DOWNSTREAM EFFECTS of LAND USE in the FITZROY CATCHMENT

SUMMARY REPORT

December 1996

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DOWNSTREAM EFFECTS OF LAND USE IN THE FITZROY CATCHMENT

November 1993 - December 1996

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EXECUTIVE SUMMARY

The Fitzroy River catchment in central Queensland is one of the largest on the east coast of Australia with a catchment area above Rockhampton of about 140,000 km^2. Five major sub-basins contribute to this catchment. These consist of streams of the Connors/Isaac, Nogoa, Comet, Dawson and Mackenzie river systems. Rainfall is summer dominant and during the study period was generally well below average throughout the area. Some sections of the catchment experienced the driest seasons since records have been kept. Streamflows, correspondingly, were mostly below average. The northern sub-basins (Connors/Isaac) had very low flows, while some above average flows occurred in the southern sub-basins (Comet and Dawson). These low flows may mimic, in a crude way, reduced flows likely to result if major dams are constructed in some of the sub-basins. Land uses in the catchment during the period were not closely monitored, but because of the dry conditions, reduced dryland cropping activity and meagre ground cover in many grazing areas were common.

Feb 96 Jul 97

A multidisciplinary ecological approach has been used from November 1993 to December 1996 to assess the *state of health* of streams within the Fitzroy catchment. Eleven primary river monitoring sites, at which streamflows were monitored, were chosen to represent the major sub-basins. Of these, two were at relatively "upper catchment" locations. An additional four sites were selected on the Dawson River. Thirteen other secondary sites, including wetland areas, other stream locations, dams and on-farm dams were also studied. While some primary sites were sampled up to 25 times, because of resource limitations, most sites were sampled far less frequently.

A wide range of parameters was recorded to enable an assessment of water quality and stream health. These included :-

(a) Physical/chemical
- streamflows, temperature, electrical conductivity, dissolved oxygen, pH, Secchi depth, & suspended solids (suspended particulate matter) turbidity
- nutrients (nitrogen and phosphorus), pesticides (insecticides and herbicides) and some heavy metals

(b) Biological
- aquatic and semi-aquatic plants (macrophytes)
- algae (phytoplankton) and zooplankton
- aquatic invertebrates
- fisheries resources

Biological results, including diversity and abundance of invertebrates and native fish species, indicate a fairly healthy state for most sites. For the invertebrates, relatively high numbers of Trichoptera and Ephemeroptera were found at most of the primary sites and were well represented in terms of numbers of families found. Since these organisms are often associated with high water quality, the data sugests that the state of health of the river system is relatively good at these sites. Twenty-six species of fish, including only one exotic species, were recorded in this study. Species numbers (diversity) declined farther up the catchment in line with reduced habitat availability, and bony bream dominated gill net captures throughout the catchment. Because this is the most comprehensive fisheries project in the Fitzroy catchment to date, this base line data can be used to monitor future trends.

While these biological results are encouraging, concentrations of some other parameters are of concern.

Levels of suspended solids (SS) in river water samples, especially under flow conditions, were high. The median value for SS was 142 mg /L, with a range from 8 mg/L to 4,395 mg/L. Under flow conditions, four values greater than 3,000 mg/L (3 tonnes per megalitre) were recorded. These high levels are in general agreement with other data recorded independently for the March 1994 flow in the lower Fitzroy River and with data from another study of the central and north western rivers of New South Wales. While no specific guideline values are currently available for Australian conditions, levels of SS in the Fitzroy system, by overseas standards, are very high.

Similarly, nutrient (nitrogen and phosphorus) concentrations at all but upper catchment locations were high. Median concentrations for N and P greater than the suggested ANZECC, 1992 upper guidelines for streams (0.75 mg/L and 0.1 mg/L for N and P respectively) were recorded at most sites, especially under flow conditions. These nutrient levels are as high or higher than those reported in the ongoing study of the central and north western rivers of New South Wales.

Of the sub-basins, the Comet, Dawson and Fitzroy showed the highest concentrations of total nitrogen, with median values greater than 1mg/L. For the Dawson system, median N and P values were highest for the central part of the sub-basin, in the Theodore and Moura areas. A similar pattern was evident for total phosphorus levels, with the Comet having the highest median concentration of 0.44 mg/L, and the mid Dawson the highest levels within this sub-basin. Median values for total nitrogen to total phosphorus ratios for all river sites were less than 10.

High cyanobacterial (blue-green algal) cell densities appeared at various times throughout the catchment and not only at downstream sites on the Mackenzie and Fitzroy Rivers. Lower cell densities occurred in water samples containing a high level of suspended solids. Blue-green algal dominance and increased cell densities normally occurred in samples with lower levels of suspended solids. Cyanobacteria and phytoflagellates are adapted to obtaining light in such waters of reduced light penetration and the occurrence of these appeared to be related to the high concentrations of suspended solids in waters of the catchment. Other factors that would have selected for blue-green algal dominance were high concentrations of nutrients (especially orthophosphate), low levels of nitrate nitrogen on many occasions, lower flows in the latter half of the year in some instances and high pH.

Atrazine was by far the most commonly detected pesticide, being identified at least once at 9 of the 11 primary river sites and at all four of the additional Dawson River sites. The only exceptions were at the upper catchment sites at Baroondah on the Dawson River and at Craigmore on the Nogoa River. The median concentration of atrazine detected was 0.27 µg/L. While this value is below water quality guidelines, concentrations greater than 2 µg/L were detected in the Dawson, Mackenzie, Comet, Nogoa and Fitzroy sub-basins. Levels greater than 2µg/L, while not common, clearly exceed both the 1996 Draft NHMRC/ARMCANZ Australian Drinking Water Guidelines and the 1993 Canadian Water Quality Guidelines for the protection of freshwater aquatic life.

"Cotton" chemicals weren't detected upstream of irrigated cotton areas. They were detected, however, quite commonly downstream from the cotton areas at Emerald (Nogoa) and Theodore/Moura (Dawson) during the cotton (summer) seasons and especially under flow conditions. Endosulfan concentrations exceeded both the 1992 ANZECC Water Quality Guidelines for the protection of aquatic ecosystems and the 1996 Draft NHMRC/ARMCANZ Australian Drinking Water Guidelines on numerous occasions. These levels of chemicals may be responsible for reductions (compared with upstream sites) in the abundance and range of invertebrates recorded below the Emerald Irrigation Area in the current study. Further work is needed to establish clearly whether the presence of these chemicals in streams has a significant effect on the aquatic biota.

This "snapshot in time" of the Fitzroy catchment reveals a large and productive area of land, drained by an extensive but somewhat ephemeral network of streams. In times of higher flows, water moves into the lower Fitzroy River and past Rockhampton into the Pacific Ocean at the southern end of the Great Barrier Reef.

If we do not expect pristine conditions, the network of streams that makes up the Fitzroy catchment appears at present to be in reasonable condition, certainly by comparison with parts of the Murray-Darling. There are, however, a number of serious issues that confront the Fitzroy system now and for the future. These issues may have a "local" or catchment wide focus.

Riparian vegetation along the streams, in many places is in a poor state. This has been exacerbated by the recent drought conditions. Nutrient concentrations in the streams are high except at upper catchment locations. Part of this nutrient load arises from natural processes, but intensive industries and activities such as towns, feedlots, irrigated and dryland agriculture, if they are not managed carefully, have the potential to add greatly to the nutrient load in streams. Blue-green algae dominate the phytoplankton at many stream locations throughout the catchment. Careful management of nutrient loads, flows and other factors will be needed in the future if more widespread algal blooms are to be avoided, especially if present flows are to be reduced in some sub-basins by major dam construction. Pesticide residues can appear only as a result of human activity. Levels present in the streams need to be evaluated against current and future guidelines for environmental and drinking water requirements. Some stream problems in the system have an historical aspect. Pollution of the Dee River, by acid mine drainage downstream from Mt. Morgan, for example, has arisen from 100 years of mining activity and poses a considerable challenge for the future.

From a water quality and stream health perspective, potential wealth generated by proposed future development and land use activities needs to take account of the impact of these activities on the riverine environment. Decisions on land uses arising from future development need to take into account experiences in other parts of Australia and overseas. These activities need to be managed to minimize further impacts on water quality and the riverine environment. The **real** "profit" (benefit to cost ratio) to be gained from enterprises needs to be evaluated. The cost of attempts at rehabilitation of water quality and the riverine ecosystem is all too evident in the Murray-Darling experience. Enlightened decisions will be required if the ideal of economically and environmentally sustainable development is to be achieved for the Fitzroy system in the future.

1. INTRODUCTION.

The Fitzroy catchment, with an area of some 140,000 km² is one of the largest in eastern Australia. It straddles the Tropic of Capricorn and comprises almost 10% of the agriculturally productive land in Queensland. While seasonal variations and market forces will effect land use patterns, dominant land uses and their approximate percentages of the catchment include grazing (~ 90%) and cropping (~ 6%), (Lobegeiger, 1988). While grazing is the dominant land use, coal mining makes the largest contribution (~ 66%) to the value of primary commodity production using about 1% of the catchment area (Noble *et al.,* 1996). The Fitzroy system discharges into the marine environment near Rockhampton at the southern end of the Great Barrier Reef. Within the catchment, the numerous smaller towns and rural communities are directly dependent on surface water and groundwater resources. The streams of this sub-tropical, semi-arid region are somewhat ephemeral with summer rainfall dominant. Runoff events from rainfall are sometimes infrequent but are often substantial when they occur carrying large quantities of suspended material (Kelly and Wong, 1996). Several large sub-catchments, including the Connors, Isaac, Nogoa, Mackenzie, Comet and Dawson contribute to flows in the Fitzroy River which has a mean annual discharge of about 5×10^6 ML (N. Kelly, pers comm.).

Resource uses within the Fitzroy catchment, the physical environment, flora and fauna have been recently discussed (Duivenvoorden *et al.*, 1992). Historically, water quality studies in the catchment have been site specific or concerned mainly with physico-chemical parameters and major ions (Chudek, 1995). More recently, sporadic toxic algal blooms have occurred in some upper catchment impoundments and as far downstream as Rockhampton. As well, traces of insecticides and herbicides have been detected in surface waters and herbicides in groundwaters within the region. A number of water quality initiatives, including the present project and an expansion of the Ambient Water Quality Monitoring Network have resulted.

Community involvement in these initiatives is increasing steadily through the National Landcare Program and through catchment groups such as the Fitzroy Catchment Coordinating Group Inc. which has recently released a draft Natural Resource Management Strategy for the region.

The aim of the current project (1993-1996) was to determine the "state of health" of the Fitzroy system using a multidisciplinary, ecological, whole of catchment approach. This report summarises data on "stream health" from a project with limited resources applied to a large catchment. It is hoped that the information will contribute in some small way to a successful future for the Fitzroy system.

The present is an exciting and challenging time for the Fitzroy catchment. Within the Fitzroy Water Infrastructure Strategy of the Queensland Government, proposals for dams on the Comet, Dawson and Mackenzie Rivers are under consideration. Decisions will be made on dam construction and water allocations including those for "environmental flows". The catchment has been recently identified as one of the "focus catchments" in the National Eutrophication Management Program. Collaborative research activities between State and Federal agencies are being negotiated.

Comprehensive water quality data for the catchment are limited and the spatial and temporal dynamics of flows, suspended solids, nutrients and algal growth are poorly understood. Some problems with blue-green algal blooms and other "stream health" issues are evident.

Can the decision process learn from problems in the Murray-Darling system and achieve sustainable development of the Fitzroy catchment water resources?

1.1 Sampling Strategies.

Detailed sampling methodologies for chemical and biological parameters are included in individual sections. Overall sampling strategies and the reasons for them are outlined here. Major constraints included:-

- the project term (3 years) is a very short time even in the modern history of a catchment. Data then provide only a "snapshot in time" for the designated period
- the catchment is large, consisting of several sub-basins - the Connors, Isaac, Nogoa, Mackenzie, Comet and Dawson
- flows are infrequent but often significant when they occur requiring considerable time for the streams to return to background (base flow) conditions. Rainfall is summer dominant.

If even crude estimates of suspended solid, nutrient and pesticide loads were to be made, then reliable flow data were required.

Eleven primary river sites were chosen (Table 1.1 and Fig. 1.1, Nos. 1 to 11) to represent the major sub-basins. Two of these (Nos. 8 and 11) are at relatively upper catchment locations. Truly pristine river sites other than near stream sources are not available. Flow data for the primary sites are available from established gauging stations in the Ambient Water Quality Monitoring Network which has the responsibility for monitoring longer term trends.

The primary sites were sampled for physico-chemical, chemical and biological parameters on three occasions (May 1994, October 1994 and May/June 1995 - data summarised in this report) and for most indicators also in May-June 1996. The October sampling represented a "before flow" situation and the May-June samplings "after flow" conditions.

Four additional sites (Dawson sites, Table 1.1 and Fig. 1.1, Nos. 12 to 15) were selected along the Dawson River for more frequent sampling of physico-chemical and chemical parameters. The Dawson is a large sub-catchment and has land uses typical of the whole Fitzroy catchment - grazing, irrigated and dryland cropping, coal mining, forestry, national parks and rural urban communities along the stream.

In response to flows and seasonal agricultural factors, further samplings of other river sites were made in all sub-basins during the project.

The water chemistry and biology (including fisheries resources) of a number of secondary sites were also studied, some on a single occasion only (Table 1.1, Figs. 1.1 and 1.2, Site Nos. 16 to 28). These locations included wetlands, river sites and on-farm dams with varying degrees of recognisable land use impacts.

With the cooperation of cotton growers at Emerald, the offsite movement of suspended solids and nutrient from an irrigated cotton farm and the chemistry and biology of an on-farm tailwater storage dam were studied.

Water samples were collected manually for several reasons:-

- high cost of auto samplers for a large number of sites and difficulty locating samplers where stream heights vary greatly.
- need to maintain sample integrity - preservation and/or refrigeration and rapid transit to laboratories.
- need for flexibility in responding to rainfall and flows over a large catchment.

Unfortunately, access to some locations by ground vehicles under moderate to high flow conditions was impossible.

Table 1.1. Site Index for Figure 1.1 (Catchment Map).

Site 1	*Mid Fitzroy*	Eden Bann Weir
Site 2	*Lower Connors*	Twin Bridges
Site 3	*Lower Isaac*	Yatton
Site 4	*Mid Mackenzie*	Below Bingegang Weir
Site 5	*Lower Mackenzie*	Coolmaringa
Site 6	*Lower Don*	Rannes
Site 7	*Lower Dawson*	Beckers
Site 8	*Upper Dawson*	Baroondah
Site 9	*Lower Comet*	17.2 km bend
Site 10	*Lower Nogoa*	Duckponds
Site 11	*Mid Nogoa*	Craigmore
Site 12	*Delusion Creek Junction*	Above Mid Dawson
Site 13	*Theodore Weir*	Mid Dawson
Site 14	*Moura Weir*	Mid Dawson
Site 15	*Capricorn Highway Crossing*	Lower Dawson
Site 16	*Riverslea*	Upper Fitzroy
Site 17	*Upper Wetland*	Taroom Lagoon
Site 18	*Lower Wetland*	Lake Mary
Site 19	*Grazing Farm Dam*	Property near Springsure
Site 20	*Agricultural Farm Dam*	Emerald Irrigation Area (EIA)
Site 21	*Theresa Dam*	Theresa Ck - Clermont
Site 22	*Callide Dam*	Callide Ck - Biloela
Site 23	*Industrial*	Crinum Ck near Lillyvale
Site 24	*Semi Urban*	Moores Ck - Rockhampton
Site 25	*Upper Nogoa*	Raymond
Site 26	*Below Fairbairn Dam I*	Nogoa R - above Emerald
Site 27	*Below Fairbairn Dam II*	Nogoa R - above Emerald
Site 28	*Lower Nogoa II*	Between EIA and Duckponds

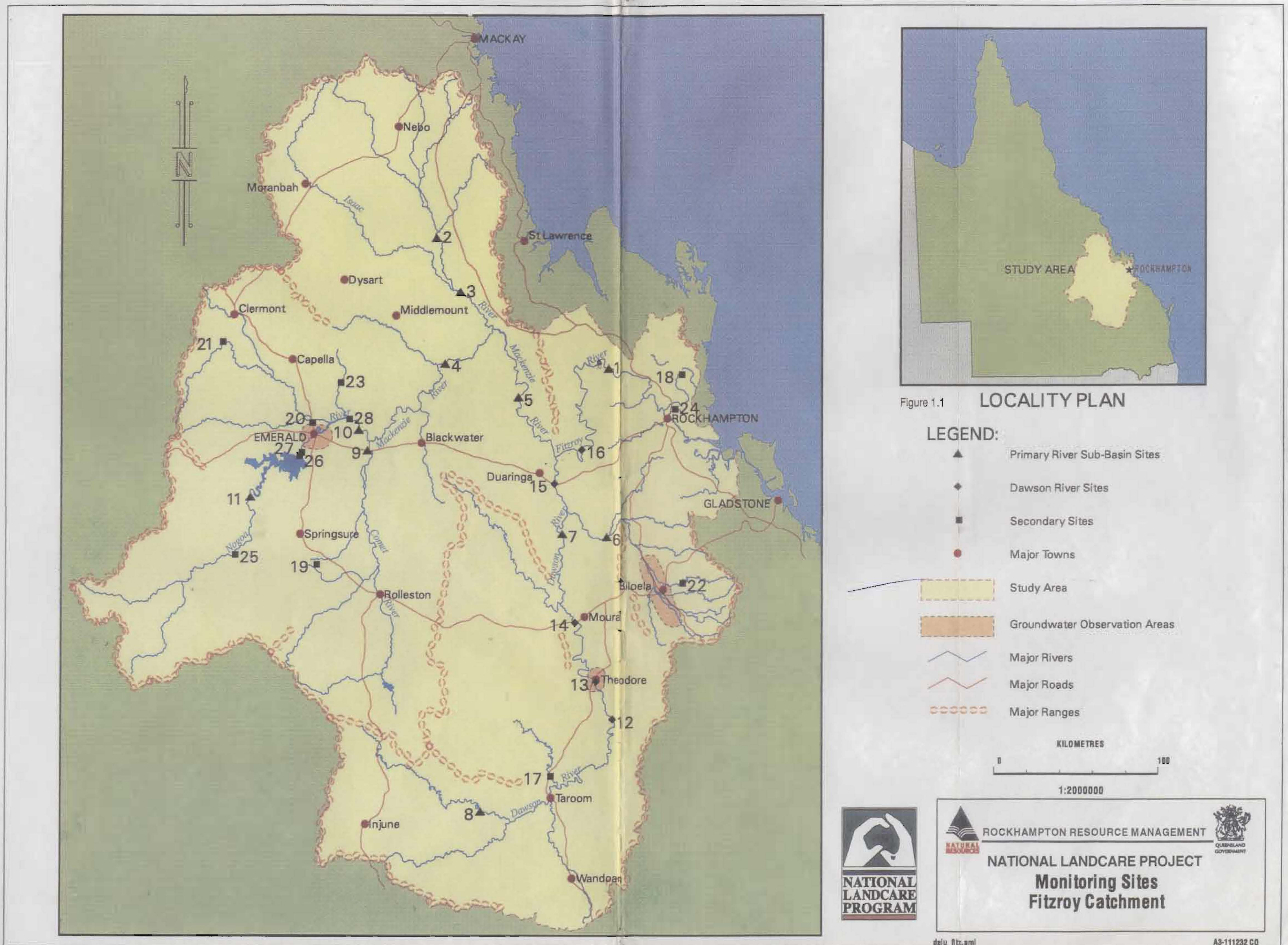
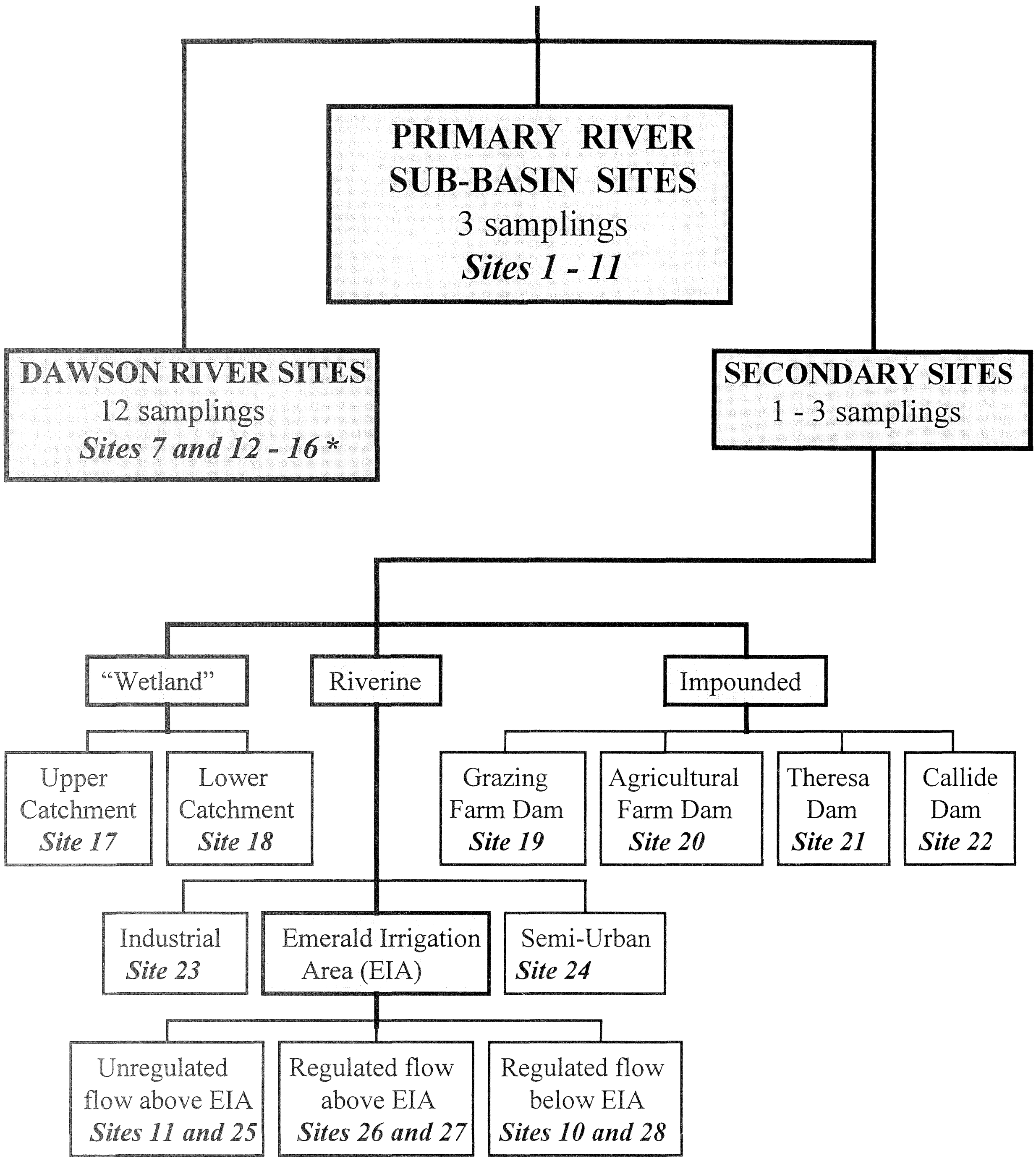


Figure 1.1 LOCALITY PLAN

Figure 1.2. Sampling Activities for DELU Project 1993 - 1996.



* Includes the Upper Fitzroy site at Riverslea (Site No. 16), sampled for physico-chemical and chemical parameters only.

Note: See Fig. 1.1 and Appendix B for further details regarding site locations.

2. RAINFALL AND STREAMFLOW.

N. Kelly. Queensland Department of Natural Resources, Rockhampton, Qld, 4702.

2.1 Introduction.

Central Queensland has a harsh environment. Rainfall is generally low and variable in nature. Permanent streams are few and extended dry periods are commonly followed by major floods. Stream flows are therefore variable in quantity and quality and unpredictable in occurrence. Temperatures although not as variable as rainfall, are extreme and range from hot summers (35 to 40 degrees Celsius), to frosts in winter. Mean monthly evaporation is higher than the mean monthly rainfall in each month, indicating that moisture is quickly lost. Spring and early summer are when the greatest deficit between rainfall and evaporation occurs. Annual pan evaporation is around 2,100 mm. Climate in the central region, because of its variability, is better described by ranges, extremes and frequency distributions than by averages and totals.

2.2 Major influences of climate in the Fitzroy Basin.

Nearly half of the Fitzroy basin lies to the north of the Tropic of Capricorn. It is located on the edge of a very dry continent and adjacent to the warm Pacific Ocean. The basin lies between two major pressure systems, south of the monsoon trough's January position and north of the sub tropical ridge in July.

In summer, south east to north east winds blow across the warm Coral Sea bringing moist air into the catchment. By winter the monsoon trough and the sub-tropical ridge have moved northward. Lighter south west to south east winds bring much drier air into the catchment.

Short term variations to seasonal conditions can result from the positions of the low pressure cells in the monsoon trough or the high pressure cells in the sub-tropical ridge. Superimposed on these low level systems are successions of developing and decaying upper troughs and ridges which can destabilise the airmass and increase the likelihood of rain. Tropical cyclones or a strong northwest monsoon may bring heavy rainfall in summer, as may a surface cold front and upper trough system in winter.

The climate can be generally described as sub-tropical, sub-humid with summer dominated rainfall.

2.3 Rainfall in the Fitzroy Basin.

Rainfall in the Fitzroy Basin is extremely variable. Monthly totals can be several times higher or lower than the mean monthly total. The relative degree of annual and monthly variation is illustrated in Table 2.1, which contains information from five rainfall stations representative of the Fitzroy Basin. The annual coefficient of variation (standard deviation/ mean) is around 0.35 showing moderate variability, however the range of monthly coefficients of variation is around

0.8 - 1.3 showing a high degree of variability. The median rainfall is a better indicator of average rainfall than the mean as the extreme wet years tend to inflate the mean figures.

Table 2.1. Rainfall Statistics - Fitzroy River Basin.

Station Name	Station Number	Period of Record	Mean Annual Rainfall mm	Annual Standard Deviation mm	Annual Coefficient of Variation	Monthly Range Coefficient of Variation
Rockhampton	039082	1870 - 1967	949	331	0.35	0.7 - 1.5
Rockhampton	039083	1938 - 1994	841	297	0.35	0.8 - 1.2
Marlborough	033050	1869 - 1994	880	326	0.37	0.9 - 1.4
Nebo	033054	1869 - 1994	758	269	0.36	0.8 - 1.5
Clermont	035019	1869 - 1994	669	248	0.37	0.8 - 1.5
Emerald	035027	1882 - 1992	640	207	0.33	0.8 - 1.3
Springsure	035065	1864 - 1994	681	239	0.35	0.7 - 1.3
Taroom	035070	1869 - 1994	677	188	0.28	0.6 - 1.1

Source information: Compiled from Bureau of Meteorology daily rainfall readings and the Department of Natural Resources Hydsys-Hystatr V31 program.

Summer is the dominant rainfall season. Rainfall generally decreases with increasing distance from the coast and also decreases from north to south. Mean annual rainfall is a maximum in the northern near-coastal part of the catchment where it reaches 1,500 mm reducing to around 840 mm near Rockhampton. Inland the mean annual rainfall drops to around 600 mm with about two-thirds of the basin having mean annual rainfall of 700 mm or less.

The Fitzroy basin lies within the zone of influence of tropical cyclones and many of the flood producing rainfall events are due to the passage of cyclones over or close to the catchment. The cyclone season for tropical Australia is November to April which coincides with the summer dominant rainfall period. Rainfall intensity has a large impact on stream runoff. Of the 16 recorded floods on the Fitzroy River at Yaamba and The Gap with peak discharges greater than 7,000 cubic metres per second, 13 are linked to cyclonic influence. A further 20% of peak flows below 7,000 cubic metres per second can also be attributed to cyclonic influence.

2.4 Rainfall during the project period , 1993 - 1996.

Rainfall during the study period was generally well below average throughout the Fitzroy Basin, some areas experiencing the driest seasons since records have been kept. Annual totals for the same seven representative rainfall stations in the Fitzroy Basin are shown in Table 2.2 for the period 1993 to 1996.

Table 2.2. **Rainfall Statistics - Fitzroy River Basin, 1993 - 1995.**

Station Name	Station Number	Period of Record	Mean Annual Rainfall mm	Annual Rainfall mm 1993	Annual Rainfall mm 1994	Annual Rainfall mm 1995	Annual Rainfall mm 1996
Rockhampton	039083	1938 - 1994	841	590	518	787	509*
Marlborough	033050	1869 - 1994	880	454	470	538	674*
Nebo	033054	1869 - 1994	758	485	326	442	363*
Clermont	035019	1869 - 1994	669	403	551	524	412*
Emerald	035027	1882 - 1992	640	425	458	487	306*
Springsure	035065	1864 - 1994	681	449	380	629	411*
Taroom	035070	1869 - 1994	677	593	504	755	301*

Source information: Compiled from Bureau of Meteorology daily rainfall readings.
* Records from January 1996 to July 1996 only.

Seven tropical cyclones had the potential to strongly influence rainfall during the study period. Only the remnants of one, 'Barry', which originated in the Gulf of Carpentaria, in January 1996 delivered widespread rainfall to the Fitzroy Basin. The remaining tropical cyclones were 'Oliver', east coast, February 1993; 'Rewa', east coast, January 1994; 'Sadie', Gulf of Carpentaria, February 1994; 'Violet', east coast, March 1995; 'Warren', Gulf of Carpentaria, March 1995 and 'Celeste', east coast, January 1996.

Other significant rainfall events during the study period occurred in:
- January 1993, with heavy rain in the upper Isaac catchment.
- October and November 1993, falls up to 240 mm in the upper Dawson catchment.
- February 1994, welcome falls along the coast and around Emerald.
- March 1994, heavy widespread falls, 100-240 mm, throughout the Dawson and Central Highlands, especially around Capella.
- February 1995, isolated heavy falls to 140 mm in the upper Dawson around Taroom.
- November 1995, some widespread falls in parts of the Dawson, Mackenzie and Comet catchments.
- April-May 1996, widespread falls over the southern part of the catchment with falls up to 400 mm being recorded.

2.5 Streamflow.

The Fitzroy River Basin is the largest on the east coast of Australia with a catchment area above Rockhampton of about 140,000 square kilometres. Five major sub-basins contribute to the Fitzroy River Basin. The northern part of the catchment is drained by streams of the Isaac/ Connors River system which flow south easterly. These are joined upstream of Tartarus by the Mackenzie River whose major tributaries are the Nogoa River, Theresa Creek and the Comet River. The southern part of the catchment is drained by the Dawson River which joins the Mackenzie River near Duaringa. Downstream of the confluence, the river becomes the Fitzroy which finally flows through Rockhampton to the Pacific Ocean (Fig. 1.1).

Table 2.3. Streamflow Statistics in the Fitzroy Basin.

Stream Name and Location	Gauging Station Number	Period of Record	Mean Annual Discharge Megalitres	Mean Annual Runoff mm	Annual Coefficient of Variation	Monthly Range Coefficient of Variation
Fitzroy R @ The Gap	130005A	1964 - 1996	5,160,000	38	1.1	1.4 - 3.6
Fitzroy R @ Riverslea	130003B	1974 - 1996	5,500,000	42	1.0	1.2 - 3.1
Mackenzie R @ Coolmaringa	130105A	1971 - 1996	4,470,000	58	1.1	1.1 - 2.9
Mackenzie R @ Bingegang	130106A	1971 - 1996	1,450,000	28	1.1	1.1 - 4.1
Nogoa R @ Craigmore	130209A	1972 - 1996	389,000	28	1.0	1.1 - 3.8
Nogoa R @ Duckponds	130219A	1993 - 1996	Insufficient Data	-	-	-
Dawson R @ Beckers	130322A	1964 - 1996	787,000	19	1.3	1.9 - 4.5
Dawson R @ Utopia Downs	130324A	1966 - 1996	111,000	19	1.2	1.3 - 4.6
Don R @ Rannes	130306B	1924 - 1996	279,000	41	1.4	2.0 - 5.1
Isaac R @ Yatton	130401A	1962 - 1996	1,960,000	100	1.2	1.6 - 3.4
Connors River @ Pink Lagoon	130404A	1966 - 1996	2,000,000	230	1.2	1.4 - 3.5
Comet R @ 17.2km	130504A	1971 - 1996	448,000	28	1.1	1.5 - 4.4

Source information: Compiled from Department of Natural Resources streamflow records and the Hydsys -Hystatf V33 program.

As with rainfall, streamflow in the Fitzroy Basin is summer dominant and extremely variable. Monthly and annual totals can be several times higher or lower than the mean monthly and annual totals respectively. For example, the mean annual discharge per calender year measured for the Fitzroy River at The Gap since 1964 is around 5,000,000 megalitres. In the same period, annual discharge has varied from 172,000 megalitres in 1969, to 22,100,000 megalitres in 1991.

The relative degree of annual and monthly variation is illustrated in Table 2.3 which contains information from eleven stream gauging sites representative of the Fitzroy Basin.

As rainfall generally decreases from north to south across the catchment and with increasing distance from the coast, the northern rivers of the Isaac/Connors River system produce a relatively larger proportion of catchment runoff than the Mackenzie and the Dawson Rivers.

Table 2.4. Annual Streamflow Discharges in the Fitzroy Basin.

Stream Name and Location	Period of Record	Mean Annual Discharge Megalitres	Annual Discharge Megalitres 1993	Annual Discharge Megalitres 1994	Annual Discharge Megalitres 1995	Annual Discharge Megalitres 1996
Fitzroy R @ The Gap	1964 - 1996	5,160,000	495,000	2,560,000	679,000	2,960,000 *
Fitzroy R @ Riverslea	1974 - 1996	5,500,000	546,000	2,590,000	764,000	2,360,000 *
Mackenzie R @ Coolmaringa	1971 - 1996	4,470,000	467,000	2,100,000	381,000	1,270,000 *
Mackenzie R @ Bingegang	1971 - 1996	1,450,000	121,000	1,280,000	208,000	838,000*
Nogoa R @ Craigmore	1972 - 1996	389,000	115,000	179,000	92,300	60,100*
Nogoa R @ Duckponds	1993 - 1996	Insufficient Data	-	691,000	86,000	255,000*
Nogoa R @ Raymond	1950 - 1985	220,000	-	-	-	-
Dawson R @ Beckers	1964 - 1996	787,000	115,000	482,000	454,000	996,000*
Dawson R @ Utopia Downs	1966 - 1996	111,000	34,300	36,000	160,000	89,200*
Don R @ Rannes	1924 - 1996	279,000	3,560	101,000	2,680	182,000*
Isaac R @ Yatton	1962 - 1996	1,960,000	46,100	476,000	32,700	272,000*
Connors R @ Pink Lagoon	1966 - 1996	2,000,000	504,000	353,000	81,300	337,000*
Comet R @ 17.2km	1971 - 1996	448,000	502,000	432,000	104,000	318,000*

Source information: Compiled from the Department of Natural Resources streamflow records and the Hydsys- Hymonth V31 program.
* Records from January 1996 to March 1996 only.

2.6 Streamflow during the project period, 1993 - 1996.

Streamflow during the project period was generally well below average. Rainfall and cyclonic influences which produced significant runoff were presented in Section 2.4 (Rainfall during the project period, 1993 - 1996). Of these rainfall periods, two streamflow events resulted in over

2,000,000 megalitres flowing through the Fitzroy River. The first, in March 1994, saw widespread rainfall from an active monsoon trough in the Coral Sea produce medium to high streamflows in the Dawson, Comet, Mackenzie, Isaac and Fitzroy Rivers. The second, an influence from the remnants of tropical cyclone 'Barry' in January 1996, resulted in medium to high flows in the Dawson, Comet, Mackenzie, and Fitzroy Rivers. Annual streamflow discharges for the same representative stream gauging stations are shown above in Table 2.4.

Monthly, total, mean and median streamflows for the project period are shown in Appendix C. This presentation also displays the variability and seasonality of streamflow in the Fitzroy River Basin.

3. LAND USES in the CATCHMENT.

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3.1 Introduction.

Land uses in a catchment are determined by the natural resources, the socio-economic characteristics of the people who live in the catchment and access to markets for the goods and services produced in the catchment.

McDonald (1992) reports that the first recorded white men to explore the Fitzroy catchment were in a team led by Ludwig Leichhardt in 1844-45. During this time, Leichhardt named the Dawson, Comet, Mackenzie and Isaac Rivers and in 1846 Sir Thomas Mitchell named the Nogoa River. In 1853, the Archer Brothers confirmed Leichhardt's theory of a large river (the Fitzroy), which was formed from these other rivers and flowed into Keppel Bay.

Initially the wealth of the catchment came from wool and gold, but within a decade, beef cattle had replaced sheep in coastal areas and a century later, coal has replaced gold as the region's richest mineral.

For the duration of the current project, no information was collected on land use changes in the catchment. A review of Australian Bureau of Statistics data indicates some trends and characteristics of the catchment and these are described here.

3.2 Natural Resources.

The natural resources of the catchment have been described by Lobegeiger (1988) and Forster and Shields (1992) and are one of the factors which affect agricultural land use in the catchment.

The soils of the catchment are very diverse. Large variations in landform, lithology, drainage, geomorphic processes and climate have greatly influenced the development of different soils and the use of these soils for agriculture. During the 1960's, CSIRO carried out land and soil investigations for inland sub-catchments of the area (Story *et al.,* 1967; Gunn *et al.,* 1967 and Speck *et al.,* 1968) and more recently QDPI investigated the remaining coastal area (Forster in prep). More detailed investigations have recently been carried out in the extensive cropping areas (Muller in prep. and Burgess in prep.) and in the alluvium along various rivers of the area.

The catchment can be divided into six broad topographic and vegetation units which overlap:

1. Coastal undulating lowlands have soils which are shallow duplex soils supporting mostly native pastures used for beef production. The predominant vegetation type is woodlands with some tea tree and marine vegetation.

