HERVEY BAY CITY COUNCIL

Eli Creek Catchment Management Plan

Volume 1

OCTOBER 2003

Success through Partnership

JWP

Hervey Bay City Council

Eli Creek Catchment Management Plan

Volume 1

October 2003

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1 Executive Summary

1.1 Introduction

The Hervey Bay City Council commissioned JWP to undertake a Catchment Management Plan for the Eli Creek Catchment.

The Eli Creek Catchment is shown on Figure 1.1 and is generally contained within the areas of Dundowran, Urraween, Eli Waters and Point Vernon. The total catchment area to the mouth of Eli Creek is approximately 3,460 ha.

Currently, approximately 17% of the catchment is developed and as the catchment urbanises, the percentage of catchment development will increase to 60%.

The impact of this urbanisation will be:

- Increase in flood flows, velocities and water levels; and
- Decrease in water quality, and environmental health.

This Catchment Management Plan (CMP) provides Council, developers and the community with recommendations for best management practices and mitigation options to ameliorate or manage the effect of urban development. The outcomes of this CMP will be used as supporting information to an Infrastructure Charge for the entire Eli Creek Catchment.

The plan does not include management requirements for the waterways within the Eli Waters Estate which will be addressed as part of the estate development.

1.2 Study Overview

The catchment has been broken down into 9 major subcatchments. Drainage strategies exist for some of the subcatchments and this information is reviewed in the study and incorporated where practical.

A community survey was undertaken to establish the environmental values of the catchment and the waterways. The response to the consultation by the community was low, however in conjunction with consultation with Council, it was sufficient to establish environmental values for the catchment. The primary environmental values were recreation (visual, primary and secondary contact), preservation of wildlife habit and protection of aquatic ecosystems.

Hydrologic and hydraulic analyses were undertaken of the catchment in its existing and fully developed state using the RAFTS and MIKE-11 modelling programs. Assessment of future conditions allowed the establishment of drainage strategies for the subcatchments currently without strategies and highlighted drainage problem areas.

Water quality and environmental planning were investigated and the program AQUALM was used to derive pollutant concentrations for the existing and fully developed catchment. Water quality objectives were formulated for the environmental values and available monitoring data was examined to establish whether stormwater from the existing catchment achieved environmental targets.

Mitigation strategies are proposed to address water quantity and water quality issues in the catchment. The strategies incorporate detention basins and conveyance paths to accommodate catchment runoff and a variety of stormwater treatment measures including riparian zones, wetlands, sedimentation basins and pollutant traps to mitigate the impacts of deterioration in runoff quality.

The strategies have been costed and these costs are to be utilised to determine infrastructure charges for the development within the catchment. The costings include road upgrades, channel works, pipe drainage, diversion structures, revegetation, land acquisition and all other physical works necessary to accommodate the future urbanisation of the catchment. The total cost of physical infrastructure is estimated to be $46 million. Future development of the catchment is estimated to fund approximately $31 million of this cost through infrastructure charges. The balance of the cost will need to be funded from the existing properties.

LEGEND

CATCHMENT BOUNDARY

300 0 300 600 900

Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 1.1

Catchment Location

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2 Description of Creek and Catchment

2.1 Catchment

The Eli Creek catchment is shown on Figure 2.1. The catchment extends to the east past Tooth and Main Streets, South beyond Urraween Road, west to Dundowran and north to the ocean. The total area of the catchment to the mouth of the creek is 3460 hectares.

The catchment can be divided into nine major subcatchments, which are commonly known as:-

- Point Vernon
- Tooth Street
- Nissen Street
- Fairway Drive
- Lower Mountain Road
- Grinstead Road
- Eli Waters
- Condor Lake
- Islander Road West

2.2 Topography

In general, the topography of the catchment is flat and consequently the drainage patterns in some areas are poorly defined. The steepest parts of the catchment are in the developed areas of the Nissen Street subcatchment. It is clear that the velocities are high in the waterway upstream of Urraween Road, as some of the waterway is badly eroded.

The Grinstead Road subcatchment is predominantly flat, and it is reported that floodwaters from local storms inundate the area, and take a long time to drain.

Similarly, there are pockets within the Islander Road west subcatchment at the Hervey Bay golf course which are reported to remain wet for long periods following heavy rainfall.

2.3 Creek

The identifiable portion of Eli Creek lies between Condor Lake and the mouth. The main channel of Eli Creek near the mouth is substantial in size, with a width in excess of 30 m. To the west of the main creek, the watercourse exists as meandering streams with pockets of remnant vegetation and ponded waterbodies on low lying floodplains.

Much of the runoff into Eli Creek originates in the subcatchments upstream of Condor Lake. The eastern arm of Condor Lake accepts runoff from the Nissen Street and Fairway Drive subcatchments. The creek in the Fairway Drive subcatchment is well defined and heavily vegetated. In the Nissen Street subcatchment, most of the remnant vegetation has been removed, and the watercourse exists as a wide grassed channel. The western arm of Eli Creek drains the Lower Mountain Road subcatchment, and the watercourse partially exists as a large wet bottom channel, and partly as a narrow ephemeral drain.

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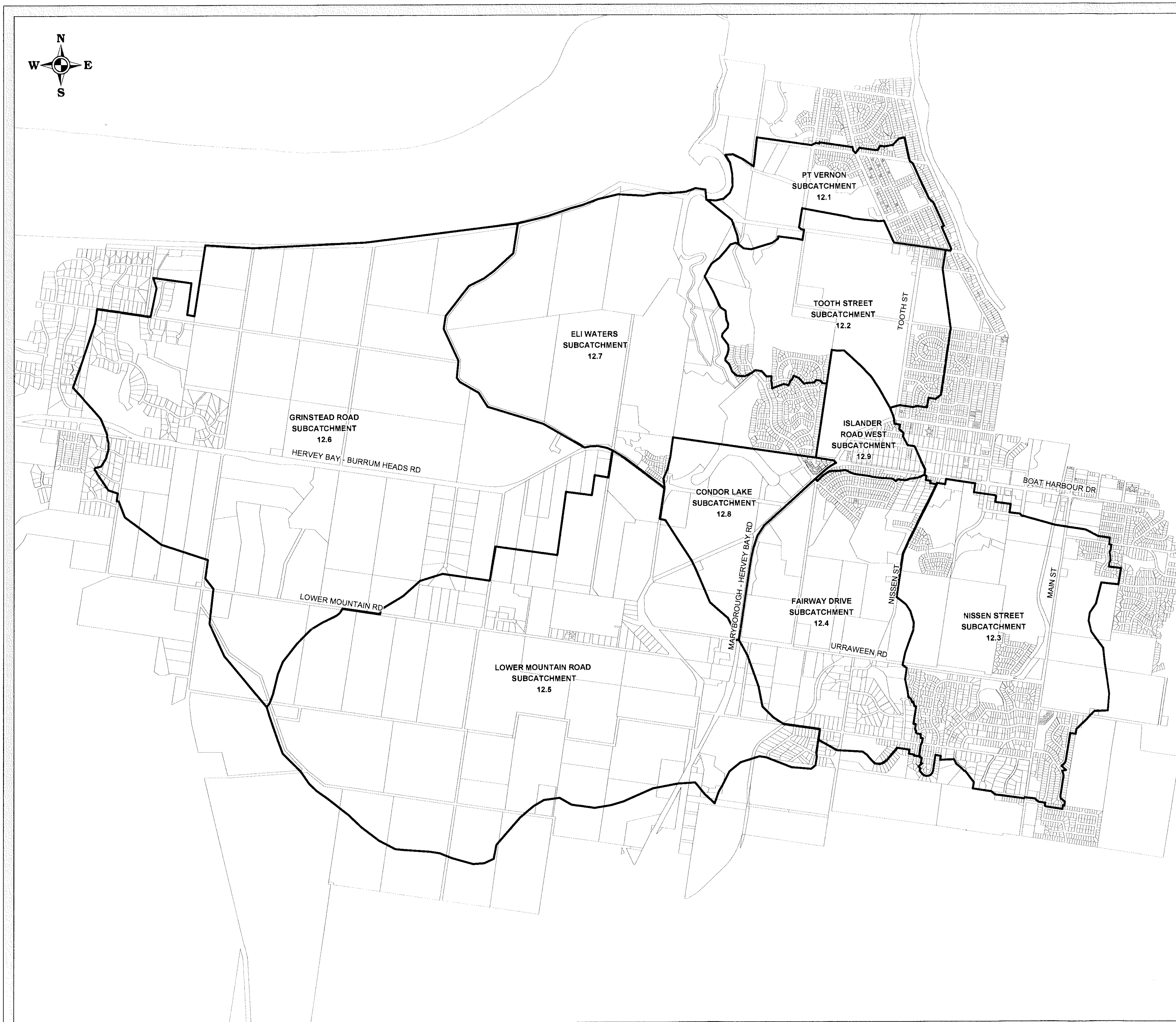

HERVEY BAY CITY COUNCIL

LEGEND

SUBCATCHMENT BOUNDARY

300 0 300 600 900

Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 2.1

Catchment Map

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2.4 Existing Catchment Development

The predominant existing land uses within the catchment are detailed in Table2.1 and Figure 2.2.

Use	Area (ha)	% of Catchment
Industrial	50.5	1.5
Residential Low Density	257.0	7.4
Open Space	957.1	27.7
Road	234.7	6.8
Commercial	13.2	0.4
Rural	1574.8	45.7
Residential Medium Density	6.9	0.2
Water Body	13.9	0.4
Non Urban	90.3	2.6
Park Residential	138.0	4.0
Utilities	3.9	0.1
Active Open Space	59.8	1.7
Educational Facilities	40.9	1.2
Hospital	10.6	0.3

Table 2.1 Existing Land Use

Approximately 76% of the catchment is rural, and open space, and currently only 14.9% of the catchment has developed to commercial, residential and industrial land uses.

The majority of the existing urban development is in the Urraween subcatchment. Other pockets of existing urban landuse exist in the Fairway Drive and Eli Waters subcatchments.

There are some developments in the Fairway Drive catchment which have adopted on-site detention as a drainage strategy. Where it has occurred, the prescribed hydrological landuses for open space (pre-existing) have been adopted.

The land uses have been verified by site inspection and aerial photography. Note that the land use names are representative of hydrologic conditions for particular land use types and may not be consistent with Town Planning Zones.

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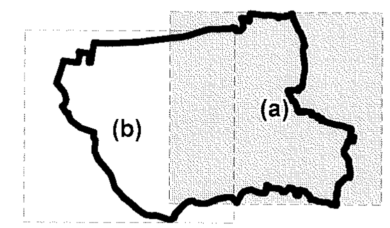
HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- ACTIVE OPEN SPACE
- COMMERCIAL
- EDUCATIONAL FACILITY
- HOSPITAL
- INDUSTRIAL
- NON URBAN
- OPEN SPACE
- PARK RESIDENTIAL
- QUARRY
- RESIDENTIAL LOW DENSITY
- RESIDENTIAL MEDIUM DENSITY
- RURAL
- UTILITIES
- WATERWAY



200 0 200 400 600
Metres
Scale: 1:20,000

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Eli Creek
Catchment Management Plan

Figure 2.2 (a)

Existing Land Uses

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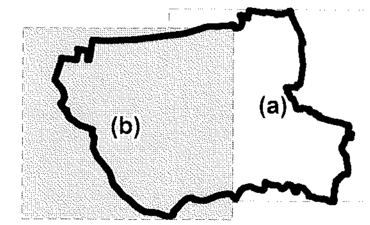
HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- ACTIVE OPEN SPACE
- COMMERCIAL
- EDUCATIONAL FACILITY
- HOSPITAL
- INDUSTRIAL
- NON URBAN
- OPEN SPACE
- PARK RESIDENTIAL
- QUARRY
- RESIDENTIAL LOW DENSITY
- RESIDENTIAL MEDIUM DENSITY
- RURAL
- UTILITIES
- WATERWAY



200 0 200 400 600
Metres
Scale: 1:20,000

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Eli Creek
Catchment Management Plan

Figure 2.2 (b)

Existing Land Uses

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2.5 Proposed Future Catchment Development

Future land use has been determined by reference to the Hervey Bay City Council Strategic Plan and development control plans. This is shown on Figure 2.3 and Table2.2.

Use	Area (ha)	% of Catchment
Industrial	187.8	5.4
Residential Low Density	1586.4	46.0
Open Space	115.6	3.3
Road	234.7	6.8
Commercial	13.2	0.4
Rural	849.0	24.6
Residential Medium Density	6.9	0.2
Water Body	65.9	1.9
Non Urban	75.0	2.2
Park Residential	201.9	5.9
Utilities	3.9	0.1
Active Open Space	59.8	1.7
Educational Facilities	40.9	1.2
Hospital	10.6	0.3

Table 2.2 Future Land Use

The total developable area is 2286 ha which includes industry, residential low, medium and 'park' densities, road resource, commercial, utilities and schools. Areas designated as open space, rural, water body, non-urban and active open space are not included in this total.

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HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- ACTIVE OPEN SPACE
- COMMERCIAL
- EDUCATIONAL FACILITY
- HOSPITAL
- INDUSTRIAL
- NON URBAN
- OPEN SPACE
- PARK RESIDENTIAL
- QUARRY
- RESIDENTIAL LOW DENSITY
- RESIDENTIAL MEDIUM DENSITY
- RURAL
- UTILITIES
- WATERWAY

(b) (a)

200 0 200 400 600
Metres
Scale: 1:20,000

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Eli Creek
Catchment Management Plan

Figure 2.3 (a)

Fully Developed
Land Uses

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HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- ACTIVE OPEN SPACE
- COMMERCIAL
- EDUCATIONAL FACILITY
- HOSPITAL
- INDUSTRIAL
- NON URBAN
- OPEN SPACE
- PARK RESIDENTIAL
- QUARRY
- RESIDENTIAL LOW DENSITY
- RESIDENTIAL MEDIUM DENSITY
- RURAL
- UTILITIES
- WATERWAY

200 0 200 400 600
Metres
Scale: 1:20,000

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Eli Creek
Catchment Management Plan

Figure 2.3 (b)

Fully Developed
Land Uses

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3 Existing Drainage Strategies

3.1 General

The Eli Creek Catchment, also known as catchment C12, can be divided into nine (9) relatively independent subcatchments. Some of these subcatchments have been identified and are recognised individually by Council, and some have not. A summary of the sub-catchments is given in Table 3.1 below and are shown on Figure 2.1.

ID	Name	Details	Current Drainage Strategy Report
12.1	Point Vernon	This catchment is also referred to as "Kehlet Street"	GHD, November 1996
12.2	Tooth Street		None
12.3	Nissen Street	Also called "Senior College"	BGA, May 1991
12.4	Fairway Drive	Also called "Pantlins Lane"	BGA, June 1994 and Planning Policy S1A.4 No D1, June 1994
12.5	Lower Mountain Road	Also called "Christensens Road"	GHD, December 1997
12.6	Grinstead Road		None (1)
12.7	Eli Waters		WBM 1993, BGA, 1998
12.8*	Condor Lake	* Proposed additional subcatchment originally part of the Eli Waters subcatchment	
12.9*	Islander Road West	* Proposed additional subcatchment originally part of the Eli Waters subcatchment.	None

(1) Two options identified and costed in GHD's review of November 1996.

Table 3.1 Subcatchments in the Eli Creek Catchment

Subcatchment 12.8 isolates the area upstream of Condor Lake currently identified within the Eli Waters subcatchment. Eli Waters is predominately located downstream of the lake. Subcatchment 12.9 isolates the area upstream of Old Maryborough Road.

3.2 Point Vernon

GHD was commissioned by Council to prepare a drainage strategy for the Point Vernon catchment. The catchment was divided into two and the southern half of the catchment is part of the Eli Creek catchment.

All of the Point Vernon catchment is zoned for Residential Low Density development and currently approximately 30% of the catchment is developed. The developed area is located predominately east of Murphy Road.

The objectives for the existing drainage strategy were:-

- To determine the peak flow rates for future catchment conditions;
- The investigation of options for drainage works;
- Provide recommendations for drainage works;

- Provide cost estimates and recommendations on headworks charges;
- Provide recommended development fill levels.

The URBS and HEC-RAS programs were used to analyse the fully developed catchment. The strategy recommends: -

1. Grass lined channels west of North Street and Murphy Road and south of Banksia Street.

2. Construction of Q10 culverts at Eli Creek Road, North Street and Archer Drive. The Q10 flow was based on ultimate catchment development conditions.

3. Construction of a wetland at the confluence of the Martin Street open channel and the main southern open channel.

This CMP adopts the outcomes of the southern section of the Point Vernon Strategy, and no further analysis was required.

3.3 Nissen Street

The Nissen Street drainage strategy was formulated by Barlow Gregg and Associates in May 1991 for Illubunda Pty Ltd / Hagan Pty Ltd and Sabriver Pty Ltd. This strategy was adopted by Council, however there was some modification to the outflow permitted at Nissen Street and this is documented in the Fairway Drive report.

The drainage strategy for Nissen Street is for full catchment urbanisation with detention basins upstream of Nissen Street.

3.4 Fairway Drive

The Fairway Drive subcatchment was analysed in 1994 by Barlow Gregg and Associates. The report prepared by the consultant was not adopted by Council. The existing drainage strategy for this subcatchment is on site detention.

Cardno and Davies undertook a report for ClassicSands (Diamond Creek Estate) in May 1997. The report recommended that an overland flow channel be constructed downstream of Nissen Street parallel to the main watercourse, and another excavated open channel be constructed upstream of Maryborough – Urangan Road.

3.5 Lower Mountain Road

The catchment was originally analysed by GHD in December 1996 (*Lower Mountain Road Drainage Strategy, December 1996)* and an addendum report was issued in December 1997. The original (1996) commission recommended the following:-

- The downstream Eli Waters Estate should not be adversely affected by catchment development in terms of flood immunity and water quality;
- The strategy shall take into account existing development and its impact on the location of drainage reserves such that Q100 floods shall not exceed 5.7m AHD at Lower Mountain Road. The minimum development level at Lower Mountain Road is currently 6.0m AHD;
- The strategy shall take into account construction works undertaken by the Department of Main Roads on the Pialba-Burrum Heads Road;
- The main flow path should incorporate a ‘wet bottom’ channel;
- Peak flow rate of $80m^3/s$ at Pialba-Burrum Heads Road is required.

The addendum report lists various design criteria used for the study. These include:-

- Existing flow paths downstream of the Hervey Bay Industrial Estate to be used,
- The rear drain formed to include the 70m in Drury Lane and Council Land,
- Flows from natural runoff and approved development only, and
- Natural retention upstream of Lower Mountain Road.

These were essentially the recommendations for option 2 of the original 1996 study.

The programs RAFTS and HEC-RAS were used to determine runoff quantities and water levels. Natural detention in flat areas was also assessed as part of the study as a means of attenuating peak flow rates and reducing peak flood levels. Natural detention storage was assumed at node 1.05 upstream of Lower Mountain Road.

The result of the investigation for the existing catchment indicated that flows are expected to be contained within the channel between Pialba-Burrum Heads Road and the Northern Drain. The flow bypass from Lower Mountain Road catchment to Drury Lane Zone catchment is not expected to occur. The effect of removing the levee on the northern bank of the north drain was investigated and it was found that a significant amount of flow would have bypassed Lower Mountain Road to Drury Lane. Water levels at Pialba-Burrum Heads Road were reported to remain relatively unchanged.

The strategy recommends:-

- Utilisation of natural retention upstream of Lower Mountain Road;
- Proposed drainage works for the industrial estate be undertaken;
- Undertake a geotechnical investigation;
- Undertake a detail survey;
- Acquire easements and reserves.

3.6 Eli Waters

The Eli Waters Estate is located at the mouth of Eli Creek and consists of a number of tidal exchange lakes and open watercourse areas. The subcatchment accepts runoff from all subcatchments except Point Vernon which discharges to Eli Creek further downstream.

The subcatchment consists wholly of land currently being developed by Fayman Consolidated. The EIS was originally prepared by BGA in 1993.

There are significant volumes of reports on the Eli Waters Estate. The current drainage strategy is to only accept upstream existing catchment flows.

Water levels and flows through the development partially depend on the tide level, and the consulting engineer for Eli Waters undertook a sensitivity analysis with the water level in the ocean at RL 1.0. Unless noted otherwise, all water levels and flows documented in this report for the Eli Waters development are based on an RL 1 ocean water level.

3.7 Previous Studies Summary

The existing drainage strategies and investigations have calculated various water levels and flows that need to be considered when formulating the overall strategy for the catchment. These are given in Table 3.2 and are shown on Figure 3.1.

Location	MIKE-11 Reference	Description	Requirement
Nissen Street Outflow [3]	URRAWEEN 3.128	Outflow	57.2 m^3 /s
Downstream Nissen Street [3]	URRAWEEN 3.227	Water Level	RL 7.94
Downstream of Lower Mountain Road [1]	CENTRAL 2.235	Water Level	RL 5.7 max.
Downstream of Lower Mountain Road [1]	CENTRAL 2.414	Outflow	58 m^3 /s
Pialba – Burrum Heads Road [1]	CENTRAL 4.265	Outflow	80 m^3 /s
Condor Lake [2]	CENTRAL 4.96	Outflow	204 m^3 /s
Condor Lake [2]	CENTRAL 4.936	Water Level	RL 4.08
Grinstead Road [2]	NTHWEST 2.206	Outflow	19 m^3 /s
Lower Grinstead Road [2]	WEST 3.014	Outflow	67 m^3 /s
Maryborough – Urangan Road [3]	URRAWEEN 4.35	Outflow	80 m^3 /s
Maryborough – Urangan Road [2]	URRAWEEN 4.35	Outflow	131 m^3 /s

Notes: 1. GHD, 1996
2. WBM/BGA, 1993
3. CMBK, 1997.

Table 3.2 Previous Studies

Table 3.2 shows that there has been some inconsistency in the reporting of existing flows, due to the use of various modelling programs and design philosophies.

HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- SUBCATCHMENT BOUNDA
- WATERWAY
- ★ ROAD CROSSING

300 0 300 600 900

Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 3.1

Previous Studies

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4 Relevant Legislation

There are several Acts of Parliament that have influence over the outcomes of this study. The legislation pertinent to water quality, flooding and financial outcomes of the study are discussed below.

