Chapter 5: Water

5.1 Summary and indicators

5.1.1 Summary

Clean water is essential to the environment, the society and the economy of the Gold Coast. Not including the extensive beaches, some 6% (8706ha) of the area of the Gold Coast is water including Southern Moreton Bay. This water is in some 480km of rivers and streams, as well as 774ha of lakes, dams and canals which wind their way through the Gold Coast landscape.

State
There is considerable information on the quality of the water in the Gold Coast. However, most of this data focuses on the drinking and surface waters of the area. The quality of the drinking water consistently meets all health standards and the quality of the surface waters currently meets National guidelines for all waterways, at most times. While this is encouraging, the frequency of sampling may not be sufficient to adequately record the water quality during major runoff events. There are however exceptions in the coastal lowlands where severe intermittent acid sulfate effects have been recorded. The groundwater resources of the Gold Coast are not extensive and have not been considered economically significant. Consequently, the current quality of the groundwater resources is not well understood. The health of the riparian land and the stream beds is also not well understood.

Pressure
The Gold Coast faces considerable pressures in maintaining and enhancing the water quality. This task is made more difficult due to the growth of the City as well as the increasing number of tourists, visitors and daytrippers.

Response
The Council is responding to the state of the water and the pressures faced by implementing a number of programs and projects. These include:

- *Gold Coast Catchment Management Strategy*
- *Waterwatch*
- *Gold Coast City Council's Water Consumption Reduction Strategy*
- *Improved water treatment and re-use*
- *Northern Waste-Water Treatment Strategy*
- *Hinze Dam Catchment Management Program*
- *Stormwater Awareness Program*
- *Stormwater runoff studies*
- *Local Development Guidelines*
- *Integrated Catchment Management Program*
- *Catchment Management plans for major Catchments*
- *Community and Industry Awareness Program*
- *Acid Sulfate Soil Management Policy*

Conclusion

The Council is also considering a number of future initiatives, including:

- *feasibility of a Groundwater Monitoring program*
- *Biological Monitoring*
- *Event Monitoring*
- *Determining Environmental Flows*

5.1.2 Indicators

Sub-theme	Indicators
State- ⇒ Surface and gr'dwater quality	Temperature, suspended solids, Rubbish and weeds in canals and lakes
State- ⇒ Riparian and Stream bed conditions	Status
State- ⇒ Drinking water Quality	E.coli, pathogens,pH, Salinity, nutrients, chemicals
Pressure- ⇒ Surface and groundwater use	Volume of water extracted, Dams, Deliberate stormwater detention/channelling /disruption to stream flow due to urban development, Recreational use of canals, rivers, beaches and reefs.
Current Response- ⇒ audit/inspection /monitoring programs for non-scheduled premises	Nature, Number conducted, Estimated percentage coverage, Cost
Current Response- ⇒ Riparian zone rehabilitation programs	Extent and condition of riparian vegetation
Current Response- ⇒ Industry pollution reduc'tn prog's	no. and type /effectiveness
Current Response- ⇒ Prop. and catch. planning (incl. use of rainwater)	no. and style of groups/plans etc. Cleaner production-storm water

5.2 Introduction

Clean water is one of the basic requirements for healthy ecosystems and life in general. For the Gold Coast the health of the water systems is essential to the region.

Much of the current area of the City of Gold Coast has been described as the Country of Five Rivers (Jones 1989). These rivers are the Logan, the Albert, the Pimpama, the Coomera, and the Nerang. There are also two large creek catchments in the Gold Coast, the Tallebudgera and the Currumbin. All of the rivers flow into the waterways of Southern Moreton Bay which includes the Southport Broadwater. The two main creeks flow directly into the Coral Sea. Figure 5.1 shows the major catchments and waterways of the Gold Coast. Some 6% (8706ha) of the Gold Coast's area is covered by water. This area does not include the water off the ocean beaches but does include the Southern Moreton bay and the Broadwater. The Tweed River forms part of the southern boundary of the City and flows from the river can affect water quality along the Gold Coast's southern beaches.

The Gold Coast is heavily dependent on the rivers, streams, wetlands, mangroves, estuaries and beaches of the area. The development of the Gold Coast as a residential and tourist area has reinforced the value of water and its surrounding environments. For example, there have been many developments, including canal estates, associated with the Nerang River and the Broadwater, and the Tallebudgera and Currumbin Creeks.

The quality and quantity of water, both surface and groundwater, largely depends on the land type in the catchments of the rivers and streams, the land condition and land uses.

Most of the water used on the Gold Coast, for any purpose, is surface water. Natural surface water qualities are determined by the land type, whereas the land condition determines the rate at which sediments and other natural contaminants will move into the water bodies. Land use determines the type and amounts of man-made pollutants that enter the waterways.

Groundwater quality is often, but not always, determined by the land in the immediate catchments. In some cases groundwater originates from very distant areas such as in the great artesian basin, however, there are no examples of this type of groundwater system in the City. The groundwater resources of the Gold Coast are local in nature and are of limited extent and quality. Consequently the quality of this water also largely depends on the land, its condition and uses in the catchment, particularly near to the groundwater resource.

