Surf Coast Shire

Painkalac Creek and Estuary

Pollution Source Investigation

Final Report

June 2005

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1. Introduction

GHD Pty Ltd was engaged by the Surf Coast Shire Council to undertake an investigation to identify pollution sources in the lower Painkalac Creek catchment. This investigation is part of a series of estuary and river health studies being conducted throughout the region (including Erskine River/Stony Creek and Anglesea River), through funding from the Corangamite Catchment Management Authority (CCMA).

This investigation focussed on the identification of pollution sources for the lower Painkalac Creek and Estuary only. Considerable investigation of pollution sources in the upper catchment of the Painkalac Creek Estuary was undertaken by the CCMA in 2004. Their investigations included identifying priority areas to be targeted, with funding since being made available for local landholders to undertake on-ground works such as riparian fencing and revegetation. Whilst the contribution of pollution sources from the upper catchment was identified and recognised as part of this study, the focus of recommendations arising from this study specifically relates to the lower catchment area.

In responding to the need to have a single, clear, guiding document on the management and responsibility of the Painkalac Creek Estuary, the Surf Coast Shire has commenced work on developing an estuary management plan for the Painkalac Creek Estuary. The management plan will consider and incorporate:

- The results and recommendations of this pollution sources investigation;
- The guidelines for estuary management issues, objectives and actions, as detailed in the Central West Victoria Estuaries Coastal Action Plan (2004) Appendix 5;
- The outcomes of the community workshop for Painkalac Creek and Estuary project;
- The Estuary Entrance Management Framework currently being developed by Deakin University; and
- Any other relevant studies or investigations, such as “Surf Coast Shire Urban Stormwater Management Plan” (2001) and “Painkalac Creek Wetlands and Floodplain Environmental Study” (1990).

1.1 Objectives

The objectives of the investigation were:

- To identify potential point and diffuse sources of pollution within the lower Painkalac Creek and Estuary catchment area;
- To identify suitable water quality monitoring sites;
- To undertake a limited water quality testing program to provide a snapshot of current water quality in the creek and estuary;
- To make recommendations on the future monitoring regime, including location, frequency and parameters; and
- To provide recommendations for addressing any identified pollution sources.

1.2 Study Area

The primary area of interest for this investigation was the lower reach of the Painkalac Creek, between the boundary of the Angahook-Lorne State Park and the coast, as shown in Figure 1. The lower catchment area that lies to the north of the Great Ocean Road consists of open pasture on private land and a 16.3 ha parcel of land owned by the Surf Coast Shire which has a Trust for Nature Conservation Covenant. The area to the south of the Great Ocean Road is a combination of Council owned and managed land and Crown land managed by a committee of management (Great Ocean Road Coast Committee).

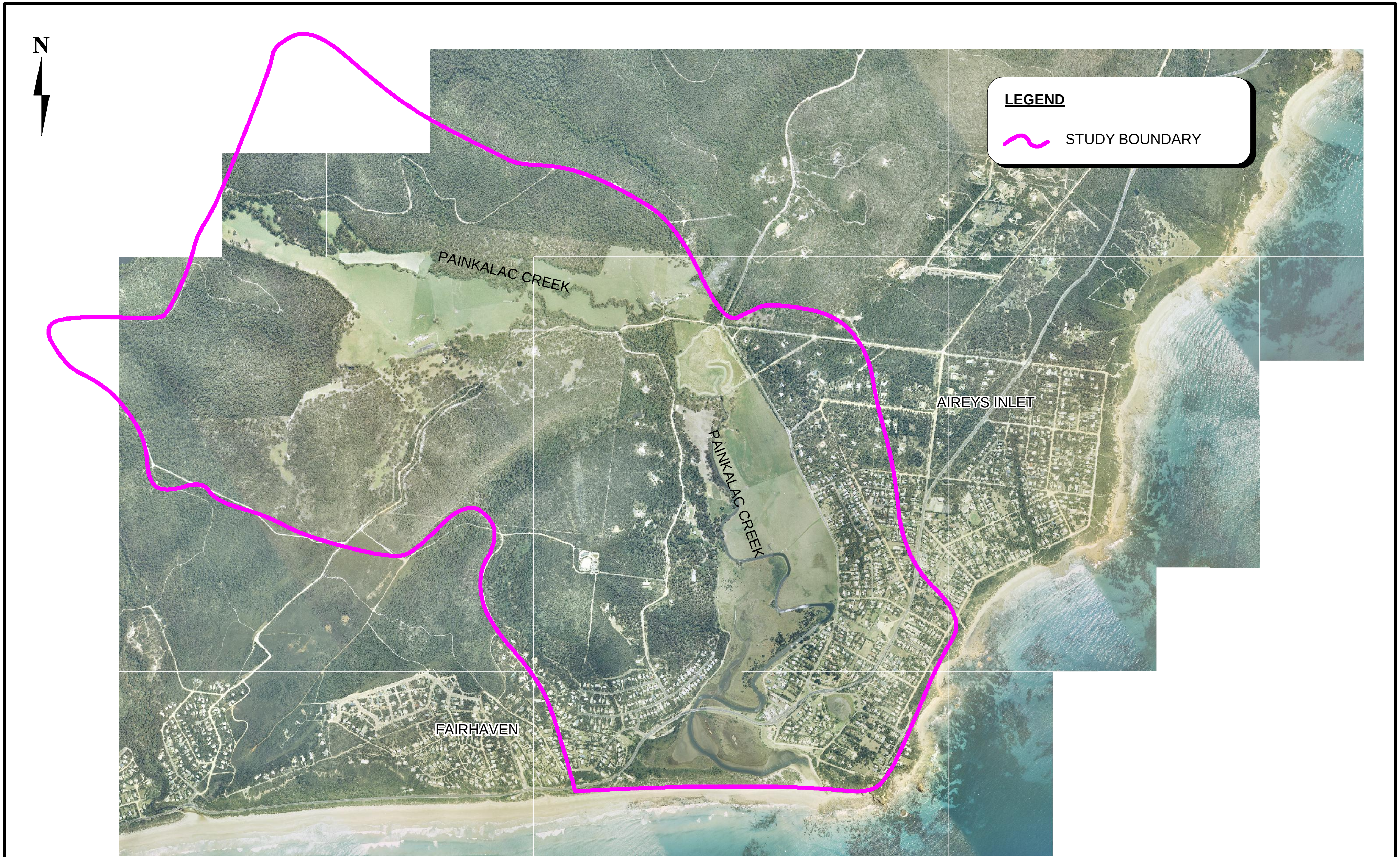
The Draft Corangamite River Health Strategy (CCMA, 2004) rates the Painkalac Creek as being in 'marginal' condition based on the standard Index of Stream Condition (ISC) methodology. Ratings are in five categories from excellent to very poor, with marginal being in the middle. A number of creeks along the Otway Coast are rated as being in good or excellent condition, however most creeks and rivers in populated areas are rated as marginal or lower. The Painkalac Creek is also flagged as being a river of regional social and economic significance and is considered to be a priority waterway in the Corangamite catchment. It is a waterway associated with a Marine National Park or Sanctuary, that being the Eagle Rock Marine Sanctuary. The Draft River Health Strategy rates the Painkalac Creek as a high risk waterway, due to pressures from tourism and population growth. The issues raised in this investigation are considered to be potential threats to the Painkalac Creek and Estuary, but do not currently cause major damage to the water quality or estuarine health.

1.3 Background

The Mon-mart clan of the Wathaurong have lived in the region for more than 25,000 years prior to European arrival. The population density of the area is believed to have been low.

European settlement of the area began in 1839. The area was initially used for cattle and timber milling. The township of Aireys Inlet was established in the 1880's with the sale of land in the district. A school opened in 1893, and in 1894 the opening of the Grand Hotel began the provision of tourism services. Access to the area was improved greatly by the construction of the first section of the Great Ocean Road in 1922 and the bridge across the Painkalac Creek in 1932, resulting in a gradual increase in population numbers.

From the 1960's, agriculture and timber gave way to tourism as the dominant occupations, although some agriculture still exists in the area.



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Checked. RH	14-6-2005	Location	**g:\31\16616\GIS\workspaces**
Approved. TV	14-6-2005	Map Grid	**AGD 66 (Zone 55)**

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Project: **Lower Painkalac Creek Pollutant Source Investigation**

Title: **FIGURE 1: STUDY AREA**

Project No: **31/16616**	Date: **14/06/2005**	**A4**	**Scale: 1:25000**	Sh **1** of **1**	Rev. **0**

2. Description of the study area

Estuaries are important ecological features which function in nutrient recycling, trapping of sediments, and are high in biodiversity. In general, the study area is comprised of low relief alluvial floodplain and the Estuary. The Estuary is a barrier, or “blind” estuary, which means the estuary is seasonally closed. In natural circumstances the bar could expect to be partially breached four to six times a year, with total breaching occurring under extensive flooding such as would occur approximately once every 10 years (PCVSSC, 1990).

Wissing (2005, unpublished) describes the estuary characteristics as being low sediment trapping efficiency, naturally low turbidity, negative hydrodynamics, a salt wedge, and partial mixed circulation. However, the sediment trapping efficiency would depend on the state of the estuary sand bar, salinity and flow velocity. Sands will settle out quickly and generally remain within the estuary or floodplains. Dispersive solids such as fine silts and clays, however, will generally be transported to the estuary where salinity levels then effect colloidal deposition. Salinity is influenced by water temperature, evaporation and dilution factors (PCVSSC, 1990). Turbidity is naturally highly variable. The turbidity of waterways passing through floodplains, which naturally contain alluvial dispersive soils, is typically high. Lower turbidity occurs in the estuary during extended periods of low flow, but high turbidity typically occurs following high rainfall events due to the erosive nature of the catchment soils.

Hydrology

The hydrodynamics of the estuary are complex, and also dependent upon flows. Flows in the lower portion of the estuary are influenced not only by rainfall and streamflow from upstream catchments, but also by the degree of closure at the mouth.

The average rainfall of the area is approximately 725 mm per annum with most rainfall falling over the winter-spring period (PCVSSC, 1990). The seasonality of natural flows mimics the rain pattern closely, with very low to nil base flows over the summer-autumn dry period, although there is high variability due to occasional unseasonal falls.

The catchment area of the lower Painkalac Creek and Estuary is approximately 39.6 square kilometres, which includes the catchment of Distillery Creek. The tidal influence gradually weakens upstream, however it extends approximately to the junction of Distillery and Painkalac Creeks.

