream power generation and a number of flood control schemes in place in the catchment. The upper section of this part of the river has been channelised by the extraction of sand, but the lower delta area is made up of braided channels (*i.e.* a myriad of channels caused by the changeable nature of the river bed).
The Waikato River is one of the most utilised rivers in New Zealand, and by New Zealand standards is considered to be polluted, although water quality is improving. In the Lower Waikato, the Waipa River has a major influence on water quality, and results in the dilution of most water quality parameters. Contamination of tributary streams by surface run-off containing phosphorus, nitrogen and potassium is occurring, and contributes to some of the water quality problems in the river. The Lower Waikato is also exposed to a range of domestic, agricultural and industrial discharges as well as surface run-off, which all contribute to the further enrichment of the river.
The depth of the river varies, but is generally around 5-6 m; it is subject to tidal fluctuations of up to 15 cm at Tuakau Bridge and 10 cm at Mercer during high tides and low flows.
To the north of the Waikato River, the catchment in this reach is primarily used for pastoral farming (*i.e.* dairy farming), with areas of highly intensive horticultural land around Pukekohe,

Bombay and Waiuku. Dairy farmland is increasingly being developed for horticultural purposes. South of the river, sheep and mixed livestock farming are the predominant land uses. The immediate catchment area is 1,837 sq.km.

The climate of the Waikato is generally one of warm humid summers, mild winters and moderate rainfall with a peak in winter. The mean annual temperature is about 12.5°C, with mean monthly temperatures varying by about 10°C. The average annual rainfall is about 1,200-1,600 mm.

Ecological features: The Waikato River is a significant wildlife and fish habitat, and is important in maintaining the diversity and abundance of flora and fauna in the Waikato Region, with the delta in particular providing a rich habitat for a range of species. The river delta contains a number of islands, some of which are vegetated with native Kahikatea *Dacrycarpus dacrydioides* and Totara *Podocarpus totara*. Large areas of natural wetland communities occur on the islands in the delta, including New Zealand Flax *Phormium tenax*, Raupo *Typha orientalis*, rushes *Juncus* spp., sedges *Carex* spp. and submerged plants. The vegetated areas near the river mouth are made up of sedges and rushes. On the more stable dunes, the native sand-binding plant Pingao *Desmoschoenus spiralis* is present, along with Spinifex and Marram Grass *Ammophila arenaria*. A large proportion of the catchment area is vegetated with exotic plant species.

Land tenure: The Waikato River and estuary area are a mixture of Crown land, Maori land and private land.

Conservation measures taken: A number of islands in the lower river upstream of the delta and estuary (totalling approximately 68 ha) are Crown land, with the status of Government Purpose (Wildlife Management) Reserve. These are managed by the Department of Conservation. Significant islands are freehold land owned by the Auckland/Waikato Fish and Game Council. The delta, estuary and river currently have no formal protection status, although Port Waikato sandspit is designated a Recreation Reserve.

The complexity of the Waikato River and the demands placed on it mean that management of the river is a complex issue, with a number of organisations having responsibility for various aspects of it. The Waikato Regional Council has the responsibility for water and soil conservation, including the quality of the river, abstractions, use and discharges of water, as well as channel and catchment erosion. The waters of the Waikato have been classified according to their requirements for waste control and water quality management under the Water and Soil Conservation Act 1967. The various classes of water have certain minimum water quality requirements which must be maintained in order to promote the conservation and best use of the water. The Waikato River has a Class "D" status. Electricorp (a state-owned enterprise) has a direct impact on the river through management of the upstream dams for electricity production. The Department of Conservation is responsible for the management of the Government Purpose (Wildlife Management) Reserves and wildlife generally. The Fish and Game Council manages some of the islands in the delta for game-bird purposes. The Fish and Game Council also sets quota (bag limits and catch limits) for the hunting and fishing seasons; sets the timing of the hunting and fishing seasons; sets the methods of hunting and fishing; issues hunting and fishing licences; and carries out enforcement in relation to these functions.

Conservation measures proposed: No information.

Land use: Conservation of flora and fauna, protection of wildlife and recreational use in the Government Purpose (Wildlife Management) Reserves. Protection of wildlife and the fostering of recreational hunting in the areas owned by the Auckland/Waikato Fish and Game Council. The land surrounding the Waikato River is primarily in dairy farming and horticultural use, and there are only a few remnant areas of the original podocarp and broadleaf forests that once covered the area. The river itself acts as a multiple-use resource for recreation, water supply

and waste disposal purposes. It provides a water source for domestic water supply, rural supplies, irrigation and industrial use (*e.g.* dairy factories, coal mines and abattoirs), and is used for the generation of hydro-electric power. The human population in the area around this part of the river is very dispersed, but likely to be in the order of 2,000-3,000, with the major cities of Auckland (1,000,000) and Hamilton (100,000) within a 70 km radius.

Possible changes in land use: Development projects likely to occur in this area relate to new power generation projects, coal mining, further urban expansion and a change in land use from pastoral farming to horticultural use.

Disturbances and threats: The Waikato River has over the years been subject to a range of disturbances and modifications from the headwaters to its outlet. There are eight hydro-electric power stations on the Waikato River system upstream of Rangiriri. Discharges into the river include industrial effluents, sewage, storm water, thermal discharges and diffuse run-off from rural lands. Many of the latter contribute to eutrophication of the river. Discharge of heated water from the Huntly Power Station is of particular concern, because of its effect on aquatic flora and fauna. Drainage and flood protection schemes, in particular, have reduced the area of adjoining swampland, and limited the habitat available to waterbirds and fish. All of these factors are a continuing threat to the river system.

Sand abstraction and quarrying have a high visual impact on the river and a direct impact on fish spawning habitat. These activities have resulted in a fall in water levels in the river. This has affected the Whangamarino Wetland (Site 11), and steps are now being taken to alleviate the problem by raising water levels in the wetland with the assistance of a weir. Sand abstraction and quarrying have also resulted in damage to archaeological sites. Cattle grazing occurs in places down to the water's edge, causing damage to marginal vegetation. Trail bikes and dune buggies are causing extensive damage to the sandspit vegetation and disturbing breeding birds. Natural processes can also be seen at work, with the northern bank of the river continually eroding. On the south head, modification of river margins has occurred.

Hydrological and biophysical values: The Waikato River plays a general role in the recharge and discharge of groundwater and the support of food chains. At any one time, vast quantities of water are stored within the system in Lake Taupo and the Waikato hydro-lakes, as well as numerous small lakes throughout the catchment. The peat bogs and mineralised swamps in the Lower Waikato also serve as storage areas, and are well utilised in various flood control schemes. For example, Whangamarino Wetland is part of a major water storage area for flood control. Groundwater represents an important component of the water balance of the catchment, and is a potentially useful source of agricultural and domestic water supply.

The Waikato River is an important migration route for fish migrating to and from the sea or the associated lakes or wetlands of the lower Waikato Region. The Waikato River system supports the single most important whitebait and eel fishery in North Island.

Social and cultural values: The Waikato River has particular significance to the Maori people of the area (*i.e.* the Tainui people), both physically and spiritually. It is also the centre of the Maori King movement. A number of archaeological Maori settlements are known in the lower Waikato, although further intensive search is required. The river is also a traditional whitebait, mullet and eel fishery for the Maori people. It is used for a range of recreational activities, and has high aesthetic and visual values. It provides an important educational resource for schools through to universities.

Noteworthy fauna: The estuarine habitat near Port Waikato is used by a wide variety of bird species, and supports both estuarine and freshwater wetland species. The sandspit and tidal flats at the mouth of the Waikato River are important for migratory shorebirds, notably Banded Dotterel *Charadrius bicinctus*, Wrybill *Anarhynchus frontalis* and Bar-tailed Godwit *Limosa lapponica* (New Zealand Wildlife Service, 1981a). The islands are used as high tide roosts.

Other notable species occurring in this area include Banded Rail *Rallus philippensis assimilis*. The North Island Fernbird *Bowdleria punctata vealeae* occurs along the estuarine margins.

Some 31 species of birds have been recorded as inhabiting the river, associated swamps and shore vegetation. These include White-faced Heron *Egretta novaehollandiae*, Pacific Reef Egret *E. sacra*, Black Swan *Cygnus atratus*, Mallard *Anas platyrhynchos*, Grey Duck *A. superciliosa*, New Zealand Shoveler *A. rhynchotis variegata*, Spotless Crake *Porzana tabuensis plumbea*, Pied Stilt *Himantopus leucocephalus* and White-fronted Tern *Sterna striata*, as well as shags *Phalacrocorax* spp. and some gulls *Larus* spp. The New Zealand Dabchick *Poliocephalus rufopectus* and New Zealand Scaup *Aythya novaeseelandiae* occur in very low numbers, and the Brown Teal *Anas aucklandica chlorotis* has been recorded as a very occasional visitor.

The Australasian Bittern *Botaurus poiciloptilus* breeds in the thick *Typha* and *Scirpus* swamps. Other species reported to breed in the area include Variable Oystercatcher *Haematopus unicolor*, New Zealand Dotterel *Charadrius obscurus* and Caspian Tern *Sterna caspia*.

There are a number of native and introduced fish species in the river. Native species include the four native Galaxiid species (whitebait), Short-finned and Long-finned Eels *Anguilla australis* and *A. dieffenbachii*, Grey Mullet *Mugil cephalus*, Common Smelt *Retropinna retropinna*, Common Bully *Gobiomorphus cotidianus* and Torrent Fish *Cheimarrichthys fosteri*.

Noteworthy flora: The native sand-binding plant Pingao *Desmoschoenus spiralis* is present on the more stable sand dunes near the river mouth.

Scientific research and facilities: A number of scientific studies have been undertaken on various aspects of the Waikato River. The Waikato Regional Council regularly monitors water quality at a number of stations along the river.

Conservation education: Port Waikato is a popular school camp site. A lodge is located at the Port, and is available for use by school and other groups. The area is used extensively for coastal and geological studies by schools and universities. The river offers considerable potential for educational purposes.

Recreation and tourism: The river offers a range of recreational activities including whitebaiting and fishing, bird-watching and game-bird hunting, as well as a range of land-based activities (*e.g.* walking) which are associated with the area. However, off-road motorbikes and dune buggies are having adverse effects on the sand dunes.

Management authority: Various organisations are involved in the management of the river (see under "Conservation measures taken" above). The Department of Conservation (Waikato Conservancy) has responsibility for management of Crown land and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources and the preparation of coastal plans. The Auckland/Waikato Fish and Game Council has responsibility for the management of sport fishing and game-bird hunting.

Jurisdiction: Territorial: Waikato District Council and Franklin District Council. Functional: Waikato Regional Council, Department of Conservation and Auckland/Waikato Fish and Game Council.

References: New Zealand Wildlife Service (1981a); University of Waikato (1981); Waikato Valley Authority (1979, 1985).

Reasons for inclusion:

1a The Lower Waikato River and Estuary are a particularly good example of a lowland river system with a diverse estuarine delta.

2a The wetland supports populations of at least four globally threatened species of birds, *Poliocephalus rufopectus*, *Botaurus poiciloptilus*, *Charadrius obscurus* and *Anarhynchus frontalis*.

2b The wetland supports a variety of plant and animal species which are uncommon or rare elsewhere in New Zealand (*e.g. Desmoschoenus spiralis*), and is thus of special value in maintaining the genetic and ecological diversity of the region.

2c The wetland is of special value as breeding habitat for several uncommon and threatened species of birds, notably *Botaurus poiciloptilus*, *Haematopus unicolor*, *Charadrius obscurus* and *Sterna caspia*.

Source: Helen Neale.

Whangamarino Wetland (11)

Location: 37°18'S, 175°07'E. In Waikato District, 62 km south of Auckland City, North Island.

Area: c.7,290 ha.

Altitude: Average elevation 4.2 m.

Overview: Whangamarino Wetland is the second largest bog and swamp complex in the North Island of New Zealand. Some 239 wetland plant species have been recorded from the area, of which 60% are indigenous, with several classified as rare or vulnerable. It is important waterfowl habitat, with some tens of thousands of Anatidae (Black Swan *Cygnus atratus*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Shoveler *A. rhynchotis*) using the wetland from late autumn to spring, depending on water levels. The site includes the 5,690 ha "Whangamarino Wetland" Ramsar Site. This site was listed under the Ramsar Convention on 4 December 1989.

Physical features: Whangamarino Wetland is contained within three large shallow basins drained by the Maramarua and Whangamarino Rivers and the Reao Stream. The wetland is bounded to the east by the Maungaroa fault and to the west by a range of low hills from Te Kauwhata to Meremere. To the east is the Hapuakohe Range, which dates from the Upper Jurassic age; clays eroded from these hills form the base of the wetland. A few small islands of siltstone outcrop within the wetland. More recent Waitemata sediments form the base of the low hills on the other side of the wetland, and above this base are gravels, sands and clays from the Whangamarino formation. These materials also form emergent islands of high ground in the wetland. The most significant geological factor in relation to management of the wetland is the presence of coal below the site. It is significant because of the potential commercial value of the coal resource and possible effects of extraction on the integrity of the wetland. The coal is some 400-500 m below the surface of the Reao Arm, and increases elsewhere to an average depth of 800 m below the surface.

The predominant soils of the wetland are organic peat soils which form in the hollows and on the low-lying flats where the water table is permanently high and anaerobic conditions have led to the accumulation of organic matter. Recent soils from alluvium have formed over the organic soils, or have mixed with organic soils, along the margins of the rivers and streams in the wetland where inorganic materials are periodically being added to the land surface.

Whangamarino Wetland in non-flood conditions is fed by a catchment area of some 48,900 ha. In a flood, the wetland also receives water from the greater Waikato River catchment, via Lake Waikare. In its uncontrolled state (pre-1959) during high flow conditions, water from the Waikato River moved into Lake Waikare north of Ohinewai by means of reverse flows up Te Onetea and Rangiriri Streams. The lake acted as a major ponding area, and once water levels reached a certain point, it flowed overland into the Whangamarino Wetland. From there, the waters eventually drained back into the Waikato River via the Whangamarino Wetland and

River. However, as the Waikato River rose, flows reversed up the Whangamarino River and the wetland then acted directly as a ponding area for flow from the Waikato River as well as for Lake Waikare overflow and catchment flow (Hannah, 1981).

The lower Waikato-Waipa Flood Protection Scheme began in 1961. With regard to the Whangamarino wetland, it aimed at permitting limited development of land for agriculture. Such land was to be protected by stop-banking and pumping. The remainder of the wetland was to act as a controlled flood-ponding area for the Whangamarino, Maramarua and Kopuku river catchments, with a capacity of 60 million cubic metres of water. The controlled ponding function of the wetland was achieved in part by erecting a control structure at the confluence of the Whangamarino and Waikato Rivers, to prevent direct backflow by the Waikato River, and by installing an outlet control at Lake Waikare.

Water levels in the peat bogs fluctuate by about 10 cm. Water levels in the mineralised zone fluctuate considerably, and can vary by about 2.0-2.5 m during the course of a year.

The majority of waterways in the wetland are highly turbid as a result of carrying high levels of silt from Lake Waikare or due to the leaching of humic materials from the peat areas. The Maramarua arm carries high silt loads from the eastern hills and an adjoining open-cast coal-mining overburden dump.