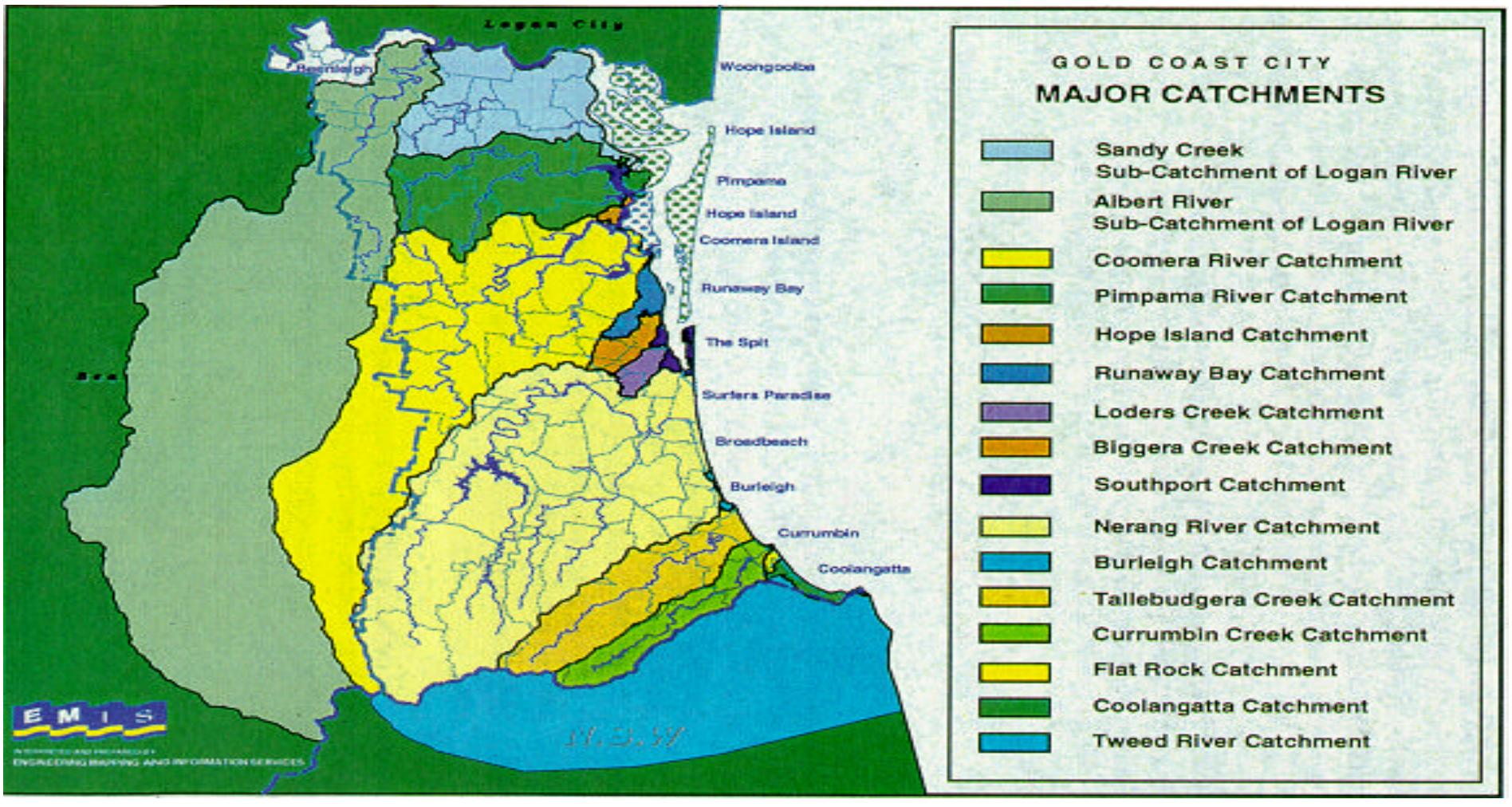

Figure 5.1: Gold Coast catchments and waterways

Much of the upper parts of the river catchments are protected with National Parks and Reserves, although some grazing and cropping occurs in conjunction with limited residential development. There is an increasing degree of urbanisation as the rivers and streams approach the ocean, particularly around the Nerang River and Tallebudgera and Currumbin Creeks. The rivers in the north of the City follow the same pattern from the ranges in the west down to the Pacific Highway. However, most development is clustered around the Pacific Highway with some spread further east from Oxenford to Hope Island. Further eastern encroachment is limited by the waterways of Southern Moreton Bay.

Using the State-Pressure-Response model, this chapter presents a series of indicators that relate to groundwater systems the condition of riparian land (the land adjacent to the rivers and streams) and the stream beds themselves, the provision of drinking water to the Gold Coast, and finally the quality of the surface waters on the Gold Coast.

5.3 State

5.3.1 Groundwater

There are groundwater reserves on the Gold Coast, but these were of minor economic significance and, as a consequence, there has been little data gathered on them. A study of groundwater in the Gold Coast region in 1979 by the Queensland Water Resources Commission found the overall groundwater potential for the region to be poor (quantity). Most ground water in the City comes from a shallow body of freshwater that rests on a denser body of saltwater. The resource could be subject to contamination from saltwater if overused. Groundwater in the coastal areas supply low yields of good quality water and the use of this resource is declining. As a consequence, the Council does not currently monitor the quantity or quality of these groundwater bodies.

Where groundwater is used via a spear pump system, there is often iron staining on driveways and fences suggesting that the groundwater contains high levels of iron. Additionally, odours are apparent when using groundwater, suggesting the presence of sulfide in the water.

5.3.2 Riparian zone and stream bed condition

There is limited data available on the condition of the riparian land on the Gold Coast. The integrity of the riparian land helps determine the rate of sediment moving into the stream, particularly from stream-bank erosion. These areas also provide shading of the water, and a variety of foods and habitats. Consequently they contribute to the health and biodiversity of the organisms in the waterway. The Gold Coast City Council has completed a Nature Conservation Strategy and begun a study into the integrity of the Gold Coast's waterways.

Table 5.1 shows the approximate length of each major river and creek on the Gold Coast. The riparian vegetation of almost all estuarine waterways in the coastal

lowlands of the Gold Coast has been cleared or removed at some time for agriculture, residential development and flood/drainage control. The lack of riparian vegetation, inadequate management plans for sedimentation and erosion control and inappropriate stormwater design, appears to be a major source of stream bed sediments. The lack of a legal requirement for Environmental Impact Statements (EIS) for developments prior to 1991 has resulted in difficulties in applying adequate controls to developments approved before that date.

There is little data on species diversity for fresh or estuarine environments of the Gold Coast. This is particularly the case for stream bed, or benthic, organisms. The origin, composition and deposition rate of sediment plays a large role in determining biological diversity in aquatic systems. The benthic fauna and flora make up the diet of aquatic animals like fish and crustaceans. Generally these benthic organisms are quite sensitive to changes in sediment characteristics.

There is also limited data on the condition of the beds of the City's rivers, lakes and streams. However, the rate and quality of sediment deposition in the Gold Coast waterways appears to have changed in response to changing land uses and significant concerns are held by the community particularly in areas such as Coombabah Lake and Loders Creek.

Parts of the environment of the Gold Coast have been highly modified over the last one hundred and twenty years. Agricultural practices including the clearing of the land and the drainage of wetlands and floodplains for pasture and cropping have significantly altered or impacted upon stream bed conditions. The construction of residential canals and lakes in the Nerang and Coomera River catchments and the catchments of the Currumbin, Tallebudgera, Saltwater and Biggera Creeks has transformed coastal wetlands, estuarine mudflats, saltmarsh/mangrove and melaleuca/tea-tree communities into predominantly estuarine waterways. The urbanisation of the coastal plain and its associated stormwater infrastructure has greatly changed the hydrology of many streams and tributaries. The development of rural residential communities in the immediate hinterland has also had effects on hydrology and water quality.

