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January – December 2003

Baseline water quality

Stream, lake and saline waters

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Baseline Water Quality Survey of the Auckland Region Annual Report January – December 2003

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Contents

Executive Summary

The Auckland Regional Council and its antecedent organisations have been monitoring water quality as part of the Long Term Baseline (LTB) surveys, since the mid-1980s. In this Annual Report, data from the LTB surveys are presented for 16 streams, 14 saline water sites in Manukau, Waitemata and Kaipara Harbours and the Hauraki Gulf, and for seven lakes for the period January – December 2003. Time series graphs are also presented for the monitoring period, in which data quality has been checked; generally back to 1987-1991, depending on the parameter.

Monitoring data from investigations of sites in Mahurangi Estuary, Upper Waitemata Harbour and Tamaki Estuary have also been summarised for the period January – December 2003. These data are presented in a companion document (ARC 2004).

1.0 Introduction

This report summarises water quality data collected as part of Long Term Baseline (LTB) surveys covering the period January – December 2003, carried out by the Environmental Management Division of the Auckland Regional Council. Aquatic resources surveyed include freshwater streams and lakes throughout the region and saline sites in the Kaipara, Manukau and Waitemata Harbours and the Hauraki Gulf. This is the fourth in a series of annual reports describing the monitoring data for the 12-month period of the previous calendar year (in this instance, 2003). Every five years a comprehensive summary of the data will be undertaken, as was done previously (ARC 1995, Wilcock & Stroud 2000). The principal aims of this report are (1) to document water quality data over the specified period, and (2) to provide brief comment on this most recent data by comparison with the latest summary of the baseline water quality survey of the Auckland region (Wilcock & Stroud 2000) and the most recent annual report (Wilcock & Martin 2003). An annual report of water quality survey data from Mahurangi Estuary, Upper Waitemata Harbour and Tamaki Estuary for the period January – December 2003 is provided as a companion document to this report (ARC TP 235, 2004).

The ARC undertakes monitoring programmes for the resources of the Auckland region as part of its statutory responsibilities under Sections 30 and 35 of the Resource Management Act (1991).

The principal aims of LTB water quality surveys are as follows:

1. Determine the temporal and spatial variability of selected water quality parameters at sites with different land-use influences throughout the region.
2. Provide a baseline of water quality information from which the presence, direction and magnitude of trends can be determined.

Subsidiary to these aims are:

1. Identification of the present and potential impacts of catchment development activities.
2. Collection of baseline data for calibration of short-term surveys of similar areas.
3. Evaluation of improvement in water quality in response to pollution abatement activities.
4. Assessment of the effectiveness of land use planning policies intended to protect water quality.
5. Ensuring that existing environmental controls are adequate to avoid unacceptable adverse environmental impacts.

As in recent annual reports (Wilcock & Kemp 2002, Wilcock & Martin 2003), we have plotted time-series for water quality variables at all sites, so that they now cover the periods 1992 to 2003 for the freshwater and lake sites, and 1987-2003 for the saline sites. Data collected prior to this can be accessed through the references cited in ARC Technical Publication 132 (Wilcock & Stroud 2000), referred to throughout this report as TP132.

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2.0 Sampling sites and survey details

A team of field officers with an appropriately equipped vehicle collects all freshwater stream samples.

The ARC's saline LTB monitoring is carried out predominantly by helicopter instead of the more conventional sampling by boat. The exception to this practice is the Shelly Beach site in the Kaipara Harbour, which is accessed via a wharf. There are several advantages to gathering samples and data by helicopter, viz.:

1. Samples can be collected at approximately the same stage of the tide and within a narrow time frame.
2. The time for travel from collection to the laboratory is greatly reduced.
3. Sampling can be undertaken under more adverse weather conditions than is generally possible by small boat.
4. Substantial cost savings are involved in terms of equipment and staff resources.