2. Coastal ranges rise abruptly from the coastal lowlands and are hilly to mountainous with a predominance of eucalypt species and some softwood and rainforest scrub. The dominant grass is speargrass.
3. Floodplains occur throughout the area along all the major rivers. Soils vary from alluvial clay loams to heavy clays. The major vegetation species are blue gums, coolabah, brigalow and some gidgee inland. Although flooding can be a major problem, many areas are cultivated.

4. Open grasslands have soils which are generally variable depth cracking clays. Trees and shrubs are scarce and blue grass communities dominate. These areas are used for extensive improved pasture and cropping.

5. Eucalypt woodlands are spread throughout the catchment across a range of landscapes. The soils are duplex and characterised as shallow with low to moderate nutrient status and water storage capacity. Dominant vegetation types are ironbark, bloodwood and poplar box. These areas are used for beef production from a range of pastures.

6. Brigalow scrub vegetation covers large areas and includes brigalow, blackbutt, yellow-wood and some gidgee and belah. The soils are mostly cracking clays with some areas of duplex soils. This unit is widely developed to improved pastures such as buffel grass or used for cropping.

Climate, particularly rainfall, is discussed in Chapter 2 of this report. From an agricultural perspective, rainfall is the biggest single influence on agricultural production, soil erosion and river flow. The catchment has a summer dominant rainfall pattern with mean annual values of 500 mm in the west increasing to around 1,200 mm in the east, but all areas experience extreme variability. The temperatures are not as variable as the rainfall, but the extremes are important in plant growth. A majority of the area experiences frost during winter and summer temperatures sometimes in excess of 40°C. Monthly evaporation is higher than the average monthly rainfall in each month indicating a soil moisture deficit.

3.3 Agricultural Land Use.

Cropping is carried out on soils able to store adequate moisture and after significant rainfall events. Some irrigated agriculture is carried out along the Comet, Nogoa, Mackenzie and Dawson Rivers. Gazetted irrigation areas are located at Emerald and Theodore.

Grazing is carried out on a range of land types varying from highly productive improved pastures on cleared areas of dense brigalow scrub to rough grazing of native pastures.

For the duration of the project, agricultural land use in the catchment was largely determined by the below average rainfall experienced for the period. Drought conditions due to a lack of summer rainfall affected most of the catchment during the last five years.

The catchment occupies around 8% (11.8 million hectares) of the area used for agricultural production in Queensland. Detailed data on land use is not available for the catchment but data is collected for the 13.1 million hectare Fitzroy Statistical Division of which the Fitzroy catchment is a major component. Figures for the years 1994 to 1995, suggest that agricultural land use is the dominant land use in terms of area with 82% of the Division used for agricultural purposes.

Useful data is only available for the years 1993 to 1994 and 1994 to 1995. A summary of relevant agricultural information is given in Table 3.1.

Table 3.1. Summary - Agricultural Land Use Information - Fitzroy Statistical Division.

	1993/94	**1994/95**
Area of Agricultural Establishments	10,646,000 ha	10,808,000 ha
Total area Cropped	300,000 ha	300,000 ha
Grain Sorghum	105,000 ha 191,000 t	125,000 ha 170,000 t
Wheat	44,000 ha 29,000 t	62,000 ha 44,000 t
Cotton	21,000 ha 31,000 t	24,000 ha 66,000 t
Cut for hay	9,000 ha 47,000 t	10,000 ha 50,000 t
Forage Sorghum	38,000 ha	Not available
Pasture Legumes	40,000 ha	Not available
Sown Grasses	1,207,000 ha	Not available
Grass and Legume Pasture	480,000 ha	Not available
Total beef cattle	1,656,000	1,622,000

The distribution of cropping areas in the catchment for 1992 is shown in Figure 3.1. This has been interpreted from 1992 Landsat Thematic Mapper satellite imagery with limited field work to validate the information. The information was collated by the Resource Management Unit at the Resource Sciences Centre, Indooroopilly for the purpose of classifying the cropping areas of central Queensland.

Other agricultural land uses in the catchment include:

- 105 existing and 22 recommended licensed feedlots in the catchment as at 31 July 1996.
- cotton processing plants located at Emerald, Yamala and Biloela.
- approximately 45,000 hectares of irrigation on 687 establishments predominantly from regulated irrigation areas (62% of total area) and underground supplies (26% of total area).

3.4 Other Land Uses.

There is a diversity of other land uses which occur in the catchment. There are nine local authorities situated wholly in the catchment and seven partly in the catchment (Table 3.2).

Table 3.2. Local Authorities in the Fitzroy Catchment.

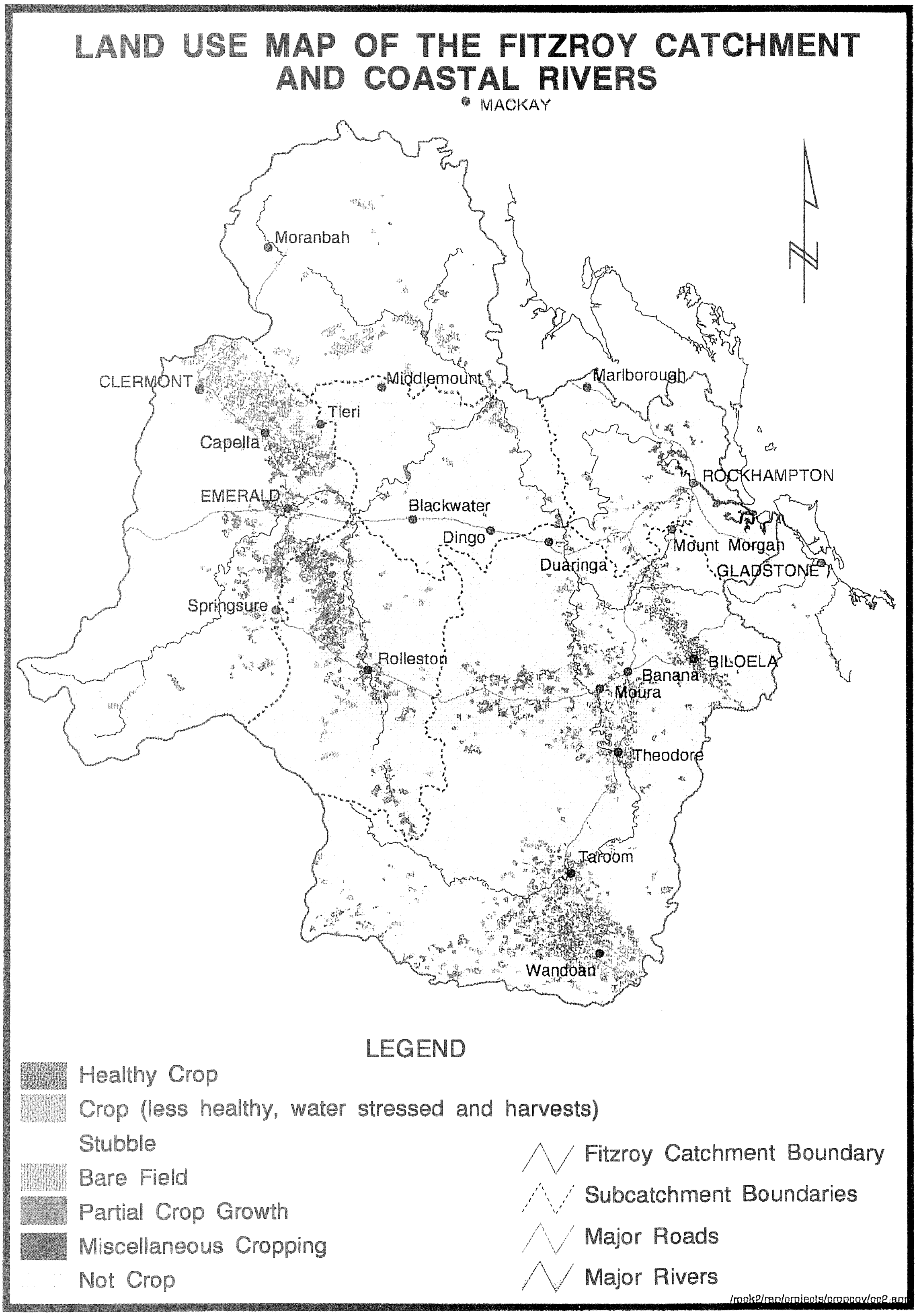
Wholly contained in.	Partly contained in.
Banana	Belyando
Bauhinia	Broadsound
Duaringa	Bungil
Emerald	Calliope
Fitzroy	Livingstone
Mt. Morgan	Nebo
Peak Downs	Sarina
Rockhampton	
Taroom	

The population of the actual catchment is difficult to determine, but the population of the Fitzroy Statistical Division as at 30 June, 1994 was approximately 179,000 . This represented 5.6% of the total population of Queensland and the Division had an average annual growth rate of 1.9% for the period 1989 to 1994. Table 3.3 shows the distribution of this population in towns.

Table 3.3. Towns and Populations in the Fitzroy Catchment (1994 data)

Size of Town	Number of Towns in Category
More than 10,000 people	One (Rockhampton Pop 67,082)
1,000 to 10,000 people	Eight
500 to 1,000	Nine
Less than 500	Twenty five

Mining is a land use in the catchment which contributes valuable income to the region. As at December 1994, there were 15 coal mines and 17 other metalliferous mines and quarries in catchment. The amount of coal and value of production from the coal mines was estimated to be 34 million tonnes and $1.8 billion for 1994/95. As at 1992, Roe (1992) estimated that there is 31,700 hectares (less than 0.5% of the catchment) which has been disturbed for coal mining in the catchment.


LAND USE MAP OF THE FITZROY CATCHMENT AND COASTAL RIVERS
MACKAY
Moranbah
CLERMONT
Middlemount
Tieri
Capella
EMERALD
Blackwater
Dingo
Duaringa
Marlborough
ROCKHAMPTON
Mount Morgan
GLADSTONE
Springsure
Rolleston
BILOELA
Banana
Moura
Theodore
Taroom
Wandoan
LEGEND
Healthy Crop
Crop (less healthy, water stressed and harvests)
Stubble
Bare Field
Partial Crop Growth
Miscellaneous Cropping
Not Crop
Fitzroy Catchment Boundary
Subcatchment Boundaries
Major Roads
Major Rivers

4. PHYSICAL and CHEMICAL WATER QUALITY.

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4.0.1 Introduction.

Three types of activities relevant to the quality of water resources in the Fitzroy system were undertaken:

- river monitoring (major activity).
- groundwater monitoring.
- sediment and nutrient export studies - irrigated cotton.

Site locations are illustrated in Fig. 1.1 and more detailed site descriptions are provided in Appendix B.

Limited monitoring for nitrate levels and pesticide residues in groundwater resources in the Callide, Dawson and Nogoa sub-catchments was carried out. This followed previous work supported by the Land and Water Resources Research and Development Corporation (LWRRDC).

Sediment and nutrient (nitrogen and phosphorus) exports in runoff at the furrow and taildrain locations were studied during the 1993/94 season for an irrigated cotton site at Emerald. Concurrent pesticide transport studies on the site (1993 - 96) were supported by LWRRDC and the Cotton Research and Development Corporation.

4.0.2 Methods.

Approaches to the collection of river water samples depended on the size of the water body (stream) and the prevailing flow conditions at the time of sampling.

Under base flow or low flow conditions, composite samples were taken mid-stream using a tube sampler from a dinghy. Temperatures and dissolved oxygen levels were measured *in situ* at a number of depths from surface to stream bed. Electrical conductivity and pH were recorded on-site. Representative samples for nutrient analysis were placed in polyethylene bottles (1L) previously acid washed and rinsed with high quality laboratory water (quality exceeds all standards for Type 1 Reagent Grade water). Samples for pesticide residue analysis were placed in borosilicate glass bottles (1L) which had previously been rinsed with analytical grade ethanol and acetone. Samples for nutrient or pesticide residue analysis were cooled on-site in eskies or portable refrigerators and either frozen until sent to the laboratory (samples for nutrient analysis) or refrigerated and freighted by air to the laboratory within 48 hours (samples for pesticide analysis).

Under moderate to high flow conditions samples were taken mid-stream by surface dipping (0 - 25 cm) from suitable structures over the streams (culverts, road bridges, weirs) or on limited occasions by casting from stream banks. These "surface" samples taken under flow conditions might be expected to underestimate the suspended solid load being carried by the stream and also the load of substances possibly adsorbed on the suspended particles (phosphorus, pesticides). Results, however, from more rigorous sampling undertaken in flood conditions in the lower

Fitzroy (Kelly and Wong, 1996) seem to indicate that errors may not be as large as anticipated. After collection, "flow" samples were treated similarly to those taken under base flow conditions.

Levels of suspended solids were established in the laboratory by filtration of a representative sample through a glass microfibre filter (nominal pore size 0.7 μm).

Some initial replicated sampling was carried out at the mid Fitzroy River site (Site No. 1, Fig. 1.1) at different locations in the stream and from surface to stream bed. Results indicated that at least under base flow conditions, composite samples taken by a vertical tube were representative.

Groundwater was sampled by using "observation" bores maintained by the Water Resources Group (QDNR) and production (irrigation) bores in the Callide Valley. Observation bores were pumped out and allowed to recharge with at least three bore volumes prior to collection of water samples. Samples were taken when the pH, temperature and electrical conductivity of the discharging water had stabilised. Bore water samples for nutrient (nitrate) and pesticide residue analysis were collected and treated with the protocols used for river water samples.

Runoff from flood irrigated cotton blocks was sampled for nutrients at furrow and taildrain locations using automated samplers, collecting into acid washed polyethylene bottles. The bottles were collected immediately after the event (within 24 hours) and treated as for river and groundwater samples.

Chemical analyses of water samples were carried out at the Resource Sciences Centre, Queensland Department of Natural Resources (QDNR), Brisbane. These laboratories have a long history in agriculturally related chemical analyses and NATA accreditation in major analysis methodology. As well, a range of chemical analysis results from this project were compared with those from other independent monitoring activities (Ambient Water Quality Monitoring Network, QDNR and Rockhampton City Council). These programs maintain separate sampling regimes and utilise different laboratories.

4.1 PHYSICO-CHEMICAL INDICATORS.

4.1.1 Dissolved Oxygen (DO).

Guidelines:

- Aquatic ecosystem protection - not less than 6 mg/L or 80 - 90% saturation (ANZECC, 1992).

No account was taken of diurnal variations expected in dissolved oxygen levels. Readings for most sites (at least for surface water) met ecosystem protection guidelines for most of the samplings. Some low DO levels in surface waters were recorded occasionally in the mid Dawson River, in the lower Comet River and in the drying pools of the mid Nogoa River. Low levels of DO were recorded at depth (> 1.5 m) at several river, dam and wetland sites.

4.1.2 pH.

Guidelines:

- Aquatic ecosystem protection - 6.5 to 9 units (ANZECC, 1992).
- Raw water for drinking subject to coarse screening - 6.5 to 8.5 units (NHMRC/AWRC, 1987; ANZECC, 1992).

For surface water samples, individual pH values except for two, satisfied the guidelines for aquatic ecosystem protection (6.5 to 9.0 units). Two low pH values (4.6 and 6.1 units) were recorded for the Dee River following flow events past the Mt Morgan mining site. Apart from the Dee River, waters from the Dawson River showed the widest range of pH values (6.5 to 9.0 units).

Median pH values for the sub basins ranged from a low of 7.15 units for the Connors River to a high of 7.97 for the Nogoa River. The generally alkaline nature of the surface waters of the catchment is not surprising as soil types are dominated by alkaline classes (Refer to Chapter 3).

About 2% of surface water samples failed to meet the guidelines for raw water for drinking, subject to coarse screening (6.5 to 8.5 units).

The quality of groundwater resources in the region is extremely variable. About 4% of groundwater samples were outside the guidelines for raw water for drinking subject to coarse screening (6.5 to 8.5 pH units), with a median value for the 82 samples of 7.13 units.

4.1.3 Electrical Conductivity.

Guidelines:

- Protection of Aquatic Ecosystems: < 1,500 µS/cm (ANZECC, 1992).
- Irrigation water: < 280 µS/cm (low salinity), 280 - 800 µS/cm (medium salinity), 800 - 2,300 µS/cm (high salinity), 2,300 - 5,500 µS/cm (very high salinity), > 5,500 µS/cm (extremely high salinity) (ANZECC, 1992, from Hart, 1974).
- Raw water for drinking subject to coarse screening: < 1,500 µS/cm (derived from ANZECC 1992 guideline of 1,000 mg/L total dissolved solids).
- Livestock watering: < 4,400 µS/cm (derived from ANZECC 1992 guideline of 3,000 mg/L total dissolved solids).

All 267 surface water samples from the catchment met the guidelines for livestock watering. Only 2 samples from the lower Don River site, Rannes (Site No. 6, Fig. 1.1) failed to meet the guideline for raw water for drinking subject to coarse screening (< 1,500 µS/cm). More than 80% of samples fell within the low salinity range for irrigation (< 280 µS/cm) with 17% in the medium salinity range (280 - 800 µS/cm). For the sub-basins, median values ranged from a low of 170 µS/cm for the Comet River to a high of 292 µS/cm for the Isaac system.

A wide range of electrical conductivities were recorded for ground water samples (213 - 13,500 µS/cm) reflecting the variable quality of the resource. Almost 50% of samples were outside the guidelines for raw water for drinking subject to coarse screening (< 1,500 µS/cm). For irrigation purposes, about 5% were in the low salinity range and about 60% in the medium and high salinity ranges (200 - 2,300 µS/cm). Almost 20% of samples did not meet the guideline for livestock watering (< 4,400 µS/cm) but of the 18 irrigation bores tested in the Callide Valley only one was in this category.

Results for pH and electrical conductivity of surface waters at the river sites are summarised in Fig. 4.8 at the end of this chapter.

4.1.4 Turbidity.

Approaches to guidelines for stream water clarity, colour, turbidity and suspended particulate matter (SPM) under Australian conditions have been presented (ANZECC, 1992). At present, no specific values are available for turbidity and SPM.

In the current work, water clarity and turbidity were estimated throughout the study using a Secchi disc and thus were measured under base flow or low flow conditions only. During and after flows, streams in the Fitzroy system are moderately to highly turbid.

A wide range of Secchi values was recorded (0.05 - 2.25 m) for river, dam and wetland sites. For the major river sites, both the highest and lowest readings (1.9 m and 0.05 m respectively), were made at the same location on the lower Dawson River (Site No. 7, Fig. 1.1).

For the sub-basins, median values ranged from 0.22 m for the Fitzroy and 0.23 m for the Dawson to 0.77 m for the Connors/Isaac. For the Dawson system, median values for Secchi readings were higher at the upper (0.68 m, Site No. 8) and lower (0.38 m, Site No. 15) sub-basin locations than at the mid-Dawson sites (0.23 m, Site No. 13; 0.18 m, Site No. 14).

4.1.5 Suspended Solids (Suspended Particulate Matter).

Surface (stream) Waters.

No specific guideline values are available for Australian conditions. Judging by some previous overseas criteria, suspended solid (SS) levels in streams of the Fitzroy system, at least under flow conditions, are very high (ANZECC, 1992). By adsorptive processes, suspended solids may act as a major transport mechanism for nutrients (especially phosphorus) and pesticides.

Under flow conditions in the current study, water samples were taken by surface dipping (0 - 25 cm). Other studies in the catchment under flow conditions (Kelly and Wong, 1996), have investigated the spatial variation of suspended solids in a flow in the lower Fitzroy River in March 1994. For this study, mean concentrations of SS in "surface" samplings were not very different from those at depth.

Of 278 samples taken for the Fitzroy catchment, the median value for SS was 142 mg/L and the range from 8 mg/L to 4,395 mg/L. Under flow conditions, four measurements greater than 3,000 mg/L (3 tonnes per megalitre) were recorded, two each from the Comet and Nogoa Rivers. Of the total samples, about 70% were taken during flows or under conditions affected by prior flows.

The values recorded are in general agreement with data recorded independently for the March 1994 flow in the lower Fitzroy River (Kelly and Wong, 1996) and with data for the central and north west rivers of NSW (Preston, 1996).

Of the total data set, the Fitzroy had the highest median level (417 mg/L)of SS, contrasting with much lower values of 37, 49 and 50 mg/L for the Connors, Nogoa and Isaac basins respectively. The Dawson (157 mg/L), Comet (202 mg/L) and Mackenzie (301 mg/L) sub basins had intermediate values.

Under base flow conditions, median values for all sub-basins were low with a range from 19 mg/L (Isaac) to 82 mg/L (Fitzroy).

For flow conditions, median values were much higher. The Fitzroy again had the highest (693 mg/L) and the Isaac/Connors the lowest (51 mg/L). Of the other sub-basins the Mackenzie (590 mg/L) and Comet (420 mg/L) were higher than the Nogoa (361 mg/L) and the Dawson (244 mg/L).

Within the Dawson sub-basin, median values for suspended solids increased from an upper location (25 mg/L, Site No. 8, Fig. 1.1) to a lower Dawson site (219 mg/L, Site No. 15, Fig. 1.1). Quite high levels of SS (337 mg/L), were recorded however, near the upper Dawson town of Taroom under flow conditions. The six weirs on the Dawson River between Taroom and Site No. 15 no doubt complicate the passage of suspended solids down the river.

Suspended solids data for the primary Fitzroy sites and for the Dawson sub-basin are summarised as box plots in Figs. 4.1 and 4.2 respectively. Data for the total Fitzroy catchment are summarised in Fig. 4.9 at the end of this chapter.

Runoff from Irrigated Cotton.
Levels of suspended solids moving off a flood irrigated cotton block at Emerald were studied during the 1993/94 and 1994/95 seasons. Samples were collected at the furrow and taildrain locations and also at a Crump weir on the drainage channel about 1.5 kilometres "downstream" from the cotton farm. Runoff from a number of cotton farms contribute to flows at the Crump weir. Measurements were also made on the input irrigation water supplied via the Selma channel from the Fairbairn Dam on the Nogoa River.

Suspended solid levels in the input water from the Selma channel were consistently low in this period, with a median of 31 mg/L and a high of 42 mg/L for the two seasons. In contrast, SS levels in runoff waters were mostly high. Data are summarised in Table 4.1.

Table 4.1. Suspended Solids (mg/L) from a Flood Irrigated Cotton Block near Emerald.

	Selma Channel	Furrow	Taildrain	Crump Weir
n =	9	24	56	41
Median	31	980	1764	154
Range	6 - 42	96 - 13,714	134 - 13,221	19 - 12,420

Median values for the furrow and taildrain SS were well above those for any river site studied in the current work. The median at the Crump weir (154 mg/L) was comparable with values at many mid to lower catchment river sites. As noted, instantaneous levels of SS of more than 12,000 mg/L (12 tonnes per megalitre) were measured at the furrow, taildrain and Crump weir locations.

Figure 4.1. Suspended Solids, Total Nitrogen and Total Phosphorus - Fitzroy Catchment, 1993 - 1996.

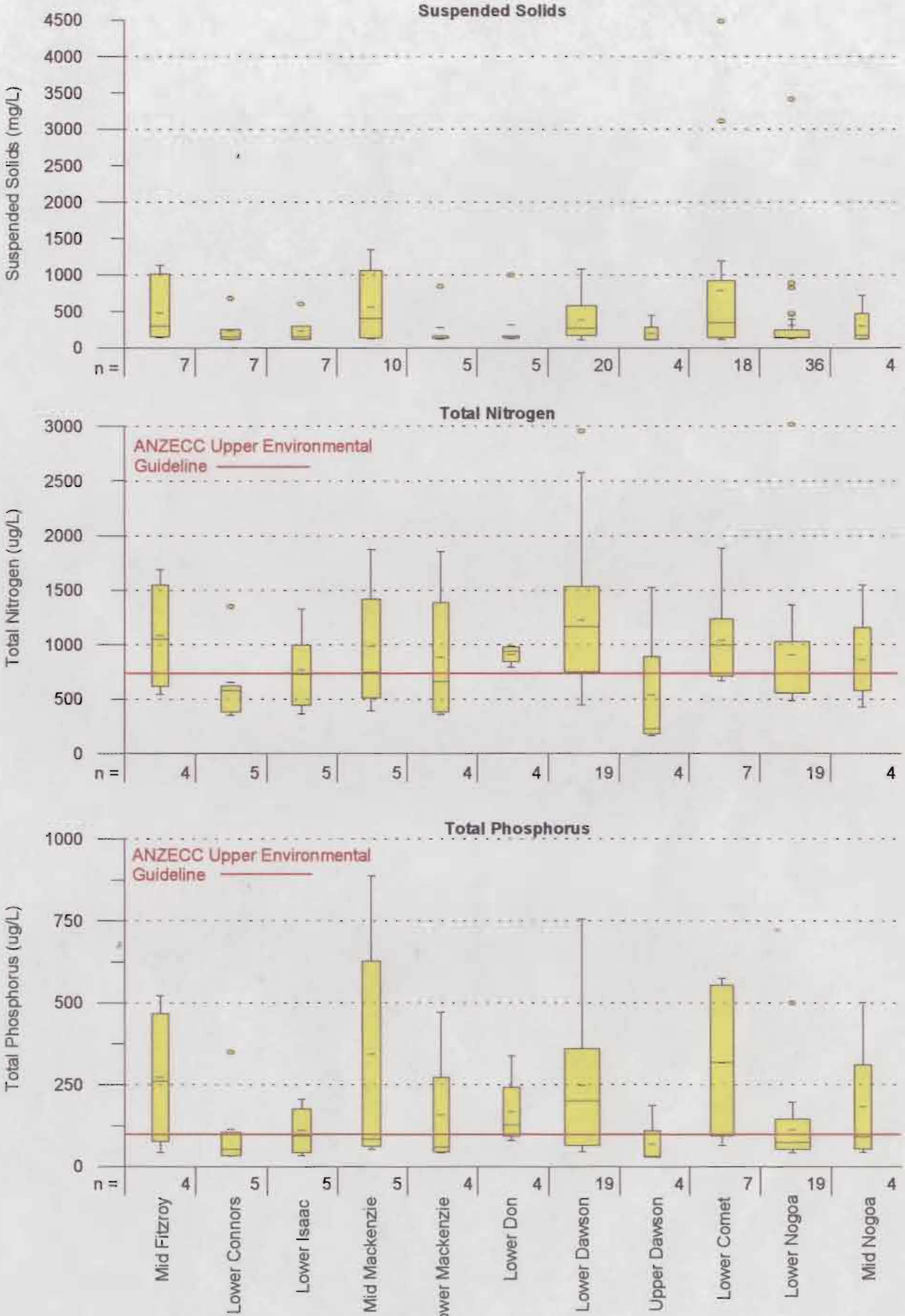
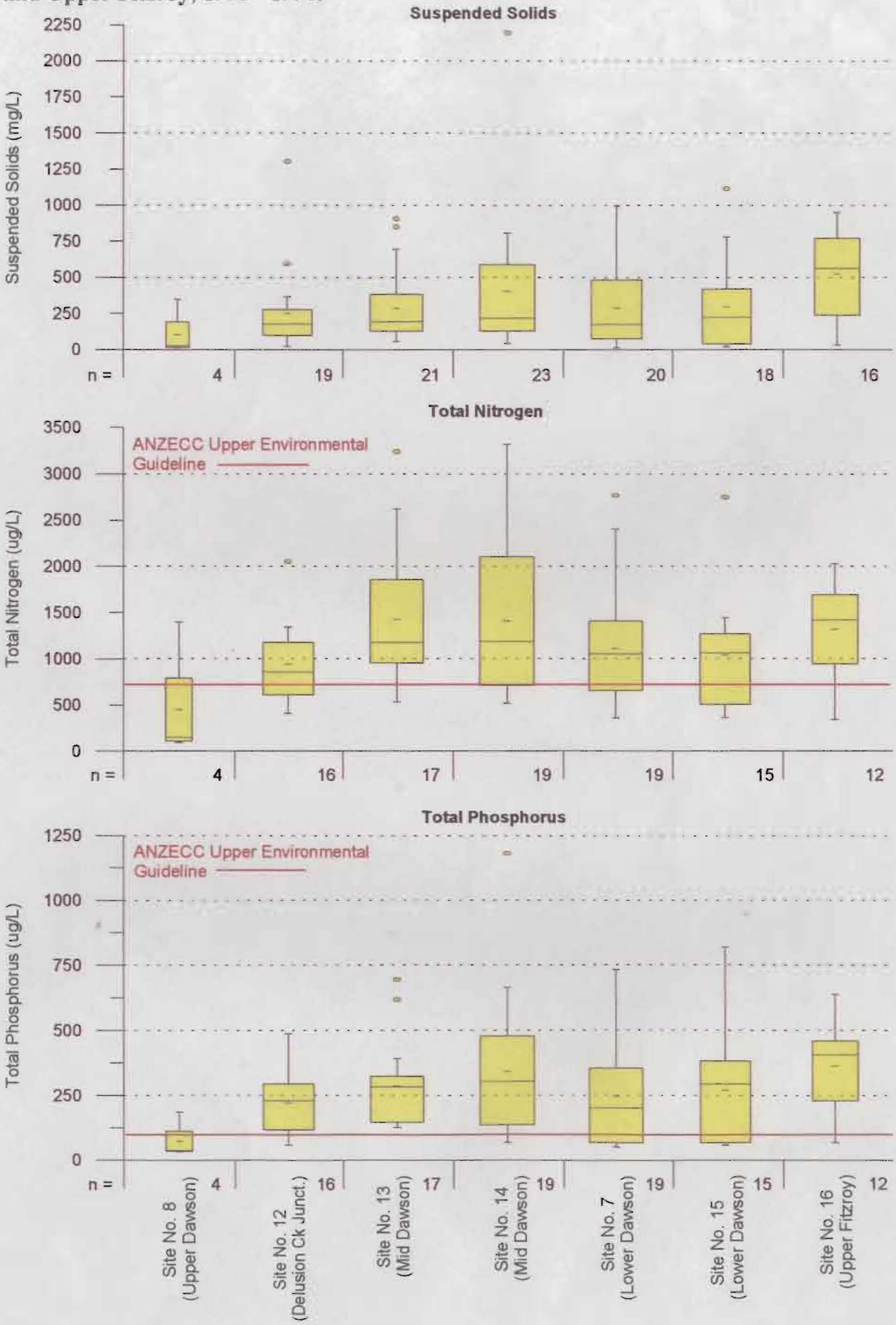


Figure 4.2. Suspended Solids, Total Nitrogen and Total Phosphorus - Dawson Catchment and Upper Fitzroy, 1993 - 1996.



4.2 NUTRIENTS.

4.2.1 Nitrogen.

Total Nitrogen - Guidelines:
Indications of the level of total nitrogen (TN) at or above which algal problems have been known to occur for Australian conditions have been noted (ANZECC, 1992). These concentrations are:

- 100 - 750 µg/L for rivers and streams.
- 100 - 500 µg/L for lakes and reservoirs.

Surface (stream) Waters.
The median value for total nitrogen (TN) for 178 river water samples taken throughout the Fitzroy catchment was 972 µg/L, obviously exceeding the upper indicative level of 750 µg/L (ANZECC, 1992). Median values for the sub-basins are presented in Table 4.2.

Table 4.2. Median Total Nitrogen Values (µg/L) for Catchment Sub-basins.

	Connors	Isaac	Mackenzie	Nogoa	Comet	Dawson	Fitzroy
n =	5	5	9	27	9	102	16
Median	570	719	735	751	1,020	1,065	1,497

The size of the data sets is small for several of the sub-basins and caution should be exercised in interpretations but TN results for most of the sites are in good agreement with those obtained independently in the Ambient Water Quality Monitoring Network of the Dept of Natural Resources (N. Kelly, pers comm.).

Median levels for the Nogoa, Comet, Dawson and Fitzroy were at or above the upper guideline value (750 µg/L) with the Fitzroy the highest at 1,497 µg/L. The northern sub-basins (Connors and Isaac) appeared to carry the lowest concentrations of TN.

Sampling frequency was not high enough for most sub-basins to allow load estimates, but later in this report load estimates for suspended solids, total nitrogen, total phosphorus and the herbicide atrazine are made for a flow in the upper Fitzroy arising from "Dawson water" (Section 4.4).

Under **base flow** conditions, samples from all the primary river sites (Site Nos. 1 to 11, Fig. 1.1), had median TN values of less than 750 µg/L except for the lower Don River site, Rannes (Site No. 6) which had a value of 890 µg/L. Under **flow** conditions, TN medians for **all** sites were greater than 750 µg/L, with the northern sub-basins having the lowest medians (945 and 976 µg/L for the Connors and Isaac respectively). The highest individual TN value recorded for a river site was 3,434 µg/L in the mid Dawson. Even the "upper catchment" Dawson site (Site No. 8, Fig. 1.1) recorded a TN value of 1,490 µg/L under flow conditions.

Within the Dawson sub-basin, TN medians for all sites except for the upper catchment location at Baroondah (Site No. 8, Fig. 1.1) exceeded the 750 µg/L level. Under both base flow and flow conditions, TN values tended to increase going from upper to lower sub-basin sites, although values for the mid Dawson at Theodore and Moura (Site Nos. 13 and 14 respectively) were higher than those for the lower Dawson (Site No. 15, Fig. 1.1).

TN data for the primary river sites (Site Nos. 1 to 11, Fig. 1.1) and for the Dawson sub-basin sites are presented above as box plots in Figs. 4.1 and 4.2 respectively. Data for the total Fitzroy catchment are also summarised in Fig. 4.10 at the end of this chapter.

Runfff from Irrigated Cotton.

Levels of TN in runoff from a flood irrigated cotton block at Emerald were measured during the 1993/94 and 1994/95 seasons. Samples were collected at the furrow and taildrain locations and also at a Crump weir on the drainage channel about 1.5 kilometres "downstream" from the cotton farm. Measurements were also made on the input irrigation water supplied via the Selma Channel from the Fairbairn Dam on the Nogoa River. Data are summarised in Table 4.3.

Table 4.3. Median Total Nitrogen Values (μg/L) for Runoff from Irrigated Cotton.

	Selma Channel	Furrow	Taildrain	Crump Weir
n =	8	22	55	40
Median	556	7,100	12,312	5,775
Range	514 - 680	1,660 - 110,187	2,403 - 42,615	464 - 25,180

TN levels for the input water from the Fairbairn Dam were all below the ANZECC, 1992 upper guideline of 750 μg/L for streams. In contrast, TN values in runoff from the cotton block were extremely high, median values being an order of magnitude above the upper guideline value.

A TN concentration of more than 110,000 μg/L was recorded for early season runoff at the furrow location. The median TN value down the drainage channel at the Crump weir was high but much lower than at the taildrain location. **The desirability of keeping this nitrogen rich water out of the riverine system, either by recycling or by off-stream storage is obvious**. At Emerald, except under significant runoff from rainfall events, not much of this nitrogen-rich water should reach the Nogoa River although the median TN value (730 μg/L), downstream at Duckponds (Site No. 10, Fig. 1.1), is higher than that for the input water from the Fairbairn Dam (556 μg/L), (Rummenie and Noble, 1996). Other sources of nitrogen to the river from the town are possible.

Data for separate nitrogen species (total Kjeldahl nitrogen, nitrate nitrogen) for filtered and unfiltered samples both for river sites and runoff from irrigated cotton are available but for brevity are not included in this report.

4.2.2 Phosphorus.

Total Phosphorus - Guidelines:

Indications of the level of total phosphorus (TP) at or above which algal problems have been known to occur under Australian conditions have been noted (ANZECC, 1992). These concentrations are:

- 10 - 100 μg/L for rivers and streams.
- 5 - 50 μg/L for lakes and reservoirs.

Surface (stream) Waters.

The median value for total phosphorus (TP) for 179 river water samples taken throughout the Fitzroy catchment was 170 μg/L, obviously exceeding the upper indicative level of 100 μg/L (ANZECC, 1992). Median TP values for the sub-basins are presented in Table 4.4.

Table 4.4. Median Total Phosphorus Values (µg/L) for Catchment Sub-basins.

	Connors	Isaac	Mackenzie	Nogoa	Comet	Dawson	Fitzroy
n =	5	5	9	27	9	102	16
Median	50	90	70	70	440	215	396

The size of the data sets is small for several of the sub-basins and caution should be exercised in interpretations but TP results for most of the sites are in good agreement with those obtained independently in the Ambient Water Quality Monitoring Network of the Dept. of Natural Resources (N. Kelly, pers comm.).

Median TP values for the Connors, Isaac, Mackenzie and Nogoa sub-basins were below the ANZECC upper guideline of 100 µg/L while values for the Comet, Dawson and Fitzroy were well above. **It appears from this data that the Comet and Dawson sub-basins along with the Fitzroy itself have the highest TP concentrations in the catchment**, while the northern sub-basins supply lower concentrations of the element. Larger data sets, especially for the northern sub-basins, would be required to confirm this. An estimate of the **load** (concentration x flow) of nitrogen and phosphorus carried down the Dawson during a significant flow event is given later in Section 4.4.

Under **base flow** conditions, median TP values for most sites were at or below 100 µg/L except for the mid Dawson where a median concentration of 140 µg/L was recorded. During **flows**, median TP levels for **all** sites exceeded 100 µg/L, ranging from 170 to 740 µg/L. **Highest values were noted in the Comet, Mackenzie and Dawson sub-basins**.

Within the Dawson sub-basin, under base flow conditions, median TP values greater than 100 µg/L were noted in the mid Dawson at Theodore and Moura with lesser concentrations in the upper and lower Dawson. During flows, values greater than 100 µg/L were recorded along the length of the river, with highest concentrations occurring in the mid and lower reaches.

TP data for the primary river sites (Sites Nos. 1 to 11, Fig. 1.1) and for the Dawson sub-basin sites (Site Nos. 12 to 15) are summarised above as box plots in Figs. 4.1 and 4.2 respectively. Data for the total Fitzroy catchment are also summarised in Fig. 4.10 at the end of this chapter.