The climate resembles that of much of the lower Waikato Basin, with an average annual rainfall of 1,200 mm. Temperatures are mild, with mean daily values ranging from 19°C in summer to about 9°C in winter. Frosts are infrequent, and fog is common in winter. Westerly winds prevail, and average annual sunshine hours are about 2,050-2,150.

Ecological features: The wetland complex is made up of peat bog, swampland, mesotrophic laggs, open water and river systems. The Ramsar Site occupies most of the wetland area. The vegetation within the wetland is closely linked to the pattern of bog and swamp. The variation between extremes of acidic peat bog and mineralised swamp is reflected in a diversity of plant associations (Ogle & Bartlett, 1981). A vegetation map drawn for the entire wetland (Strachan, 1981) indicates that in the area subject to the management plan, some 3,000 ha contain peat bog plant species and some 2,600 ha contain swampland vegetation.

The peat bogs contain relatively few plant species, almost all of them indigenous. The sedges *Baumea*, *Schoenus* and *Tetraria* spp., wire rush *Empodisma* spp., Umbrella Fern *Gleichenia dicarpa* and Manuka *Leptospermum scoparium* are the dominant species. The most common peat bog plant associations are *Baumea* spp. dominant with *Leptospermum scoparium* present (c.40%); *L. scoparium* dominant with some *Baumea* spp. (c.20%); and *L. scoparium* with *Schoenus* sp.

The swamplands support a more diverse range of plants, many of which are exotic species. Willows *Salix* spp. dominate some areas, while other sites comprise herbaceous vegetation only. Water Plantain *Alisma plantago-aquatica*, willow weeds *Polygonum* spp., Water Purslane *Ludwigia palustris*, sedges *Carex* spp., rushes *Juncus* spp., buttercups (mostly *Ranunculus flammula*) and various grasses become abundant in summer and autumn as water levels drop. Seed production from these and other herbs is of great importance to species of Anatidae. The most common swampland associations are dense Pussy Willow *Salix atrocinerea* (c.20%); tall Manuka *Leptospermum scoparium* (c.18%); mixed herbaceous plants and grasses (c.15%); and dense crack willow (c.11%). Other associations include mixed herbaceous plants and scattered willows, and open crack and pussy willow and mixed plants. The diversity of plant habitats is such that there is a wide variety of species which are less common or conspicuous and are difficult to map. In the past, larger areas of peat bog, kahikatea swamp forest and mesotrophic sedge swamp were present.

Nineteen macrophyte species are found in aquatic habitats in the wetland. These include submerged and free-floating plants. The vegetation of rivers, streams and flowing water around the wetland consists of extensive beds of submerged and semi-emergent plants, forming rafts

of vegetation extending from the banks. Much of the water in the main waterways is coloured by peat, and supports various species able to withstand turbid water conditions. The introduced macrophytes *Egeria densa* and *Ceratophyllum demersum* are most widespread in these waters. The large open water bodies contain submerged *Nitella* spp., *Myriophyllum propinqum*, *Potamogeton* spp. *etc*. In areas protected from the wind, free-floating *Azolla rubra* is associated with semi-emergents. In small ponds and sheltered open water areas, often at the edges of swamp and in areas bordered by willows, free-floating species known collectively as duckweed often form a complete coverage. Floating Sweet Grass *Glyceria maxima* is aggressively colonising large areas of shallow open water in channels and river margins.

Land tenure: Approximately 4,960 ha (including 320 ha above the wetland margin) are Crown land held as Stewardship Area and administered by the Department of Conservation. Some 565 ha of the Crown land are leased for grazing on a temporary basis. Approximately 730 ha are privately owned by the Auckland/Waikato Fish and Game Council (formerly the Auckland Acclimatization Society). The remaining 1,600 ha are in private ownership.

Conservation measures taken: The Crown land is held as Stewardship Area administered by the Department of Conservation. It became Stewardship Area on allocation to the Department of Conservation on 1 April 1987. Some 5,690 ha of Whangamarino Wetland were listed as a wetland of international importance under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention) on 4 December 1989. At present, conservation management of the wetland is currently undertaken by the Department of Conservation and the Auckland/Waikato Fish and Game Council. The latter has a statutory role to promote game and sport fish, and habitat protection. Some owners of adjoining private land also manage their areas of wetland for conservation purposes, although the majority of private land is farmed.

Programmes currently under action by the Department of Conservation include willow control in selected areas, fire control, some management of recreation activities (including licensing of huts for game-bird shooting), issuing of licences and leases for grazing, general administration, monitoring wildlife, promotion of wildlife values, and enforcement of the provisions of the Wildlife Act 1953. Monitoring is being carried out on an area burnt during a fire in 1989, to determine recolonisation rates by various bird species; vegetation is also being monitored. The fire swept through vegetation, but did not burn into the underlying peat due to high water levels.

The Auckland/Waikato Fish and Game Council manages its own lands to provide game-bird habitat and shooting stands. The Fish and Game Council also sets quota (bag limits and catch limits) for the hunting and fishing seasons; sets the timing of the hunting and fishing season; sets the methods of hunting and fishing; issues game hunting and fishing licences; and carries out enforcement in relation to these functions. Waikato Regional Council controls water levels in the wetland for flood protection purposes.

Conservation measures proposed: The main objectives for future management have been outlined in the Whangamarino Wetland Management Plan, prepared by the Department of Conservation in 1989. This Management Plan recommended that the water levels in the wetland be reinstated. In order to achieve this, the Department of Conservation and the Auckland/Waikato Fish and Game Council have been pursuing a water right application to raise water levels in the wetland to a minimum water level of about 3.40 m.a.d, or a level sufficient to maintain a wetland ecosystem without adversely affecting adjoining land uses. The water right was granted by the Waikato Regional Council in 1992, but was appealed. The appeal was withdrawn prior to it being heard at an appeal hearing, after a negotiated settlement was reached between the parties concerned. Construction of the weir to enable the raising of

the water level was scheduled to take place during the summer of 1992/93 (December to March).

In order to protect and maintain the wetland ecosystem, it is critical that water levels be managed and held at a minimum level up to a metre higher than occurs on average at present. To do this, it is necessary to acquire or negotiate agreement with the owners of low-lying portions of adjoining properties. For water level management and habitat protection, the acquisition of or agreement over parts of one privately owned property will continue to be sought. Management of the leased areas adjoining the wetland may also be required.

The Management Plan also recommends that the protective status of Whangamarino Wetland be changed from "Stewardship Area" to "Government Purpose (Wetland Management) Reserve" to acknowledge the value of the wetland. As far as possible, the spread of exotic plants from swamp land into peat bog areas and into mineralised wetland not presently infested should be controlled. In the long term, management should work towards replacement of exotic plants in selected places with indigenous species suited to a wetland location. Research should be continued into the most cost-effective method of controlling exotic plants, and advice sought in vegetation management programmes.

Endangered, vulnerable or rare species of indigenous plants or animals will be protected throughout the Whangamarino Wetland, whether located in peat bogs or swampland. The protection of such species on adjoining wetlands will be actively promoted. The protection and conservation of other indigenous species of plants and animals will also be a priority throughout the wetlands, and any recreational or other developments will be assessed in terms of their impacts on these species. A number of other management objectives relate specifically to the peat bogs and mineralised swamp areas, and can be found in the Management Plan.

Land use: A prominent topographical feature of the northern part of the wetland is a causeway, some 4-5 metres wide, constructed across the wetland between 1950 to 1958. The causeway carries the pylons which support the rope-and-bucket cableway carrying coal from the coal mines at Kopuku to the Meremere Power Station. The causeway also provides direct road access between the mine and the power station and access to duck-shooting areas in the adjacent wetlands. The causeway has affected water levels within the wetland, by assisting in maintaining water levels in the area of wetland upstream of the causeway. Invasion of exotic weeds is not as great in this area as elsewhere, because water levels are higher and subject to less pronounced fluctuations.

Some 565 ha of Crown land are leased for grazing on a temporary basis under 12 leases or licences. About 1,700 stock units are carried, mostly dry cows or heifers. There is some adverse impact on the wetland area by stock straying from several adjoining properties or leased areas. Most grazing licences contain conditions regarding removal of stock prior to and during duck-shooting.

The wetland, including Lake Waikare, forms part of an important eel fishery. Short-finned Eels *Anguilla australis* are the favoured species. In 1979, some 78 tonnes of eels were taken from the Whangamarino and Maramarua Rivers. The peak time for eeling occurs as high flood levels begin to drop and the eels begin to move back into the main waterways. There is also some commercial fishing for Grey Mullet *Mugil cephalus* from the Whangamarino River, but the quantities taken are not known. The potential market for catfish *Ictalurus nebulosus* was investigated in 1980, but was not found to be economically viable. According to local fishermen, catfish far exceed eels by weight in fyke net hauls. At present, one fisherman is involved in harvesting Koi Carp *Cyprinus carpio*, and this number is likely to increase in the near future.

Some 73 ha are leased for purposes related to the coalfield, including the dumping of overburden on the northeastern margin of the wetland.

Apiculturalists also utilise the wetland throughout the year.

Use of adjacent areas of reclaimed wetland varies from conventional sheep and beef cattle farming on poorer quality land to dairying. Market gardening and cash cropping occur on land which is part of the Motukaraka and Bell Road drainage schemes. The presence of timber in the peat has hindered development, as has the soil's low-lying nature and low temperatures.
Pastoral uses, including sheep, beef, dairy and goat farming, predominate in surrounding areas above the wetland margins. A forestry industry has been established at Maramarua State Forest to the east of the wetland. To the west, around Te Kauwhata, horticulture and viticulture are important. At Kopuku, a large open-cast coal mine exists, with dumps of overburden adjoining and in part extending over the wetland, creating a compression ground wave which has affected the topography of the adjoining peatland. The general trend on adjoining land is towards more intensified management, especially on soils above the wetland margin.
The human population of the area around Whangamarino within a 10 km radius would be approximately 2,500, but within a 100 km radius, there would be about 1,200,000 (including Hamilton and Auckland cities). The wetland is therefore readily accessible to approximately one third of the population of New Zealand.
Possible changes in land use: Whangamarino Wetland is strategically located amidst several major energy developments or proposals. To the west is the Meremere Power Station, to which coal from the Kopuku mine (east of the wetland) is transported via the causeway which crosses the wetland immediately south of the Maramarua River. A major new power station has been proposed at Clune Road, southeast of Meremere. It is likely to be supplied with coal from the Maramarua coalfield northwest of the Kopuku mine. This coal could be transported to the power station via the causeway. Truck, rail and bucket cableway are among the transport modes being evaluated, as is their likely impact on the wetland. Widening of the causeway is a possible option. The Ohinewai coalfield southwest of Lake Waikare is also being evaluated for coal production by open-cast methods. The development of this coalfield could have a considerable effect on the water quality of Lake Waikare with consequences for Whangamarino wetland. An open-cast mine is proposed for farmland on the southern side of the Kopuku Arm of the wetland, and expansion of the existing Kopuku mine is possible.
Liaison with development agencies and monitoring of proposals will be undertaken to ensure that wetland values are recognised and the impacts of any development carefully considered.
Disturbances and threats: The drop in water levels is the most significant threat to the wetland, and is the principal management issue. The impact of the principal flood protection works has been: (a) increased ponding in Lake Waikare at peak floods, but overall a lower lake level and more rapid drainage into and through the wetland, giving lower water levels in the lake; and (b) lower peak flood levels in the Whangamarino Wetland. As well as the Whangamarino and Lake Waikare works, there have been river "training" works in the lower Waikato River and these, combined with sand abstraction and the possible prevention of sand replacement because of hydro-electric dams up river, have had the effect of lowering riverbed levels in the Meremere-Mercer reach of the Waikato River by an average of 1.3 metres. The cumulative impact of this and the flood protection scheme has been as follows:

- lowering of Waikato River water levels by 0.74 metres over ten years (Hannah, 1981), and the follow-on effect of this on the Whangamarino and Maramarua Streams and on wetland water levels generally;
- more rapid receding of flood water and shorter duration of inundations, with some once permanently wet areas drying out in summer, resulting in diminished habitat value and possible peat shrinkage and encroachment of exotic plants such as willows.

While the rate of reduction of levels in the Waikato River is expected to decline, lower levels pose a considerable threat to the wetland. Existing control structures cannot be used to hold water in the wetland. The granting of a water right to raise the water level in the wetland to

3.40 m.a.d. and scheduled construction of a weir to implement the water right will alleviate this threat.

The causeway across the northern portion of the wetland has had some effect on hydrology; it appears to have restricted flooding and siltation in the Maramarua Stream, it has created an easterly drainage flow in the wetland on its south side, and it may have accentuated ground level differences to its north and south.

Lower water levels have been noticeable to recreational hunters as well as wetland managers, and have resulted in considerable interest in reinstatement of levels to what they were in 1967 (*i.e.* an average minimum level of 3.55-3.63 m.a.d.). This would not diminish the effectiveness of the flood control scheme, as it was designed to a base level of 4.23 m.a.d with the subsequent increased storage capacity (due to falling levels) an added bonus. While 3.62 m.a.d has been the preferred reinstatement level, possible peat shrinkage in intervening years indicates that a water level of 3.40 m.a.d may be sufficient to maintain a wetland ecosystem. Flooding in 1986, and subsequent survey work at key locations, tend to confirm the 3.40 m.a.d level. Levels for the six months until April 1988 averaged about 2.0 m.a.d. Without reinstatement of water levels or control of any further decline in water levels, the ecological and recreational value of the wetland will be lost, and large areas will dry out for extensive periods and perhaps fall prone to willow invasion.

The invasion of mineralised areas of swampland by willows and other exotic species constitutes the second most significant management issue. Some 800 ha have been invaded by a dense willow jungle. Hand clearance has been undertaken in one area north of the causeway, and other clearance techniques such as aerial spraying are currently being evaluated. The practicality of clearance is also being considered, as is the question of replacement with native vegetation such as Kahikatea *Dacrycarpus dacrydioides*. *Glyceria maxima* and other aquatic weeds threaten to cover open water areas completely, if not controlled.

In the peat bog and some semi-mineralised areas, rare, endangered and scientifically important plants require protection from domestic livestock, accidental fire, recreational use and from drying out of the peat.

Hydrological and biophysical values: The wetland plays a significant role in flood control and sediment trapping, and is of great importance in supporting aquatic and terrestrial food chains. It provides spawning habitat for Inanga *Galaxias maculatus* (whitebait) and habitat for large numbers of waterfowl.

Social and cultural values: The pre-1860 (Maori) history of the wetland is not particularly well known. However, it is known that the area was important to early Maori inhabitants and extensively used by them as a source of food, plant materials and for transport. Hunting and fishing camps have been found in other wetland areas, as have eeling "pa" (Maori fortress). It is possible that similar camps were also located on small hillocks in the wetland. There are at least nine former "pa" sites around the eastern margins of the wetland, but on the western side, "pa" sites appear to be in close proximity to the Waikato River. Such sites are located at or near present day settlements, for example Meremere, Horahora and Te Teokeo.

Post-1860 history of the Whangamarino is linked to early land policy beginning with the confiscation of land from the Waikato Maori following the Waikato Campaign of 1863-64. Governments of the day (1860-1870) were under pressure to provide land for settlement and to raise revenue to retain the services of Imperial Regiments. This resulted in increased pressure to dispose of land, and for many years Government policy was to settle all that land which could be settled. The most suitable land for production was thus disposed of; the least desirable land (*i.e.* wetland) remained Crown land.