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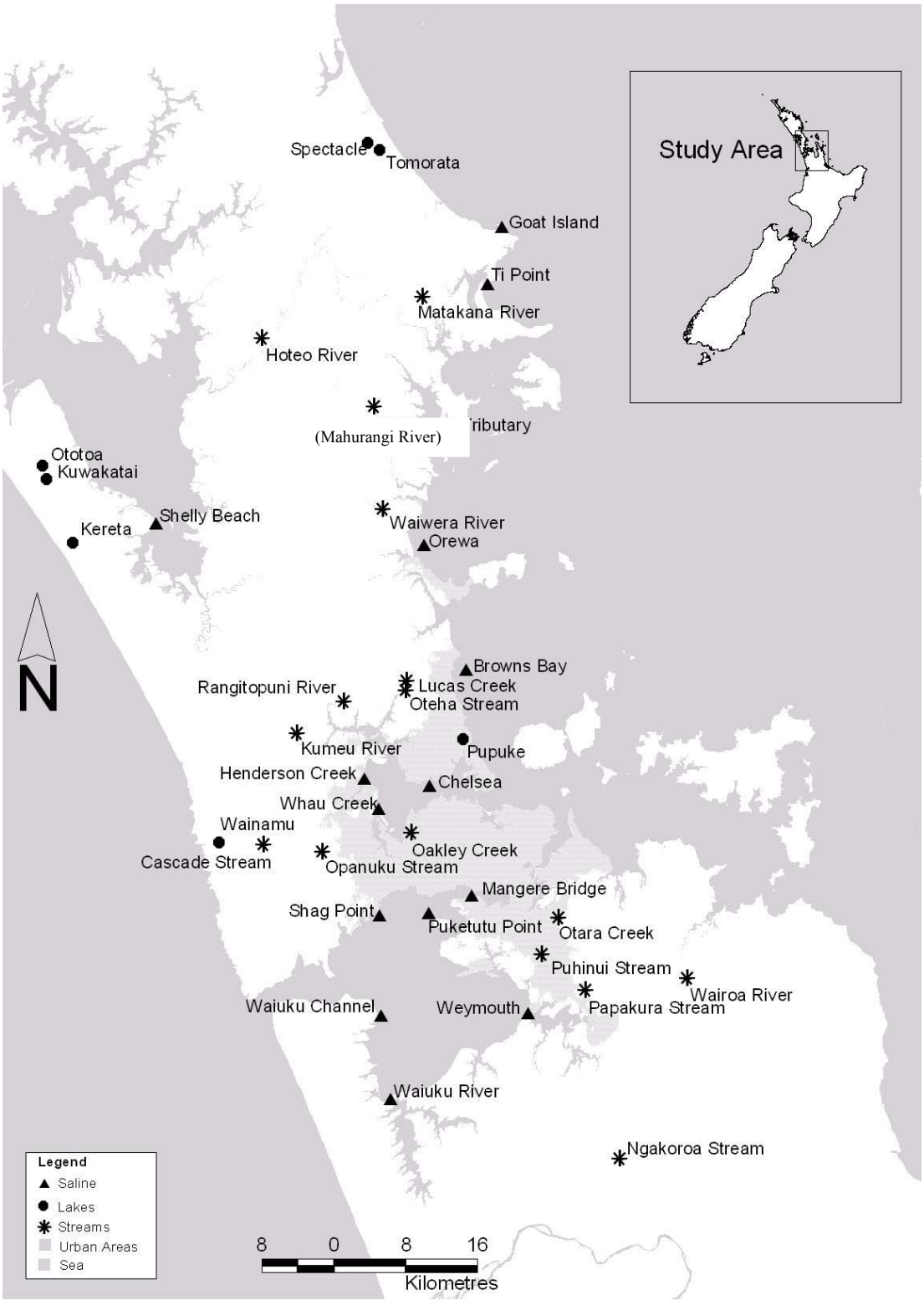
LTB lake sites, except for Lake Pupuke, are also accessed by helicopter, although sampling is carried out from an inflatable boat once the helicopter has landed. Shore based sampling which took three to four days by a land-based team with a boat, can now be accomplished in six hours.

Figure 2.1:
Location of freshwater, saline and lake monitoring sites.



2.2 Freshwater Streams Surveys

A total of sixteen freshwater sites representing notably different catchment development types, were sampled monthly for a range of water quality parameters.

The sites sampled are shown on a map of the region in Fig. 2.1 and are listed in Table 2.1 in alphabetical order, along with 1:50000 scale map references and complete monitoring periods.

Table 2.1:

LTB freshwater sampling sites, map references and monitoring periods.

Stream (code)	Map reference (NZMS 260)	Sampling period
Cascades Stream (N9)	Q11: 461 781	26/06/86 - 01/12/03
Hoteo River (N5)	Q09: 456 343	24/06/86 - 01/12/03
Kumeu River (N8)	Q10: 497 905	26/06/86 - 01/12/03
Lucas Creek (N2)	R10: 618 962	03/08/93 - 01/12/03
Mahurangi River (N3)	R09: 583 296	24/06/86 - 01/12/03
Matakana River (N4)	R09: 636 387	06/12/86 - 01/12/03
Ngakoroa Stream (S5)	R12: 856 432	25/06/86 - 03/12/03
Oakley Stream (S1)	R11: 624 796	08/08/94 - 03/12/03
Opanuku Stream (S2)	R11: 526 773	26/06/86 - 03/12/03
Otara Stream (S3)	R11: 787 700	17/10/85 - 03/12/03
Oteha Stream (N1)	R10: 618 953	24/06/86 - 01/12/03
Papakura Stream (S4)	R11: 817 620	25/06/86 - 03/12/03
Puhinui Stream (S7)	R11: 768 660	02/02/94 - 03/12/03
Rangitopuni River (N7)	R10: 548 940	24/06/86 - 01/12/03
Wairoa River (S6)	S11: 931 634	25/06/86 - 03/12/03
Waiwera River (N6)	R10: 593 154	24/06/86 - 01/12/03

For ease of sampling, the sites were split into two units based on logistical constraints, namely, northern and southern. The two sampling units were sampled on sequential days (whenever possible), with nine sites in the northern run and seven in the southern. Surface samples were taken at each site on the following days: 7 Jan; 4 Feb; 4 Mar; 1 Apr; 6 May; 4 Jun; 1 Jul; 7 Aug; 2 Sep; 30 Sep; 4 Nov and 1 Dec for the northern sites (N1-N9), and 8 Jan; 5 Feb; 5 Mar; 2 Apr; 7 May; 5 Jun; 2 Jul; 5 Aug; 5 Sep; 29 Sep; 5 Nov and 3 Dec for the southern sites (S1-S7).