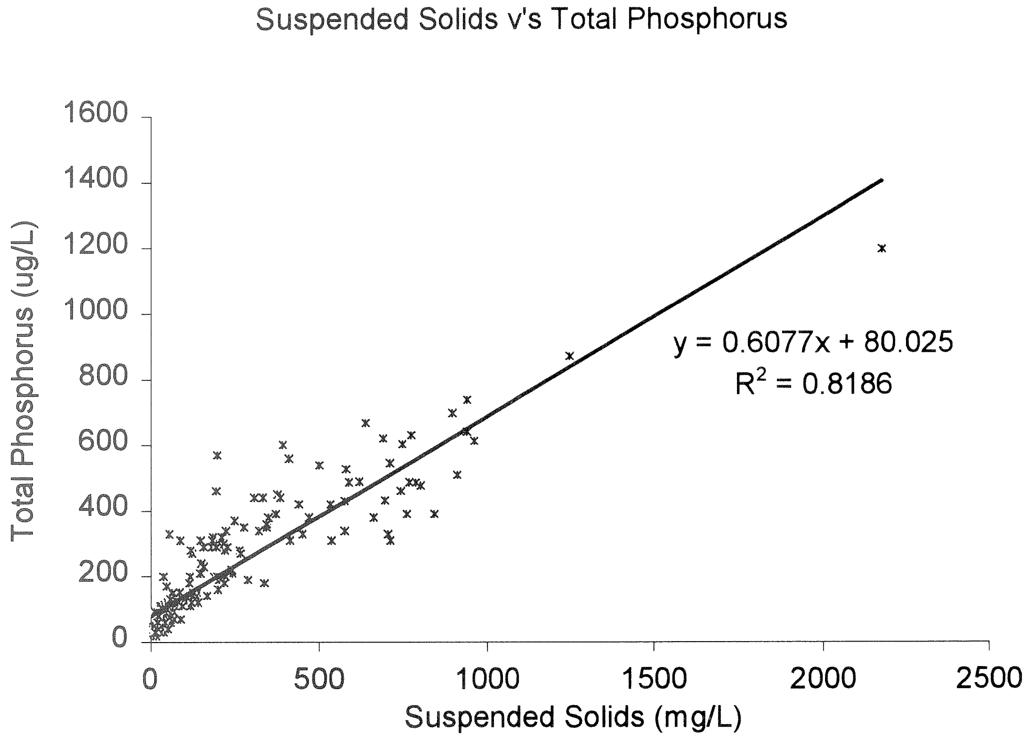
Data from the current work indicate that during flows more than 60% of the phosphorus in riverine water samples is associated with suspended solids (removed by filtration at 0.7 µm). Correlations between concentrations of suspended solids and phosphorus (total P and suspended P) are presented in Fig. 4.3.

Runoff from Irrigated Cotton.

Levels of TP in runoff from a flood irrigated cotton block at Emerald were studied during the 1993/94 and 1994/95 seasons. Samples were collected at the furrow and taildrain locations and also at a Crump weir on the drainage channel about 1.5 kilometres "downstream" from the cotton farm. Measurements were also made on the irrigation input water supplied via the Selma Channel from the Fairbairn Dam on the Nogoa River. Data are summarised below in Table 4.5.

TP levels for the input water from the Fairbairn Dam were all below the ANZECC, 1992 upper guideline of 100 µg/L for streams. In contrast, median TP values in runoff from the cotton block at the furrow and taildrain sites were well above this upper guideline. The median value at the Crump weir (148 µg/L) was lower than the medians at the furrow and taildrain but well above the ANZECC upper level.

Figure 4.3. Suspended Solids and Phosphorus (Total and Suspended) Correlations - Fitzroy Catchment, 1993 - 1995.



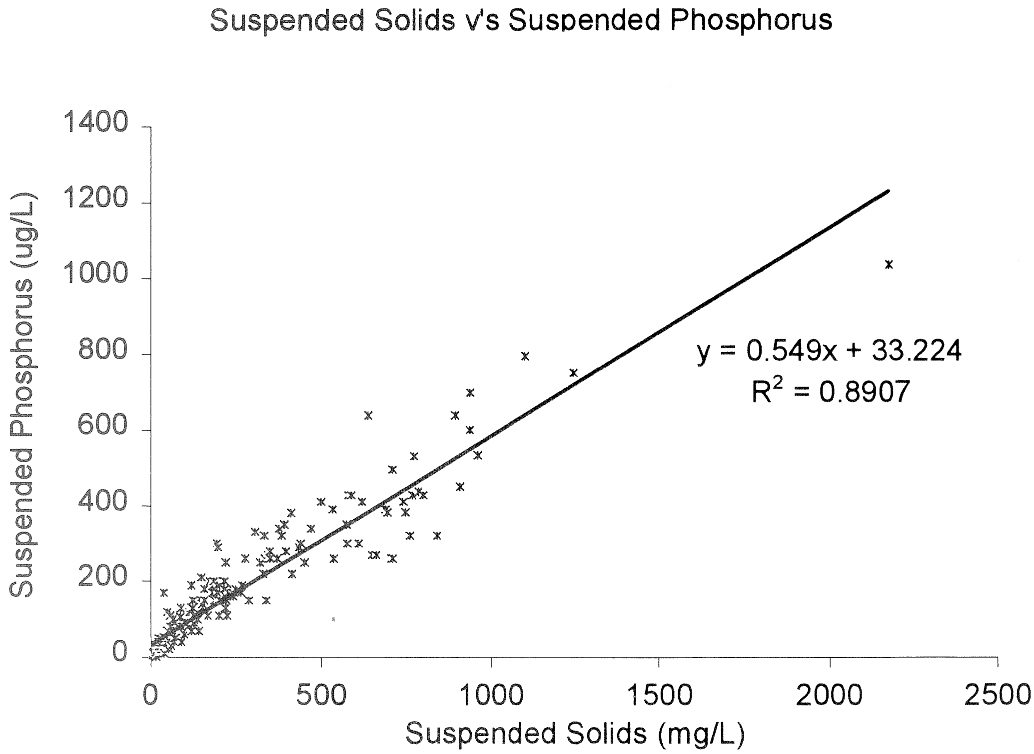


Table 4.5. Median Total Phosphorus Values (μg/L) for Runoff from Irrigated Cotton.

	Selma Channel	Furrow	Taildrain	Crump Weir
n =	8	22	55	40
Median	40	311	458	148
Range	10 - 60	50 - 4,050	30 - 4,990	10 - 5,570

The median TP values recorded at the furrow and taildrain (311 and 458 μg/L) are comparable with those noted for river sites in the Comet, Dawson and Fitzroy sub-basins (440, 215 and 396 μg/L respectively) and are much higher than the median value recorded for the Nogoa (70 μg/L). **The desirability of keeping this phosphorus-rich water from the taildrains out of the Nogoa riverine system, either by recycling or by off-stream storage is obvious.**

Data for separate phosphorus species (soluble P, suspended P and dissolved reactive P) are available for both river samples and those for runoff from irrigated cotton but for brevity are not discussed in this report.

4.2.3 Total Nitrogen to Total Phosphorus Ratios.

Guidelines:
The limitations in using total nitrogen to total phosphorus (TN:TP) ratios as a guide to potential blue-green algal growth problems has been documented (ANZECC, 1992). While more detailed site-specific physico-chemical, chemical and biological data are required, the NSW Blue-Green Algal Task Force (1992) has indicated that a TN:TP ratio of less than 29:1 is conducive to the growth of blue-green algae.

Surface (stream) Waters.
TN:TP ratios for all river sites were low with median values all less than 10. No individual ratio value greater than 25 was found for the river sites. The lowest medians (approx. 2) were recorded for the Comet sub-basin, probably reflecting the high phosphorus concentrations noted for this river system in the current study (Section 4.2.2). **While many other factors are involved in the production of blue-green algal blooms, the high phosphorus concentration and low TN:TP ratios noted for the Comet system suggest that further study of the current algal dynamics of the river would be worthwhile, especially as construction of a major dam on the river is presently under consideration.**

Considered in isolation, the very low TN:TP ratios for the Fitzroy riverine system would suggest that blue-green algal blooms should be more common than they currently are. Other factors including limitations on light penetration (suspended solids) and flows are presumably controlling growth. **For sustainable use of the riverine resource, a much better understanding of factors involved in the dynamics of algal growth (and how to manage them) is urgently needed.**

Runoff from Irrigated Cotton.
Median values of TN:TP for runoff from an irrigated cotton farm ranged from 23 to 33, reflecting high nitrogen levels in the runoff. This was confirmed by a high median value of the ratio (76) noted for water in a tailwater storage dam on a cotton farm, which was nitrogen rich but quite low in phosphorus once the suspended material had settled out.

4.3 PESTICIDES.

The Fitzroy catchment is a large and diverse agricultural area. Pesticides are used in both rural and urban areas. Land uses in the catchment vary somewhat with seasonal and market influences (Refer Chapter 3), but percentages of the area used are dominated by grazing (80 - 90%) and cropping (5 - 10%). In the current work, most effort for pesticides was directed at monitoring for residues in surface waters, but a limited assessment of groundwater in the catchment was also carried out.

An audit of the annual pesticide usage in the catchment would be valuable but is currently not available. Such pesticide audits, conducted on either a catchment (Rayment and Simpson, 1993; Simpson *et al.,* 1992) or industry (Hamilton and Haydon, 1996) basis offer a rational approach for discussion of pesticide use and ways to minimise potential environmental impacts.

Major agricultural pesticide usage that might impact on the riverine system in the catchment is expected to arise from grazing (herbicides - woody weeds) and cropping (herbicides - weeds and insecticides - insects) activities. The environmental fate of the pesticides used depends very much on their physical and chemical properties as well as on their place of application. Their potential environmental impact in the short and longer term also depends on their toxicological properties with regard to the flora and fauna of the catchment and adjacent marine areas.

Project resources did not allow for the screening of large numbers of pesticides over a very large catchment at frequent intervals. In reality, this approach would not represent a very effective use of resources. Instead, the spatial and temporal use of pesticides for major land uses was taken into account and the sampling strategy for pesticide residues in surface waters adjusted accordingly.

Details of pesticides screened for, detection limits and sample numbers are included in Appendix D. In summary, a range of pesticides were screened for at least four times at the 11 primary river sites (Fig. 1.1, Nos. 1 to 11) during the project period. Dawson River sites (Site Nos. 12 to 15) were sampled far more frequently, as were flows in all sub-basins.

"Grazing" herbicides were monitored at most sites as grazing enterprises dominate the region. "Cotton" chemicals (selected herbicides and insecticides) were screened for at sites just above and downstream from cotton production areas, with sampling frequency being highest during the cotton (summer) growing season. The herbicide atrazine, used for weed control in broadacre cropping was frequently detected during initial sampling, and therefore was subsequently screened for at all sites.

Groundwater samples were monitored for atrazine and selected "cotton" chemicals.

Table 4.6, taken from the 1995/96 Report on Pesticide Monitoring of the Central and North West Regions Water Quality Program (Cooper, 1996) summarises water quality guidelines for a range of commonly used pesticides.

Table 4.6. Water Quality Guidelines, Standards and Health Advisory Levels for Pesticides in Water (all values expressed as μg/L).

	1987 NHMRC Australian Drinking Water Guidelines	1996 Draft NHMRC/ ARMCANZ Australian Drinking Water Guidelines**	1993 WHO Drinking Water Guidelines	1991 USEPA Office of Drinking Water Lifetime Health Advisory levels	1992 ANZECC Water Quality Guidelines for the protection of aquatic ecosystems	USEPA Ambient Water Quality Criteria for protection of aquatic organisms (acute exposure)	1993 Canadian Water Quality Guidelines for the protection of freshwater aquatic life
Insecticides							
Endosulfan	40	0.05	n.a.	n.a.	0.01	0.22	0.02
Profenofos	0.6	0.3	n.a.	n.a.	n.a.	n.a.	n.a.
Parathion	30	10	n.a.	n.a.	0.004	0.065	
Chlorpyrifos	2	n.a.	n.a.	n.a.	0.001	0.083	n.a.
Herbicides							
Atrazine	n.a.	0.5	2	3	n.a.	n.a.	2
Glyphosate	200	10	n.a.	700	n.a.	n.a.	65
Diuron	40	n.a.	n.a.	10	n.a.	n.a.	n.a.
Fluometuron	100	n.a.	n.a.	90	n.a.	n.a.	n.a.
Metolachlor	800	2	10	100*	n.a.	n.a.	8
Prometryn	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pendimethalin	600	n.a.	20	n.a.	n.a.	n.a.	n.a.
Trifluralin	500	0.1	20	2	n.a.	n.a.	0.1

Note: n.a. = not available

* USEPA note that all systems should monitor for metolachlor unless shown not to be present.

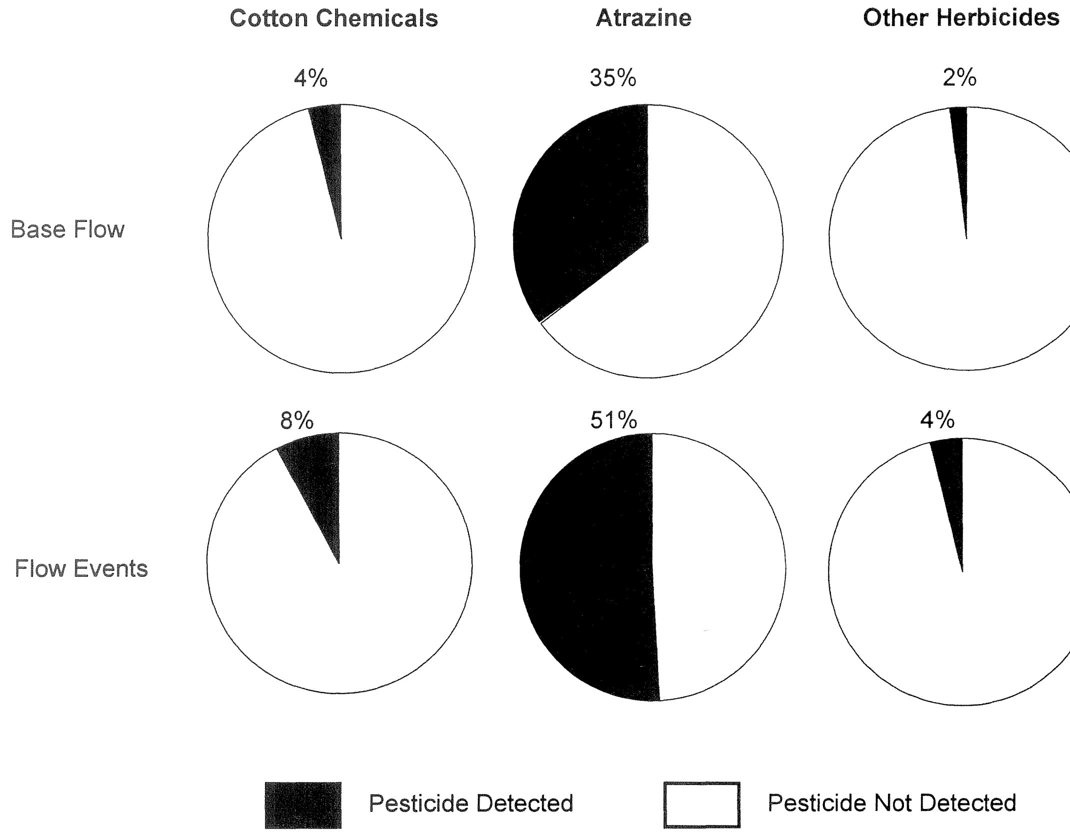
**Guideline Action levels - if pesticides exceed this level, then investigate source and rectify where possible.

Fig. 4.4 shows the percentages of major pesticide groups detected in surface water samples as a proportion of the total number of samples under base flow and flow conditions. Not unexpectedly, detections were more common under flow conditions when runoff had entered the streams. Further details regarding detections of pesticides in the surface waters of the Fitzroy catchment are summarised at the end of the chapter in Fig. 4.11.

Atrazine was by far the most commonly detected pesticide, being detected at least once at 9 of the 11 primary sites and at all four additional Dawson River sites (Fig. 1.1). The only primary sites at which atrazine was not detected were the "upper" catchment sites on the Dawson River at Baroondah and on the Nogoa River at Craigmore (Fig. 1.1, Site Nos. 8 and 11). The median concentration of atrazine detected in 132 river water samples was 0.27 μg/L. While this value is below water quality guidelines (Table 4.6), concentrations greater than 2 μg/L were detected in the Dawson, Mackenzie, Comet, Nogoa and Fitzroy sub-basins on at least one occasion. **These levels, while not common, clearly exceed both the 1996 Draft NHMRC/ARMCANZ Australian Drinking Water Guidelines and the 1993 Canadian Water Quality Guidelines for the protection of freshwater aquatic life (both listed in Table 4.6). The widespread distribution of this herbicide in surface waters of the catchment is also a matter of concern.**

"Cotton" chemicals were not detected upstream of irrigated cotton areas at Theodore/Moura on the Dawson River and at Emerald on the Nogoa River but were quite commonly detected downstream during the cotton (summer) seasons especially under flow conditions. Fig. 4.5 includes the temporal distribution for detections of "cotton" pesticide groups in the Fitzroy catchment over the project period.

Figure 4.4. Percentage of Major Pesticide Groups Detected in Surface Water Samples (as a proportion of total sampling) in the Fitzroy Catchment, 1993 - 1996.

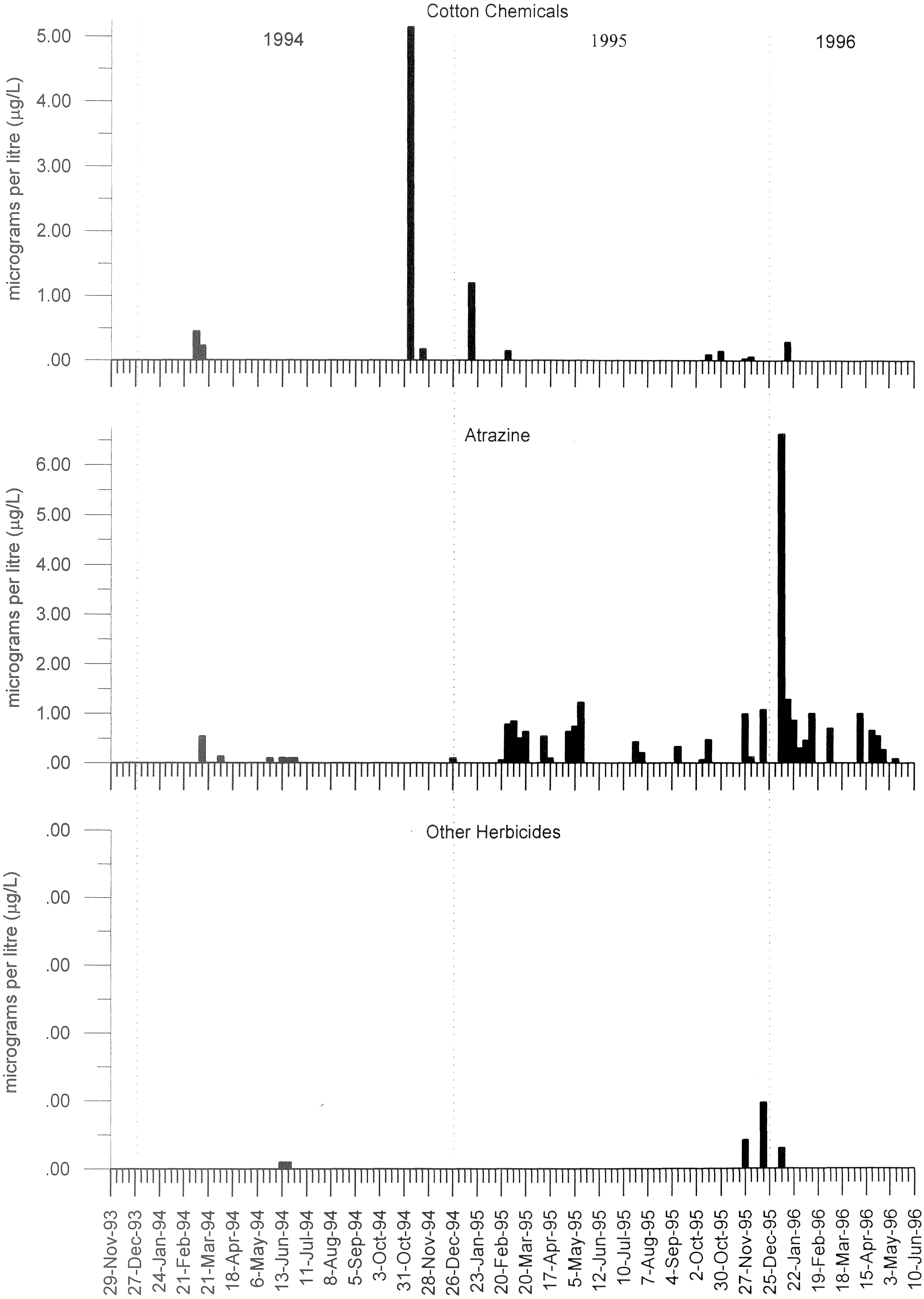


For the Dawson, "cotton" chemicals were detected on occasion as far downstream as Site No. 7 (Fig. 1.1). However, for the Nogoa, they were detected no further downstream than Site No. 10 (Duckponds). Prometryn was detected on one occasion in the upper Fitzroy at Site No. 16 (Riverslea) and DDE (arising from the historical use of DDT) was detected once in the mid Fitzroy at Site No. 1 (Eden Bann). "Cotton" chemicals were generally not detected out of season (in winter). Concentrations of "cotton" chemicals found were generally below water quality guidelines except for endosulfan. The value of 0.01 μg/L endosulfan, set in the 1992 ANZECC Water Quality Guidelines for the protection of aquatic ecosystems, is about the lowest concentration that can be easily detected in turbid river water samples. **As such, when endosulfan was detected during this study, it was invariably at or above this value, and exceeded the 1996 Draft NHMRC/ARMCANZ Australian Drinking Water Guidelines value of 0.05 μg/L (Table 4.6), on numerous occasions.**

"Grazing" herbicides were not commonly detected in the study, but low concentrations of tebuthiuron ("**GRASLAN**") were found on several occasions in the waters of the Comet, Mackenzie, Dawson and Fitzroy sub-basins.

The temporal distribution of detections of the major pesticide groups in the Fitzroy catchment are shown below in Fig. 4.5. As discussed, atrazine was detected throughout the year, but more commonly in summer flows and "cotton" chemicals were detected predominantly during the cotton (summer) season.

Figure 4.5. Temporal Distribution of Detection of Major Pesticide Groups in Surface Water Samples of the Fitzroy Catchment, 1993 - 1996.



Investigations of pesticide residues in groundwater resources of the catchment were less extensive. Low levels of atrazine were found on at least one occasion in observation bores in each of the Callide (Biloela), Dawson (Theodore) and Nogoa (Emerald) areas. No pesticide residues were detected in 18 production (irrigation) bores in the Callide Valley in September, 1994. **While this limited data suggests that widespread contamination of groundwater in the catchment by pesticides is unlikely, the ubiquitous occurrence of atrazine in surface waters makes some future screening of groundwater desirable.**

4.4 LOAD ESTIMATES.

4.4.1 Load Estimates in the Dawson and other Sub-basins.

The major sub-basins make significant but different contributions to flows in the lower Fitzroy (Table 2.3, Chapter 2). The relative sizes of these contributions varies from year to year and is highly dependant upon rainfall distribution patterns within the catchment. Anecdotal evidence suggests that when significant rainfall and runoff occur in only some of the sub-basins, the long-time observer of flows in the lower Fitzroy can predict the main source of the water (due to its physical characteristics such as colour and turbidity), as having arisen from the northern sub-basins (Connors/Isaac) or the southern sub-basins (Comet/Dawson). Water chemistry and quality from the different sub-basins is likely to reflect the different soil types and land use patterns in these areas.

In recent years, some problems with blue-green algae have been experienced in the Fitzroy River Barrage at Rockhampton and elsewhere in the catchment. A knowledge of flows and concentrations of suspended solids and nutrients (especially phosphorus) is important in understanding algal dynamics.

To understand how flows from the sub-basins influence water quality in the lower Fitzroy, assessments of **loads** (concentrations x flows) of suspended solids, nutrients and pesticides from the different sub-basins as well as physico-chemical characteristics are needed. Ideally, the concentrations of these parameters and the corresponding flows would be measured at the downstream ends of each of the sub-basins at frequent intervals, especially during major flow events when large quantities of materials are transported. In this way accurate estimates of loads could be made.

In this project, sampling frequency was generally too low for accurate load estimates to be carried out.As well, sampling was not always event based. The load results presented in this section should be regarded as crude approximations only.

Fig. 4.6 shows summarised instantaneous load data sets (concentration times corresponding flow on a number of occasions at the site), for Suspended Solids, Total Nitrogen and Total Phosphorus at several locations along the Dawson sub-basin (Site Nos. 7, 8, 12, 13 and 14) and at Riverslea (Site No. 16) on the upper Fitzroy. The data sets are severely skewed showing the influence of major flow events. **It is clear however, that TN and TP loads increase steadily moving down the Dawson sub-basin and into the upper Fitzroy**.

Fig. 4.7 similarly gives estimates of loads (tonnes/day) for the major sub-basins of the Fitzroy catchment albeit based on small data sets.

Figure 4.6. Load Estimates - Dawson Sub-basin and Upper Fitzroy.

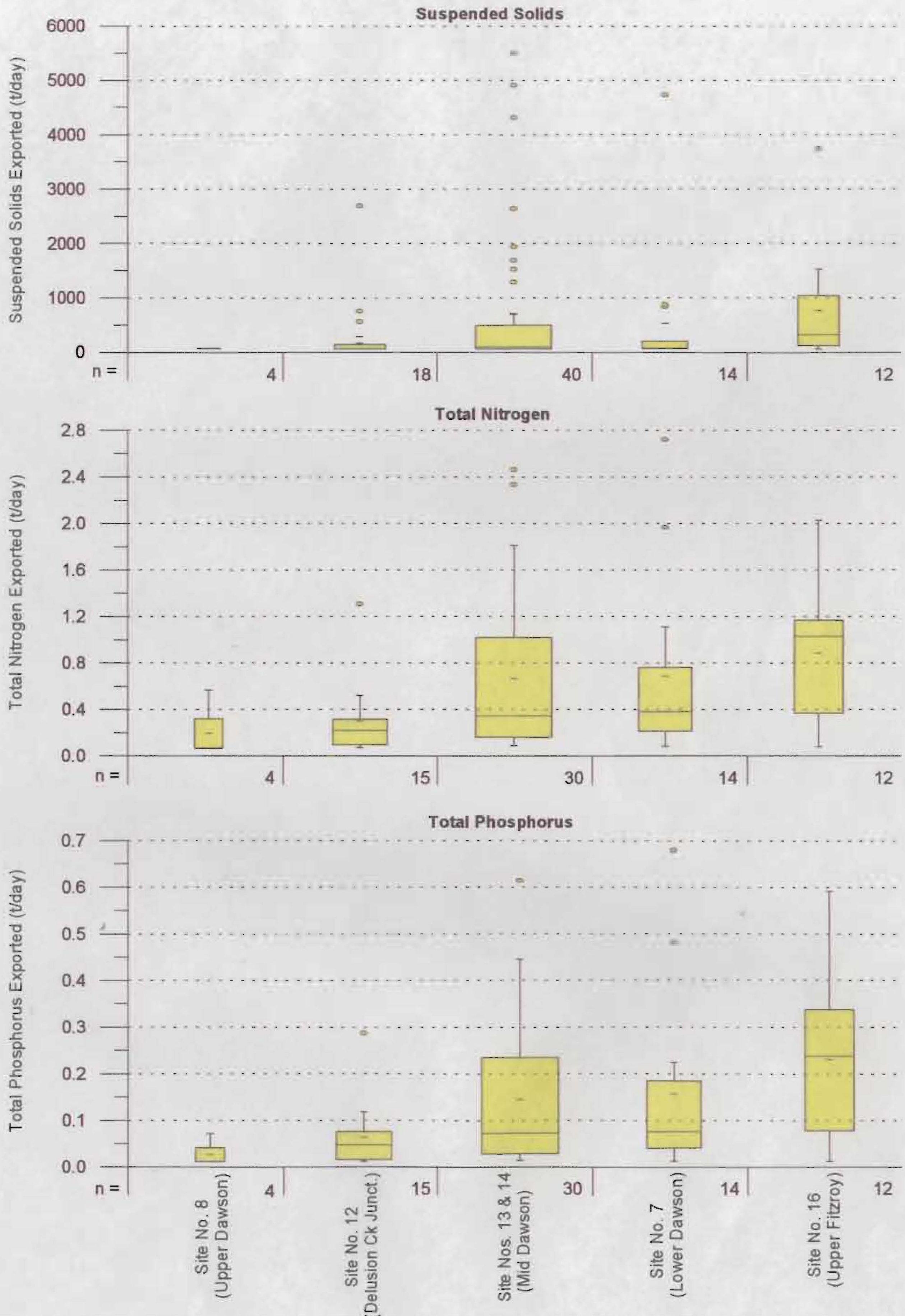
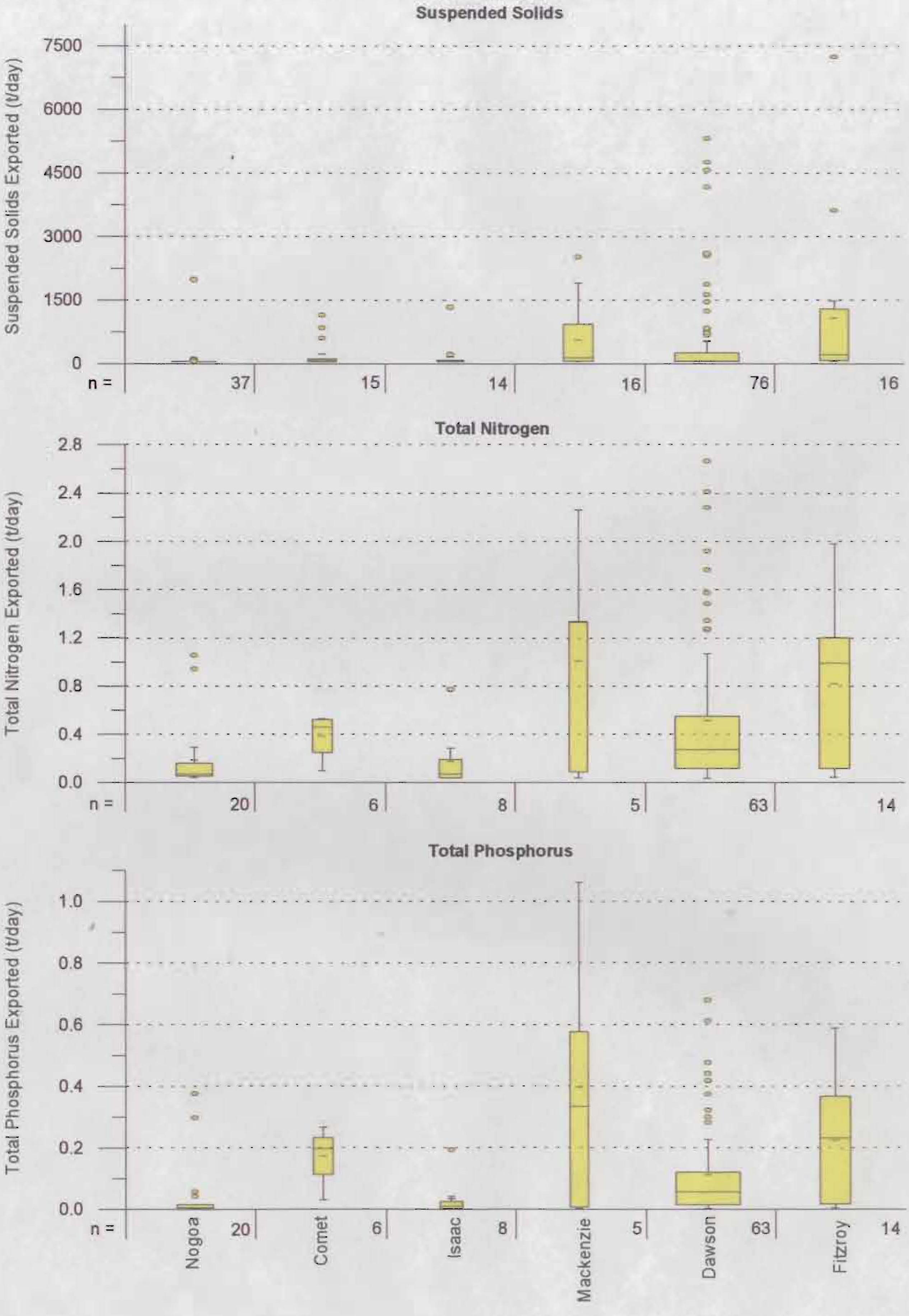


Figure 4.7. Load Estimates - Fitzroy Catchment - Major Sub-basins.



Estimates of loads for the sub-basins seem to indicate that the Nogoa and Isaac/Connors contribute lower loads of TN and TP than do the Mackenzie, Dawson and Comet. More complete data sets are needed, especially for significant flows in the sub-basins, to accurately assess load contributions to the Fitzroy.

4.4.2 Load Estimates for a Flow in the Dawson Sub-basin

Significant rainfall was recorded in the Wandoan/Taroom area of the upper Dawson sub-basin in February 1995. Combined with rainfall elsewhere in the sub-basin, this produced a significant flow in the Dawson which moved into the upper Fitzroy during late February and early March. Sampling of this event was carried out just prior to, during and after this flow on eight occasions at the upper Fitzroy site, Riverslea (Site No. 16). The total volume of water passing Riverslea during this event was approximately 326,000 ML.

Water quality parameters during flows are often different to those for base flow conditions. Table 4.7 illustrates this for the flow past the Riverslea site. The SS, TN and TP levels increased under flow conditions while EC and pH decreased.

Table 4.7. Water Quality Parameters at Riverslea under Flow and Base Flow conditions.

	pH	EC (μS/cm)	SS (mg/L)	TN (mg/L)	TP (mg/L)
Base flow	8.3	280	55	0.57	0.09
Flow	7.0 - 7.7	140 - 279	123 - 939	0.72 - 2.73	0.12 - 0.64

For this event, daily flow data were recorded. Estimates of suspended solids, total nitrogen, total phosphorus and atrazine **loads** that passed Riverslea were made using the daily flow information, the instantaneous concentration measurements and linear interpolations between these instantaneous concentration data. The eight samplings, although taken before, during and after the flow peak were spread over almost a month, therefore the load estimates in Table 4.8 should be regarded as crude approximations only.

Table 4.8. Estimates of Suspended Solids, Total Nitrogen, Total Phosphorus and Atrazine Loads for a Flow past Riverslea (upper Fitzroy) in Feb/March, 1995.

Parameter	Load	Mean Concentration
Suspended Solids	163,000 tonnes	500 kg/ML
Total Nitrogen	500 tonnes	1.53 kg/ML
Total Phosphorus	120 tonnes	0.37 kg/ML
Atrazine	74.5 kg	0.23 mg/ML

The results highlight the large quantities of suspended solids and nutrients that move from sub-basins into the lower Fitzroy under flow conditions.

4.5 HEAVY METALS and MAJOR IONS.

Because of resource limitations, studies were of a preliminary nature only and results should be interpreted accordingly.

4.5.1 Heavy Metals.

Sampling for **heavy metals** consisted of three activities with a single sampling for each:

- river **water** samples from Site Nos. 6, 12 and 15 (Don and Dawson sub-basins) and two locations (Walmul and Dululu) on the Dee River (a tributary of the Don and downstream from the Mt Morgan mine site) in January, 1996.
- streambed **sediment** samples from Site Nos. 1, 6, 7, 10, 11 and 14 (Fitzroy, Don, Dawson and Nogoa sub-basins) in the winter of 1995.
- freshwater **mollusc** (species of the genus *Alathyria*) samples from the 11 primary river sites and Callide Dam (Site Nos. 1 to 11 and 22) in June, 1994.

Heavy metal concentrations in the river **water** samples are summarised in Table 4.9.

Table 4.9. Total Heavy Metal Concentrations in Selected River Water Samples (mg/L).

	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Median	0.02	0.10	0.04	0.96	0.03	0.01	0.16
Range	0.02 - 0.1	0.01 - 1.0	0.01 - 0.06	0.20 - 1.5	0.03 - 0.07	0.01 - 0.04	0.04 - 0.26

For As, Se, Hg, Cd, Co and Mo, levels in water were below the detection limits of 0.05, 0.04, 0.1, 0.01, 0.05, 0.03 mg/L, respectively. Details of guidelines for acceptable heavy metal levels in water are available (ANZECC, 1992; NHMRC/ARMCANZ, 1994, Aust Drinking Water Guidelines, Draft).

While the heavy metal levels in these samples in general indicate that the water is acceptable as drinking water for livestock, in several instances concentrations exceed suggested levels for the Protection of Aquatic Ecosystems (ANZECC, 1992) and for Drinking Water (NHMRC/ ARMCANZ, 1994, Australian Drinking Water Guidelines, draft). It should be stressed that:

- this was a very limited sampling and in the context of the Fitzroy catchment was purposely biased towards sections of the Dee, Don and Dawson River systems where some impact from the former mining activities at Mt Morgan might be expected.
- the concentrations stated are **total** levels for the water samples i.e. include the heavy metal content of the aqueous phase and the suspended material.

Concentrations of heavy metals in water samples exceeded the suggested upper limits for the Protection of Aquatic Ecosystems in the following ways:

- copper and zinc levels at five of the six sites (all except Site No. 12, Dawson near Delusion Creek).
- chromium levels at Site No. 6 on the Don (Rannes) and Site No. 15 on the Dawson (Capricorn Highway crossing).
- lead levels at Site No. 6 on the Don (Rannes) and at Walmul on the Dee River.

Similarly, levels exceeded the suggested upper limits for Drinking Water as follows:

- manganese at all sites except Site No. 12 on the Dawson (near Delusion Ck).
- chromium at Site No. 6 on the Don (Rannes) and Site No. 15 on the Dawson (Capricorn Highway crossing).
- nickel at Site No. 6 on the Don (Rannes).
- lead at Site No. 6 on the Don (Rannes) and at Walmul on the Dee River.