4.1 Environmental Protection Policy and Environment Protection Act

The Environment Protection (Water) Policy (EPP Water) was drafted under the provisions of Chapter 2 of the Act. The purpose of the EPP (Water) is to achieve the objectives of the Act in relation to Queensland Waters, and the policy provides details of how the objectives of the Act can be achieved via a set of environmental objectives.

This Act is relevant to this study because Section 42(1) of the EPP(Water) states that "*A local government that has an urban stormwater system must develop and implement an environmental plan about urban stormwater quality management that improves the quality of stormwater in a way that is consistent with the water quality objectives for waters affected by the system*".

Requirements within the EPP (Water) that are particularly relevant to this study include:-

- The identification of environmental values for the waterway;
- Deciding and stating water quality guidelines and objectives to enhance or protect the environmental values;
- Making consistent and equitable decisions about the waterway that promote efficient use of resources and best environmental management; and
- Involve the community through consultation and education, and promoting community responsibility.

4.1.1 Environmental Values (EV's)

Section 9 of the EP Act define an "environmental value" as:-

- A quality or physical characteristic of the environment that is conductive to ecological health or public amenity or safety; and/or
- Another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

The environmental values to be enhanced or protected under the EPP (Water) are:-

- if the water:-

  (a) is a pristine water – biological integrity of a pristine aquatic ecosystem; or
  (b) is not a pristine water – biological integrity of a modified aquatic ecosystem

A pristine aquatic ecosystem is defined in Schedule 2 as an aquatic ecosystem that has not been, or is not subject to human interference through:-

(a) releases (whether direct or indirect) into a water forming part of the ecosystem; and
(b) activities in the value's catchment area.

Accordingly, the waters of the Eli Creek Catchment are categorised as "Not a pristine aquatic ecosystem". A further list of environmental values detailed in the policy relevant to these waters include:-

- suitability for recreational use;
- suitability for minimal treatment before supply as drinking water,
- suitability for agriculture use; and
- suitability for industrial use.

4.1.2 Water Quality Guidelines

Section 9 of the Policy details the water quality guidelines that protect a stated environmental value. Particularly three documents are used to determine water quality guidelines for an environmental value for a water:-

(a) site specific documents
(b) the AWQ guidelines; and
(c) documents published by a recognised entity (e.g. ANZECC).

Decisions on the most appropriate guidelines to adopt for the catchment depends on various factors, especially if the water quality guidelines proposed for the catchment would involve economic or social impacts that are unacceptable to the community (Part 4, S5(a)), or if the water quality objectives are an improvement on existing water quality (Part 4, S5(b)). Part 5, Section 19(2) states that Council must consider the existing water quality, topography and local conditions when formulating water quality strategies and objectives.

4.2 Integrated Planning Act 1997

This Act commenced on 30 March 1998 and replaced the Local Government (Planning and Environment) Act, 1990.

The purpose of this Act is to seek to achieve ecological sustainability by:-

(a) coordinating and integrating planning at the local, regional and State levels;
(b) managing the process by which development occurs; and
(c) managing the effects of development on the environment (including managing the use of premises).

The following provisions of Section 1.2.3 state what advancing the Acts purpose includes, as well as how these relate to the outcomes of this study:-

(a) ensuring decision-making processes:-
  (i) are accountable, coordinated and efficient;
  (ii) take account of short and long-term environmental effects of development at local, regional, State and wider levels;
  (iii) apply the precautionary principle;
  (iv) seek to provide for equity between present and future generations;

(b) ensuring the sustainable use of renewable natural resources and the prudent use of non-renewable natural resources;

(c) avoiding, if practicable, or otherwise lessening, adverse environmental effects of development;

(d) supplying infrastructure in a coordinated, efficient and orderly way, including encouraging urban development in areas where adequate infrastructure exists or can be provided efficiently;

(e) applying standards of amenity, conservation, energy, health and safety in the built environment that are cost effective and for the public benefit; and

(f) providing opportunities for community involvement in decision making.

Chapter 5 of the Act discusses infrastructure charges. An infrastructure charge is a charge fixed as a general charge under the Local Government Act 1993 for the capital cost of a development infrastructure item. Part 1 of the Chapter states that an infrastructure charge can only be fixed for a development infrastructure item if the item is identified in an infrastructure charges plan.

Under Section 5.1.4(i) an infrastructure charges plan is defined as the part of a planning scheme that:-

(a) identifies development infrastructure items making up a network of development infrastructure items; and
(b) states the desired standard of service for the network having regard to user benefits and environmental effects of the network; and
(c) evaluates alternative ways of funding the items.

This study provides background information for input into an Infrastructure Charges Plan to be undertaken as part of this project.

4.3 Water Resources Act 1989

The purpose of the Act is to consolidate and amend the law relating to:-

- rights in water, the measurement of water, the construction, control and management of works with respect to water conservation and protection, irrigation, water supply, drainage, flood control and prevention, improvement of the flow in or changes to the courses of watercourses;
- protecting and improving the physical integrity of watercourses
- the safety and surveillance of dams; and
- for purposes incidental thereto and consequential thereon.

The Department of Natural Resources has a regulatory role in respect of works or other activities taking place in or adjacent to a watercourse.

Of particular relevance to this study is Part 4 divisions 2 and 5. Section 38 of Division 2 states that a licence is required to undertake works in a watercourse if the works involve:-

(a) constructing on the person's land a referable dam or alters, repairs, maintains, uses, operates, abandons or removes a referable dam already constructed; or

(b) constructs works or uses works already constructed in or on a watercourse, lake or spring:-
   (i) to conserve water
   (ii) to take water therefrom or water contained in or conserved by a weir, barrage or dam; or

(c) constructs works or uses works already constructed in or on a watercourse, lake or spring or on or in connection with land that abuts any of them:-

   (i) for the purpose of drainage
   (ii) for the prevention of flooding of land by water or the erosion of banks
   (iii) for improvement in the flow of water in or changes to the course of any of them; or

(d) takes water from a channel constructed by the corporation outside an irrigation area; or

(e) constructs:-
  (i) in that part of a river, creek or stream downstream of the point at which the river, creek or stream becomes a watercourse within the meaning of his Act and upstream of the point at which the river, creek or stream ceases to be capable of navigation by vessels ordinarily employed in that river, creek or stream for the purpose of carrying goods;
  (ii) in a lake;
  (iii) works in the nature of a barrage; or

(f) uses works in the nature of a barrage constructed in that part of a river, creek or stream or in a lake specified in paragraph (e) and in existence immediately prior to the commencement of the Water Act Amendment Act 1979.6, or

(g) constructs on the person's land a levee bank or uses a levee bank so constructed; or

(h) constructs on the person's land an artesian bore or uses an artesian bore so constructed or enlarges, deepens or alters in any manner an artesian bore; or

(i) in districts in which there is in force at the material time a regulation under Section 31 constructs on the person's land a sub-artesian bore or uses a sub-artesian bore so constructed or enlarges, deepens or alters in any manner a sub-artesian bore; or

(j) constructs in a designated area controlled works; or

(k) keeps or uses, in a designated area, controlled works constructed before the constitution of the designated area.

Division 5, Section 70 states that a person must not destroy vegetation, excavate or place fill in a watercourse unless authorised by a permit under Section 71. The Act defines a watercourse to include the bed and banks and any other element of a river, creek or stream that confines or contains water upstream of the point to which the spring tide normally flows and reflows, whether this is caused by either a natural or constructed barrier. Vegetation is taken to mean any native plants, including any native trees, shrubs, bushes, seedlings, saplings and reshoots.

5 Community Consultation

5.1 Overview

The opportunity for the community to participate in the planning process and review the outcomes of the Eli Creek Catchment Management Plan was provided through Community Consultation.

The purpose of the Community Consultation was to:-

- Recognise the uses of the waterway in order to develop Environmental Values and water quality objectives.
- Document instances of flooding within the catchment.
- Gain an appreciation of the communities attitude towards future development and funding.

Additionally, Community Consultation is a requirement under Section 12 of the EPP (Water) which states that the views of the community should be sought when determining environmental values and water quality objectives.

5.2 Methodology

A survey of the landowners and the greater community was undertaken through a questionnaire. A copy of the questionnaire is given in Appendix E.

5.3 Survey Results

A copy of the Resident's Questionnaire is contained in Appendix E.

A total of 200 out of 5,000 responses were received, and these results were input into an ACCESS database for analysis. Therefore the percentage of respondents was low at 4 percent.

Each of the categories have been reported and discussed in the following sections.

5.3.1 Waterway Usage

Thirty nine percent of the responses indicated that they use the waterway in some form. A summary of the uses is given below in Table 5.1.

Use	% Respondents that Indicated a Use
Primary Recreation (eg swimming/diving)	7.5
Secondary Recreation (eg boating/rowing)	15.5
Visual Recreation (eg walking/picnicking)	29.5
Irrigation	1.5
Lifestock watering	1.5
Farm Water Supply	0.5
Drinking Water Supply	1.0
Aquaculture	1.0
Industrial Use	0.5

Table 5.1: Summary of Waterway Uses

The locations where the respondents indicated that they used the creek included:-

- mouth of Eli Creek
- park north of Doolong Road at Main Street
- Eli Waters Lake and Creek
- off Martin Street
- Condor Lake.

5.3.2 Waterway Value

Fifty percent of respondents identified a value in the waterway. The responses are summarised in Table 5.2.

Value	% Respondents that Indicated the value
Aquatic Ecosystems	41.5
Wildlife Habitat	44.5
Cultural Heritage	14.0

Table 5.2: Summary of Waterway Values

Some locations where these values were identified through the questionnaire have been shown on the Environmental Values plan (Ref. Section 7), however many residents who commented on location indicated that the entire waterway has these values.

5.3.3 Location of Degradation

The residents indicated that various areas within the catchment are degraded. The primary locations given by the residents are shown on Figure 5.2.

The main areas identified were:-

- Waterway area upstream of Nissen Street
- Eli Creek mouth
- Eli Creek near the old rubbish dump
- Eli Creek wastewater treatment plant
- Degradation due to development of Eli Waters

5.3.4 Flooding Areas

Several locations in the waterway were identified from anecdotal information as areas where flooding has been known to be a problem. These areas are listed in Table 5.3 below, and are shown on Figure 5.2. A number of these areas have been rectified by Council.

Type of Flooding Reported	Details
Road Flooding	• Burrum Heads Road • Dirt Road from Martin Street to old tip • Old Maryborough Road near new roundabout and adjacent to golf course • North Street – Corner of North Street and Martin Street • Road to Eli Creek • Tooth Street
Urban Areas	• Eli Waters existing development • Pialba Downs Estate • Eli lakes

Table 5.3 Areas Reported to have Flooding Problems

These flooding locations were provided by the community, and may be subject to interpretation.

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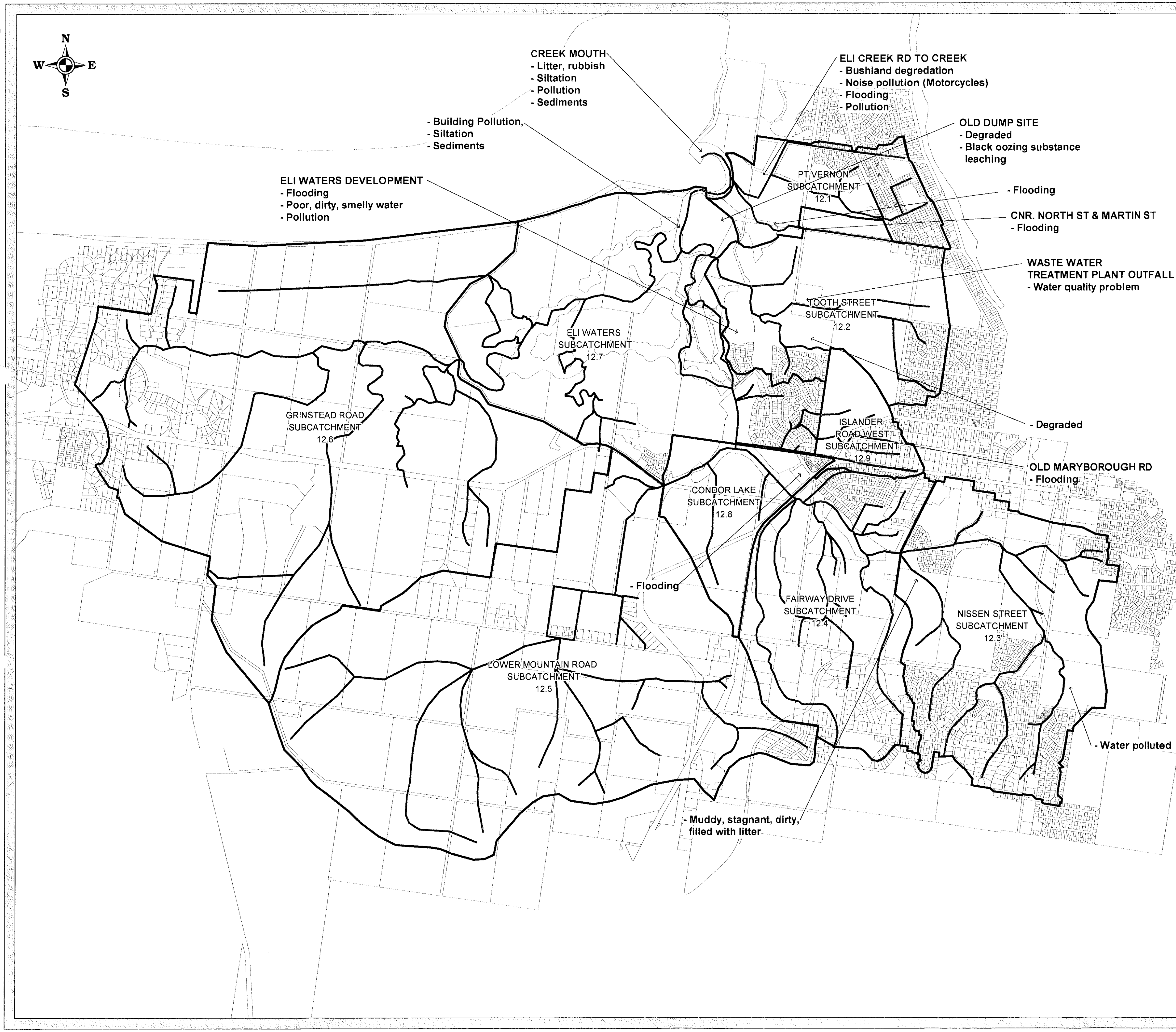

HERVEY BAY CITY COUNCIL

LEGEND

CATCHMENT BOUNDARY
WATERWAYS

300 0 300 600 900
Metres
Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 5.2

Waterway Degradation
Areas

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5.3.5 Water Quality Problems

Several locations were given by the residents as having water quality problems. These are given in Table 5.4.

Pollutant/Problem	Location
Water quality	• Eli Creek WWTP Outfall • Creek north of Doolong Road
Building Pollution	• Lakes and Mangroves • Eli Lakes and Creek
Odour	• Pialba Downs Estate • Wide Bay Drive • Eli Waters • Adjoining golf course • Crossing Main Street
Siltation	• Maryborough-Hervey Bay Road • Culvert under road into senior college yards • Downstream of Eli Creek Treatment Plant
Litter, Rubbish	• Behind North Street tip • Point Vernon • Mouth • Main Street crossing • Nissen Street crossing behind Chancellor Park estate
Pollution Seepage	• Old rubbish dump

Table 5.4: Locations of WaterQuality Problems

The locations are shown on Figure 5.2.

5.3.6 Locations of High Environmental Significance

Figure 5.3 shows the locations that were identified to be of high environmental significance and should be protected. The areas identified included wetlands, wildlife habitats, and other areas identified in the community consultation.

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LEGEND

CATCHMENT BOUNDARY

WATERWAYS

300 0 300 600 900

Metres

Scale: 1:30,000

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Catchment Management Plan

Figure 5.3

Areas of High
Environmental Significance

JWP

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5.3.7 Support for Preservation and Rehabilitation

Do you support moves by Council to preserve and re-establish bushland and habitat corridors along Eli Creek and its tributaries?

Total Replies to Questionnaire	200	
Total Responses to Question	172	
Response Rate	86%	
Response	Yes	No
Total	129	43
Percent of "Total Responses to Question"	75%	25%
Percent of Total Replies to Questionnaire	64.5%	21.5%

In general, the community supports preservation and rehabilitation.

5.3.8 Support for Addressing Various Issues

Should measures be taken to address bushland degradation, flooding and water quality issues along Eli Creek and its tributaries?

Total Replies to Questionnaire	200	
Total Responses to Question	165	
Response Rate	82.5%	
Response	Yes	No
Total	134	31
Percent of "Total Responses to Question"	81.2%	18.8%
Percent of Total Replies to Questionnaire	67%	15.5%

The majority of respondents believe that measures should be taken to address bushland degradation and other stormwater issues.

5.3.9 Use of Ratepayers Funds

Where bushland corridors, improvement measures and land acquisition cannot be funded from contributions by developers, should Council use ratepayer funds for this purpose?

Total Replies to Questionnaire	200	
Total Responses to Question	170	
Response Rate	85%	
Response	Yes	No
Total	65	105
Percent of "Total Responses to Question"	38.2%	61.8%
Percent of Total Replies to the Questionnaire	32.5%	52.5%

The respondence were, in general, not in favour of the use of ratepayers funds.

5.3.10 Levy

Would you be prepared to pay a levy to enable Council to address bushland degradation, flooding and water quality issues along Eli Creek and its tributaries?

Total Replies to Questionnaire	200	
Total Responses to Question	181	
Response Rate	90.5%	
Response	Yes	No
Total	40	141
Percent of "Total Responses to Question"	21.1%	77.9%
Percent of Total Replies to the Questionnaire	20%	70.5%

The respondents were not in favour of paying a levy.

5.3.11 Amount of Contribution per household

If so (Section 7.3.10), please indicate the amount per household per year you would be prepared to pay

Total Replies to Questionnaire	200			
Total Responses to Question	32			
Response Rate	16%			
Response	$ 25.00	$ 50.00	$ 75.00	$ 100.00
Total	25	5	1	1
Percent of "Total Responses to Question"	78.1%	15.6%	3.1%	3.1%
Percent of Total Replies to the Questionnaire	12.5%	2.5%	0.5%	0.5%

The response rate on this question was low, and most people indicated that they would be prepared to pay up to $25 per year.

5.3.12 Other Comments

Do you have any other comments to assist the study?

Most respondents provided comments. Comments relevant to the study included:-

- Developers should contribute to costs.
- Funding should be sort from State and Commonwealth funds or grants.

There were other comments, and these are given in Appendix F.

5.4 Summary

Overall, there was a low level of community interest in this study, and this should be taken into account when establishing environmental objectives.

People use the Eli Waters Lakes for primary contact recreation purposes, and these should be protected.

A full printout of all of the responses is given in Appendix E.

6 Hydrologic and Hydraulic Analysis

6.1 Overview

The overall purpose of any hydraulic modelling is to describe the movement or behaviour of floods as they pass through the watercourse and associated floodplains. Flood flows and levels, extent of inundation, flow quality and flow velocities at various locations along the study reach are outcomes of a hydraulic model.

Development of the catchment will effect the existing behaviour of floods in the system by increasing peak runoff, and runoff volume, velocity and lower the immunity of road crossings.

To assess the impact of development, two catchment development scenarios were analysed. Analyses of the existing catchment (2001) shows where existing flooding problems occur and provides the base flows and levels for comparison with the fully developed catchment scenario. Analyses of the developed catchment shows the impact of flooding from increased urbanisation of the catchment.

The hydrological program RAFTS was used to predict existing and future flood flows in the catchment. To do this, the Eli Creek catchment was divided into 190 subcatchments according to local topography and anticipated flood flow direction. The subcatchments are centred around the trunk drainage paths and overland flow drainage paths.

Hydrographs from the RAFTS model were input into the hydraulic model for water level determination.

The quasi two-dimensional hydrodynamic program, MIKE-11 developed by the Danish Hydraulic Institute, was selected for the hydraulic analysis. The MIKE-11 model incorporates the main channel and tributaries of Eli Creek upstream of Eli Waters.

6.2 Hydrological Model

The nonlinear runoff routing program RAFTS was used to perform the hydrologic analysis. Hydrographs for design events were produced by routing rainfall through subcatchment storages and along channel links.

Analysis involves division of the catchment into subcatchments, derivation of various physical properties of the subcatchments and assembly of the subcatchments by nodal network. Routing of flow along the creek is performed by nominating a lag time on each model reach based on flow velocity. Subcatchment hydrographs are added in sequence to the flow based on location within the nodal network. The subcatchment hydrographs were then input to the hydraulic model as is discussed in a later section of this report. The subcatchment breakdown is shown in Figure 6.1.

Model input data has been based on orthophoto contour and vegetation information, several site visits and a site survey of stream profiles and vegetation roughness.

Model parameters for subcatchment storage have been selected from recommended design values for vegetation types. The storage routing parameter and nonlinearity exponent have been estimated by the relationship developed by Aitken, 1986.

Subcatchments were modelled as two sub areas divided into pervious and impervious portions.