Detailed descriptions of the sites that remained unchanged, including surrounding catchment uses and any known point sources influencing water quality, are given in technical publications TP28 (ARC 1993) and TP65 (ARC 1995), as updated using 1997 land uses classes (table 2.2) derived from satellite images (TERRAlink, 1997). Definitions for land use categories are given in Appendix 50.

Table 2.2:

Land use in catchments of the LTB freshwater monitoring programme. (Source Terralink, 1997)

Site	Class name	Area (Hectares)	% Catchment
Cascades Stream - Confluence	INDIGENOUS_FOREST	270	100.0
	Total	270	100.0
Hoteo River - Grubbs	INDIGENOUS_FOREST	4011	15.0
	MINES_DUMPS	10	0.0
	PLANTED_FOREST	4809	18.0
	PRIM_PASTORAL	16648	62.3
	SHRUB	1172	4.4
	URBAN	61	0.2
	Total	26711	100.0
Kumeu River – Weza Lane	INDIGENOUS_FOREST	303	6.6
	PLANTED_FOREST	204	4.5
	PRIM_HORTICULTURAL	222	4.8
	PRIM_PASTORAL	3588	78.3
	SHRUB	219	4.8
	URBAN	20	0.4
	URBAN_OPEN_SPACE	25	0.5
	Total	4582	100.0
Lucas Creek - Gills Rd	INDIGENOUS_FOREST	18	3.0
	PLANTED_FOREST	3	0.4
	PRIM_PASTORAL	378	60.5
	SHRUB	86	13.7
	URBAN	140	22.4
	Total	625	100.0
Mahurangi River - Forest HQ	INDIGENOUS_FOREST	10	2.1
	PLANTED_FOREST	456	96.2
	PRIM_PASTORAL	5	1.0
	SHRUB	3	0.7
	Total	474	100.0
Matakana River - Wenzlick	INDIGENOUS_FOREST	358	25.5
	PLANTED_FOREST	208	14.8
	PRIM_PASTORAL	641	45.6
	SHRUB	199	14.2
	Total	1406	100.0
Ngakaroa Stream - Mill Rd	INDIGENOUS_FOREST	2	0.5
	PLANTED_FOREST	4	0.8
	PRIM_PASTORAL	431	95.1
	SHRUB	16	3.6
	Total	454	100.0
Oakley Creek	INDIGENOUS_FOREST	27	2.3
	URBAN	992	82.6
	URBAN_OPEN_SPACE	182	15.2
	Total	1201	100.0

Site	Class name	Area (Hectares)	% Catchment
Opanuku Stream - Candia Rd	INDIGENOUS_FOREST	1230	74.7
	PRIM_PASTORAL	280	17.0
	SHRUB	137	8.3
	URBAN	1	0.1
	Total	1647	100.0
Otara Stream - East Tamaki	INDIGENOUS_FOREST	42	2.4
	PLANTED_FOREST	21	1.2
	PRIM_PASTORAL	1581	90.6
	SHRUB	19	1.1
	URBAN	78	4.5
	URBAN_OPEN_SPACE	4	0.3
	Total	1746	100.0
Oteha Stream - Days Bridge	INDIGENOUS_FOREST	64	5.7
	PRIM_PASTORAL	66	5.8
	SHRUB	16	1.4
	URBAN	627	55.5
	URBAN_OPEN_SPACE	356	31.6
	Total	1128	100.0
Papakura Stream - Porchester Rd	INDIGENOUS_FOREST	291	6.2
	PLANTED_FOREST	119	2.5
	PRIM_HORTICULTURAL	41	0.9
	PRIM_PASTORAL	4004	85.5
	SHRUB	90	1.9
	URBAN	34	0.7
	URBAN_OPEN_SPACE	105	2.2
	Total	4685	100.0
Puhinui Stream - Ford	INDIGENOUS_FOREST	71	6.0
	PRIM_PASTORAL	625	52.3
	SHRUB	14	1.1
	URBAN	476	39.8
	URBAN_OPEN_SPACE	9	0.7
	Total	1195	100.0
Rangitopuni River - Mill Flat Rd	BARE_GROUND	22	0.3
	INDIGENOUS_FOREST	614	7.3
	MINES_DUMPS	52	0.6
	PLANTED_FOREST	1191	14.2
	PRIM_HORTICULTURAL	267	3.2
	PRIM_PASTORAL	5878	70.3
	SHRUB	306	3.7
	URBAN	10	0.1
	URBAN_OPEN_SPACE	24	0.3
	Total	8363	100.0
Wairoa River - Tourist Rd	INDIGENOUS_FOREST	2898	19.6
	PLANTED_FOREST	2393	16.1
	PRIM_PASTORAL	8481	57.2
	SHRUB	1048	7.1
	Total	14820	100.0