A summary of heavy metal concentrations in streambed **sediments** is presented in Table 4.10.

Table 4.10. Heavy Metal Concentration in Streambed Sediments (dry matter basis) , ("macro" elements as %, "trace" elements as mg/kg).

Macro	%									
Elements	Al	Ca	Fe	K	Mg	Na	P	S	Si	Ti
Median	5.9	0.55	2.9	0.84	0.99	0.44	0.05	0.01	34	0.37
Range	2.2 - 10.3	0.11 - 0.97	0.8 - 7.1	0.49 - 1.5	0.14 - 1.9	0.2 - 0.7	0.02 - 0.08	0.001 - 0.42	26 - 40	0.07 - 0.81

Trace	mg/kg													
Elements	As	Se	Hg	Cd	Ba	Co	Cr	Cu	Mn	Ni	Pb	Sr	V	Zn
Median	2.8	0.09	0.02	0.02	292	13	79	24	543	39	12	93	65	66
Range	1.9 - 6.3	0.03 - 0.41	0.007 - 0.07	0.005 - 0.17	188 - 585	3 - 28	13 - 242	9 - 113	114 - 1136	5 - 135	6 - 22	33 - 182	13 - 187	38 - 139

Without replicated data, care should be taken in comparing results from different sites. For this limited data set, sediments from:

- the lower Don site Rannes (Site No. 6) showed the highest levels of As, Se, Hg, Cd, Al, Co, Cu, Mn, S, Ti, V and Zn.
- the mid Fitzroy site Eden Bann (Site No. 1) showed the highest levels of Cr, Ni and Mg.
- the Moura site on the mid Dawson (Site No. 14) showed the highest levels of Ba, Pb and Sr.

Results for analysis of the freshwater **molluscs** are summarised below in Table 4.11.

Fish

Table 4.11. Heavy Metal Concentrations in Freshwater Molluscs (mg/kg fresh weight).

	Cd	Zn	Pb	Fe	Mn
Median	0.02	28.0	0.08	262	151
Range	0.01 - 0.09	17 - 56	0.02 - 0.30	50 - 1007	50 - 433

There are limited published data available with which to compare these results. Compared with molluscs taken from 'clean' marine waters, Cd levels in the freshwater animals are very low (G. Barry, pers comm.). Without replicated data, care should be taken in comparing values for the animals from different sites. For these limited results, Cd values for molluscs from the lower Don (Rannes) and the lower Dawson (Beckers), (Site Nos. 6 and 7 respectively), were at the top of the range. Samples from the lower Don site, Rannes, had the highest Zn levels and those from the lower Dawson site, Beckers, had the highest Pb concentrations.

Do heavy metal levels in the molluscs reflect those in the sediments and water at the same site?

This study did not aim to answer this question. A more intensive (and replicated) sampling program would be needed. It is interesting, however, to look at this limited data set, in this light. Molluscs live in the bottom sediments and are filter feeders. They also have a wide distribution throughout the Fitzroy catchment.

Mollusc and sediment samples were both analysed from each of Site Nos. 1, 6, 7, 10 and 11, though samples were taken at different times. A water sample was also analysed from Site No. 6. Mollusc and sediment samples were both analysed for the elements Cd, Zn, Pb, Fe and Mn. Cd, Zn, Pb and Mn levels for sediment from Site No. 6 (Rannes), were all at the upper end of the range as were levels of Cd, Zn and Mn in mussels from the site. The Pb level in mussels from this site however, was quite low. Similarly, levels of Cd and Pb in mussels from Site No. 7, (Beckers) were comparatively high, while levels of these elements in the sediment were at the lower end of the range.

A more extensive and rigorous study would be needed to clarify these points. The potential movement of sediment and of these animals under flow conditions would also need consideration.

4.5.2 Major Ions.

The concentrations of major ions were measured in duplicate filtered and unfiltered samples from the primary river sites (Site Nos. 1 to 11) under base-flow conditions once in May/June, 1994.

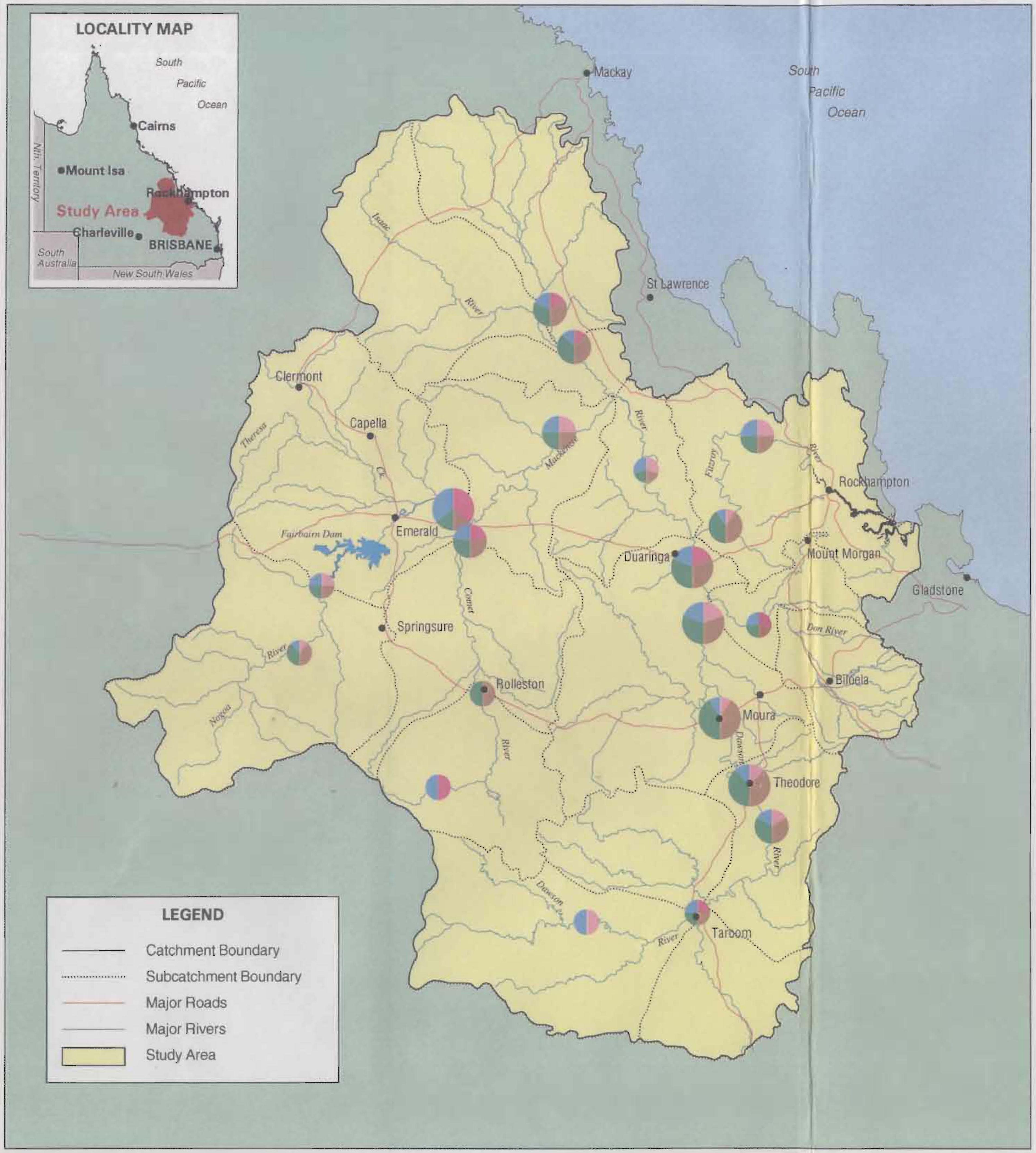
These data are summarised in Table 4.12.

Table 4.12. Concentrations (mg/L) of Major Ions in Water Samples from the Primary River Sites (Site Nos. 1 to 11).

	Cl	HCO_3	CO_3	Ca	K	Mg	Na	S	Si
n =	50	25	25	50	50	50	50	50	50
Median	26.5	42.7	12.6	11.0	4.4	9.5	19.7	1.1	6.7
Range	5.0 - 416	26.8 - 98.8	4.2 - 27.6	3.2 - 44.7	0.8 - 6.9	5.2 - 49.3	10.9 - 175	0.2 - 20.5	0.8 - 9.4

For the majority of samples, the level of major ions indicated that the water was acceptable for most uses. The Sodium Absorption Ratios (SAR) were low (0.6 - 4.4), indicating a general suitability for irrigation.

Data for Site No. 6 on the lower Don (Rannes), make it quite different from the other sites. Values for Cl, Ca, Mg, Na and S for this site were all at the high end of the range. Cl levels indicate that the water is not suitable for irrigation of sensitive crops (ANZECC, 1992) and for aesthetic reasons not suitable for drinking water (NHMRC/ARMCANZ 1994, Australian Drinking Water Guidelines, draft). These differences may be due to the incursion of ground-water at the site and possibly effects from past mining activities at Mt Morgan.



ELECTRICAL CONDUCTIVITY AND pH
Fitzroy Catchment 1993 - 1996
DELU Project

SCALE 1:2 500 000

kilometres 50 0 50 100 kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Figure 4.8

REFERENCE

Electrical Conductivity

BASE FLOWS		FLOW EVENTS
	<280 uS/cm	
	280-1500 uS/cm	
	>1500 uS/cm	

pH

BASE FLOWS		FLOW EVENTS
	<6.5	
	6.5-8.5	
	>8.5	

0 - 6 Samples taken

7 - 18 Samples taken

> 18 Samples taken

NATURAL RESOURCES

Land Resource Information Systems
Resource Management
Central Region
Rockhampton

QUEENSLAND GOVERNMENT

SUSPENDED SOLIDS
Fitzroy Catchment 1993 - 1996
DELU Project

SCALE 1:2 500 000

kilometres 50 0 50 100 kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

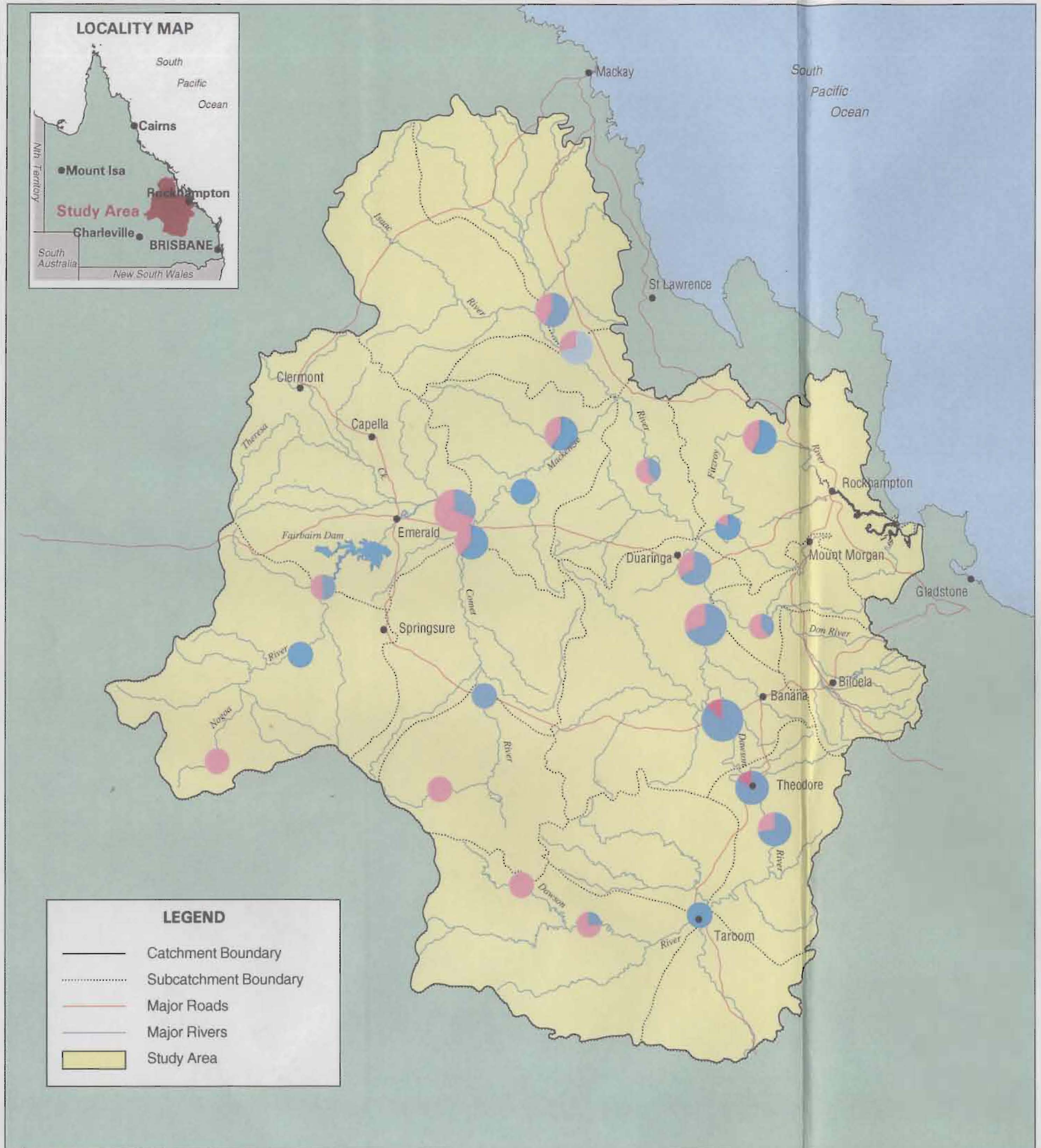


Figure 4.9

REFERENCE

Suspended Solids

BASE FLOWS		FLOW EVENTS
	0 - 0.1 gm/L	
	0.1 - 0.5 gm/L	
	> 0.5 gm/L	

0 - 6 Samples taken

7 - 18 Samples taken

> 18 Samples taken

NATURAL RESOURCES

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QUEENSLAND GOVERNMENT

TOTAL N and TOTAL P Fitzroy Catchment 1993 - 1996 DELU Project

SCALE 1:2 500 000

kilometres 50 0 50 100 kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

NATIONAL LANDCARE PROGRAM

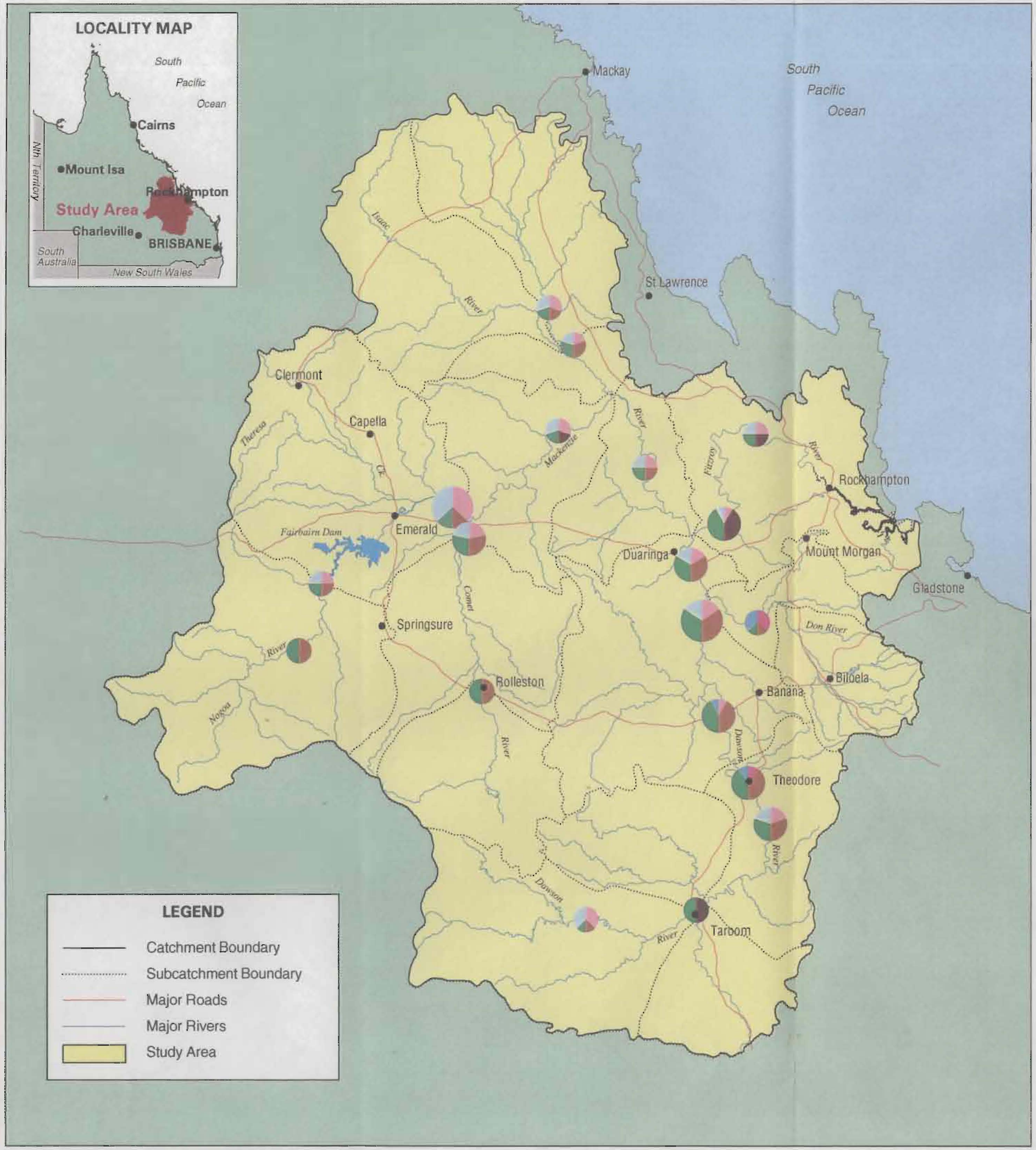

Figure 4.10

REFERENCE

Total Nitrogen

BASE FLOWS		FLOW EVENTS
	0 - 0.75 mg/L	
	0.75 - 1.5 mg/L	
	> 1.5 mg/L	

Total Phosporus

BASE FLOWS		FLOW EVENTS
	0 - 0.1 mg/L	
	0.1 - 0.2 mg/L	
	> 0.2 mg/L	

0 - 6 Samples taken

7 - 18 Samples taken

> 18 Samples taken

NATURAL RESOURCES

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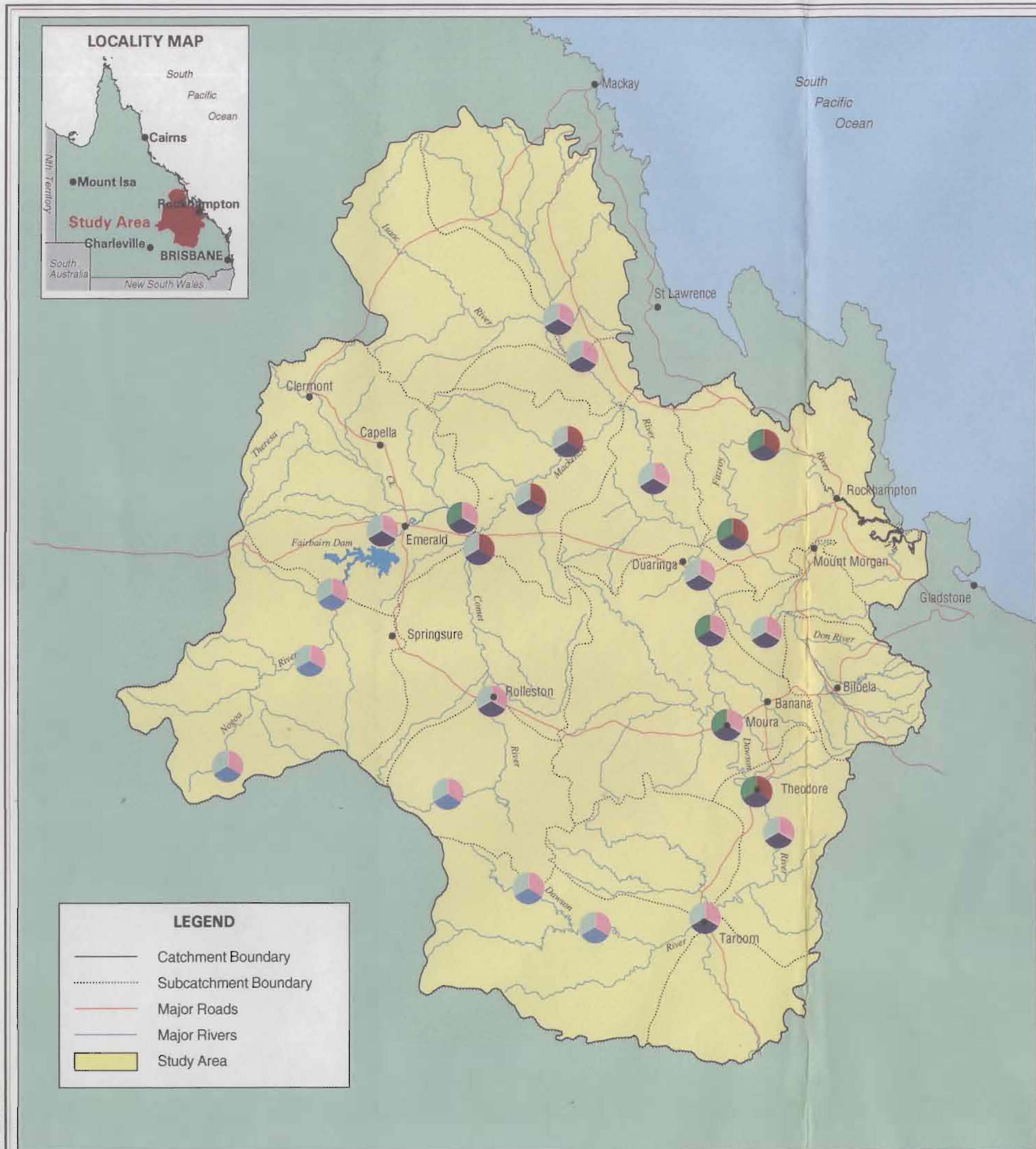


PESTICIDE DETECTIONS
Fitzroy Catchment 1993 - 1996
DELU Project

SCALE 1:2 500 000

kilometres 50 0 50 100 kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

NATIONAL LANDCARE PROGRAM

Figure 4.11

REFERENCE

Cotton Chemicals

Detected | Not Detected

Atrazine

Detected | Not Detected

Other Chemicals

Detected | Not Detected

NATURAL RESOURCES

Land Resource Information Systems
Resource Management
Central Region
Rockhampton

QUEENSLAND GOVERNMENT

5. AQUATIC and SEMI-AQUATIC PLANTS.

L. J. Duivenvoorden. Centre for Land and Water Resources, Central Queensland University, Rockhampton, 4702.

5.1 Introduction.

Aquatic plants or macrophytes play an integral role in freshwater aquatic systems. One of their most important roles is to help prevent soil erosion by binding the soil together along river and stream banks. They provide niches for animal life such as juvenile fish, water birds and myriads of aquatic invertebrates. They are eaten by many of these animals and provide an important food source in this way. They also help to prevent eutrophication of streams by absorbing nutrients and filtering soil particles out of water as in runs into waterways. They also compete with phytoplankton for nutrients that get into the water column and act as substrates for the microscopic organisms that live on them and also remove nutrients from the water. These organisms are in turn eaten by small grazing animals that are very important in sustaining fish and bird populations - especially during their breeding season. Aside from these important roles, water plants usually add much aesthetic appeal to water bodies and can help people ascertain the health of aquatic systems. In this study, the aquatic macrophytes at 11 primary sites in the Fitzroy River system were surveyed twice in 1994 and once in 1995 to assess the ecological "state of the health" of the river system. Other secondary sites were also surveyed.

5.2 Methods.

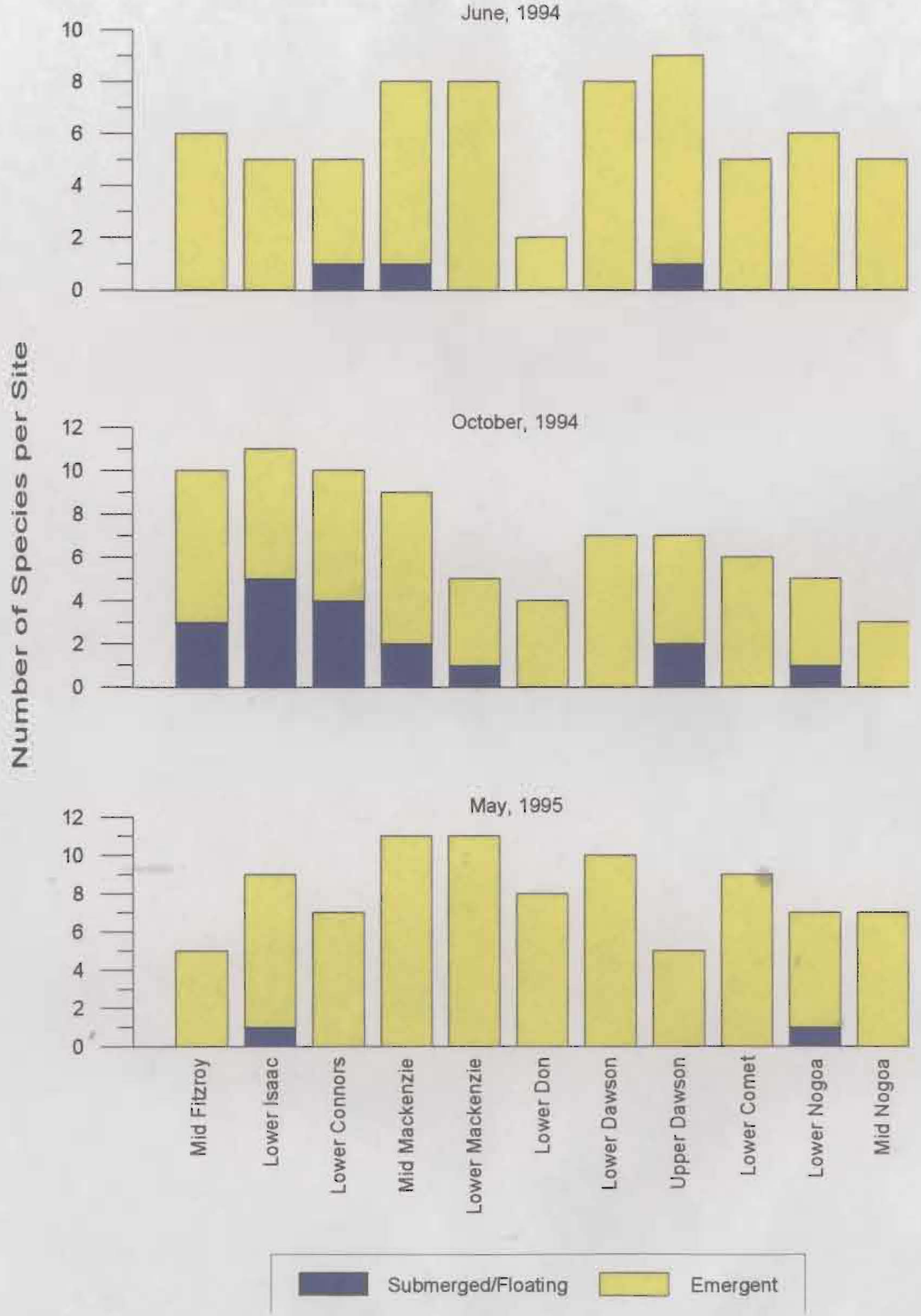
Site surveys entailed documenting the aquatic macrophytes present along approximately 200 m of stream bank or wetland area by recording presence/absence data as well as noting the most common and dominant aquatic or semi-aquatic plants present. At most sites the assessment was accomplished within one hour and this included collection of specimens not readily identifiable in the field. Collected specimens were pressed in newspaper and later identified in the laboratory. Plants that could not readily be identified were sent to the Queensland herbarium for identification. Specimens were stored at Central Queensland University (Freshwater Ecology Laboratory) for future reference.

5.3 Results and Discussion.

5.3.1 *Primary Sites.*

In June, 1994, the aquatic plant species most commonly occurring at the sites were species of *Lomandra, Cyperus, Persicaria, Muelenbeckia* and *Marsilea*. The species found were all desiccation resistant and were often found well up on the banks of the rivers away from the stream bed. Only three species of submerged aquatic plants were recorded - one at each of three sites. Generally, five to eight aquatic plant species were found per site, there being little difference between sites in this regard (Fig. 5.1). At Site No. 6 (on the Don River at Rannes) only two species were found and this may be related to high grazing pressure at this site. The number of species found per site was generally similar to the number found at similar sites in earlier studies of the Fitzroy River catchment (Duivenvoorden, 1992).

Figure 5.1. Number of Aquatic Macrophyte Species per Site at 11 Sites in the Fitzroy Catchment Sampled in June and October, 1994 and May, 1995.



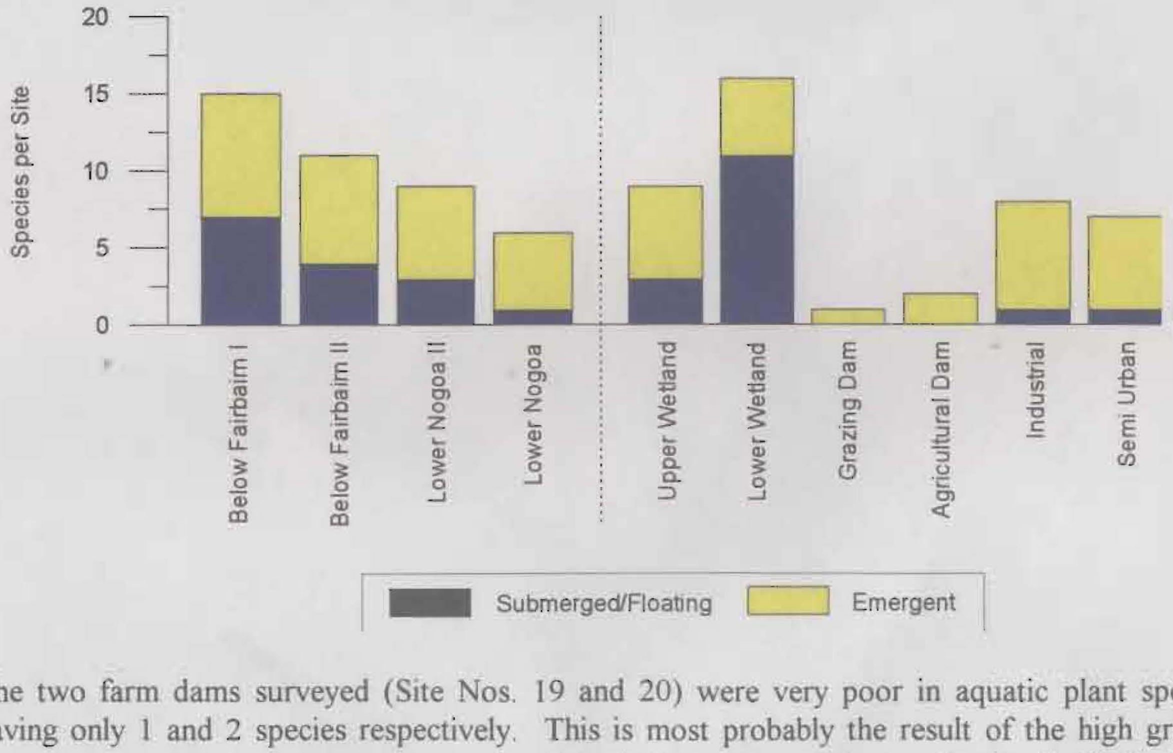
Compared to June, a larger number of submerged and floating species were found at sites in October (a total of eight including the macroscopic algae *Chara* and *Nitella*). Submerged species were more abundant (occurring at 7 of the 11 sites) and the most common were *Ottelia alismoides* and *Potamogeton crispus*. The increased occurrence may have been due to increases in water clarity as the dry season progressed. This would have increased light availability to the submerged plants and hence allowed them to grow. In contrast, *Cyperus rotundus* and *Marsilea drummundii* were found at fewer sites, most probably as a result of seasonal growth patterns. Generally, the number of species found per site in October was similar to that found in June.

In May, 1995, the pattern of macrophytes distribution was generally similar to that found in June, 1994. The overall numbers of species found per site were similar and there were few submerged or floating species present at this time of the year. Of note is the highly dynamic nature of the aquatic plant species present - many species were lost from some sites and replaced by others (See Duivenvoorden, 1992 for further information).

5.3.2 *Secondary Sites.*

One of the two wetland sites sampled in the catchment, the lower catchment wetland site, Lake Mary (Site No. 18), was relatively rich in aquatic macrophyte species, a total of 16 species having been found there (Fig. 5.2). The upper catchment wetland site, (Site No. 17), was in fact an overflow billabong for Palm Tree Creek and only 9 species were recorded at the time of the survey from this site. Extensive wetland areas are traditionally rich in aquatic plant species and the Lake Mary site is moderately rich in species compared to other sites surveyed within the catchment by Duivenvoorden (1992). This also corresponds well with the high invertebrate diversity found at these sites (see Chapter 7).

Figure 5.2. Number of Aquatic Macrophyte Species per Site at Four Sites on the Nogoa River System and at Six Sites on Streams, Dams and Wetlands within the Fitzroy Catchment Sampled between October, 1995 and January, 1996.



The two farm dams surveyed (Site Nos. 19 and 20) were very poor in aquatic plant species, having only 1 and 2 species respectively. This is most probably the result of the high grazing pressure on the plants at the former dam and at the latter, the great capacity for *Typha* (bulrush) and *Urochloa mutica* (Paragrass) to out compete other aquatic plant species. The lack of a range of aquatic plant species reduces the habitat available for other aquatic biota and this is reflected in the biological results presented for these sites in the other chapters of this report.

For the sites on the Nogoa River studied in relation to the Emerald Irrigation Area (EIA), the sites upstream of the EIA (Site Nos. 26 and 27) had 15 and 11 species respectively, while the sites below (Site Nos. 28 and 10) had 9 and an average of 6 species respectively. This distribution pattern is similar to the distribution pattern found for the aquatic invertebrates (discussed in Chapter 7). The results support the contention that the Emerald Irrigation Area has a marked effect on the aquatic biota of the Nogoa River.

6. PLANKTON (Phytoplankton and Zooplankton)

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6.1 Introduction.

Plankton are at the base of food chains in aquatic systems. The abundance and structure of the planktonic population rapidly reflects changes in water quality and flow. Some components of the planktonic population which develop may then cause other changes in water quality parameters. Cyanobacteria (blue-green algae) for example, may produce undesirable tastes, odours and toxins. This may render the water unsuitable for use by animals or humans.

The plankton of the Fitzroy River catchment is relatively unknown. Recent studies of the lower Fitzroy River at Rockhampton have shown an algal population dominated by cyanobacteria in the late winter to summer (when the water column was stratified). Thirty species of zooplankton (1 ciliate, 27 rotifers, 4 cladocerans and 3 copepods) were identified (Fabbro and Duivenvoorden, 1992, 1996; Fabbro and Watson, 1992). Cyanobacteria found in the lower Fitzroy River and known to have toxic strains in Australian waters include *Anabaena circinalis, Cylindrospermopsis raciborskii* and *Microcystis aeruginosa* f. *aeruginosa.* Bloom samples dominated by *Nostoc* cf. *Linckia* from this area have also been found to be toxic by mouse bioassay (Fabbro and Duivenvoorden 1993). Diatoms have been studied at selected sites in the catchment (Foged, 1978), but there is no published information about the other phytoplankton or zooplankton in the remainder of the catchment. With such a scant body of information, this study aims to provide an initial investigation of the phytoplankton and zooplankton of the Fitzroy River catchment. Where possible, conditions associated with cyanobacterial dominance and bloom formation also were investigated.

6.2 Methods.

6.2.1 *Phytoplankton.*

The phytoplankton at 11 selected primary sites (Sites 1 to 11, Fig. 1.1) in the Fitzroy River catchment was surveyed on two occasions in 1994 (June and October) and once in May 1995. Occasionally, samples also were obtained from selected sites on the Dawson River and from various dams, wetlands and smaller streams. A comparison also was made during the (i) late winter/early spring, (ii) early summer and (iii) late summer/early autumn (after inflows) between two dams in the catchment area. These were Theresa Dam, near Clermont, with a history of problematic cyanobacterial blooms and Callide Dam near Biloela with no history of such problems. Samples were collected in duplicate by hosepipe and preserved using either 4% calcium buffered formalin or Lugol's iodine. Algae were identified using relevant Australian and international keys. Counts for cell density were determined using a Sedgwick Rafter Counting Cell at 400 or 320 X magnification after concentration to one tenth of the original volume. Individual cells in 30 randomly selected Sedgwick Rafter squares or in 100 organisms (cells, trichomes or colonies), were counted. Results reported are the means of the data obtained.

6.2.2 *Zooplankton.*

Zooplankton was sampled at the same time as phytoplankton at the 11 primary Fitzroy catchment sites on the first sampling occasion only. Vertical tows were made through the water column using a 25 μm plankton net. The concentrated sample then was preserved using 70% ethanol.

6.3 Results.

6.3.1 *Phytoplankton.*

Primary sites.

Mean phytoplankton cell densities at the eleven sites on all sampling occasions were less than 5,000 cells/ml with the exception of the Lower Don Site (Site No. 6) in May 1995 (Fig. 6.1). Cyanobacteria (blue-green algae) dominated at times of increased cell density. Species richness ranged between 0 and 35 taxa per site during the sampling period.

The assemblage of phytoplankters present in June 1994 differed from that in May 1995. In June 1994, diatoms and chlorophytes were dominant (Fig. 6.2 and Table 6.1). However, in May 1995, flagellated euglenophytes and cryptophytes dominated in the conditions of higher sediment load and warmer water temperatures.