Sediment analysis of the Gold Coast waterways has been undertaken for dredging purposes. There has been some analysis of sediment for faunal diversity in some locations, however, there has been no coordination of these studies. The Department of Natural Resources has commenced a biological monitoring program that includes benthic analysis in some of the waterways in the City. Analysis of sediment for heavy metal contamination in estuarine sediment and offshore sands is routinely performed on the sediments of Currumbin and Tallebudgera Creeks and for the beach nourishment programs. These analyses have not found significant traces of any heavy metals or of any pesticides.

Table 5.1: Stream length of major Gold Coast rivers and streams
Lengths include dams and natural lakes but excludes constructed waterways

Stream Name	Stream Length
Currumbin Creek	23.8

Tallebudgera Creek	29.4
Nerang River	57.8
-Little Nerang Creek	28.0
-Crane Creek	2.6
-Mooyumbin Creek	3.3
-Small and 2 other creeks	1.8
-Mudgeeraba Creek	26.3
-Bonogin Creek	12.1
-Gin House Creek	4.0
-Little Tallebudgera Creek	11.2
Loders Creek	1.6
Biggera Creek	3.0
Behm Creek	3.0
Coomera River *	46.1
-Clagiraba Creek	7.0
-Guanaba Creek	6.7
-Wongawallen Creek	8.2
-Howard Creek	4.8
-Running Creek	4.8
-Tamborine Creek	3.2
-Brygon Creek	1.6
-Yuan Creek	4.3
-Oaky Creek	3.4
-Coombabah Creek	17.1
-Saltwater Creek	17.3
Pimpama River	29.3
-Hotham Creek	15.3
McCoys Creek	2.5
Logan River **	39.8
-Albert River ***	24.0
-Sandy Creek	23.7
-Halfway Creek	5.9
-Bridge Creek	3.8
Total Gold Coast Stream Length	**476.8**

*** The Coomera River rises around 35 km inside the Beaudesert Shire.**

**** The Logan River rises in the Beaudesert Shire and has a total length of 175 km and includes a number of large tributary creeks.**
The 39.8 km within the Gold Coast represents the Boundary with Logan City.

***** The Albert River rises in the Beaudesert Shire and has a total length of 134 km and includes a number of other large tributary creeks**

5.3.3 Drinking water quality

The reticulated drinking water supply on the Gold Coast comes mainly from the Hinze and Little Nerang Dams. Beenleigh's water supply comes from Logan City. Land

uses and practices in the catchments of these dams and the management of the dams themselves play a large role in the provision of safe drinking water to the Gold Coast.

The catchments of the dams cover an area of 207km^2 (20700ha). This area is bounded by the McPherson, Beechmont, Nimmel and Tallai Ranges and includes the Numinbah Valley and Springbrook Plateau. Table 5.2 below provides a breakdown of major land uses within the catchment.

Table 5.2: Approximate proportions of the Hinze and Little Nerang Dams catchments under different land uses
(source Gold Coast City Council Hinze Dam Catchment Management Plan 1996)

Land use	Area (ha)	Proportion of catchment (%)
National Park/Reserve*	15,939	77
Pasture- Beef/Dairy	3,105	15
Urban	207	1
Rural Residential and other land uses	1,449	7
Total	20,700	100

*** includes lands owned by the Gold Coast City Council and some private lands**

Water is harvested from two dams in the region. The Little Nerang Creek which drains the southern and eastern Springbrook plateau is impounded at Neranwood and supplies water to the Southern Gold Coast. Overflow from the Little Nerang Dam flows into the Hinze Dam. The Hinze Dam impounds the Little Nerang Creek and the Nerang River at Advancetown. The catchment of the Nerang River includes Numinbah Valley, Western Springbrook Plateau and the Eastern Beechmont and McPherson Ranges.

The dams themselves impound around 172,800 million litres. To ensure a continuous supply of safe and pleasant tasting drinking water, the Gold Coast has two water treatment plants, at Mudgeeraba and Molendinar.

The Mudgeeraba Water Treatment Plant receives water from the Little Nerang Dam and the Hinze Dam for distribution of potable drinking water to Mudgeeraba and south to Coolangatta. The Molendinar Water Treatment Plant receives water from the Hinze Dam and supplies water to most of the Gold Coast, providing water as far north as Coomera. The Northern Gold Coast region receives potable water from the Logan City Council.

These plants both operate on a 24 hour basis and together they can treat up to 260 million litres per day. This capacity is almost reached over the period from late December to the end of January when daily demand approaches 220 million litres. This period coincides with hot weather and peak tourist and daytripper numbers visiting the Gold Coast.

Table 5.3: Composition of reticulated drinking water of the City of Gold Coast
Source: Inorganic test data from GCCC laboratory.

Test		Average Result	NH&MRC guidelines (1996) #
INORGANIC			
Aluminium	mg/L	0.13	0.2
Ammonia (as NH_3)	mg/L	0.012	0.5
Antimony	mg/L	<0.001	0.003
Cadmium	mg/L	<0.002	0.002
Calcium	mg/L	7.2	-
Chloride	mg/L	18	250
Chlorine	mg/L	<0.2	0.6
Chromium	mg/L	<0.01	0.05
Colour, True	p.c.u	<2	15
Copper	mg/L	0.03	1.0
Hydrogen Sulphide, dissolved	mg/L	nd	0.05
Fluoride	mg/L	<0.1	1.5
Hardness	mg/L	28	200
Iron	mg/L	<0.05	0.3
Lead	mg/L	<0.002	0.01
Magnesium	mg/L	2.2	-
Manganese	mg/L	<0.02	0.1
Nickel	mg/L	nd	0.02
Nitrate (as NO_3)	mg/L	0.127	50
Nitrate (as $NO_{2)}$	mg/L	<0.07	3
pH		7.3	6.5 - 8.5
Sodium	mg/L	8.0	180
Sulphate	mg/L	6	250
Total dissolved solids	mg/L	80	500
Turbidity	n.t.u	0.60	5
Zinc	mg/L	<0.03	3
ORGANIC			
Carbon tetrachloride	mg/L	<0.002	0.003
Total trihalomethanes	mg/L	<0.04	0.25
MICROBIOLOGICAL			
Total coliforms	cfu/100ml	0	0
Escherichia coli (E.coli)	cfu/100ml	0	0

 # = National Health & Medical Res. Council health/aesthetic guideline whichever is lower
n.t.u. = Nephelometric turbidity units
cfu = Colony forming unit
nd = not detected

Peak water usage during the summer of 1996/97 was 216 megalitres in a day from the Molendinar and Mudgeeraba Water Treatment Plants. The reticulated drinking water supplied to residents by Council consistently meets the Drinking Water Quality Guidelines (1996) set by the National Health and Medical Research Council (NH&MRC) as shown in Table 5.3. Water quality is monitored continuously through the treatment process.