On top of the natural breaching described above, the bar is artificially breached from time to time, when water levels are deemed to pose a flood threat. An artificial mouth opening protocol is currently undergoing development.

The Painkalac Creek was dammed in 1981 to create the Painkalac Reservoir, which supplies the townships of Aireys Inlet and Fairhaven with water. Barwon Water indicated that the current flow release regime is to release up to 0.5 ML into the lower Painkalac Creek when available. This effectively extends the period of low flows at the beginning of the wet season in autumn until the dam reaches 410 ML. However, higher than natural flows can also result in the low flow summer season if water is considered to be available, that is, if the dam is at capacity.

A salt wedge occurs where freshwater from upstream flows over the denser salty water of the estuary. Mixing is typically minimal and often limited to the interface of the fresh and saline waters.

Negative hydrodynamics are a characteristic of blind estuaries and occur where the evaporative loss is higher than freshwater inputs to the system, resulting in overall loss of water, increasing salinity and water temperature and concentrating pollutants. This occurs due to the minimal flushing and long residence time of the water.

Blind estuaries are at risk of eutrophication due to the long residence time of waters, and the accumulation of brackish water with high productivity, leading to stagnation, low oxygen levels and algal blooms. Consequently, management of flows and catchment-derived inputs such as nutrient and sediment is important to preserving estuarine ecological health.

Soils

There are three main soil types in the study area. In the lower creek and estuary areas, there are saline, grey gradational soils, associated with *Poa* grassland and saltmarsh. These soils consist of organic silty clay to silty clay-loam overlying a grey and yellow mottled B horizon. Soil permeability is low and site drainage is very poor. The floodplain typically has yellow and yellow-brown sodic duplex soils, which consist of a dark-grey sandy loam surface horizon over a bleached A2 of sandy loam to sandy clay loam. B horizon is a yellow brown clay, with poor drainage. The sodic nature of the clay subsoils makes them prone to dispersion, therefore gullying and erosion can be a problem. The poor drainage of the soils leads to seasonal ponding. The water table here is shallow and saline, leading to salinisation and poor drainage. Further up the catchment, soils are similar, however the environment is fresh water.

The erosive nature of the soils in the study area means that erosion and sediment in run-off is an issue in the catchment. The dirt roads in the townships of Aireys Inlet and Fairhaven erode easily, and sediment collects in gutters and low-lying areas. In high rainfall events, much of this sediment ends up in the creek and adjacent wetlands. Horse and cattle access to the creek, and the degradation of riparian vegetation, is also contributing to erosion and sedimentation of the creek and estuary. Sediment deposition can pose a threat to the wetlands (PCVSSC, 1990).

Flora and Fauna

A study conducted in 1990 for the Painkalac Creek Valley Study Steering Committee (PCVSSC) found 15 vegetation communities in the study area. These consist largely of tussock-grasslands and rush and sedge communities, as well as saltmarsh in the lower reaches of the estuary and, further up the catchment, Red Ironbark Open Forest. The study rated vegetation in the area as highly significant overall. The vegetation provides habitat for a large number of fauna species, including Brown Antechinus, Koala, Common Ringtail Possum, Common Brushtail Possum, Eastern Grey Kangaroo, Swamp Wallaby, and a number of native rats, as well as up to 133 species of birds and reptiles.

The wetlands, comprising the rush and sedge communities and saltmarsh, are very important ecologically. Wetlands have been described as natural “treatment cells”, or as functioning as the “kidneys” of waterways because of their role in trapping sediment and in forming a “sink” for nutrients such as nitrogen. However, these functions can be compromised if “overloading” with sediments and nutrients occurs.

Catchment Land use

The predominant land uses within the study area are residential, grazing, recreation and conservation. Several small areas have been set aside for conservation within the lower estuary and floodplain. The townships of Aireys Inlet and Fairhaven lie on hills to either side of the floodplain. The northern section of the floodplain is used for grazing horses and a large proportion of the area north of the floodplain, from the junction of Distillery and Painkalac Creeks to the Painkalac Reservoir is privately-owned agricultural land used for cattle grazing and for recreation and tourism purposes.

Aireys Inlet and Fairhaven support large number of tourists during the peak summer season, which create additional demand on resources during that period. Many of the residential houses in the two towns are unoccupied for a large proportion of the year.

3. Methods

3.1 Desktop literature review

GHD conducted a review of all readily available literature regarding the environment of the Painkalac Creek and Estuary, and incorporated the findings of the review into the analysis of data in this report and in identifying pollution sources and prioritising actions.

3.2 Stakeholder Consultation

Stakeholder consultation was conducted over a period of several weeks, and included phone conversations, meetings and informal discussions with local residents, both permanent and transient tourist populations, community groups and relevant agencies as identified by Surf Coast Shire (Table 1).

Table 1 List of stakeholder agencies and individuals identified by Surf Coast Shire

Agency	Contact Name	Position
Great Ocean Road Committee	Rod Goring	Manager GORCC
DSE Anglesea	Micheal Noekler	Coastal Planner
DSE Colac - Planning	Steve McDougall	Flora and Fauna
CCMA	Greg Peters	River Health Officer
Western Coastal Board	Jen Lilburn	Executive Officer
Barwon Water	Rowan McKenzie	Strategic Planner
Anglesea Tourism and Traders Association	Nicole Mahar	
Parks Victoria	Dale Antonyson	Ranger in Charge
Angair	Ros Gibson	member
AIDA	Rachel Faggoter	member
Friends of …. groups	See AIDA and ANGAIR	member
Individual	Guy Tuddenum	meterologist

3.3 Water Quality Testing

3.3.1 Site selection and parameters

The purpose of water quality testing for this study was to provide information on the current water quality conditions.

Sampling sites were chosen to allow comparison to previous studies that have been conducted, and to allow the detection of changes in different stretches of the river that reflect different land uses or discharges. Sample sites are shown in Figure 2. Sampling was conducted on four different occasions, to ensure adequate replication, although it should be noted that the results represent a ‘snapshot’ in time, and do not give adequate indication of the long-term conditions. Ideally, sampling of baseline conditions should be conducted regularly over a period of several years, to allow for seasonal variation, and even longer to allow for longer-term variation in rainfall and other climatic conditions. No rainfall events were recorded for the duration of the current study, therefore, this is considered to be a dry season study, and does not assess the impact of rainfall, high flow or stormwater run-off.

Samples recovered during each sampling event were analysed for a range of water quality parameters, chosen to allow comparison with previous studies and to provide an indication of ecological health. Parameters included:

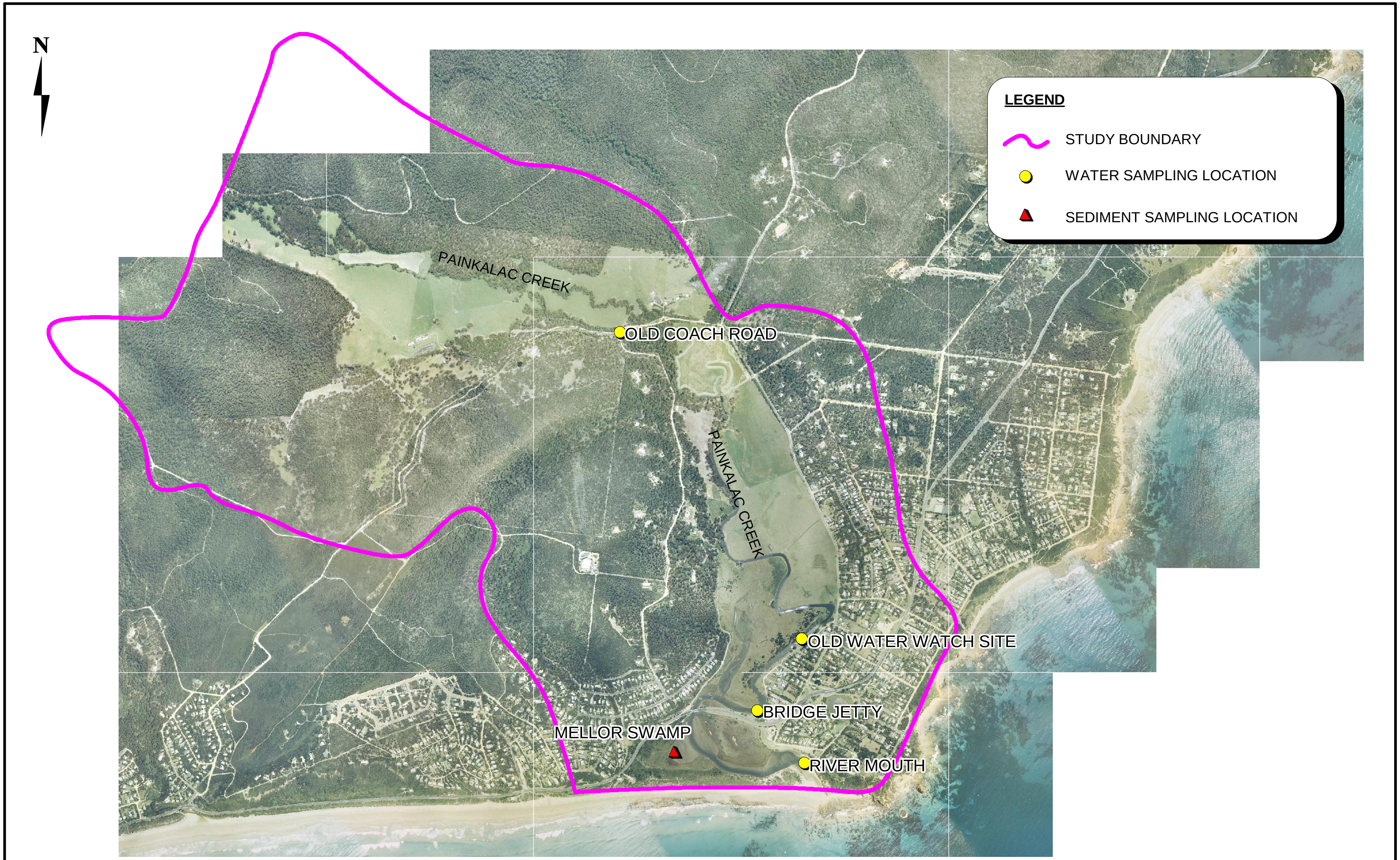
- ***E. coli*** **and** ***Enterococci*** - these are bacteria found in the intestines of most warm blooded mammals. As the bacteria don’t survive long outside the digestive tract, they are an indicator of a recent source of faecal contamination.
- ***Nutrients (Total Nitrogen, Total Phosphorus, nitrate, total Kjeldahl nitrogen, orthophosphate)*** - Elevated nutrient levels indicate pollution from sources such as stormwater run-off, fertilisers, detergents and organic matter. Soils that get washed into waterways also contain nutrients from their organic matter content, therefore elevated nutrients can indicate excessive run-off of sediments from stormwater and erosion.
- ***Biological oxygen demand (BOD)*** **-** indicator of algal and bacterial growth resulting from organic enrichment.
- ***Dissolved oxygen (DO)*** - indicator of biological activity, but is the result of the balance between oxygen demand and oxygen sources such as fresh water inputs and aeration. Low dissolved oxygen levels can indicate that the water body is becoming unsuitable for aquatic life.
- ***Turbidity*** - an indicator of suspended matter in the water column, such as clay fines.
- ***Electrical conductivity (EC)*** - measures salinity levels, and is an indicator of evaporation, dilution and the extent of the tidal range. In fresh water bodies, it is also an indicator of soil salinisation.
- ***pH*** – a measure of water acidity. pH that is outside of the natural range is an indicator of an imbalance, the cause of which would need further investigation, although naturally occurring acid sulphate soils can be a cause of low pH in some catchments. pH levels and salinity also affect the way other pollutant behave in the water, and therefore are important in assessing the overall health of the system.