Major events in the history of the wetland are as follows:

- use of the waterways and wetland area for transport, as a source of food (eels, Giant and Banded Kokopu, waterfowl, Cabbage Tree) and plant materials;

- use of the waterways for access by the missionary Hamlin in 1834 and for stock movement by barge and small boat;
- planting of willow stakes near Rangiriri in 1885, and wattles near Te Kauwhata for tannin;
- flax farming on swamp areas near Kopuku Canal and Island Block Road (the flax was used for rope making);
- use of waterway margins for wildfowl hunting;
- involvement of the Wildlife Service in management of the wetland since at least 1962;
- allocation to the Department of Conservation as Stewardship Area on 1 April 1987;
- a surface fire swept through about 2,000 ha of the wetland in 1989;
- listing as a Ramsar Site on 4 December 1989.

The conservation versus development debate over the wetland has taken place from the 1960s to the present day, and has culminated in a decision by the Planning Tribunal that drainage should not proceed on private properties in the Reao Arm because ownership of the land does not in itself carry the right to alter the natural conditions of the land in such a way (*i.e.* divert natural water that is on the land). Protected area status has subsequently been recommended for adjoining land, and has largely been achieved on a willing seller/willing buyer basis.

Public use of the wetland today involves a wide variety of activities including education and recreation. The principal factor relating to existing or future public use is that about a third of the country's population live within a 100 km radius of the wetland. While there are other areas offering competing "attractions", the Whangamarino has unique features which may be of considerable interest to educational, conservation and specialist groups.

Noteworthy fauna: Whangamarino Wetland is an important habitat for a range of bird species including several rare and endangered species, notably the Australasian Bittern *Botaurus poiciloptilus*, Brown Teal *Anas aucklandica chlorotis*, Spotless Crake *Porzana tabuensis plumbea* and North Island Fernbird *Bowdleria punctata vealeae*.

The total New Zealand population of the Australasian Bittern *Botaurus poiciloptilus* is possibly less than 1,000 individuals, of which 200-250 may dwell in the wetland. This is the major breeding area in the Waikato. Bittern are recorded from most types of vegetation, but a high proportion occur in mineralised swamp areas. A diversity of habitats and a large area of wetland are needed to sustain a breeding population. An investigation into habitat use and movement of the bitterns was carried out by a student as part of a Masters thesis in the northern part of the wetland. This study was completed in 1992, and indicated that bitterns are highly mobile within the wetland and make seasonal but extensive use of it. Water depth was shown to be an important factor in determining the use of an area by the birds; a critical depth of 10 inches relates to the length of the bill and neck when the birds are feeding. Water quality and quantity are important in relation to food supply and visibility of prey, as is influx of water into areas for part of the year to provide appropriate feeding habitat.

The Brown Teal *Anas aucklandica chlorotis* is one of New Zealand's rarest ducks and one of the five rarest ducks in the world. Brown Teal have been recorded in the wetland and nearby water bodies, and it is possible that a small breeding population still exists in the area.

Eighty-nine Spotless Crake *Porzana tabuensis plumbea* were observed or heard during a brief survey in 1980. They are largely restricted to swamp margins, particularly between pasture land and peat bogs where vegetation standing in water enables them to avoid predators. Swamp drainage and predators are major threats to these birds.

Some thousands of pairs of North Island Fernbird *Bowdleria punctata vealeae* formerly inhabited the wetland, and constituted one of the largest populations in New Zealand. Of the 569 fernbird located in a survey in 1981, most were located in areas with *Leptospermum*, usually associated with sedges, wire rush and ferns on acid peat. Since they are territorial and

poor fliers, fernbird are totally dependent on existing vegetation. Changing water regimes which lead to enrichment of peat, or burning which removes the favoured two tier vegetation, are threats to the population, and since the 1989 fire the population has been reduced.

The wetland also supports large numbers of several species of Anatidae, particularly Black Swan *Cygnus atratus*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Shoveler *A. rhynchotis variegata*. Numbers of Black Swan *Cygnus atratus* vary between 1,500 and 3,000. Peak numbers occur in winter and spring when water levels are high, and at that time, about 7% of the New Zealand population of swans may be present. Numbers of Grey Teal *Anas gracilis* in winter and spring vary between 2,000 and 3,000 birds, and may represent as much as 5% of the New Zealand population. Several breeding areas have been provided for this species by waterfowl hunting groups such as Ducks Unlimited and some private individuals. The Mallard *Anas platyrhynchos* is the commonest duck in the wetland. Numbers in winter and spring can exceed 20,000-25,000, and some 40,000 were thought to be present in 1965. The wetland is a major wintering area for the Waikato population of this species, birds moving to nearby lakes during dry periods. The wintering population of Grey Duck *Anas superciliosa* is estimated at 6,000-7,000. As with other species, the Grey Duck uses the wetland on a seasonal basis, especially for wintering and breeding. New Zealand Shoveler *Anas rhynchotis variegata* favour fertile lowland swamps, and Whangamarino is one of the most significant habitats for this species in the Waikato. The maximum numbers occur during winter and spring, when between 2,000 and 3,000 birds are present.

Two species of Australian green bell frog, *Litoria aurea* and *L. raniformis*, have been found in the wetland, mainly in fertile swamps. Eighteen species of fish have been recorded. Both Long-finned Eel *Anguilla dieffenbachii* and Short-finned Eel *A. australis*, but especially Short-finned, provide major commercial fisheries. Inanga *Galaxias maculatus* are abundant in the lower reaches of rivers, downstream of the Waikato River thermal power stations. Common Smelt *Retropinna retropinna* are found in the two rivers, and Catfish *Ictalurus nebulosus* and Goldfish *Carassius auratus* are abundant. Grey Mullet *Mugil cephalus* run in the lower reaches of the two rivers in the early summer months. Whangamarino Wetland is one of the remaining strongholds for the Black Mudfish *Neochanna diversus*. Measuring up to 142 mm in length, these small, endemic, galaxiid fish are swamp dwellers; they are found throughout the wetland in permanent and temporary water bodies, and occur most abundantly in still and gently flowing waters seeping from springs. There is a general lack of information about the species, and because so much of its habitat is under threat, it has been listed as a globally threatened species by IUCN, in the category "Indeterminate".

A number of invertebrates occur in the wetland including seven species of mollusc, seven species of water flea, Amphipods, the common northern crayfish and a fresh water crab. Large numbers of the shrimps *Tenagomysis chiltoni* and *Paratya curvirostris* appear periodically in the Whangamarino River. Aquatic insect life includes dragonflies, damselflies, water beetles, non-biting midges, craneflies and midges. A tiny water skate *Microvelia* sp. is possibly the most abundant animal in the wetland. The only species of moth in New Zealand with an aquatic larva, *Nymphyla nitens*, is common in the wetland.

A number of introduced mammals are present in the wetland including possums, ferrets, stoats, weasels and cats. Domestic livestock often graze some parts of the wetland.

Noteworthy flora: The following species are of note:

- *Fuschia perscandens* (Creeping New Zealand Fuschia): the northernmost record of this species in New Zealand is in an area of grazed remnant Kahikatea forest near the Kopuku mine.
- *Dracophyllum lessonianum*: near its southern limit in New Zealand at this location.

- *Myriophyllum robustum* (Water Milfoil): recently recorded in several areas of the northern wetlands; the largest known populations in North Island.
- *Corybas carseii* (an orchid): the only recent sighting of this endangered species is in the Reao Arm where there may be a reasonable population.
- *Lycopodium serpentinum* (a club moss): the Whangamarino population is now thought to be extinct.
- *Utricularia laterifolia* (a bladderwort): found growing with *Myriophyllum robustum* in several areas of the northern wetlands.
- *Utricularia australis* (Floating Bladderwort).
- *Utricularia novae-zelandiae*.
- *Cyclosorus interruptus* (a fern).
- *Prasophyllum aff. patens*: an undescribed endemic orchid.

Whangamarino Wetland is rich in mosses. Thirteen new species have been added to the New Zealand flora from this area. Some 23 species are considered to be of interest (Ogle & Bartlett, 1981). Liverworts are abundant and lichens are well represented. A new, recently discovered species of *Pseudocyphellaria* (*P. sereciofulva*) is of interest.

Scientific research and facilities: A number of studies have been carried out at the wetland and these are listed under "References" below. The wetland has considerable potential for further research which could range from basic floral, faunal and wetland management research to peatland management for agricultural and horticultural use. Research on water levels, fire recovery monitoring and freshwater crabs is continuing. There is considerable scope for further scientific research into the wetland and ecological processes.

Conservation education: The Department of Conservation runs interpretative summer programmes based around the wetland. These involve taking a barge-load of people through the wetland looking at the flora and fauna, and discussing the history and management of the wetland. Analysis of 1981 census data indicates that almost 25% of the population within an 80 km radius of the wetland are students, some 240,000 in all (Harvey, 1984). Increasing interest in subjects relating to the natural environment suggests that the wetland could have a far greater role in conservation education. There is potential for disused public buildings in the locality to be developed as a "base camp". Provision of explanatory information on botany, wildlife, ecology, access points and energy development would assist visitor understanding, as might off-season use of huts *etc.* for overnight accommodation.

Recreation and tourism: Duck hunting is the commonest recreational activity in the Whangamarino. A hunter survey (Cheyne, 1981) in 1979 involved some 700 hunters who spent around 11,172 days in the wetland, both in preparing "maimais" (game-bird hunting stands) and hunting. Ducks and swans are the main game-birds of interest, although other game-birds are occasionally hunted. Swampland along stream margins are the places most used by the duck-hunters. Low water levels over recent years have reduced the quality of the duck hunting. Gun-dog trials are usually held monthly from July to April, near the junction of the Whangamarino and Maramarua Rivers. Some 600 days a year are spent in the wetland by participants involved in this activity. Most boating is related to duck hunting, although, some power-boating is carried out in the main water ways. Local people engage in recreational fishing, *e.g.* coarse angling at the Whangamarino-Maramarua confluence, and there is also eel and mullet fishing. Cross-bow hunting of Koi Carp is becoming a significant recreational activity in the wetland.

Management authority: The Department of Conservation (Waikato Conservancy) has responsibility for management of Crown land and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources. The Auckland/Waikato Fish and Game Council is responsible for the management of sport fishing (trout and salmon) and game-bird hunting.

Jurisdiction: Territorial: Waikato District Council and Waikato Regional Council. Functional: Department of Conservation and Auckland/Waikato Fish and Games Council.
References: Cheyne (1981); Davoren *et al.* (1978); Department of Conservation (1989a); Fry (1976); Hannah (1981); Harvey (1984); Ogle & Bartlett (1981); Ogle & Cheyne (1981); Strachan (1981); Strickland (1980).
Reasons for inclusion:

1a Whangamarino Wetland is an outstanding example of a wetland characteristic of its region; it is the second largest bog and swamp complex in the North Island of New Zealand.

2a Whangamarino Wetland supports appreciable numbers of threatened plants and animals, including eight plants, *Corybas carseii*, *Lycopodium serpentinum*, *Utricularia laterifolia*, *U. australis*, *U. novae-zelandiae*, *Cyclosorus interruptus*, *Myriophyllum robustum* and *Prasophyllum aff. patens*, two birds *Botaurus poiciloptilus* and *Anas aucklandica*, and a fish *Neochanna diversus*.

2b Whangamarino Wetland is more diverse botanically than any other large lowland peatland in the North Island, and its oligotrophic portions have a combination of very specialised plants which no longer occur elsewhere in the Waikato Region or beyond. This diversity gives it an ability to support a wide range of regionally rare communities.

2d Whangamarino Wetland supports a large number of species of plants and animals that are endemic to New Zealand. The wetland is one of the remaining strongholds for two endemic plants, *Corybas carseii* and *Myriophyllum robustum*, and for the Black Mudfish *Neochanna diversus*.

3a Whangamarino Wetland regularly supports over 20,000 waterfowl.

3c Whangamarino Wetland regularly supports approximately 20% of the New Zealand population of *Botaurus poiciloptilus* (including 20% of the breeding pairs), 7% of the New Zealand population of *Cygnus atratus*, and 5% of the New Zealand population of *Anas gracilis*. The wetland also supports at least 1.7% of the breeding pairs of *A. gracilis*. These are 1988 figures. Numbers are likely to be somewhat reduced, as a lowering of water levels in the subsequent period has resulted in reduced habitat for wildlife. However, reinstatement of water levels was planned for 1993.

Source: Helen Neale.

Waikato Lowland Lakes and Mineralised Swamp Lands (12)

Location: Waahi 37°34'S, 175°08'E; Whangape 37°28'S, 175°03'E; Waikare 37°27'S, 175°12'E. Approximately 75-80 km south of the city of Auckland, North Island.
Area: Total area of wetlands c.7,308 ha. (See Appendix 4 for details).
Altitude: Sea level to 20 m.
Overview: The Waikato lowland lakes (although highly modified) are part of a wetland system which includes Whangamarino Wetland and the Waikato River. This is the most important freshwater wildlife habitat in New Zealand. The eleven main wetlands are listed in Appendix 4.
Physical features: The basement rocks underlying the Waikato Region are comprised of mesozoic "greywacke" type sandstones and mudstones which were laid down under the sea. These rocks have undergone tectonic upheaval which has resulted in the formation of ranges around the perimeter of the Waikato catchment.

During the Tertiary period, various phases of land subsidence led to the deposition of an overlay of softer sedimentary rocks, including marine limestones and coal measures. Most of these tertiary sediments have since been removed by erosion. Following this period, volcanic activity played a significant role in shaping the Waikato landscape, and outpourings of lava from violent eruptions of the Tongariro/Ruapehu complex laid down layers of soft ignimbrite rock, spreading as far north as the mid Waikato. Following this period of ignimbrite volcanism, a series of violent eruptions spread ash over the central North Island, and subsequently both ash and eroded volcanic rock were carried northwards by the Waikato River.

During the Pleistocene, increased erosion and a build up of sediment in the bed of the Waikato River led to an overflow of the river across a low saddle into the Karapiro Valley and a change in course (the river previously flowed out to the Firth of Thames). There followed an extensive deposition of alluvium in the Hamilton Basin, with the formation of an alluvial fan. Floods of pumice material carried by the river following the Taupo eruptions were deposited in the Lower Waikato to form terraces alongside the river, blocking off tributaries and forming the lakes and swamps of the lower Waikato Region.

Many of the lakes and swamps (mineralised zones) in this area are hydrologically linked to the Waikato River, and are influenced by the river physically, chemically and biologically. Water levels fluctuate seasonally, and large areas of swamp dry out during summer, when rainfall and river levels are low. The implementation of the Waikato/Waipa flood control system, designed to protect agricultural land in the lower catchment, resulted in the water levels of many lakes being controlled for flood protection purposes. Lake Whangape is the only lake which still has a natural connection with the Waikato River.

Four main soil types occur within the lower Waikato Valley:

- gley and organic, derived from alluvium and peat and found on low-lying land adjacent to the Waikato River and its tributaries;
- brown granular loams, derived from older weathered andesite and rhyolite volcanic ash, and found on rolling hills;
- yellow brown earths, formed on steep land where the ash layer has eroded away;
- yellow brown loams, derived from younger rhyolitic and andesite volcanic ash on alluvial flats.