5.3.4 Surface water quality

The surface waters of the Gold Coast can be classified into four major types:

- Wetlands
- Beaches and the Broadwater
- Rivers, creeks, estuaries and natural lakes
- Constructed canals and lakes

The healthy functioning of each of these waterway types contributes to the water quality of the Gold Coast.

The Gold Coast City Council water quality monitoring program incorporates all of the waterway types listed above, monitoring in excess of 200 sites in 39 waterways. The monitoring program records as many of the following parameters that are relevant to each site:

- Contact/amenity value
- Date
- Time
- Tide
- Temperature
- Weather
- Previous 24hr rainfall
- Flow rate
- *Escherichia coli* (*E.coli*: faecal coliforms)
- pH
- Dissolved oxygen
- Conductivity
- Nitrogen: total, organic, oxidised and ammonia
- Phosphorus: total, orthophosphate and phosphate
- Organic carbon
- Salinity
- Secchi depth
- True colour
- Sulfate
- Chloride
- Chlorophyll a
- Algal Count
- Turbidity

The monitoring program is fundamental to the confidence the community has in the quality of the City's waterways. However, the measures it uses are also indicators that can flag problems in water quality. Currently, any issues of concern are mostly associated with recreation and human health, and the potential for algal blooms due to an excess of nutrients.

Falls of rain cause stormwater runoff. This runoff is collected from urban areas, and from roads, and channelled through the stormwater drainage system into receiving waters, where it can affect the water quality. The 'first flush' of stormwater usually contains the highest concentration of pollutants from any storm event. Such events are not generally captured by the current monthly sampling program.
The information that would be gained from monitoring these events may be vital to sustainable catchment management.

In addition to storm flows from rainfall, releases of water from dams and weirs are required to maintain the environment of the waterway. This is because dams, weirs, and the irrigation of land, interrupt the natural functioning of the waterway.

Environmental flow is a term used to describe the timing and levels of flow in a stream required to sustain the ecological integrity of a waterway.

Natural stream-flow variations in the Gold Coast region are considerable and seasonally influenced, which is typical of streamflows in tropical and subtropical systems. The dry winter and spring months contrast to the intense rainfall of late spring and summer creating distinct stream flow patterns. Consequently the tributaries of numerous waterways within the region are intermittent watercourses.

There has been little research undertaken to assess the importance of the natural functioning of the rivers and streams, or of the impacts that the major dams (Hinze and Little Nerang) may be having on these ecosystem's environmental flows in relation to the health of the Gold Coast waterways. The Council releases 2.6 Ml/day to maintain a flow in the Nerang River. This rate was mainly determined to satisfy irrigators' needs and is maintained with flow monitoring at Weedons Crossing, Nerang. There has been little consideration given to the size and timing of environmental flows to ensure the healthy functioning of the riverine ecosystem.

The following four sections deal with the current state of each of the main types of waterways on the Gold Coast.

5.3.4.1 Wetlands

Wetlands within the Gold Coast region consist of both natural and artificial systems and occur throughout the City in various sizes and environmental condition. Both natural and artificial wetlands provide important habitat for aquatic organisms and birds, but can also provide functions such as flood protection by detention storage and treatment of stormwater by nutrient, litter and sediment removal. The Coombabah Lake is an example of a natural wetland and is classified as a Ramsar site.

While artificial wetlands are still yet to prove themselves as a long term viable means of treating stormwater in Australia, there is emerging evidence of their potential. Artificial wetlands can have significant community benefits (passive recreation), ecosystem benefits (increased habitat). Considerable controversy has arisen concerning their true effectiveness, especially with their ability to address stormwater quality problems.

The Gold Coast City Council is presently investigating the feasibility of establishing a number of pilot wetlands through the Gold Coast region in order to undertake further research into the design and performance of wetlands for stormwater improvement.
There are also a number of artificial wetlands proposed as part of residential estates. Such wetlands provide both an excellent research opportunity and an effective community education forum.

5.3.4.2 Beaches and the Broadwater

The beaches and the Broadwater represent the major marine and estuarine environments on the Gold Coast and provide habitats for local biota and are important

opportunities for tourism, recreation and local industries. Table 5.4 presents summary data on the water quality of the beaches and Broadwater.

The water at thirteen beach sites are sampled monthly in winter and weekly during the summer months and the samples tested for microbiological (faecal) contamination. *Escherichia coli* is a bacteria that indicates microbiological contamination of water by faeces from animals, including humans. High levels of *E.coli* indicate the likely presence of pathogens and make water unsuitable for primary contact, ie. swimming.

Over the period between January 1995 and September 1996, Gold Coast beaches were characterised by low *E. coli* levels which were well within the Australia and New Zealand Environment Conservation Council (ANZECC) guidelines. The samples are taken from between the patrol flags on each beach. Therefore, sample sites vary between each survey as the position of the flags will vary according to surf conditions.

The Gold Coast Broadwater is subject to two different surveys each month. The first is designed to monitor *E. coli* levels for recreational waters and the second is to monitor effects of the treated effluent coming from the ocean outfall on water quality. Both surveys showed that median *E. coli* levels comply with ANZECC guidelines for primary (swimming) and secondary (boating) contact waters. The discharge from the outfall occurs half an hour after the start of the outgoing tide and ceases half an hour prior to the commencement of the incoming tide.

This sampling is required because Council's sewage treatment plants are licensed, by the Department of Environment, for discharge to surface waters in the City. A condition on this licence is that there should be minimal or no impact on the environment as a result of the discharges. Consequently, wastewater is treated to a level which is acceptable to health and environmental guidelines prior to discharge. The Ocean Survey results discussed above demonstrate the effectiveness of this process.

5.3.4.3 Rivers, creeks estuaries and natural lakes

The Gold Coast region contains a diverse range of river and creek forms, from ephemeral creeks in the hinterland to floodplains and rivers and estuaries along the coastline. The largest and most significant river system for the Gold Coast is the Nerang River and its tributaries as it provides most of the Gold Coast's drinking water and performs a significant role in recreation. This river system rises in the McPherson Range. Upper reaches of the river systems flow through scenic mountain areas. Middle or riverine reaches of the waterways typically flow through rural residential and agricultural land uses, before entering the often more urbanised estuarine or coastal reaches. The upper, riverine and estuarine reaches all provide environmental, commercial and recreational opportunities for water use.