In October 1994, algal densities were higher at sites closer to the mouth of the river (Fig. 6.1). Phytoflagellates and cyanobacteria became prominent components of the population (Fig. 6.2 and Table 6.1). Whilst 5 upstream sites recorded less than 160 cells/ml, cell densities at sites on the Fitzroy and Mackenzie rivers in the lower central section of the catchment were higher and dominated by cyanobacteria. Common cyanobacterial genera were *Anabaenopsis, Aphanizomenon, Cylindrospermopsis* and *Pseudanabaena.*

Selected dams, streams and wetlands.

Mean cell densities were variable at the selected dam, creek and wetland sites (Fig. 6.3). High densities were obtained in the agricultural farm dam (Site No. 20) and at the lower wetland site - Lake Mary (Site No. 18). The pattern of cyanobacterial dominance at times of increased cell density found at the eleven primary river sites also occurred at these sites. Phytoflagellates and cyanobacteria were important elements of the phytoplankton population at all sites (Fig. 6.4). Genera identified at the Taroom wetland site (upper Dawson River) included *Pseudanabaena, Anabaena, Ceratium* and *Trachelomonas. Anabaena* and *Ceratium* frequently are associated with eutrophication (Reynolds, 1980). The *Anabaena circinalis* found in this sample is a common potentially toxic bloom forming cyanobacterium in Australian rivers (Baker, 1991).

Algal blooms (> 15,000 cells/ml) were recorded in Theresa Dam in August and November 1995 and in October 1995 in Callide Dam (Fig. 6.5). In late summer after inflows, Callide Dam recorded a higher mean cell density than Theresa Dam, in which no cells were recorded. Cyanobacteria dominated the majority of samples from both sites. The major genera of cyanobacteria present differed between these sites. The larger cyanobacterial forms of *Microcystis, Cylindrospermopsis* and *Anabaena* were found in Theresa Dam but smaller Chroococcales (*Aphanocapsa, Aphanothece, Chroococcus* and *Gleothece*) were found in Callide Dam along with *Pseudanabaena* and *Cylindrospermopsis*. Whereas no algal cells were detected in the Theresa Dam samples following inflows, samples from Callide Dam were dominated by the cyanobacterium *Pseudanabaena.*

Figure 6.1. Mean Cell Densities of Cyanobacteria and other Algal Groups, Primary River Sites, Fitzroy Catchment, 1994 - 1995.

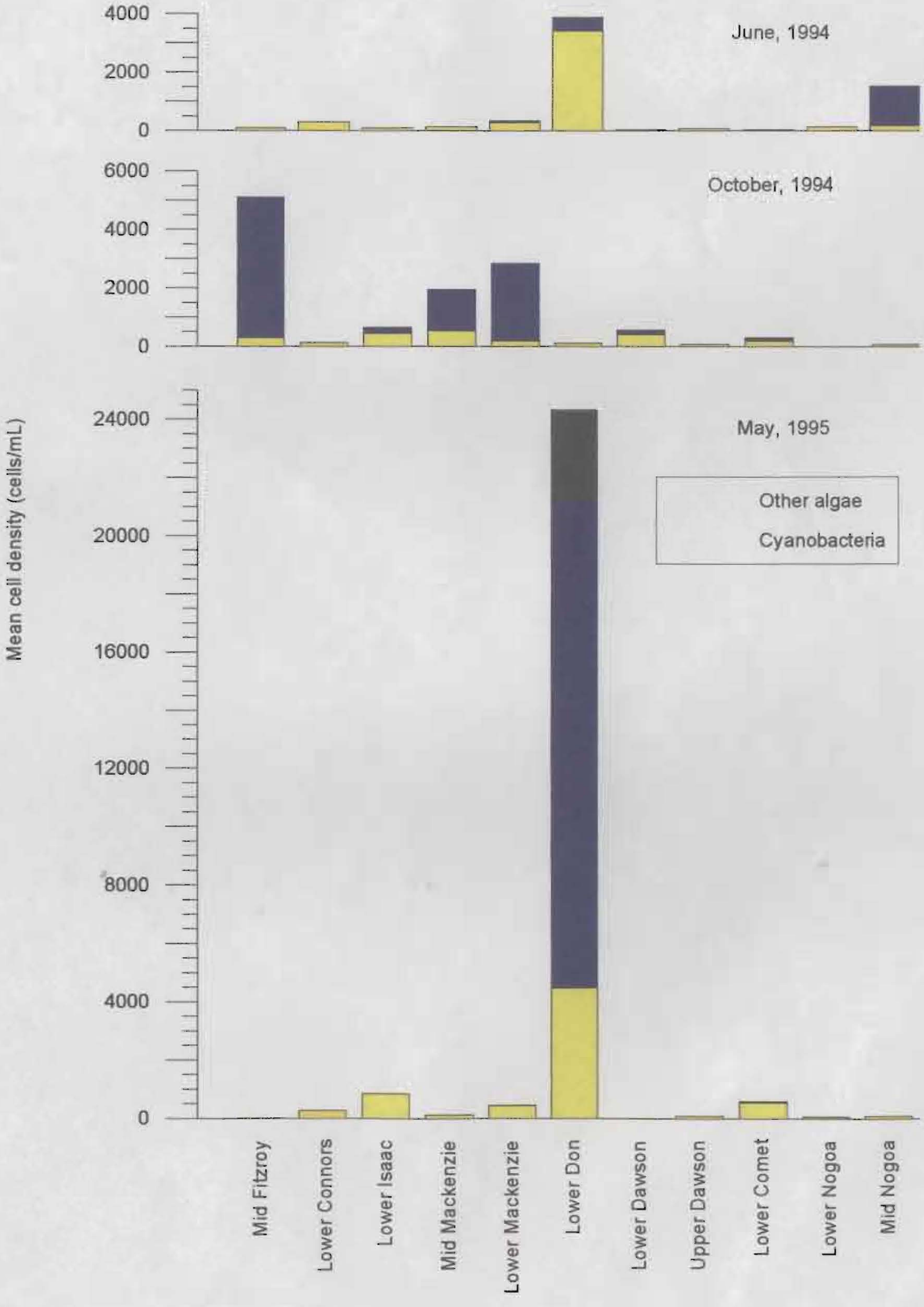


Table 6.1. Phytoplankton Genera Identified from the 11 Primary River Sites in June 1994, October 1994 and May 1995.

Phytoplankton genera recorded		June 1994	October 1994	May 1995
Bacillariophyta:	*Aulacoseira (Melosira)*	+	+	+
	Cocconeis	+		+
	Fragilaria	+		+
	Frustulia	+	+	+
	Gyrosigma	+	+	+
	Navicula	+	+	+
	Nitzschia	+	+	+
	Synedra	+	+	+
	Gomphonema	+		
	Stauroneis	+		
	Stenopterobia	+		
	Surirella	+		
	Cymbella			+
	Epithemia		+	
Chlorophyta:	*Actinastrum*	+		
	Pyramimonas	+		+
	Ankistrodesmus	+	+	+
	Carteria	+	+	+
	Chlamydomonas	+	+	+
	Scenedesmus	+	+	+
	Pandorina	+	+	
	Gonium		+	
	Staurastrum		+	
	Tetrastrum		+	
	Closterium		+	+
	Coelastrum			+
	Cosmarium			+
	Staurodesmus			+
Euglenophyta:	*Euglena*	+	+	+
	Trachelomonas	+	+	+
	Lepocinclis	+	+	
	Strombomonas	+	+	
	Phacus		+	
Pyrrophyta:	*Glenodinium*	+	+	+
	Peridinium	+	+	+
Chrysophyta:	*Dinobryon*	+	+	
Cryptophyta:	*Cryptomonas*		+	+
Cyanobacteria:	*Anabaena*	+	+	+
	Pseudanabaena	+	+	+
	Raphidiopsis	+		+
	Aphanocapsa	+		
	Nostoc	+		
	Chroococcus			+
	Phormidium			+
	Gleocapsa			+
	Merismopoedia		+	+
	Cylindrospermopsis		+	+
	Anabaenopsis		+	
	Aphanizomenon		+	
	Oscillatoria		+	
	Spriulina		+	

Figure 6.2. Relative Abundance of Major Algal Groups (%), Primary River Sites, Fitzroy Catchment, 1994 - 1995.

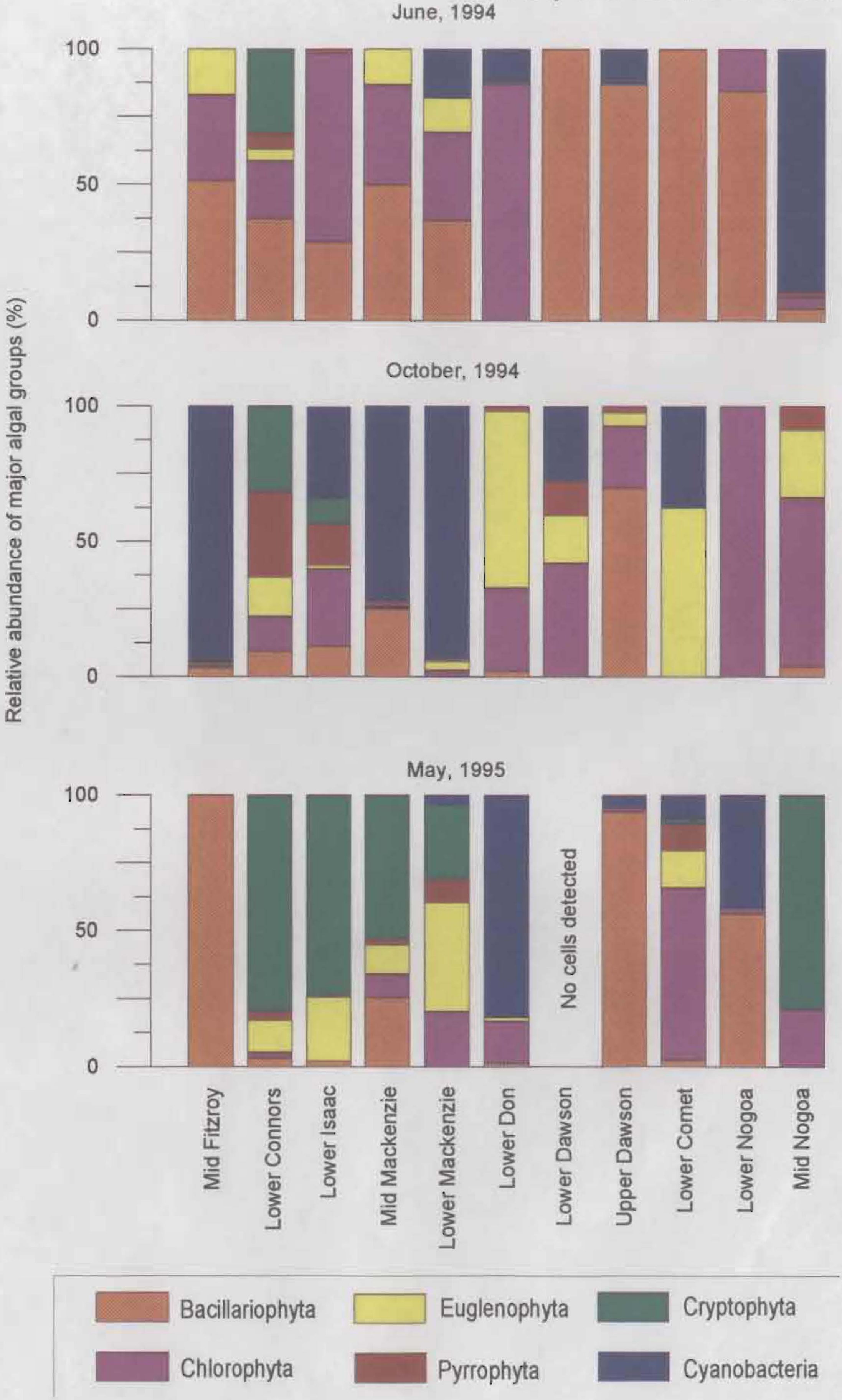


Figure 6.3. Mean Cell Densities of Cyanobacteria and Other Algal Groups for a Single Sampling, Secondary Sites, Fitzroy Catchment, 1995 - 1996.

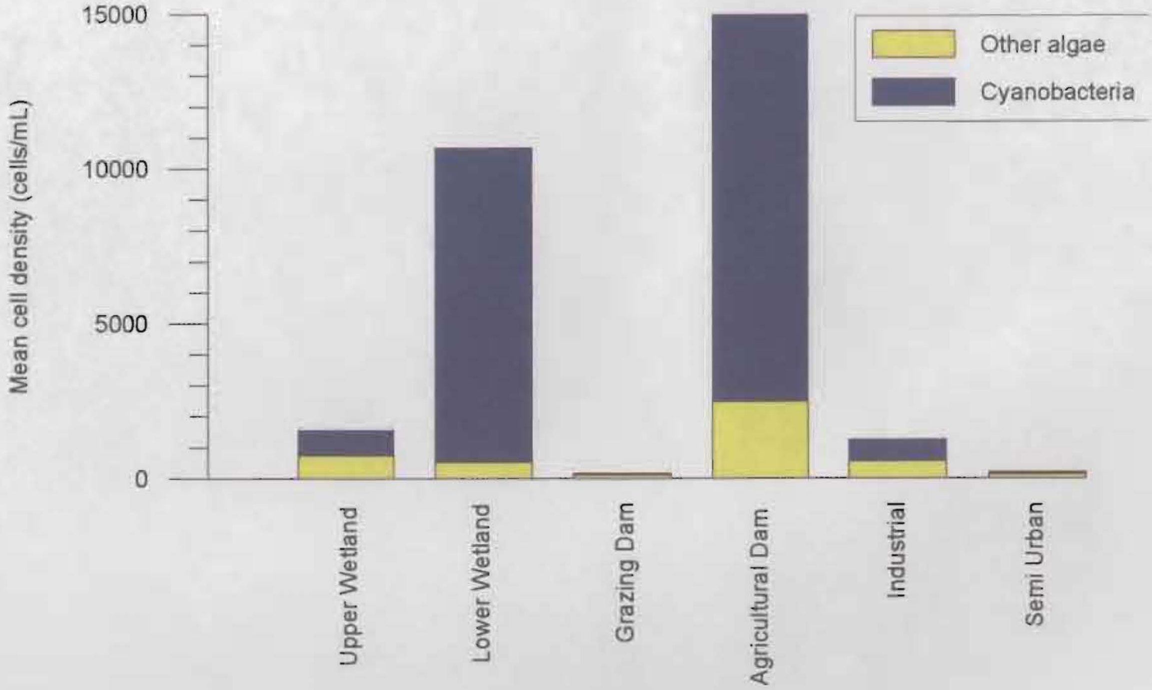


Figure 6.4. Relative Abundance of Major Algal Groups for a Single Sampling, Secondary Sites, Fitzroy Catchment, 1995 - 1996.

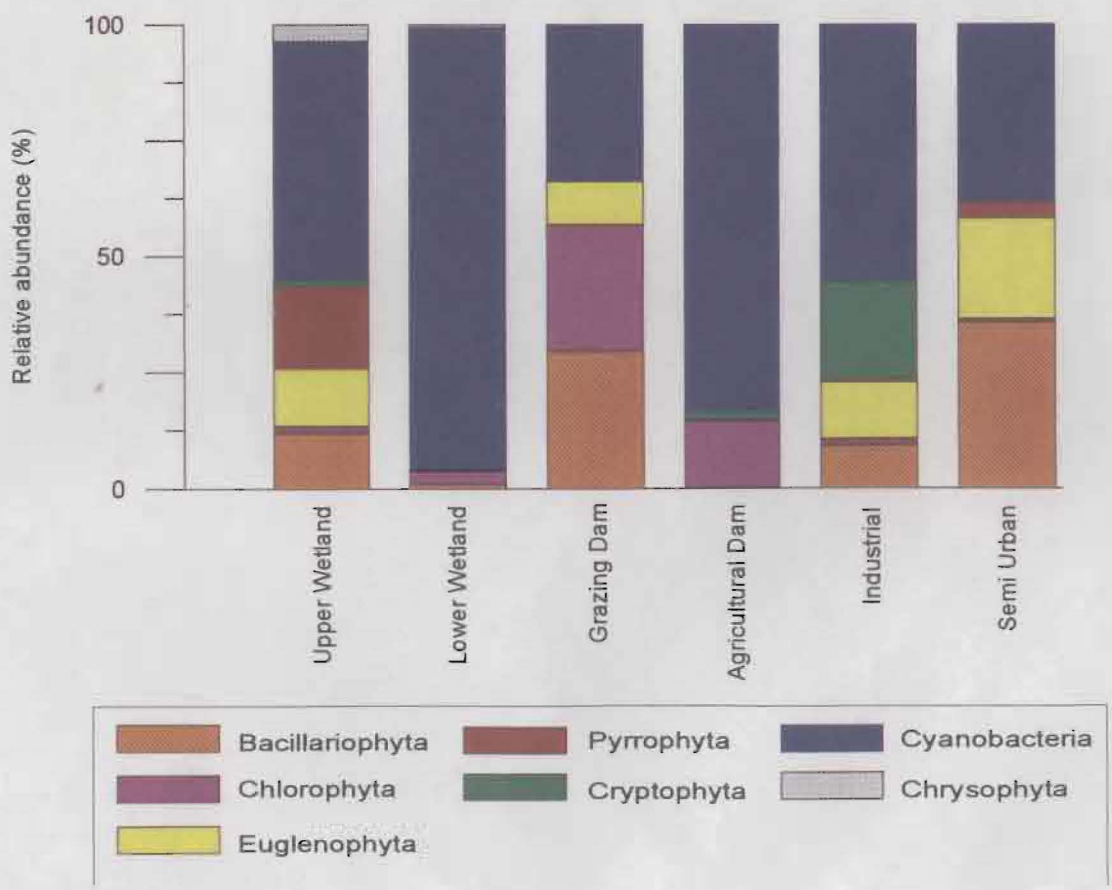
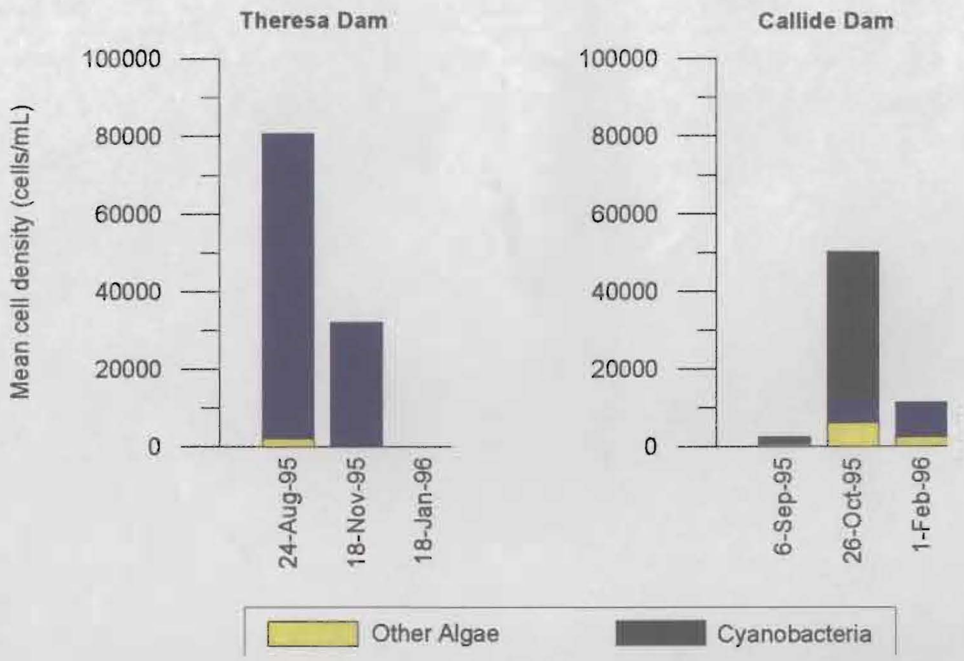


Figure 6.5. Mean Cell Densities, Theresa Dam and Callide Dam, 1995 - 1996.



Dawson River Sites.

A more detailed study was made of selected sites along the Dawson River. One objective was the analysis of conditions related to cyanobacterial bloom formation. During the study, a cyanobacterial bloom formed in late 1994 in Moura Weir as the sediment load decreased (Johnstone *et al.* 1995). The bloom also occurred a week after inflows into the stratified weir. Such small flows have the potential to recharge surface waters with bioavailable phosphate released from the sediments into the anoxic hypolimnion at times of stratification. This pattern was not repeated in 1995 (unpublished data).

Other Dawson river sites sampled in 1994 included Theodore Weir, the Dawson River near Delusion Creek and the Dawson River at the point where it intersects with the Capricorn Highway (Site Nos. 12, 13 and 15, Fig. 1.1). One sample from the Capricorn Highway site on 18 October, 1994 contained 5,160 cells/ml. The cell density was less than 155 cells/ml at all other Dawson River sites sampled at this time and coincided with high sediment load.

6.3.1 *Zooplankton.*

The zooplankton of rivers is often dominated by rotifers with cladocerans and copepods occurring to a lesser extent (Shiel, Walker and Williams, 1982). In the present study, the most commonly occurring zooplankters were rotifers (Table 6.2 and Fig. 6.6). Genera recorded included *Brachionus, Filinia, Keratella, Polyarthra, Synchaeta* and *Trichocerca*. A small number of copepod species were present at each site and cladocerans were detected at only four of the 10 primary sites where zooplankters were recorded. Species richness was greatest at downstream sites - the lower Dawson site and sites on the Fitzroy and Mackenzie Rivers. Zooplankton were not present in the sample taken from the lower Nogoa River (Site No. 10).

Figure 6.6. Number of Zooplankton Taxa at Primary River Sites, Fitzroy Catchment, October, 1994.

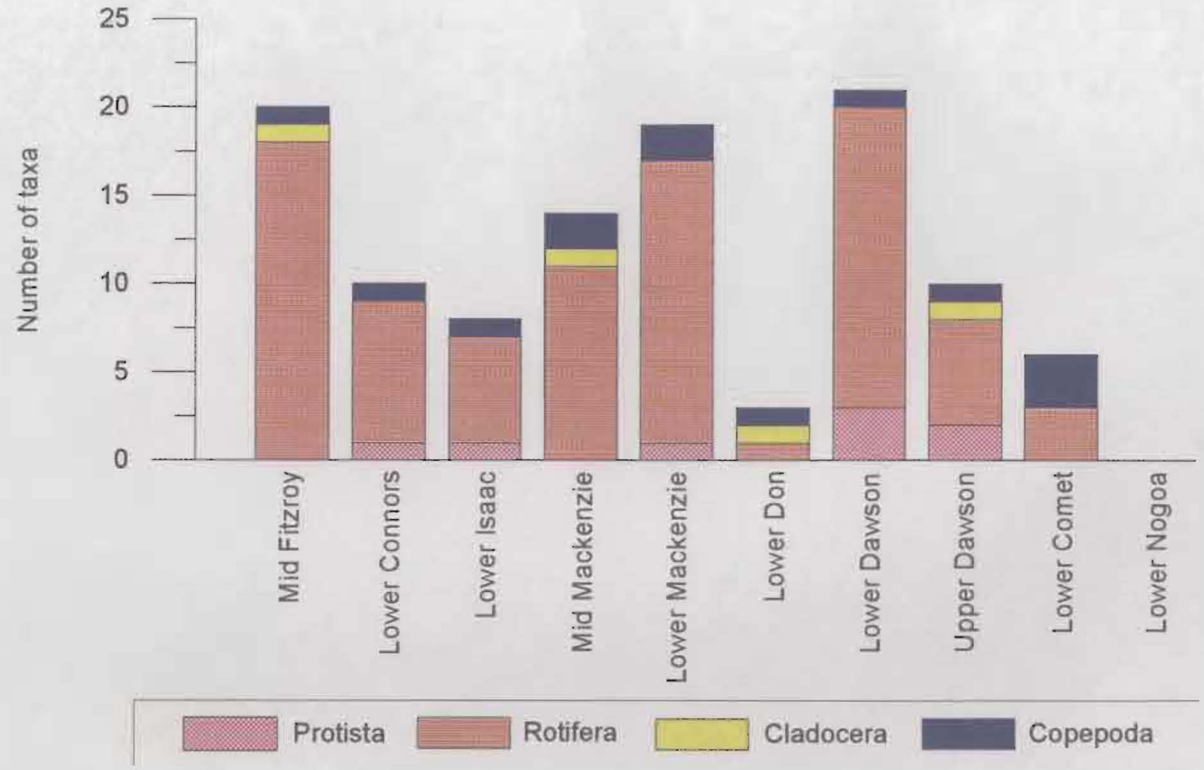


Table 6.2. Zooplankton Genera Identified from the 11 Primary River Sites, October, 1994

Protista:	*Arcella*	**Rotifera:**	*Rotaria*
	Centropyxis		*Anuraeopsis*
	Cyphoderia		*Asplanchna*
	Difflugia		*Brachionus*
Cladocera:	*Daphnia*		*Conochilus*
	Diaphanosoma		*Filinia*
	Macrothrix		*Hexarthra*
Copepoda:	*Boeckella*		*Keratella*
	Calamoecia		*Polyarthra*
	Mesocyclops		*Synchaeta*
			Trichocerca

6.4 Discussion.

6.4.1 *Phytoplankton.*

In this project, various sections of the tropical Fitzroy River catchment were sampled during years of high turbidity and drought. The phytoplankton samples taken during this period were characterised by generally low abundances. When algal cell densities increased, cyanobacteria dominated. This pattern of cyanobacterial dominance occurred in both wetland and riverine sites throughout the catchment. Although only the zooplankton *composition* was analysed during this study, the structure of the population was similar to that of most rivers.

Low algal densities often were associated with high levels of suspended solids eg. the mid Fitzroy site (Site 1, Eden Bann), and the lower Nogoa site (Site 10, Duckponds), in May 1995 (see Fig. 6.1). Low penetration of light into the water column (as a result of a high load of suspended solids) would have produced extremely difficult conditions for algal growth. The widespread occurrence of such conditions is shown by the low Secchi depths at the eleven primary river sites during this study.

The availability of light can also influence the composition of the phytoplankton population. The most common elements of the population - phytoflagellates and cyanobacteria, are not reliant upon water movement for their suspension. Selective positioning using either flagellae or gas vacuoles enables them to move to the small section near the surface of the water body where light is available. The differences in algal abundances following inflows into Callide and Theresa Dams may be explained by the differences in sediment loads at that time. Callide Dam had a sediment load ranging between 55 and 74 mg/L following inflows whereas the values in Theresa Dam were far higher (353 to 410 mg/L).

High nutrient levels, lack of mixing or flow, high temperatures, high pH/low CO_2 and lack of available nitrogen are other factors which enable cyanobacteria to dominate the phytoplankton of a water body (Paerl, 1988; Reynolds and Walsby, 1975; Shapiro, 1990). Nutrient levels recorded in this study were often high (See Fig. 4.1). Total phosphorus levels ranged between 0.02 and 1.195 mg/L. However, much of this phosphorus was bound to sediments and not bioavailable in the form of orthophosphate. High levels of orthophosphate were recorded at the mid Fitzroy site (Site 1, Eden Bann) in June 1994 and May 1995 (unpublished data), but levels were lower in the October 1994 sampling and at many of the upstream sites. The decreased levels at the mid Fitzroy site in October 1994 would have resulted, at least in part, from incorporation into algal tissue.

Nitrate nitrogen was below detectable limits on many sampling occasions (unpublished data). Such an absence of available nitrogen would have selected for cyanobacteria capable of nitrogen fixation. This would have been a contributing factor in relation to the success of nitrogen-fixers such as *Anabaena, Aphanizomenon, Anabaenopsis* and *Cylindrospermopsis.*

The tropical location of most of the Fitzroy River catchment ensures warm temperatures for most of the year. This coupled with the pH range and increases in pH in the summer months were additional factors which would have selected for cyanobacterial dominance. In the Fitzroy River catchment in October, 1994, the pH at sites dominated by cyanobacteria was in the range 8.2 to 9.2 and was higher than that recorded at sites where other algal groups dominated.

High sediment loads can also influence the structure of the zooplankton community. Planktonic cladocerans, especially daphnids, which rely on the suspended materials in the water column as a food source are adversely effected by high sediment levels. Abundance, growth and survival and feeding rates can be affected (Kirk, 1992; Kirk and Gilbert, 1990). This may have caused the absence of cladocera at many of the sites during this project.

The quality of the phytoplanktonic food source can also influence the abundance of zooplankton and the population structure. The sites with the greatest richness of species were also the sites with the highest phytoplankton cell densities in October, 1994. There is a growing body of evidence illustrating that cyanobacteria have adverse effects upon cladocerans especially in relation to feeding (Lampert, 1987). This factor may also have contributed to the lack of cladocerans at many of the primary river sites. The complete absence of all zooplankton at the Lower Nogoa site may be the result of decreased availability of phytoplankton but physical or chemical conditions at the site must also be considered as they may have produced difficult conditions for the survival of any planktonic organisms. Of note here also is the lower abundance of aquatic macroinvertebrates found at this site compared to similar sites throughout the catchment (see Chapter 7).

There are many similarities between the Fitzroy River system and the Darling River. The high turbidity of the Darling River has been suggested as sufficient to limit algal photosynthesis (Shiel and Walker, 1985). Both rivers have rotifer dominated zooplankton and absence of larger forms. Shiel (1986) gave a number of possible reasons for the structure of the Darling population. These included insufficient algae as a food source for larger herbivores and limited feeding and locomotion of larger zooplankton in waters containing a high level of suspended solids. Clearing of the water column has been associated with increased algal productivity and cyanobacterial dominance in both rivers (Johnstone *et al.*, 1995; Bowling and Baker, 1996; Fabbro and Duivenvoorden, 1996). However, the occurrence of a large toxic algal bloom has not to date been documented as occurring in the Fitzroy catchment.

6.5 Conclusion.

The high sediment and nutrient load carried by this river system has serious implications with regard to the abundance and structure of the potamoplankton or river plankton. Whilst reduction in sediment load will increase primary productivity and decrease the riverine nutrient loading in the long term, riverine conditions during this study showed the potential for cyanobacterial blooms rather than those of any other group when suspended solid levels are low. It is essential that future river management takes into account this propensity for cyanobacterial dominance and every attempt is made to minimise where possible the conditions which select for the dominance and increased cell density of this group

6.6 Summary.

High cyanobacterial (blue-green algal) cell densities appeared at various times throughout the catchment and not only at downstream sites on the Fitzroy and Mackenzie rivers in late 1994. Lower mean cell densities occurred in samples containing a high load of suspended solids. In contrast, cyanobacterial dominance and increased mean cell densities normally occurred in samples with reduced loading of such solids. Phytoflagellates and cyanobacteria are adapted to obtaining light in such waters of reduced light penetration and the occurrence of these groups appeared to be related to the high load of suspended solids in river waters. Other factors which would have selected for cyanobacterial dominance were high concentrations of nutrients (especially orthophosphate), absence of detectable levels of nitrate nitrogen on many occasions, lower flows in the latter half of the year and high pH. We should be adopting management strategies which decrease the bioavailability of nutrients and hence decrease the potential for growth of undesirable algal species.

The zooplankton population of the Fitzroy system is of a similar structure to that of other river systems. Decreased species richness coincided with decreased phytoplankton cell densities and increased sediment loading. Highest richness occurred at sites on the lower Dawson, the Mackenzie and the Fitzroy Rivers. The cyanobacterial dominance or high sediment load at many of the sites may have contributed to the absence of cladocerans at many of the sites.

7. AQUATIC INVERTEBRATES.

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7.1 Introduction.

Aquatic macroinvertebrates play a significant role in the functioning of aquatic ecosystems, being particularly important in nutrient recycling and serving as a food source for other aquatic organisms. Most fish and many aquatic bird species are heavily reliant on these organisms for food. Macroinvertebrates are also very good indicators of the "health" of aquatic systems and are now used widely in the biological monitoring of streams around Australia. Their value in this regard comes from their relatively sedentary habit, their association with bottom sediments (the place where many pollutants end up) and their range of sensitivity to pollution. Stream "health" may be assessed by comparing the communities found at relatively undisturbed sites with those more affected by anthropogenic influences. Very "healthy" freshwater systems generally have a diverse range of macroinvertebrate fauna, though this may be affected by the range of habitats present at a site and variables such as floods and droughts.

In this study, several sites were surveyed for aquatic invertebrates to produce base-line data for each of the major drainage basins in the catchment. Eleven primary sites were surveyed twice in 1994 (June and October) and once in 1995 (May). These years were both very dry in the catchment and so the survey was repeated following a more "typical" 1995/1996 wet season. The results of this latter survey, however, are not yet available. Other secondary sites were also surveyed during the study to produce a more comprehensive data set of sites not on major rivers in the catchment, but on smaller creeks, wetlands and farm dams. Some attention was also given to sites immediately upstream and downstream of the Emerald Irrigation Area, to determine possible effects of the area on the macroinvertebrate life of the Nogoa River. At these latter sites, surveys were only carried out once in late 1995 or early 1996. Locations of these and other sites are given in Fig. 1.1.

7.2 Methodology.

At each site, four two minute samples of macroinvertebrates were taken with a pond net (1 mm mesh size), preserved in 70% alcohol and taken back to the laboratory for sorting, identification and enumeration. During field collections, emphasis was placed on sampling each of the major habitat types present at each site - for example, in areas with aquatic plants and in areas with leaf material. Specimens were identified to family level only.

Microcrustacea (eg. copepods, ostracods) and Acarina (water mites) were not recorded. Plecoptera (stoneflies) and Oligochaeta (freshwater worms) were extremely rare and data for these are not presented here. Statistical tests were used to determine similarities between sites and included cluster analysis based on presence/absence and abundance data.

7.3 Results and discussion.

7.3.1 *Primary sites*

The major taxa (types) of invertebrates found during the surveys were:
- Coleoptera (beetles)
- Diptera (flies)
- Ephemeroptera (mayflies)
- Hemiptera (sucking bugs)
- Odonata (dragon and damsel flies)
- Trichoptera (caddis flies)
- Bivalvia (mussels)
- Gastropoda (snails)
- Decapoda (shrimps and crayfish) and
- Isopoda (shrimp-like animals).

Over 70 invertebrate families were identified and numbers of individuals counted. The average number of families per site generally ranged between 22 - 28 (Fig. 7.1). The major taxa were represented at most sites. In October 1994, the number of families per site generally decreased (compared to June), with particularly large reductions at Site Nos. 1 and 6 on the Fitzroy and Don rivers respectively. Interestingly, the pattern of distribution in the number of families per site found in June, 1994 was almost identical to that found in May, 1995 - the only major exception being a decrease in the number at the Fitzroy River site. The lower Comet and mid Nogoa sites (Site Nos. 9 and 11), generally displayed the lowest numbers of families per site, while numbers at Site No. 1 on the Fitzroy were lower in October 1994 and May 1995 than in June, 1994 (probably due to the construction of the Eden Bann Weir).

Average abundance per sample was usually between 200 - 500 animals, the most important components being the Diptera (mainly Chironomidae), Hemiptera, Gastropoda and Decapoda (Fig. 7.2). Diptera were more abundant in October than in June, 1994, while Decapoda were more abundant in June than in October. In May, 1995 (after wet season flows) higher levels of Decapoda were again found (Fig. 7.2). The reduced levels of Decapoda later in the dry season may be a result of increased predation on these animals when stream pools become isolated as the dry season progresses. The higher number of Diptera towards the end of the dry season may be related to increases in food supply to these filter feeding organisms as particles settle out with reduction in flows during this period.

Sites in the lower Comet (Site No. 9), and lower and mid Nogoa (Site Nos. 10 and 11), generally had lower abundance of invertebrates than other sites. The Comet River site was heavily impacted by cattle and suitable habitat for macroinvertebrates was restricted to highly turbid shallow pools. The mid Nogoa site (Site No. 11), dried up in October, 1994 (no invertebrates recorded) and as for the Comet River site did not have as wide a range of habitats suitable for aquatic invertebrates as other sites. Submerged or floating macrophytes were not recorded at either of these two sites. These factors may explain the lower abundance of invertebrates at these sites, though other factors may have been involved. The lower abundance found at the mid Nogoa site was difficult to explain given that it appeared to have a diverse range of habitats for macroinvertebrates and so prompted further study of this and other sites in the Emerald Irrigation Area in 1995/1996 (reported below).

Figure 7.1. Number of Macroinvertebrate Families per Site - Primary Sites, Fitzroy Catchment, 1994 - 1995.