There is a considerable amount of information available on the water quality of the various lakes, and specific information can be found in the various reports listed under "References" below. In general, the lakes are shallow, exposed and saucer-shaped with large fetch areas; they vary from mesotrophic to eutrophic with low water clarity. Agricultural development and coal-mining overburden have contributed to the high sediment loadings in the lakes, and the plant communities (macrophytes) have adjusted to these man-induced changes.

The catchment area for the lakes comprises a considerable proportion of the lower Waikato catchment, but the total area is unknown. The majority of the catchment is in pastoral use, with semi-intensive sheep and beef farming, intensive sheep and cash crops, and intensive dairy, sheep and beef farming. The catchment is dominated by the Waikato River which flows through the area and into the Tasman Sea at Port Waikato.

The Waikato Region experiences mild winters, warm humid summers, and moderate rainfall. The mean annual rainfall is approximately 1,200 mm. Precipitation is approximately twice as great in winter as in summer, the monthly means for Huntly (Central Waikato) varying from 138 mm in June to 72 mm in January. In summer, thunderstorms may contribute high daily totals. Air temperatures are generally in the range 9-19°C, and humidity generally exceeds 75%. Westerlies prevail over the Waikato Region as a whole, and winds tend to be strongest in spring.

Ecological features: Since the arrival of Europeans in the lower Waikato River basin approximately 100 years ago, agricultural development, urban expansion, mining and other

land uses have resulted in the loss of approximately 85% of the mineralised swamp and bog systems, although no great reduction in lake area has occurred. Additionally, changes to natural drainage patterns, introduction of exotic plants and animals, catchment development and water pollution have modified other parts of the wetland system, reducing natural values and habitats. However, these lakes and adjoining swamp areas continue to support large populations of native and exotic waterbirds, as well as recreational and commercial fisheries.

The original catchment vegetation of the area would have been mixed hardwood-podocarp rainforest with dense stands of Kahikatea *Dacrycarpus dacrydioides* forest in the low-lying valley bottoms. Shrub (brushwood) and fernlands were also present. By the end of the 1870s, the forest was being exploited for timber and cleared for agriculture. Today, only a few isolated remnants remain, and many swamps and marginal areas have been modified. Many swamp areas have been invaded by willow *Salix* spp. and other exotic plants. Raupo *Typha orientalis*, a native species, has almost completely disappeared. The submerged aquatic vegetation has similarly been largely replaced by exotic species, in particular the exotic water-weeds *Elodea canadensis* and *Egeria densa*, although in recent years there has been a dramatic change in community composition in a number of lakes. The marginal lake vegetation consists mainly of Manuka *Leptospermum scoparium*, Pussy Willow *Salix cinerea*, Crack Willow *Salix fragilis* and emergent macrophytes such as *Eleocharis sphacelata*, *Scirpus lacustris*, *Typha orientalis*, *Juncus* sp. and *Ludwigia palustris*.

Although some of the waterbirds, such as the North Island Fernbird *Bowdleria punctata vealeae*, are sedentary, the majority are very mobile, ranging freely over the wetland complex. Many species are opportunistic, and changes in water levels cause mass movements of birds between the swamps and the shallow lakes in search of food, with other movements being occasioned by the need to find nesting sites or moulting areas, or caused by disturbance by hunters *etc*. Likewise migratory fish, such as the Long-finned and Short-finned Eels *Anguilla* spp., Grey Mullet *Mugil cephalus*, native Galaxiids (whitebait) and sea-run trout, move between the sea, the river and the standing waters of the lakes and swamps. Within the wetland complex, the shallow lakes are vital components, since they provide not only areas of permanent habitat for some species, but also summer feeding grounds and courtship, nesting and moulting areas for thousands of birds, annually forced out of the swamps by the drying up of the shallow open waters there.

Land tenure: The lakes are Crown land. The majority of the adjoining land is privately owned.

Conservation measures taken: The following reserves have been established:

- Lake Whangape, Government Purpose (Wildlife Management) Reserve: 1,330.37 ha, gazetted in 1986.
- Lake Rotongaro, Government Purpose (Wildlife Management) Reserve: 482.4 ha, gazetted in 1979.
- Lake Rangiriri, Government Purpose (Wildlife Refuge) Reserve.
- Lake Waikare, proclaimed Part Wildlife Refuge in 1988. Adjoining a Government Purpose (Wildlife Management) Reserve of 62.88 ha, gazetted in 1983.
- Lake Okowhao, Government Purpose (Wildlife Management) Reserve: 22.619 ha, gazetted in 1976.
- Lake Kimihia, Government Purpose (Wildlife Management) Reserve.
- Lake Hakanoa, Government Purpose (Wildlife Refuge) Reserve: 73.007 ha, gazetted in 1983.

The Lake Whangape Reserve incorporates an extensive area of mineralised swamp. Most of the lakes are managed by the Department of Conservation, with the exception of Lake Waahi,

which was set apart for the purposes of the Coal Mines Act and remains in this status. Lake Waahi is adjacent to a Government Purpose (Wildlife Management) Reserve of 53.49 ha, gazetted in 1987.

Conservation measures proposed: Lake Rotokawau (Conservation area) and Lake Ohinewai (27.68 ha, Conservation area adjoining the Ohinewai Recreation Reserve) have been proposed as Government Purpose (Wildlife Management) Reserves. A draft management plan has been prepared for Lakes Whangape and Rotongaro, with a number of recommendations relating to the protection of habitats and ecosystems.

Land use: The primary objectives for all reserves are to protect and enhance wildlife, fish and plant communities in the lakes and in particular threatened species. The majority of the land around the lakes is used for agriculture, horticulture and pastoral uses (dairy and dry stock farming). Coal mining is an important industry in the area. The lakes themselves are important traditional and commercial fisheries. Species exploited include Short-finned and Long-finned Eels *Anguilla* spp., Grey Mullet *Mugil cephalus*, Koi Carp *Cyprinus carpio*, Common Smelt *Retropinna retropinna* and Catfish *Ictalurus nebulosus*.

The town of Huntly in the centre of this area has a population of approximately 6,000. There is a scattered rural population around the wetlands. The wetlands are within 60 km of two major cities, Auckland (c.1,000,000) and Hamilton (c.100,000), and are therefore readily accessible to about one third of the population of New Zealand.

Possible changes in land use: Agricultural development in the lower Waikato has had, and continues to have, a variety of effects on the lakes and swamplands of the area. Unfortunately, these modifications have resulted not only in a direct loss of wetland areas, but also in a loss of naturally fluctuating water regimes. Continued viability of these lakes and swamps is an ongoing cause for concern.

Coal mining in the past was largely confined to underground mines in easily worked areas, and did not greatly affect the wetlands. With the advent of improved coal extraction techniques, it has now become technically feasible, as well as economically viable, to undertake large-scale underground and open-cast mining. The impact of projected coal mining development on the lower Waikato Region will be considerable. Open-cast mining can destroy wetland areas, and run-off from overburden poses the risk of loss of wildlife values through water pollution by colloidal particles. Pit water and drainage from spoil heaps need to be treated before discharge, to ensure that water quality, plant beds and ultimately wildlife populations are protected.

In future, the lakes of the lower Waikato are likely to receive a greater influx of visitors and more intensive recreational use. Development of public access, public interpretation and educational aids will assume increasing importance in the management of these areas.

Disturbances and threats: Land development for agriculture has been the major reason for wetland drainage in the past, and further drainage and swamp clearance continue today on privately owned land. Individual drainage schemes, although often small, are collectively significant, eroding wildlife and fish habitats. The natural seasonal fluctuations in water levels have been affected by the drainage activities. The frequency and duration of flooding have been reduced, and this often means that water levels are lowered. The water dependent ecosystems of lake and swamp are now more vulnerable, and require management of water levels to ensure that they do not suffer irreversible ecological change during dry periods. In some situations, water management could result in a considerable enhancement of wildlife and fisheries values.

Water levels affect both the seasonal growth and community structure of wetland plants, and also the movements and breeding cycles of birds and fish. In dry years, there may be reduced breeding success due to lack of water or inadequate food supplies. In shallow lakes, a lowering of the lake level can significantly increase erosion and wave action on the lake bed and

shoreline, with adverse impacts on water clarity, plant beds and dependent wildlife. These effects have been clearly illustrated in Lake Waikare, Lake Rotowaro and Lake Waahi. Significant reductions in the numbers of the majority of wetland species, especially native and endemic species, have occurred through habitat loss and increased levels of human activity in and around the wetlands.

There is some conflict between management of the lakes for conservation purposes by the Department of Conservation and control of lake water levels by the Waikato Regional Council for flood protection purposes.

A large number of plants and animals now occurring in the Waikato Region have been introduced. Introduced exotic species which have affected indigenous wildlife populations include game-birds and sport fish, predators such as cats, stoats, weasels and ferrets, and exotic wetland plants such as the submerged species *Egeria densa*, *Elodea canadensis* and *Ceratophyllum demersum*, emergent *Ludwigia* sp., and willows *Salix* spp. The introduced Mallard *Anas platyrhynchos* is common throughout the wetlands, as are several introduced fish species such as Koi Carp *Cyprinus carpio* (a gazetted "noxious fish") and Rudd *Scardinus erythrophthalmus*. Introduced predators, especially feral cats and stoats, have had significant impacts on ground-nesting birds. Exotic plants have proved highly successful competitors with native species, particularly in areas already modified by man's activities. The invasion of two exotic plants, *Elodea canadensis* and *Egeria densa*, into lakes and waterways has frequently resulted in the displacement of native species and the establishment of dense monotypic, or near monotypic, stands of exotic aquatic plants. Willows have been planted along stream margins and around lake shores, and have invaded many mineralised swamps. Willows, and Crack Willow in particular, have replaced native plants in the riparian zones. The willows have the advantage of stabilising stream banks and slowing water flow, but under a dense willow canopy, wetland herbs, rushes and reeds, which add to the variety of habitats available, are shaded out.

With land use in surrounding areas intensifying (for farming, horticulture, coal mining *etc.*), protection of the lake ecosystems and their wildlife values becomes more difficult. Their vulnerability is well illustrated by the recent collapse of the aquatic macrophyte stands in a number of lakes, with an accompanying switch to phytoplankton dominance. The conversion of swampland to pastoral farmland or cropland, to which fertilizer is applied, generally results in a higher nutrient export through run-off and seepage to streams, rivers, swamps or lakes receiving this water. The soils are enriched with dung and fertilised, and buffer zones between the wetland and surrounding area are often cleared, so that pasture extends to the water or swamp edge. Stock frequently have unrestricted access to the water. Catchment development for agriculture has undoubtedly contributed to a rapid enrichment and organic infilling of the shallow Waikato lakes. The majority are eutrophic, and some are now hyper-eutrophic.

Hydrological and biophysical values: The lakes have in the past played a general role in the recharge and discharge of groundwater and the maintenance of water quality. This role has been modified by flood control works, and is now a role largely controlled by people. Agricultural development in the lower Waikato has required, first and foremost, improved drainage and protection of the land from flooding. Construction of drains, stop-banking and the installation of floodgates on major channels have aided the conversion of swamp and peat bog to farmland, and significantly reduced the incidence of floods in protected areas. The hydraulic efficiency of the Waikato River has been improved through dredging of the river bed and river training works.

All of the lakes play a general role in the support of food chains and are of high value for wildlife.

Social and cultural values: The primary use of the lakes is for game-bird hunting and traditional and commercial eel fishing. The lakes have considerable significance to the local Maori, and many lakes have historical Maori occupation sites associated with them.

Noteworthy fauna: The lakes support a wide diversity of waterfowl including several threatened species. Anatidae are a major component of the bird fauna, and include Black Swan *Cygnus atratus*, Canada Goose *Branta canadensis*, Paradise Shelduck *Tadorna variegata*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Shoveler *A. rhynchotis variegata*. Healthy populations of three species of shag *Phalacrocorax* spp., Australasian Bittern *Botaurus poiciloptilus*, White-faced Heron *Egretta novaehollandiae*, Spotless Crake *Porzana tabuensis plumbea*, Pukeko *Porphyrio porphyrio melanotus*, Pied Stilt *Himantopus leucocephalus*, some gulls *Larus* spp. and North Island Fernbird *Bowdleria punctata vealeae* are present. Diving species, such as New Zealand Dabchick *Poliocephalus rufopectus* and New Zealand Scaup *Aythya novaeseelandiae*, now only occur in low numbers, and the endangered Brown Teal *Anas aucklandica chlorotis* is very rare. Other waterfowl which have been recorded in the wetlands include Royal Spoonbill *Platalea regia* (uncommon), Banded Rail *Rallus philippensis assimilis* (found at selected sites only), Marsh Crake *Porzana pusilla affinis*, Banded Dotterel *Charadrius bicinctus* (uncommon) and Caspian Tern *Sterna caspia* (uncommon). No specific information is available on numbers of birds present in the area.

The lakes support a small but significant population of the endemic Black Mudfish *Neochanna diversus*. Other native fish include Long-finned Eel *Anguilla dieffenbachii*, Short-finned Eel *A. australis*, Common Smelt *Retropinna retropinna*, whitebait *Galaxias* spp. and Grey Mullet *Mugil cephalus*. Invertebrates include an unusual freshwater crab.

Noteworthy flora: No species of particular note are found within the general area; many of these lakes and their associated wetlands are now dominated by exotic species with native vegetation comprising only a minor percentage of the flora.

Scientific research and facilities: A number of studies have been carried out on various aspects of the wetland system. These are listed under "References" below. The potential exists for a range of research projects to be carried out, and a number of topics have been proposed. Collectively, the shallow Waikato lakes present an interesting situation for comparative ecological studies, the results of which would be both of scientific interest and of value for lake management. The recent collapse of the aquatic macrophyte stands in a number of lakes and the accompanying switch to phytoplankton dominance are of considerable scientific interest.

Conservation education: The Waikato wetlands have considerable potential for educational purposes and are currently under-utilised. Whangape is the best example in terms of wildlife values, with 56 bird species and 14 fish species. Lake Rotokawau also has high educational value due to its extensive wetland margins. However, the lakes have limited value as examples of natural ecosystems, since they are all highly disturbed with a high proportion of exotic flora and fauna.

Recreation and tourism: The lakes are used extensively for game-bird hunting during the May-June season. Black Swan, Canada Goose, Paradise Shelduck, Grey Duck, Mallard, New Zealand Shoveler and Pukeko are the main species taken. There is some passive enjoyment of the lakes by local residents and the Waikato Ornithological Society. Fishing is also an important recreational activity, and some lakes, *e.g.* Hakanoa, are used for sailing.

Management authority: The Department of Conservation (Waikato Conservancy) is responsible for management of all the lakes, except Lake Waahi, and management of wildlife. Coalcorporation (a state-owned enterprise) manages Lake Waahi. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources. The Auckland/Waikato Fish and Game Council manages sport fishing and game-bird hunting.

Jurisdiction: Territorial: Waikato District Council and Waikato Regional Council. Functional: Department of Conservation and Auckland/Waikato Fish and Game Council.
References: Boswell *et al.* (1985); Buxton *et al.* (1986); Chapman (1975, 1980); Garrick & Saunders (1986); Kingett and Associates & Lockley (1984); McLea (1986); Ministry of Energy (1987); New Zealand Wildlife Service (1985); Stephens (1978); Thompson *et al.* (1983); Ward *et al.* (1985); Wells (1976); Wells *et al.* (1987); Worthy & Whitehouse (1982).
Reasons for inclusion:

1a The Waikato lowland lakes are a particularly good example of a lowland lake system characteristic of New Zealand.