Site	Class name	Area (Hectares)	% Catchment
Waiwera River - Valley Springs	INDIGENOUS_FOREST	482	16.2
	PLANTED_FOREST	4	0.1
	PRIM_PASTORAL	1591	53.6
	SHRUB	893	30.1
	Total	2970	100.0

2.3 Saline Surveys

The sites referred to in this report (Fig. 2.1) are the same as those detailed in TP 132, with the exception of the following sites for which sampling has been discontinued: Kawau Bay, Mahurangi, Papakura Channel and Hobsonville. The water quality of these sites for the period July 1987 - December 2000 has been reviewed previously (Wilcock & Kemp 2001). The sites in sampling order are as follows:

Manukau Harbour

1) Weymouth

2) Waiuku River

3) Waiuku Channel

4) Puketutu Point

5) Mangere Bridge

6) Shag Point

East Coast and Waitemata Harbour

1) Goat Island

2) Ti Point

3) Orewa

4) Browns Bay

5) Chelsea

6) Henderson Creek

7) Whau Creek

Kaipara Harbour

1) Shelly Beach

Sites have been selected to best represent or integrate the influences of specific land uses on water quality.

Due to logistical constraints, the saline LTB samples were collected on two separate days depending on the appropriate combination of tidal regime and time of day. The Manukau and Kaipara Harbours are collected concurrently, while the middle Waitemata Harbour and Hauraki Gulf are collectively sampled as a separate sampling run.

Surface and depth measurements of salinity were taken at each site to ensure that waters were fully mixed. A difference in salinity between top and bottom of greater than 2 parts per thousand was used as an indication of incomplete mixing. If incomplete mixing was detected samples were taken at the top and bottom of the water column for analysis and comparison.

The survey protocols adopted allow samples to be collected approximately 1–2.5 hours after high tide for the Kaipara Harbour, middle Waitemata Harbour and Hauraki Gulf sites and 2.5–4 hours for the Manukau Harbour.

Surveys were conducted at monthly intervals (with a few exceptions) over the periods
04 shown in Table 2.3, which also lists alternate names that have been used for some sites, and map coordinates (eastings and northings) are also given.

Table 2.3:

LTB saline monthly monitoring sites (codes), map references and monitoring periods.

Site (code)	Easting	Northing	Monitoring period
Mangere Bridge (SM05)	2668634	6472374	07/10/87 –02/12/03
Puketutu Point (SM04)	2664289	6470427	07/10/87 – 02/12/03
Shag Point (Titirangi) (SM06)	2658790	6470166	07/10/87 – 02/12/03
Waiuku Channel (Grahams Beach) (SM03)	2659019	6459062	07/10/87 – 02/12/03
Papakura Channel*			07/10/87 – 10/06/99
Weymouth (SM01)	2675181	6459101	07/10/87 – 02/12/03
Waiuku River (Clarks Beach) (SM02)	2660023	6449792	07/10/87 – 02/12/03
Goat Island (SE01)	2670914	6546509	20/08/93 – 08/12/03
Ti Point (SE02)	2670783	6540222	19/03/91 – 08/12/03
Kawau Bay (Algies Beach)*	2667746	6529941	19/03/91 – 17/06/99
Mahurangi*	2665035	6521486	19/03/91 – 17/06/99
Orewa (SE05)	2663769	6511321	19/03/91 – 08/12/03
Browns Bay (SE06)	2668401	6497168	19/03/91 – 08/12/03
Chelsea (SE07)	2664122	6484305	19/03/91 – 08/12/03
Hobsonville*	2659770	6489031	19/03/91 – 17/06/99
Henderson Creek (SE09)	2657153	6485367	19/03/91 – 08/12/03
Whau Creek (SE10)	2658723	6482007	19/03/91 – 08/12/03
Shelly Beach (Kaipara Harbour) (KA1)	2634008	6513666	6/11/91 – 02/12/03

* Discontinued sites

2.4 Lake Surveys

Seven freshwater lakes from throughout the region were sampled quarterly for a range of parameters.

The general locations of the lakes sampled are shown in Fig. 2.1. Descriptions of all the lakes, except Pupuke, and maps showing greater detail of lake size, shape and surrounding land use, have been presented in TP 89 (ARWB 1990). Information on Lake Pupuke has been presented in a number of ARC reports, the most recent being TP 93 (ARWB 1993). Locations of the lake sites and total monitoring periods used for time-series plots are listed in Table 2.4. A description of land use in each catchment is given in Table 2.5 (see Appendix 50 for definition of terms used in Table 2.5).

Table 2.4:

LTB lake monitoring sites, map references and monitoring periods.

Site	Easting	Northing	Monitoring period
Tomarata	2658864	6555154	19/11/92 – 18/11/03
Spectacle	2657607	6555922	19/11/92 – 18/11/03
Ototoa	2621480	6520125	19/11/92 – 18/11/03
Kuwakatai	2621896	6518636	19/11/92 – 18/11/03
Kereta	2624825	6511571	19/11/92 – 18/11/03
Wainamu	2641049	6478309	19/11/92 – 20/11/03
Pupuke	2668158	6489781	19/11/92 – 17/03/03

The lakes were sampled in the order given below:

1) Wainamu
2) Kereta
3) Kuwakatai
4) Ototoa
5) Spectacle
6) Tomarata
7) Pupuke

Previous findings have established that lake water quality can be adequately represented by depth profiles from a station located where the lake is deepest. In general, each profile comprised a surface sample and others taken at depth intervals of 5 or 10 m, with the exception of Lake Pupuke, for which samples were collected at 5, 25 and 50 m (ARC 1995, Gibbs et al. 1999).