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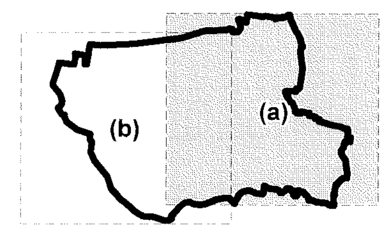
LEGEND

- RAFTS SUBCATCHMENT BOUNDARY
- SUBCATCHMENT BOUNDARY
- WATERWAYS



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Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.1 (a)

Rafts Subcatchments

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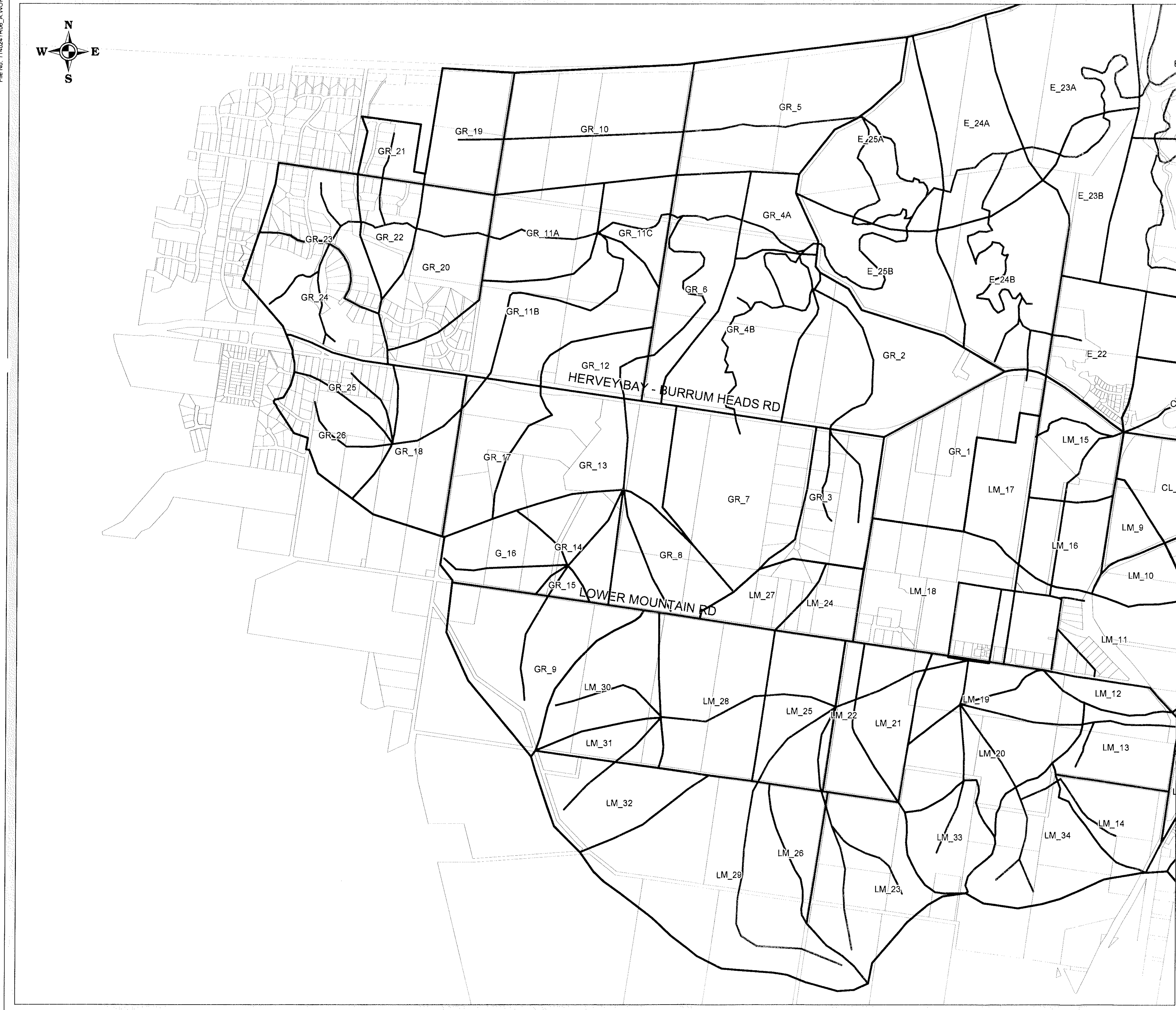


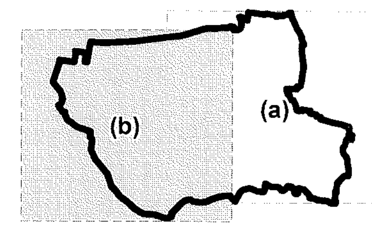
HERVEY BAY CITY COUNCIL

LEGEND

RAFTS SUBCATCHMENT BOUNDARY

SUBCATCHMENT BOUNDARY

WATERWAYS



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Metres

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HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.1 (b)

Rafts Subcatchments

JWP

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6.3 Rainfall

Rainfall for each design event was obtained from the Hervey Bay City Council rainfall intensity tabulation. A reproduction of the tabulation is contained in Appendix B.

6.4 Rainfall Losses

15 mm initial loss and 2.5 mm /hour continuing losses were adopted on pervious surfaces for all design storms. These loss rates are consistent with AR&R (1987) which recommends a continuing loss of 2.5 mm/hr and an initial loss of between 15-35 mm for use in eastern Queensland, and JWP typically use 15 mm initial and 2.5 mm continuing loss when determining flood flows in urban and rural catchments unless detailed flood flow calibration is undertaken. Council drainage guidelines do not specify preferred loss rates.

6.4.1 Sensitivity to Variations in Loss Rates

A sensitivity check of flood flow to variation in rainfall losses was undertaken and the ultimate 100 year ARI 120 minute duration storm was analysed using loss rates adopted from other studies. The loss rates adopted in other studies are given below:

Report	Initial Loss	Continuing Loss
Point Vernon Drainage Strategy, GHD 1996	0 (10-100 yr)	N/A
Nissen Street Drainage Strategy, BGA 1991	25	5.0
Eli Waters EIS, BGA 1998	5.0	2.5
Lower Mountain Road, GHD 1997	5.0 (Ext) 2.0 (Ult)	2.5 (Ext) 0.0 (Ult)

Table 6.1 Loss Rates used in Other Studies

To assess the effect of this variation, a sensitivity analysis was undertaken for three cases:

- Initial Loss 35mm, Continuing Loss 2.5mm/hr
- Initial Loss 15mm, Continuing Loss 2.5mm/hr (adopted)
- Initial Loss 5mm, Continuing Loss 0mm/hr

The results are given in Table 6.2 below.

Location	Node	Peak flow using 35mm IL 2.5mm/hr CL (m^3/s)	Percent difference from adopted	Peak flow using 15mm IL and 2.5mm CL (m^3/s)	Peak flow using 5mm IL 0.0mm CL (m^3/s)	Percent difference from adopted
Grinstead Rd	GR_5	19.5	-7	21.1	22.1	5
Grinstead Rd	GR_4A	89.3	-20	111.3	126.0	13
Hervey Bay - Burrum Heads Rd	GR_13	18.5	-20	23.0	26.2	14
Hervey Bay - Burrum Heads Rd	LM_15	55.7	-5	58.8	65.8	12
Hervey Bay - Burrum Heads Rd	CL_1	195.1	-10	217.1	229.6	17
Outlet	Outlet	322.8	-14	376.2	408.0	8
Lower Mountain Rd	LM_19	47.0	-19	57.7	65.1	13
Sorrensons Rd	LM_25	25.5	-23	33.0	38.6	17
Maryborough Urangan Rd	D_UW3	119.9	-13	138.1	147.3	7
Nissen St	UE_3	70.3	-13	80.9	87.7	8

Table 6.2 Comparison of Peak Flows for Varying Loss Rates

The flows in Table 6.2 above are not the final 100 Year ARI flood flows. These are discussed in the hydraulics section and presented in Appendix D. The flows in Table 6.2 merely demonstrate the probable variations in flood flow as a result of a change in loss parameters.

Table 6.2 shows that the inflows may vary by $\pm$ 20% by adopting alternative loss parameters.

6.5 RAFTS Parameters

The parameters used in the RAFTS mode are indicated in Table 6.3 below.

Land Use	% Impervious	Pern
Industrial	100	0.015
Residential Low Density	45	0.025
Open Space	0	0.10
Road	80	0.02
Commercial	100	0.015
Rural	2	0.07
Residential Medium Density	60	0.025
Water body	100	0.015
Non Urban	5	0.04
Park Residential	20	0.04
Utilities	50	0.025
Active Open Space	0	0.04
Educational Facilities	20	0.025
Hospital	0	0.10

Table 6.3: RAFTS Parameters

The RAFTS parameter PERN is a subcatchment area surface routing coefficient that is used to differentiate surface roughnesses. The parameter PERN is input as a Mannings 'n', representing the average subcatchment storage and roughness. The subcatchment storage (B factor) is altered according to a scale typically from 0.5 (impervious surfaces PERN = 0.015) to 3 (forest PERN = 0.1).

The Bx storage coefficient is used when calibrating a gauged catchment. During calibration of a gauged catchment the Bx parameter is modified to suit the storage of the subcatchments to alter the shape, peak and timing of a hydrograph. A B_x factor of 1 was adopted for this study.

6.5.1 Comparison with Other Studies

The RAFTS parameters (% Impervious, Pern) were compared with those adopted for previous studies throughout the catchment including the Lower Mountain Road Report by GHD and the Nissen Street Report by BGA. The parameters were not documented in the Eli Waters EIS. Other reports did not use RAFTS for hydrologic analysis.

Land Use	Lower Mountain Rd, GHD		Catchment East of Nissen Street, BGA		Eli Creek CMP, JWP	
	% Impervious	Pern	% Impervious	Pern	% Impervious	Pern
Open Space	0	0.05 (Existing) 0.025 (Developed)	N/A	N/A	0	0.10
Commercial / Retail	N/A	N/A	50	0.015	100	0.015
Urban	70	0.05 (Existing) 0.025 (Developed)	25	0.025	45	0.025
Rural	N/A	N/A	5	0.05	2	0.07
Industrial	90	0.05 (Existing) 0.025 (Developed)	N/A	N/A	100	0.015

Table 6.4: Parameters adopted for previous studies

The two major landuses in the catchment are urban (low density residential) and open space.

The percent impervious adopted by BGA in the Nissen Street study is lower than that used in this analysis. The flood flows calculated in this report may therefore be higher than those calculated by BGA.

The higher Pern value on open space areas may produce lower flows than was calculated by GHD in the Lower Mountain Road analysis.

The other differences in RAFTS parameters will not significantly affect model behaviour compared with other studies.

6.6 Model Calibration

As there was no recorded flood flows in the creek for the local catchment, no direct calibration of the model could be performed. The design peak flows for developed catchment conditions were compared with the rational method and the results are given in Table 6.5.

Both the rational formula flows and the RAFTS flows were derived without consideration of in-stream and floodplain storage.

Location	RAFTS Peak Q100 Flow and (Location)	Rational Method Flow Calculations
Sorrensons Road	33.8 m^3/s (LM_25)	34 m^3/s
Grinstead Road	23.9 m^3/s (GR_5)	23 m^3/s
Grinstead Road	111.3 m^3/s (GR_4A)	110 m^3/s
Hervey Bay – Burrum Heads Road	23.0 m^3/s (GR_13)	25 m^3/s
Hervey Bay – Burrum Heads Road	71.1 m^3/s (LM_15)	71 m^3/s
Lower Mountain Road	60.5 m^3/s (LM_19)	60 m^3/s
Nissen Street	83.5 m^3/s (UE_3)	88 m^3/s

Table 6.5: Q100 Flow Comparison

Based on the comparisons, the RAFTS model was considered to represent peak flood flows.

6.7 Hydrological Analysis

Storms with rainfall durations of 60 minutes to 12 hours were simulated in the RAFTS model for the 100, 50 and 10 year ARI storms. These flows were input into the MIKE-11 hydraulic model for determination of peak flows and water levels.

6.8 Hydraulic Modelling

6.8.1 Survey Information

Survey information for creek cross sections has been obtained from previous studies, existing and new ground survey and contour information from Council's GIS. All levels are on Australian Height Datum.

There was not sufficient survey available to model the Eli Waters floodplain, or the Eli Creek main channel downstream of Condor Lake. This area is flat, and it is difficult to determine the low flow drainage paths.

In the absence of survey information, the analysis of the existing system undertaken by BGA was adopted as the basis of the existing flooding regime.

The survey information used for the Grinstead Road sub-catchment was based on 5m GIS contours. This is suitable for a preliminary analysis and alternative, more accurate survey methods should be used, and the model re-analysed for detail design purposes.

The survey used in the Nissen Street and Fairway Drive sub-catchments was predominantly based on 1m GIS contours. The trunk drain from Maryborough-Urangan Road to the railway generally adopted the levels given by CMBK in the analysis of the Diamond Creek Estate subdivision, and drawings of the proposed drainage structures prepared by Connell Wagner.

Survey information used for the analysis of the Lower Mountain Road sub-catchment predominantly adopted the drainage strategy cross sections, as proposed by GHD.

Additional ground survey was undertaken upstream of Lower Mountain Road. These sections were used to determine the extent of inundation and storage potential upstream of the road crossing.

6.8.2 Roughness Coefficients

Surface conditions in the main channel and flood plains were evaluated from orthophoto maps and detailed inspection of the site. Manning 'n' values used in the hydraulic model were based on observed data and have been continuously varied to properly simulate the prototype roughness.

Analyses have been performed using single 'n' values for each flow area. Values have been combined in hydraulically simple channels to produce a composite roughness value. Allowance has also been made in 'n' values for meandering and eddy losses.

Roughness Values are shown on Figure 6.2.

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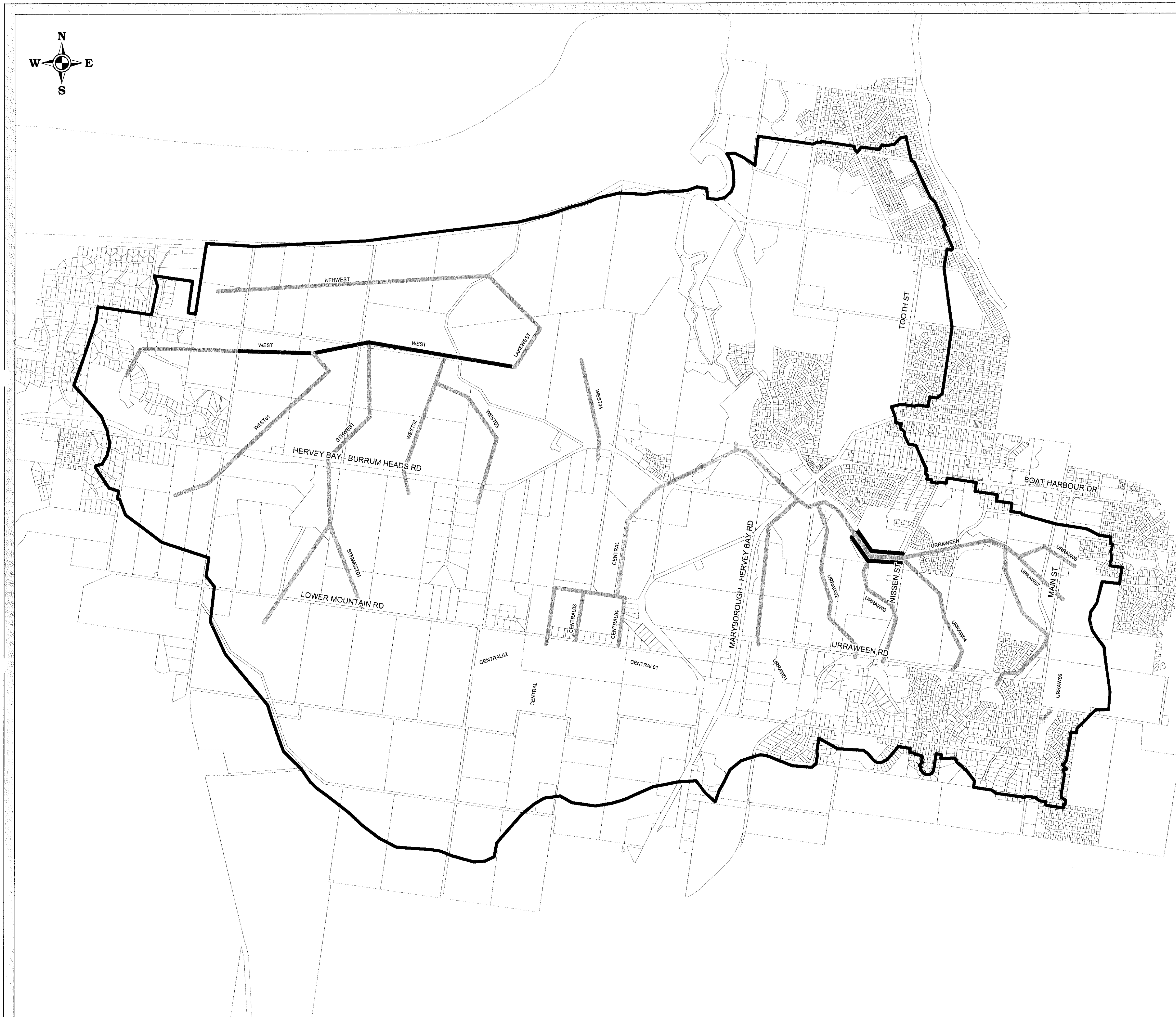

HERVEY BAY CITY COUNCIL

LEGEND

CATCHMENT BOUNDARY

n Values

0.02
0.045
0.06
0.07
0.08
0.10

300 0 300 600 900

Metres

Scale: 1:30,000

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Eli Creek
Catchment Management Plan

Figure 6.2

Roughness Values

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Flow Profile	Roughness
Waterbody	0.02
Mown Grass	0.045
Scrub	0.06
Light Vegetation	0.07 / 0.08
Moderate Vegetation	0.10
Dense Vegetation	0.15

Table 6.6: Manning's Roughness Values

6.8.3 MIKE-11 Model

The MIKE 11 hydrodynamic model is an unsteady flow model used to simulate flows in open channels.

The model is based on an implicit finite-difference approach and can be applied to looped networks and quasi two-dimensional flow simulations. The model is capable of simulating sub-critical as well as super-critical flow conditions through a numerical scheme which adapts according to local flow conditions.

Inputs to the model include discharge hydrographs at various inflow points, and time dependant or flow/height relationships at the model boundaries.

The computational grid comprises alternating Q (discharge) and H (water level) points and is generated with Q points placed midway between neighbouring H points and at structures. The differential equations are solved via a 6 point finite difference scheme with alternating Q and H points known as the Abbott-Lonescu scheme. The momentum equation is centred about the Q points while the continuity equation is centred about the H points.

A generalised matrix solution procedure utilising the double sweep algorithm is applied to both subcritical and supercritical flow conditions by ascribing the centring of the scheme to a function of the flow state (i.e. the Froude number).

For the purposes of modelling the drainage area, the hydraulic model specifically incorporated:-

- fully dynamic solution scheme
- centred (with respect to time – delta = 0.55) computation scheme
- maximum delta – x = 1000 m
- event durations ranged between 1 and 12 hours.

The hydrodynamic model requires input of external boundary conditions at extremities of the model network. The boundary conditions used in the study are as follows:-

- Hydrographs produced by RAFTS at tributaries contributing flow to the drainage area.
- Rating curve at downstream boundary.

The MIKE 11 Model is shown in Figure 6.3.

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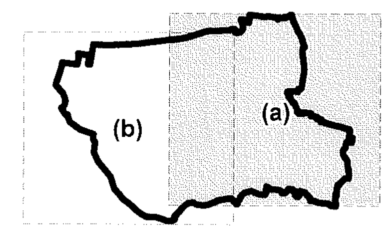
LEGEND

MIKE-11 WATERWAYS

MIKE-11 CROSS SECTIONS



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Metres

Scale: 1:20,000

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Eli Creek
Catchment Management Plan

Figure 6.3 (a)

MIKE-11 Model

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File No. 114024TR23_A.WOR

HERVEY BAY CITY COUNCIL

LEGEND

MIKE-11 WATERWAYS

MIKE-11 CROSS SECTIONS

LINK CHANNEL

(b) (a)

200 0 200 400 600

Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.3 (b)

MIKE-11 Model

JWP

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PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

6.8.4 Calibration

No flood levels were available from historic flood events. The model should be re-analysed if calibration information (flood levels, rainfall) becomes available.

6.8.5 Start Water Levels

Eli Creek is tidal, and start levels influence flood flows and flood levels from the upstream catchment. Because of this, separate analyses for peak flow and water level are required. Additionally, because the proposed configuration for Eli Waters has not been finalised, establishing exact water levels downstream cannot be performed.

To determine the impact of development on the receiving waters, a constant tailwater of RL 1m was assumed at the mouth of Eli Creek. This is identical to the sensitivity analysis conducted as part of the Eli Waters EIS. A rating curve based on existing conditions was derived at each inflow point to the Eli Waters estate as there was insufficient survey information to model the existing waterway. Data points for the rating curves were obtained from the Eli Waters EIS and are shown on Figures 6.4, 6.5 and 6.6. The start water levels are above the design storm tide level of RL 2.1m AHD.

6.8.6 Modelling Strategy

The Nissen Street, Lower Mountain Road and Point Vernon catchments have drainage strategies, prepared for and adopted by Council. Some of the strategies are already constructed and the final designs have been undertaken.

There has also been various studies undertaken of the catchment to determine the "existing" catchment flows, particularly the Eli Waters EIS which specifies target peak flows on the main tributaries for existing catchment conditions.

In general, when there is an existing, adopted drainage strategy in a particular sub-catchment, full catchment urbanisation plus the drainage strategy has been analysed with the exception of the Fairway Drive catchment.

The impact of developing the catchments that do not have a drainage strategy was assessed by analysing existing and post development catchment conditions.

The hydraulic modelling therefore is based on the following:

Nissen Street

- The proposed detention basins upstream of Nissen Street have been analysed;
- The catchment upstream has been fully urbanised for both existing and developed catchment analysis scenarios;
- The waterway has been confined to the extent of the proposed detention basins;
- No modification to the tributaries for ultimate catchment development.