In addition to testing water samples for indicators of poor water quality, one sample of sediment from the estuary was collected and screened for a suite of heavy metals, hydrocarbons and oils and grease, which may accumulate over time. Sources of these contaminants are run-off from road surfaces and development sites in the area, and inputs from recreational boats. It should be noted that due to land uses in the catchment, sampling was not conducted for pollutants that would not reasonably be expected to be found, such as organic residues from pesticides and herbicides.

3.3.2 Guidelines

Water quality results were compared to the default trigger values for physical and chemical stressors in South-east Australia for slightly disturbed ecosystems, as published in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000, prepared by the Australian and New Zealand Environment and Conservation Council (herein, the ANZECC Guidelines). Samples taken from the tidally-influenced sections of the creek and the estuary (from below the junction of the Distillery and Painkalac Creeks) were compared to the values for estuaries, and samples taken upstream of the junction were compared to values for lowland rivers, although there is some overlap in characteristics between the two because of the gradual decrease in tidal influence. The trigger values are not designed to be definitive threshold values, but rather to provide a guideline to determine at what point a potential risk exists and further investigation is warranted. The ANZECC Guidelines recommend deriving trigger values using statistical analysis of historical data, but the lack of comprehensive historical data for the catchment means this was not possible, and using inadequate data as a guideline would be potentially risky.

Sediment results were compared to ANZECC (2000) interim sediment quality guideline low trigger values for maintaining ecological health in aquatic ecosystems.



DATA SOURCE

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Approved. TV	14-6-2005	Map Grid	**AGD 66 (Zone 55)**

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Project: **Lower Painkalac Creek Pollutant Source Investigation**

Title: **FIGURE 2: SAMPLING LOCATIONS**

Project No: **31/16616**	Date: **14/06/2005**	**A4**	**Scale: 1:25000**	Sh **1** of **1**	Rev. **0**

4. Results

4.1 Discussions with Stakeholders

The process of stakeholder consultation raised a range of general environmental issues of concern.

The major issue raised by stakeholders was the issue of altered flows in the lower catchment since the construction of the Painkalac Reservoir, and the resulting effect on the creek and estuary. While a lack of adequate flow is not considered to be a source of pollution, it is certainly an environmental issue. As discussed in the description of the study area, flows affect the water quality and ecology of the whole catchment. A detailed investigation of environmental flow requirements was beyond the scope of this investigation, but is highly recommended.

Other issues raised were the increasing pressure on the catchment resulting from additional development in the area, the loss of riparian vegetation resulting from inappropriate mowing schemes, the causes of the fish kill in early 2005, the colour of water in the creek and the need for a mouth opening protocol.

The Surf Coast Shire, in partnership with the Corangamite Catchment Management Authority, Deakin University and other stakeholders, is currently developing a mouth opening protocol for the Painkalac Estuary. The causes for the fish kill cannot be determined retrospectively without adequate information regarding conditions at the time, however increased knowledge about the factors affecting the ecological health of the creek and estuary could help prevent the same thing from happening in the future. The other issues raised are discussed below.

4.2 Site Inspections

Site inspections were conducted on a number of occasions during the course of this project. There were no significant rainfall events in the catchment over the study period, and flow was generally low.

The river mouth had a similar appearance during each of the site visits. The mouth was closed for the duration of the study, and water was still and becoming slightly stagnant. There were patches of decaying algae in the shallows on the eastern side of the estuary, and on two occasions, a weak sulphurous smell was apparent. The water colour was green and clarity poor to moderate (the bottom was not visible below a depth of 30 cm at any time during the study, although it has been visible during other visits prior to the commencement of the study). A thin film of algae/organic debris was evident on the estuary bottom in shallow areas.

The water quality at the bridge and Waterwatch sampling sites were of similar appearance. The water colour was again green, with poor-moderate clarity. The banks at these sites are mostly steep and in places eroded, although between the two sites is an area with gently sloping banks and exotic grass that is used as a launching site for canoes.

The bridge sampling site was approximately 30 metres downstream of a stormwater discharge point. No obvious pollution was observed from the pipe during the study, although it should be noticed that no significant rain fell during the period.

Water at the Old Coach Road site was distinctly different from the other three sites. The colour was “tea” brown, with an oily residue floating on top and visible organic debris in the water column. Clarity was very poor, with the bottom only visible in a centimetre of water. These characteristics are probably due to leaching of organic compounds from the *Eucalypts* upstream and adjacent to the site, and possibly bank erosion upstream.

The lower reaches of the creek are vegetated largely with sedges and rushes, although exotic pasture grasses and weeds extend to the shoreline in some places, and more extensive vegetation occurs within the centre, difficult to access areas of the floodplain. Further up in the agricultural areas the stream bank becomes severely degraded, in some places resembling trampled dust due to stock access. These degraded areas would be significant contributors of sediment during high flows.

Although some litter and algal scum was observed around some stormwater drainage points, this was minimal and no evidence of significant pollution point sources was identified during any of the site inspections.

4.3 Water Quality Sampling

4.3.1 Historical Data

A number of studies have been conducted on the Painkalac Creek and Estuary in the past. Table 2 summarises the studies and what each of them tested.

Table 2 Summary of previous water quality testing in the lower Painkalac Creek and Estuary

Organisation	Sites	Data	Dates
Corangamite Waterwatch program	River Reserve Rd	PH, turbidity, DO, EC, soluble phosphorus, water temperature	1995-98
Barwon Water	Dam inlet and outlet	Monthly flow data	1999-present
Shire of Barrabool	River mouth, bridge and duck pond	*E. coli* counts	1977-81
Shire of Barrabool	River mouth, bridge and Bambra/Bridge Rd	*E. coli*, BOD, Ammonia N, Anionic surfactants	1982-89
Adam Pope, PhD Thesis, Deakin University	River mouth and creek near Old Coach Rd	Physico-chemical parameters, nutrients	1999-2002
Catherine Yule, Honours Thesis, Monash University	Bridge, Duck Pond, Above Dam and Below Dam (200 m and 1.2 km)	Major inorganic ions and total alkalinity	1978
EPA	Fairhaven Drain and Alan Noble Sanctuary	BOD, *E. coli*	1987
Barwon Water	Reservoir and Reservoir outlet	30 parameters	

Water quality testing has been conducted in the area intermittently for many years; however, testing has been conducted by different organisations at varying sites and for varying purposes, therefore there is no consistent data over time. There has not been a comprehensive study examining all the factors likely to affect water quality.

The catchment above the dam is largely undisturbed forest. In the upper catchment high rainfall events result in high levels of sediment and organic matter being washed into the creek and consequently the Reservoir. Also, high flow events can resuspend bottom sediments in the Reservoir, which still contain high levels of organic material and ash as a result of the Ash Wednesday fires. Water quality of the Painkalac is historically highly variable, however, most parameters sampled in the past were usually within the ANZECC guidelines for water quality.

Following is an overview of the historical data collected at various locations within the study area and a broad evaluation of the creek/estuary water quality based on reported results.

River Mouth/Estuary

Based on previous studies, water quality in the estuary is usually of good quality, although significant pollution events can occur periodically, particularly after high rainfall events. None of the parameters that have been measured in the past were consistently above ANZECC trigger values.

Bridge

Based on previous studies, water quality in the estuary is usually of good quality, although significant pollution events can occur periodically, particularly after high rainfall events. None of the parameters that have been measured in the past were consistently above ANZECC trigger values.

Waterwatch site

Dissolved oxygen at this site was lower than recommended on numerous occasions. This may indicate poorer water quality at this site, but it may also represent the increased frequency of sampling at this site, which was used as the Waterwatch program sampling site. Turbidity at this site is historically highly variable, which reflects the rapid increase in turbidity that can occur after high rainfall events.

Old Coach Road

None of the parameters that have been measured at this site in the past were consistently outside of ANZECC guidelines.

Summary

While average *E. coli* levels in the creek and estuary are within the ANZECC guidelines, there have periodically been very high *E. coli* events. Historical evidence of wastewater seepage and discharge, high *E. coli* levels, and incomplete records of the location and number of septic tanks in the area indicate that septic tank discharge may be an issue from time to time.

4.3.2 Current Water Quality Testing

The results of the testing area summarised in Appendix A.

Discussion

Dissolved oxygen, total nitrogen, ammonia nitrogen E.coli and Enterococci levels were outside of the ANZECC guidelines for some sampling events.

The following figures show how these parameters varied with distance from the river mouth.