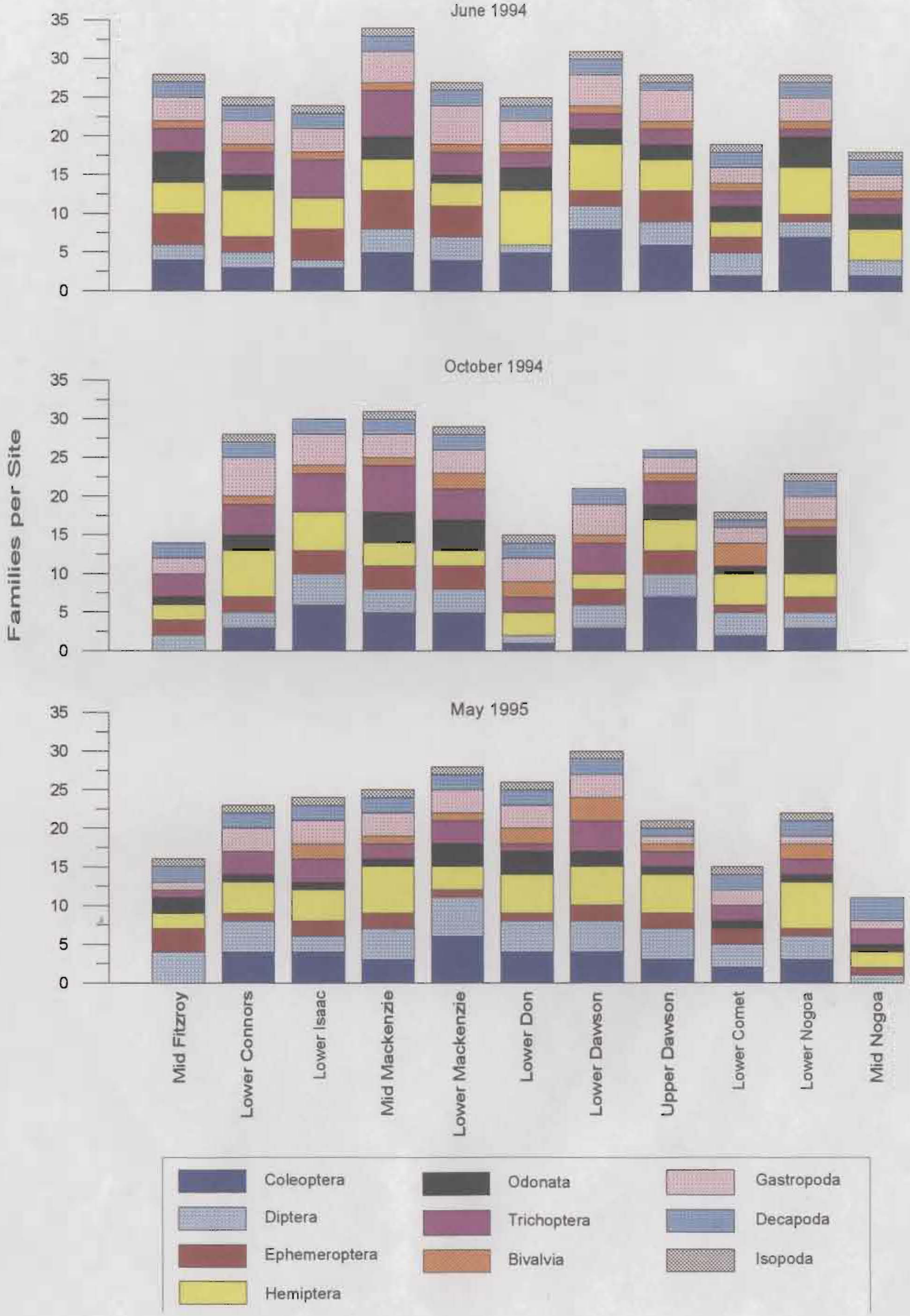
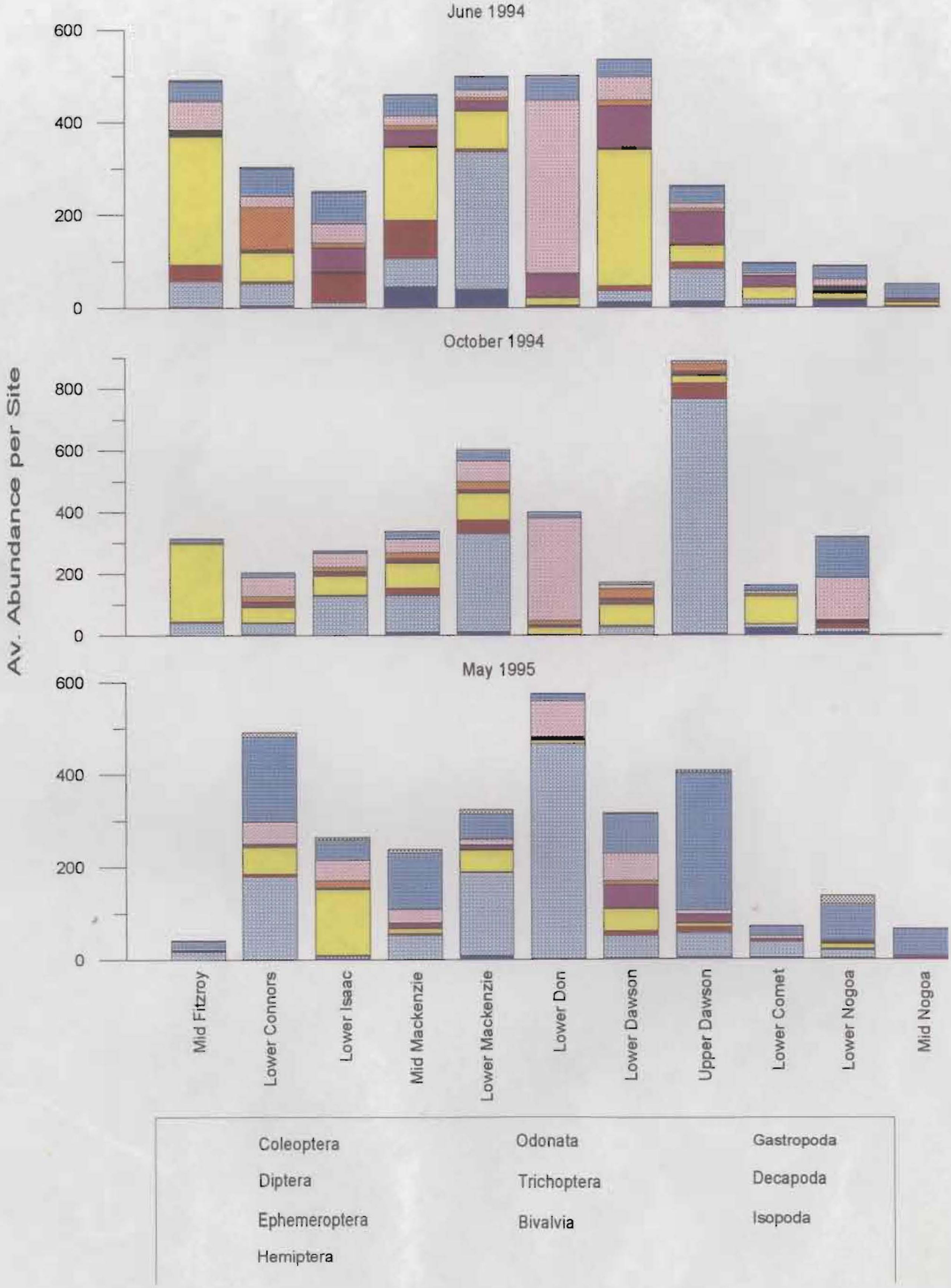


Figure 7.2. Average Abundance (mean of four replicates) of Macroinvertebrates - Primary Sites, Fitzroy Catchment, 1994 - 1995.



The site on the Don River (Site No. 6), was unusual in being dominated by Gastropoda in two of the three sampling occasions. This site is also unusual in its water chemistry, which is likely to be strongly affected by sub-surface flows, including intrusions of ground water high in certain salts.

Cluster analysis of the June invertebrate data (based on presence/absence data) separated the mid Nogoa and lower Comet sites (Site Nos. 11 and 9), from the rest, probably as a result of the low number of families recorded there. In October, Site No. 9 was again separated from the others, while Site No. 11 had dried up. The mid Fitzroy site (Site No. 1) was also distinct from the others at this time, only having 14 invertebrate families present. This site was located immediately upstream of the construction site of Eden Bann Weir which was completed in the latter half of 1994 and this may have influenced the invertebrate fauna at the site. The number of invertebrate families at the Don River site (Site No. 6) was markedly lower in October compared to June 1994 and reasons for this are not clear. Possible explanations include acid mine drainage pollution from the Dee River similar to that recorded by Duivenvoorden (1995), or ground water intrusion high in salts. (Conductivity values recorded for this site for June and October 1994 were 1,800 and 2,200 microSiemens/cm respectively.)

In May, 1995, Site Nos. 9 and 11 once again clustered separately from most of the others based on presence/absence data. Site Nos. 1, 8 and 10 also clustered with Site No. 9 on this occasion, probably reflecting the generally lower numbers of invertebrate families found at these sites.

Overall, relatively high numbers of Trichoptera and Ephemeroptera were found at most of the primary sites during the study and were well represented in terms of the numbers of families found. Since these organisms are often associated with high water quality, the data suggests that the "state of the health" of the river system at these locations is relatively good.

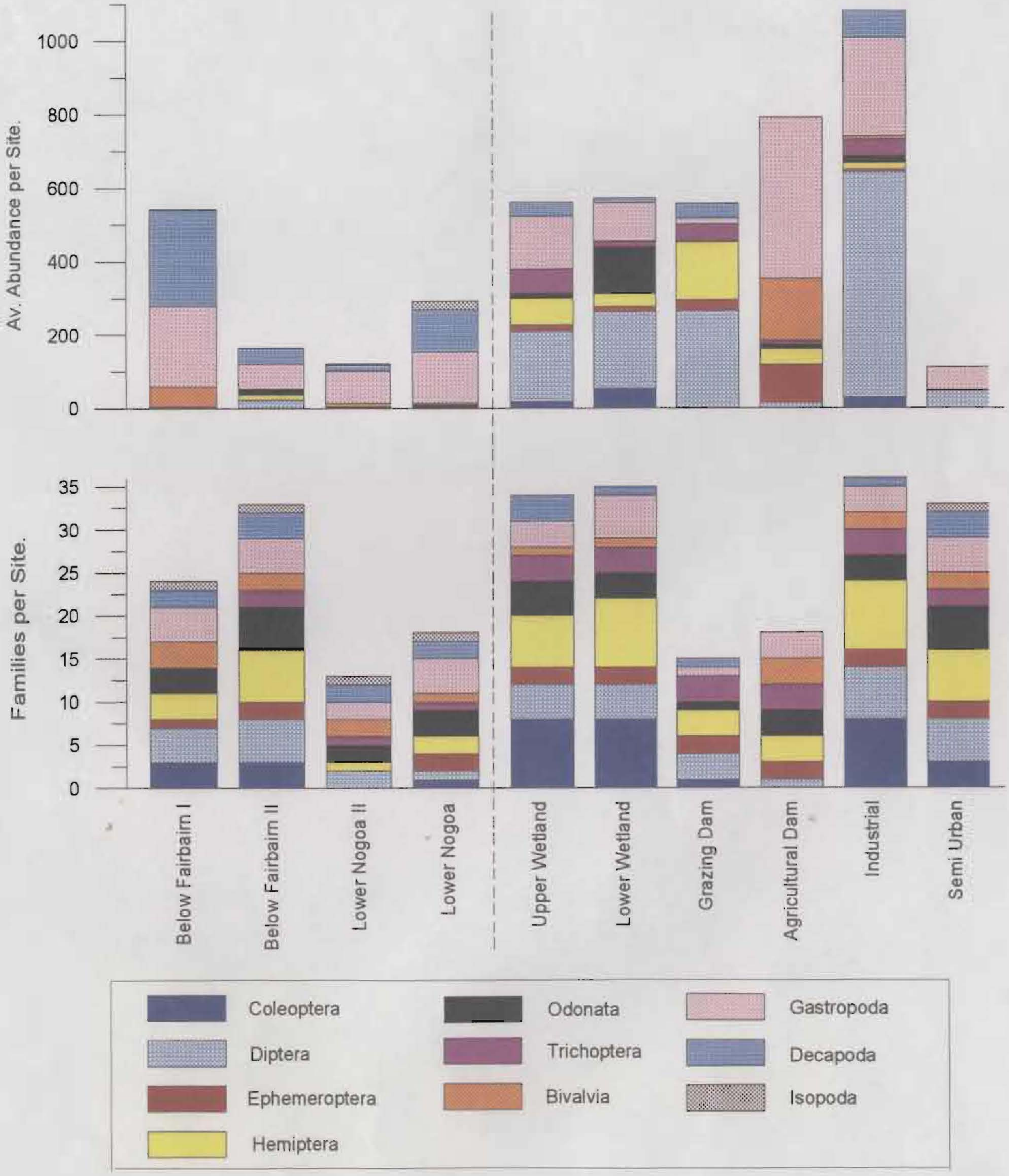
Secondary Sites

The two wetland sites (Site Nos. 17 and 18) sampled in the catchment had a relatively diverse range of macroinvertebrates, having between 34 and 35 taxa (Fig. 7.3). The structure of their invertebrate populations was also very similar, even though one was in the upper catchment (near Taroom) and the other in the lower catchment (near Rockhampton). Similar results were found for the two lower order streams (Site Nos. 23 and 24, in the Mackenzie and Fitzroy sub-basins respectively). Abundance of invertebrates was generally also high at these sites, except for the semi-urban site on Moores Ck (Site No. 24). It had surprisingly low abundance considering its diverse range of invertebrate fauna (Fig. 7.3).

Compared to the wetland and creek sites, the two farm dams surveyed (Site Nos. 19 and 20) were relatively low in the number of invertebrate taxa. For the grazing farm dam near Springsure (Site No. 19) this may be explained by the paucity of suitable habitat for macroinvertebrates, whereas for the agricultural farm dam (Site No. 20), pesticide residues may have been of significance. Invertebrate habitat at this site consisted largely of dense stands of the bulrush, *Typha* sp. as well as the aquatic grass *Urochloa mutica*.

A more detailed study of two sites upstream (Site Nos. 26 and 27) and two sites downstream (Site Nos. 10 and 28), of the Emerald Irrigation Area showed that at the time of sampling, sites upstream had a more diverse range of invertebrate taxa than those downstream (Fig. 7.3).

Figure 7.3. Average Abundance (mean of four replicates) and Number of Macroinvertebrate Families per sSte for Four Sites on the Nogoa River (January 1995) and for Six Secondary Sites in the FitzroyCcatchment (October 1995 - January 1996).



This indicates that the irrigation area may have had a significant effect on the invertebrate fauna of the Nogoa River. If the irrigation area did have some impact on the aquatic biota, one might expect the site immediately downstream of the irrigation area to be most heavily impacted, with the effects being less noticeable with distance downstream as the stream recovers from the effects. The data presented in Fig. 7.3 suggests that this did occur, with the site immediately downstream of the irrigation area, (lower Nogoa II, Site No. 28) having the lowest taxa richness and invertebrate abundance of all four sites surveyed. Differences in invertebrate habitats between sites may result in such changes in the invertebrate fauna, but this does not easily account for the differences observed between sites in the types of invertebrate taxa recorded. Of particular note is the disappearance of Ephemeroptera from the site immediately downstream of the irrigation area. These organisms are known to be highly sensitive to aquatic pollutants and the reduction in their occurrence supports the contention that the irrigation area may at times have an effect on the aquatic biota. This is further supported by the absence of zooplankton samples collected from the lower Nogoa site (Site No. 10), in June, 1994. Further study of this area is warranted. In particular, studies to determine the extent and magnitude of the observed effects on both spatial and temporal scales.

8. FISHERIES.

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8.1 Introduction.

Fish are the most visible and well known of our aquatic biota, with the public generally very aware of their condition and using them to measure indications of our stream "health". It is now accepted that we need to maintain fish communities in as natural a state as possible. However, to maintain these communities we require knowledge of the status and trend of our fisheries resources and their relationships to other stream biota, water quality and physical habitat parameters. This knowledge can be used to effectively manage our stream environments and all that impact upon them.

Unfortunately in Queensland we have a very low level of knowledge and understanding with regards to our freshwater fisheries resources. The only documented study to date of the fisheries resources within the Fitzroy catchment, was by Midgley in 1979, who undertook a fisheries study of 21 sites on behalf of the then Queensland Fisheries Service. Regular fisheries sampling has been undertaken by the QDPI under the Freshwater Recreational Enhancement Program (refer to section 8.3.2) which commenced in this catchment in 1987. These results remain unpublished to date. The current project, the first replicated fisheries study of the Fitzroy catchment, has provided base-line data. The establishment of this base-line data has made the observance of future changes in the fisheries resource possible.

The Fitzroy catchment is a warm-water stream in the North-east Coast Drainage (Merrick and Schmida, 1984) with a diverse fish community and complex species-habitat relationships. This project recorded some 26 fish species of 15 families with the results comparing favourably with those of similar semi-arid catchments of sub-tropical Australia. In general terms, freshwater fish species diversity (on a catchment basis) increases as latitude decreases. Fish species present in the catchment have evolved to cope with the ephemeral nature of the system, with many species responding to this cycle of drought and flood by opportunistic migration, spawning and rearing strategies.

8.2 Methods.

8.2.1 *Study Sites.*

Fisheries sampling was undertaken at 21 sites (Fig. 8.1). Eleven primary sites consisting of approximately two sites per sub-basin were selected to represent upper and lower sub-basin influences (Sites 1 to 11, Fig. 1.1). Sampling was undertaken on one occasion prior to seasonal flows and on two occasions after seasonal flows. A further ten secondary sites (Sites 17 to 28 {excluding Site Nos. 21 and 22}, Fig. 1.1) were sampled to represent catchment wetlands (upper and lower), regulated (influenced by flows released from an impoundment) and unregulated streams, as well as influences of industry, urban encroachment and an intensive irrigation area. A more complete description of sites is provided in Appendix B.

8.2.2 *Apparatus and Sampling Methods.*

To provide valid comparisons between fisheries sites, sampling equipment and techniques were standardised.

Two monofilament panel nets were used with six mesh sizes ranging from 25 to 150 mm. Both nets had a drop of 2.5 m and a length of 38 m. Nets were set between 1400 and 1530 hours for a period of 5 hours. The first 50 individuals of each species at each sampling were weighed and measured with numbers of subsequent captures recorded.

Eight baited fish/crustacean traps with a width and depth of 0.25 m, a length of 0.45 m and covering mesh of 3 mm aperture were baited with dog biscuits and set for a total of 6 hours, but were checked and emptied at two hourly intervals.

A 7.8 m long nylon seine net with a 2.2 m drop and 3 mm mesh was used in sites wherever conditions allowed efficient use of this equipment. (The seine net was towed in shallow water [<1.2 m] which was free from major obstructions.)

In general, all fisheries sampling apparatus is to some degree selective which influences the captures recorded. Both nets and traps are regarded as passive devices in that fish need to be mobile to be captured.

Site water quality parameters were recorded using a TPS® 90FL water quality meter configured to monitor dissolved oxygen, water temperature, pH and conductivity. Turbidity was assessed with the use of a Secchi disc.

8.3 Background.

8.3.1 *Non Endemic Species.*

Three species of native fish have been translocated into the catchment, silver perch (*Bidyanus bidyanus*), murray cod (*Maccullochella peelii peelii*) and sooty grunter (*Hephaestus fuliginosus).* Both silver perch and murray cod are native to the Murray-Darling System with sooty grunter native to north Queensland streams (Merrick and Schmida, 1984). All three were introduced in an attempt to enhance the recreational fishery.

The silver perch appears to have been unsuccessful in its recruitment within the catchment, with only one specimen collected in this study (Upper-Nogoa). Anecdotal reports suggest irregular captures of silver perch by recreational fishers targeting golden perch. Murray cod were released into the Fairbairn Dam (1989-92) by the local fish stocking group, QDPI translocation policy now preventing any further stocking of this species into the Fitzroy catchment. Regular captures of murray cod are reported in Fairbairn Dam. There have been a few isolated reports of angler returns of sooty grunter.

8.3.2 *Fish Stocking.*

Fish stocking in the Fitzroy catchment is only a recent innovation with the first documented fish stock being released in 1971 in Callide Dam (Table 8.1). Since 1987, stockings into the Fitzroy catchment have been undertaken under a Queensland Government Program (Fresh-water Recreational Enhancement Program) which is administered by the QDPI and supported by local Fish Stocking Groups. The program's purpose is to enhance the recreational fishing within areas of the catchment, particularly in artificial habitats (dams and weirs).

Table 8.1. Fish Stocked in the Fitzroy Catchment,1971-96.

Stocking Group	Period of Stocking	Golden Perch	Silver Perch	Sleepy Cod	Saratoga	Sooty Grunter	Barramundi	Jewfish	Murray Cod
DPI in Connors R	1982-1983					30,000			
Baralaba	1989-1995	55,524	8,670						
Taroom	1990-1995	31,000	128,136	18,430					
Theodore	1990-1995	38,428	32,500	6,500					
Moura	1988-1991	4,348	23,704						
Callide Dam	1971-1994	102,948	95,456	11,000	122		50,000		
Fairbairn Dam	1987-1994		237,210		100				80,500
Middle-mount	1989-1992	39,624	34,295	10,000	20				
Fitzroy Barrage	1987-1996	246,410		4,900	30		235,942		
Bedford Weir	1996	12,000							
Mount Morgan	1990-1996	24,230	7,600	5,500					
Theresa Ck.Dam	1987-1991	17,688	36,242		20			1000	
TOTAL		572,200	603,813	56,330	292	30,000	285,942	1000	80,500

Under the Fish Stocking Program a low level of monitoring of impoundment and riverine sites is carried out to establish an indication of the success of the fish stocking. Whilst the DPI and stocking group resources are limited, undertaking a level of assessment of the stocking effort is worth while. As part of this monitoring, it is important to gauge the impact of the introduction of the translocated species upon the endemic fish population of the Fitzroy catchment.

8.4 Results and Discussion.

8.4.1 *Fish Species Present.*

The Fitzroy catchment is somewhat unique in the context of freshwater fish communities in that it contains representatives of both tropical and temperate Australian species. The species list below (Table 8.2) presents the 26 fish species recorded in all sampling for the current project. Throughout the project 12,641 fish were recorded in both traps and gill nets.

Table 8.2. Fish Species Recorded during DELU Project, 1993-1996.

Family	Species	Common Name
Megalopidae	***Megalops cyprinoides***	Oxeye Herring / Tarpon
Anguillidae	***Anguilla reinhardti***	Long-finned Eel / Freshwater Eel
Clupeidae	***Nematolosa erebi***	Bony Bream
Osteoglossidae	***Scleropages leichardti***	Spotted Barramundi / Saratoga / Dawson River Salmon
Ariidae	***Arius graeffei***	Lesser Salmon Catfish / Blue Catfish
Plotosidae	***Neosilurus hyrtlii***	Hyrtl's Catfish / Hyrtl's Tandan
	Neosilurus ater	Black Catfish / Narrow-Fronted Catfish
	Tandanus tandanus	Freshwater Catfish / Jewfish / Eel-Tailed Catfish
Belonidae	***Strongylura kreffti***	Freshwater Long Tom
Poeciliidae	***Poecilia reticulata***	Guppy (exotic)
Atherinidae	***Craterocephalus stercusmuscarum***	Fly-Speckled Hardyhead
Melanotaeniidae	***Melanotaenia splendida splendida***	Red-Striped Rainbowfish / Eastern Rainbowfish
	Pseudomugil signifer	Pacific Blue-eye / Southern Blue-eye
Ambassidae	***Ambassis agassizi***	Agassiz's Glassfish / Olive Perchlet
Percichthyidae	***Macquaria ambigua***	Yellow-Belly / Golden Perch
Teraponidae	***Amniataba percoides***	Banded Grunter / Barred Grunter / Black Striped Banded Trumpeter
	Bidyanus bidyanus	Silver Perch
	Leiopotherapon unicolor	Spangled Perch
	Scortum hillii	Leathery Grunter / Black Bream
Apogonidae	***Glossamia aprion***	Mouth Almighty
Eleotridae	***Hypseleotris compressa***	Empire Gudgeon
	Hypseleotris sp. A	Midgley's Carp Gudgeon
	Hypseleotris sp. B	Western Carp Gudgeon
	Oxyeleotris lineolatus	Sleepy Cod
	Philypnodon grandiceps	Flathead Gudgeon / Longheaded Gudgeon
	Mogurnda adspersa	Purple Spotted Gudgeon

8.4.2 *Seasonal Sampling Results.*

Fisheries results have been reported in two ways: diversity, which is the total number of species recorded at a site; and abundance, which is the total number of fish captured. To provide for comparisons between sites a catch per unit effort value (CPUE) is calculated to represent the total number of fish captured per gill net hour.

In sampling the eleven primary sites, there was little variation in the fish abundance levels noted from the gill net data (fish >75 mm.). Total numbers for the samplings were May/June 1994 (1,127), October 1994 (981) and May/June 1995 (1,031). In October 1994, two sites had insufficient water for fisheries sampling (end of the dry season). If data from these two sites are removed from the two May/June sampling totals, the numbers (for the remaining nine sites), are remarkably consistent (1,052, 981 and 1,005 fish). Bearing in mind the separation of the sites within the catchment and their different habitats, it presents a very consistent level of fish abundance.

The results from the primary sites provide an indication that species numbers decline further up the catchment (Fig. 8.1). These findings are consistent with catchment longitudinal changes of fish communities documented by Bishop *et al.* (1986) in an Australian stream. Further, they concluded that species diversity is frequently positively correlated with habitat complexity and that conversely, lack of diversity may be regarded as a indicator of reduced habitat availability. These findings are reinforced in the Fitzroy catchment with streams becoming more ephemeral (seasonal) further up the catchment and accordingly offering lower levels of instream habitat on a seasonal basis. To reinforce the wide variation in species habitat requirements, two species captured require a marine environment to reproduce, whilst several others are capable of moving between the freshwater and marine environment.

To compare the 11 primary sites of the study, a simple dimension value (waterbody width by maximum depth) was plotted with the mean CPUE (Fig. 8.2). As can be seen in Fig. 8.2, values of the CPUE are reasonably consistent with the calculated stream dimension. It is assumed that the elementary site dimensions reflect greater habitat availability. With the exception of very large waterholes, the greater the site dimension value the larger the catch of fish. The deep centre section of large waterbodies is not consistently utilised by numbers of fish when compared with bankside habitats (Puckridge and Drewien, 1988; Kennard *et al.*, 1995).

FITZROY CATCHMENT
Fish Species Distribution

SCALE 1:2 500 000

kilometres 50 0 50 100 150 kilometres

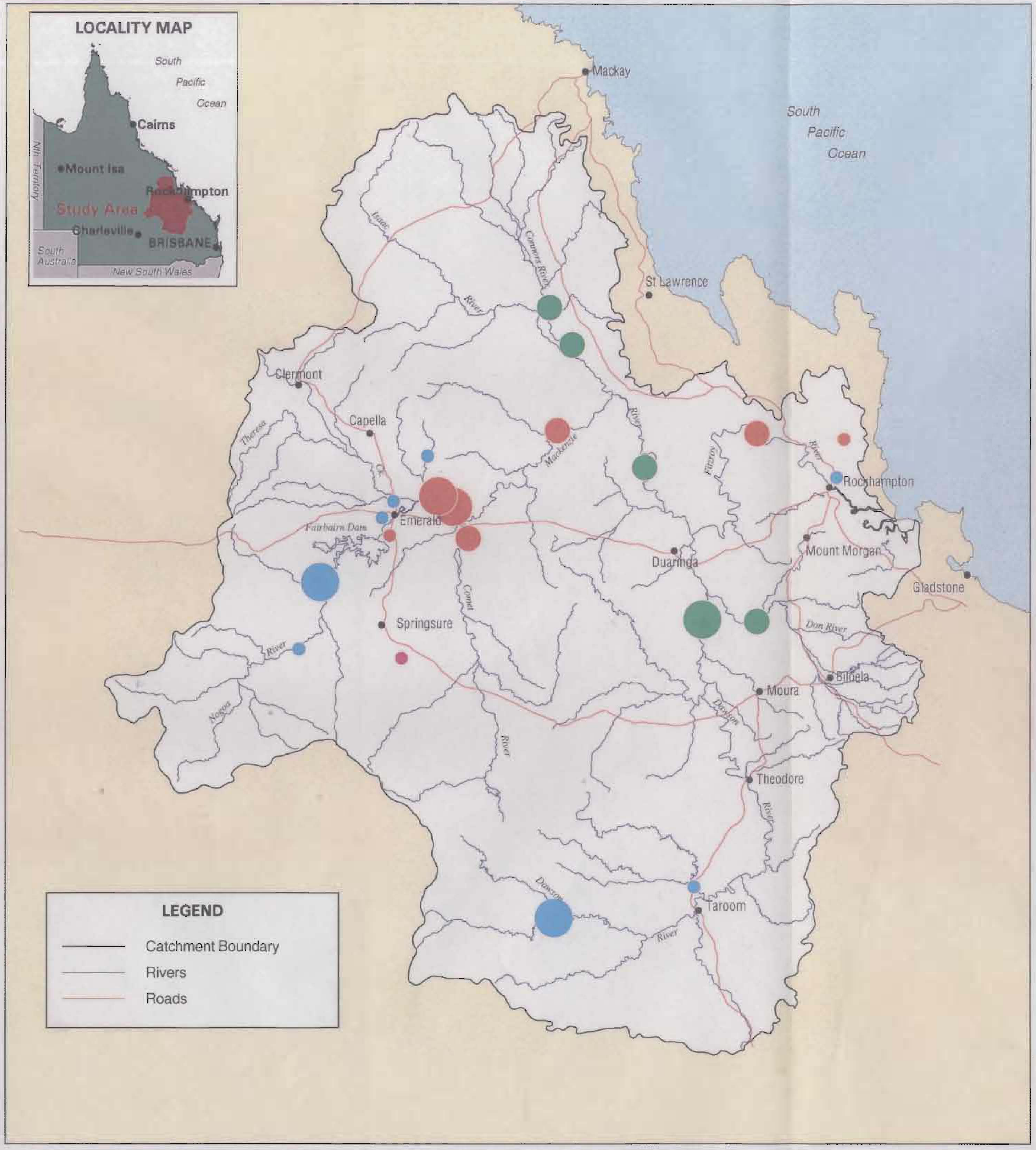


Figure 8.1

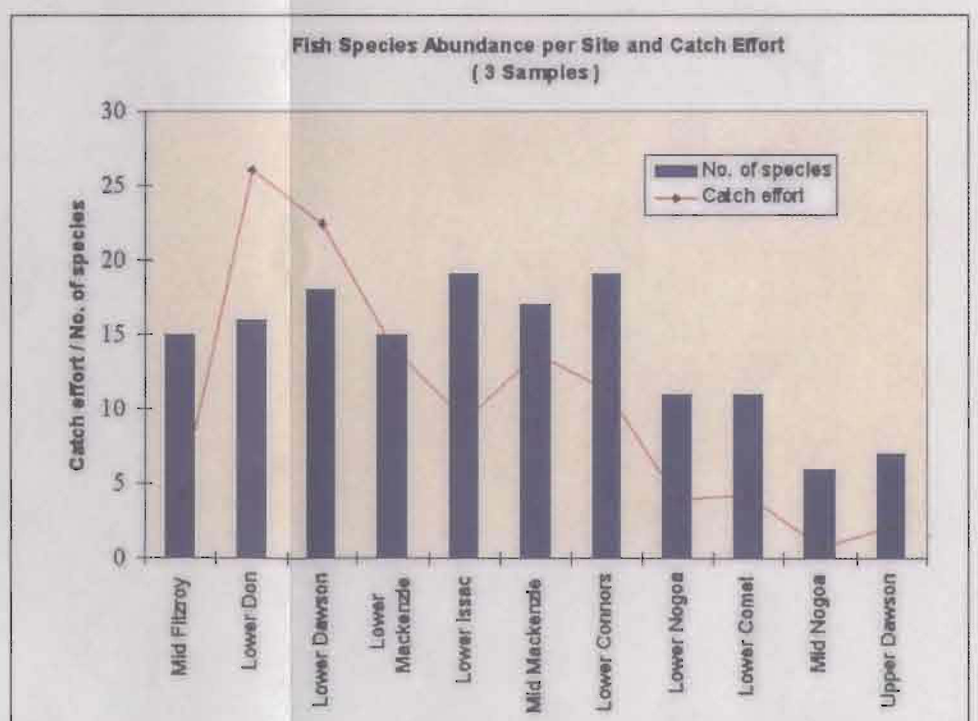
REFERENCE

Species Numbers

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20

Sample Frequency

- 1 - 2 Samples
- 3 Samples
- 4 - 5 Samples



- Primary site results recorded with sites presented from lower to upper Catchment
- Results reflect a decrease in species numbers and abundance further up the catchment

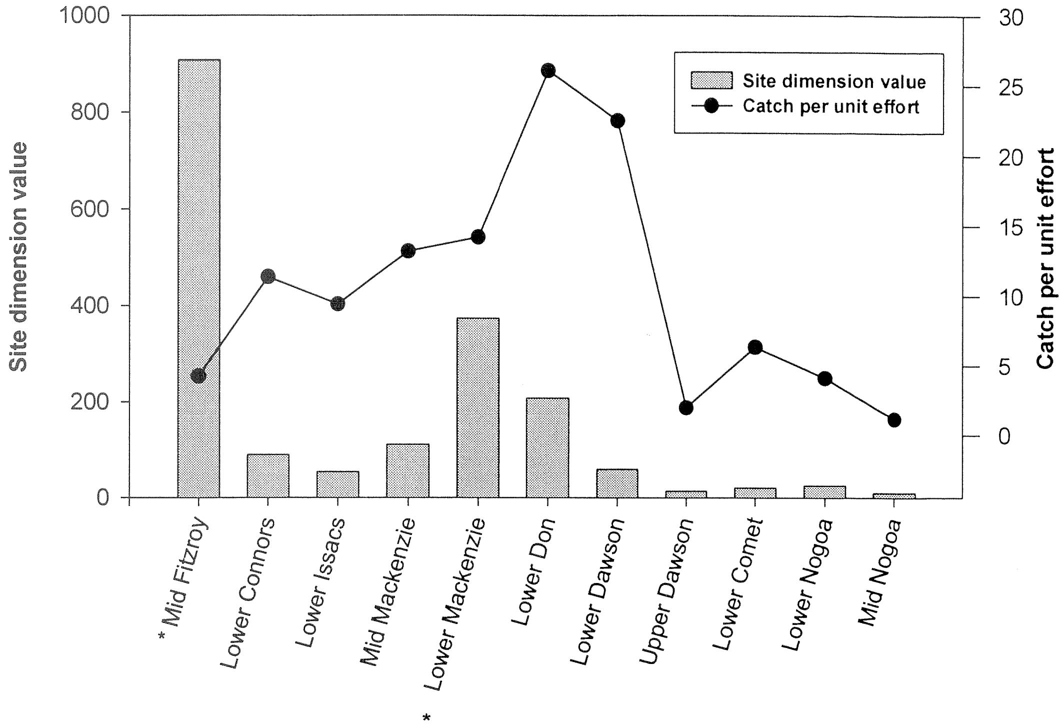
Figure I

NATURAL RESOURCES

Land Resource Information Systems
Resource Management
Central Region
Rockhampton

QUEENSLAND GOVERNMENT

Figure 8.2. Site Dimensions and Mean Catch Effort - Primary Sites, Fitzroy Catchment 1994 - 1995.



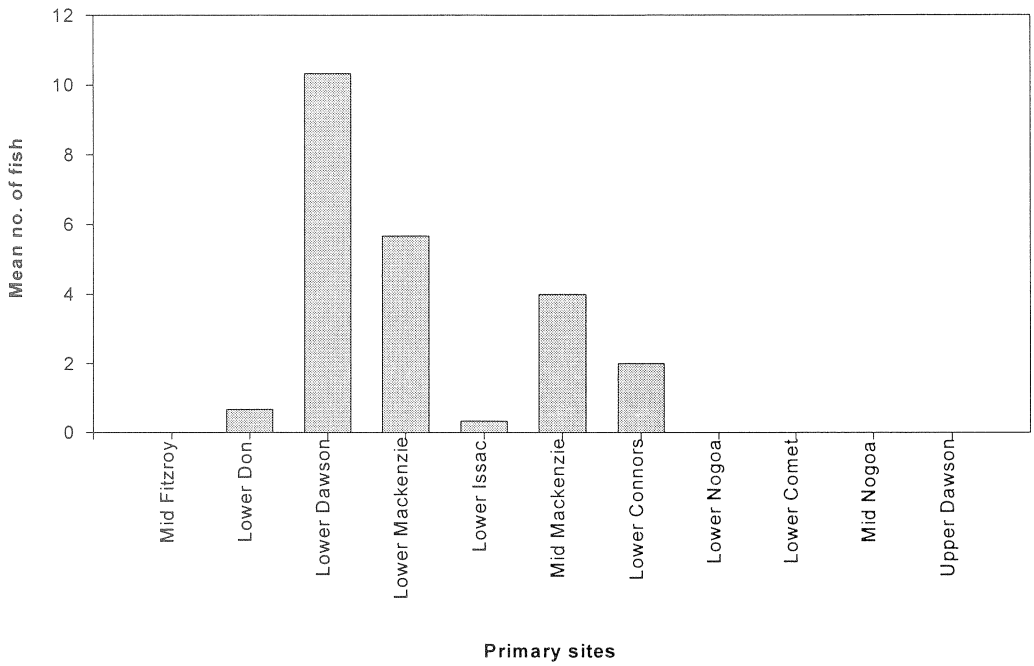
***denotes major waterbody > 20 km**

8.4.3 *Conservation Status of Certain Species.*

Four species encountered in this study have been classified by the Threatened Fishes Committee of the Australian Society for Fish Biology (Harris, 1985). In 1995, this committee reviewed all species classifications and applied a conservation status to certain fish species. Classifications are as follows: *Extinct, Endangered, Vulnerable, Potentially Threatened, Indeterminate, Restricted, and Uncertain Status.*

Both saratoga (*Scleropages leichardti*) and purple spotted gudgeon *(Mogurnda adspersa)* are classified as *restricted.* This project recorded saratoga at 6 sites (Site Nos. 2 to 7) within the mid section of the catchment (Fig. 8.3). Saratoga is considered to be sensitive to changes in habitat conditions and overfishing, due to its low fecundity and slow growth rate (Merrick and Schmida, 1984). Purple spotted gudgeon was identified at 5 sites in very low numbers (less than 5 per site).

Figure 8.3. Saratogoa Captures - Primary Sites, Fitzroy Catchment, 1994 - 1995.



A third species, black bream (*Scortum hillii*) has been classified *uncertain status*. It was recorded at 13 sites within the catchment. The fourth species, silver perch *(Bidyanus bidyanus)* which has been translocated into the catchment, is classified as *potentially threatened.*

8.4.4 *Exotic Species.*

Only one species of exotic fish was recorded throughout the project, the guppy (*Poecilia reticulata)* which is native to South America. This species was recorded at the Moores Creek site only (Site No. 24). It may be assumed that this is an isolated population that has resulted from release from domestic aquaria in Rockhampton.