Data reviewed in this report cover the four surveys made in March, May, September and November of 2003. There are noteworthy gaps in the 2003 data record:

- Surface and bottom samples were collected at most sites.
- Lake Wainamu was sampled on only three occasions (the September sampling round was missed).

- Lake Pupuke was sampled over its full depth on one occasion only, 17 March.

Table 2.5:

Landuse in catchments of the LTB lakes monitoring programme. Site codes and map coordinates (eastings and northings) are also given. Data source Terralink, 1997.

Site	Class name	Area (hectares)	%Catchment
Lake Kereta	INDIGENOUS_FOREST	107	15.2
	PLANTED_FOREST	113	16.1
	PRIM_PASTORAL	451	64.0
	SHRUB	33	4.7
	CATCHMENT TOTAL	704	100.0
	INLAND_WATER	26	
Lake Kuwakatai	INDIGENOUS_FOREST	21	4.9
	PRIM_PASTORAL	363	85.8
	SHRUB	39	9.3
	CATCHMENT TOTAL	423	100.0
	INLAND_WATER	33	
Lake Ototoa	INDIGENOUS_FOREST	158	36.2
	PLANTED_FOREST	95	21.7
	PRIM_PASTORAL	179	40.9
	SHRUB	5	1.2
	CATCHMENT TOTAL	437	100.0
	INLAND_WATER	125	
Lake Pupuke	URBAN	88	82.1
	URBAN_OPEN_SPACE	19	17.9
	CATCHMENT TOTAL	107	100.0
	INLAND_WATER	114	
Lake Spectacle	BARE_GROUND	3	0.4
	INDIGENOUS_FOREST	61	8.3
	PLANTED_FOREST	241	32.6
	PRIM_PASTORAL	430	58.3
	SHRUB	3	0.4
	CATCHMENT TOTAL	738	100.0
	INLAND_WATER	57	
Lake Tomarata	INDIGENOUS_FOREST	10	8.3
	PLANTED_FOREST	64	54.3
	PRIM_PASTORAL	44	37.3
	CATCHMENT TOTAL	117	100.0
	INLAND_WATER	16	
	INLAND_WETLANDS	17	
Lake Wainamu	INDIGENOUS_FOREST	413	84.7
	PRIM_PASTORAL	17	3.4
	SHRUB	58	11.9
	CATCHMENT TOTAL	488	100.0
	INLAND_WATER	17	

Site	Class name	Area (hectares)	%Catchment
	INLAND_WETLANDS	2	

Dissolved oxygen/temperature profiles were taken at 1 m intervals throughout the whole water column of all lakes except Lake Kereta.

The water quality of the lakes covering the period from spring 1992 to autumn 1998 has been reviewed recently (Gibbs et al. 1999) and is updated here by including all data up to November 2003.

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3 Methods and data quality assurance

The sampling protocols for the LTB surveys have changed little from those reported in various earlier ARC technical publications.

A standard list of physico-chemical parameters was monitored at each site on each sampling occasion. A core group of parameters was monitored irrespective of the resource under scrutiny, with key indicator parameters added as necessary.

A full list of the parameters included, what they measure, and likely sources and impacts on the environment, are summarised in Appendix 42 of TP132. It should be noted that because very low concentrations at or near the analytical detection limit were consistently found, nitrite-N (NO_2-N) was discontinued from the routine suite of LTB water quality variables starting from January 2002.

All samples collected in the surveys were analysed by the Watercare Services Ltd Laboratory at Mangere. Analytical methods utilised in these surveys are described in "Chemical Methods Manual" and "Microbiological and Biological Methods Manual" compiled by Laboratory Services, Watercare Services Ltd. These methods generally follow the "Standard Methods for the Examination of Water and Wastewater 20th Edition" (APHA 1998).

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4 Statistical analysis and data presentation

4.1 Freshwater and Saline sites

Water quality results are highly variable because of the wide variety of external factors influencing them. Because most of the parameters are non-normally distributed, the median has been used in this report as the measure of central tendency (typical value). The median is the middle value (or the mean of two middle values) when data are arranged in increasing or decreasing order of magnitude. Because it is based on rank rather than value, the median is not as easily affected by extreme values as is the mean. All outliers were included in calculation of summary statistics unless they were obvious typographical errors.

Variability in the data has been expressed as the interquartile range divided by the median (IQR/M). This value is the non-parametric equivalent of the coefficient of variance.