2a Collectively, the lakes support significant populations of several globally threatened species including one fish, *Neochanna diversus*, and two birds, *Poliocephalus rufopectus* and *Botaurus poiciloptilus*. The endangered Brown Teal *Anas aucklandica chlorotis* also occurs.

2d The lakes and mineralised swamps are of special value for a number of endemic species and subspecies of birds, including *Aythya novaeseelandiae, Rallus philippensis assimilis, Porzana pusilla affinis* and *Bowdleria punctata vealeae.*

Source: Helen Neale.

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Firth of Thames (13)

Location: 37°13'S, 175°23'E. Approximately 52 km southeast of Auckland, North Island.
Area: c.8,500 ha.
Altitude: 1.1 m below sea level to 2.1 m above sea level.
Overview: The Firth of Thames is an internationally important feeding area for up to 25,000 waterfowl, most of which are migratory shorebirds. The Firth is one of New Zealand's three most important coastal stretches for shorebirds. Some 7,800 ha of the wetland were listed as a wetland of international importance under the Ramsar Convention.
Physical features: The Firth of Thames lies in the northern part of the Hauraki graben bounded by fault lines along the Hunua and Coromandel ranges. The Waikato River originally flowed through the Hauraki graben and emptied into the Firth, bringing with it much of the fertile alluvium of the region. Today, the Waihou, Piako and Waitakaruru Rivers flow into the Firth from the south and, together with the strong northwest wave action (responsible for chenier build up), determine the biological character and natural resource values of the Firth. The catchment area of the Firth is 3,600 sq.km.
The sea floor of the Firth consists of fine clay, silt and sand sediments laid over pumice sands; the maximum depth of the inter-tidal area is 2.2 metres at mean high water spring tides. The graded shell beach ridges between Miranda and Kaiaua are an example of a Chenier Plain, a landform unique in New Zealand and rare globally.
The average annual rainfall is approximately 1,200 mm, and the mean annual temperature about 13°C.
Ecological features: The shallow tidal flats of the Firth of Thames, exposed at ebb tide, cover approximately 8,500 ha and can be divided into four main wetland types: shallow estuarine water and mudflats (7,000 ha); shell banks (40 ha); grass flats (30 ha); and mangrove forest, saltmarsh and swamp (730 ha). The shell banks present in the area are used as high tide roosts by many birds, while adjacent grass flats are used for feeding and as roosts by some species.

The remaining area from Miranda to the Waihou River mouth consists of soft mudflats, flourishing and expanding mangrove communities and some intermingling saltmarsh (mainly *Salicornia australis*). Mangrove *Avicennia resinifera* is within 100 km of its southern limit at this site, and is increasing in area. Mangroves have high ecological value, and this extensive area of mangroves is therefore of considerable significance. Saltmarsh occurs behind the mangroves, in the zone reached only by fortnightly or monthly spring tides, and forms wide rush beds. The Maori Musk *Mimulus repens*, a plant species associated with the saltmarsh, is uncommon nationally and found at one locality in the Firth. Further inland still, the formation known as saltmeadow is flooded only by exceptionally high tides. The soil is salty and often waterlogged, and the plants are usually succulent. The saltmeadow forms a narrow fragile community.

The mistletoe *Ileostylus micranthus* occurs in the area, growing on *Coprosma propiqua*. A high proportion of the vegetation is exotic species, particularly in the better drained sites, and several exotic species with restricted distributions in New Zealand are found here.

Land tenure: The Ramsar Site is Crown land. The majority of land adjoining the site is in private ownership.

Conservation measures taken: The Ramsar Site is primarily shallow estuarine water, mudflat and mangrove forest. These areas are Crown land, managed by the Department of Conservation, but currently have no special protection status. A 30 ha Coastal Reserve (Crown land, managed by the Department of Conservation) has been included as part of the Ramsar Site. This reserve is flanked by approximately 1.6 km of coastline north of Miranda; it is adjacent to a major series of shell banks, and has been included as part of the wetland. Management of the area has been slight to date. The practice of grazing the grass-covered shorebird roosting areas has benefited the birds using these areas, particularly the Banded Dotterel *Charadrius bicinctus*.

Privately owned land adjoining the site lies under several territorial authorities, and protection status varies accordingly. The Franklin County Council has designated all land adjoining the coast as "Government Purpose Wildlife Reserve", while the majority of other adjoining land is zoned as "rural" (*i.e.* general farming practices are allowed, but industrial use is excluded).

A 27.7 ha farm property between the coast road and the sea to the south has recently been placed under Conservation Covenant. This is an agreement between the landowner and the Department of Conservation to maintain the area in its natural state. Grass on the shell-bank within the Conservation Covenant area has been kept short by grazing, to the benefit of birds using the area for roosting.

Auckland Regional Council in their Regional Plan recognise the Kaiaua-Miranda coastline as having international and national significance. The Waikato Regional Council seems to have made no moves toward formal protection of wildlife values on that part of the coast which it administers.

Conservation measures proposed: One of the primary aims in the future is to place some form of coastal planning zone which provides protection/reservation for the area from the seaward margin to the terrestrial margin. A number of management proposals have been recommended by the Royal Forest and Bird Protection Society of New Zealand and the Miranda Naturalists Trust. The following recommendations relate to the Miranda area of the Firth in particular:

- There is a need for public access tracks and interpretative trails, and the provision of viewing points, hides and possibly vegetation planting.
- A planting programme in certain areas, including suitable indigenous screen plants, and special plantings for specific species (if needed) could be undertaken.
- The continued provision of short-grass roost sites is necessary.

- There may be a need for management of high-tide roosts if sea levels rise in the future.
- Purchase of any land between the Kaiaua-Miranda Road as it comes on the market should be pursued or the land covenanted.

Land use: Protection of wildlife, bird-watching and photography are the predominant activities in the Ramsar Site. Grazing occurs where grass is established, although most areas of the wetland are not available for grazing as they are inter-tidal. The surrounding terrestrial areas are primarily used for pastoral farming. The Firth is used for fishing, both commercial and recreational, and game-bird hunting takes place during the hunting season.

The population of the Hauraki Plains is 5,019 (1986), with the Thames community totalling 6,114. The wetland is less than 80 km away from two major centres of population, Auckland and Hamilton. It is therefore accessible to one third of the population of New Zealand.

Possible changes in land use: The wetland is generally recognised as being of high value by local authorities and the resident population, and it is unlikely that any changes in land use at the wetland itself will occur. A number of possible developments in the catchment could affect the wetland, including prospecting and mining, housing development, land development and poor land use. The provision of a protected zone through coastal planning would provide some protection against such developments.

The Waihou and Piako Rivers discharge sediment and nutrient into the Firth, and further deterioration in water quality could result from unsuitable farming practices in the catchment.

Disturbances and threats: In the past, much of the surrounding land has been cleared of forest, resulting in sediment deposition and loss of some habitat in the Firth. Some slips are still occurring in the catchment today. Restrictions on access and better management of the site may be required in the future to allow the public to view the area while minimising the impact on it and the species using it. Livestock grazing is a threat to the mangrove area, and fencing should be established to protect the mangrove community.

Hydrological and biophysical values: The primary hydrological value of the wetland is in providing a habitat and food source for waterfowl and fish. The Firth also plays a role in sediment trapping and prevention of coastal erosion. The Firth of Thames supports an important fishery of local significance, with flounder and snapper being the main fish species caught; incidental catches include species such as sand shark.

Social and cultural values: The area was a traditional food gathering site for the Maori, who used both fish and waterfowl. Prior to their protection, Bar-tailed Godwit *Limosa lapponica* were harvested. The Firth provides an important shared resource for various tribes. It continues to be a major floundering area, with access especially from Kaiaua. The Firth is recognised as an important wildlife and fish habitat, and various groups visit the area for scientific or educational purposes. The Miranda Naturalists Trust operates its own education centre at Miranda. The main use of the Firth itself is by local fishermen, and there is extensive commercial fishing in the area.

Noteworthy fauna: The Firth of Thames supports particularly dense populations of waterfowl in relation to the amount of inter-tidal habitat available. Species of birds using the inter-tidal mud and sand flats or adjacent shallow waters include one grebe species (Podicipedidae), five cormorants (Phalacrocoracide), four herons (Ardeidae), Royal Spoonbill *Platalea regia*, Black Swan *Cygnus atratus* and six species of ducks (Anatidae), one gallinule (Rallidae), two oystercatchers (Haematopodidae), two stilts (Recurvirostridae), six plovers (Charadriidae), 27 other shorebirds (Scolopacidae), two skuas (Stercoraridae) and seven gulls and terns (Laridae). Most of these are migratory species, spending their winter season in the Firth, and many of them are rare or uncommon in New Zealand. The average number of waterfowl present in the area over the year is about 25,000, while the total number present may peak at as many as 40,000 birds during the summer months. A large proportion of these are migratory shorebirds

from the northern hemisphere, the most abundant species being Bar-tailed Godwit *Limosa lapponica* and Red Knot *Calidris canutus*. The Bar-tailed Godwit is the most abundant of the arctic migrants, with an estimated 100,000 spending the southern summer in New Zealand. About 10,000 (10% of the New Zealand population) occur in the Firth of Thames during the summer, and much smaller numbers of immatures remain throughout the winter. Numbers of Red Knot vary considerably from 2,000 to 11,000. Pacific Golden Plover *Pluvialis fulva* and Ruddy Turnstone *Arenaria interpres* are regular visitors in smaller numbers, and there are usually 20-30 Curlew Sandpiper *Calidris ferruginea*, up to 20 Sharp-tailed Sandpiper *C. acuminata*, a few Red-necked Stint *C. ruficollis* and about 10 Far Eastern Curlew *Numenius madagascariensis* present.

Three of the most abundant internal migrants are South Island Pied Oystercatcher *Haematopus finschi*, Pied Stilt *Himantopus leucocephalus* and Wrybill *Anarhynchus frontalis*. There has been a spectacular increase in the numbers of South Island Pied Oystercatcher since counting began, and this species now makes up a significant percentage of the total number of shorebirds in the Firth. The oystercatcher been legally protected since 1940, but climatic factors may also be contributing to their population increase. The Pied Stilt winters at Miranda, where numbers fluctuate widely from year to year. The Miranda area is the most important wintering area for Wrybills. Birds start arriving from the Canterbury River beds at the end of December, and numbers build up until they eventually comprise 50-60% of the total population of the species. The main departure of the birds from the Firth occurs in August, with approximately 10% of the birds departing later. These are primarily immatures. Depending on such factors as the height of the high tide and the weather, Wrybills in the Firth either occupy a series of discrete roosts or all congregate at a single site.

The New Zealand Dotterel *Charadrius obscurus* and Black Stilt *Himantopus novaezelandiae* regularly visit the area in small numbers, and the former species is known to nest at Miranda.

Noteworthy flora: The mistletoe *Ileostylus micranthus* is found growing on *Coprosma propinqua* in the Miranda region, and Maori Musk (*Mimulus repens*), a saltmarsh species, is found at one locality in the Firth. Both of these species are uncommon in New Zealand.

Scientific research and facilities: The wildlife of the area has been monitored since the 1940s, with regular bird counts and studies undertaken by the Miranda Naturalists Trust and Ornithological Society of New Zealand. Work on the botany and entomology of the saltmarsh and mangrove areas has also been undertaken. There is considerable scope for more research in the future.

Conservation education: A number of organisations and school parties visit the Firth of Thames for educational purposes. The Miranda Naturalists Trust operates its own centre at Miranda which is used for educational purposes and promotion of research. The Trust produces some educational material and pamphlets on the area and its wildlife.

Recreation and tourism: The potential exists to develop this area for tourists and recreational activities compatible with the aims of the area.

Management authority: The Department of Conservation (Waikato Conservancy) has responsibility for management of Crown land and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources and the preparation of coastal plans.

Jurisdiction: Territorial: Hauraki Plains District Council, Waikato District Council, Franklin District Council and Waikato Regional Council. Functional: Department of Conservation.

References: Auckland Regional Authority (1987a, 1987b); Bacon (1976); Hay (undated); Morton (1983, 1985-86, undated); New Zealand Wildlife Service (1981b); Sibson (1978); Veitch (1978).

Reasons for inclusion:

1a The Firth of Thames is a particularly good example of a coastal inter-tidal habitat.

2a The Firth of Thames supports several threatened species, including the mistletoe *Ileostylus micranthus* and three birds, *Himantopus novaezelandiae, Charadrius obscurus* and *Anarhynchus frontalis*.

2b The Firth of Thames supports a wide diversity of waterfowl species, including many which are uncommon or rare elsewhere in New Zealand, and is thus of special value in maintaining the genetic and ecological diversity of the region.

2d The Firth of Thames supports populations of several endemic species of plants and animals, including the mistletoe *Ileostylus micranthus* and several bird species.

3a The Firth of Thames regularly supports in excess of 20,000 waterfowl.

3c The Firth of Thames regularly supports over 1% of the regional populations of *Anarhynchus frontalis* (50-60%), *Limosa lapponica* (3%) and *Calidris canutus* (up to 5.5%).

Source: Helen Neale.

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Kopuatai Peat Dome (14)

Location: 37°26'S, 175°33'E. On the Hauraki Plains, bounded by the Piako and Waitoa Rivers and Elstow Canal, 70 km northeast of Hamilton, North Island.

Area: 9,665 ha.

Altitude: 3-6 m.

Overview: The site consists of a peat dome and surrounding mineralised wetland. Kopuatai Peat Dome is the largest raised (domed) bog in New Zealand. It is also the only significantly unaltered restaid bog left in New Zealand. As the last example of its kind that remains intact, and because it supports a vegetation type unique in New Zealand and therefore the world, the site is of considerable conservation value. It is an important location for the Greater Jointed Rush *Sporadanthus traversii*. Kopuatai has been listed as a wetland of international importance under the Ramsar Convention.

Physical features: Peat began developing within a small graben (the Kopuatai depression) 13,500 years ago, and at present the depth of the peat has been measured at up to 12 m towards the centre, thinning out to 1-2 m near the edge. The underlying sediments comprise reworked volcaniclastic and estuarine sediments. The hydrology of the peat dome and the interconnection of the peat dome and the waters of the surrounding catchment is poorly understood. However, the bog is a raised peat bog; its hydrological regime is dominated by rainfall, with little interaction between the dome and the rivers bounding the bog. The physical features of the peat dome and the adjoining mineralised wetland areas are considered to be very important for flood control and protection, as they provide storage for flood water from the Piako and Waitoa catchments.

There are two main types of wetland in the Ramsar Site, peatland and mineralised wetland. The peatland is acidic, low nutrient wetland with its only water supply being rain. Within the peat dome area, there are several ponds with an average water depth of 1-2 m and a maximum depth of 3 m. In contrast, the mineralised area is river-influenced, occasionally flooded and consequently of far higher nutrient content. Lagoons are present in this wetland type. The mean annual rainfall is 1,112 mm, and the mean temperature ranges from 13.4°C in January to 8.7°C in July. Frosts occur on an average of 52 days per year, and fog on an average of 32 days per year.