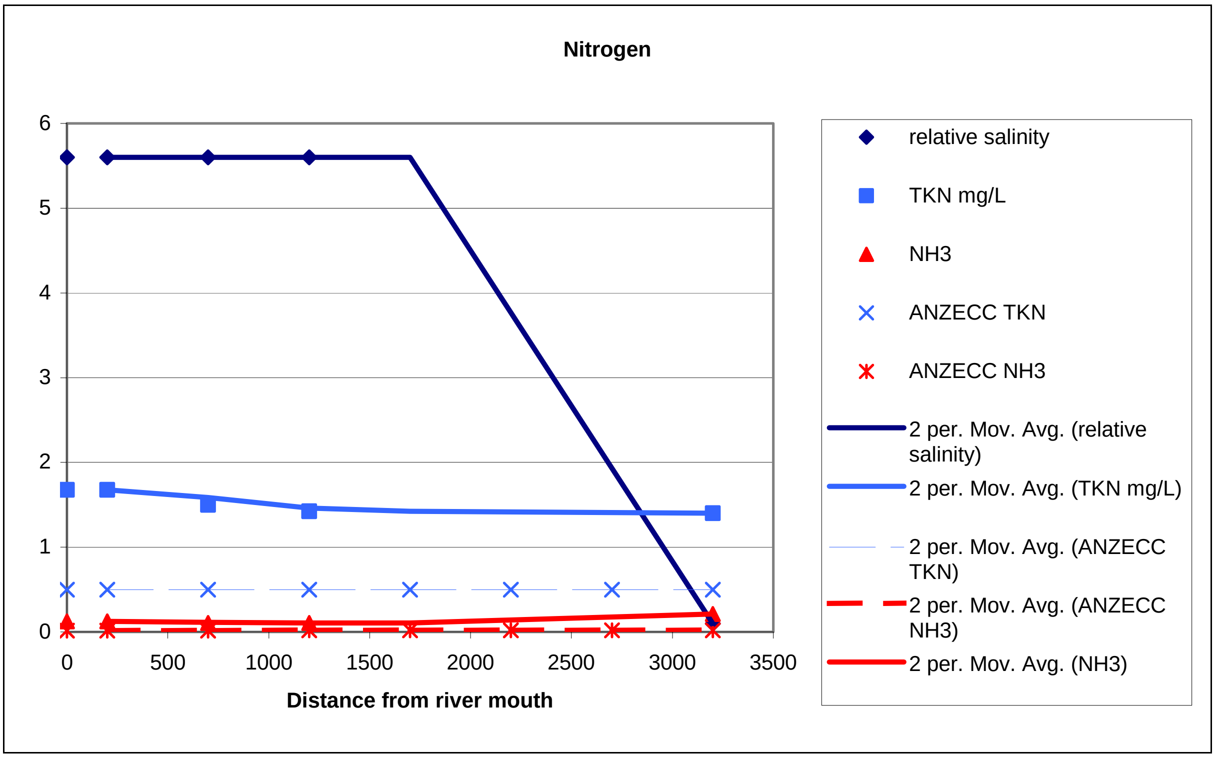

Figure 3 Nitrogen levels in Painkalac Creek.

(TKN = Total Kjeldahl Nitrogen (TKN = NH3 + Organic-N), NH3 = Ammonia. Mov. Avg. = moving average)

Figure 3 shows that while total nitrogen levels are elevated relative to ANZECC guidelines and to historical data (not shown here), the proportion of this which in a toxic form (NH_3) is relatively low. Ammonia can come from fertiliser inputs, livestock waste and septic tanks, and is also a product of natural bacterial decomposition. Total oxides of nitrogen comprised a very small proportion of total nitrogen. This indicates that most of the nitrogen in the creek is in organic form, however this nitrogen can be broken down by bacteria into ammonia, a process that is dependent upon conditions in the creek such as temperature. The toxicity of ammonia is also dependent upon pH and temperature.

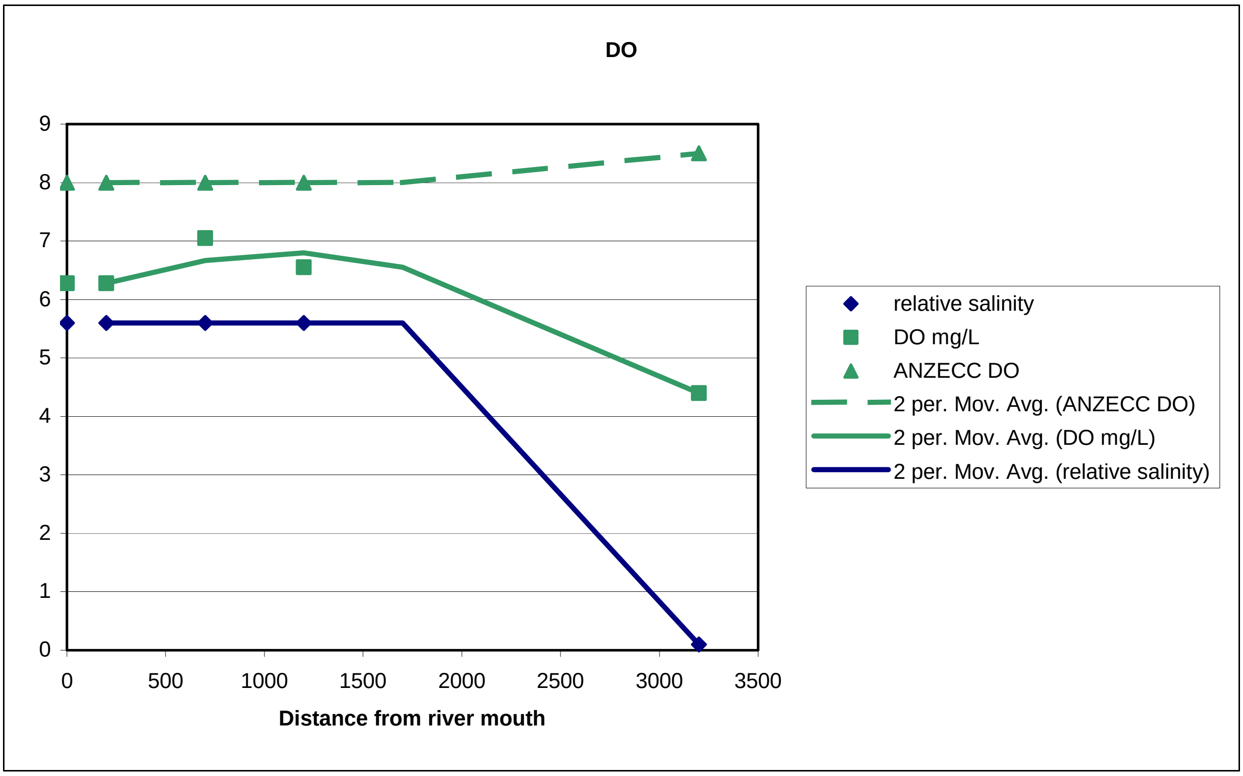

Figure 4 Dissolved oxygen in Painkalac Creek

(DO = dissolved oxygen, mg/L = milligrams per litre, Mov. Avg. = moving average)

Figure 4 shows that average dissolved oxygen levels in the creek were below ANZECC recommended guidelines. They were also below historical averages (not shown). In addition, the guidelines expect higher dissolved oxygen levels in freshwater than marine waters, but the Painkalac Creek shows the opposite trend, i.e., DO was lower further upstream.

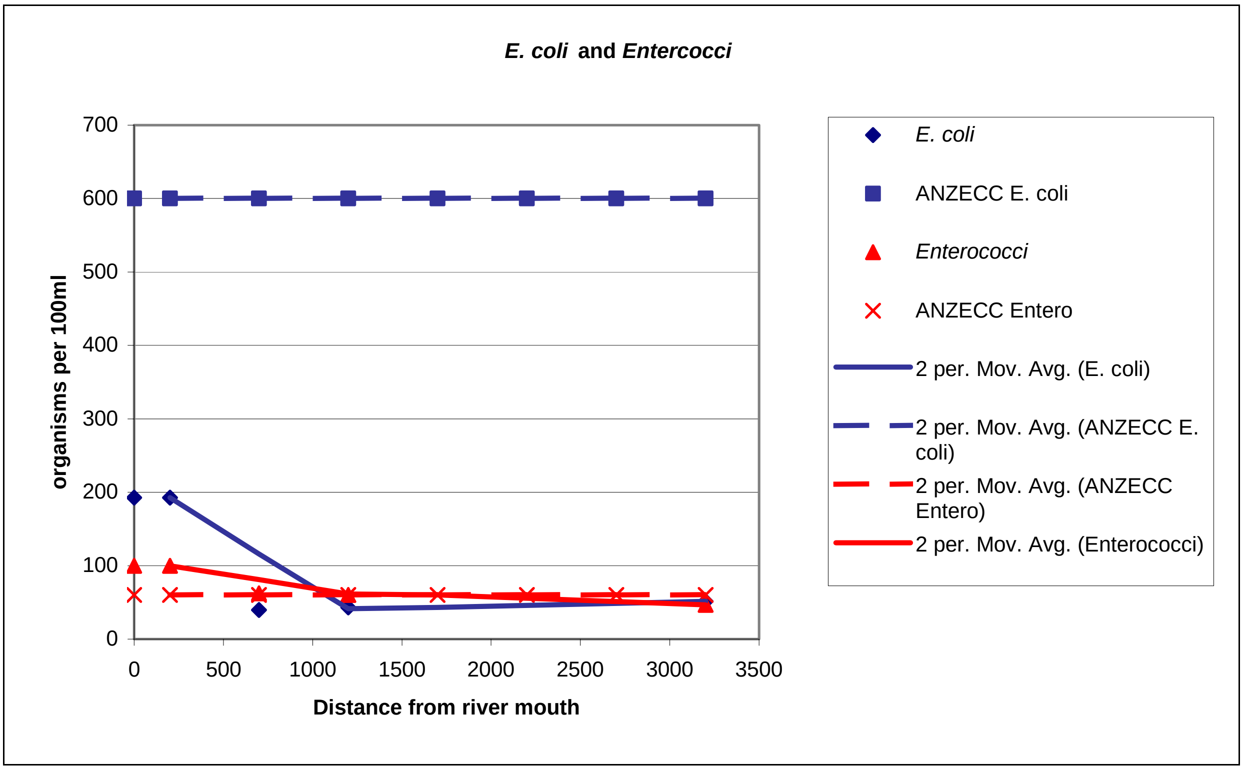

Figure 5 ***E. coli*** **and** ***Enterococci*** **in Painkalac Creek**

(Mov. Avg. = moving average)

Figure 5 shows that the levels obtained in each *E. coli* sample were below the ANZECC guidelines for primary contact for individual samples, but that *Enterococci* levels exceeded guidelines on a number of sampling events.