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Tables are listed in the Appendices giving monthly data for each variable at all sites, and are summarised by median and IQR/M (%) values for the year Jan-Dec 2003. In previous years, where datasets included an entry as being less than a detection limit, the result cited in the relevant table was equal to half the detection limit (e.g., < 2 mg/L for BOD would have been cited as 1.0 mg/L). At ARC request, we have this year included the raw result in all tables. This offers the advantage that a result falling below a method detection limit is clearly identifiable, although the accompanying summary statistics still make use of the convention that "less than" entries assume values equal to half the detection limit. The appropriateness of this convention may be further explored at the time of the next five-yearly data review.

Time-series plots for the entire monitoring records of each site, for which data with adequate quality assurance have been recorded, follow the tables of data in Appendices 1-40.

2.5 Lakes

Quarterly sampling data for all variables are tabulated for each lake, along with mean and median values for the period March – Nov 2003, in Appendices 41-47.

The depth profiles of dissolved oxygen and temperature for the current year are shown in Appendix 48, while time-series plots for the seven lakes and for the entire monitoring period (Nov 1992 – Nov 2003) are shown in Appendix 49.

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5 Results and Discussion

5.1 Freshwater sites

For each sampling run (northern or southern) the same sequence and approximate timing of sampling was followed. In this way the temporal variability inherent in some parameters, such as dissolved oxygen, temperature and pH, was minimised for a particular site. To minimise the effects of variable weather, the sampling runs for the nine northern and seven southern sites were made on sequential days.

5.1.1 Water clarity and suspended solids

Although not demonstrated by the SS record, there is a general lowering of black disk transparency with respect to site medians for both the previous year and the longer-term record. This is supported by a corresponding increase in turbidity at many of the study sites. The generality of movement invites an explanation in terms of weather conditions at the time of sampling.

5.1.2 Temperature and pH

The cooler water temperatures noted in 2002 are in large measure reversed in the record for 2003. The maximum temperature observed was 21.3°C (Hoteo, 4 February). pH values ranged from 6.8 (Puhinui, 4 February) to 9.2 (Lucas, 4 February). The pH of freshwaters can fluctuate considerably over a 24 hour period due to processes that are entirely natural. Nonetheless, the value 9.2 is unusually high in a natural water system and is indicative of significant algal photosynthesis, an explanation not supported by the dissolved oxygen record for the site on that day.

5.1.3 DO and BOD

Dissolved oxygen (%saturation) values for each site were comparable to or higher than the respective long-term medians. Otara Stream again had the lowest recorded value (32.6% on 4 February).

The BOD record for 2003 is very similar to that obtained in earlier years, with the great majority of results being recorded as less than the method detection limit of 2 mg/L. In such a situation, the convention of assigning a value equal to half the detection limit can be questioned. Only 9 of 192 results were greater than 2 mg/L, with 3 results greater than 4 mg/L. The maximum value observed was 4.3 mg/L, being for the Kumeu site on 3 September.

5.1.4 Faecal bacteria

Median counts of both presumptive and confirmed faecal coliforms for 2003 were comparable to those observed in previous years. Despite this, there was a greater incidence of high faecal counts, with faecal coliforms in excess of 10,000 MPN/100 mL recorded on fifteen occasions, compared to only five occasions in 2002. The Papakura site had the worst bacteriological quality, with a median value of 4000 MPN/100 mL, a maximum value of at least 160,000 MPN/100 mL and with counts exceeding 10,000 MPN/100 mL on five of the 12 sampling occasions.

5.1.5 Nutrients

Ammonia toxicity generally increases with pH, due to the increasing presence of the more-toxic non-ionised component, NH_3. ANZECC & ARMCANZ (2000) accommodate this by offering ecosystem guidelines for the protection of 95% of freshwater species over the pH range 6.0 – 9.0. We have chosen to compare the 2003 dataset for total ammonia with the most severe of these guidelines, the value 0.18 mg/L appropriate to a pH of 9.0. No result in the 2003 dataset exceeds this value and– more realistically – where the value 0.18 mg/L is approached, the accompanying pH value is such that the [NH_4-N] is close to an order of magnitude below the appropriate water quality guideline. For the single result (pH 9.2, at Lucas Creek on 4 February) outside the range addressed by the ANZECC guidelines, we calculate an approximate guideline of 0.138 mg/L NH_4-N, comfortably above the result 0.09 mg/L obtained for that sample.

Median nitrate levels are similar to those observed in the previous two years and to the long-term medians (1992-2000). Low values are observed in the native bush site (Cascades), with elevated levels (up to 4 mg/L) in the market garden stream (Ngakoroa). The orthodox winter maxima are observed in the streams draining pasture.

For total phosphorus, both median values and variability are slightly higher than observed in 2002. For dissolved reactive phosphorus, the 2003 results are in satisfactory agreement with those obtained in previous years.

5.1.6 Chloride and conductivity

Results for both variables generally confirm the historical data record. Where uncharacteristically low values of chloride were obtained -— for example Oakley, 7 January and Oteha 7 January and 1 April – the observations are supported by the electrical conductance record, suggesting that the results are correct and that samples may have been collected during a rainfall event.

5.1.7 Metals

For soluble copper only 2 of 48 results exceed the method detection limit of 0.005 mg/L. Total copper results marginally exceed this limit but the median value for all sites is only 0.006 mg/L. The maximum values observed were for the Lucas Creek site, with values 0.013, 0.019, 0.021 mg/L recorded.