This section presents an overview of water quality in 11 regularly monitored waterways located within the Gold Coast City Council. A complete analysis of these data is contained in the Council's Health of the Waterways report. Table 5.4 provides these data for each major river and stream that is monitored. Parameter levels quoted are average results which attempt to show the usual condition of each waterway. In

addition the sampling frequency used in the monitoring system may not be sufficient to determine water quality in all situations.

The monitoring program tested the samples for a range of tests as described above. The most relevant parameters determined are:

- *E. coli;*
- Total Nitrogen (Total N); and ,
- Total Phosphorus (Total P) levels indicate the amount of contamination by nutrients from urban and rural land uses. Elevated levels can lead to excess growth of algae (blooms);
- pH indicates the level of acidity (pH<7) and alkalinity (pH>7). Neutral levels (ph=7) are preferred for most organisms;
- Dissolved Oxygen (DO) levels indicate the amount of oxygen available to organisms in the water body. Levels between 6.5 and 10 mg/l are recommended.

Temperature influences the nature and activity of many organisms in water bodies and can influence the level of DO. Water temperature remains more constant than air temperature. However, extremely low water temperatures can restrict the safe recreational use of water in poorly flushed water bodies. Temperatures between 12 and 35 ^{o}C are acceptable.

Sediments in waterways arise from erosion processes from stream banks, and poor erosion control measures around areas cleared of vegetation. These sediments can lead to siltation of waterways, disrupt benthic habitats, reduce light penetration through the water and can transport nutrients and other chemicals that are adsorbed onto the surface of the sediment. A measure of these sediment loads is Total Suspended Solids (TSS). Gold Coast City Council is currently analysing suspended solid levels and results were not available in time for this report.

In general the data indicate that the quality of surface waters in the City is high and complies with ANZECC guidelines. Water temperatures in waterways typically varies between 13 and 25^{o}C for freshwater systems, and averages around 20^{o}C for estuarine and marine systems. There was one water temperature of 32^{o}C recorded at Loders Creek.

Nonetheless, there are some exceptions to the generally high quality of surface water in the City. Many of these exceptions occur in reaches of streams which are only used for visual amenity. That is not to say the levels are acceptable but that they pose no threat to human health. These issues are identified by the symbol ✍ in Table 5.4.

Table 5.4: Water quality indicators for Gold Coast beaches, the Broadwater, and rivers and streams.

✓= complies with ANZECC guidelines, ✍= complies in most cases see text, ✖ = Doesn't comply with guidelines, N/A = Not Available

Waterway	First year of monitoring	No. of sampling sites	Contact/ amenity value [1]	*E. coli* (organisms/100ml)	Total nitrogen (mg/l)	Total phosphorus (mg/l)	pH (Acid or Alkali)	Dissolved Oxygen (mg/l)
ANZECC Guidelines for Water Quality			**Primary Secondary visual**	**150 1000 N/A**	**<0.75**	**<0.1**	**6.5<pH>9**	**>6**
Beaches	1986	13	Primary	0-6	N/A	N/A	N/A	N/A
Broadwater: monthly ocean outfall	1986	10 13	Primary Primary	0-33 0-70	N/A	N/A	N/A	N/A
Albert River	1996	4	Secondary	8-45	0.10-0.60	0.06-0.11✍	6.9-7.7	N/A
Pimpama River ✍ (non-tidal reaches only)	1996	6	Visual	7-90	0.35-0.67	0.06-0.07	6.6-7.2	8.0-10.0
Hotham Creek	1996	4	Primary	30-90	0.23-0.40	0.04-0.07	6.0-7.3	6.7- 9.0
Biggera Creek	1994	4	Primary	15-120	0.32-0.38	0.05-0.08	7.8-7.9	6.5-10.0
Coombabah creek / lake	1986	8	Secondary	20-120	0.55-0.70	0.07-0.11✍	7.4-7.7	6.5- 8.5
Loders Creek	1994	5	Primary	100-1990 ✍	0.40-0.85 ✍	0.05-0.16✍	7.2-7.8	7.0- 8.4
Lower Nerang River	1986	10	Primary	13-120	0.00-0.55	0.04-0.07	7.1-7.9	6.3- 8.7
Upper Nerang River -Numinbah -Springbrook	1992 	 8 7	 Primary Primary	 12-900 ✍ 10-65	 0.17-0.37 0.24-0.31	 0.05-0.09 0.03-0.06	 6.9-7.5 6.3-6.7	 N/A N/A
Mudgeeraba Creek	1993	5	Visual	N/A	0.05-0.25	0.08-0.11✍	6.8-7.2	N/A
Tallebudgera Creek	1986	12	Primary	5-150	0.05-5.00 ✍	0.00-0.60✍	6.7-7.6	6.4- 9.0
Currumbin Creek	1991	13	Primary	5-200	0.15-0.40	0.02-0.14✍	7.7-8.0	7.4- 9.6

1.Contact amenity value:
Primary = primary recreational contact -swimming.
Secondary = secondary recreational contact - boating/fishing/wading
Visual = of visual or scenic amenity only

- Loders Creek exceeded ANZECC Guidelines for *E. coli*, Total nitrogen (N), and Total phosphorus (P). The high number of E. *coli* recorded in the creek occurred in an area which is only of visual amenity and not used for swimming. The high readings for nitrogen and phosphorus only occurred over brief periods in the three years of monitoring.

- The Numinbah Valley section of the upper reaches of the Nerang River exceeded the Guidelines for *E. coli* at one location only. The source of contamination at this site is known and negotiations are taking place with the relevant State Government Authority.

- The acidity of water in the Springbrook section of the Nerang River exceeded the guidelines for pH probably due to the nature of the soils and rocks in the area.

- The Albert River and the Coombabah, Currumbin and Mudgeeraba Creeks only exceeded the Guideline for Total P at some times. Most of the time the water quality in these Rivers and streams is within the guidelines. In the case of Currumbin Creek the high levels of Phosphorus are historical and relate to the period prior to 1993 only. Subsequent periods being within the guidelines.

- The Tallebudgera Creek had historically high levels of total Nitrogen and Phosphorus. However, discharge of treated effluent into the creek was ceased in March 1993. This resulted in low levels of these nutrients in the creek since that date.

pH is an important monitoring parameter along the lower reaches of the Pimpama and along Mudgeeraba Creek because the area is affected by acid sulfate soils. While there are known problems along the lower Pimpama as listed below, pH levels along Mudgeeraba Creek remain relatively stable, averaging around 7.0. However, the chloride to sulfate ratios have in both the lower Pimpama and the Mudgeeraba Creek are commonly below 5.5:1. This indicates the likely presence of acid sulphate soil when compared to desired ratios of approximately 7:1.