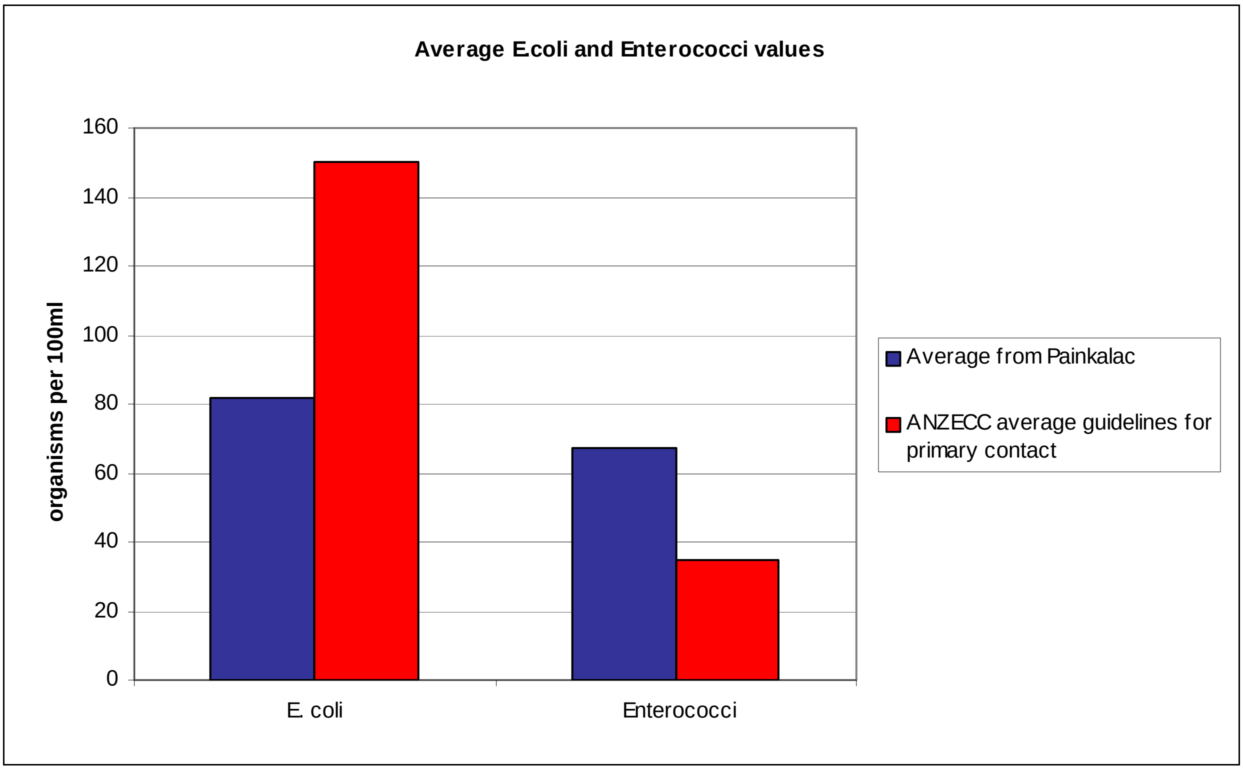

Figure 6 Average *E. coli* and *Enterococci* in Painkalac Creek

Figure 6 shows that average *E. coli* levels were within ANZECC guidelines for primary contact, but average *Enterococci* levels were higher than recommended for safe primary contact.

Historical averages for E. coli are 82 organisms per 100ml at the river mouth and 86 at the bridge, however the very high standard deviations for both results, 184 and 160 respectively, show the high variability in this parameter.

River Mouth

Dissolved oxygen levels at the river mouth were well below the ANZECC recommendations for estuaries, and lower than previously recorded in the area (Pope, unpublished data, 1999-2002), probably due to low flows and the lack of fresh water inputs over the recent months. Total Nitrogen levels were more than four times the ANZECC recommended levels and previously recorded levels. *E. coli* and *Enterococci* levels were both over the recommended levels for primary contact recreation, but acceptable for secondary contact recreational uses such as boating and canoeing. *E. coli* levels were almost three times the average levels recorded over the period from 1977-81 by the Shire of Barrabool, although there were periods during that study that *E. coli* levels were ten times those recorded in the present study. Dissolved oxygen is probably low due to high nitrogen levels, which stimulate algal and bacterial growth. Nitrogen is the limiting factor for growth in Australian waters. However, low flows and a long residence time in the estuary would also contribute to low dissolved oxygen, which may account for differences in the DO levels in the estuary compared to further upstream, even though nitrogen levels were similar.

All other parameters were within the ANZECC guidelines.

Bridge

Nitrogen levels were again over the ANZECC recommendation levels, however dissolved oxygen was only marginally below the recommended level. *E. coli* was within the acceptable limits for primary recreation, and was actually lower than the average from the 1977-81 period (Shire of Barrabool), however *Enterococci* was still high.

All other parameters were within the ANZECC guidelines.

Waterwatch

This site exhibited similarities to the Bridge site. Nitrogen levels were again well over the recommendations. Dissolved oxygen was only marginally below the recommended low trigger value, however, the historical average for the site based on Waterwatch data collected during the 1990s was within the recommended levels. *E. coli* was within the acceptable limits for primary recreation, however *Enterococci* was still high.

All other parameters were within the ANZECC guidelines.

Old Coach Road

Turbidity is naturally highly variable in Australian lowland creeks. The highest turbidity was at the Old Coach Road site, which was visibly much more turbid, however the values obtained are all within the ANZECC guidelines. The creek had the typical appearance of Australian waterways bordered by *Eucalypts*, whose leaves contain tannins, phenolic compounds and natural oils which leach into the water, giving it a murky brown “tea” appearance with an oily residue on the surface.

Dissolved oxygen was the lowest at this site, well below recommended levels for supporting diverse aquatic biota. Nitrogen and *Enterococci* were again both high. All other parameters were within the ANZECC guidelines, however, the overall water quality at this site appears to have decreased since the previous studies (Pope, unpublished data).

The land upstream of this site is privately owned farmland that is used for cattle and horses, which have access to the creek. In many places the creek and riparian zone is severely degraded and denuded. This would certainly increase erosion of the banks and surrounding landscape, and contribute to elevated sediment and nutrient load and turbidity of the creek during rainfall events.

Summary

It is very difficult to generalise about water quality over a long period of time and over such an area, as water quality is a highly dynamic variable, and each data point represents only a moment in time. However, from the data available it would appear that the Painkalac Creek and Estuary are in relatively good condition. As discussed previously, the overall condition of Painkalac Creek was rated as “marginal” using the Index of Stream Condition (ISC) method, and reported by the Corangamite Catchment Management Authority Draft River Health Strategy (2004). The ISC assessment is broader than water quality alone, and is based on analysis of a number of variables, including water quality, physical form, hydrology, streamside condition, and aquatic life. The ISC assessment illustrates that water quality in isolation is not sufficient to adequately assess the ecological health of a system. The current high nitrogen levels would pose a greater risk to aquatic health during periods of prolonged low flow and higher temperatures, when there is a high risk of eutrophication occurring. High *E. coli/Enterococci* events also pose a temporary threat to aquatic and human health.

4.3.3 Sediment Testing

The results of sediment testing in the estuary (refer to Appendix A) revealed that these are currently no issues associated with the build-up of hydrocarbons, oil, grease or heavy metals in the Painkalac Estuary. No parameters were above ANZECC interim sediment quality guideline low trigger values for maintaining ecological health in aquatic ecosystems. The high results obtained for aluminium, iron, silica and sodium, and to a lesser extent calcium, magnesium and potassium, are expected because these are all constituents of the sands and clays that make up the sediment itself.

5. Pollution Sources

5.1 Results

The results of this study indicate that water quality in the Painkalac Creek and Estuary is currently in relatively good condition, according to the recognised standards. It should be noted that the water quality results obtained during this study are a snapshot in time and do not necessarily represent the water quality conditions that would results in other circumstances, such as after high rainfall events or in peak tourist season. The major factors that could potentially compromise water quality in the Painkalac Creek and Estuary according to this study are elevated nitrogen levels, slightly elevated levels of faecal coliform bacteria and low dissolved oxygen levels.

Sources of Nitrogen

Nitrogen inputs can come from stormwater run-off, sediment that is either entering the creek or resuspended, cattle and horse faeces and other biological material. The most likely sources of nitrogen during the study period, based on the literature review, site inspections and local knowledge, are cattle and horse faeces, septic tank leakage and inputs of organic-enriched sediments from upstream erosion. The organic enrichment is in the form of livestock faeces. Dog faeces may also be a significant contributor in the lower estuary.

Sources of faecal coliform bacteria (*E. coli* and *Enterococci*)

E.coli and *Enterococci* are indicators of warm-blooded animal faeces. Given the proximity of cattle and horses to the creek, it seems likely that they are the most significant warm-blooded animal contributor in the catchment. There may be some seepage from septic tanks permeating the groundwater and eventually the creek, however, given that the *E. coli* count of raw sewage is in the order of 10^5-10^6 organisms/100 ml, this appears to be a diffuse source, and not in close proximity to the creek. Historically, there have been observations of septic seepage in the area (PCVSSC, 1990). Past recordings of high *E. coli* levels may reflect overflow of septic tanks in high use periods such as the summer tourist season.

Effective functioning of on-site effluent disposal units is dependent on a number of factors such as soil drainage, soil permeability and depth to rock. If soils are waterlogged, septic tank effluent cannot be absorbed. Purification of effluent is also inhibited by lack of oxygen in the soil and a shallow A horizon. The characteristics of the soils in the lower floodplain and estuary areas, such as poor drainage and a shallow A horizon, means that often on-site effluent treatment from septic tanks is not adequate. The untreated effluent may then be seeping laterally along the sand-clay interface into the groundwater and ultimately into the creek (PCVSSC, 1990). Soils on the creek terraces and lower slopes have more capacity for effluent disposal due to better site drainage, however the number of septic tanks that can be sustained is limited by the proximity to the creek. The 1990 report by Ecology Australia *et al* stresses the importance of reticulated sewage in the area, and the appropriate design of the sewage reticulation scheme to provide full protection to the creek even in the event of breakdown and power failure.