For soluble and total lead, the results are below the method detection limit of 0.02 mg/L for all four sites on all sampling occasions. Some improvement in method sensitivity is advisable.

Soluble Zn concentrations for the Oakley, Oteha and Puhinui sites occasionally exceeded 31 μg/L which is the trigger value for the protection of 80% of freshwater species (ANZECC & ARMCANZ 2000).

5.2 Saline Sites

5.2.1 Water clarity and suspended solids

Median values for suspended solids, turbidity and Secchi disk depth measurements in 2003 continue to be consistent with the historical record (Wilcock & Stroud, 2000).

5.2.2 Temperature and pH

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The temperature and pH records are unremarkable and generally similar to those obtained for previous years.

5.2.3 DO and BOD

Waters at all sites remain well oxygenated, with dissolved oxygen concentrations marginally lower than 80% saturation being observed on only nine occasions. However, an anomalously low result of 59% saturation is recorded for the Shelly Beach site on 8 August 2003.

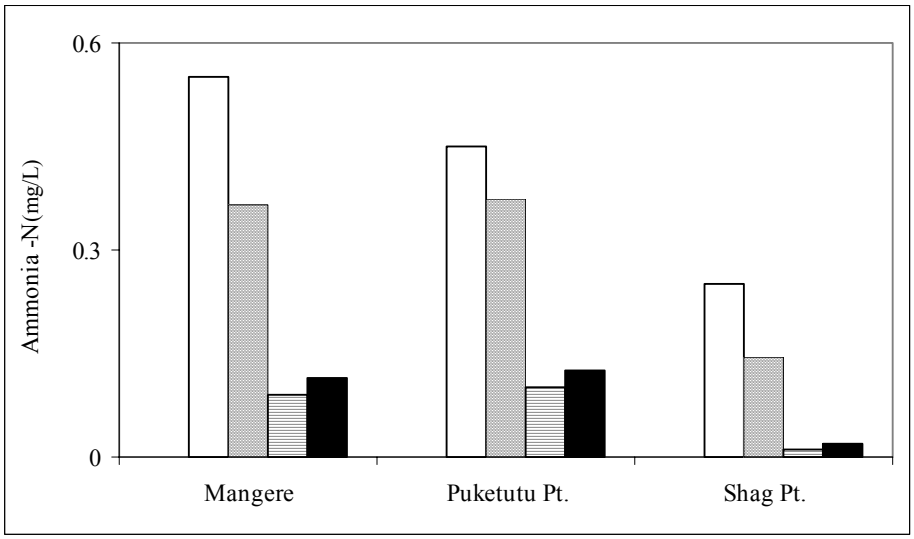
BOD results are consistently less than the method detection of 2.0 mg/L. The only values higher than 2 mg/L were recorded for the Shelly Beach site, and even there the maximum value observed was 2.3 mg/L. As with the freshwater site records, the summary statistics give an annual median value of 1.0 mg/L for all sites.

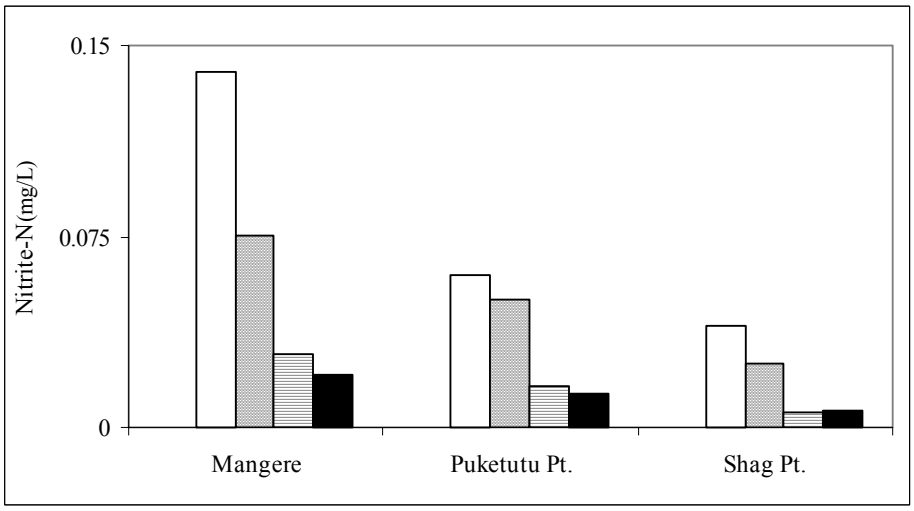
5.2.4 Nutrients and chlorophyll *a*

Improvements in microbial and chemical water quality were evident at the closest monitoring sites immediately following upgrading of the Mangere Wastewater Treatment Plant in 2000. This was illustrated (Wilcock & Martin, 2003) by reference to annual median concentrations of the sewage tracers ammonia–nitrogen and nitrite-nitrogen. By extending these time-series, we can see (Fig. 5.1) that the system had re-established a steady state by the year 2003. For the other sites, the 2003 results for ammonia- and nitrite-nitrogen are consistent with the long-term record.

