WATERWAY ASSESSMENT IN THE DANDENONG VALLEY:

THE HEALTH OF CORHANWARRABUL, MONBULK AND FERNY CREEKS

Report Prepared for
Melbourne Water Corporation

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EXECUTIVE SUMMARY

This study aims to assess the health of waterways in the Corhanwarrabul catchment (which includes Ferny and Monbulk Creeks) and to identify those factors which most impact their aquatic ecosystems. The long-term objective in managing these waterways is to provide a sustainable, diverse and native flora and fauna that would typically occur in a waterway within a sensitively managed urban environment. This study identifies the major issues that need to be addressed to improve the health of the aquatic ecosystems in the catchment. It is intended that similar surveys will be conducted every five to ten years to assess how the health of these systems change over time. This regular monitoring will also provide feedback about how well these waterways and catchments are being managed by relevant organisations and land owners.

Aquatic ecosystems are influenced by many interrelated factors, particularly water quality, stream hydrology, catchment characteristics, the extent and type of riparian vegetation and the condition and type of stream beds and banks. A variety of indicators was used in this study to examine the current condition of these waterways and to identify the major factors influencing the biota. Water quality during base flows was surveyed at two sites in Corhanwarrabul Creek, five sites in Ferny Creek, five sites in Monbulk Creek and one site each in Clematis and Ferntree Gully Creeks at roughly fortnightly intervals between January and April 1997. A brief assessment of water quality was also made following a storm event.

The physical condition of these waterways was assessed using the Waterway Condition Monitoring Program methodology.

A broad spectrum of biological indicators was surveyed to provide an assessment of the aquatic ecosystem that exists and to provide indications regarding the most important influences on ecosystem health. The diatom (benthic microscopic plant) flora was surveyed at one site on Corhanwarrabul Creek, two sites on Ferny Creek and two sites on Monbulk Creek using artificial substrata. Macroalgae (such as large filamentous algae) were surveyed at each water quality site on one occasion. The aquatic macroinvertebrates were qualitatively sampled from pool and riffle habitats using a rapid bioassessment technique. Fish were surveyed on one occasion from one site on Corhanwarrabul Creek, a wetland on the floodplain of Corhanwarrabul Creek, three sites on Monbulk Creek and two sites on Ferny Creek.

A clear advantage of this multidisciplinary approach is that work programs will be directed to focus on the most relevant issues. For example, improvement in water quality is not a universal way of improving waterway health: water quality improvements only would be an *a priori* issue if it enhances ecological values.

Corhanwarrabul Creek has a major impact on flows and water quality in Dandenong Creek. Corhanwarrabul Creek contributes about a third of the flows in Dandenong Creek at Police Road. In addition, historical data indicate that Corhanwarrabul Creek improves water quality in Dandenong Creek.

The base flow water quality was generally good in all waterways surveyed. All streams were well aerated, had low conductivities, low to moderate levels of organic pollution (as indicated by BODs), and acceptable levels of nutrients. However, the diatoms and macroalgae present indicate moderate levels of organic and inorganic pollution throughout the catchment. Organic pollution slightly increased downstream in Ferny Creek and decreased downstream in Monbulk Creek.

Overall, Ferny Creek had fluoride concentrations three times higher in Monbulk, Ferntree Gully and Clematis Creeks. These results indicate that approximately one third of base flows in Ferny Creek come from fluoridated water used for domestic water supply. The source of this fluoridated water would include run-off from watering gardens, washing vehicles, leaking pipes and other activities. In addition, a small proportion of this fluoridated water may also be run-off from septic systems.

Slightly higher conductivity and *E. coli* levels occur in Ferny Creek than in Monbulk Creek. Total phosphorus levels were low throughout the catchment. Nitrate concentrations were high in the headwaters of Monbulk and Ferny Creeks and in Clematis and Ferntree Gully Creeks, presumably from groundwaters. The suspended solids and turbidities during base flows exceeded State environment protection policy objectives in headwater streams, but were below these objectives in the remaining sites. Poor water clarity in Ferntree Gully Creek could be attributed to increased run-off from the January 1997 Mt. Dandenong bushfires.

There were generally low levels of metals present in sediments of most waterways, although concentrations of zinc, copper and lead tended to be more elevated in urban areas, particularly in Ferny Creek at Lysterfield Road. There would be many potential sources of these metals in urban catchments; major contributions probably are motor vehicles, pavement degradation, water pipes, roof erosion and atmospheric fall-out from incinerators, vehicle emissions and other activities.