Causes of low dissolved oxygen

Dissolved oxygen is not a pollutant but rather an indicator of waterway health. Conditions during the study period contributing to the low levels of dissolved oxygen could be low flows, the closed state of the estuary, lack of rainfall, unseasonally high temperatures, high nutrient levels leading to excessive algal growth and the decay of organic matter.

5.2 Sources of Pollution in the Painkalac Lower Catchment

Based on the results of the water quality testing, site visits, literature review and community consultation, the major factors compromising health of the lower Painkalac Creek and Estuary are likely to be:

- nutrient-rich sediment;
- stormwater run-off; and
- possibly seepage of inadequately treated septic tank effluent.

Factors contributing to the sediment load are the erosive nature of alluvial soils, the extent of degradation of riparian vegetation and bank stability, increased run-off volume and velocity from increased sealed surfaces, and increased bare surfaces from land clearing, development and unsealed roads.

Table 3 Major factors compromising health of the lower Painkalac Creek and Estuary

Source/s	Point or Diffuse	Type of Pollution	Result/Threat	Factors contributing to Source
Sediment from erosion and stormwater run-off	Diffuse	Nutrients (N) *E. coli, Enterococci* Turbidity	Increased algal growth, resulting in decreased dissolved oxygen Decreased water clarity Damage/death to aquatic organisms such as seagrass, fish, macro invertebrates	Livestock access to creek Decrease in riparian vegetation Stormwater run-off from sealed surfaces, dirt roads, developments
Septic tank leakage	Diffuse/ Point	*E. coli, Enterococci* Nutrients (N)	Increased algal growth, resulting in decreased dissolved oxygen Algal blooms Water not safe for primary recreational uses	Septic tanks not properly maintained and serviced.
Stormwater run-off from roads and commercial areas	Diffuse	Hydrocarbons Oil and grease Heavy metals	Pollution accumulation in sediment Negative impacts on aquatic ecology	

5.3 Discussion of results

Effluent/seepage from poorly maintained septic tanks and animal faeces contribute nutrients as well as harmful bacteria, which make the waterway unsuitable for primary, and in some cases secondary contact. Sediment from erosion and stormwater run-off decreases light penetration in the water column and smothers aquatic biota. Nutrients, in this case nitrogen, can lead to excessive algal growth, and consequently harmful toxic algal blooms, and depleted dissolved oxygen, which in turn can cause harm to aquatic fauna and in extreme cases lead to fish kills. It is rarely one factor or another alone that leads to severe cases such as fish kills, but rather tends to be a number of factors working together. For instance, high nitrogen levels can be far more damaging when combined with low flows and high water temperature, which also stimulates algal growth.

The main sources of pollution in the Painkalac Lower Catchment are diffuse sources, making it difficult to pinpoint areas for action. The issues that threaten the health of the creek and estuary need to be treated within the context of the system they occur in, rather than as individual points.

6. Risk Assessment

6.1 Risk Rating

Risk assessments can help to prioritise actions and mitigation measures by rating the threat posed by each pollution source. The rating is based on an assessment of the likelihood of occurrence of the threat, and the severity of the resulting consequence if it does occur. This assessment is intended as a guide only. Although stakeholder consultation regarding the potential threats and issues was conducted, a formal risk assessment involving stakeholder rating of each risk using the Australia standard (AS4360: 1999 Risk Management) has not been conducted. The risks are rated in the local context, based on their potential to threaten the current health of the creek and estuary. Therefore, prioritisation of risks is done in the context of the risk of not maintaining the currrent state of the waterway.

Table 4 Risk ratings of the major pollution sources in the Painkalac Creek and Estuary

Source/s	Type of Pollution	Result/Threat	Risk Rating
Sediment from erosion and stormwater run-off	Nutrients, N Turbidity	Increased algal growth, resulting in decreased dissolved oxygen Decreased water clarity Damage/death to aquatic organisms such as seagrass, fish, macro invertebrates	High
Septic tank leakage	*E. coli, Enterococci* Nutrients, N, P	Increased algal growth, resulting in decreased dissolved oxygen Algal blooms Water not safe for human recreational uses	Medium
Stormwater run-off from roads and commercial areas	Nutrients N Sediment Turbidity	Increased algal growth, resulting in decreased dissolved oxygen Decreased water clarity Damage/death to aquatic organisms such as seagrass, fish, macro invertebrates	Probably High

6.2 Discussion

6.2.1 Sediment

The effect of increasing the sediment load in the Painkalac Creek and Estuary on the ecological health of the waterway will be cumulative, and depends upon other factors such as water temperature and flows. In addition to smothering bottom-dwelling aquatic biota, the sediment increases the nitrogen load of the waters, stimulating algal growth. Excessive algal growth can result, depleting the water of oxygen. The decay of dead organic matter further depletes oxygen levels. The rate at which these processes occurs is highly dependant on factors such as water temperature, which influences algal and bacterial growth, the flow velocity of the creek and the amount of freshwater input, which provides fresh oxygen to prevent dissolved oxygen levels becoming dangerously low. In a system like the Painkalac Lower Catchment, with naturally low and intermittent flows, which have been altered and further decreased by the flow release regime of the Painkalac Reservoir, the impact of these combined factors is potentially high. The fish kill which occurred earlier this year (February 2005), may be an example of what can occur given the right combination of environmental factors.

6.2.2 Septic tank leakage

While leakage of effluent does appear to be an issue, the extent of the issue remains unclear from the context of this report. Faecal coliform levels at the time of this study were above the recommended guidelines for primary recreation, however were acceptable for secondary contact recreation. Therefore, the level of risk depends upon the objectives for water quality within the catchment. Additionally, there was not sufficient information available to be able to determine the exact source of the contamination. Levels appeared to be relatively consistent across the study sample sites. It may be, and appears likely, that there are numerous, diffuse sources of contamination from poorly maintained septic tanks throughout the townships of Aireys Inlet and Fairhaven.

6.2.3 Stormwater run-off

As there were no rainfall events during the course of the current sampling period, none of the water quality results obtained can be attributed to stormwater inputs. However, research (CRCWQT, 2004) has shown that stormwater events can increase pollutant load 100 fold or more, depending on the size of the event, therefore it is highly likely that stormwater run-off would be a significant contributor of pollutants.

7. Actions/Mitigation Measures

Table 5 provides a summary of recommended actions in the catchment, with explanation of the works provided following. Priority rating are considered in a local context to preserve ecological health and public amenity of the Painkalac Creek and Estuary.

Table 5 Actions to improve water quality in the Painkalac Creek and Estuary

Pollution Source	Action	Priority
Stormwater run-off and sedimentation	Investigate and implement water sensitive urban design where possible. Implement riparian revegetation programs where riparian vegetation has been cleared or degraded. Alter council mowing regimes for riparian zones. Implement reactive management strategies from the Surf Coast Shire Stormwater Management Plan. Raise awareness of, and enforce where appropriate, the Surf Coast Shire Local Law for Stormwater Controls on Building Sites.	High
Septic Tanks	Compile list of all properties with septic tanks. Develop and implement a septic tank management education program for residents using septic tanks in the catchment.	High
All	Implement on-going, regular water quality monitoring program.	High

7.1 Description of Actions

7.1.1 Water Sensitive Urban Design

Water sensitive urban design is being successfully used to minimise stormwater run-off in urban developments, and offers an alternative to traditional stormwater management strategies. It seeks to minimise the extent of impervious surfaces and mitigate changes to the natural water balance. An integrated approach is applied which regards stormwater as a resources rather than as a waste product to be disposed of. Techniques used include detention and retention basins to lower peak flows, and grassed swales and vegetation to facilitate water infiltration and pollution filtration.

Grassed swales, or bioswales are essentially a depression or channel that is vegetated with nutrient tolerant species such as sedges and reeds, which serve to slow run-off velocity, trap sediment and absorb water and nutrients. Bioswales can be used to significantly reduce the amount of sediment and nutrients entering waterways, and in some cases, are being used as an alterative to stormwater drains altogether. Bioswales can also trap and collect litter, and so may require regular maintenance cleaning, in the form of removal of gross pollutants, or could be used immediately downstream of Gross Pollutant Traps (GPTs). Currently in Aireys Inlet there already exists a series of grassed depressions along roadside verges, for example, along Bambra Rd, which effectively trap and hold stormwater run-off. However these are not present throughout the town. Roads without swales are visibly guttered and eroded after rainfall events. Swales should be positioned along natural drainage lines and at the base of hills to collect run-off before it enters the creek.

It is recommended that the Surf Coast Shire planning scheme be amended where necessary to ensure that site modifications such as property regrading, soil disturbance and vegetation removal are kept to a minimum, with drainage provided for all impervious surfaces on the property. It is also recommended that onsite stormwater detention systems be made mandatory for new developments.

The installation of rainwater tanks for the use of roof water would also help to minimise stormwater run-off. It is recommended that Surf Coast Shire encourage the installation of rainwater tanks, possibly by offering a rebate, as suggested in the SCS Stormwater Management Plan Table 4.1. Reactive Management Strategy 1. Other Reactive Management Strategies from the Stormwater Management Plan should also be implemented, such as 'develop and implement regional field demonstrations with groups of developers, consultants and contractors to promote best practice stormwater management and water sensitive urban design methods' (Table 4.2) and all the actions from Table 4.3 – Sewage Leaks.

7.1.2 Riparian Revegetation

Riparian vegetation is essential to waterways health. It stabilises banks, provides habitat, prevents erosion, removes nutrients from the water and sediment, traps sediment and some pollutants, helps maintain dissolved oxygen levels and acts as the kidneys of the system. Vegetation along some stretches of the lower Painkalac Creek is severely degraded due to agricultural and recreational uses. Implementing a riparian revegetation program would be highly beneficial, in particular along the floodplain from Old Coach Road to the Painkalac Bridge (see Figure 7). Additionally, modification to council mowing protocols could help to maintain riparian vegetation, in leading up to the bridge. It is recommended that a pedestrian path across the bridge be clearly marked out, possibly with coarse sand and wooden edging, and that revegetation with indigenous species be conducted beyond the path. This should enable enough of a buffer to ensure car and pedestrian safety, and still allow native vegetation to grow along the river, instead of allowing weeds to encroach upon the banks.

Species to include in revegetation programs should be indigenous and replicate the species that could have been expected to occur naturally in the areas to be replanted. This may involve choosing different species from different stretches of creek. The lower reaches of the estuary itself, below the bridge, are unlikely to require revegetation, as the area is currently well vegetated, probably because the swampy nature of the area has restricted access by humans or cattle.