Ecological features: The important vegetation types are dominated by the endemic, nationally vulnerable Greater Jointed Rush *Sporadanthus traversii*. This giant restaid "rush" covers about

2,200 ha, mostly towards the east and south. Also found in this oligotrophic zone are Manuka *Leptospermum scoparium*, Tamingi *Epacri*s spp., mosses and liverworts (*Lycopodium* spp. and *Sphagnum* spp.). Cryptogamic flora is poorly studied, but *Campylopus acuminatus* var. *kirkii* is at least rare. Extensive areas of the vulnerable club moss *Lycopodium serpentinum* occur at this site, which is the New Zealand stronghold for the species. The predominant vegetation found in the mesotrophic areas consists of sedges (*Cladium* and *Baumea* spp.) and rushes (*Schoenus* spp.).

The original vegetation found along the mineralised fringes would have been Raupo *Typha orientalis*, sedges *Carex* spp., Cabbage Tree *Cordyline* sp. and New Zealand Flax *Phormium tenax*. Most of this vegetation has now been taken over by more aggressive exotic plant species. Large areas are covered in Crack Willow *Salix* sp. A great diversity of dicot herbs (mostly adventives), native monocots and ferns make up the ground cover under the willows (Irving *et al.*, 1984).

An ecologically important remnant of Kahikatea *Dacrycarpus dacrydioides* forest occurs in the southwest corner of Kopuatai.

Land tenure: All of the land in the Ramsar Site is Crown land and administered by the Department of Conservation. The adjoining land is primarily low-lying farm land in private ownership.

Conservation measures taken: The peat dome area is Crown land held as Stewardship Area and managed by the Department of Conservation. It was allocated to the Department of Conservation as Stewardship Area on 1 April 1987. Adjoining the peat dome area on its west boundary are mineralised wetland areas which are Crown land held as Wildlife Management Reserves and managed by the Department of Conservation. There are five Wildlife Management Reserves:

- Flax Block Wildlife Management Reserve: 810.7 ha, gazetted on 25 May 1982.
- Patetonga Lagoon Wildlife Management Reserve: 35.45 ha, gazetted on 5 August 1982.
- Pattersons Lagoon Wildlife Management Reserve: 26.00 ha, gazetted on 7 September 1978.
- Partatai Block Wildlife Management Reserve: 33.77 ha, gazetted on 12 October 1989.
- Waemaro Wildlife Management Reserve: 56.56 ha, gazetted on 24 May 1982.

In 1979, a Working Party drawn from all the main groups with an interest in the area prepared a submission on the status of the peat dome area and its future use and management. As a result of this submission, a 20 year development moratorium was placed upon the land to allow time for detailed scientific investigations and development feasibility studies, so that the dome would be managed wisely. Prior to this, the land was managed by the Department of Lands and Survey. The 20 year moratorium was effectively nullified in 1987, when the Department of Conservation was created. The peat dome was allocated to the Department of Conservation as Stewardship Area on 1 April 1987. The Department is responsible for managing it.

Kopuatai Peat Dome (9,665 ha) was listed under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention) on 4 December 1989. Existing and future management policies are and will be consistent with Kopuatai's listing under the Ramsar Convention.

Entry to the Peat Dome is prohibited unless a permit is first obtained, due to the fragile nature of the area. The Wildlife Management Reserves are managed for the protection of wildlife and recreational hunting. These areas are open to public use, with the predominant use of this area at present being game-bird hunting, which requires the hunter to obtain a hunting permit. Game-bird hunting is controlled by the Auckland/Waikato Fish and Game Council. A number of licensed private huts are situated along the eastern side of the Piako River to allow duck

shooters overnight accommodation in the area. These huts are subject to Department of Conservation regulations which pertain to issues such as tidiness, removal of vegetation and disposal of rubbish. These huts will be allowed to remain, provided they meet Departmental requirements. However, no further huts are to be constructed. The construction of ponds for waterfowl habitat by recreational hunters is allowed, under Departmental supervision. Certain areas within the Wildlife Management Reserves are grazed for the purposes of weed control.

Conservation measures proposed: A management plan is to be prepared for Kopuatai within the next five years. The status of the peat dome is to be changed from Conservation area to Government Purposes (Wetland Management) Reserve in the future.

There is an urgent need to understand the hydrological dynamics of Kopuatai to ensure that the special features of the bog are preserved. Further study of the central bog depression, the direction of the peat flow and water retention properties of the different plant associations and the peat they form will assist with an understanding of the bog hydrology. Kopuatai is recognised as a ponding area within the Piako/Waitoa Catchment Scheme. The Waikato Regional Council has recently set up a study to investigate water level movement around the peat dome. Water quality monitoring programmes will be established to quantify the effect that present and potential future developments may have on the surface and groundwater quality of the wetlands.

There is an urgent need to study the cryptogams in the wetland. The control of possums which spread tuberculosis will be required. Tuberculosis control is important in terms of New Zealand's agricultural production, particularly the farming of animals.

Land use: Conservation of flora and fauna, protection of wildlife and recreational hunting are the main land uses associated with the wetland. Some grazing takes place in the Wildlife Management Reserves, where there is good road access. Small areas are used for the cultivation of maize. The peat dome is relatively unaffected by surrounding drainage.

Pastoral uses predominate on the surrounding areas, including sheep, beef and dairy farming. The vegetation is predominately pasture with some manuka, blackberry, gorse, rushes, willows (close to the rivers) and bracken fern. Some peat mining is taking place on the area adjoining the dome, but the remainder of the adjoining area is primarily in pasture. A blueberry farm has been established on some of the area previously mined for peat.

A total of 5,019 people live on the Hauraki Plains in the general area of Kopuatai. The wetland is about one hour's drive from two major centres of population, Auckland and Hamilton, and is potentially accessible to one third of the population of New Zealand.

Possible changes in land use: The Department of Conservation will continue to manage Kopuatai to ensure its protection and preservation. Drainage of the mineralised wetland areas in the Wildlife Management Reserves is likely to continue if adjoining land owners do not adopt complimentary policies and practices relating to drainage, water quality and erosion control measures.

Disturbances and threats: The most serious threat to the wetland, particularly the mineralised wetland areas, is continuing drainage of the surrounding area. The Piako River has been channelised, and unnaturally low water levels exist. Reinstatement of natural water levels is necessary to ensure that the entire wetland area is maintained. Peat mining is not seen as a serious threat to the wetland, but there is an ongoing threat from fires and possums infected with tuberculosis.

Hydrological and biophysical values: Kopuatai plays a significant role in flood protection and sediment trapping in the Piako/Waitoa Catchment area. A greater understanding of the hydrological dynamics of Kopuatai is essential for future management. The bog is also of importance in supporting aquatic and terrestrial food chains; it provides important spawning habitat for Inanga *Galaxias maculatus* and habitat for a range of waterfowl.

Social and cultural values: It is known that the area, particularly the mineralised wetland zone, was important to the Maori, and extensively used by them as a source of food (whitebait, waterfowl, cabbage tree) and plant materials, and for transport. The area continues to be important for fishing for whitebait. The peat dome area is used primarily for conservation of flora and fauna. The Wildlife Management Reserves are used for protection of wildlife and some recreational shooting. Scientific research is encouraged.

Noteworthy Fauna: Fifty-four species of birds have been recorded at Kopuatai. Species found within the wetland include Australasian Bittern *Botaurus poiciloptilus*, Banded Rail *Rallus philippensis assimilis*, Marsh Crake *Porzana pusilla affinis*, Spotless Crake *P. tabuensis plumbea* and North Island Fernbird *Bowdleria punctata vealeae*. The Australasian Bittern has a scattered distribution on the mineralised fringe of the wetland. The Kopuatai Peat Dome and nearby Mangatiti Swamp are the only freshwater sites where Banded Rail has been recorded. The Spotless Crake is not uncommon in suitable habitat, but is at risk due to habitat destruction. The fernbird is present throughout the peat bog, but has a patchy distribution.

Many species of Anatidae, including Black Swan *Cygnus atratus*, Grey Teal *Anas gracilis*, Mallard *A. platyrhynchos*, Grey Duck *A. superciliosa* and New Zealand Shoveler *A. rhynchotis variegata*, utilise the more fertile and biologically more productive mineralised and open water areas.

Alien mammals species are also present in the wetland, the predominant species being possum, mustelids, cats, rodents and the occasional wild pig. All of these have a detrimental effect on the native fauna. Southern Fur Seals have been known to stray up the Piako River, beyond Kopuatai.

The waters of Kopuatai contain a number of important fish species, including the endemic and globally threatened Black Mudfish *Neochanna diversus*, which has been recorded on the semi-mineralised fringes of the peat bog. The mudfish, along with the Long-finned and Short-finned Eels, *Anguilla dieffenbachii* and *A. australis*, are probably the only fish to be found in the peat dome proper. Mudfish may be threatened by the spread of the Mosquito Fish *Gambusia affinis*, an exotic species. The mineralised fringe areas and the rivers contain various native species including Inanga *Galaxias maculatus*, both species of eel and Grey Mullet *Mugil cephalus*. Inanga, the juveniles of which form the greatest component of the whitebait catch, are abundant, and these wetlands are an important spawning area for the species. Other quite common species include the Common Smelt *Retropinna retropinna* and Common Bully *Gobiomorphis cotidianus*. Flounder *Rhombosolea leporina* are also to be expected in the rivers. Exotic fish form a large part of the fish population. These include species such as Rudd *Scardinus erythrophthalmus*, Brown Bullhead *Ictalurus nebulosus* (also known as Catfish), Goldfish *Carassius auratus* and Mosquito Fish.

The most notable invertebrates inhabiting Kopuatai are the large orb-weaver spider *Eriophora heroine* and an undescribed blood-red worm (de Lange, 1989). Little research has been carried out on the invertebrate fauna of the peat dome, and it is quite likely that new species will be discovered on further study.

Noteworthy Flora: Threatened species recorded on Kopuatai include:

- *Lycopodium serpentinum* (Creeping Clubmoss): frequently found in the open peat bog areas with low vegetation.
- *Sporadanthus traversii* (Greater Jointed Rush): the dominant species on approximately one third of the peat dome.
- *Cyclosorus interruptus* (a fern): occasionally recorded on mineralised river banks and semi-mineralised bog edges.
- *Utricularia australis* (Floating Bladderwort): scattered throughout the peat dome, especially on edges of peaty pools.

- *Utricularia laterifolia* (a bladderwort): locally common in open peat bog areas with *Campylopus acuminatus* var. *kirkii* and *Goebelobryum unguiculatum*, both of which are rare.
- *Utricularia novae-zelandiae* (a bladderwort): scattered throughout the peat dome, especially on edges of peaty pools.
- *Calochilus robertsonii* (an endemic orchid): known to be present in Kopuatai; a single plant was found in 1988 and 1989.

A significant remnant stand of Kahikatea forest (*Dacrycarpus dacrydioides*) occurs on the southwest corner of Kopuatai, and there is also an area of Kahikatea to the northwest. Less than 2% of the original Kahikatea forest is left in the North Island, and only a part of this remains in an ecologically viable state.

Scientific research and facilities: Major scientific research to date consists of a vegetation survey of the peat dome, and earth sciences research involving radio-carbon dating (history of vertical displacement of Kerepehi Fault at Kopouatai Bog in the Hauraki Lowlands since c.10,700 years ago; and dissolution and depletion of ferro-magnesian minerals from Holocene tephra layers in an acid bog, and implications for tephra correlation). Scientific research is encouraged at Kopuatai, but there are no facilities for research within the peat dome itself. Waikato Regional Council has initiated a study into water levels around the wetland. No other major projects are under way.

Conservation education: No educational programmes are currently under way. Educational activities consistent with the management of the area are to be encouraged within Kopuatai to promote a wider understanding of its values. Development of any programmes will need to ensure that impact on the wetland is minimised. To promote a wider understanding of the special botanical, wildlife and landscape values of the area, educational, research, tourism and recreational activities are to be investigated and encouraged if compatible with wetland management.

Recreation and tourism: One of the Wildlife Management Reserves, the Flax Block, is an important area for duck and pheasant hunting. Hunting is being encouraged through the Auckland/Waikato Fish and Game Council. The Fish and Game Council also set quotas (bag limits) for the hunting season, sets the timing of the hunting season, issues hunting permits and carries out enforcement in relation to these functions. Partial re-instatement of water levels in this area was completed in 1990, and casual observations by Departmental of Conservation staff indicate that numbers of birds are much greater than in previous years.

Management authority: The Department of Conservation (Waikato Conservancy) has responsibility for management of Crown land and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources. The Auckland/Waikato Fish and Game Council is responsible for the management of sport fishing (trout and salmon) and game-bird hunting.

Jurisdiction: Territorial: Hauraki District Council, Piako-Matamata District Council and Waikato Regional Council. Functional: Department of Conservation and Auckland/Waikato Fish and Game Council.

References: Bell (1979); de Lange (1989); Harris (1978); Harrison (1987); Harrison & Vine (1986); Irving *e al.* (1984); Ogle (1983).

Reasons for inclusion:

1a Kopuatai Peat Dome is the only true peat dome/restaid bog remaining intact in New Zealand, and is the largest remaining freshwater wetland left in the North Island. It is the best example of its kind in New Zealand, and supports a vegetation type unique in the world.

2a The wetland supports populations of a number of threatened species, including seven plants, *Lycopodium serpentinum*, *Sporadanthus traversii*, *Cyclosorus interruptus*,

Utricularia australis, *U. laterifolia*, *U. novae-zelandiae* and *Calochilus robertsonii*, one bird, *Botaurus poiciloptilus*, and one fish, *Neochanna diversus*.

2b It is of special value for maintaining the genetic and ecological diversity of the region.

2d It supports a number of species of plants and animals that are endemic to New Zealand, notably the Greater Jointed Rush *Sporadanthus traversii* and Black Mudfish *Neochanna diversus*.

Source: Helen Neale.

Kawhia Harbour (15)

Location: 38°08'S, 174°49'E. On the west coast of North Island, approximately 54 km southwest of Hamilton City.

Area: c.6,600 ha.

Altitude: Sea level.

Overview: Kawhia Harbour is a large estuary with associated rush and reed communities. A number of locally vulnerable plant species are present in the area, which also has high geological, cultural and historic values. The harbour is rated as an outstanding wildlife habitat due to its importance for international and internal migratory bird species. Between 3,000 and 4,600 shorebirds have been recorded in the harbour during the June/July and November/December bird counts.

Physical features: The area is dominated by the Kawhia Regional Syncline, a sedimentary rock structure of the Tertiary and Jurassic Age which is frequently exposed on the west coast and contributes to the hilly nature of the area. In numerous other places, the older rocks of the Kawhia Syncline have been covered by softer Tertiary sandstone, siltstones and limestones, and limestone outcrops are present in the area. The region has also been influenced by volcanism, which has further contributed to the hilly nature of the landscape. A number of caves and cliffs in the southern part of the harbour contain fossils regarded as internationally important for their Jurassic sequence. The harbour itself is a bar-built estuary formed in a drowned valley at a time of relatively low sea level. The coastline to the north of the harbour entrance is dominated by extensive sand hills up to 100 m in height, while to the south of Kawhia are black iron sand beaches and dunes which are mined for the iron ores. No information is available on the climate of this area, but in 1986, the annual temperature range at Mokau to the south was 0.2^{o}C-27^{o}C and the rainfall 1,432 mm. The catchment area for the harbour is 480 sq.km.