Chlorophyll *a* medians for all sites were comparable to those observed for the 2002 year.

Figure 5.1:
Ammonia and nitrite nitrogen median concentrations for Mangere Bridge, Puketutu Point and Shag Point (Titirangi), for the following periods: 1992-2000 (white), 2001 (cross-hatched,) 2002 (striped) and 2003 (black).





5.2.5 Faecal bacteria

For those sites traditionally having the highest presumptive and confirmed faecal coliform counts (Henderson, Mangere, Puketutu, Weymouth), both median and maximum values were higher than those observed in 2002. Although this suggests that the summary statistic is not a consequence of isolated high values, the shift is not significant, given the demonstrated high variability within these datasets.

The seasonal elevation of microbial counts observed for the Henderson site in earlier years is clearly evident in the 2003 record for all three indicators; presumptive and confirmed faecal coliforms, enterococci. For June and July the faecal counts were

2200, 3000 MPN/100mL respectively, while the equivalent enterococci counts were 1060, 780 cfu/100mL. These values are an order of magnitude higher than the maximum values recorded for any other site.

For the majority of sites, median values for 2003 are essentially unchanged from earlier years.

5.2.6 Chloride and salinity

Appendix 28 presents the results of laboratory measurements of salinity. Although the results do not agree well with either calculated or field-measured salinity and there are some high values which are unlikely to be correct, the coverage is complete and, overall, is no less reliable than the calculated or field-measured results.

Salinity is a rudimentary variable and it should be possible to make accurate measurements with relative ease. It may be prudent to have both the laboratory and field operated salinity meters calibrated or serviced.

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Significant variability in salinity can be expected in coastal waters due to tidal state and rainfall influences on the freshwater inputs. Despite this, the chloride and salinity records for the 2003 year are very similar to those obtained in previous years.

5.3 Lake Sites

5.3.1 Lake Kerata

Water quality variables were generally similar in magnitude to those observed in previous years**.** Field notes record the presence of ducks, geese, swans and koi carp in large numbers on all sampling occasions.

There are no temperature or DO records for the 2003 year.

5.3.2 Lake Kuwakatai

Turbidity, chlorophyll and total nutrient levels are elevated, as might be expected for this productive lake, which is influenced by agricultural activity.

Water quality is generally similar to that observed in previous years. The depth profile for 11 September showed the lake to be well mixed and dissolved oxygen saturation was at least 80% down to 7 m. However, by 20 November thermal stratification was establishing and dissolved oxygen levels decreased rapidly below a depth of 3 m to nearly zero at 7 m.

5.3.3 Lake Ototoa

Lake Ototoa water quality was similar to that observed in previous years, with no distinction to be drawn between surface and bottom (20 m) waters.

On 11 September the water column was well-mixed and fully oxygenated down to 20 m. By 18 November, a sharp thermocline had established at 12 m depth and dissolved oxygen levels reduced to around 20% saturation in the bottom water.

5.3.4 Lake Pupuke

Depth profile data are provided for dates 7 October and 14 November 2003, although additional information is generated within other ARC monitoring programmes. On both these dates the depth profile demonstrates thermal stratification at depths at or less than 20 m, with the thermocline more pronounced in October. The elevated concentration of ammonia- nitrogen observed in bottom waters (50 m) on 17 March is consistent with the low dissolved oxygen levels recorded.

5.3.5 Lake Spectacle

Spectacle is a shallow lake (maximum depth around 5 m throughout 2003) and no distinction could be drawn between surface and bottom waters. This conclusion is consistent with the depth profile data for 11 September and 18 November which show the water column to be fully mixed with oxygen levels of 80-90% saturation.

Some results for the 11 September sampling round are worthy of note The chloride result of 19.9 mg/L is half the value normally observed and this value is not supported by a change in the related but less specific measurement of electrical conductance. Further, the elevated and unusual concentrations of NH_4-N, NNN (nitrate- plus nitrite-nitrogen) and coliforms raise the prospect of an accidental discharge to surface water.

5.3.6 Lake Tomarata

The elevated levels of NH_4-N and NNN observed in 2002 were not evident in 2003. The 11 September and 18 November depth profiles show the water column to be fully mixed, with uniform temperature and high dissolved oxygen levels throughout the 6 m water column.

5.3.7 Lake Wainamu

In 2003, surface and depth (7.5 m) samples were collected on three occasions only , weather conditions preventing the sampling round scheduled for September. Water quality was generally very similar to that observed in previous years and no distinction could be drawn between surface and bottom water.

The depth profile data for 6 March 2003 show significant reduction in dissolved oxygen concentrations at depths below 3 m. The 20 November profile showed this condition to be less marked, although re-establishing after winter water column turnover.

6.0 Conclusions

Water quality data collected from long-term monitoring of 16 freshwater sites, 14 saline sites and 7 lakes has been reviewed for the year Jan – Dec 2003. The data is of good quality and is generally very similar to data collected in recent years from these sites.

Indications are that the changes observed over the past three years at monitoring sites closest to the recently upgraded Mangere Wastewater Treatment Plant, represent a permanent improvement in water quality within the Manukau Harbour.

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