The macroinvertebrate fauna was rated as being in good condition throughout Monbulk Creek, but was rated as being very poor to fair in Ferny Creek downstream of New Road. Clematis Creek and Ferny Creek at Sophia Grove were rated as being in good condition, while Ferntree Gully Creek was rated as being in excellent condition.

Ten fish species (five native and five exotic) and two cray species were collected from a survey of catchment streams. The health of the fish and cray community is rated as being poor in all waterways surveyed. The major reason for the poor diversity and abundance of native fish is that there are several constructions (weirs and concrete channels) in the lower Dandenong Valley that prevent the upstream passage of diadromous fish (ie. native fish that spend time in fresh and marine waters during their life cycle).

Dwarf galaxias, which are recommended by the Scientific Advisory Committee for listing under the Victorian Fauna and Flora Guarantee Act 1988 as a vulnerable species, occur in the Dandenong Valley and are likely to occur in floodplain wetlands in the Corhanwarrabul catchment. The populations in the Dandenong Valley are under pressure from increasing urbanisation and other developments, which may result in the loss of wetlands critical to its survival. Adequate wetland habitat should be conserved along the floodplain of the Corhanwarrabul catchment to protect this species and other indigenous species that require this habitat.

Platypus occur in Monbulk and Corhanwarrabul Creeks. One male has also been collected from Ferny Creek at New Road, but no platypus occur in Ferny Creek downstream of the retarding basin. The absence of juvenile platypus in Corhanwarrabul Creek and Monbulk Creek downstream of the Monbulk Retarding Basin indicates that this area may only provide sub-optimal habitat for platypus. In comparison, Monbulk Creek upstream of the retarding basin provides excellent habitat for platypus.

The majority of waterways have very degraded riparian zones dominated by willows and other exotics. Severe stream bed degradation and bank erosion occur in large sections of Corhanwarrabul, Monbulk and Ferny Creeks.

The health of waterways in the Corhanwarrabul catchment can be enhanced by improving the riparian zone and condition of the stream bed and banks. Exotic species, particularly willows, blackberries, morning dew, ivy, pittosporum and gorse, need to be controlled. These areas need to be revegetated with indigenous species which will provide a constant source of leaf litter (ie. food) for aquatic ecosystems. Stream beds and banks also need to be managed to minimise sedimentation within the stream and to create more habitat for aquatic life. Best management practices also need to be employed to treat urban run-off and manage storm flows to protect and enhance the aquatic ecosystems in receiving waters.

Comparatively small improvements in stream health will occur as a result of water quality improvements when compared to improving the physical condition of catchment waterways.

RECOMMENDATIONS

Managing the physical condition of waterways - riparian zones
The integrity of the aquatic ecosystems in the Corhanwarrabul catchment can be most improved by improving the physical condition of waterways, rather than focusing on water quality issues. A number of actions are recommended to ensure that catchment waterways are managed to protect and enhance in-stream habitats and riparian zones.

Melbourne Water Corporation (MWC), as the regional waterway manager, has the responsibility to improve the conditions of our streams. This task can only be done with the cooperation of land owners, the Cities of Knox and Yarra Ranges, Landcare and other community groups. A Stream Frontage Management Plan is recommended to rehabilitate riparian zones in private freehold and leased stream frontages. This plan would involve fencing off the riparian zone and re-establishing the riparian buffer. It is recommended that MWC initiate an Activity Plan to prioritise stream works for major waterways in the catchment.

It is recommended that a willow removal program is established and willow-infested riparian zones are revegetated with native species. Willow removal should be given a high priority in waterways, such as in Ferny Creek near Hancock Drive, where the willows are reducing the hydraulic capacity of the stream.

MWC should also encourage the control of exotic plants in riparian zones, as part of a Stream Frontage Management Plan. A maintenance program should also be developed to control future invasions of exotic plants.

It is recommended that the riparian zones have an adequate width to shade the waterway, limit the access of dogs and people to 90% of the banks, and support a reasonable stand of vegetation. Detailed recommendations for the width of riparian zones in the catchment should be determined as part of the preparation of MWC Activity Plans.

Treating urban run-off and managing storm flows
Appropriate measures should be taken to treat urban run-off and attenuate storm flows to protect the biota in receiving waters. It is recommended that a review be conducted to examine possibilities for treating urban run-off and managing storm flows in established urban areas. It is also recommended that any new developments in the catchment follow best practice guidelines presented in the Stormwater Committee (1998) draft report.

Managing the physical condition of waterways - waterway & wetland habitats
Many waterways, particularly those in the lower catchment, have degraded in-stream habitats. Works should be conducted to create suitable habitats in these waterways. Detailed proposals to improve in-stream habitat should be prepared in a MWC Activity Plan. It is anticipated that a current research program investigating the relationship between platypus, in-stream habitats and macroinvertebrates, will provide valuable recommendations regarding the types of habitat to be constructed and protected in Corhanwarrabul and lower sections of Monbulk and Ferny Creeks.