Ecological features: Kawhia Harbour is of high value for its flora, fauna and geological values. It is the most extensive of the West Coast harbours in Waikato Region. There is considerable variation in the vegetation around the estuary shoreline, depending on the extent to which the adjoining land has been developed. Beds of eelgrass *Zostera* sp. are often present on the tidal sand and mudflats. Where saltmarsh has developed at the upper tide level, common species are Jointed Rush *Juncus articulatus*, Sea Rush *J. maritimus* var. *australiensis*, Saltmarsh Ribbonwood *Plagianthus divaricatus* and species of *Scirpus* and *Baumea*. Saltmarsh is generally present in minor areas only, forming a narrow strip along sheltered shorelines, but more extensive areas occur in bays and inlets subject to freshwater drainage. Where fresh water is present and away from the tidal influence, saltmarsh often merges into freshwater wetland vegetation, with such species as willows (exotic species of *Salix*), Manuka *Leptospermum scoparium*, New Zealand Flax *Phormium tenax*, Raupo *Typha orientalis*, Cabbage Tree *Cordyline australis* and *Cyperus* sp. Species of *Scirpus*, *Juncus* and *Carex* are

also present, as well as exotic grasses. Patches of the aggressive exotic weed *Spartina townsendii* are present, and this is of concern.
Developed pasture may extend right to the saltmarsh zone in the estuary, although in places, a band of regenerating native vegetation is present. Small areas of secondary forest occur around the estuary, but are not common.
Land tenure: The harbour bed is Crown land. Te Motu Island is Maori owned, with the other islands being Crown land. The surrounding land is predominantly in freehold private or Maori ownership.
Conservation measures taken: There are nine Scenic Reserves, totalling 420 ha, around the margins of the harbour (outside the boundary of the wetland); these are managed by the Department of Conservation. The wetland itself has no formal protection.
Conservation measures proposed: The main aims of future management are to advocate for more ecologically sensitive land use practices in the catchment, and to promote public awareness of the values of healthy estuarine systems.
Land use: The wetland is used for fishing, game-bird hunting (*e.g.* duck shooting), whitebaiting and educational programmes. The surrounding area is predominantly used for pastoral farming (*e.g.* dry stock farming). The population of the Kawhia community is 360. The city of Hamilton (approximately 100,000 people) is within 54 km of the harbour.
Possible changes in land use: None known.
Disturbances and threats: Continuing disturbance to the catchment area and increased enrichment have in the past been two of the main threats to the estuary. Erosion of the catchment is minimal, but land development has generally resulted in increased sediment and nutrient run-off. The impacts of land clearance and development still occur today. There are a number of reclamation and foreshore structures at Kawhia settlement and Te Maika which alter the natural shoreline in those areas. A number of refuse dumps around the harbour impact on the fringe vegetation. Other potential threats include reclamation of the harbour, invasion by the exotic aquatic weed *Spartina* and water pollution.
Hydrological and biophysical values: The harbour is of great importance in supporting aquatic and terrestrial food chains. It is an important spawning area for fish, and is important both for migratory marine fish and for a number of native freshwater fish which have a marine component in their life cycle. It also assists in the prevention of coastal erosion and sediment trapping from the harbour catchment, and plays a role in the maintenance of water quality.
Social and cultural values: The area is of particular significance to the local Maori, with two stones at Maketu Marae on the harbour foreshore marking the last resting place of the Tainui Canoe, one of the ancestral Maori canoes. On the foreshore is the ancient "pohutukawa" Tangi-te-korowhiti to which the canoe is believed to have been anchored. The harbour was important as a source of food (fish, shellfish and birds) for the Maori. There are also a high number of recorded archaeological sites around Kawhia and at Te Maika. The harbour is used by schools for educational purposes and is used for whitebaiting, fishing and duck hunting.
Noteworthy fauna: The harbour provides habitat for a range of international and internal migratory waterfowl as well as a variety of resident species. The Bar-tailed Godwit *Limosa lapponica* is the commonest of the international migratory shorebirds, with up to 3,000 occurring at one time. Other international migrants using the harbour in smaller numbers include Ruddy Turnstone *Arenaria interpres*, Whimbrel *Numenius phaeopus* and Far Eastern Curlew *N. madagascariensis*. The harbour is a major destination for two internal migratory species, the Black Stilt *Himantopus novaezelandiae* and Wrybill *Anarhynchus frontalis* from the Waitaki Basin in South Island. The South Island Pied Oystercatcher *Haematopus finschi* occurs in large numbers in winter; over 2,500 have been recorded, representing almost 3% of the total New Zealand population. The New Zealand Dotterel *Charadrius obscurus* is resident in the area, and has a significant breeding population at Kawhia. Other waterfowl occurring in

significant numbers include the Royal Spoonbill *Platalea regia*, Pied Stilt *Himantopus leucocephalus* and Banded Dotterel *Charadrius bicinctus* (250-480).
In areas of the harbour where there is saltmarsh and reed vegetation, Australasian Bittern *Botaurus poiciloptilus*, Banded Rail *Rallus philippensis assimilis* and North Island Fernbird *Bowdleria punctata vealeae* have been reported.
Noteworthy flora: A number of locally uncommon plants are present in areas adjacent to the harbour, including *Pomaderris rugosa* and *Metrosideros carminea*. There is an unusual association of Whau *Entelea arborescens* in coastal forest. Other significant plants include *Hebe obtusata*, *Scandia rosaefolia* and *Empodisma minus* in the east, and King Fern or Para *Marattia salicina*, *Doodia mollis* and *Asplenium obtusatum* var. *northlandicum* around the southern inlets and peninsulas. At Motukaraka Island, within the wetland boundary, *Scandia rosaefolie* is at its southern limit, and the limestone fern *Asplenium lyalli* is also present. A number of other interesting associations occur within the reserves around the harbour.
Scientific research and facilities: A limited amount of scientific research has been carried out at Kawhia. The Ornithological Society of New Zealand has conducted regular bird counts in the harbour since 1976, and a full vegetation survey was carried out in the summer of 1991/92 by the Department of Conservation.
Conservation education: A substantial area of the foreshore of Kawhia Harbour is used by schools for estuarine and fossil studies, while studies on rocky shores are carried out at Te Maika. There is considerable potential for future educational use of the area.
Recreation and tourism: Recreational activities include boating, fishing, game-bird hunting and bird-watching.
Management authority: A number of agencies have responsibility for different aspects of the harbour. The Department of Conservation (Waikato Conservancy) is responsible for the management of Scenic Reserves and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources and the preparation of coastal plans. The Auckland/Waikato Fish and Game Council manages of sport fishing and game-bird hunting.
Jurisdiction: Territorial: Waikato Regional Council and Otorohanga District Council. Functional: Department of Conservation and Auckland\Waikato Fish and Game Council.
References: Department of Conservation (1990b); Moynihan (1986); New Zealand Wildlife Service (1981a).
Reasons for inclusion:

1a Kawhia Harbour is a particularly good representative example of a west coast harbour.

2a The harbour supports significant populations of at least three globally threatened species of birds, *Himantopus novaezelandiae*, *Charadrius obscurus* and *Anarhynchus frontalis*.

2c The harbour is an important spawning area for fishes, and a major wintering area for several species of migratory waterfowl.

2d The harbour supports substantial numbers of many of New Zealand's endemic plants and birds, notably *Pomaderris rugosa*, *Metrosideros carminea*, *Hebe obtusata*, *Haematopus finschi*, *Himantopus novaezelandiae*, *Charadrius obscurus*, *Anarhynchus frontalis* and *Bowdleria punctata*.

3c The harbour regularly supports 1% or more of the regional populations of *Haematopus finschi* (3%), *Charadrius bicinctus* (1%) and *Limosa lapponica* (1%).

Source: Helen Neale.

Taharoa Lakes (16)

Location: 38°10'S, 174°44'E. On the west coast of North Island, 60 km southwest of Hamilton and 4 km southwest of Kawhia Harbour.
Area: c.405 ha.
Altitude: 20 m.
Overview: Lake Taharoa (224 ha), Lake Numiti (13 ha) and Lake Rotoroa (23 ha) are isolated coastal dune lakes supporting a number of threatened bird species, a diverse native fishery and a rare coastal plant. An extensive raupo-flax-sedge wetland fringe around Lake Taharoa covers a further 145 ha. The lakes represent the only significant coastal freshwater wetlands on the west coast of the North Island between the Kaipara Harbour and the South Taranaki Bight.
Physical features: The Taharoa Lakes are inter-connected coastal dune lakes formed as a result of an advancing fore-dune blocking a stream valley. The main inflow to the lakes is surface flow from a scrub (brushwood) and pasture catchment on their northern and eastern sides, and from precipitation. The outlet from the lakes is via the Wainui Stream to the Tasman Sea. Lake levels are artificially maintained by a dam on the Wainui Stream. To the west of the lakes, there are extensive dunes of ironsand (a regionally significant landform) which are being mined for iron ore and are planted in exotic timber species as part of production forests. The catchment area for the lakes is 42 sq.km.
Lake Taharoa and Lake Numiti are oligotrophic with low suspended solids, total phosphorus and chlorophyll concentrations. Some oxygen depletion is evident in the deeper parts of the lakes. The maximum depth of Lake Taharoa is 9.2 m and Lake Numiti 9.1 m (Waikato Valley Authority, 1985). Lake Rotoroa is thought to be a similar depth. Surface water temperatures during the summer range from 18.9-23.0°C in Lake Taharoa (Waikato Valley Authority, 1985).
Ecological features: The extensive open water areas of the lakes are surrounded by swamplands with associations of Raupo *Typha orientalis*, New Zealand Flax *Phormium tenax*, sedges and scattered stands of Manuka *Leptospermum scoparium* and pussy willow *Salix* spp. Extensive beds of *Elodea canadensis* are found in Lake Taharoa, where the bottom of the lake is mainly characean meadow. *Potamogeton* spp. and *Myriophyllum* species are also present. As a result of ironsand mining operations, parts of the dunes adjacent to the wetland have been replanted with marram, lupin, pine and some Pingao *Desmoschoenus spiralis*. The lakes support good numbers of waterfowl of a wide variety of species, and are used extensively by Paradise Shelduck *Tadorna variegata* for moulting. They contain the most diverse natural freshwater fishery in the region, and no releases of exotic fish species are known to have occurred. They are also some of the only lakes where eels *Anguilla* spp. are not exploited commercially.
Land tenure: The lakes and adjoining land are private Maori land, administered by trustees representing the Ngati Mahuta people. Permission for access to the lakes must be gained from the trustees.
Conservation measures taken: No formal protection has been given to the lakes.
Conservation measures proposed: The specific conservation measures proposed for the lakes relate to the restoration of the native fishery, particularly the Grey Mullet *Mugil cephalus* population, and to the protection of the lake and wetland ecosystem in general. A dam 4.6 m high was built by New Zealand Steel Mining (NZSM) in the 1970s at the lake outlet to abstract water for their adjacent ironsand mining operation. A fish pass was included in the design of the dam. It was not successful, and the Grey Mullet population in the lake has been lost. The Fisheries Research Division of the Ministry of Agriculture and Fisheries (MAF) has a proposal

to reinstate the Grey Mullet population and improve populations of other fish species. The Department of Conservation will maintain an interest in the future management of the lakes, and the fisheries in particular.

Land use: The primary uses of the area adjoining the lakes are farming, ironsand mining and reafforestation (with exotic timber species) after mining. The lakes themselves are used for domestic, agricultural and industrial (*i.e.* mining) water supply. The population of the Taharoa area is 300. The city of Hamilton (approximately 100,000 people) is 60 km away.

Possible changes in land use: Development projects or major changes in land use are unlikely in this area, but the existence of NZSM at Taharoa poses an ongoing threat to the lakes. Forest clearance and replanting in the catchment, degradation of riparian margins and further control of the water regime are possible threats.

Disturbances and threats: The primary disturbance to the lakes has been caused by the development of the catchment and adjoining land into pasture and the operation of NZSM in the area. Sand mining has resulted in a loss of botanical values of the dunes. Coastal development is also a potential threat to the seaward margins of the lakes. The lakes themselves, in particular Taharoa, are susceptible to eutrophication as a result of nutrient enriched run-off from the catchment.

Hydrological and biophysical values: The wetland plays a general role in the maintenance of water quality and the support of food chains. The primary hydrological use of the lakes is for water supply purposes. There is some concern about fluctuating water levels in the lakes, and controls may be required to protect the lake shore and swamp vegetation.

Social and cultural values: The lakes have an important role in providing a traditional fishery for the local Maori, and a number of historic Maori occupation sites are known in the area. The lakes are also used for waterfowl hunting and sailing, as well as providing an industrial water source for NZSM, a public and private water supply and, to a lesser extent, a water supply for domestic livestock. The lakes also have high aesthetic value.

Noteworthy fauna: The lakes and their associated swamps support a wide variety of waterfowl, including large populations of Black Swan *Cygnus atratus* and Grey Duck *Anas superciliosa*, and smaller numbers of New Zealand Dabchick *Poliocephalus rufopectus*, Australasian Bittern *Botaurus poiciloptilus*, New Zealand Scaup *Aythya novaeseelandiae*, Banded Rail *Rallus philippensis assimilis*, Marsh Crake *Porzana pusilla affinis*, Spotless Crake *P. tabuensis plumbea* and North Island Fernbird *Bowdleria punctata vealeae*. The lakes are used extensively by the Paradise Shelduck *Tadorna variegata* for moulting. No information is available on numbers of birds present.

The lakes contain a very diverse and regionally significant native fishery with the following species present: Long-finned Eel *Anguilla dieffenbachii*, Short-finned Eel *A. australis*, Common Smelt *Retropinna retropinna*, Inanga *Galaxias maculatus*, Grey Mullet *Mugil cephalus* and Red-finned Bully *Gobiomorphus huttoni*.

Noteworthy flora: The fore-dunes still support stands of the endemic sand-binding plant Pingao *Desmoschoenus spiralis*. The lakes themselves have a good assemblage of native marginal vegetation, but do not contain any species of particular note.

Scientific research and facilities: Limited research has been carried out on the lakes to date, and the majority of studies that have been conducted relate to the fisheries of the lakes and the impacts of ironsand mining. The potential exists for further research to be carried out.

Conservation education: The lakes have the potential to be used for educational purposes, but to date no formal programmes have been developed.

Recreation and tourism: The primary recreational activities at the lakes are fishing and duck-shooting, but some sailing also occurs.

Management authority: Ngati Mahuta trustees, Taharoa. The Department of Conservation has responsibility for the management of protected wildlife. The Waikato Regional Council

has statutory responsibilities under the Resource Management Act 1991 for water resources. The Auckland/Waikato Fish and Game Council manages sport fishing and game-bird hunting.
Jurisdiction: Territorial: Waitomo District Council and Waikato Regional Council. Functional: Ngati Mahuta trustees, as land owners; also the Department of Conservation and Auckland/Waikato Fish and Game Council.
References: Boswell *et al.* (1985); Department of Conservation (1990b); Moynihan (1986); Strickland (1985); Waikato Valley Authority (1985).
Reasons for inclusion:

1a The Taharoa lakes are particularly good, representative and unmodified examples of coastal dune lakes, a wetland type characteristic of New Zealand and becoming rarer as a result of pastoral and urban development of coastal dunes.

2a The lakes support populations of two globally threatened species of birds, *Poliocephalus rufopectus* and *Botaurus poiciloptilus*.