Revegetation programs could potentially include community involvement, thus reducing labour costs.

7.1.3 Septic Tank Audits

The Surf Coast Shire should develop and implement a septic tank management education program for residents using septic tanks in the catchment. As mentioned above, we recommend implementing the actions described in Table 4.3 of the Surf Coast Shire Stormwater Management Plan. This would include on-going monitoring of water quality and biology of receiving environments. As mentioned earlier in this report, there is no consistent on-going water quality data available for the Painkalac Creek and Estuary. Given the highly variable nature of the environment, on-going, consistent data is essential for determining the best management strategies to maintain ecological health.

DATA SOURCE

Prepared. TV	14-6-2005	Workspace	recommended works.wor
Checked. RH	14-6-2005	Location	g:\31\16616\GIS\workspaces
Approved. TV	14-6-2005	Map Grid	AGD 66 (Zone 55)

GHD MANAGEMENT ENGINEERING ENVIRONMENT

9 Clare St
Geelong VIC 3000
Tel : 61 3 5222 7935
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Project: **Lower Painkalac Creek Pollutant Source Investigation**

Title: **FIGURE 7: LOCATION OF RECOMMENDED REMEDIATION WORKS**

Project No: **31/16616**	Date: **14/06/2005**	**A4**	**Scale: 1:25000**	Sh **1** of **1**	Rev. **0**

8. Conclusions and Recommendations

8.1 Summary

Based on site inspections, discussions with relevant stakeholders, review of historical reports, it was concluded that the main pollutant sources in the Lower Painkalac Creek and Estuary bank erosion, stormwater run-off and septic system/sewage leaks, all of which are diffuse sources. The main pollutants derived from these sources, as evidenced by review of historical and current water quality data were nitrogen and *Enterococci.*

Effluent/seepage from poorly maintained septic tanks and animal faeces contribute nutrients as well as harmful bacteria, which make the waterway unsuitable for primary, and in some cases secondary contact. Sediment from erosion and stormwater run-off decreases light penetration in the water column and smothers aquatic biota. Nutrients, in this case nitrogen, can lead to excessive algal growth, and consequently harmful toxic algal blooms, and depleted dissolved oxygen, which in turn can cause harm to aquatic fauna and in extreme cases lead to fish kills. It is rarely one factor or another alone that leads to severe cases such as fish kills, but rather tends to be a number of factors working together. For instance, high nitrogen levels can be far more damaging when combined with low flows and high water temperature, which also stimulates algal growth.

The major pollution sources in the Painkalac Lower Catchment are diffuse sources, making it difficult to pinpoint areas for action. The issues that threaten the health of the creek and estuary need to be treated within the context of the system they occur in, rather than as individual points. No other significant point or diffuse pollution sources were identified.

These sources can be mitigated by the implementation of riparian rehabilitation programs, stormwater management strategies and urban water sensitive design principles, and regular maintenance checks of septic systems.

8.2 Recommendations

It is recommended that a detailed investigation into environmental flow requirements for the lower Painkalac Creek and Estuary, and how flows interact with other factors to affect water quality and overall ecological health. Also recommended is a more detailed study into the ecological health of the creek and estuary through, for example, a study on the invertebrate communities which provide a good indicator of ecological health.

9. Limitations

This report has been prepared by GHD for Surf Coast Shire Council. The contents and conclusion of this report may be inappropriate for any third party in the context of that third party's particular purposes and circumstances. Any party other than those above should obtain its own independent information or advice and no responsibility is accepted and no duty of care is assumed by GHD Pty Ltd to any third party who may use or rely on the whole or any part of the content of this document.

The work conducted by GHD under this commission has been to the standard that would normally be expected of professional environmental consulting firm practising in this field in the State of Victoria. However, although strenuous effort has been made to identify and assess all significant environmental issues required by this brief we cannot guarantee that other issues outside of the scope of work undertaken by GHD do not remain.

It should be noted, that in preparation of this report GHD has relied upon certain information and documentation supplied by the vendor. GHD has accepted this information in good faith.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure-specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of this report that has been modified other than by GHD.

This document does not purport to provide legal advice and any conclusions or recommendations herein must not be relied upon as a substitute for such advice.

10. References

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Appendix A

Water and Sediment Quality Testing Results

Water Quality Centre Barwon
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WATER ECOscience WQC BARWON

Certificate of Analysis

Date: *01-Jun-05* **Report No.: 0505018**

Client:	**GHD**	**Sample ID:**	**0505018-001**
Contact:	**Ruth Harper**	**Collection Date:**	**02-May-05 10:15:0**
Client Sample ID:	**GHD: Sample 1**	**Received Date:**	**02-May-05**
Site Description:	**River Mouth**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	560	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	230	org/100ml
Ammonia as N	BAR069	0.002	0.21	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	3	mg/L
Electrical Conductivity	BAR001C	0.1	55000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	5.0	mg/L
pH	BAR001D	0.1	7.5	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.1	mg/L
Total Nitrogen as N	BAR028B	0.5	1.1	mg/L
Total Phosphorus as P	BAR110A	0.005	0.025	mg/L
Turbidity	BAR040	0.1	6.6	NTU

NATA No. 992

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Mark Sheedy
Biology / Microbiology

Frank Matthies
Chemistry / Biology

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WEM = Mt Waverley Micro 992:989
WEC = Mt Waverley Chem 992:985
Microbiology samples analysed within 24 hours of collection date.

WATER ECOscience WQC BARWON

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Certificate of Analysis

Date: *01-Jun-05* **Report No.: 0505018**

Client:	**GHD**	**Sample ID:**	**0505018-002**
Contact:	**Ruth Harper**	**Collection Date:**	**02-May-05 11:40:0**
Client Sample ID:	**GHD: Sample 2**	**Received Date:**	**02-May-05**
Site Description:	**Bridge**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	20	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	54	org/100ml
Ammonia as N	BAR069	0.002	0.22	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	55000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	6.8	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.3	mg/L
Total Nitrogen as N	BAR028B	0.5	1.3	mg/L
Total Phosphorus as P	BAR110A	0.005	0.013	mg/L
Turbidity	BAR040	0.1	2.4	NTU

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Microbiology samples analysed within 24 hours of collection date.

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Date: *01-Jun-05* **Report No.: 0505018**

Client:	**GHD**	**Sample ID:**	**0505018-003**
Contact:	**Ruth Harper**	**Collection Date:**	**02-May-05 12:25:0**
Client Sample ID:	**GHD: Sample 3**	**Received Date:**	**02-May-05**
Site Description:	**Water Watch**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	20	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	73	org/100ml
Ammonia as N	BAR069	0.002	0.19	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	5.2	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	0.8	mg/L
Total Nitrogen as N	BAR028B	0.5	0.8	mg/L
Total Phosphorus as P	BAR110A	0.005	0.020	mg/L
Turbidity	BAR040	0.1	2.5	NTU

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WEC = Mt Waverley Chem 992:985
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Certificate of Analysis

Date: *01-Jun-05* **Report No.: 0505018**

Client:	**GHD**	**Sample ID:**	**0505018-004**
Contact:	**Ruth Harper**	**Collection Date:**	**02-May-05 12:50:0**
Client Sample ID:	**GHD: Sample 4**	**Received Date:**	**02-May-05**
Site Description:	**Old Coach Road**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	130	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	100	org/100ml
Ammonia as N	BAR069	0.002	0.29	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	<2	mg/L
Electrical Conductivity	BAR001C	0.1	940	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	4.0	mg/L
pH	BAR001D	0.1	6.4	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.3	mg/L
Total Nitrogen as N	BAR028B	0.5	1.3	mg/L
Total Phosphorus as P	BAR110A	0.005	0.034	mg/L
Turbidity	BAR040	0.1	30	NTU

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WEC = Mt Waverley Chem 992:985

Microbiology samples analysed within 24 hours of collection date.

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Certificate of Analysis

Date: *01-Jun-05* **Report No.: 0505018**

Client: **GHD** **Sample ID: 0505018-005**

Contact: **Ruth Harper** **Collection Date: 02-May-05 11:30:0**

Client Sample ID: **GHD: Sample 5** **Received Date: 02-May-05**

Site Description: **Sediment**

Analyte	Method	Reporting Limit	Result	Unit
C10-C14	EXT - TPHS	50	<40	mg/Kg
C15-C28	EXT - TPHS	100	<100	mg/Kg
C29-C36	EXT - TPHS	100	<100	mg/Kg
C6-C9	EXT - TPHS	20	<40	mg/Kg
Aluminium	WEC080	2.0	31000	mg/Kg
Antimony	WEC080	0.50	<0.5	mg/Kg
Arsenic	WEC080	0.50	8.7	mg/Kg
Barium	WEC080	2.0	32	mg/Kg
Beryllium	WEC080	0.50	0.9	mg/Kg
Boron	WEC080	20	<40	mg/Kg
Cadmium	WEC080	0.10	<0.1	mg/Kg
Calcium	WEC061S	1.0	5300	mg/Kg
Chromium	WEC080	0.50	27	mg/Kg
Cobalt	WEC080	0.50	7.6	mg/Kg
Copper	WEC080	0.50	5.1	mg/Kg
Iron	WEC080	5.0	23000	mg/Kg
Lead	WEC080	0.50	17	mg/Kg
Magnesium	WEC061S	1.0	4600	mg/Kg
Manganese	WEC080	0.50	74	mg/Kg
Mercury	WEC080	0.01	<0.05	mg/Kg
Molybdenum	WEC080	0.50	1.5	mg/Kg
Nickel	WEC080	0.50	14	mg/Kg
Potassium	WEC061S	1.0	3700	mg/Kg
Selenium	WEC080	0.50	<0.5	mg/Kg
Silica	WEC061S	1.0	30000	mg/Kg

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Frank Matthies
Chemistry / Biology

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Date: *01-Jun-05* **Report No.: 0505018**

Client:	**GHD**	**Sample ID:**	**0505018-005**
Contact:	**Ruth Harper**	**Collection Date:**	**02-May-05 11:30:0**
Client Sample ID:	**GHD: Sample 5**	**Received Date:**	**02-May-05**
Site Description:	**Sediment**		