The Department of Environment have monitored the lower Pimpama since 1994 and report considerable seasonal and spatial variability across the catchment with respect to temperature, conductivity (between <0.30 and >50.0 ms/cm) and turbidity (mostly 10 N.T.U. up to 50 N.T.U. after rainfall). This variability is natural but its affects can be exacerbated by human activity. The following main points, many linked to the presence of acid sulfate soils were also identified in the study:

- pH is frequently reported below 4.0, particularly after rainfall;
- dissolved oxygen levels often recorded below 50% saturation (80-90% for long term habitat survival);
- total dissolved aluminium recorded above 30 mg/l at several sites (6000 times greater than ANZECC guidelines. Most sites <0.5 mg/l (100 times greater);
- while there are insufficient data to recommend a guideline for marine or brackish waters (ANZECC 1992), the total and dissolved iron levels frequently exceed the maximum of 1mg/l for freshwater systems and levels above 0.5 mg/l are not uncommon.

5.3.4.4 Constructed canals and lakes

The artificial canal and lake systems on the Gold Coast are the most extensive in Queensland and mostly consist of narrow, multi-branched tidal inlets developed as residential areas. These systems provide opportunities for passive recreation, boating, swimming and angling.

These canals and lakes often form small water catchments and in some areas form part of the City's stormwater drainage system. The systems can also offer some benefits for flood mitigation. The water in these canals are therefore susceptible to contamination from stormwater. Lakes are similarly susceptible to contamination from stormwater and require careful monitoring due to the limited flushing action within these water bodies. Hence the monitoring of the canal and lake system is divided into two areas, canals and lakes.

- **Canals**

The canal system was first analysed for water quality conditions in 1989 (Moss, 1989). The study looked at canals in Palm Beach and Surfers Paradise and found that generally high water-quality conditions were maintained throughout these systems. However, periodic deterioration in water quality was noted where stratification of the water was apparent leading to poor flushing of bottom waters. *E. coli* levels were reported as complying with primary contact recreational waters (Water Quality Council of Queensland criteria). However higher values were found following runoff events.

Current monitoring of the canal system is performed at only a limited number of sites. Current water quality data reflect the earlier findings of Moss (1989) and indicate a high level of water quality, with the exception of periods of lower quality associated with falls of rain. These events lead to elevated levels of nitrogen and *E. coli.* The primary source for these higher values appears to be from rainfall washing lawn fertiliser and pet faeces into the canals.

A review of the water quality monitoring program by the Health and Regulatory Services Branch of Council has recently recommended that water quality monitoring in canal systems be increased to provide a greater understanding of stormwater effects on these waterways. In addition, an assessment of how effective the natural flushing mechanism of these systems are operating is required as these canals are frequently used for recreational purposes.

- **Constructed lakes**

Most lakes within the city are maintained as either freshwater or saltwater systems by the management of tidal exclusion weirs. The freshwater lakes include the Robina Lakes system and the saltwater lakes include the Burleigh Lakes system. Table 5.5 below shows all of the constructed freshwater and saltwater lakes on the Gold Coast.

Table 5.5: The freshwater and saltwater lakes of the Gold Coast

Freshwater lakes	Saltwater lakes
Robina lakes system -Clear Island Lake -Robina West Lake - South Lake	Burleigh lakes system -Silvabank Lake -Lake Heron -Swan Lake -Burleigh lake -Miami Lake -Pelican Lake
Lake Hugh Muntz (Mermaid Waters)	Pizzey Park Lake (Miami)
	Cyclades Lake (Currumbin)
	Pine Lake (Murtha Drive, Currumbin)
	Paradise Lake (Coombabah)
	Lake Runaway (Runaway Bay)
	Nineteenth Avenue Lake (Elanora)

Water quality within the Robina Lakes system complies with guidelines for a freshwater regime, and a significant and diverse ecosystem has established in the lakes as a result. The system has been monitored on a quarterly basis since 1987. Rainfall was found to be a significant factor influencing water quality by causing short term deteriorations with slight elevations in total nitrogen and total phosphorus. However, nutrients remain relatively low and satisfy the ANZECC guidelines for the prevention of significant algal blooms. Nuisance algal blooms occur occasionally and are thought to be due to elevated levels of phosphorus from internal and external sources (Cardno and Davies 1996).

Stormwater runoff, irrigation using secondary-treated effluent and sediment discharges from upstream developments are likely sources of phosphorus entering the system. Evidence of stratification has been observed with salinity and temperature changes occurring with depth in most lakes. Thermal stratification is reduced by wind mixing and water inflows.

Results of water quality monitoring in the tidal lakes indicate water quality within these systems generally comply with the ANZECC guidelines for the protection of aquatic ecosystems in respect to pH, temperature, dissolved oxygen and conductivity.

5.4 Pressure

The water resources of the Gold Coast face significant pressures and to maintain the quality of these resources will require consistent action on behalf of the Council and the community.

The number of people enjoying the Gold Coast waterways and resources is considerable. The estimated resident population of 356,571 people in 1996 (Australian Bureau of Statistics, 1997) is growing at a rate around 4.8% or 15,000 new residents each year. In addition tourists and day-visitors are estimated to add the equivalent of an extra 90,000 residents averaged over a year.

This section discusses our current level of understanding of the pressures these waterways are under. It follows the same sequence as section 5.3: State, namely:

- groundwater;
- riparian zone and stream-bed condition;
- drinking water quality;
- surface water.

5.4.1 Groundwater

There are no quantitative data on pressures affecting groundwater resources of the Gold Coast. For example there are no records of the number of spear pumps nor their capacity. There is also no data on the quality and quantity of the resource. However, there appears some evidence (iron staining on driveways and fences and sulfide odours from the water) to indicate natural leaching of irons and sulfide from the soil.

However, this resource could be being further degraded through the paving of the intake areas, overuse. While unlikely, due to the lack of major polluting industries on the Gold Coast, there is some minor potential contamination of the resource from:

- leachate from land fills;
- agricultural activity; and,
- chemical spills.

Despite the lack of major polluting Industries on the Gold Coast there is an increased risk of chemical spillage than would otherwise be the case due to the transports carrying chemicals and fuels through the Gold Coast along the Pacific Highway.