Rating Curve LAKEWEST 0.600 (BGA Node 59)

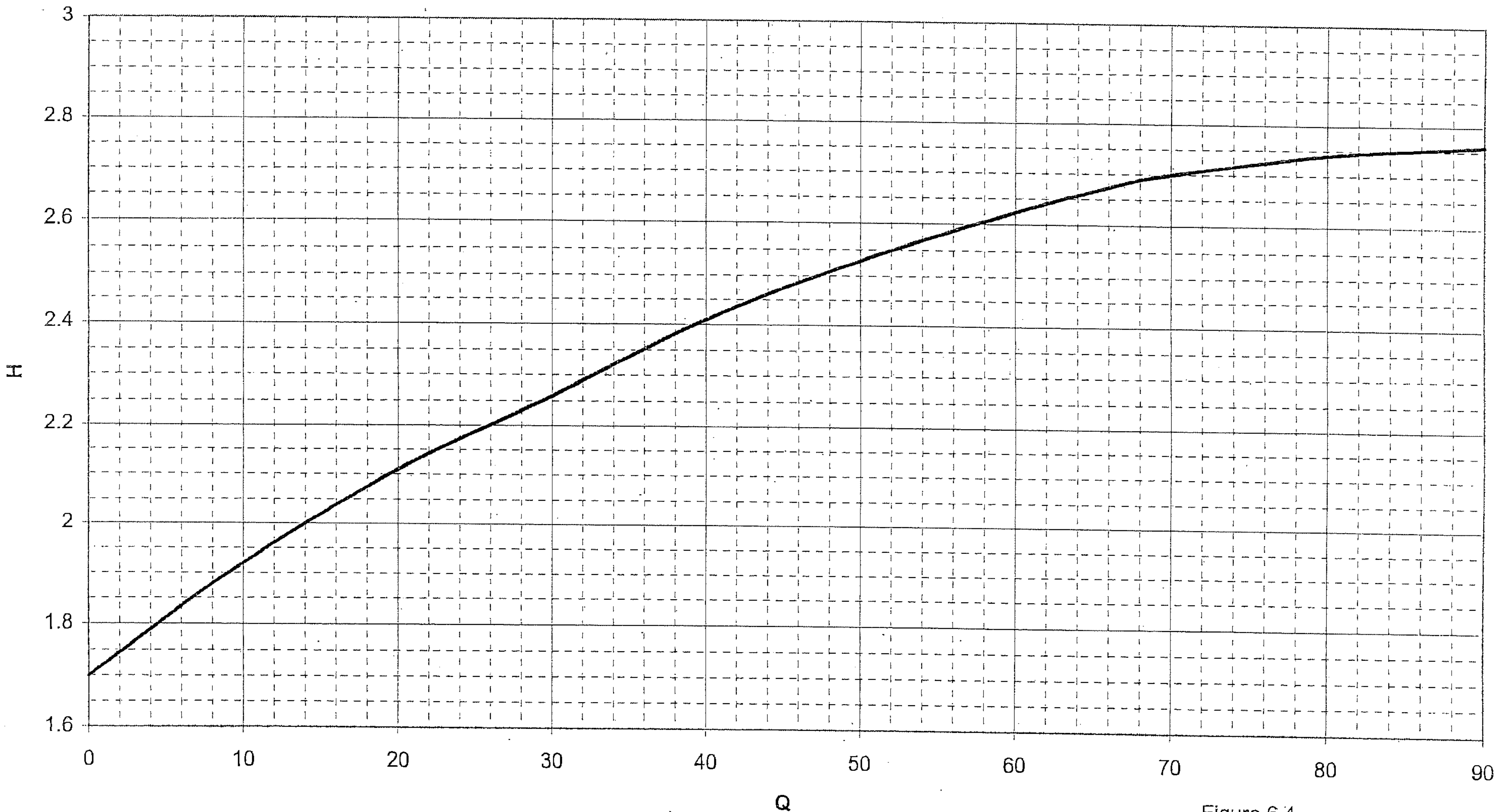


Figure 6.4

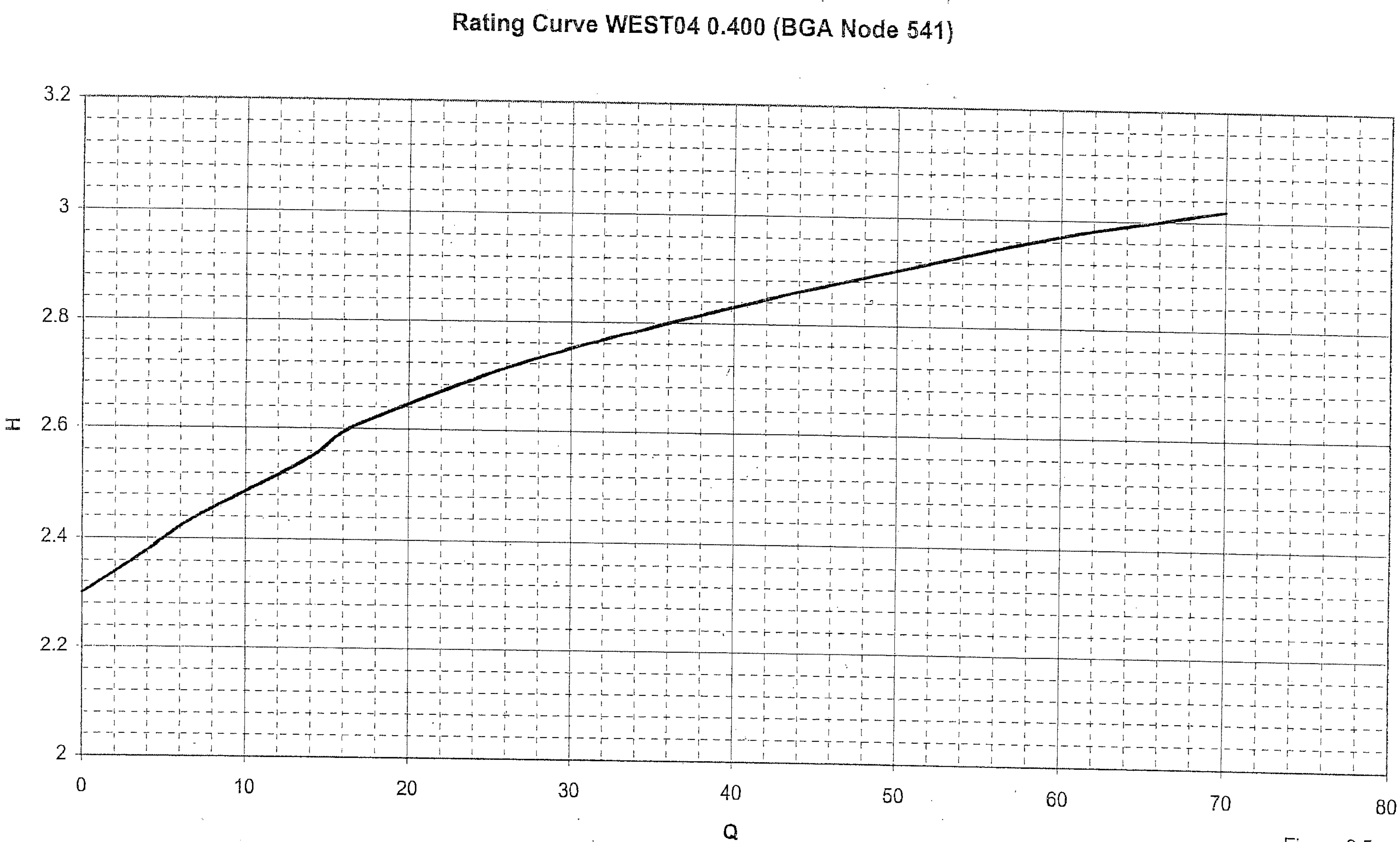

Rating Curve WEST04 0.400 (BGA Node 541)
3.2
3
2.8
2.6
2.4
2.2
2
H
0
10
20
30
40
50
60
70
80
Q

Figure 6.5

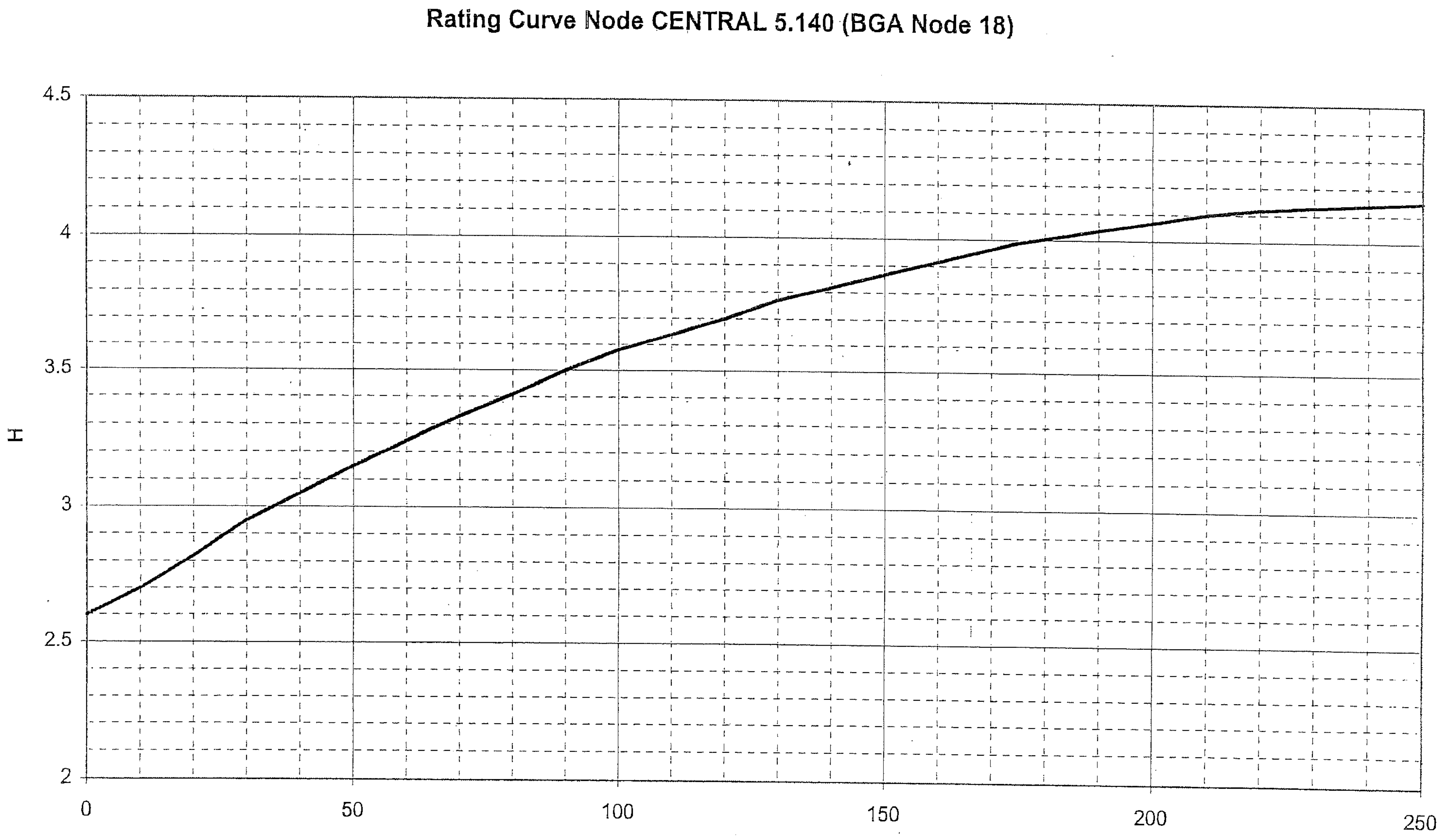

Rating Curve Node CENTRAL 5.140 (BGA Node 18)
H
4.5
4
3.5
3
2.5
2
0
50
100
150
200
250
Q

Figure 6.6

Lower Mountain Road

- Watercourse works as described for Option 2 in GHD stormwater strategy for the catchment. This option involves the provision of a linear pond with a 61m wide bed and depth of 1m to 2m. Details are contained in Appendix H;
- Utilisation of natural detention area upstream of Lower Mountain Road.

Fairway Drive

- The existing drainage strategy adopted for this catchment is one which requires on-site attenuation;
- Cardno and Davies (now CMBK) proposed a grassed overland flow path between Nissen Street and the boundary of the Diamond Creek Estate. Downstream of the Diamond Creek estate, the report recommended that the existing waterway downstream of the Diamond Creek estate be replaced with a grassed lined channel with a bottom width of 6m;
- Given the environmental significance of the area upstream of Maryborough – Urangan Road, and a reluctance to disturb or destroy the existing vegetation in this area, the existing waterway downstream of the Diamond Creek Estate has been analysed without modification;
- The ultimate analysis includes the proposed diversion channel downstream of Nissen Street. The diversion channel is a channel from the new Southern Nissen Street crossing which rejoins the main channel approximately 500 metres downstream of Nissen Street. This channel has been based on the proposal detailed in the CMBK report, 1997. Details of the channel are contained in Appendix H and are described as follows:
    - Downstream of Nissen Street the existing bed level is lowered from a storage area/channel approximately 100 metres wide which extends at this width a length of approximately 200 metres downstream. A channel with bed width 30 metres continues from this point to rejoin the main channel approximately 370 metres downstream of Nissen Street;
    - Two lateral channels with 10 metres and 19 metres top widths, and maximum bed levels of 7.0m AHD and 6.6m AHD respectively link the storage area to the main channel of Eli Creek. The narrower channel is immediately downstream of Nissen Street. The wider channel is located in the next area of thin vegetation approximately 120 metres downstream of Nissen Street.
- The diversion channel works were not incorporated in the existing analysis;
- The existing main channel between Nissen Street, Maryborough-Urangan Road has not been modified;
- The ultimate analysis adopts the same waterway in the tributaries as is for existing conditions;
- At Nissen Street, Cardno and Davies proposed 3 / 2.4m x 0.9m RCBCs under the road into the creek's southern flow path. This was not consistent with Option 3 proposed by Connell Wagner to Council in the draft report "Nissen Street Catchment – Hervey Bay Preliminary Detention Basin Design" which proposed 2 / 1.2m x 0.6m RCBCs. JWP found that with the proposed filling within the floodplain for Diamond Creek Estate, Nissen Street does not have Q10 flood immunity with 2 / 1.2m x 0.6m RCBCs proposed by Connell Wagner. Q10 flood immunity was achieved with 3 / 2.4m x 0.9m RCBCs consistent with the proposal by Cardno and Davies if the culvert invert level was RL 6.5. In order to achieve Q10 immunity with the culvert invert at the existing surface level, RL 7.1 downstream of Nissen Street, then 5 / 2.7 x 0.6 RCBCs are required.
- 5 / 2.7 x 0.6 RCBCs were adopted for both the existing and ultimate analyses.
- The impact of the planned distributor road between Hervey Bay – Maryborough Road and Main Road was hydraulically assessed using the model. The proposed road included partial filling of existing detention basins within the Nissen Street catchment. The planned road formation was found to have no adverse impact on flood levels or peak discharges owing to the limited size of the basin and the presence of weir number 56 which acted as a hydraulic control for upstream levels.

Point Vernon

- The Point Vernon sub-catchment does not discharge into the Eli Waters Estate and consequently is not restricted by downstream constraints.

Islander Road West

- This catchment was analysed using XP-UDD, and is discussed in Appendix A.

Grinstead Road

- Link channels were modelled for existing catchment condition between the northern and southern flowpaths. The link channels were removed for the ultimate analysis;
- MIKE-11 model of ultimate development conditions included floodplain filling which will be required as development proceeds. The waterway width was assumed to be restricted to 90m in the main channel and south-west tributaries, and 40m on WEST01, WEST02 and WEST03.
- In order to achieve flood levels consistent with existing development at Anson's Road, the fully developed model has included a channel from the Eli Waters canal to Anson's Road. The channel will involve excavation to RL 1.5 and provision of a waterway width of 150m. The channel will be revegetated and contain a linear wetland to accommodate low flow drainage. Details of the channel are contained in Appendix H.

Eli Waters

- The Eli Waters hydraulic configuration may change as subsequent approvals and works proceed. Therefore, the proposed lake system could not be reliably analysed;
- Instead, rating curves were developed for the nodes upstream of the development. This is discussed in Section 6.8.5.

Tooth Street

- As there are no drainage strategies for the Tooth Street catchment, both existing and fully developed catchment scenarios were analysed;
- The Tooth Street catchment was analysed as part of the XP-UDD analysis of Islander Road. Therefore, this waterway was not included in the MIKE-11 model;
- Hydrographs and flows from the XP-UDD analysis of the Islander Road West catchment were input to a backwater model to size appropriate drainage infrastructure;
- The Tooth Street drainage strategy is discussed in Appendix F.

Condor Lake

- There is no drainage strategy for the Condor Lakes sub-catchment and both existing and developed flows were analysed.

In general, road crossings were not altered from existing conditions and new or proposed roads were not included in the analysis of the existing and ultimate catchments. New road crossings are discussed in Section 9.

6.8.7 Flood Performance

The flood flows and flood levels quoted in this section are for the condition where the water level in the ocean is RL 1.0. Analysis of higher ocean levels will increase flood levels near the outlet and decrease flow because of higher tailwater conditions. Eli Creek is tidal and start levels influence flood flows and flood levels from the upstream catchment. This is discussed in Section 6.8.5.

6.8.7.1 Grinstead Road

Flood flows and levels at various locations are given in Table 6.6 below.

Location (MIKE-11 Reference)	Existing Flood Level / Flood Flow (m, AHD) (m^3/s)	Ultimate Flood Level / Flood Flow (m, AHD) (m^3/s)
Upstream Grinstead Road (NTHWEST 2.181 / 2.206)	3.14 / 5.1	3.22 / 9.3
Upstream of Greensill's Road (NTHWEST 1.203 / 1.222)	3.69 / 2.8	3.95 / 4.9
Upstream of Anson's Road (NTHWEST 0.181 / 0.343)	3.96 / 0.8	4.18 / 2.2

Table 6.6: Grinstead Road

The outflow for ultimate catchment conditions is calculated to be approximately 50% of what was calculated by WBM in the Eli Waters EIS (refer Table 2.2).

The depth of inundation is shallow, being less than 0.4m for existing conditions over most of the floodplain. The increase due to restriction of the waterway and catchment urbanisation is in the vicinity of 0.1 to 0.3m.

There was a significant effect on water levels elsewhere in the catchment as a result of urbanisation and waterway constriction.

In general, overland flow paths have not been excavated into the existing ground along the channel sections. This is due to the following:

- The likelihood and presence of acid sulphate soils;
- Obtaining an outlet into Eli Waters.

It was, however, necessary to undertake channel excavation works along the proposed open channel section downstream of Ansons Road which extends through to Eli Waters Estate. These excavation works were necessary owing to the need to reduce flood levels in the area to minimise inundation to existing properties. This aspect is discussed in further detail in Section 6 of this report.

The slope of the channels is flatter than current Council design standards with slopes of 1 in 2,500 being used for channels WEST02 and WEST04. The available contour information suggests that the topography falls away from the main watercourse to pond north of Hervey Bay – Burrum Heads Road. There is no outlet to this surface flow and it is likely that this area remains wet for a long period after heavy rain.

Table 6.7 is provided to indicate the changes to hydrographic conditions as a result of urbanisation and waterway modification.

Location	MIKE-11 Reference	Existing Flood Level (m, AHD)	Ultimate Flood Level (m, AHD)
Downstream Burrum Heads Road	WEST01 0.934 STHWEST 1.528 WEST02 0.16 WEST03 0.153	4.38m 4.28m 3.36m 3.19m	5.03m 4.43m 3.56m 3.80m
Downstream Anson's Road	WEST 1.072	3.66m	3.03m

Table 6.7: Grinstead Road Subcatchment Flood Levels

Ultimate flood flows in the WEST branch increased significantly from the existing conditions, ranging from 36.0 m^3/sec to approximately 60 m^3/sec. This flow estimate is similar to that calculated in the Eli Waters EIS. The increase in flow is due primarily to the proposed excavated channel extending from Ansons Road to Eli Waters Estate. In this situation, the channel resulted in the confinement of flows which previously flowed at a lower depth across a much greater floodplain width.

The analysis method adopted for this sub-catchment (MIKE-11) may not be the most suitable form of analysis, especially when analysing existing conditions. In the ultimate state, MIKE-11 is well suited because stormwater is conveyed in distinct channels. In the existing situation, the flow is two-dimensional in nature.

6.8.7.2 Nissen Street

The outflow from Nissen Street under developed catchment conditions is 51.8 m^3 /s. This compares well with CMBK 47.8 m^3/s, and Connell Wagner 47.12 m^3/s. The peak storm duration was found to be the 90 minute event, however both the 90 minute and 2 hour analyses produced similar water levels.

The calculated flood level downstream of Nissen Street was RL 7.95m which is 0.25m higher than that calculated by CMBK. The main reasons for the increase in water level were due to a high 'n' value in the waterway upstream of Maryborough – Urangan Road. A check was subsequently undertaken on the filling levels in the Diamond Creek Estate. While freeboard requirements in this area were reduced, the existing fill levels in the Diamond Creek Estate were found to be adequately located above the 1 in 100 year ARI flood event.

6.8.7.3 Fairway Drive

The flow at Maryborough – Urangan Road for developed catchment conditions is approximately 84m^3 /s and the peak storm duration was calculated to be 120 minutes. This result compares favourably with CMBK, 1997 (refer Table 2.2). The results obtained by both JWP and CMBK are significantly less than the result obtained by WBM/BGA, 1993 (refer Table 3.2).

There is insignificant difference between the peak existing and ultimate flows. Hydrographs at Maryborough-Urangan Road show the effect of development (Figure 6.7).