Analyte	Method	Reporting Limit	Result	Unit
Silver	WEC080	2.0	<2.5	mg/Kg
Sodium	WEC061S	1.0	13000	mg/Kg
Sulphur	WEC061S	1.0	2100	mg/Kg
Tin	WEC080	0.50	<0.5	mg/Kg
Vanadium	WEC080	0.50	62	mg/Kg
Zinc	WEC080	0.50	51	mg/Kg
Oil and Grease*	BAR113S	5.0	1400	mg/Kg-dry

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Date: *01-Jun-05* **Report No.: 0505130**

Client:	**GHD**	**Sample ID:**	**0505130-001**
Contact:	**Ruth Harper**	**Collection Date:**	**09-May-05 9:30:00**
Client Sample ID:	**GHD: Sample 1**	**Received Date:**	**09-May-05**
Site Description:	**River Mouth**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	79	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	51	org/100ml
Ammonia as N	BAR069	0.002	0.11	mg/L
Nitrate as N	BAR069	0.002	0.034	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.042	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	6.0	mg/L
pH	BAR001D	0.1	7.6	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.006	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	3.2	mg/L
Total Nitrogen as N	BAR028B	0.5	3.2	mg/L
Total Phosphorus as P	BAR110A	0.005	0.017	mg/L
Turbidity	BAR040	0.1	4.9	NTU

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Date: *01-Jun-05* **Report No.: 0505130**

Client:	**GHD**	**Sample ID:**	**0505130-002**
Contact:	**Ruth Harper**	**Collection Date:**	**09-May-05 10:05:0**
Client Sample ID:	**GHD: Sample 2**	**Received Date:**	**09-May-05**
Site Description:	**Bridge**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	75	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	75	org/100ml
Ammonia as N	BAR069	0.002	0.093	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	7.2	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	2.3	mg/L
Total Nitrogen as N	BAR028B	0.5	2.3	mg/L
Total Phosphorus as P	BAR110A	0.005	0.018	mg/L
Turbidity	BAR040	0.1	2.5	NTU

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Date: *01-Jun-05* **Report No.: 0505130**

Client:	**GHD**	**Sample ID:**	**0505130-003**
Contact:	**Ruth Harper**	**Collection Date:**	**09-May-05 10:20:0**
Client Sample ID:	**GHD: Sample 3**	**Received Date:**	**09-May-05**
Site Description:	**Water Watch**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	77	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	68	org/100ml
Ammonia as N	BAR069	0.002	0.11	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.007	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	7.1	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	2.1	mg/L
Total Nitrogen as N	BAR028B	0.5	2.1	mg/L
Total Phosphorus as P	BAR110A	0.005	0.019	mg/L
Turbidity	BAR040	0.1	2.4	NTU

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Date: *01-Jun-05* **Report No.: 0505130**

Client:	**GHD**	**Sample ID:**	**0505130-004**
Contact:	**Ruth Harper**	**Collection Date:**	**09-May-05 10:41:0**
Client Sample ID:	**GHD: Sample 4**	**Received Date:**	**09-May-05**
Site Description:	**Old Coach Road**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	32	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	42	org/100ml
Ammonia as N	BAR069	0.002	0.44	mg/L
Nitrate as N	BAR069	0.002	0.005	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.011	mg/L
BOD	BAR008	2	<2	mg/L
Electrical Conductivity	BAR001C	0.1	960	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	3.1	mg/L
pH	BAR001D	0.1	6.5	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.7	mg/L
Total Nitrogen as N	BAR028B	0.5	1.7	mg/L
Total Phosphorus as P	BAR110A	0.005	0.030	mg/L
Turbidity	BAR040	0.1	30	NTU

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Date: *01-Jun-05* **Report No.: 0505225**

Client:	**GHD**	**Sample ID:**	**0505225-001**
Contact:	**Ruth Harper**	**Collection Date:**	**16-May-05 10:30:0**
Client Sample ID:	**GHD: Sample 1**	**Received Date:**	**16-May-05**
Site Description:	**River Mouth**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	66	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	43	org/100ml
Ammonia as N	BAR069	0.002	0.060	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	3	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	7.0	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.0	mg/L
Total Nitrogen as N	BAR028B	0.5	1.0	mg/L
Total Phosphorus as P	BAR110A	0.005	0.015	mg/L
Turbidity	BAR040	0.1	4.8	NTU

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Date: *01-Jun-05* **Report No.: 0505225**

Client:	**GHD**	**Sample ID:**	**0505225-002**
Contact:	**Ruth Harper**	**Collection Date:**	**16-May-05 10:45:0**
Client Sample ID:	**GHD: Sample 2**	**Received Date:**	**16-May-05**
Site Description:	**Bridge Jetty**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	40	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	67	org/100ml
Ammonia as N	BAR069	0.002	0.053	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	5.4	mg/L
pH	BAR001D	0.1	7.9	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.0	mg/L
Total Nitrogen as N	BAR028B	0.5	1.0	mg/L
Total Phosphorus as P	BAR110A	0.005	0.017	mg/L
Turbidity	BAR040	0.1	2.7	NTU

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Date: *01-Jun-05* **Report No.: 0505225**

Client:	**GHD**	**Sample ID:**	**0505225-003**
Contact:	**Ruth Harper**	**Collection Date:**	**16-May-05 11:10:0**
Client Sample ID:	**GHD: Sample 3**	**Received Date:**	**16-May-05**
Site Description:	**Water Watch**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	42	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	56	org/100ml
Ammonia as N	BAR069	0.002	0.050	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	7.3	mg/L
pH	BAR001D	0.1	7.9	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.007	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	0.9	mg/L
Total Nitrogen as N	BAR028B	0.5	1.0	mg/L
Total Phosphorus as P	BAR110A	0.005	0.030	mg/L
Turbidity	BAR040	0.1	2.1	NTU

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Date: *01-Jun-05* **Report No.: 0505225**

Client:	**GHD**	**Sample ID:**	**0505225-004**
Contact:	**Ruth Harper**	**Collection Date:**	**16-May-05 11:30:0**
Client Sample ID:	**GHD: Sample 4**	**Received Date:**	**16-May-05**
Site Description:	**Old Coach Road**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	12	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	21	org/100ml
Ammonia as N	BAR069	0.002	0.047	mg/L
Nitrate as N	BAR069	0.002	<0.002	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	<0.002	mg/L
BOD	BAR008	2	<2	mg/L
Electrical Conductivity	BAR001C	0.1	980	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	6.0	mg/L
pH	BAR001D	0.1	6.7	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.3	mg/L
Total Nitrogen as N	BAR028B	0.5	1.3	mg/L
Total Phosphorus as P	BAR110A	0.005	0.041	mg/L
Turbidity	BAR040	0.1	23	NTU

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Client:	**GHD**	**Sample ID:**	**0505300-001**
Contact:	**Ruth Harper**	**Collection Date:**	**23-May-05**
Client Sample ID:	**GHD: Sample 1**	**Received Date:**	**23-May-05**
Site Description:	**River Mouth**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	66	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	76	org/100ml
Ammonia as N	BAR069	0.002	0.11	mg/L
Nitrate as N	BAR069	0.002	0.006	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.018	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	57000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	7.1	mg/L
pH	BAR001D	0.1	7.8	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	1.4	mg/L
Total Nitrogen as N	BAR028B	0.5	1.4	mg/L
Total Phosphorus as P	BAR110A	0.005	0.020	mg/L
Turbidity	BAR040	0.1	3.2	NTU

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Client:	**GHD**	**Sample ID:**	**0505300-002**
Contact:	**Ruth Harper**	**Collection Date:**	**23-May-05**
Client Sample ID:	**GHD: Sample 2**	**Received Date:**	**23-May-05**
Site Description:	**Bridge Jetty**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	23	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	54	org/100ml
Ammonia as N	BAR069	0.002	0.063	mg/L
Nitrate as N	BAR069	0.002	0.007	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.018	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	57000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	8.8	mg/L
pH	BAR001D	0.1	7.9	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.006	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	1.4	mg/L
Total Nitrogen as N	BAR028B	0.5	1.4	mg/L
Total Phosphorus as P	BAR110A	0.005	0.021	mg/L
Turbidity	BAR040	0.1	2.0	NTU

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Client:	**GHD**	**Sample ID:**	**0505300-003**
Contact:	**Ruth Harper**	**Collection Date:**	**23-May-05**
Client Sample ID:	**GHD: Sample 3**	**Received Date:**	**23-May-05**
Site Description:	**Water Watch**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	33	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	43	org/100ml
Ammonia as N	BAR069	0.002	0.066	mg/L
Nitrate as N	BAR069	0.002	0.005	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.016	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	56000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	6.6	mg/L
pH	BAR001D	0.1	7.9	pH Units
Reactive Phosphorus as P	BAR110B	0.005	0.006	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.5	1.8	mg/L
Total Nitrogen as N	BAR028B	0.5	1.8	mg/L
Total Phosphorus as P	BAR110A	0.005	0.027	mg/L
Turbidity	BAR040	0.1	1.9	NTU

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Client:	**GHD**	**Sample ID:**	**0505300-004**
Contact:	**Ruth Harper**	**Collection Date:**	**23-May-05**
Client Sample ID:	**GHD: Sample 4**	**Received Date:**	**23-May-05**
Site Description:	**Old Coach Road**		

Analyte	Method	Reporting Limit	Result	Unit
E.coli (MPN Colilert)	BAM009	0	31	MPN/100mL
Enterococci (MPN Enterolert)	BAM017	0	23	org/100ml
Ammonia as N	BAR069	0.002	0.070	mg/L
Nitrate as N	BAR069	0.002	0.009	mg/L
Total Oxidised Nitrogen as N	BAR069	0.002	0.019	mg/L
BOD	BAR008	2	2	mg/L
Electrical Conductivity	BAR001C	0.1	1000	µmhos/cm
Oxygen, Dissolved	BAR013	0.1	4.5	mg/L
pH	BAR001D	0.1	6.7	pH Units
Reactive Phosphorus as P	BAR110B	0.005	< 0.005	mg/L
Total Kjeldahl Nitrogen as N	BAR028A	0.1	1.3	mg/L
Total Nitrogen as N	BAR028B	0.5	1.3	mg/L
Total Phosphorus as P	BAR110A	0.005	0.038	mg/L
Turbidity	BAR040	0.1	34	NTU

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Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	R. Harper	T. Vass	T. Vass*	T. Vass	T. Vass*	15/6/05
1	R. Harper	T. Vass	T. Vass*	T. Vass	T. Vass*	10.08.05

* Denotes signature on original