5.4.2 Riparian zone and stream bed condition

The integrity of vegetation in the riparian zone is critical to the stability and ecological health of the waterway. The riparian vegetation helps to stabilise banks preventing stream-bank erosion and changes to the stream bed conditions. The vegetation also provides shading, food and habitat to other plants and animals that live with the waterway.

The greatest pressure on the riparian vegetation of the Gold Coast is from urban development and consolidation. However, there is a range of pressures, which include:

- alteration of catchment hydrology (eg. increased in paved surfaces);
- timing and volume of environmental flows;
- increased sedimentation and siltation, for example from road works and building sites following clearing, excavation and earthworks;
- destruction or direct removal of vegetation;
- degradation of water and soil quality;
- invasion of exotic flora and fauna.
- trampling of vegetation by cattle grazing; trampling of vegetation by humans;
- rubbish (litter) accumulation;
- and stream bank erosion due to waves from boats.

5.4.3 Drinking water quality

The major pressures on the City's drinking water is the quality of water supplied from the Hinze and Little Nerang dams and the cost of treatment and the peak demands in the system over the summer holiday period (220 Ml/day). In order to maintain good water quality in the dams it is imperative that a healthy and functional catchment area is maintained. If water received at the treatment plants is of good quality, then the cost of treatment is more economical. Consequently, development, land use and management in the catchment can have significant effects on the water supply.

The dairy industry in the Numinbah Valley has the potential to put excess nutrients into the waterway. The current management of the industry using best practice standards is, therefore, essential to the health of the waterway and to the cost of treating the water for drinking.

5.4.4 Surface water

There are two major sources of pressure on the surface waters of the Gold Coast.

Firstly, the construction of the two dams and the use of many of the freshwater reaches of rivers and streams for irrigation has dramatically altered the hydrology of the area. Water is harvested from the City's waterways for agricultural and domestic purposes. A licence may be required from the Department of Natural Resources (DNR) to harvest water by landowners whose properties have stream boundaries (riparian landowners). Water harvesting restrictions are generally achieved by limiting pump size and self regulation.

Secondly, stormwater can carry pollutants from the land into the waterway. The impact this will have on water quality depends on the nature of the contaminants already in the waterway and those in the stormwater. These pollutants can be from both urban and industrial areas as well as from agricultural areas, and generally arise from littering and poor management. Septic and home-treatment systems (eg. Biocycle) are also a potential problem with respect to water quality.

Stormwater runoff contains a wide range of pollutants from these sources, the concentrations of which depend on the surrounding land uses. Some of the characteristic pollutants found in stormwater include:

- macro-pollutants (eg. from household garbage, litter and dead trees);
- suspended particles (eg. sediment from erosion);
- nutrients (eg. from fertilisers and septic tanks etc;
- high Biological Oxygen Demanding (BOD) substances (eg. from animal faeces);
- pathogenic microorganisms and viruses (eg. from animal faeces and sewage leaks);
- heavy metals and other toxic substances (eg. from industry, roadways and parking lots);
- hydrocarbons and petroleum products (eg. from industry, roadways and parking lots);
- organic and other pesticides (eg, from farms and home gardens).

Assessment of the effects that each of these pollutants can have on receiving waters has been widely documented, and include reduction in water quality, decreased biodiversity, reduced habitat condition and reduced recreational opportunities.

Of all the potential pollutants, nutrients appear to be the major concern throughout the City. Sources of nutrients include diffuse and points sources. Diffuse sources include runoff from catchment areas with pollutants such as sediment, fertilisers, pesticides and herbicides from agricultural and urban activities. Point-sources may include water and wastewater treatment plants, shopping centres and industrial discharges. The Gold Coast City Council has licences to discharge appropriately treated waste water from its Sewerage Treatment Plants. This is done through ocean outfalls at the Southport Seaway.

In natural systems the riparian vegetation can act as a filter to reduce the levels of pollutants reaching the waterways. However, the disturbed nature of riparian vegetation along some waterways may provide little in the way of filtering capacity.

Excessive levels of nutrients in waterways can encourage algal blooms and aquatic plant growth causing depletion of oxygen levels, unpleasant odours and reduced light penetration.

Contamination of waterways within the Gold Coast City Council with organic material is common, resulting from garbage or garden waste being washed or dumped into the waterways. This waste increases the BOD of bacteria in the water. The demand is created as the organic material is consumed. These bacteria grow in number and in turn take extra dissolved oxygen from the waterway. This reduces oxygen levels for fish and other aquatic biota and in extreme cases can lead to anaerobic conditions (no oxygen) and odours (H_2S or rotten egg gas).

Heavy metals and other toxic substances generally enter the aquatic environment via runoff from industrial sites, roads and from atmospheric fallout. The availability and toxicity of metals such as Aluminium is increased under acid conditions that often result from disturbed acid sulfate soils. Heavy metals and other toxic substances can have an adverse effect on the aquatic environment, including the reduction in water quality and reduced biodiversity. Additionally, pesticides and herbicides can enter the aquatic environment from rural and residential areas. Such pollution often results from incorrect application of the chemical. Heavy metal and pesticide levels in water have not been monitored extensively on a City wide basis due to the low levels of risk.

5.5 Response

This section discusses the current responses by the Council to the various states and pressures already discussed. The section follows the same sequence used in both section 5.3: State and 5.4: Pressure, namely:

- groundwater,
- riparian zone and stream-bed condition
- drinking water quality
- surface water.

5.5.1 Groundwater quality

The groundwater systems of the Gold Coast were never extensive and have declined in importance to our economy over recent years. Consequently they have had little attention. Nonetheless, some developments are required to conduct groundwater monitoring as a water quality approval condition of development, and the Council is currently investigating the establishment of a groundwater monitoring program and providing sewerage to Jacob's Well to reduce the risk of groundwater contamination from septic systems.

5.4.2 Riparian zone and stream bed condition

The Council has a number of initiatives to maintain and increase riparian vegetation, as well as to combat problems caused by past removal and degradation. These projects include:

- specifying conditions on developments that affect riparian areas;
- identifying degraded areas;
- implementing action to revegetate degraded areas;
- networking with various community groups to conduct revegetation projects; and,
- community awareness programs.

Sediments have been identified as a major determinant of stream bed condition, which in turn determines the nature of aquatic organisms that live in each part of the waterway.

The Gold Coast Catchment Management Strategy, presently being developed, is to include a survey of the riparian areas of the City's major catchments.

Council is also in the process of releasing a draft Sedimentation and Erosion Control Policy. This proposed policy will assist in the reduction of sediment entering waterways. Additionally the Environmental Protection Act (EPA) 1994 and the Environmental Protection (water) Policy 1997 provide legislation to prevent, or at least minimise, stream bed sedimentation. This policy takes effect from March 1998 and may classify some developments as environmentally relevant activities.