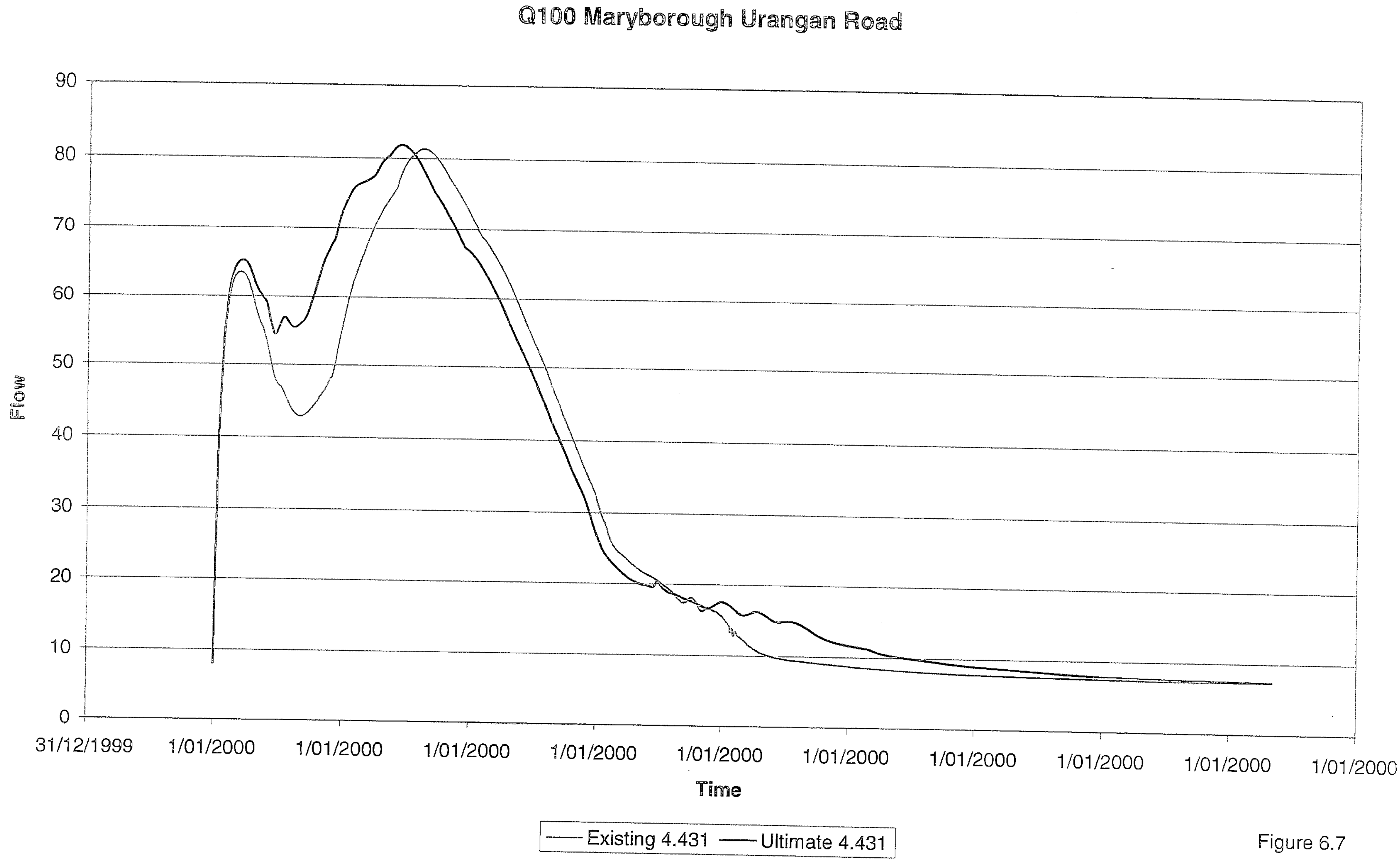

Q100 Maryborough Urangan Road
90
80
70
60
50
40
30
20
10
0
Flow
31/12/1999
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
1/01/2000
Time
Existing 4.431
Ultimate 4.431

Figure 6.7

6.8.7.4 Lower Mountain Road

Flood flows and levels at various locations in the Lower Mountain Road sub-catchment are given below in Table 6.9.

Location	MIKE-11 Reference	Existing Flood Level	Ultimate Flood Level
Upstream Pialba – Burrum Heads Road	Central 4.223	RL 4.42m	RL 4.48 m
	Central 4.265	67 m^3/s	67.0 m^3/s
Downstream Lower Mountain Road	Central 2.235	RL 5.64m	RL 5.64m
	Central 2.414	52 m^3/s	53 m^3/s

Table 6.9: Lower Mountain Road Sub-catchment

The flow at Lower Mountain Road is comparable to the flow calculated by GHD (58 m^3/s) and the water level is lower than the design constraint of 5.7m. The peak storm duration was 360 minutes.

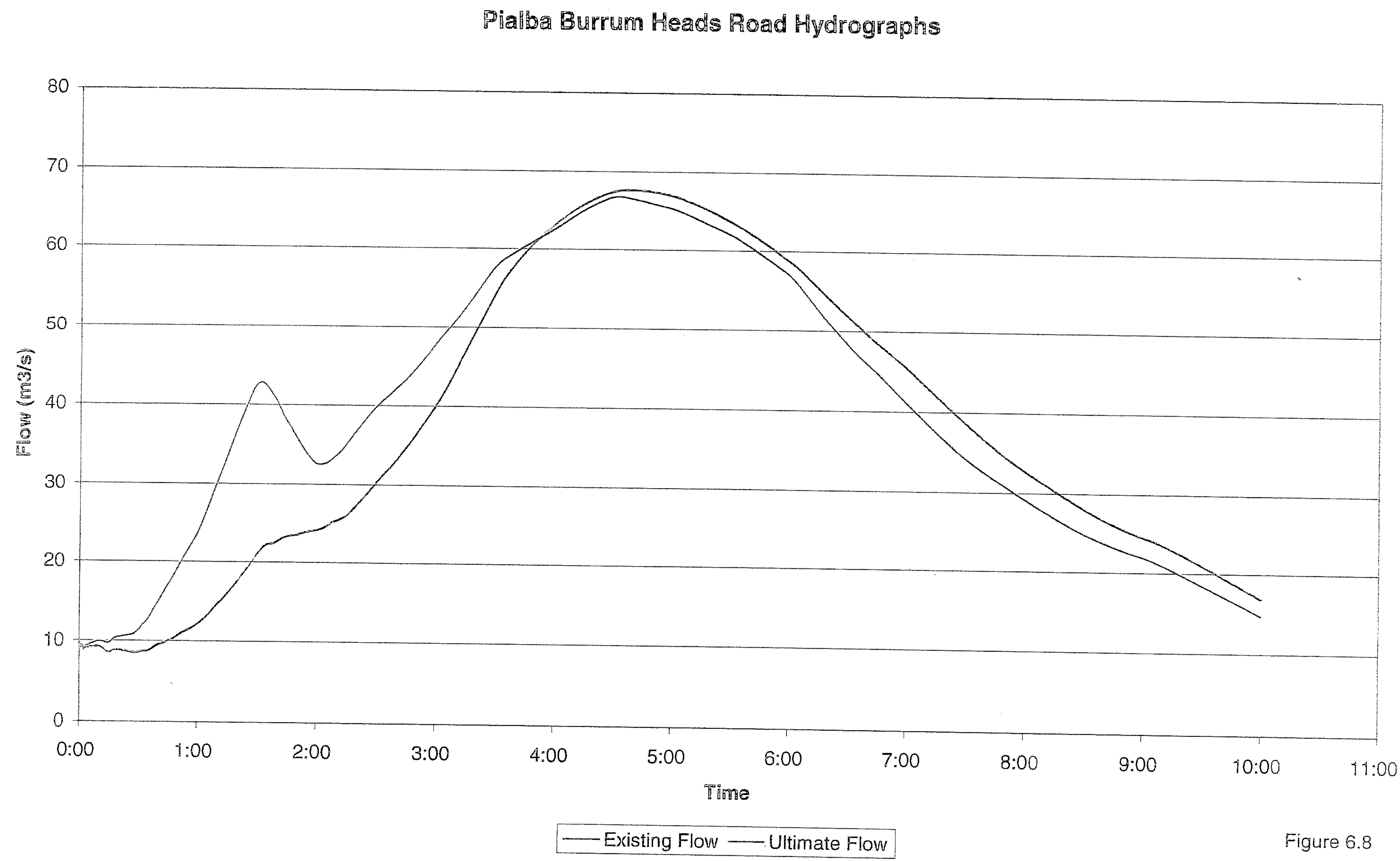
There was insignificant change as a result of development to the flow at Pialba – Burrum Heads Road. Hydrographs for existing and ultimate catchment conditions (360 min) at the road crossing are given in Figure 6.8. This clearly shows two hydrograph peaks. The first, smaller peak is the effect of local development (at about 1.5 hr) and the major peak results from the upstream catchment (4.5 hr).

6.8.7.5 Condor Lake

Condor Lake is a major storage located upstream of Eli Waters. The spillway is of rock gabion construction at a level of RL 2.20 and about 15m long. The level of the earth embankment varies from about RL 2.4 to RL 3.0 at the western edge.

The 100 year water level in Condor Lake was calculated to be RL 4.10m (ultimate condition (CENTRAL 4.936)) and the outflow was calculated at 134m^3/s. The peak storm duration was the 360 minute event. The peak flow is approximately 65% of that calculated by WBM. The peak flood level is approximately 0.01m higher than was previously calculated.

The height of the embankment varies from about 0.2m to 0.6m. Overtopping of the embankment in regular flood events would appear to be common. Failure due to overtopping is a possible occurrence and every endeavour should be made to protect the embankment.


Pialba Burrum Heads Road Hydrographs
80
70
60
50
40
30
20
10
0
Flow (m3/s)
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
Time
Existing Flow
Ultimate Flow
Figure 6.8

6.8.7.6 Eli Waters

Immediately downstream of Condor Lake, there is a house with a floor level of RL 4.137. The calculated downstream flood level is RL 3.88 which provides this house with 260mm freeboard from Eli Creek flood flows.

6.9 Road Crossings and Other Infrastructure

6.9.1 General

Figure 6.9 and Table 6.10 show details of existing and proposed infrastructure in the catchment.

Weir No.	MIKE-11 Reference	Description	Size	U/S IL	D/S IL	Weir RL
11	CENTRAL 2.21 and WEIR11	Lower Mountain Road	6/2600 x 600 RCBC	4.49	4.45	5.42
12	WEIR12 0.01 and WEIR12	Lower Mountain Road	3/2100 x 600 RCBC	4.54	4.41	5.62
13	WEST04 0.105 and WEIR13	Pialba – Burrum Heads Rd	3/1500 x 750 RCBC	2.27	2.23	3.78
14	CENTRAL 3.0	Future Internal Road	TBA	TBA	TBA	TBA
15	CENTRAL04 0.25	Future Main Road	TBA	TBA	TBA	TBA
16a	NISS_WR 3.17 and Nissen 3.16	Nissen St Proposed	3/2400 x 900	6.54	6.5	8.20
16b	URRAW_WR 3.17 and Urraween 3.16	Nissen St Existing	2/2100 x 2100	5.78	5.77	8.45
17	NTHWEST 0.206	Unnamed Road ‘A’ West in Grinstead Road	No Culvert	N/A	N/A	3.66
18	NTHWEST 1.22	Future Connector Rd ‘B’	TBA	TBA	TBA	TBA
20	WEST 1.055 and WEIR20	Anson’s Road	2/450 RCP	2.38	2.688	3.17
21	WEST 2.067	Future Connector Rd ‘B’	TBA	TBA	TBA	TBA
22	WEST 2.654	Sempf’s Road	TBA	TBA	TBA	TBA
23	WEST01 0.429 and WEIR23	Dundowran Road	3/2100 x 900 RCBC	6.54	6.53	7.51

Weir No.	MIKE-11 Reference	Description	Size	U/S IL	D/S IL	Weir RL
24	WEST01 0.673 and WEIR24	Hervey Bay – Burrum Heads Road	4/1200 RCP L = 15m	5.555	4.765	6.5
25	STHWEST 1.49 and WEIR25	Hervey Bay – Burrum Heads Road	4/1200 x 600 RCBC	2.6	2.5	4.19
26	STHWEST 1.73 and WEIR26	Greensill Road	2/450 RCP	2.078	2.058	2.79
28	WEST02 0.132 and WEIR28	Hervey Bay – Burrum Heads Road	13/1200 x 750	2.17	2.11	4.21
29	WEST03 0.124 and WEIR29	Hervey Bay – Burrum Heads Road	4/1200 x 600 RCBC	2.4	2.35	4.21
30	CENTRAL01 0.125 and WEIR30	Maryborough – Urangan Road	2100 RCP; L = 16m	17.9	18.758	21.36
31	CENTRAL01 0.427 and WEIR31	Scrub Hill Road	3/2100 x 600 RCBC	12.866	13.031	Estimated RL 15.0
32	NTHWEST 2.21 and WEIR32	Grinstead Rd – Future	TBA	TBA	TBA	TBA
34	STHWEST 2.51	Road Reserve	TBA	TBA	TBA	TBA
36	CENTRAL 4.265 and WEIR36	Hervey Bay – Burrum Heads Road	10/3000 x 1200 RCBC; L = 26m	3.11	3.07	5.06
37	URRAW01 0.08 and WEIR37	Christensen Road	1/375	39.274	39.279	39.75
39	URRAW01 1.201 and WEIR39	Urraween Road	5/450 RCP; L = 6.5m	18.063	17.941	19.01
40	URRAWEEN 4.35 and WEIR40	Maryborough – Urangan Rd	5/3000 x 1500 RCBC; L = 6m	2.947	2.83	5.08
41	URRAW03 0.096 and WEIR41	Urraween Road	1/2100 x 1500	24.303	24.306	26.47

Weir No.	MIKE-11 Reference	Description	Size	U/S IL	D/S IL	Weir RL
42	URRAW02 0.082 and WEIR42	Urraween Road	1/300 (Estimated)	28.3	28.2	28.63
43	URRAW03 0.507 and WEIR43	Nissen Street	2/900 RCP; L = 11m	14.687	14.741	15.77
44	URRAW07 0.22 and WEIR44	Future Crossing	TBA	TBA	TBA	TBA
45	URRAW07 0.054 and WEIR45	Main Street	1/375 RCP; L = 16m	21.473	21.024	22.05
46	URRAW08 0.079 and WEIR46	Future Crossing	TBA	TBA	TBA	TBA
47	URRAW08 0.211 and WEIR 47	Main Street	1/600 RCP; L = 16m	14.006	13.737	14.76
48	URRAW06 1.002 and WEIR48	Main Street	3/1200 x 600 RCBC	16.708	16.676	17.59
50	URRAW06 0.352 and WEIR50	Doolong Road	2/1050 RCP; L = 6m	26.371	26.35	27.7
54	CENTRAL04 and WEIR54	Lower Mountain Road	1/600	4.826	4.694	6.09
55	URRAWEEN 2.736	Control Structure 2 Proposed	5/2400 x 1500	6.83	6.77	9.32
56	URRAWEEN 2.302	Control Structure 3 Proposed	3/2400 x 1200	8.75	8.71	11.65
57	WEST 0.630	Embankment	No Culvert	N/A	N/A	3.17
58	CENTRAL 4.96	Condor Lake	No Culvert	N/A	N/A	2.2
59	BURRUM 0.03	Maryborough – Urangan Rd	6/1350	3.12	3.048	5.4

Weir No.	MIKE-11 Reference	Description	Size	U/S IL	D/S IL	Weir RL
60	URRAWEEN 2.444	Pedestrian Walkway	8/2700 x 1900	8.25	8.21	9.52

Table 6.10: Existing / Proposed Road Crossing Information

File No. 114024TR26_A.WOR

HERVEY BAY CITY COUNCIL

LEGEND

CATCHMENT BOUNDARY
WATERWAYS
DETENTION BASIN/POND
8 ROAD CROSSING

300 0 300 600 900

Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.9

Existing/Proposed
Infrastructure

JWP

John Wilson and Partners Pty. Ltd.
ABN 85 011 022 503
PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

6.9.2 Roadway Immunity

The desired level of service for road crossings in the catchment is generally Q50. The desired level of service for Nissen Street (crossing 16a and 16b) and Scrub Hill Road (crossing 31) is Q10. Q50 and Q10 analyses of the ultimate system have been undertaken and the results are presented below in Table 6.11 and Table 6.12.

The levels of crossings 12, 36, 37, 40, 42, 59 and 60 were verified by ground survey.

From this table, it is apparent that some of the existing road profiles are not capable of conveying Q50 flows from the developed catchment, and will require upgrading. This is discussed in Section 9.

				Q50 Flood Levels		Q50 Flood Flows	
Weir No.	**MIKE-11 Reference**	**Description**	**Weir RL**	**Upstream**	**Downstream**	**Culvert**	**Roadway**
11	CENTRAL 2.21 and WEIR11	Lower Mountain Road	5.42	5.8	5.55	19.2	31.1
12	WEIR12 0.01 and WEIR12	Lower Mountain Road	5.62	5.8	5.8	1.7	-
13	WEST04 0.105 and WEIR13	Pialba – Burrum Heads Rd	3.78	3.98	3.09	11.3	9.2
14	CENTRAL 3.0	Future Internal Road		4.76	4.54		48.1
15	CENTRAL04 0.25	Future Main Road		4.4	4.4		0.7
16a (1)	NISS_WR 3.17 and Nissen 3.16	Nissen St Proposed	8.20	8.39	7.87	20.4	7.0
16b (1)	URRAW_WR 3.17 and Urraween 3.16	Nissen St Existing	8.45	8.39	8.07	20.9	0.5
17	NTHWEST 0.206	Anson's Road	3.66	4.13	4.13		1.9
18	NTHWEST 1.22	Greensill's Road	TBA	3.9	3.88		4.3
20	WEST 1.055 and WEIR20	Anson's Road Downstream of Akarra Lagoons	3.17	3.44	2.93	0.5	12.4
21	WEST 2.067	Future Connector Rd 'B'		2.92	2.92		27.0
22	WEST 2.654	Sempf's Road		2.88	2.88		39.4
23	WEST01 0.429 and WEIR23	Dundowran Road	7.51	7.73	7.25	12.3	1.0

				Q50 Flood Levels		Q50 Flood Flows	
Weir No.	**MIKE-11 Reference**	**Description**	**Weir RL**	**Upstream**	**Downstream**	**Culvert**	**Roadway**
24	WEST01 0.673 and WEIR24	Hervey Bay – Burrum Heads Road	6.5	6.85	5.39	8.1	6.4
25	STHWEST 1.49 and WEIR25	Hervey Bay – Burrum Heads Road	4.19	4.41	4.4	3.5	13.8
26	STHWEST 1.73 and WEIR26	Greensill Road	2.79	4.31	4.31	0	14.7
28	WEST02 0.132 and WEIR28	Hervey Bay – Burrum Heads Road	4.21	3.58	3.56	5.0	0
29	WEST03 0.124 and WEIR29	Hervey Bay – Burrum Heads Road	4.21	3.81	3.74	2.7	0
30	CENTRAL01 0.125 and WEIR30	Maryborough – Urangan Road	21.36	21.43	18.84	12.8	1.2
31 (1)	CENTRAL01 0.427 and WEIR31	Scrub Hill Road	15	14.82	14.6	7.7	15.3
32	NTHWEST 2.21 and WEIR32	Grinstead Rd – Future	TBA	3.2	2.87	8.2	0
34	STHWEST 2.51	Road Reserve	TBA	4.28	4.28		14.2
36	CENTRAL 4.265 and WEIR36	Hervey Bay – Burrum Heads Road	5.06	4.33	4.19	56.8	0
37	URRAW01 0.08 and WEIR37	Christensen Road	39.75	40.58	39.32	0.3	6.4
39	URRAW01 1.201 and WEIR39	Urraween Road	19.01	19.34	17.66	2.3	12.4
40	URRAWEEN 4.35 and WEIR40	Maryborough – Urangan Rd	5.08	5.11	4.54	64.5	0.3

				Q50 Flood Levels		Q50 Flood Flows	
Weir No.	**MIKE-11 Reference**	**Description**	**Weir RL**	**Upstream**	**Downstream**	**Culvert**	**Roadway**
41	URRAW03 0.096 and WEIR41	Urraween Road	26.47	26.53	24.9	9.6	0.2
42	URRAW02 0.082 and WEIR42	Urraweeb Road	28.63	29.74	27.5	0.2	1.6
43	URRAW03 0.507 and WEIR43	Nissen Street	15.77	16.25	14.86	3.5	9.15
44	URRAW07 0.22 and WEIR44	Future Crossing	TBA	17.21	16.32	2.4	0
45	URRAW07 0.054 and WEIR45	Main Street	22.05	22.28	20.67	0.2	1.2
46	URRAW08 0.079 and WEIR46	Future Crossing	TBA	14.96	14.96	5.9	3.2
47	URRAW08 0.211 and WEIR 47	Main Street	14.76	14.96	13.51	0.6	3.6
48	URRAW06 1.002 and WEIR48	Main Street	17.59	18.21	18.07	3.3	18.0
50	URRAW06 0.352 and WEIR50	Doolong Road	27.7	28.23	27.2	5.7	7.0
54	CENTRAL04 and WEIR54	Lower Mountain Road	6.09	5.8	4.84	0.6	0
55	URRAWEEN 2.736	Control Structure 2	9.32	8.76	8.55	35	0
56	URRAWEEN 2.302	Control Structure 3	11.65	11.31	9.38	32.8	
57	WEST 0.630	Embankment	3.17				5.5
58	CENTRAL 4.96	Condor Lake	2.2				119.0

				Q50 Flood Levels		Q50 Flood Flows	
Weir No.	**MIKE-11 Reference**	**Description**	**Weir RL**	**Upstream**	**Downstream**	**Culvert**	**Roadway**
59	BURRUM 0.03	Maryborough – Urangan Rd	5.4	5.16	4.75	20.2	0
60	URRAWEEN 2.444	Pedestrian Walkway	9.52	9.17	8.89	32.8	0

Note: (1) Road requires Q10 immunity

Existing road crossings requiring upgrades

Table 6.11: Road Immunity Details, Q50

				Q10 Flood Levels		Q10 Flood Flows	
Weir No.	**MIKE-11 Reference**	**Description**	**Weir RL**	**Upstream**	**Downstream**	**Culvert**	**Roadway**
16a	NISS.WR 3.17 and NISSEN 3.16	Nissen Street Proposed	8.2	8.18	7.7	16.5	0
16b	URRAW_WR 3.17 and Urraween 3.16	Nissen Street Existing	8.45	8.18	7.93	17.5	0
31	CENTRALOI 0.427 and WEIR31	Scrub Hill Road	15	14.67	14.41	7.4	0

Table 6.12 Road Immunity Details, Q10

6.10 Property Flooding

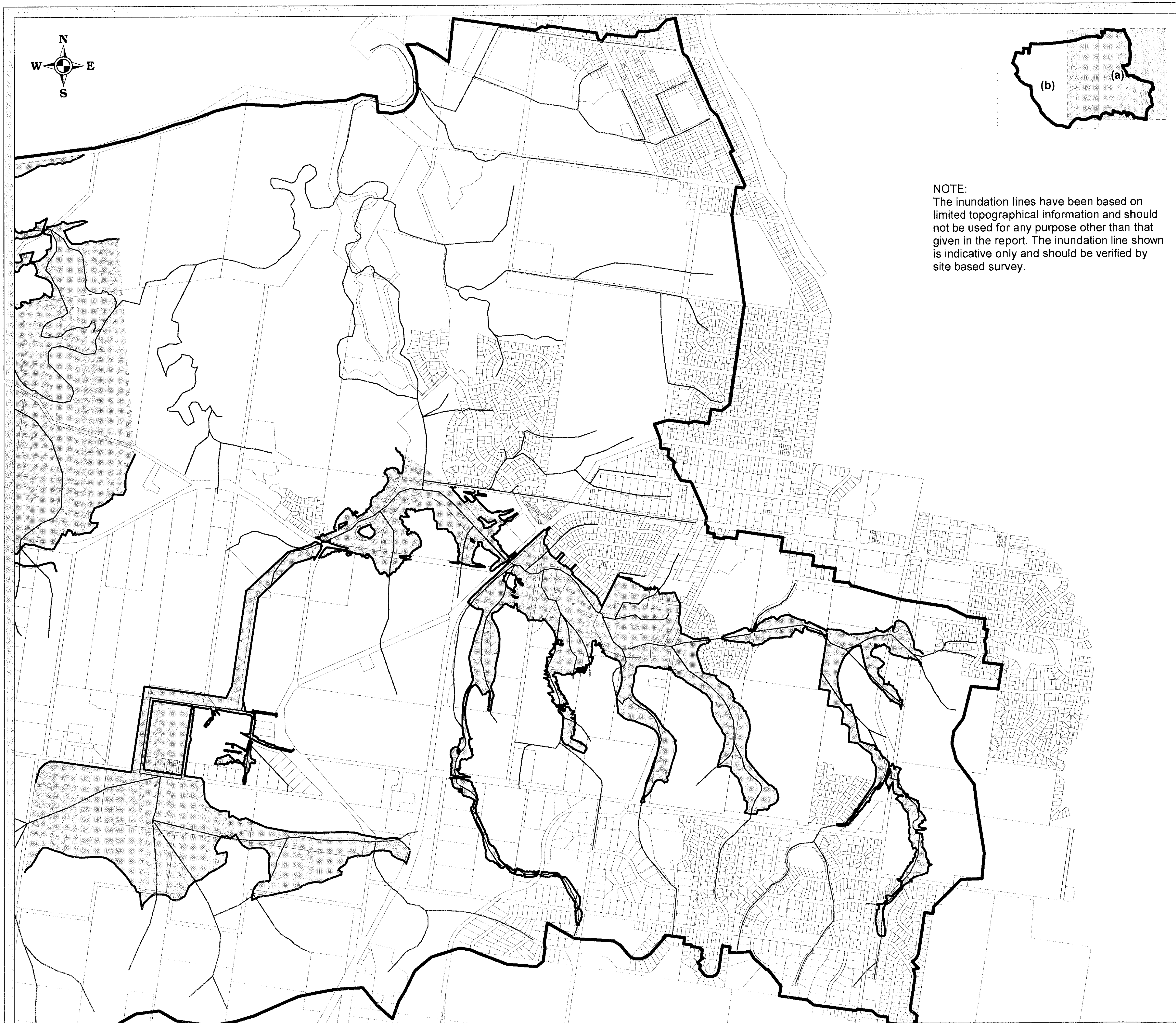
The calculated flood level upstream of Nissen Street is RL 8.48m and the flood level calculated by CMBK is 8.38m. Flood levels downstream of Nissen Street calculated by CMBK are 7.70m and by JWP are 7.95m, and upstream of Maryborough – Urangan Road are 5.24 (CMBK) and 5.3 (JWP). Ground survey of properties was undertaken to verify that existing properties in these areas have sufficient flood immunity. The inundation boundary incorporates this information and properties do not seem to be affected by flooding.