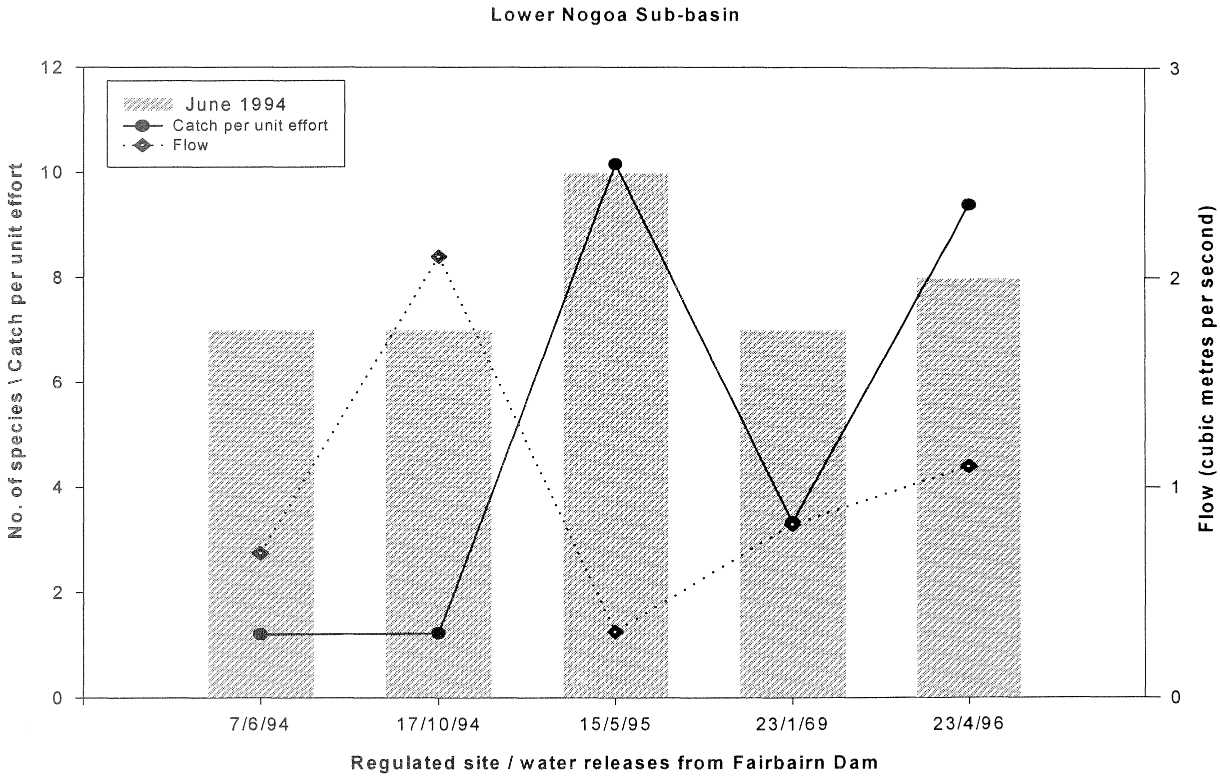
Other exotic species that are known to occur in the catchment include the common goldfish (*Carassius auratus).* This species is regularly reported from the Dawson and Mackenzie sub-basins (Berghuis and Long, 1995). These fish would have also been released from domestic aquaria. The mosquito fish (*Gambusia holbrooki*) has been reported from around several towns in the catchment. This species was released by some Local Authorities in a failed attempt to control mosquito populations. It has now been established that populations of native rainbowfish and pacific blue-eyes have, under most circumstances, a more significant impact upon mosquito populations.

Whilst it is unfortunate that these three exotic species occur in the catchment, this compares favourably with reports of ten exotics in the Murray-Darling Basin (Morrison, 1988). European carp (*Cyprinus carpio)* which has had the greatest impact in that catchment has so far not been recorded in the Fitzroy catchment. If this species was to be released in the Fitzroy catchment similar negative impacts on the ecology of the river could be expected.

8.4.5 *Regulated Stream Site.*

The lower Nogoa site (Site No. 10) was sampled as a primary site but was additionally sampled to gather data as a regulated site. Site No. 10 had consistent flows released from Fairbairn Dam for mining, urban and irrigation consumption. Results, including the flow data, are presented (Fig. 8.4) to illustrate the influence of various flow regimes on fish diversity and abundance. The results across different seasons and flow rates show a highly variable CPUE or abundance which is worthy of further investigation. The result of May 1995, where both the CPUE and number of species rose, coincided with the lowest flow rate for the samplings. Whilst this site is a lower sub-basin site, it consistently recorded a lower species diversity than other similarly located sites elsewhere in the catchment.

Figure 8.4. No of Species and CPUE Plotted with Flow for the Lower Nogoa Site on Five Occasions between June 1994 and May 1996.

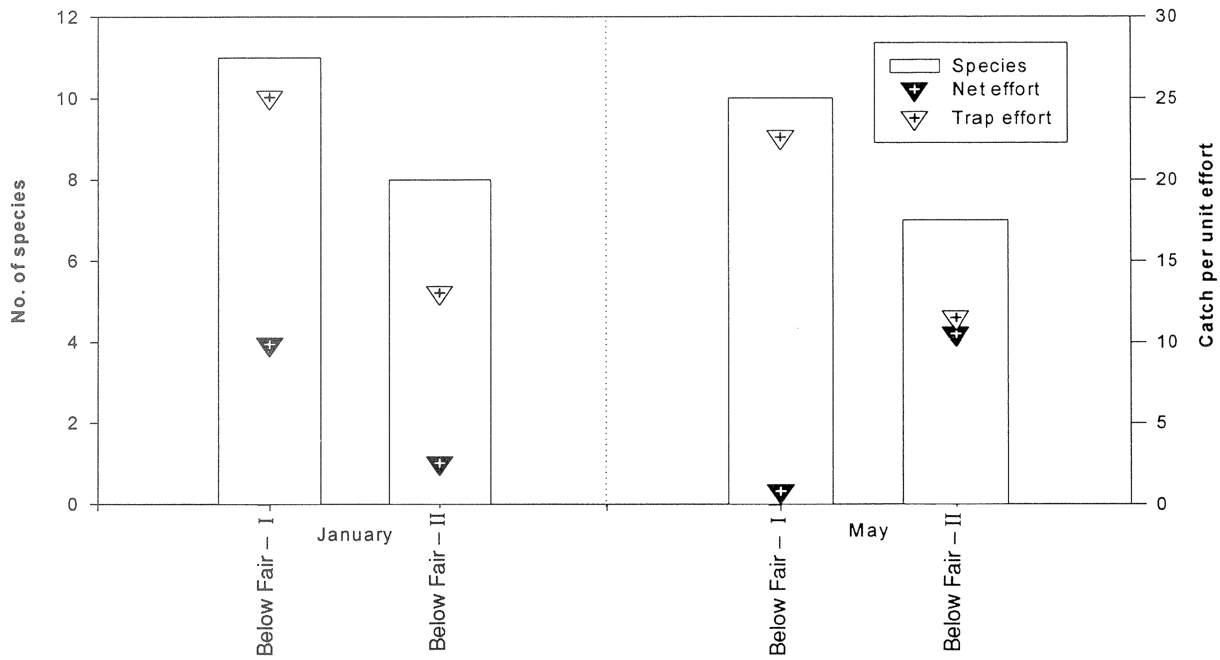


In a recent study on a Queensland coastal stream, Kennard *et al.* (1995), established that fish species have a microhabitat preference upon which they are completely dependent at various stages of their life cycle. Moreover, Bain *et al.* (1988), demonstrated in a warm water North American stream the adverse influence of artificial stream flows upon habitat availability and accordingly the abundance of fish. Further, under Australian semi-arid conditions, Walker and Thoms (1993) found strong evidence of impacts from regulated flows upon all stream biota in the lower Murray River.

8.4.2 *Influences of Stream Barriers.*

Two sites on the Nogoa River immediately downstream of Fairbairn Dam (Site Nos. 26 and 27) were sampled in January (high flow) and May 1996 (low flow). The Below Fairbairn I site (Site No. 26) was within 500 metres of the barrier and the Below Fairbairn II site (Site No. 27) was approximately 5 kilometres downstream. Diversity and abundance levels recorded provided evidence of the ability of flow releases to stimulate fish to migrate with a resultant aggregation occurring below the barrier. With the higher flows in January, greater species numbers and CPUE were recorded at the Below Fairbairn I site, whereas in the May sampling, the diversity dropped at both sites and the abundance rose (CPUE - net effort) at the Below Fairbairn II site (Fig. 8.5).

Figure 8.5. No. of Species Caught and CPUE for Below Fairbairn Dam Sites I and II, Nogoa River, January and May 1996.



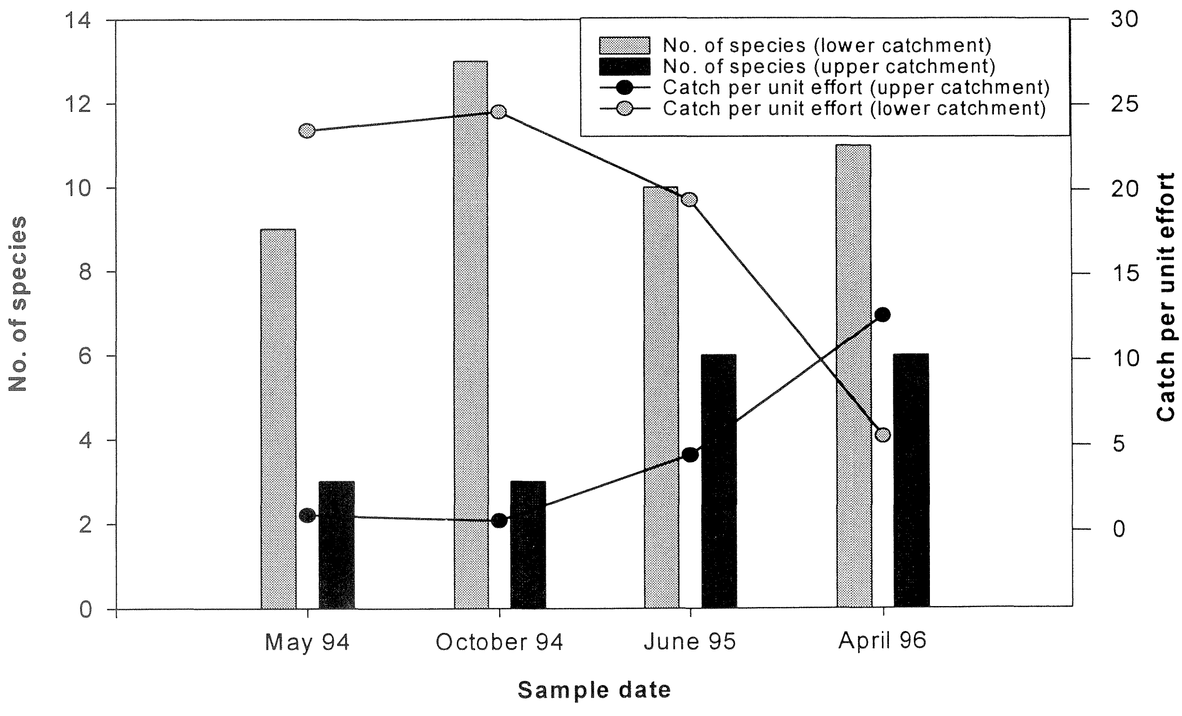
These results suggest that an aggregation effect is occurring as a result of this stream barrier, with the greater numbers of fish near the dam wall having been stimulated to migrate upstream in the higher flow. The influence of the flow is not as great upon the smaller species (trap effort) as they occupy micro-habitats closer to the bank out of the flow and tend not to migrate as much as larger species. Koehn *et al.* (1994) demonstrated in a southern Australian stream the influence of both stream velocity and depth upon species size classes. The higher return of the traps when compared to pre-flow sampling of the primary sites (CPUE at the primary sites ranged from 0.2 to 28 fish per trap hour) may be a reflection of the spawning season (spring/summer) of the species captured complimented by the constant habitat maintained by the flow releases.

8.4.3 *Dawson Sub-basin Findings*

Dawson River sub-basin sites (Site Nos. 7 and 8), were sampled on four occasions. Three samplings were undertaken in 1994/95 (Figure 8.6), representing one pre- and two post-summer flow samplings. A fourth sampling (April, 1996) was conducted after a record flood event (1 in 50 year), during the summer of 1995/1996. Two points are worthy of note. Firstly, prior to April 1996, the lower sub-basin site (Site No. 7) had a greater return of species and CPUE - a result also reflected at other lower sub-basin sites in the catchment. The second comment is that in April 1996 the CPUE value for the upper catchment site had increased, while that for the lower catchment had decreased. This was the first time in this study that the CPUE for the upper site had been larger.

A possible explanation for this is that flood waters may have provided a dispersal mechanism for fish (the majority of species being highly mobile) to travel upstream and occupy habitat not normally available. The Dawson sub-basin results were dominated by bony bream (*Nematolosa erebi)*, which is known to migrate in flood flows (Puckridge and Drewien, 1988).

Figure 8.6. No. of Species Caught and CPUE on Four Occasions for Two Dawson Sub-basin Sites, May 1994 - April 1996.



8.4.4 *Recorded Water Quality.*

Five physico-chemical parameters (dissolved oxygen [DO], pH, temperature, conductivity and turbidity) were recorded at each site. All results were within the range for supporting fish populations. In this project, the range of recorded DO results was 5.1 to 10.7 ppm (recorded at 1 metre between 1430 and 1530 hrs). As well as supporting fish communities, DO can be regarded as an indicator of the biochemical condition of a waterbody at a given time and place (Hem, 1970).

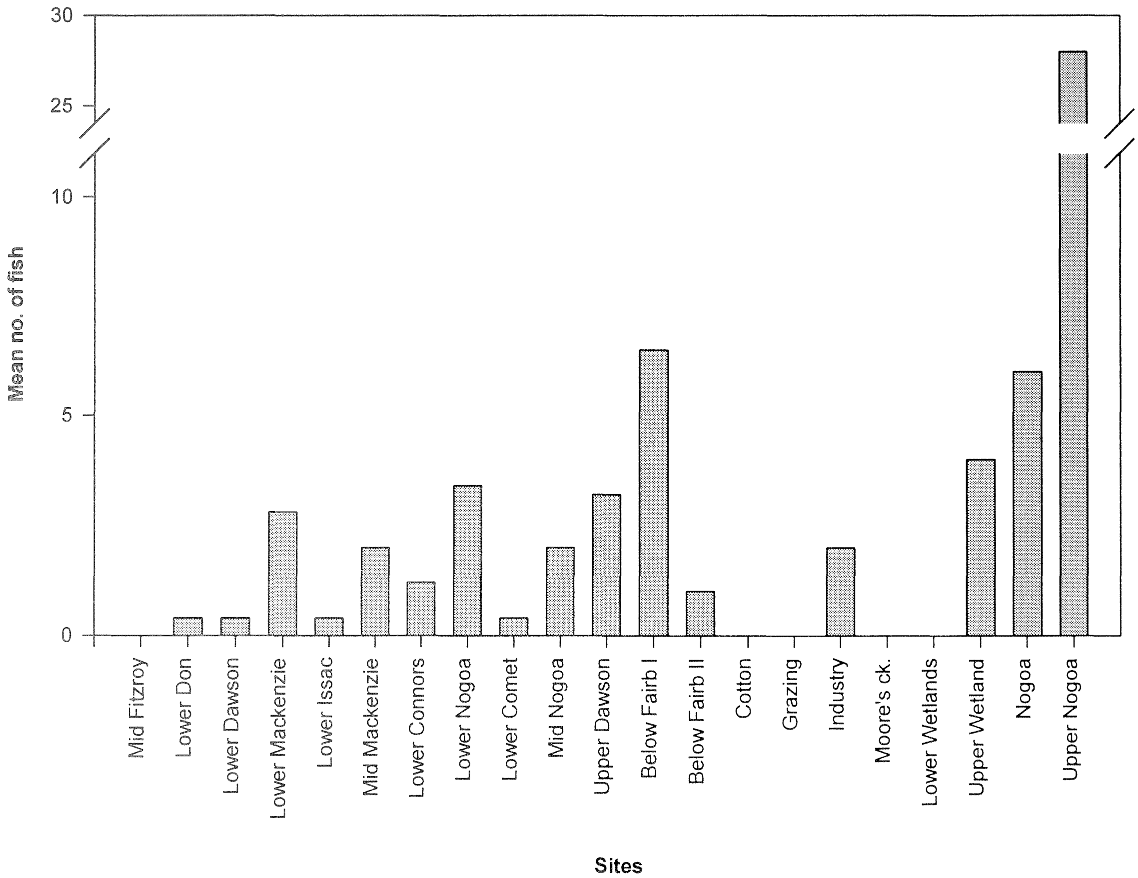
8.4.5 *Additional Findings.*

At one offstream storage site in an agricultural area (Site No. 20), six species of fish were recorded with good abundance levels. As a wide range of sizes were observed within the fish populations, it would appear that the fish are reproducing despite documented levels of endosulfan contamination which exceeded current ANZECC environmental guidelines (refer section 4.3).

Bony bream dominated gill net captures throughout the catchment (75%). Elsewhere in Australia, Puckridge and Walker (1990) have documented this highly fecund herbivore as increasing in numbers against trends of instream habitat loss, whilst other native species decline in abundance. It is not suggested that disturbance levels are acute enough in the Fitzroy catchment to bring about a response similar to that in southern Australian streams but the current data set does provide us with a benchmark against which future trends in the catchments fish populations may be established.

Golden Perch (yellow-belly) which is the most targeted freshwater recreational species in the Fitzroy was found at 16 of the 21 sites (Fig. 8.7). However, the majority of the captures were in the Nogoa sub-basin, which has a substantial amount of barrier free river above Fairbairn Dam. This species is a migratory spawner requiring summer floods to successfully recruit.

Figure 8.7. Golden Perch Captures - Fitzroy Catchment, 1994 - 1996.



Pacific Blue-eye (*Pseudomugil signifer)* was recorded in three of the four samplings at the upper Dawson site. This was the uppermost riverine site in the catchment, yet this small species (50 - 70 mm) has only previously been recorded in fresh and brackish coastal waters (McDowall, 1996).

8.5 Conclusions.

The project demonstrated differences in species diversity and abundance levels at the sites sampled, with the numbers of species recorded comparing favourably with a previously documented investigation in this catchment (Midgley, 1979). Waterbody size, habitat type, stream flow, seasonal changes and distance from the mouth of the Fitzroy were all shown to influence both species diversity and abundance levels of fish. However, the wide range of both spatial and temporal variability evident in the physico-chemical results of this project was even more pronounced within the fisheries results. The limited number of times sampling took place, the mobility of fish, the difficulty in obtaining truly representative sites and influences of natural events (floods) made interpretation difficult. Even so, this is to date, the most comprehensive fisheries project ever carried out in the Fitzroy catchment and the resulting data has provided base-line information with which future fisheries trends in the catchment may be established.

As there is limited historical data with which to compare current data, comment on the impact of catchment development upon fish abundance and population structure is difficult. However, it may be suggested that there have been impacts upon the fish population structure through modifications to both instream and riparian habitat as well as from fishing pressure. Russell and Hales (1993) have demonstrated in the Johnstone River that productivity of riverine fish communities is determined by both habitat and food resources and these factors are intricately linked to the structure and composition of riparian zones.

This project added substantially to the knowledge of Fitzroy catchment fisheries resources. Yet the direct and indirect impacts of catchment modification, current land use practices, stream barriers and stream water quality (results presented in other sections of this report) need further investigation to establish long term trends in the complex fish community. In light of the proposals to further modify the catchment with the construction of several weirs and two large storages, with the resulting impact upon stream flows, further studies to assess these impacts are important if the resource is to be maintained. In the future, all new water infrastructure projects will need to be better managed to minimise the potential adverse impacts.

In 1991, the Murray-Darling Basin Commission published a Fish Management Plan (Lawrence, 1991). This plan listed the major factors contributing to the decline of native fish populations within the basin: flow regulation, barriers to fish migration, reduced instream habitat, reduced floodplain habitat, reduced water quality and an increase in exotic species and diseases. Whilst there is evidence that the Fitzroy catchment has not reached the state of decline of the Murray-Darling, future management plans need to be very mindful of the Murray-Darling experience.

9. RECOMMENDATIONS

9.1 General

- continue monitoring to establish changes and trends in water quality in the catchment using the Ambient Water Quality Monitoring Network as the main mechanism
- interpret and report on this data for the Fitzroy catchment at least **annually** to allow for fine tuning of the system, and maximum benefit (information) from resources expended. Trends and changes will only be established in the 5 -10 yr time frame, but major resource management decisions may be made in a shorter time frame (1 - 3 yr), so that information on the current state of the resource (water quality and stream health) is needed immediately. Annual reporting is working well in the large monitoring network for the central and north western rivers in New South Wales
- emphasise the need for an assessment of water quality emanating from **individual sub-basins** in the Fitzroy system, especially under flow conditions. This information would assist resource managers and decision makers in evaluating the impact of land use options within sub-basins
- increase the level of biological monitoring of streams and impoundments within the catchment, and integrate this more closely with the current Ambient Water Quality Monitoring Network, which is predominantly physico-chemical and chemical. Currently, most biological data (phytoplankton, zooplankton, invertebrate, macrophyte, fisheries) are somewhat limited because of resource constraints and are arising from a number of separate studies
- initiate discussions on the concept of major water users in the region contributing towards the cost of water quality and stream health monitoring programs. The cotton industry in central and north western New South Wales contributes significantly to such monitoring programs there
- support more focussed monitoring for site or sub-basin specific issues such as rehabilitation of the Dee River downstream from Mt Morgan

9.2 Pesticides

- establish more clearly whether residues of atrazine and perhaps other broadacre herbicides remain fairly common in many sections of streams in the catchment and if so, at what concentrations. Evaluate these levels against current and future Australian Environmental and Drinking Water Guidelines, and if there is cause for concern, investigate changes in usage patterns and other management options to reduce concentrations in the streams
- liaise more closely with the Australian Cotton Growers Research Association, the Australian Cotton Foundation, cotton growers and aerial contractors to encourage the industry in their move towards the establishment of Best Management Practices. Management options to minimise the movement of "cotton" chemicals off-farm and into the riverine systems in the Dawson, Nogoa and Comet sub-basins are essential. This will be especially relevant if dams are constructed on the Dawson and Comet Rivers and cotton production areas increase significantly in these sub-basins
- publish results of pesticide studies more widely and more frequently

9.3 Nutrient and Suspended Solid Loads

- continue studies to identify spatial and temporal links between suspended solids and nutrient levels and sources, algal cell densities and associations and flows within the sub-basins
- investigate the relationships between flows, suspended solids and nutrients in each of the sub-basins and especially the role of land use patterns, major flow events, flow regulation and extraction on the production, cycling and transport of nutrients
- determine by studies of offshore and onshore historical sediment profiles whether the rate of sediment deposition offshore has increased dramatically during the period of man's major land use activities (the last 50 years)

9.4 Biology

- continue studies aimed at understanding and if necessary manipulating the spatial and temporal dynamics of phytoplankton and related biological and physical systems in streams, impoundments and dams throughout the catchment
- commence studies to determine if herbicide and pesticide residues identified in sections of streams in the Fitzroy system are having an impact on the stream biota, particularly macrophytes, invertebrates and fish. Continue and strengthen liaison with groups doing similar work elsewhere in Australia and overseas
- commence a study to document the impacts on biota of "regulated" sections of streams and provide recommendations on water management practices that may mitigate such impacts
- document the size, location and significance of aquatic communities present in floodplains and wetlands likely to be affected by reduced duration and volumes of flows if further dams are constructed in some of the sub-basins

10. REFERENCES.

Australian and New Zealand Environment and Conservation Council (ANZECC) 1992. *Australian Water Quality Guidelines for Fresh and Marine Waters*, National Water Quality Management Strategy, Canberra.

Australian Bureau of Statistics. 1995. *Agriculture Queensland.* ABS Catalogue No. 7113.3. Commonwealth of Australia.

Australian Bureau of Statistics. 1996. *Agriculture Queensland.* ABS Catalogue No. 7113.3. Commonwealth of Australia.

Australian Bureau of Statistics. 1996. *Queensland Year Book 1996.* ABS Catalogue No. 1301.3 Commonwealth of Australia.

Bain, M. B., Finn, J. T. and Booke, H.E. 1988. 'Streamflow regulation and fish community structure', *Ecol.,* **69**:38-392.

Baker, P. 1991. *Identification of Common Noxious Cyanobacteria.* Part I - Nostocales. Melbourne: Urban Water Research Association of Australia.

Barry, G. 1996. *personal communication.* Resource Sciences Centre, Department of Natural Resources, Brisbane.

Berghuis, A. and Long, P. 1995. *Dawson River Resource Document, Central Queensland 1995.* Department of Primary Industries, Central Region, Queensland.

Bishop, K. A., Allen, S. A., Pollard, D. A. and Cook, M. G. 1986. *Ecological studies on the freshwater fishes of the Alligator River Region, Northern Territory,* Research Report, **4**. Australian Government Printing Service, Canberra.

Bowling, L. C. and Baker, P. D. 1996. 'Major cyanobacterial bloom in the Barwon-Darling River, Australia, in 1991, and underlying limnological conditions', *Mar. Freshwat. Res.*, **47**:643-657

Bureau of Meteorology, Daily Rainfall Records.

Burgess, J. W. (in prep). *Soils and Land Suitability of the Windeyers Hill area, Queensland.* Queensland Department of Primary Industries Bulletin.

Chudek, E. 1995. *Water Quality of the Fitzroy River Basin and Proposed Monitoring Network*, Volume 1. Water Resources Division, Queensland Department of Primary Industries, Brisbane.

CMPS and F. 1992. Rockhampton Flood Management Study. Water Resources Commission.

Cooper, B. 1996. Central and North West Regions Water Quality Program. 1995/96 Report on Pesticides Monitoring. NSW Department of Land and Water Conservation TS 96.048.

Davies, B. and Willcocks, J. 1992. 'Climate Variability in the Fitzroy Catchment', *Fitzroy Catchment Symposium Proceedings,* University of Central Queensland, Rockhampton.

Department of Natural Resources. Queensland streamflow records. Hydrometric Services.

Duivenvoorden, L. J. 1992. 'Aquatic macrophytes of the Fitzroy River catchment', *Fitzroy Catchment Symposium Proceedings*, Central Queensland University, Rockhampton.

Duivenvoorden, L. J., Yule, D. F., Fairweather, L. E. and Lawrie, A. G. (Eds.) 1992. *Fitzroy Catchment Symposium Proceedings*, University of Central Queensland, Rockhampton.

Duivenvoorden, L. J. 1995. *Biological Assessment of the Dee River, Central Queensland.* III Biological status of the Dee River in relation to Acid Mine drainage: March, 1995. Consultancy report for the Queensland Department of Minerals and Energy. 94pp.

Fabbro, L. D. and Duivenvoorden, L. J. 1992. 'Water quality aspects of the Fitzroy River in Rockhampton - a look at the blue-green algae problem', paper presented at Central Region Engineering Conference, Rockhampton.

Fabbro, L. D. and Duivenvoorden, L. J. 1993. *A photographic guide of common cyanobacteria of Central Queensland.* Rockhampton.

Fabbro, L. D. and Duivenvoorden, L. J. 1996. 'Profile of a bloom of the cyanobacterium Cylindrospermopsis raciborskii (Woloszynska) Seenaya and Subba Raju in the Fitzroy River in Tropical Central Queensland', *Mar. Freshwat. Res.*, **47**:685-694.

Fabbro, L. D. and Watson, G. 1992. 'Freshwater zooplankton of the lower Fitzroy River', *Fitzroy Catchment Symposium Proceedings*, University of Central Queensland, Rockhampton.

Foged, N. 1978. 'Diatoms in eastern Australia', *Bibl. Phycol. Band,* **41**. J. Cramer

Forster, B. A. and Shields, P. G. 1992. 'Soils and Agricultural Use', *Fitzroy Catchment Symposium Proceedings*, University of Central Queensland, Rockhampton.

Forster, B. A. (in prep). *Land Systems of the Capricornia Coastal Area, Queensland.* Queensland Department of Primary Industries Bulletin.

Gunn, R. H. , Galloway, R. W., Pedley, L. and Fitzpatrick, E. A. 1967. 'Lands of the Nogoa-Belyando area, Queensland', *CSIRO Land Research Series,* **18**. CSIRO.

Hamilton, D. and Haydon, G. 1996. *Pesticides and Fertilisers in the Queensland Sugar Industry - Estimates of Usage and Likely Environmental Fate.* Resource Management Institute, Department of Primary Industries Brisbane.

Harris, J. H. (ed.) 1987. *Proceedings of the Conference on Australian Threatened Fishes,* Division of Fisheries, Department of Agriculture, NSW.

Kelly, N. 1996. *personal communication.* Water and Catchment Management Group, Department of Natural Resources, Rockhampton.

Kelly, N. and Wong, W. T. 1996. 'Sediment Transport in the Fitzroy River during Flood Events', *Proceedings 1st National Conference of Stream Management in Australia*, Melbourne.

Hem, J. D. 1970. *Study and Interpretation of the Chemical Characteristics of Natural Waters,* United States Government Printing Office, Washington , USA.

Johnstone, P., Fabbro, L., Blake, T., Robinson, D., Noble, R., Rummenie, S. and Duivenvoorden, L. 1995. 'Land use, water use and blue-green algae', paper presented at *Downstream Effects of Land Use Conference*, Central Queensland University, Rockhampton.

Kennard, M. J., Arthington, A. H. and Pusey, B. J. 1995. 'Habitat and flow requirements of fish in Queensland Rivers', *Workshop on Stream Rehabilitation*, QDPI, Brisbane.

Kirk, K. L. 1992. 'Effects of suspended clay on *Daphnia* body growth and fitness', *Ecol.*, **28**:103-109.

Kirk, K. L. and Gilbert, J. J. 1990. 'Suspended clay and the population dynamics of planktonic rotifers and cladocerans', *Freshwat. Biol.,* **71**:1741-1755.

Koehn, J. D., O'Connor, N. A. and Jackson, P. D. 1994. 'Seasonal and Size-related Variation in Microhabitat Use by a Southern Victorian Stream Fish Assemblage', *Aust. J. Freshwater Res.*, **45**:1353-66.

Lampert, W. 1987. 'Laboratory studies on zooplankton-cyanobacteria interactions', *NZ. J. Mar. Res.,* **21**:483-490.

Lawrence, B. W. 1991. *Fish Management Plan*. Murray-Darling Basin Commission. ISBN 1 875209 08 5.

Lobegeiger, R. 1988. *Capricornia Region Rural Industries*. Third Edition. Regional Series RQR 89003, Queensland Department of Primary Industries, Rockhampton.

McDonald, L. E. 1992. 'Settlement and development of the Fitzroy Basin', *Fitzroy Catchment Symposium Proceedings*, University of Central Queensland, Rockhampton.

McDowall, R.M. (ed) 1996. *Freshwater Fishes of South-Eastern Australia.* Revised edition, Reed Books, Sydney, Australia.

Merrick, J. R. and Schmida, G. E. 1984. *Australian Freshwater Fishes*, Griffin Press Ltd. Adelaide.

Midgley, S. H. 1979. 'A Fish Survey of the Fitzroy River', *Queensland Fisheries Service Special.* No. **11**.

Morrison, A. K. 1988. ' Management of Introduced Species in the Murray-Darling Basin - A Discussion Paper', *Proceeding of the Workshop on Native Fish Management*, Murray Darling Basin Commission, Canberra.

Muller, P. G. (in prep). *Soils and Land Suitability of the Banana area, Queensland.* Queensland Department of Primary Industries Bulletin.

NHMRC/AWRC 1987. *Guidelines for Drinking Water Quality in Australia.* NHMRC, AWRC.

NHMRC/ARMCANZ 1994. *Draft Australian Drinking Water Guidelines.* National Health and Medical Research Council and Agricultural and Resource Management Council of Australia and New Zealand.

NHMRC/ARMCANZ 1996. *Draft Australian Drinking Water Guidelines.* National Health and Medical Research Council and Agricultural and Resource Management Council of Australia and New Zealand.

Noble, R. M., Rummenie, S. K., Long, P. E., Fabbro, L. D. and Duivenvoorden, L. J. 1996. 'The Fitzroy River Catchment: An Assessment of the Condition of the Riverine System', *Proceedings of the 8th Australian Agronomy Conference*, pp 446-449. Toowoomba, Queensland.

NSW Blue-Green Algae Task Force 1992. Blue-Green Algae - Final Report, Department of Water Resources, Parramatta.

Paerl, H. W. 1988. 'Nuisance phytoplankton blooms in coastal, estuarine and inland waters', *Limnol. Oceanogr.*, **33**(**4,2**):823-847.

Preston, C. 1996. Central and North West Regions Water Quality Program. *1995/96 Report on Nutrients and General Water Quality Monitoring.* NSW Department of Land and Water Conservation TS 96.049.

Puckridge, J. and Drewien, M. 1988. *The Aquatic Fauna of the North-West Branch of Coopers Creek,* Consultancy Report to the Department of Environment and Planning, Adelaide.

Puckridge, J. T. and Walker, K. F. 1990. 'Reproductive Biology and Larval Development of a Gizzard Shad, Nematolosa erebi (Günther) (Dorosomatinae: Teleostei), in the Murray River, South Australia', *Aust. J. Mar. Freshwater Res.*, **41**:695-712.

Rayment, G. E. and Simpson, B. W. 1993. 'Pesticide Audit for the Condamine-Balonne-Culgoa Catchment', *Water Quality Management in the Condamine-Balonne-Culgoa Catchment.* (Ed. S. J. Kenway) pp 99-166 (Condamine-Balonne Water Committee, Dalby, Queensland).

Reynolds, C. S. and Walsby, A. E. 1975. 'Water-blooms', *Biol.Rev.,* **50**:437-481.

Reynolds, C. S. 1980. 'Phytoplankton assemblages and their periodicity in stratifying lake systems', *Holarct. Ecol.,* **3**:141-159.

Roe, P. 1992. 'Mining as a Land Use in the Fitzroy Catchment', *Fitzroy Catchment Symposium Proceedings*, University of Central Queensland, Rockhampton.

Rummenie, S. K. and Noble, R. M. 1996. 'Drainage and Tailwater Recycling Reduces Nutrient, Sediment Movement', *The Australian Cotton Grower*. Vol 17, No. 6, pp 32 - 39.

Russell, B. J. and Hales, P. W. 1993. *Stream Habitat and Fisheries Resources of the Johnstone River Catchment,* Department of Primary Industries, QI93056, Brisbane.

Shapiro, J. 1990. 'Current beliefs regarding dominance by blue-greens: The case for the importance of CO_2 and pH', *Verh. Internat. Verein. Limnol.,* **24**:38-54.

Shiel, R. J. 1986. 'Zooplankton of the Murray-Darling system', In: B. R. Davies & K. F. Walker (Eds), *The Ecology of River Systems*. Publ. as Monogr. Biol, **60**, 661-677.

Shiel, R. J. and Walker, K. F. 1985. 'Zooplankton of regulated and unregulated rivers: the Murray-Darling river system, Australia', In A. Lillehammer & A. Saltveit (Eds), *Regulated Rivers*. Univ. Oslo Press: 263-270.

Shiel, R. J., Walker, K. F. and Williams, W. D. 1982. 'Plankton of the lower River Murray, South Australia', *Aust. J. Mar. Freshwater Res*., **33**:301-327.

Simpson, B. W., Rayment, G. E. and Spann, K. P. 1992. *Pesticide Use Study - Pumistone Passage Catchment*. Division of Land Management, Department of Primary Industries, Brisbane.

Speck, N. H., Wright, R. L., Sweeney, F. C., Perry, R. A., Fitzpatrick, E. A., Nix, H. A., Gunn, R. H. and Wilson, I. B. 1968. 'Lands of the Dawson-Fitzroy area, Queensland', *CSIRO Land Research Series,* **21**. CSIRO.

Story, R., Galloway, R. W., Gunn, R. H. and Fitzpatrick, E. A. 1967. 'Lands of the Isaac-Comet area, Queensland', *CSIRO Land Research Series,* **19**. CSIRO.

Walker, K. F. and Thoms, M. C. 1993. 'Environmental Effects of flow Regulation on the Lower River Murray, Australia', *Regulated Rivers: Research and Management*, **8**:103-119.

APPENDIX A

PROJECT TEAM

Principal Investigators

Bob Noble - Project Leader - DNR - Biloela Research Station.
Dr Leo Duivenvoorden - Coordinator - Biological studies (excluding Fisheries) - Central Queensland University (CQU)
Peter Long - Coordinator - Fisheries studies - DPI - Rockhampton
Stace Rummenie - Project Officer - DNR - Biloela Research Station
Larelle Fabbro - Algal studies - Central Queensland University.

Project Management (advisory) - Ken Day and Dr Don Yule - DNR - Rockhampton.

Activities

(i) Water and Algal Sampling - Physico-chemical Parameters
Stace Rummenie*, *Bob Noble, Bruce Cowie and Melindee Hastie (resigned).

(ii) Rainfall and Streamflow Data
Nigel Kelly.

(iii) Land Uses in the Catchment and Map Preparation
Ian Heiner and Ken Adsett.

(iv) Cotton Site - Emerald (LWRRDC and CRDC)
Evan Thomas (resigned), Brett Kuskopf.

(v) Inorganic and Heavy Metal Chemistry
Heather Hunter, Glen Barry and groups - Resource Sciences Centre - DNR, Brisbane.

(vi) Organic Chemistry
Bruce Simpson, Phil Hargreaves and group - Resource Sciences Centre - DNR, Brisbane.

(vii) Fisheries Studies and Invertebrate and Zooplankton Sampling
Peter Long, Andrew Berghuis and Cameron Romano, DPI - Rockhampton.