2b The lakes support a very diverse and regionally significant native fishery as well as a high diversity of waterfowl, and are thus of special value in maintaining the genetic and ecological diversity of the region.

Source: Helen Neale.

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Waipa Peat Lakes (17)

Location: 37°46'-38°02'S, 175°11'-175°20'E. Approximately 29 km south of Hamilton, Waipa District, North Island.
Area: Total area of 20 main lakes 504.84 ha. (See Appendix 5 for details).
Altitude: 60-80 m.
Overview: The Waipa District contains a number of small peat lakes which provide a nationally significant wildlife habitat, with a range of floral and faunal assemblages of considerable scientific interest. The 20 main lakes are listed in Appendix 5. Although the lakes have been modified over the years by agricultural practices, they all still show peaty characteristics and represent the largest assemblage of such habitats in New Zealand.
Physical features: With the exception of Te Otamanui Lagoon, all of the main lakes in the Waipa District are of peat origin, and it is likely that the Waipa and Waikato Rivers played an important role in their formation. The lakes were formed at the end of the last glaciation some 17,000 years ago, as a result of the blocking of river valleys by silt and sand from the ancient Waikato River. Small lakes were formed behind these gravel bars. The vegetation at this time was tussock grassland with scattered low-growing shrubs and herbs, and there was no swamp or peat surrounding the lakes. As the New Zealand climate warmed, dense forest formed. Rushes and submerged aquatic plants began to inhabit the lake fringes; peat and bog vegetation developed as the climate became wetter and warmer. The peat rapidly deepened and spread outwards, with peat growth gradually covering the sandbars which had originally dammed the lakes. As the peat further thickened, the lake waters deepened and turned dark brown and acidic as a result of leaching of humic materials from the peat. Although all the peat lakes share certain features, no two are completely alike and the timing and extent of peat influences varies from lake to lake.
One interesting aspect of the development of Lake Maratoto is that it has remained much the same size throughout its history. This is probably due to the peat growth being so slow that wave action on the lake edge and bacterial breakdown of peat particles in the water have been able to counteract any encroachment of peat into the lake.

The hydrology of the lakes has not been studied, but in pre-European times most of the lakes would have had no inlets or outlets, and changes in the water table would have been responsible for seasonal variation in lake levels. Water probably entered the lakes from the adjacent peat bogs and precipitation, and was lost predominantly via evaporation from the lake surface. Today, water still enters the lakes from the peat bogs, but catchment run-off is likely to be more important than in the past. Unpredictable variations in water level now occur as a result of changing levels of the inlet and outlet drains, and shallow lake margins may dry out as a result.

The lakes are generally very shallow, and vary from a few centimetres to nine metres deep. Most of the lakes are known to vary by about 0.5 m in depth during the year due both to surface evaporation (especially in the summer) and to drainage exceeding inflow. The lake basins are floored by 2-4 m of fine lake sediments, and these sediments have preserved at least 28 thin layers of volcanic ash blown by wind from volcanic eruptions. These layers have been used to calculate the age of the lakes and to date their history. The soils immediately surrounding the lakes consist of mainly peaty loams and loamy peats, with clay and silt loams on the low hills.

The lake catchments are generally flat to gently undulating. Most of the surrounding area is in pasture in various stages of development, although small remnant stands of the original Kahikatea *Dacrycarpus dacrydioides* forest remain in places. The total catchment area of all the lakes is unknown.

There is considerable variation in the water colour and acidity of the lakes, although true peat lakes generally have acidic waters. As a result of drainage changes and increased nutrient flow to the lakes, most of them have now reverted to a more neutral pH. Generally, the pH is between 6 and 8, with two lakes frequently measured at above 9 and Lake Maratoto regularly below 6.

The surface waters of the lakes stratify during the spring and summer, although this stratification appears to be readily broken down by wind. Temperatures of up to 31°C have been recorded in the surface waters of some of the lakes in mid-summer.

The water of all the lakes is very fertile, with high nitrogen and phosphorus levels in particular. Chlorophyll concentrations are high in most lakes, an indication of their productive nature. The lakes often show oxygen depletion in the bottom waters and super-saturation in the surface waters, typical of shallow productive lakes and indicative of high productivity and thermal stratification. All of the lakes have been drained to varying degrees over the years.

The mean monthly rainfall varies from 73 mm to 128 mm, and the climate is generally warm and humid during the summer, with wet winters.

Ecological features: The vegetation surrounding each lake varies but in general there is, on the lake edges, a border of rushes and reeds consisting mainly of *Eleocharis* spp. and Raupo *Typha orientalis*. These species often form floating mats which invade the open waters. Behind this zone, there is usually crack and pussy willow (exotic species of *Salix*) interspersed with exotic weeds such as Blackberry *Rubus fruticosus* and Gorse *Ulex europaeus*. The native vegetation of Manuka *Leptospermum scoparium*, ferns and rushes is limited to scattered remnants that are protected from farm animals. Some replanting with native species has been undertaken in an attempt to re-establish this vegetation. The replanting of Lake Serpentine by Waipa District Council is an excellent example of the positive benefits of native re-vegetation programmes.

One of the lakes, Lake Maratoto, is unique in that it has retained much of its original catchment cover of *Leptospermum scoparium*, dominant over various low growing ferns, shrubs, herbs, mosses and liverworts. On wetter areas close to the lake, typical plants of peat surfaces occur, with *Sphagnum* moss, orchids and various rushes present. The phytoplankton and zooplankton of the lakes shows great diversity, with the zooplankton associations of particular interest

scientifically. In general, the fauna and flora of the lakes are interesting, and a number of plants and animals are of particular interest. The lakes are all very productive, supporting complex biological communities which are particularly diverse in those that have clear water and of neutral pH.

Land tenure: The majority of the Waipa Lakes are Crown owned with the exception of Horseshoe Lake (owned by Hamilton City) and Pataka, Mangahia, Unnamed, Maratoto and Rotongata Lakes, all of which are privately owned. Most of the land in the surrounding catchment is privately owned.

Conservation measures taken: Lakes Rotomanuka, Rotopataka, Ngarotoiti, Serpentine, Koromatua and Ruatuna are Crown land, gazetted as Government Purpose (Wildlife Management) Reserves. Lakes Rotokauri, Cameron, Te Koutu, Rotoroa, Ngaroto and Mangakaware are Crown land, gazetted as Recreation Reserves. The reserves are as follows:

- Cameron, Recreation Reserve: 6.1480 ha, gazetted in 1985.
- Ngarotoiti, Government Purpose (Wildlife Management) Reserve: 7.84 ha, gazetted in 1983.
- Serpentine, Government Purpose (Wildlife Management) Reserve (adjoining Recreation Reserve): 30.3 ha, gazetted in 1983.
- Rotopotaka, Government Purpose (Wildlife Management) Reserve: 3.44 ha, gazetted in 1983.
- Lake Te Koutu, Recreation Reserve (managed by Waipa District Council).
- Rotomanuka, Government Purpose (Wildlife Management) Reserve: 36.56 ha, gazetted in 1983.
- Rotokauri, Recreation Reserve: 68.8 ha, gazetted in 1983.
- Rotoroa, Recreation Reserve and Wildlife Refuge (Hamilton).
- Koromatua, Government Purpose (Wildlife Management) Reserve: 18.2372 ha, gazetted in 1983.
- Mangakaware, Recreation Reserve (Closed Game Area): 48.9669 ha, gazetted in 1981.
- Ruatuna, Government Purpose (Wildlife Management) Reserve (adjoining Recreation Reserve): 18.18 ha, gazetted in 1983.
- Ngaroto, Recreation Reserve: 149.0913 ha, gazetted in 1984.

The Government Purpose Reserves are managed by the Department of Conservation. A number of the lakes have reserves associated with them, and planting of the marginal areas (vegetation transition zone) by the District Council and the Department of Conservation has been undertaken on an ongoing basis. The privately owned lakes, Mangahia, Maratoto, Pataka, Rotongata and Unnamed, are unprotected.

Conservation measures proposed: Turnbull Pond and Te Otamanui Lagoon are Crown Proposed Wildlife Management Reserves. Management plans have been prepared for Lakes Rotomanuka, Ngaroto, Rotokauri, Ruatuna, Maratoto and Serpentine, and a number of recommendations for the management of the lakes have been made. The following summary of recommendations (taken from Green, 1987) relates to the lakes generally:

- Fencing of lakes and drains to stop the encroachment of cattle.
- Modification of drainage to maintain water levels and to reduce nutrient input.
- Disposal of farm effluent and wastes on to land well away from the lakes and their contributing waterways.
- Planting of native trees around the perimeters of the lakes.
- Clearing and replacement of exotic plants (*e.g.* willows, water lilies) with the eventual aim of removing them completely.
- Removal of accumulations of unsightly rubbish.
- Protection of historical "pa" sites.

- Provision for public access to the lakes.
- Regular inspection of the condition of nearby lakes.

Land use: Protection and management of wildlife and recreational use (*e.g.* game-bird hunting) at the Wildlife Management Reserves. Recreational use at the Recreation Reserves. The lakes are used for water supply, in controlling groundwater levels and as end points for drains. They are also used for recreational activities. The majority of the catchment areas are grazed and extensively farmed. The population of the nearest town (Te Awamutu) is approximately 8,100, and there is also a scattered rural population. The city of Hamilton (approximately 100,000 people) is within 29 km of the lakes.

Possible changes in land use: A proposed subdivision of the shores of Lake Cameron by Waipa District Council could impact on the shoreline vegetation and water quality of the lakes.

Disturbances and threats: As a result of agricultural development, none of the Waipa Lakes has remained in a totally natural state. All have been modified to some degree by drainage, vegetation clearance and the effects of pastoral farming on surrounding land (*e.g.* the use of fertiliser and animal husbandry techniques). Drainage has resulted in shrinkage of the peat and lowering of the water table. The lakes were almost certainly deeper, more acidic, less productive and surrounded by marginal vegetation (transition zone) to a greater extent than exists today.

The natural values of the lakes will continue to deteriorate if further vegetation is removed from the lake margins, if effluent finds its way into the lakes, if nutrient rich run-off enters the lakes, and if cattle trampling around the shores of the lakes, peat drainage and water abstraction for irrigation continue. The continual deepening of outlet drains by local authorities under the guise of drain maintenance is also of concern, as this leads to a lowering of the water table.

Hydrological and biophysical values: The lakes are important for water supply; they play a role in controlling groundwater levels, and are also important as ponding areas during floods and for the support of food chains.

Social and cultural values: A number of lakes have a "pa" (fortified Maori settlement) associated with them, and these "pa" are recognised by archaeologists as being the best preserved pre-historic, open-air neolithic settlements in the world. The semi-waterlogged state in which the remains of these sites are found has helped preserve them, but any reduction in water level would cause deterioration in their features.

All of the lakes in Waipa District are used for game-bird hunting (*e.g.* duck shooting), with Lake Ngaroto being an important recreational area used for boating, sailing, rowing, hunting and fishing. Other lakes are used by local people for various recreational activities. A number of the lakes are used for water supply purposes, and all the lakes have considerable scientific and educational value.

Noteworthy fauna: The lakes support a variety of resident and visiting waterfowl, notably the New Zealand Dabchick *Poliocephalus rufopectus* (very few), Australasian Bittern *Botaurus poiciloptilus*, White Heron or Great Egret *Egretta alba* (rare), Banded Rail *Rallus philippensis assimilis* and North Island Fernbird *Bowdleria punctata vealeae*. A large number of other native and introduced bird species use the lakes, but information on numbers is not available.

The fish fauna includes the endemic Black Mudfish *Neochanna diversus*. The aquatic invertebrate fauna includes a number of species of considerable interest, notably the whirligig beetles *Gyrinus convexiusculus* (in Lake Rotomanuka), a water mite *Limnochares* (*Cyclothrix*) sp. (recorded for the first time in New Zealand at Lake Maratoto), the freshwater jellyfish *Craspedacusta sowerbyi*, and leeches, probably medicinal leeches (in Lake Rotongata). The co-existence of the copepods *Calamoecia lucasi* and *Boeckella delicata* in the zooplankton of some of the lakes is of considerable scientific interest.

Noteworthy flora: The presence of a number of plants is of particular interest because of to their limited distribution in this district. These are *Utricularia australis*, a bladderwort found in Lakes Rotomanuka and Serpentine, *Wolffia australiana*, the world's smallest vascular plant, and *Nitella hookeri* (stonewort), a native characean algae present in many of the lakes.
Scientific research and facilities: A number of research projects have been carried out at the lakes. Some of the main studies have included a biological survey of the lakes of Waipa County (Chapman & Boubee, 1977), a study of the seasonal biology of phytoplankton in Lake Rotomanuka and Lake Maratoto (Etheredge, 1983), a study of the comparative ecology of *Ceriodapina* and *Bosmina* at Lake Mangakaware (Greenwood, 1987), a study of the past and present benthic fauna of Lake Maratoto with special reference to the Chironomidae (Boubee, 1978a-f), and a study of the vegetation surrounding a peat lake (Wallace, 1984). There are also a number of ongoing studies on the lakes being conducted from the University of Waikato.
Conservation education: Lake Ruatuna has been developed into an educational facility, and a campsite has been established for use by schools. There is considerable scope for future development of educational facilities at a number of other lakes.
Recreation and tourism: Several of the lakes are close to main roads, and tourist buses have been observed parking to enable viewing of these lakes. Enhancement of the lakes by planting would add to the visual enjoyment of the travelling public. A range of recreational activities including boating, game-bird hunting and fishing are regularly enjoyed by local people.
Management authority: Hamilton City Council is responsible for the management of Lake Rotoroa and Horseshoe Lake, Waipa District Council for the management of Lake Cameron and Lake Ngaroto, and Waikato District Council for the management of Lake Rotokauri. The Department of Conservation (Waikato Conservancy) is responsible for the management of all other lakes and wildlife. The Waikato Regional Council has statutory responsibilities under the Resource Management Act 1991 for water resources. The Auckland/Waikato Fish and Game Council manages sport fishing and game-bird hunting.
Jurisdiction: Territorial: Hamilton City Council, Waikato District Council, Waipa District Council and Waikato Regional Council. Functional: Department of Conservation and Auckland/Waikato Fish and Game Council.
References: Boswell *et al.* (1985); Boubee (1978a, 1978b, 1978c, 1978d, 1978e, 1978f, 1983); Chapman & Boubee (1977); Etheredge (1983, 1987); Green (1979, 1987); Green & Lowe (1985); Green *et al.* (1984); Greenwood (1987); Irwin (1982a, 1982b); Lowe *et al.* (1980); Patchell (1974); Waikato Valley Authority (1981); Waipa County Council (1981); Wallace (1984).
Reasons for inclusion:

1a The Waipa lakes are particularly good representative examples of peat lakes, a wetland type characteristic of New Zealand.

2a The lakes support populations of at least three globally threatened species, the Black Mudfish *Neochanna diversus*, New Zealand Dabchick *Poliocephalus rufopectus* and Australasian Bittern *Botaurus poiciloptilus*.

2b The lakes support a number of species of plants and animals which are scarce or local elsewhere in New Zealand, and are thus of special value in maintaining the genetic and ecological diversity of the region. The co-existence of two copepod species, and the presence of several plant species of limited distribution (*e.g. Utricularia australis, Wolffia australiana* and *Nitella hookeri*) are especially noteworthy.

Source: Helen Neale.

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