As there is a significant difference in flood levels downstream of Nissen Street, fill levels within the Diamond Creek Estate have been assessed and have been discussed previously in Section 6.8.7.2.

6.11 Inundation Plans

The inundation of the catchment due to Q100 flooding is given on Figure 6.10. The inundation boundary is shown for existing conditions. The inundation line is based on limited topographical information and should not be used for any other purpose than that given in the report. The inundation line shown is indicative only.

File No. 114024TR37_A.WOR



HERVEY BAY CITY COUNCIL

LEGEND

TOTAL CATCHMENT
WATERWAYS
Q100 EXISTING INUNDATION LINE

200 0 200 400 600
Metres
Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.10 (a)

Q100 Existing Catchment
Flood Inundation Plan.
Ocean Water Level 1.00

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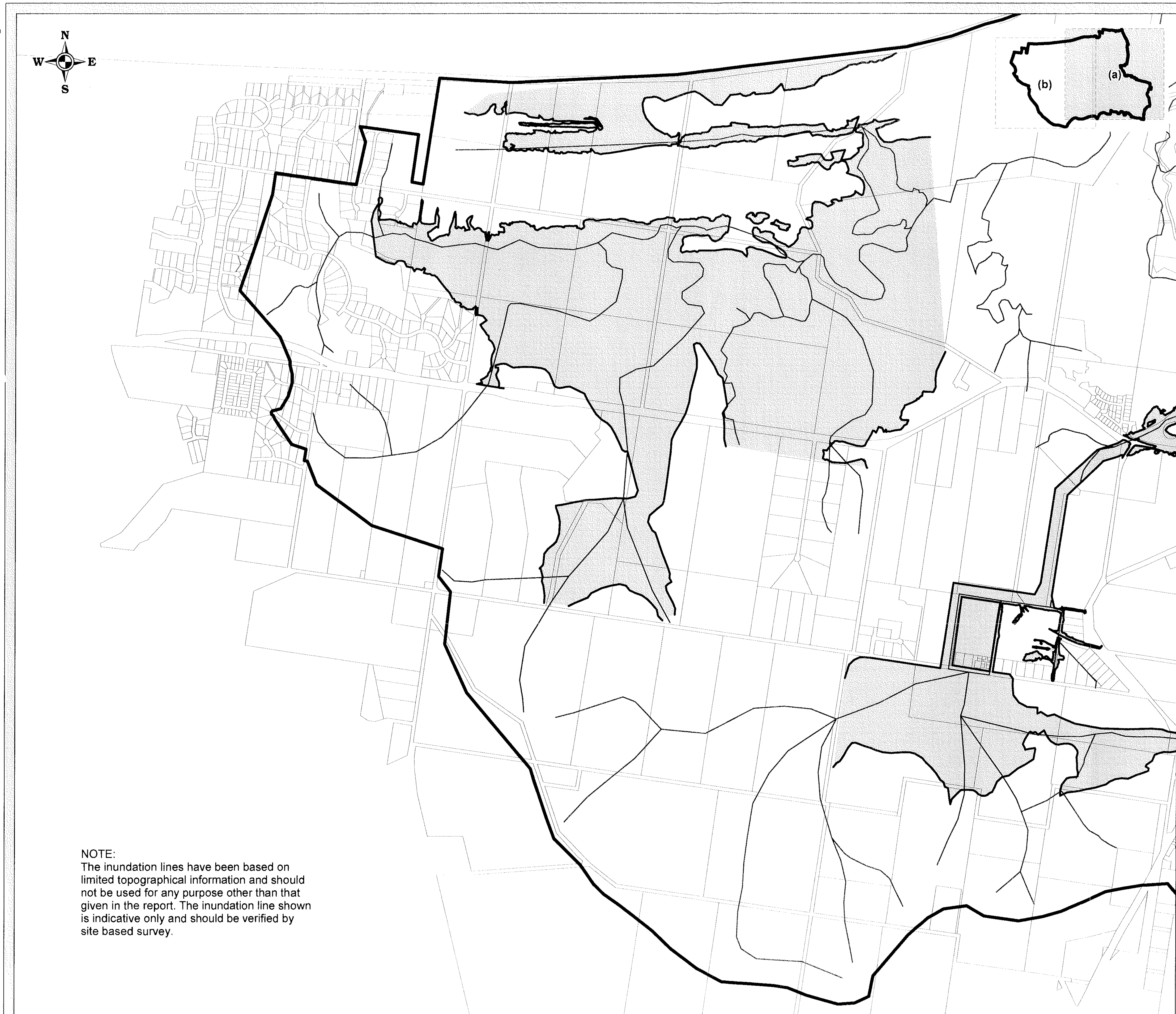
File No. 114024TR38_A.WOR



NOTE:
The inundation lines have been based on limited topographical information and should not be used for any purpose other than that given in the report. The inundation line shown is indicative only and should be verified by site based survey.

HERVEY BAY CITY COUNCIL

LEGEND

- TOTAL CATCHMENT
- WATERWAYS
- Q100 EXISTING INUNDATION LINE

200 0 200 400 600
Metres
Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 6.10 (b)

Q100 Existing Catchment
Flood Inundation Plan.
Ocean Water Level 1.00

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7 Water Quality Management

7.1 Overview

The waters of Eli Creek are protected under Environmental Protection Legislation, particularly the Environmental Protection (Water) Policy. The purpose of the policy is to *"protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future in a way that maintains the ecological processes on which life depends (ie ecological sustainability)"*.

This section of the report discusses the management of water quality in the catchment and describes the parameters addressed as part of the overall environmental planning component of this report.

7.2 Environmental Values

The EPP (Water) lists potential environmental values relevant to this catchment as follows:

- Biological integrity of a modified aquatic ecosystem
- Suitability for recreational use
- Suitability for minimal treatment before supply as drinking water
- Suitability for agricultural use
- Suitability for industrial / commercial use.

Environmental values were derived by community consultation and consultation with Council Officers. In the consultation process, questions were asked that were directly related to specific environmental values consistent with the EPP (Water). The outcome of the consultation process is shown on Figure 7.1 and the main values are:

- The value of a modified aquatic ecosystem
- The ability to support associated wildlife and protection of wildlife habitat
- Primary contact recreation
- Secondary contact recreation
- Visual recreational use of the water
- Cultural heritage
- Stock watering
- Suitability for industrial / commercial use (irrigation).

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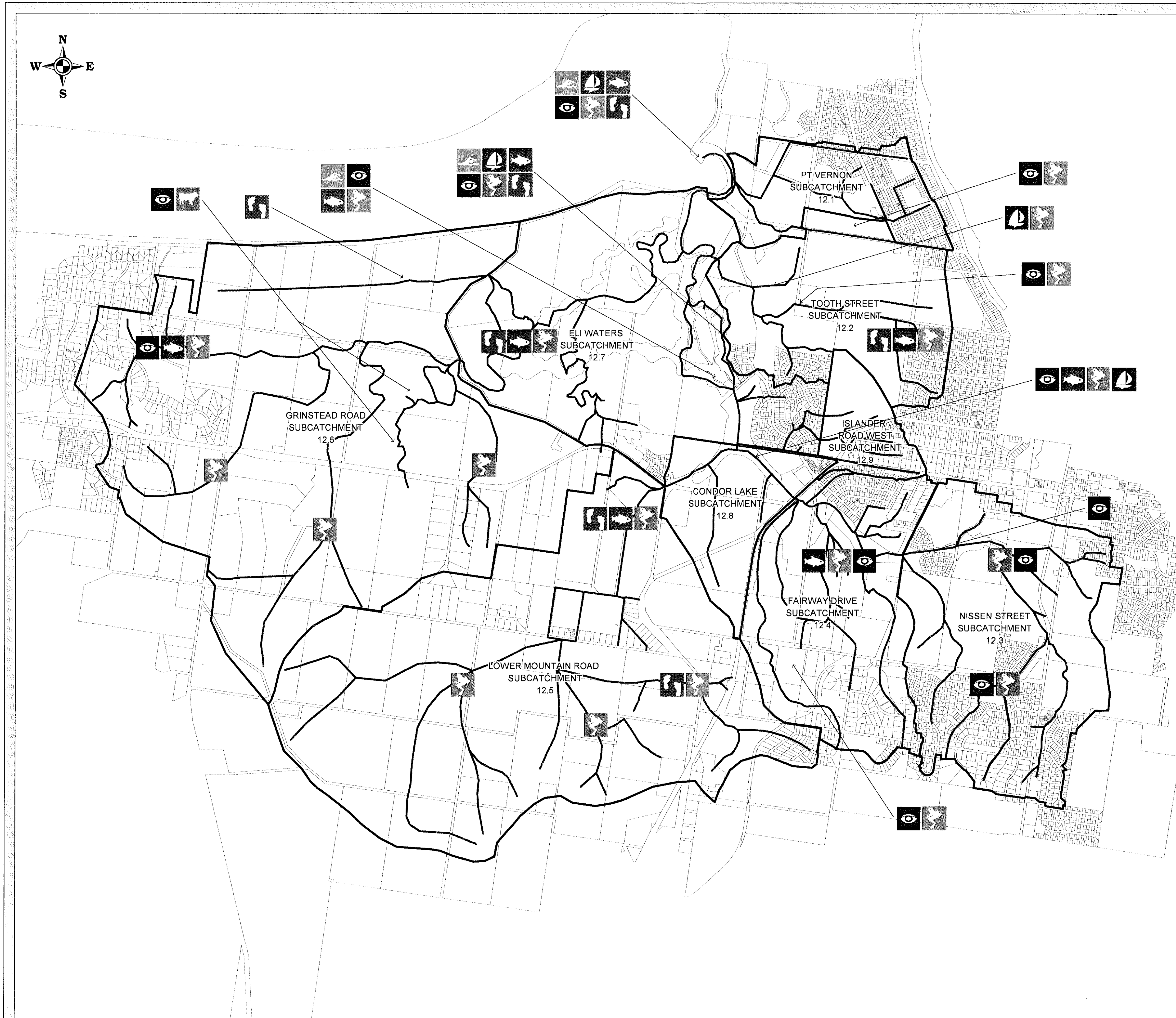

HERVEY BAY CITY COUNCIL

LEGEND

- Visual Recreation
- Primary Recreation
- Secondary Recreation
- Aquatic Ecosystems
- Wildlife Habitat
- Cultural Heritage
- Stock Water

300 0 300 600 900

Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 7.1

Environmental Values

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7.3 Water Quality Monitoring Data

A limited amount of water quality monitoring results are available, some dating back to 1992. Wide Bay Water undertakes monthly sampling in Eli Creek upstream and downstream of the sewage outfall and data has been collected on a monthly basis since May 2000. Monitoring data is given in Table 7.1. The location of the monitoring sites is given on Figure 7.2.

The results in the tidal range (Sites A – H) for TN and TP indicate that there is a substantial variation in pollutant concentration depending on tidal conditions.

Concentrations of TN and TP are recorded generally as substantially higher during a low tide.

The results obtained by Wide Bay Water provide a snapshot of water quality at a particular time. There are variables which effect the readings, which are difficult to quantify, such as:

- Tide level
- Effluent discharge flow
- Stormwater flow
- Catchment activities.

Nonetheless, the results show that the median TN and TP concentrations upstream and downstream of the outfall are comparable. SS is higher downstream, however this may be a result of activities other than the treatment plant.

Location	date	TN	TP	SS	note	Source
		(mg/L)	(mg/L)	(mg/L)		
A	29/10/92	0.11	0.01	2	high tide	Eli Waters EIS site 0, page 43
B	30/07/92	1.5	0.65		low tide	Eli Waters EIS site 1, page 43
	30/07/92	0.02	0.04		high tide	
	29/10/92	2.3	0.49	1	low tide	
	29/10/92	0.11	0.02	3	high tide	
(Median Value)		0.805	0.265	2		
C	30/07/92	6.2	1.2		low tide	Eli Waters EIS site 2, page 43
	30/07/92	1.2	0.45		high tide	
	29/10/92	2.3	0.45	2	low tide	
	29/10/92	2.7	0.59	4	high tide	
		2.5	0.52	3		
D						
E	30/07/92	1.3	0.28		low tide	Eli Waters EIS site 4, page 43
	30/07/92	0.75	0.23		high tide	
	29/10/92	1.5	0.24	4	low tide	
	29/10/92	0.18	0.03	4	high tide	
		1.025	0.235	4		
F						
G	29/10/92	0.9	0.17	15	low tide	Eli Waters EIS site 6, page 43
	29/10/92	0.37	0.08	12	high tide	
		0.635	0.125	13.5		
		0.635	0.125	13.5		
H	29/10/92	1	0.1	3	low tide	Eli Waters EIS site 7, page 43
	29/10/92	0.41	0.08	12	high tide	
		0.705	0.09	7.5		
I	14/05/92	1.53	0.18	9	following rain	Eli Waters EIS surface inflow 1, page 45
J	14/05/92	1.52	0.13	42	following rain	Eli Waters EIS surface inflow 2, page 45
K	14/05/92	1.12	0.06	59	following rain	Eli Waters EIS surface inflow 3, page 45
	29/10/92	4.8	0.35	106	following dry	
		2.96	0.205	82.5		
L	14/05/92	1.4	0.1	72	following rain	Eli Waters EIS surface inflow 4, page 45
	29/10/92	0.81	0.01	23	following dry	
		1.105	0.055	47.5		
M	24/04/01	0.432	0.21	101		BGA - water quality monitoring - 1
N	24/04/01	0.426	<0.02	132		BGA - water quality monitoring - 2
O	24/04/01	0.477	<0.02	97		BGA - water quality monitoring - 3
P	24/04/01	0.869	0.072	81		BGA - water quality monitoring - 4
Q	24/04/01	0.417	<0.02	82		BGA - water quality monitoring - 5
R	31/05/00	0.643	0.1	43	No. 2,000,000,871	Wide Bay Water- E-Disch- Up
	16/06/00	0.769	0.098	31	No. 2,000,000,953	
	21/06/00	0.539	0.043	55	No. 2,000,000,985	
	12/07/00	0.183	<0.002	57	No. 2,000,001,108	
	23/08/00	0.314	0.029	73	No. 2,000,001,366	
	13/09/00	0.378	0.033	41	No. 2,000,001,511	
	17/10/00	0.505	0.006	68	No. 2,001,718	

Location	date	TN	TP	SS	note	Source
	15/11/00	0.446	0.013	70	No. 2,001,861	
	13/12/00	0.152	<0.002	98	No. 2,002,065	
	10/01/01	0.248	<0.002	112	No. 2,100,069	
	7/02/01	0.35	<0.002	27	No. 2,100,259	
	7/03/01	0.163	<0.002	66	No. 2,100,426	
	4/04/01	0.141	<0.02	119	No. 2,100,616	
	2/05/01	0.283	<0.02	112	No. 2,100,822	
	4/07/01	0.257	<0.02	101	No. 2,100,325	
	30/07/01	0.445	0.021	191	No. 2,100,501	
		0.332	<0.02	69		
S	31/05/00	1.96	0.486	78	No. 2,000,000,872	Wide Bay Water-E-Disch-Down
	16/06/00	1.78	0.38	40	No. 2,000,000,954	
	21/06/00	0.685	0.081	51	No. 2,000,000,986	
	12/07/00	0.193	<0.002	55	No. 2,000,001,109	
	23/08/00	0.29	0.021	70	No. 2,000,001,367	
	13/09/00	0.361	0.024	50	No. 2,000,001,512	
	17/10/00	0.493	0.018	92	No. 2,001,719	
	15/11/00	0.424	0.007	95	No. 2,001,862	
	13/12/00	0.156	<0.002	98	No. 2,002,066	
	10/01/01	0.252	<0.002	95	No. 2,100,070	
	7/02/01	0.177	<0.002	24	No. 2,100,260	
	7/03/01	0.247	<0.002	117	No. 2,100,427	
	4/04/01	0.18	<0.02	96	No. 2,100,617	
	2/05/01	0.235	<0.02	95	No. 2,100,823	
	4/07/01	0.201	<0.02	128	No. 2,101,326	
	30/07/01	0.197	<0.02	195	No. 2,101,502	
		0.25	<0.02	93.5		
T	15/08/00	0.765	0.103		No. 2,000,001,296	Wide Bay Water - Eli Ck Ret Outlet

Table 7.1: **Water Quality Monitoring Data**

File No. 114024TR14_A.WOR

HERVEY BAY CITY COUNCIL

LEGEND

- CATCHMENT BOUNDARY
- WATERWAYS
- ★ WATER QUALITY SAMPLE LOCATIONS

300 0 300 600 900
Metres

Scale: 1:30,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 7.2

Water Quality
Sample Locations

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7.4 Water Quality Objectives

Section 8(2) of the EPP(Water) states three types of documents that are to be used to decide the water quality objectives of a catchment:-

- Site specific documents;
- AWQ guidelines
- Documents published by a recognised entity

There are several aspects to establishing water quality objectives (WQO's) that should be noted:-

- WQO's are long term goals for water quality management
- WQO's may not be achievable immediately
- WQO's may no longer be attainable in some waters without disproportionate cost; and
- WQO's may be modified by the community by balancing costs and benefits

It is also important to note that the legislation requires "consideration" of water quality objectives (and environmental values) along with other standard criteria. It does not state that the objectives must be achieved.

7.4.1 Site Specific Documents

There are no site specific documents that specifically address water quality objectives in the catchment. A limited amount of monitoring has been undertaken, however this monitoring has not been linked with ecological health or water quality objectives. Understanding the ecological health of the waterways is important because when combined with appropriate water quality monitoring programs, pollutant thresholds and water quality objectives can be justified on a site specific basis. The ecological health of the waterways should be established and consideration should be given to an appropriate monitoring program.

7.4.2 Protection of Aquatic Ecosystems

The water quality objectives considered for the Protection of Aquatic ecosystems were referenced from National, State and Local Government publications. In addition, water quality objectives set elsewhere in South-East Queensland were considered.

7.4.2.1 ANZECC (1992)

The ANZECC (1992) guidelines specify the following pollutant concentration ranges for the protection of a modified Aquatic Ecosystem.

Location	Indicative Concentration		
	TN	TP	SS
General waterway tributaries	100 – 750 µg/L	10 – 100 µg/L	<10% seasonal change plus optical guidelines
Lakes and Reservoirs	100 – 500 µg/L	5 – 50 µg/L	-
Estuarine	NO_3-N 10 - 100 µg/L NH_4-N < 5 µg/L	PO_4-P 5 – 15 µg/L	-

Table 7.2: Protection of Aquatic Ecosystem (ANZECC 1992)

The range of values in Table 7.2 are believed to be either the 20%ile or 80%ile depending on the level of protection required for a particular ecosystem type..

7.4.2.2 Brisbane City Council

The Brisbane City Council references the Draft Queensland water quality guidelines which state that the median pollutant concentrations for the protection of aquatic ecosystems are:-

Pollutant	Median Concentration Ranges
Total P	70 µg/L
Total N	650 µg/L
SS	15 mg/l

Table 7.3: Protection of Aquatic Ecosystems (BCC, 2000)

These values were adopted by the Brisbane City Council for catchments with similar environmental values and are described as Set A Environmental Objectives.