(viii) Algal and Invertebrate Analysis
Dr Leo Duivenvoorden*, *Larelle Fabbro and David Roberts - CQU - Rockhampton.

(ix) Aquatic Vegetation
Dr Leo Duivenvoorden, CQU - Rockhampton.

(x) Zooplankton Analyses
Dr Russel Shiel, Murray Darling Freshwater Research Centre, Albury, NSW.

Footnote: Unless otherwise indicated, project team members are from the Department of Natural Resources (DNR), Central Region.

APPENDIX B

SITE DESCRIPTIONS

The approximate location of sampling sites is given in Fig. 1.1 and Table 1.1 and a general description of sampling activities at the sites in Fig. 1.2. More specific location details are included here.

Most primary river sites were chosen to represent downstream locations of sub-catchments (basins) and upstream of river junctions or combinations of these. In some sub-basins both upper and lower catchment sites were included.

For convenience, as in Figure 1.2, sampling sites are divided into three categories:

1. Primary River Sub-basin Sites (***Site Nos. 1 to 11***)
2. Dawson River Sites - including Beckers on the Dawson and Riverslea on the upper Fitzroy(***Site Nos. 7 and 12 to 16***)
3. Secondary Sites (***Site Nos. 10, 11 and 17 to 28***)

1. PRIMARY RIVER SUB-BASIN SITES

Table - Appendix B - Primary River Sub-basin Sites

Site No.	Sub-basin	Site and Water Resources Gauging Station
1	Fitzroy	Eden Bann Weir (The Gap - 130005A)
2	Connors	Twin Bridges (Pink Lagoon - 130404A)
3	Isaac	Yatton (Yatton - 130401A)
4	Mackenzie	below Bingegang Weir (Bingegang Weir - 130106A)
5	Mackenzie	Coolmaringa (Coolmaringa - 130105A)
6	Don	Rannes (Rannes - 130306A)
7	Dawson	Beckers (Beckers - 130322A)
8	Dawson	Baroondah above Yebna Crossing (Utopia Downs - 130324A)
9	Comet	near Comet (at 17.2 km) (Comet - 130504A)
10	Nogoa	Duckponds (Duckponds - 130219A)
11	Nogoa	Craigmore (Craigmore - 130209A)

Site 1 - Fitzroy River at Eden Bann Weir 23.088°S; 150.114°E

The most downstream primary river monitoring site in this project with potential impacts from most of the Fitzroy system. The Weir, completed in late 1994, holds a considerable body of water with depths greater than 5 m and a weir pool 22 kms long. Local land use is predominantly grazing with some disturbance from weir construction.

Site 2 - Connors River near Twin Bridges 22.412°S; 148.993°E

A permanent pool on a sweep of the river with extensive sand deposition on the inside of the curve. High flows can arise from the Connors and its northern tributaries including Funnel Creek. Land use is predominantly grazing.

Site 3 - Isaac River at Yatton 22.612°S; 149.116°E

A permanent pool on the Isaac, downstream from its confluence with the Connors. Local land use is predominantly grazing but the Isaac sub-basin supports an extensive coal mining industry.

Site 4 - Mackenzie River below Bingegang Weir 23.072°S; 149.035°E

A series of pools, rock bars and sand banks just downstream from the Bingegang Weir. Land use is mainly grazing with some dryland cropping and extensive coal mining in this large area of the Mackenzie sub-basin. The site is impacted by modified stream flows (weir releases).

Site 5 - Mackenzie River at Coolmaringa 23.271°S; 149.510°E

A magnificent stretch of the mid Mackenzie, almost 100 m wide, depths up to 5 metres and 20 kilometres long, downstream from Site 4, on the southeastern flowing arm of the river, below its confluence with the Isaac. Local land use is predominantly grazing but like Eden Bann, water quality may be influenced by most activities present upstream of this site.

Site 6 - Don River at Rannes 24.098°S; 150.115°E

A permanent pool on the lower Don. Flow is minimal except after heavy rain but depths to 4m were recorded. The site is at the downstream end of the Don and Dee Rivers and the Callide Creek basins. Agriculturally, the area supports irrigated and dryland mixed farming and grazing. The large but now defunct Mt Morgan mine, upstream on the Dee River, has had a marked impact on the Dee and possibly the Don at this site. The permanence of this pool is probably due to groundwater incursion.

Site 7 - Dawson River at Beckers 24.088°S; 149.821°E

A picturesque site on the lower Dawson, consisting mostly of continuous pools and upstream of its confluence with the Don. Logs, sandbars and overhanging trees add to the site's value as an aquatic habitat. The riparian zone is fairly well wooded but ground cover is minimal with evidence of bankside erosion. Grazing is the major land use with some irrigated and dryland cropping. This waterhole is influenced by releases of water from Neville Hewitt Weir at Baralaba.

Site 8 - Dawson River at Baroondah 25.690°S; 149.190°E

Just upstream of the Yebna Crossing on the upper Dawson - an upper catchment site with shallow (1m) but permanent low flow over a sandy substrate. The riparian zone is well grassed and wooded in a narrow strip. Land use is dominated by grazing and forestry reserves. FC

Site 9 - Comet River at the 17.2 km bend 23.651°S; 148.556°E

A site on the lower Comet, 17.2 kms upstream from its confluence with the Nogoa. Under dry conditions, flow ceases and the pools become shallow or dry out completely. The banks are steep, sparsely grassed or wooded and are quite eroded. The Comet basin is used for grazing and extensive dryland cropping when suitable rainfall occurs.

Site 10 - Nogoa River at Duckponds 23.481°S; 148.474°E

On the Nogoa, just downstream of the Emerald Irrigation Area - releases from the Fairbairn Dam maintain a flow past the site at most times. The banks show moderate erosion and a road (culvert) crossing at the location has caused some disturbance. The area is used for grazing, irrigated cropping (mostly cotton) and coal mining.

Site 11 - Nogoa River at Craigmore 23.886°S; 147.756°E

A site on the mid Nogoa, just above the Fairbairn Dam, but at the downstream end of the Fairbairn Dam catchment. Under dry conditions the river at the site consists of a series of separate small water holes. A quite wide strip of the riparian zone is well grassed and wooded. Land use is mainly grazing with some dryland cropping, mostly for forage.

2. DAWSON RIVER SITES

The Dawson River is an important component of the Fitzroy system. Rising at the southern extremity of the Fitzroy catchment, the Dawson flows north finally joining the Mackenzie to form the Fitzroy River. Land uses along the Dawson are typical of those of the entire Fitzroy catchment including grazing, dryland cropping, irrigated cropping (mainly cotton), town (urban) usage, coal mining, forestry and national parks. Six weirs are present along the length of the Dawson, and flows are regulated for irrigation and urban usage.

The Dawson was the sub-basin subjected to the highest sampling frequency for physico-chem and chemical parameters in the current work (Fig. 1.2). Details of sites used in this activity are given below. These include the primary river site at Beckers (Site No. 7) and Riverslea, (Site No 16), on the upper Fitzroy, downstream of the junction of the Dawson and Mackenzie. The sites are described in sequence from upper to lower Dawson sub-basin.

Site 12 - Delusion Creek Junction 25.182°S; 150.185°E

The site is upstream of the Theodore Irrigation Area but downstream of the Glebe, Gyranda and Orange Creek weirs so that flows are partially regulated. The river here is quite shallow and runs over sand. There is a well developed riparian zone dominated by the Dawson Palm. Land uses are mainly grazing and dryland cropping - Gauging Station - Isla / Delusion - 130358A.

Site 13 - Theodore Weir 24.960°S; 150.074°E

Impounded water behind the weir near the town of Theodore. The site is large and deep and is directly adjacent to the mouth of Castle Creek. It has a lightly wooded and grassed riparian zone. The site is well used recreationally. Land and water uses are mainly urban and irrigated cropping (cotton), with grazing and dryland cropping.

Site 14 - Moura Weir 24.602°S; 149.910°E

Near the road bridge in the impounded water behind the Moura Weir - a large deep site with a lightly wooded and grassed riparian zone. The site is well used recreationally. Surrounding land uses include urban, irrigated and dryland cropping, grazing and extensive coal mining.

Site 7 - Primary river site at Beckers - refer to Section 1 of this Appendix.

Site 15 - Capricorn Highway Crossing 23.792°S; 149.763°E

The site is just upstream of where the Capricorn Highway crosses the Dawson River. This was the most downstream location in the Dawson sub-basin sampled during the project. Local land uses are dominated by grazing with some cropping but at this lower end of the sub-basin, water quality may show influences from all activities along the Dawson. The site itself is relatively wide but shallow and flows over extensive sand deposits. The riparian zone is dominated by large callistemon (bottle-brush) trees.

Site 16 - Riverslea on the Upper Fitzroy 23.571°S; 149.938°E

Local land use is mainly grazing with some cropping. The site, being just downstream of the Mackenzie - Dawson confluence, is well placed to show influences from both of these systems. When, at a given time, a major flow occurs in only one of these sub-basins (refer to Section 4. 4 of this report, for details of monitoring of a significant flow in the Dawson) this site effectively allows monitoring of the flow with little input from the other "low flow" sub-basin. Also, in a simplistic way, the differences in water quality at Riverslea and at the Rockhampton Barrage should indicate inputs along the Fitzroy sub-basin.

3. SECONDARY SITES

Secondary sites (Figs. 1.1 and 1.2 and Table 1.1) were chosen to represent a range of additional types of surface water habitats in the Fitzroy catchment. Where possible these were selected in "pairs". One of the pair, was a less "impacted" or control site and the other expected to show some effects from location or surrounding land use. Project resources limited the depth of these studies, so the work is of a preliminary nature only.

Site 17 - Taroom Lagoon (Upper Wetland) 25.523°S; 149.776°E

A small lagoon in the Taroom section of the "upper" Dawson catchment. The lagoon is filled by the Dawson river during larger flows and floods with some local input. Positioned approximately 20 km from Taroom, the surrounding land use is dominated by grazing. The site shows evidence of recreational use (fishing) and is close to local roads.

Site 18 - Lake Mary (Lower Wetland) 23.119°S; 150.591°E

An extensive and shallow wetland in the lower catchment situated about 20 km west of Yeppoon. Much of the surrounding area is swamp and subject to seasonal inundation. The site, which is situated on a grazing property, has very limited public access and is adjacent to flora and fauna reserves. As such, influences are predominantly grazing. The riparian zone is well vegetated primarily in the form of herbs and grasses.

Site 19 - Grazing Farm Dam 24.295°S; 148.195°E

A fairly small but deep dam situated on the grazing property "Barakee", south of Springsure. The dam is fed solely by local runoff from the property and is used as a water supply for stock. Its sole influences are a result of grazing and stock activities. The surrounding area is grassed but has little in the way of larger trees or shrubs.

Site 20 - Agricultural Farm Dam 23.452°S; 148.152°E

A 200 ML above ground tailwater recycling dam on an irrigated cotton farm in the Emerald Irrigation Area. Tailwaters are collected from irrigations and larger rainfall events into a sump below the dam. Water is then pumped up into the dam and stored for reuse as an irrigation supply at later dates. Extensive banks of rushes surround the dam's inner boundary. Depth is approximately 5 metres. Impacts are solely agricultural.

Site 21 - Theresa Dam - Clermont 22.975°S; 147.555°E

The Clermont water supply, produced by the construction of a dam wall on Theresa Ck just downstream of Iron Hut Ck and Policeman Ck junctions. A fairly shallow dam, with deeper reaches near the original Theresa Ck channel, and which has a maximum capacity of 9,200 ML. It began suffering from blue-green algae problems very shortly after construction and much time is still spent in controlling this problem. This is an upper catchment dam with impacts predominantly from grazing. + possibly mining?

Site 22 - Callide Dam - Biloela 24.361°S; 150.633°E

This dam supplies both the Biloela township and the Callide B Power Station with their main sources of water. Water is pumped across to the dam from Awoonga Dam (Gladstone) in order to ensure supply for the power station. This dam, produce by the damming of Callide Ck, is quite large and deep with a holding capacity of 127,000 ML - surrounding land use is predominantly grazing.

Site 23 - Crinum Ck (Industrial) 23.119°S; 150.591°E

This site, a small permanent waterbody situated at Lillyvale on Crinum Ck is downstream from the Crinum mine site and as such is influenced by its activities. A small but constant flow is observed at this site throughout most of the year (primarily the result of groundwater incursion). The riparian zone is lightly wooded and grassed with the edges of the waterhole dominated by well developed stands of rushes. Other land uses in the area include cropping and grazing. The site shows signs of being well used for recreational activities.

Site 24 - Moores Ck (Semi-Urban) 23.325°S; 150.552°E

The Moores Ck site is situated in close proximity to Rockhampton in the foothills of Mount Archer. The stream here is spring fed and clear, consisting of a series of rockpools and riffles over boulders and a gravelly substrate. The site is used extensively for recreational activities. The riparian zone is well developed but is dominated by extensive areas of weed infestation particularly lantana and rubbervine.

Site 25 - Raymond (Upper Nogoa) 24.246°S; 147.642°E

This upper Nogoa River site is influenced predominantly by grazing activities. The site is a relatively shallow (2 metres), but long waterhole situated approximately 60 kms west of Springsure. The surrounding area has been cleared fairly extensively and is dominated by grasses. There is a small zone of trees running down both banks but evidence of erosion is present. The site is known to be regularly frequented by recreational fishers.

Site 26 - Below Fairbairn Dam (I) 23.647°S; 148.069°E

The first site below the Fairbairn dam on the Nogoa River, is 500 metres downstream of the dam wall. It is adjacent to an extensive "wetland" like pool dominated by a variety of aquatic plants and is a declared fish reserve. The stream itself is regulated via controlled releases from the dam and is relatively narrow and shallow and as such, a fairly high flow rate is often present. The site is used fairly extensively for recreational purposes, particularly fishing. The riparian zone consists of a mix of trees, grasses and other plants and is in a low impacted state.

Site 27 - Below Fairbairn Dam (II) 23.628°S; 148.084°E

The second site below the Fairbairn dam on the Nogoa River, is 5 kilometres downstream of the first dam site. It is adjacent to a number of grazing blocks and has influences predominantly from these activities. The stream is similar in nature to that at the first dam site (Site 26), being regulated via controlled releases from the dam and being relatively narrow and shallow. The riparian zone is similar to that present at Site 26.

Site 28 - McCoskers (Lower Nogoa) 23.424°S; 148.393°E

This site situated on the Nogoa River, just downstream of the Emerald Irrigation Area, has influences from grazing, irrigated cropping (mostly cotton) and coal mining. The site is just upstream of the Duck Ponds site and is similar to it but without the presence of the road culvert and associated disturbances. Releases from the Fairbairn Dam maintain a flow past the site at most times. The site itself is adjacent to grazing and cropping properties. There is a well developed riparian zone both sides of the river consisting of a good mix of trees, grasses and other plants.

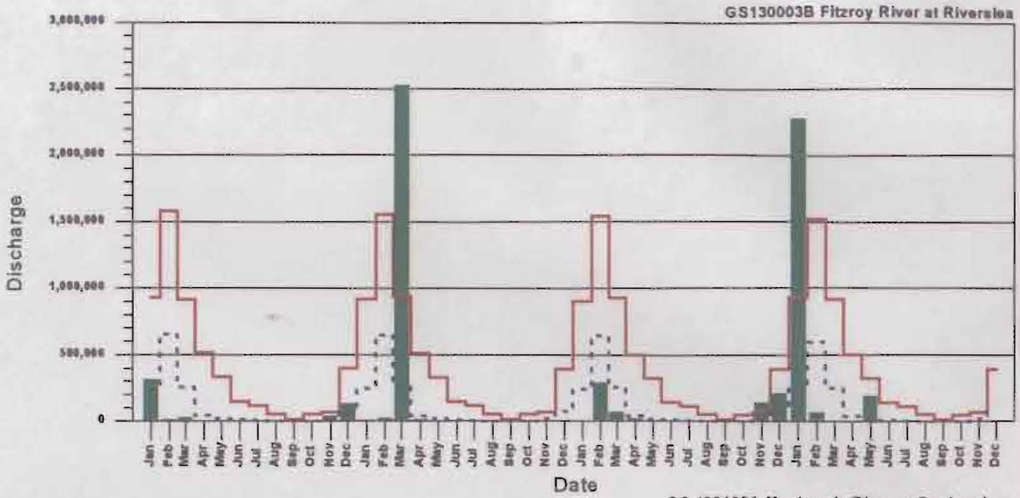
SUMMARY

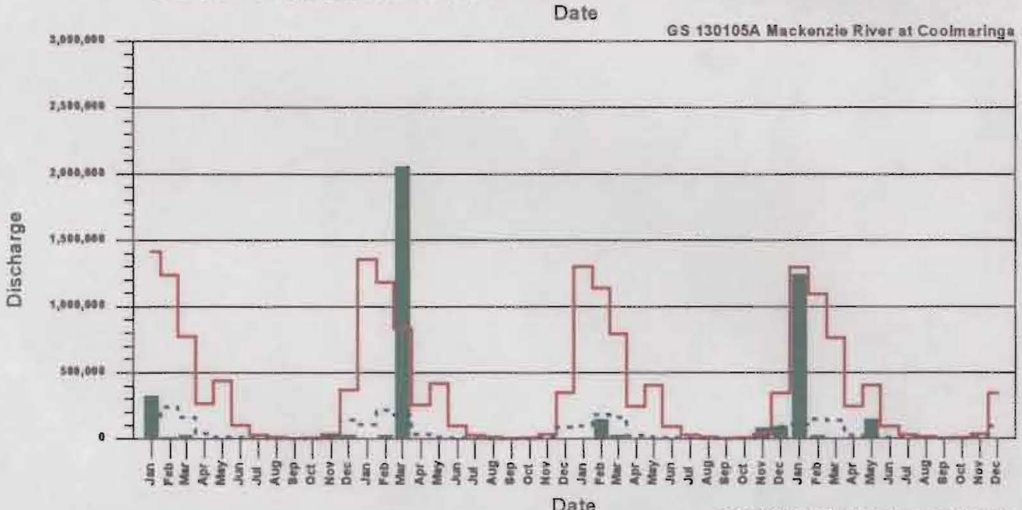
The sites selected showed a fair representation of the types of sites present within the Fitzroy catchment - the ephemeral, irregular and diverse nature of the streams being highly evident. While most riparian zones observed in the study were in relatively good condition, the wooded sections were mostly narrow and most sites showed evidence to some degree of weed invasion. Areas of parthenium, prickly acacia, parkinsonia and noogoora burr were present to a greater or lesser extent at a number of sites although this varied on a seasonal and a year to year basis.

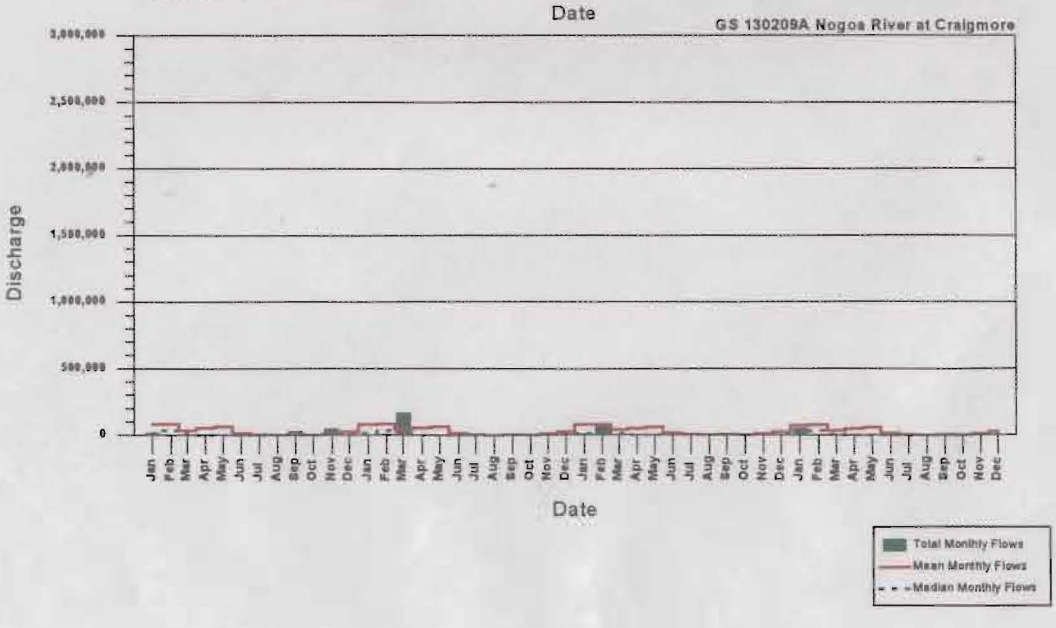
APPENDIX C

Monthly Total, Mean and Median Discharges (Ml)

January 1993 to December 1996







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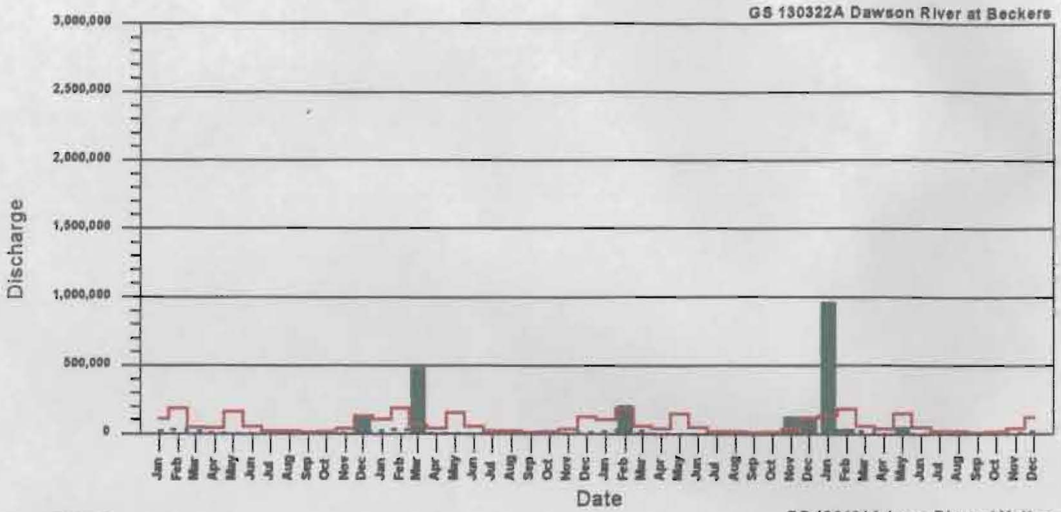
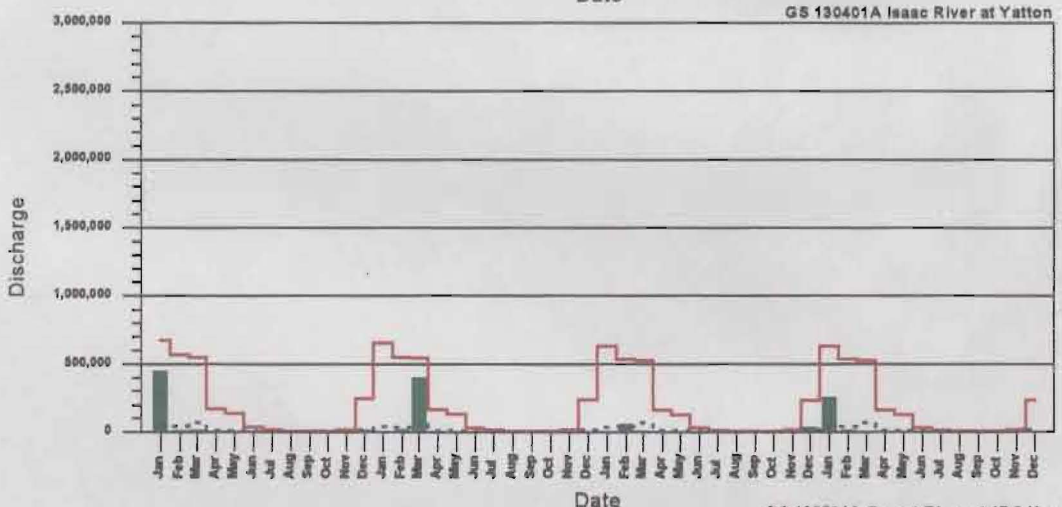
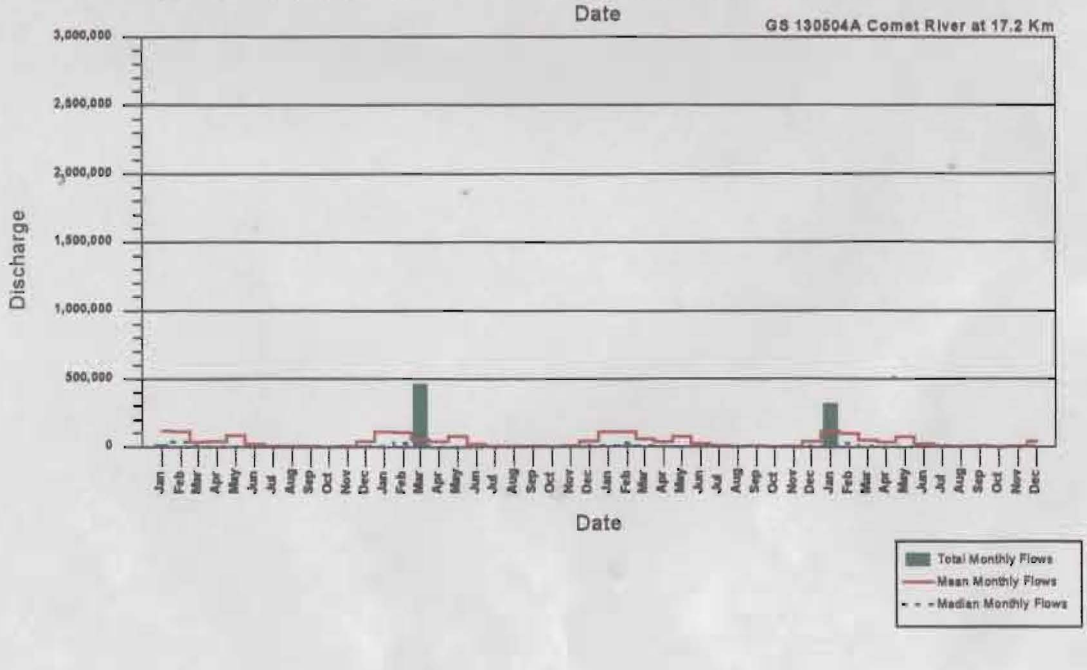
January 1993 to December 1996







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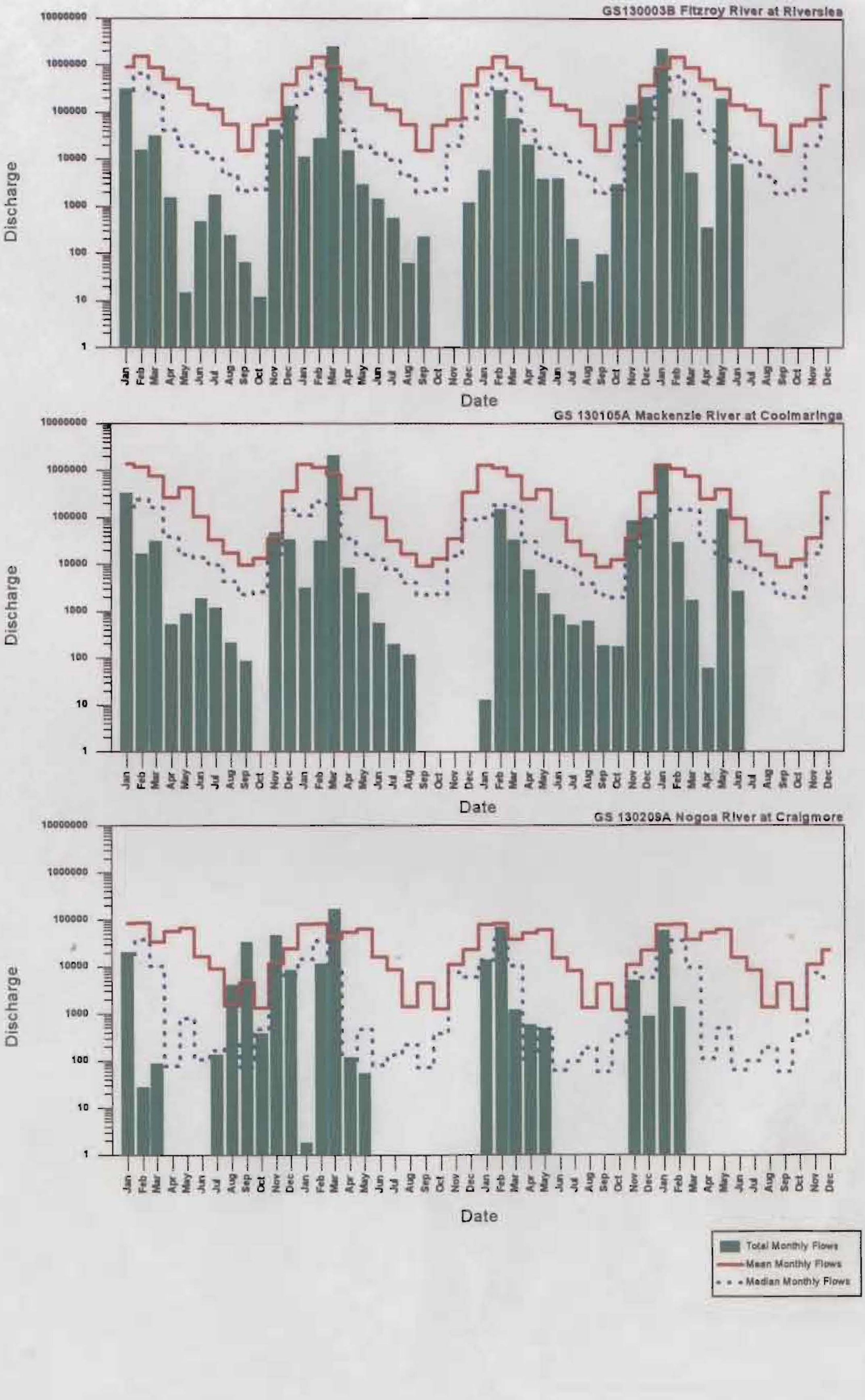
January 1993 to December 1996



Monthly Total, Mean and Median Discharges (Ml)

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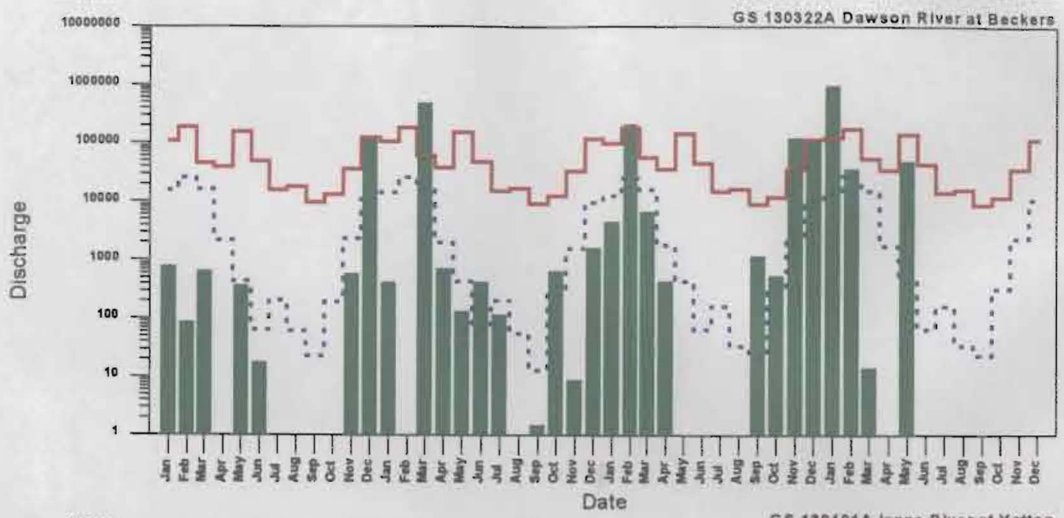

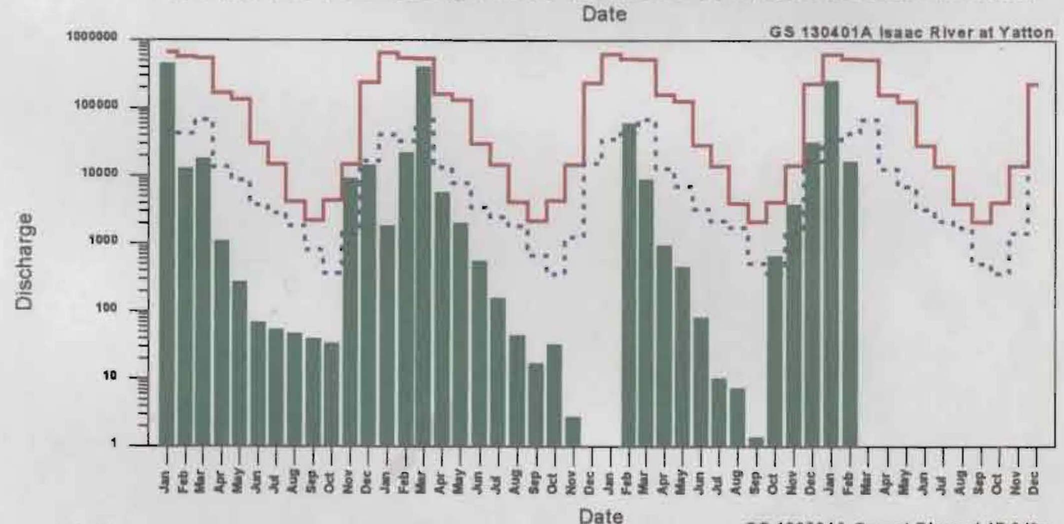

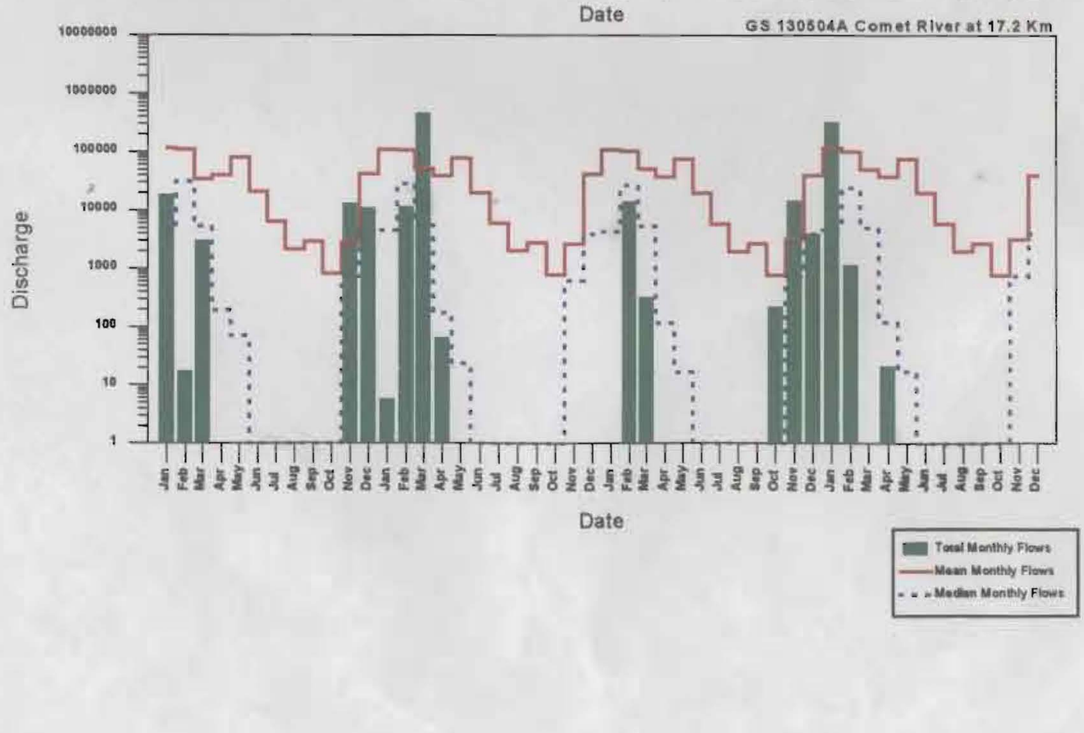

APPENDIX D

PESTICIDE DETECTION LIMITS

Analyses were performed by the Pesticide and Product Quality Group of the Resource Sciences Centre, Queensland Department of Natural Resources, Indooroopilly, Brisbane.

Pesticide Residues Typically Scanned
Samples (unfiltered) were extracted with dichloromethane and hexane and the concentrated extracts analysed for selected organochlorine, organophosphate, triazine and other residues by GC/MS.

Compounds included in the analysis with their detection limits are as follows:

Compound	Detection Limit (μg/L)
α - Endosulfan	0.20
β - Endosulfan	0.20
Endosulfan Sulphate	0.20
p,p-DDE	0.20
Profenofos	0.20
Trifluralin	0.10
Prometryn	0.20
Atrazine	0.20
Hexazinone	0.50
Tebuthiuron	0.50

Other Pesticides Scanned
Picloram: Selected samples were extracted with dichloromethane and hexane and then methylated prior to analysis by GC/MS. The detection limit for Picloram was typically 0.5 μg/L.

DDT: All of the samples collected from the Primary sites (Site Nos. 1 to 11) during the sampling of June, 1994, were extracted with dichloromethane and the concentrated extracts analysed by GC/MS for DDT and other related compounds. The detection limit was 0.1μg/L.

2, 4-D and 2,4,5-T: All of the samples collected from the Primary sites (Site Nos. 1 to 11) during the sampling of June, 1994, were also extracted and analysed for 2, 4-D and 2,4,5-T using the NATA method. The detection limit for the two compounds was 0.2 μg/L.

Diuron and Fluometuron: A small number of samples from around cotton growing areas were also screened for Diuron and Fluometuron. Detection limits were 1.5 μg/L and 1 μg/L respectively.