The enforcement of the EPA 1994 will also assist in the minimisation and prevention of industrial discharges as well as providing a data base on chemicals. These discharges can contribute to sediment as well as dissolved and suspended pollutants. The data

base of chemicals will be used in determining the type of parameters that will be analysed in future sediment analysis monitoring programs.

5.5.3 Drinking water quality

Council is continuously reviewing its water treatment processes to ensure a safe potable water supply that is cost effective. Processes are thoroughly assessed to minimise costs and chemical usage.

To provide and promote a healthy catchment area for the Hinze and Little Nerang Dams, a Catchment Management Plan has been implemented. Central to this plan is the cooperative management of the catchments with the community of the catchments.

In addition to the management of the catchment the Council has joined in with the Department of Natural Resources' Waterwise program which is a very active awareness campaign focusing on water conservation by the general community. The program aims to inform residents and industry of measures to conserve water usage.

5.5.4 Surface water

The Current state of the Gold Coast waterways appears to be acceptable, based on the ANZECC guidelines and all results from the monitoring programs that show unacceptable changes to water quality are investigated thoroughly by Council staff and remedial actions put in place. Nonetheless, there are a number of programs being developed by the Council aimed at maintaining and enhancing the quality of the water in the City.

Gold Coast City Council is beginning a number of waterway enhancing projects, ultimately designed to reduce pollution by increasing the public's awareness about the health of our waterways and providing technical advice to reduce adverse impacts on them. The waterway enhancement projects are:

- **Gold Coast Catchment Management Strategy (GCCMS):** The Water Quality management Study forms a regional component of a national and state program to achieve ecological sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development. The study aims to establish, implement and monitor water quality standards which are consistent with ecologically sustainable development and to manage the waterways of the City so that determined contact/amenity values are maintained.

- **Stormwater Awareness Program:** This program aims to overturn the general lack of awareness regarding stormwater identified in the Gold Coast community. There is little understanding of what stormwater is, where it goes and its impact on our waterways and how this can impact directly on the community. There is also confusion about the difference between stormwater and sewerage systems.
  Implementation of the stormwater awareness program includes:
  - The stencilling of stormwater inlets with the message
    "Protect our Waterways - Flows to the Ocean";

- Media campaign informing the public about stormwater awareness and solutions to improve stormwater quality;
- Distribution of stormwater awareness brochures and other marketing materials.

- **Integrated Catchment Management:** Integrated Catchment Management (ICM) is an initiative of the State Government and aims to integrate the management of land, water and biological resources of a catchment to achieve the sustainable and balanced use of those resources. This process will also update the contact/visual amenity criteria to reflect the broader environmental values detailed in the Queenslands Environment Protection (Water) Policy 1997.

  The process adopted for ICM by the Council is adapted from that being used elsewhere in Queensland. This is because the water catchments on the Gold Coast are considered too small for each to have its own Catchment Management Committee. Consequently, a single catchment management committee is to be established for the City and a number of catchment management sub-committees or groups are being established for each minor catchment. These community based groups provide a forum for community input and discussion. They are designed to identify and rank catchment issues and oversee the preparation and implementation of catchment management strategies.

  The Logan River Water Allocation Management Plan is an example of ICM where the Council and other stakeholders in the Logan River catchment have combined to develop a plan to manage the water resource of the Logan River.

- **Catchment Assessment:** The Council has recently established several catchment assessment programs. These are aimed at identifying the current state of catchment water quality, pollution sources and methods for repairing, protecting and enhancing the catchment and waterways. The catchment assessment programs that are currently under way are:
  - Tallebudgera Creek;
  - Coombabah Lake; and,
  - Loders Creek.

- **Community and Industry Awareness:** The Council has been undertaking a pro-active approach to liaising with the community and industry. Community workshops and industry education programs have been coordinated to promote best management practices. This includes the Gold Coast's own waterwatch program which aims to develop a network of community and industry groups to regularly monitor the water quality in the waterways of the Gold Coast.

- **Stormwater Research:** The Council is seeking to identify possible sites for stormwater treatment measures. Preliminary information such as catchment land use composition, catchment size, design flow rate, receiving waterway and likely pollutants has also been obtained for these sites. For each of these sites a suggested treatment measure has been established and assigned a priority rank.

The suggested treatment measures can be broadly classified into three main categories: Sediment traps, gross pollutant traps and constructed wetlands. Further investigation into the feasibility of these measures is currently being undertaken. The Council is currently also investigating suitable sampling sites and methods for a storm event monitoring program.

Monitoring various aspects of water quality at selected sites, during and after heavy storm events, will facilitate the development and assessment of effective remedial strategies in pollution control.

5.6 Conclusions and possible future projects

The quality of all water resources in the Gold Coast appears to be reasonably high, based on the data that are available. However, improvements could be made to the monitoring system so that key indicators and events are targeted and a sampling more closely related to the hydrological regime. The following suggestions have been made to improve the management of the waterways within the City.

- **Biological Monitoring:** Biological monitoring holds a significant place in the environmental management strategy of water managers worldwide. To date, no substantial biological assessment of the aquatic environment has been undertaken within the Gold Coast region.

  An effective biological monitoring program is proposed to be undertaken within the Gold Coast region to provide the link between the physico-chemical state of the waterway and its relationship with the living environment.

- **Event Monitoring:** Because a number of important aquatic environmental issues occur in an episodic manner or are site specific in nature, they do not readily lend themselves to investigation by the current sampling program. Generally, these issues are related to specific events such as storms, human intervention or disasters.

- **Pollutant Movement Studies**: Information is required on the specific nature of pollutants and their movement in sub-tropical Queensland. Research is proposed in conjunction with State Government Departments and Universities to help improve understanding and management of pollutants and to establish pollutant export and water quality models.

- **Surface Water Environmental Flows:** Council is currently developing a Water Quality Management Strategy for the Gold Coast. One of the objectives of this strategy is to investigate environmental flows. There are a number of physical and legislative restrictions to the natural flow of the river and to the release of environmental flows. For example, water impounding or harvesting within the City includes the Hinze Dam which is required by law to release water down the river mainly for irrigation use by landholders. This flow is relatively constant but can increase in dry periods due to demand from the irrigators. Such a constant flow could alter the nature of a river's ecosystem. Hence, there is a need to determine the size and timing of environmental flows to ensure the healthy functioning of the riverine system.

5.7 References

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