7.4.2.3 ANZECC (2000)

The 1992 guidelines were revised in ANZECC Water Quality Guidelines (2000).

The recommended water quality targets outlined in this document are provided as *guidelines* and are not to be regarded as standards. Australia and New Zealand contain a vast range of aquatic environments and ecosystem types, and in varying degrees of health, which requires a flexible approach to setting water quality objectives.

These revised guidelines have adopted an ecosystem issue and risk based approach, in which the focus is on the appropriate stresses potentially impacting on a designated ecosystem.

The approach comprises the use of data obtained from a reference location which is close to the type and level of protection (state or condition) desired for the system under consideration.

Six ecosystem classifications are given in the document in recognition of the diverse range of ecosystem types in Australia. These are:-

- freshwaters (flowing)
  - upland rivers and streams
  - lowland rivers
- freshwaters (standing)
  - lakes and reservoirs
  - wetlands
- estuarine
  - open (drowned river valley)
  - closed (barrier bars or islands)
  - deltaic
- coastal and marine
  - barrier lagoons or embayments
  - open coasts

The guidelines specify different water quality objectives for each different classifications.

Three levels of ecosystem protection have been adopted. These are:-

1. *High conservation/ecological value systems.* Pristine or other highly-valued ecosystems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations.

2. *Slightly to moderately disturbed systems.* Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation and marine systems would have largely intact habitats and associated biological communities.

3. *Highly disturbed systems.* These are measurably degraded ecosystems of lower ecological value.

The third ecosystem condition recognises that degraded aquatic ecosystems still retain, or after rehabilitation may have, ecological or conservation values, but for practical reasons it may not be feasible to return them to a slightly to moderately disturbed condition.

A level of protection is a *level of acceptable change* from a defined reference condition. Where appropriate, the reference condition would be defined from as many reference sites as practicable and could correspond to one of the three recognised condition levels described above.

Water quality objectives for slightly to moderately disturbed systems are given in the table below. The values are presented as trigger levels and the pollutant concentration is compared to this data to determine the level of risk. Low risk concentrations are less than the trigger levels and high risk concentrations exceed the trigger levels. It is noted that the values in the table below represent the 80%ile pollutant concentrations measured at reference sites as discussed in Section 9 of the guidelines.

The default trigger levels in Table 7.4 below may be used where either an appropriate reference system is not available, or the scale of the operation makes it difficult to justify the allocation of resources to collect the necessary information on a reference system.

Ecosystem Type	TP (µg/L)	TN (µg/L)	Key ecosystem-specific factors
Lowland river	50	500	light climate (turbidity) flow grazing bioavailable nutrient concentration
Upland river	30	250	light climate substrate type bioavailable nutrient concentration grazing
Freshwater lakes and reservoirs	10	350	light climate (turbidity) mixing (stratification) grazing bioavailable nutrient concentration
Wetlands	ND	ND	light climate (turbidity) mixing (stratification) grazing bioavailable nutrient concentration
Estuaries	30	300	light climate (turbidity) mixing (stratification) grazing bioavailable nutrient concentration
Coastal & marine	25	120	bioavailable nutrient concentration grazing

TP = total phosphorus, TN = total nitrogen.

Table 7.4: Default trigger levels for assessing possible risk of adverse effects due to nutrients in different ecosystem types (for slightly to moderately disturbed ecosystems).

7.4.3 Recommendation

Based on the available data, analysis method and other catchment constraints the following water quality objectives are proposed for the protection of modified aquatic ecosystems in the Eli Creek catchment.

Location	**Median Concentrations**		
	TN	**TP**	**SS**
Rivers and Streams	0.65 mg/L	0.07 mg/L	15 mg/L or 90%ile <100 mg/L
Lakes and Reservoirs	0.35mg/L	0.01 mg/L	15 mg/L or 90%ile < 100 mg/L
Estuary	0.3 mg/L	0.03 mg/L	-

Table 7.6: Water Quality Objectives for Eli Creek

When compared to the monitored data, TP concentrations are lower than the WQOs and TN concentrations are only slightly above the TN WQOs. From this, it is concluded that the existing pollutant levels are satisfactory at the mouth of the creek.

There are only two monitored results for Condor Lake and results for both TN and TP are higher than the WQOs. Suspended Solids concentrations (in 1992) meet the WQOs. With only two monitored results, the median pollutant concentration cannot be determined. Additional monitoring data is required.

7.4.4 Recreational Use

Section 3 of the ANZECC (1992) guidelines lists various water quality considerations relevant to recreational use. These are given below in Table 7.7.

Characteristics	**Primary Contact**	**Secondary Contact**	**Visual Use (No contact)**
Microbiological guidelines	X	X	
Nuisance organisms (e.g. algae)	X	X	X
Physical and chemical guidelines:			
Aesthetics	X	X	X
Clarity	X	X	X
Colour	X	X	X
Ph	X		
Temperature	X		
Toxic chemicals	X	X	
Oil, debris	X	X	X

Table 7.7: Recreational Water Quality Considerations

The water quality objectives for recreational use (ANZECC, 1992) are:-

Parameter	Guideline
Microbiological	
Primary contact	The median bacterial content in fresh and marine waters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL or 35 enterococci organisms/100 mL. Pathogenic free-living protozoans should be absent from bodies of fresh water.
Secondary contact	The median value in fresh and marine waters should not exceed 1,000 faecal coliform organisms/100 mL or 230 enterococci organisms/100 mL.
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, sewage fungus, leeches etc. should not be present in excessive amounts. Direct contact activities should be discouraged if algal levels of 15,000 – 20,000 cells/mL are present, depending on the algal species. Large numbers of midges and aquatic worms should also be avoided.
Physical and chemical	
Visual clarity & colour	To protect the aesthetic quality of a waterbody: • the natural visual clarity should not be reduced by more than 20%; • the natural hue of the water should not be changed by more than 10 points on the Munsell Scale; • the natural reflectance of the water should not be changed by more than 50% To protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m.
Ph	The pH of the water should be within the range 5.0 – 9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.
Temperature	For prolonged exposure, temperatures should be in the range of 15 – 35^{o}C.
Toxic chemicals	Water containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed level s given for untreated drinking waters.
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour.

8 Water Quality Analysis

8.1 Overview of Analysis

Water quality modelling has been carried out to quantify the effects of existing and future catchment development on water quality, and to assist in the selection and siting of appropriate water quality devices.

Rainfall was based on daily rainfall information from gauges within and near to the catchment. Water quality modelling was undertaken using the AQUALM program and input parameters were based on Brisbane City Council calibration data. Nutrients (TN, TP) and suspended solids (SS) were modelled in the AQUALM program for existing and ultimate catchment conditions.

The Eli Creek water quality model is based on pollutant export equations derived from a monitoring scheme undertaken by the Brisbane City Council. .

This section of the report discusses the AQUALM model of the Eli Creek Catchment. Results and comparison of available monitoring data are presented and discussed.

8.2 Prediction Method

Determination of long term streamflow records has been undertaken by a mathematical simulation of the catchment performance using rainfall records and available advice on the likely response of the catchment. This approach can be subject to variation without rigorous calibration to measured site conditions.

In relation to this analysis, limited data is available to allow for calibration and the approach has been to prepare a model using available advice on the likely performance of the catchment and to use this predictive tool to evaluate the effect and magnitude of the proposed catchment changes in relation to existing and proposed future development conditions. The modelling parameters have been based on available calibrated relationships in the Brisbane region.

8.3 Water Quality Model

The water quality modelling has been performed using the AQUALM-XP program. This model undertakes a daily water accounting on the catchment using Boughton's model of soil moisture storage. The program uses a network with a series of channel links to simulate the waterway tributary system and combines daily flows by routing along channel links using a lag determined from stream properties or average velocity. The model is run on a daily time step with runoff and pollutant load information being generated at each node within the network.

Analysis is performed by division of the catchment into subcatchments and assembly of the sub-catchments by nodal network. Characteristics of the sub-areas and pollution export are derived from calibration against recorded site performance for the catchment or other similar waterways. Network linkage data is derived from hydraulic parameters evaluated from physical characteristics of the waterways.

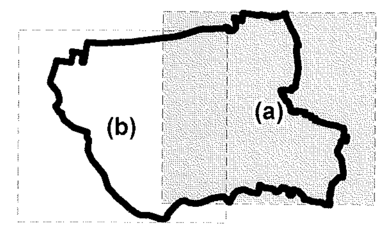
The catchment breakdown is shown on Figure 8.1.

File No. 114024TR20_A.WOR

HERVEY BAY CITY COUNCIL

LEGEND

- AQUALM SUBCATCHMENT BOUNDARY
- SUBCATCHMENT BOUNDARY
- WATERWAYS



200 0 200 400 600

Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 8.1 (a)

AQUALM Subcatchments

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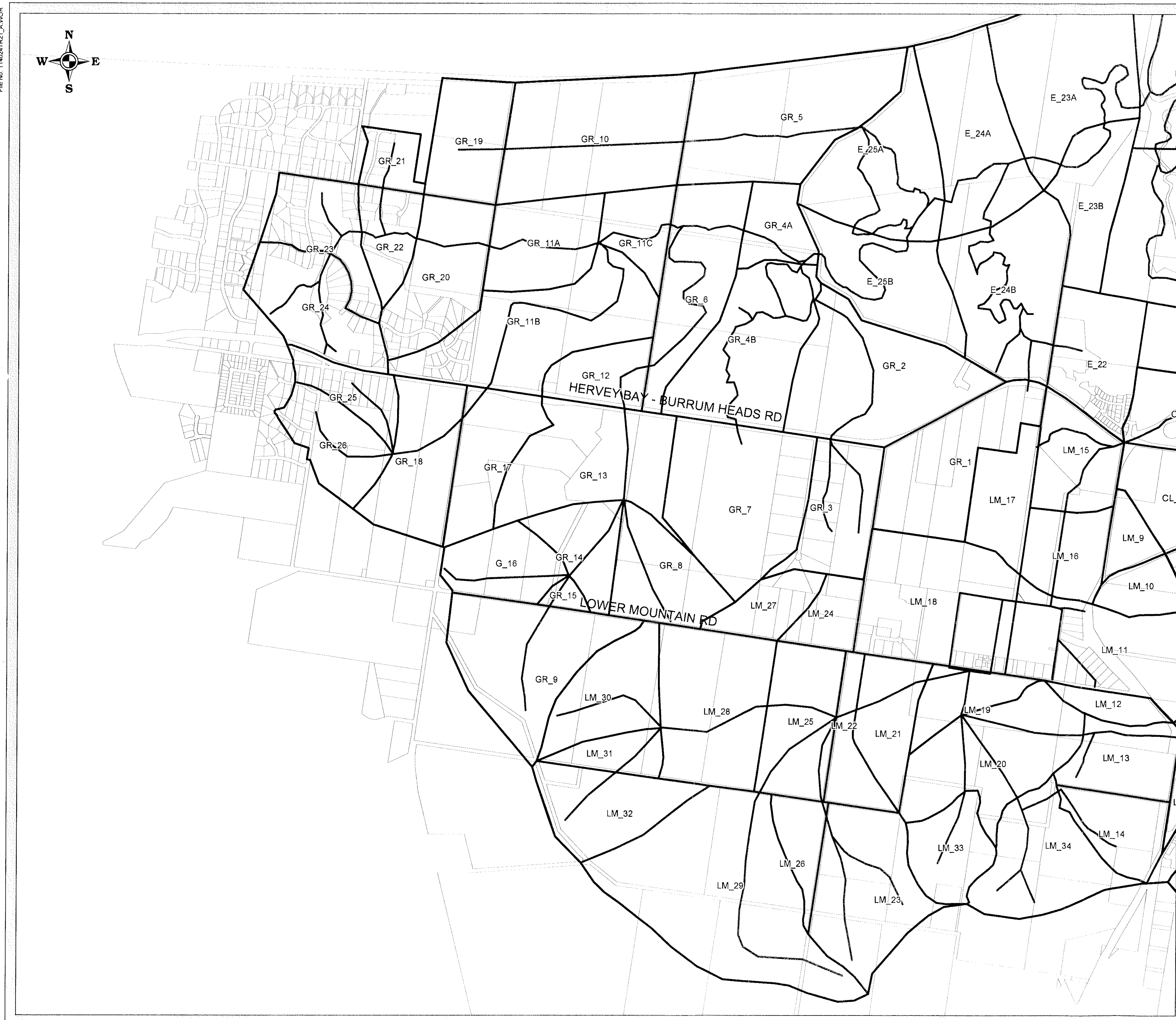
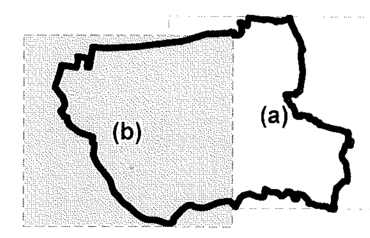
File No. 114024TR21_A.WOR



HERVEY BAY CITY COUNCIL

LEGEND

- AQUALM SUBCATCHMENT BOUNDARY
- SUBCATCHMENT BOUNDARY
- WATERWAYS



200 0 200 400 600

Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 8.1 (b)

AQUALM Subcatchments

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The level of subcatchment discretisation for AQUALM model was the same as adopted for the RAFTS hydrological model. This resulted in an AQUALM model of the Eli Creek catchment with 190 subcatchments.

The creation of the water quality model was undertaken in sequential steps as follows:

- available data was collected and reviewed;
- the catchment was subdivided into landuse categories consistent with the RAFTS model;
- representative rainfall/runoff and pollutant export parameters were identified and tested;
- the model was assembled and analysed using historical rainfall data;
- the median concentrations of available data and model results run were compared, and adjustments were made to the model;
- the model was used to investigate the predicted water quality under existing and fully developed catchment scenarios.

8.4 Available Rainfall Data

In order to determine a suitable rainfall period for which to simulate pollutant exports from the Eli Creek catchment a review of available stations was undertaken.

The rainfall stations that were identified by the Bureau of Meteorology to be within close proximity to the catchment are shown in Table 8.1.

Number	Name	Start Date	End Date
40172	Pialba Post Office	1/1/1900	31/12/1987
40699	Pialba Railway Station	1/1/1980	31/12/1987
40765	Hervey Bay Wildlife Park	1/1/1987	9/4/1999
40643	Point Vernon	1/1/1975	31/12/1987
40405	Hervey Bay Airport	12/3/1999	
40430	Urangan Hibiscus St.	1/1/1969	
540036	Urangan Tide 7m	26/3/1999	

Table 8.1: Rainfall sites

Rainfall data was obtained from the Bureau of Meteorology for Pialba Post Office (40172), Pialba Railway Station (40699), Urangan Hibiscus Street (40430) and Hervey Bay Wildlife Park (40765). Data was used for the rainfall station Hervey Bay Wildlife Park (40765) for the period from 1989 to 1999 inclusive.

8.5 Landuse Categories

The land use categories adopted for stormwater quality modelling were based on landuse categories adopted for the hydrological investigation. The fourteen adopted landuse categories are shown in Table 8.2 below.

For each of the landuse types separate allowances for watering, moisture storage coefficients and pollution export are input to the model. These are given below for each of the adopted landuse types in the model.

Landuse	Watering Allowance	Moisture Storage	Pollution Export
Industrial	Industrial	Industrial	Industrial
Residential Low Density	Urban	Urban	Urban
Open Space	Forest	Forest	Forest
Road	Urban	Urban	Urban
Commercial	Commercial	Commercial	Commercial
Rural	Forest	Rural Res.	Rural Res.
Residential Medium Density	Urban	Commercial	Urban
Waterbody	Urban	Industrial	Forest
Park Residential	Rural Res.	Rural Res.	Rural Res.
Utilities	Urban	Urban	Urban
Active Open Space	Forest	Urban	Urban
Educational Facilities	Rural Res.	Rural Res.	Rural Res.
Hospital	Rural Res.	Rural Res.	Rural Res.
Non Urban	Rural Res.	Rural Res.	Rural Res.

Table 8.2: Landuse Categories

8.6 Model Parameters

The water quality model has been used to evaluate the performance of the catchment under existing and fully developed conditions. The modelling has been performed by simulation of extended periods of rainfall record to predict pollutant level concentrations on a daily basis. This record has then been statistically analysed to provide median pollutant concentrations.

The program has the facility to simulate non-point source and point source pollutants and to model treatment facilities. Non-point source pollutant export is based on total runoff from the rainfall runoff component of the model. The AQUALM analysis has not modelled point source pollutants from the industries in the area.

Pollutant export equations and moisture storage coefficients for the existing and future catchment have been obtained from guidelines prepared by Brisbane City Council, October 2000.

The BCC AQUALM parameters are based on calibration information obtained from a monitoring program initiated in Brisbane in 1994. The landuse types urban, rural residential, commercial, industrial and forest have been monitored and these are believed to be representative of similar landuses in the catchment.

8.6.1 Watering Allowance

The watering allowance adopted for this study is the values given in the BCC guidelines. Comments from the BCC guidelines in relation to watering are:-

"When data collected for urban, rural and forest catchments was analysed, it was found that a baseflow was consistently present despite a lack of rainfall. This suggested some additional source of water in the catchment other than rainfall. Where this occurred for significant periods after rainfall, and throughflow could not account for this flow, the lawn watering component of the model was utilised to account for this."

Watering allowance for various landuse types are given in Table 8.3.

Landuse	Watering (mm/day)
Urban	0.1 mm
Commercial	0.1 mm
Industrial	0.1 mm
Rural Res	0.5 mm
Forest	1.0 mm

Table 8.3: Watering Allowance

8.6.2 Moisture Storage

Moisture storage coefficients given in the BCC guidelines were adopted for this study. These are given in Table 8.4 below.

Description	Parameter	Landuse				
		Urban	**Commercial**	**Industrial**	**Rural Res**	**Forest**
Depth of IS	IS max	10	0.5	0.5	15	15
Depth of DS	DS max	60	10	10	50	50
Depth of US	US max	50	20	7	80	110
Direct Runoff	a	0.25	0.60	0.60	0.15	0.01
Direct Runoff	b	0.00	0.00	0.00	0.00	0.00
Evapo-trans	d	0.75	0.75	0.75	0.75	0.75
DS TF	Kt	0.25	0.24	0.24	0.50	0.15
US TF	e	0.02	0.25	0.25	0.04	0.03
DS Loss	g	0.05	0.15	0.15	0.00	0.00
US Loss	f	0.10	0.15	0.15	0.20	0.30

Table 8.4: Moisture Storage Parameters

A diagram showing the parameters is given in Figure 8.2.

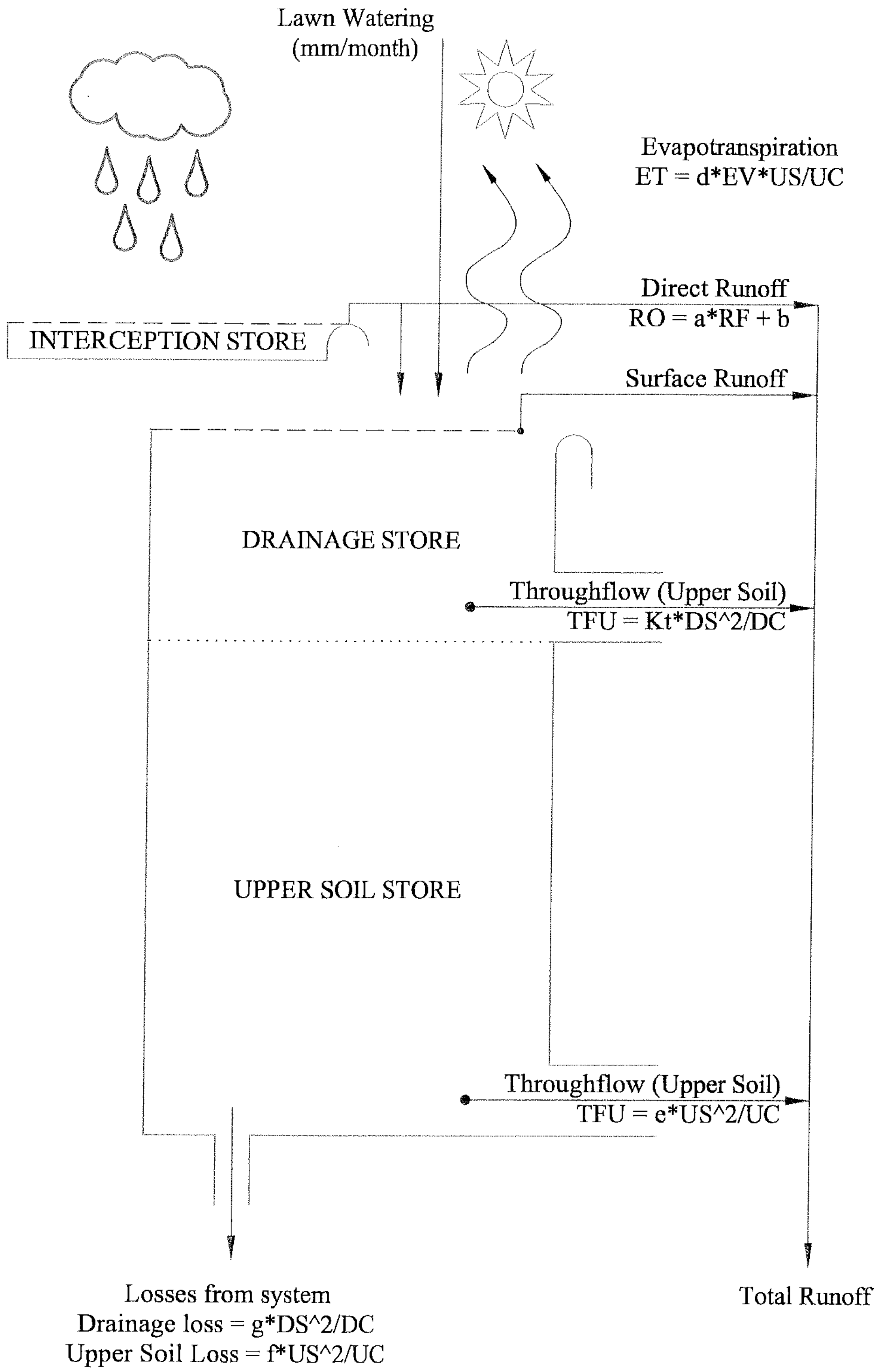

FIGURE 8.2
AQUALM Rainfall Runoff Model

8.6.3 Pollutant Export Rates

Pollutant export rates were based primarily on BCC guidelines. Pollutant export rates are given in Table 8.5.

Pollutant		Pollutant Export Rates (kg/ha)				
		Urban	**Commercial**	**Industrial**	**Rural Res**	**Forest**
SS	Surface Runoff	1.40*SR	1.10*SR	0.80*SR	0.45*SR	0.29*SR
	Throughflow	0.09*TF	0.05*TF	0.05*TF	0.05*TF	0.015*TF
TP	Surface Runoff	0.0032*SR	0.0039*SR	0.0024*SR	0.0028*SR	0.00027*SR
	Throughflow	0.0012*TF	0.0009*TF	0.0009*TF	0.0005*TF	0.0005*TF
TN	Surface Runoff	0.020*SR	0.014*SR	0.014*SR	0.020*SR	0.0054*SR
	Throughflow	0.015*TF	0.013*TF	0.013*TF	0.0073*TF	0.0035*TF

SR and TF are the codes used by AQUALM to signify surface runoff and throughflow. These codes are part of the equation to be entered into AQUALM. R represents total runoff.

Table 8.5: Pollutant Export Rates

8.6.4 Evaporation

There is no pan evaporation station in the Eli Creek catchment. The closest station is located at Gympie. The monthly pan evaporation rates recorded at Gympie were adopted, and are summarised in Table 8.6.

Month	Evaporation (mm)	Month	Evaporation (mm)
JAN	161	JUL	62
FEB	130	AUG	86
MAR	125	SEP	119
APR	95	OCT	145
MAY	69	NOV	165
JUN	59	DEC	176

Table 8.6: Monthly Average Pan Evaporation at Gympie (mm)

8.7 Storage Details

8.7.1 Ponds and Wetlands

Ponds act to reduce the quantity of pollutants in the flow by retaining particles that are attached to the pollutants. Pollutant retention versus hydraulic residence time (in days) data for Suspended Solids, Total Nitrogen and Total Phosphorus given in Table 9.12 were adopted for modelling purposes. The hydraulic residence time for each runoff event is calculated internally within AQUALM (to account for the effects of temporal variations in rainfall) and the daily pollutant inflows and outflows from a pond or wetland are summed to give monthly and annual pollutant inflows and outflows.

8.7.2 In Stream Storage

No account was made for nutrient and sediment stripping in the waterways, however waterway vegetation, if properly maintained can lead to reduced runoff volumes and peak flows by reducing runoff velocity and enhancing infiltration. Water quality enhancement would consist of removal of course sediment and other particulate pollutants due to slower velocity, filtration by waterway vegetation and some removal of soluble pollutants through biological uptake. There is no quantifiable data available on the in stream storage retention in Eli Creek, however the known ability of vegetation to strip pollutant could be incorporated into the model if data was available.

8.7.3 Pollutant Retention

Pollutant retention curves based on Hydraulic Retention times for Pollution Abatement in an Urban Lake (ACT Government, 1994) were adopted for use in this study. This is given below in Table 8.7.

Pollutant Retention %	Sedimentation System			Wetland		
	TP	TN	SS	TP	TN	SS
10	0.9	1.2	0.3	0.3	0.7	0.17
15	1.3	2.2	0.5	0.7	1.3	0.26
20	2.0	3.9	0.6	1.0	2.2	0.34
25	2.9	6.9	0.9	1.7	3.0	0.6
30	4.4	12	1.3	2.1	3.7	0.8
35	6.5	21	1.8	2.8	4.4	1.2
40	10	38	2.5	3.4	5.4	1.5
45	14	67	3.5	4.3	6.9	1.8
50	21	119	4.8	4.9	9	2.3
55	32	210	6.8	5.7	12	2.9
60	48		10	6.9	19	3.3
65	71		13	8.0	37	4.2
70	106		19	10	57	6
75	158		26	12		8
80	235		37	16		11
85			51	25		18
90			72	50		29
95			101			48

Table 8.7 Hydraulic Residence Time Required for Pollutant Retention (days)

Sedimentation curves were utilised in the analysis for Condor Lake, Eli Lake, the wet bottom channel within subcatchment area LM_15 and the pond within subcatchment area GR_1.

8.8 Comparison of Results

Water quality sampling results have been obtained from Eli Waters EIS, BGA water quality monitoring and Wide Bay water quality monitoring. The results are compiled in Table 7.1.

The measured data from sample locations has been compared with the AQUALM results for the existing catchment using the BCC parameters. The comparison is shown in Table 8.8.

Description	Monitoring Reference	AQUALM Reference	SS		TN		TP	
			Modelled	Measured	Modelled	Measured	Modelled	Measured
Eli Creek Outlet	S	PV-1	5.0	93.5	1.0	0.25	0.091	<0.02
Upstream of Outflow	R	E-20	14	69	1.0	0.332	0.09	<0.02
Condor Lake	L	Condor	16	47.5	0.86	1.105	0.098	0.055
Grinstead Road Inflow	I	GR-5	4.3	9	0.66	1.53	0.043	0.18
Grinstead Road Inflow	J	GR-4a	5.1	42	0.76	1.52	0.053	0.13
Hervey Bay Burrum Heads Road	K	GR-1	3.3	82.5	0.56	2.96	0.033	0.205

Table 8.8 Monitored Data and Calculated Data

From this table, the following is observed:-

- In general the SS concentrates calculated by AQUALM are lower than the monitored values.
- The monitored TN concentrations in the total zone were lower than the calculated values. Outside the tidal zone, the monitored and calculated values were similar, however the calculated concentrations were consistently lower.
- Similarly, the calculated TP concentrations in the total zone were higher than was recorded. In non-tidal areas, the recorded TP concentration was higher than the calculated level.

There are many potential causes of differences relating to both the monitoring technique and the modelling parameters. An inexhaustive list of potential inaccuracies includes:-

- The pollutant export relationships may be overestimating or underestimating the pollutant load.
- The total runoff may be higher than that allowed for. This would result in greater dilution and pollutant concentration values.
- Insufficient calibration data. Guidelines on monitoring (ANZECC, 1998) recommend monthly monitoring over a three year period to provide sufficient data to enable full statistical analysis.
- Timing of sampling. If all of the samples are taken only during periods of low rainfall, it is expected that low average and median concentrations would be calculated.
- No quantifiable pollutant retention data exists for overland flow through a riparian zone, however it is believed that overland flow over vegetation improves water quality by reducing the quantity of suspended solids.
- Tidal influence.
- Pollutant retention may be occurring in the waterway. It is likely that suspended solids is the easiest pollutant to remove. Reductions in Total-P and Total-N may be occurring through plant uptake and sedimentation.
- Construction activities in the catchment are difficult to model as no pollutant export equations are available for construction activities. Depending on the soil, construction activities have the potential to increase all pollutant concentration levels.

With the exception of suspended solids, in general the results calculated by AQUALM are within an acceptable range, given the many potential errors in the process.

8.9 Water Quality Results

Water quality results at various locations in the catchment for existing and fully developed catchment conditions are given in Table 8.10.

Location	Node	Existing 50th Percentile Concentration			Ultimate 50th Percentile Concentration		
		SS (mg/l)	TN (mg/l)	TP (mg/l)	SS (mg/l)	TN (mg/l)	TP (mg/l)
Western leg of Condor Lake	**LM_15**	4.6	0.7	0.47	5.4	0.82	0.058
Maryborough	**UW_3**	5.6	0.85	0.061	9	1.5	0.12
Nissen Street	**UE_3**	6.0	0.96	0.071	7.6	1.2	0.097
Condor Lake Inflow East	**CL_2**	5.5	0.87	0.063	7.7	1.3	0.099
Condor Lake Inflow West	**CL_1**	4.9	0.78	0.056	6.2	1.0	0.075
Tooth Street Outflow	**TS_1**	16.5	0.89	0.098	15	0.87	0.068
Grinstead Road North	**GR_5 (I)**	4.3	0.66	0.043	7.5	1.2	0.095
Grinstead Road South	**GR_4a (J)**	5.1	0.76	0.053	5.9	0.9	0.066
Hervey Bay Burrum Heads Road	**GR_1**	3.3	0.56	0.033	7.3	1.4	0.11

Table 8.10: AQUALM Analysis Results

The results show that pollutant concentrations are expected to increase as the catchment develops. The anomile at Tooth Street is caused by a disproportionate increase in runoff to pollutant, resulting in lower concentrations.

9 Mitigation Strategies

9.1 Water Quantity

The mitigation strategies for water quantity aim to:

- Identify and plan for adequate levels of service for all road crossings;
- Minimise the risk of flooding to existing developments.

9.1.1 Road Crossings

There are a number of existing road crossings in the catchment which require additional work to attain the desired level of service. Details of the crossings are given in Table 9.1 below. In order to upgrade the road crossings to 50 year immunity, the following is required:

Weir No.	MIKE-11 Reference	Description	Existing Road Weir Level	Required Road Weir Level	Culvert Details
11	CENTRAL 2.21 and WEIR11	Lower Mountain Road	5.42	5.85	Additional 4/2600 x 600
12	WEIR12 0.01 and WEIR12	Lower Mountain Road	5.62	5.85	Existing
13	WEST04 0.105 and WEIR13	Pialba – Burrum Heads Rd	3.78	Existing	Additional 3/1500 x 750 RCBC
20	WEST 1.055 and WEIR20	Anson's Road	3.17	Existing	4/1200 x 900
23	WEST01 0.429 and WEIR23	Dundowran Road	7.51	7.9	Existing
24	WEST01 0.673 and WEIR24	Hervey Bay – Burrum Heads Road	6.5	Existing	Additional 6/1200 RCP
25	STHWEST 1.49 and WEIR25	Hervey Bay – Burrum Heads Road	4.19	4.7	Additional 8/1200 x 600
26	STHWEST 1.73 and WEIR26	Greensill Road	2.79	4.40	New 3/2100 x 2100
30	CENTRAL01 0.427 and WEIR31	Maryborough-Urangan Road	21.36	Existing	Additional 2/1200 RCP
37	URRAW01 0.08 and WEIR37	Christensen Road	39.75	40.2	New 3/1200 x 600
39	URRAW01 1.201 and WEIR39	Urraween Road	19.01	Existing	New 4/1200 x 900
41	URRAW03 0.096 and WEIR41	Urraween Road	26.47	26.6	Existing
42	URRAW02 0.082 and WEIR42	Urraween Road	28.63	29.3	New 3/1200 x 900
43	URRAW03 0.507 and WEIR43	Nissen Street	15.77	Existing	New 4/1200 x 900
45	URRAW07 0.054 and WEIR45	Main Street	22.05	Existing	Additional 450mm dia RCP
47	URRAW08 0.211 and WEIR 47	Main Street	14.76	Existing	New 2/1200 x 600
48	URRAW06 1.002 and WEIR48	Main Street	17.59	18.3	Additional 8/1200 x 600
50	URRAW06 0.352 and WEIR50	Doolong Road	27.7	Existing	New 5/1200 x 900

Table 9.1: Crossing Details - Upgrades

An analysis of the proposed drainage structures has not been undertaken.

Details of new crossings are given in Table 9.2. This table includes the proposed new culverts at Nissen Street.

Weir No.	MIKE-11 Reference	Description	Existing Road Weir Level	Required Road Weir Level	Culvert Details
14	WEIR 14 and CENTRAL 3.0	Future Internal Road		4.8	New 8/3000 x 1200 RCBCs
15	CENTRAL04 0.25	Future Main Road		4.6	New 2/2000 x 1200
17	WEIR17 and NTHWEST 0.206	Anson's Road	3.66	4.4	New 2/900 RCP
18	NTHWEST 1.22	Greensill's Road		4.1	New 3/1200 x 900 RCBCs
21	WEST 2.067	Future Connector Road 'B'		2.6 (1)	New 7/1200 x 900 RCBCs
22	WEST 2.654	Sempf's Road		3.9 (1)	New 10/2000 x 750 RCBCs
32	NTHWEST 2.21 and WEIR32	Grinstead Road – Future		3.10	New 5/1200 x 900 RCBCs
44	URRAW07 0.22 and WEIR44	Future Crossing		16.6	New 3/900 RCP
46	URRAWO8 0.079 and WEIR46	Future Crossing		15.1	New 6/1200 x 900
16a	NISS_WR 3.17 and Nissen 3.16	Nissen Street Proposed	8.2	8.2	New 5/2700 x 600

Note: (1) Provides 10 Year ARI flood immunity.

Table 9.2 Crossing Details - New

9.1.2 Allotment Filling

Land to be used for residential and other development external to the waterway corridors and detention areas will need to be filled to above the 100 year ARI flood level in accordance with Council's freeboard requirements. Details of fill level requirements adjacent to the waterway system based on the analysis in this report are contained in Appendix H. The detailed levels are subject to qualification in relation to topography used in the analysis and will require confirmation by analysis during the development approval process.

Where allotment filling is significantly higher than existing development levels, the Developer will need to achieve an acceptable gradation in land levels to avoid unnecessary concern to existing residents. Abrupt change in the level at the boundary with existing development will not be acceptable.

9.2 Water Quality

Treatment techniques are proposed that aim to:

- Reduce the nutrient loading to the environmentally sensitive areas;
- Achieve the environmental objectives;
- Reduce the gross pollutants entering the waterways;
- Reduce the sediment and suspended solids entering the waterways.

Four principal mitigation measures for water quality are proposed and are discussed below.

9.2.1 Gross Pollutant Traps

Gross pollutants, such as litter and debris originate primarily from any land use that attracts a large population, such as urban, commercial and major roads. Traps provide a coarse screening to the runoff by removing the large pollutants and are therefore beneficial to achieving the water quality objectives for aquatic ecosystems and recreation. The proposed locations of the traps are shown on Figure 9.1. Traps have been located primarily in the upper reaches of the tributaries to the major waterways to reduce, size and cost and improve efficiency. Gross Pollutant Traps are the "front line" in a treatment train and are included as part of the sediment basin and constructed wetland schemes. A total of 25 independent traps are required.

The implementation of pollutant traps should be performed in a manner which is sympathetic to the adjacent environment and residential areas. This can be achieved through the use of underground structures, proprietary inlet or end of pipe devices, or vegetated open trash retention systems. All systems will require a degree of maintenance but vegetated systems have the potential to minimise cleaning effort and odour release.

Screening methods must ensure that safety issues are addressed and that pipe outlets are not obstructed.

All new development in the catchment, especially within Eli Waters, should have gross pollutant collection systems on each pipe network. The impact of pollutant traps is not evaluated in the AQUALM analysis.

9.2.2 Sediment Basins

Sediment basins remove large sediment particles from the stormwater runoff. The potential locations for sediment basins are shown in Figure 9.1. The locations have been based on removing most of the sediment prior to discharging to environmentally significant areas.

Where possible, sediment basins have been located at existing open space or waterway areas. In such an area, a small holding weir could be constructed upstream of the culvert outlet such that water ponds upstream for a period of time. The small weir should be designed not to impede the hydraulic capacity of the outlet structure.

Sediment basins can also be designed to permit the breakdown of organic particles (leaves etc) prior to entry to a waterbody. This is achieved in an ephemeral area, exhibiting medium to long grasses with scattered brush. The sediment basins recommended in this report should be designed to remove organic pollutants as well as coarse sediment. A total of 7 sediment basins are required, and there should be provision for gross pollutant removal on each.

9.2.3 Constructed Wetlands

Constructed wetlands remove nutrients, sediment pathogens, oil and grease from stormwater runoff. Wetlands need a reliable water supply to remain "wet" at all times. The wetlands recommended in this study are generally located downstream of urban areas on the major flowpaths to the lake systems.

A total of 8 wetlands are recommended. They have been located to protect Eli Waters Lake, Condor Lake and the receiving waters.

Performance criteria for the wetlands is as follows:

Wetland No.	Inflow Concentration (Ultimate Catchment)			% Pollutant Reduction Required			Attenuation Time Required	
	SS	TN	TP	SS	TN	TP	TN	TP
GR-5	7.5	1.2	0.095	-	63%	47%	19 days	5 days
GR-4b, 6, 11C	5.9	1.2	0.095	-	51%	24%	9 days	2 days
CL-2, UE-2	7.7	1.3	0.099	-	66%	49%	37 days	5 days
TS-1	15	0.87	0.068	-	25%	-	3 days	-

Table 9.3: Performance Criteria for Wetland Design

Table 9.2 is based on achieving the water quality objectives for either lakes and reservoirs, or rivers and streams, depending on node location.

Some of the attenuation times listed in Table 9.2 are excessive, and it is unlikely that sufficient area is available to accommodate the wetland necessary for such long periods.

The attenuation time required at CL-2 to mitigate the effect of urbanisation only is four (4) days. Therefore, 5 days of attenuation in this wetland would be expected to (i) lower TP concentrations to the WQO levels and (ii) lower TN concentratins to existing concentration levels.

The attenuation time required at GR-5 to ameliorate the effect of urbanisation is about seven (7) days. Therefore, with 7 days attenuation, the outflow water quality is expected to (i) meet the WQOs for TP and (ii) reduce TN to existing levels.

The eighth wetland is located in the Point Vernon Catchment (PV-4) as described by GHD.

The detention basin upstream of Nissen Street is low lying and subject to pondage with associated maintenance problems. This location will be suitable for construction of a wetland (UE-2) which will provide low flow storage and drainage for the basin as well as improving the aesthetic amenity of the area.

9.2.4 Riparian Corridor Revegetation

The proposed waterway corridors will be revegetated to re-establish the ecological value of the land and to provide linear treatment systems to capture sediment and nutrient.

HERVEY BAY CITY COUNCIL

LEGEND

- CATCHMENT BOUNDARY
- 'ON LINE' CONTROL PONDS
- DETENTION BASIN
- WETLAND
- WATERWAYS
- GROSS POLLUTANT TRAP
- SEDIMENT BASIN
- ROAD UPGRADE REQUIRED
- TOOTH STREET DRAINAGE
- WATERWAY CORRIDORS

200 0 200 400 600
Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 9.1 (a)

Drainage Strategy

JWP

John Wilson and Partners Pty. Ltd.
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PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

File No. 420007_02.WOR

HERVEY BAY CITY COUNCIL

LEGEND

- CATCHMENT BOUNDARY
- 'ON LINE' CONTROL PONDS
- DETENTION BASIN
- WETLAND
- WATERWAYS
- GROSS POLLUTANT TRAP
- SEDIMENT BASIN
- ROAD UPGRADE REQUIRED
- WATERWAY CORRIDORS

200 0 200 400 600

Metres

Scale: 1:20,000

HERVEY BAY CITY COUNCIL

Eli Creek
Catchment Management Plan

Figure 9.1 (b)

Drainage Strategy

JWP

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9.3 Estimates of Cost

Estimates of Cost have been determined for the following infrastructure items. Details of the estimates are contained in Appendix G.

Grinstead Road Subcatchment

Existing Road Upgrades

Pialba – Burrum Heads Road (No. 13)	$	83,000
Hervey Bay – Burrum Heads Road (No. 25)	$	276,000
Unnamed Road (No. 17)	$	139,000
Anson's Road (No. 20)	$	495,000
Dundowran Road (No. 23)	$	59,000
Hervey Bay – Burrum Heads Road (No. 24)	$	94,000
Greensill Road (No. 26)	$	467,000
Maryborough-Urangan Road (No. 30)	$	129,000

New Road Crossings

Future Road (No. 18)	$	105,000
Grinstead Road (No. 32)	$	147,000
Future Road (No. 21)	$	412,000
Sempf's Road (No. 22)	$	503,000

Other

Wetlands (GR-4b, 5, 6, 11C)	$	5,460,000
Sediment Basins (5 No.)	$	750,000
Gross Pollutant Trap (1 No.)	$	80,000
Excavation and Channel Construction	$	7,991,000

Lower Mountain Road Subcatchment

Existing Road Upgrades

Lower Mountain Road (No. 11)	$	292,000
Lower Mountain Road (No. 12)	$	141,000

New Road Crossings

Internal Road (No. 14)	$	481,000
New Main Road (No. 15)	$	95,000

Other

Excavation and Channel Construction	$	2,870,000
Gross Pollutant Trap (1 No.)	$	80,000

Islander Road West Subcatchment

Bund Wall Drainage Strategy	$	170,000
375mm dia Diversion/Pond Extension	$	42,000
Islander Road Drainage	$	938,000
Old Maryborough Road Upgrade	$	98,000
Gross Pollutant Trap (1 No.)	$	80,000

Point Vernon Subcatchment

Drainage Construction (Option 1)	$	1,510,000
Wetland (PV-4)	$	390,000
Gross Pollutant Traps (3 No.)	$	240,000
Sedimentation Basin (1 No.)	$	150,000

Tooth Street Subcatchment

Channel Construction (Option 1)	$	290,000
Gross Pollutant Traps (5 No.)	$	400,000
Wetland (TS-1)	$	510,000

Nissen Street Subcatchment

Existing Road Upgrades

Doolong Road (No. 50)	$	83,000
Main Street (No. 48)	$	162,000
Main Street (No. 47)	$	68,000
Main Street (No. 45)	$	19,000

Other

Control Structure and Detention Facility No. 1	$	540,000
Control Structure and Detention Facility No. 2 (No. 55)	$	156,000
Control Structure and Detention Facility No. 3 (No. 56)	$	2,330,000
Gross Pollutant Traps (5 No.)	$	400,000
Sediment Basin (1 No.)	$	150,000
Wetland (UE-2)	$	800,000

Condor Lake Subcatchment

Gross Pollutant Traps (3 No.)	$	240,000
Wetlands (CL-2)	$	1,800,000

Fairway Drive Subcatchment

Existing Road Upgrades

Christenson Road (No. 37)	$	132,000
Urraween Road (No. 39)	$	106,000
Urraween Road (No. 41)	$	10,000
Urraween Road (No. 42)	$	128,000
Nissen Street (No. 43)	$	89,000

Other

Gross Pollutant Traps (6 No.)	$	480,000
Excavation and Channel Construction	$	374,000

Other Infrastructure Costs

Land acquisition	$	4,200,000
Revegetation	$	7,341,000