It is recommended that developments planned for areas in the Corhanwarrabul and lower sections of Monbulk and Ferny Creeks floodplains retain, and even create, wetland habitat to protect the vulnerable dwarf galaxias.

Managing fish populations

The fish populations in Corhanwarrabul Creek and in Ferny and Monbulk Creek downstream of Lysterfield Road and the Monbulk Retarding Basin respectively, could be substantially enhanced if the movement of diadromous species was not impeded by weirs and concrete-lined channels. It is recommended that MWC initiate an investigation to identify fish barriers in Dandenong Creek downstream of the Police Road Retarding Basin, and to assess the benefits of removing these barriers. This investigation would provide a basis for a works program with identified priorities.

Fish surveys for dwarf galaxias are required in the Dandenong Valley, including the Corhanwarrabul catchment, to detail their distribution and to identify areas with significant habitat. These surveys should be conducted as part of any environmental impact assessment before any new developments on the floodplain are approved.

Managing platypus populations

Platypus populations in the study area prefer some waterways over others. It is recommended that further research is conducted to substantiate the relationships between platypus distribution and abundance and the physical attributes of catchment waterways and the abundance of macroinvertebrates (food). It is anticipated that this research will help provide recommendations regarding the types of in-stream habitat to be created to support healthy platypus populations.

Community involvement

Community awareness and ownership of some issues will be invaluable in protecting stream health. It is therefore recommended that the findings of this report should be presented to the Cities of Knox and Yarra Ranges, local media and local community groups. There are several issues that require community education, support and participation; these relate to the:

- appropriate disposal of domestic wastes;
- appropriate use of pesticides and agricultural fertilisers;
- discouraging illegal stream diversions;
- control of exotic plants and revegetation and protection of riparian zones, and
- creation of wetlands on privately owned and public land.

Providing environmental flows

Monbulk and Ferny Creeks provide a large proportion of the flows in Dandenong Creek, particularly during extended periods of dry weather . It is therefore important that the base flows in Corhanwarrabul, Monbulk and Ferny Creeks are retained to ensure adequate flows are provided for their aquatic ecosystems. Therefore, it is recommended that proposals for new stream diversions in the Corhanwarrabul catchment are restricted to high (storm) flows and that base flows are not compromised.

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1. INTRODUCTION

Corhanwarrabul Creek is a large tributary of Dandenong Creek which drains approximately 74 km^2 about 30 km south-east of Melbourne. Corhanwarrabul Creek commences at the confluence of Monbulk and Ferny Creeks, and flows 6.15 km west into Dandenong Creek, Rowville. The headwaters of Ferny Creek are located in the Tremont/ Ferny Creek region on Mt. Dandenong. Ferny Creek flows through the suburbs of Upwey, Upper Ferntree Gully, Ferntree Gully and Rowville. Monbulk Creek, which is located to the south of Ferny Creek, flows through the suburbs of Belgrave, Upwey, Lysterfield, Ferntree Gully and Rowville. The headwaters of Monbulk Creek rise in the Sherbrooke Forest National Park.

Considerable land use changes are also occurring in these catchments, which will influence the future condition of these streams and their ecosystems. A large section of the catchment has been urbanised, and housing estates are being constructed in Ferntree Gully and Rowville. Various developments (golf courses and a lake for speed boating) are also proposed for the lower catchment. Such changes in land use will affect stream water quality, base and storm hydrology, the stream condition and ultimately, the aquatic biota that inhabit these waterways.

This study aims to assess ecosystem health and water quality between reaches within the Corhanwarrabul catchment. The program takes a multidisciplinary approach in assessing the current status of these waterways. This allows identification of major issues to facilitate sustainable management of these waterways.

The specific objectives of this program are to:

- determine the current condition of catchment waterways;
- identify those land use activities and waterways that contribute to a decline in river health;
- identify those physico-chemical attributes which most influence river health;
- provide a sound data set for monitoring long-term changes in the river health of the waterway (at roughly 5 to 10 year intervals);
- provide recommendations regarding how to sustain or improve the condition of these waterways over the next decade.

River or stream health is a term used to describe the overall condition of a waterway. It refers to the water quality and the physical attributes of a waterway, but primarily focuses on the condition of the aquatic ecosystem. A broad range of environmental attributes are used to assess the health of waterways in the Corhanwarrabul catchment. These include various water quality indicators (during base and storm flows), heavy metals in sediments, macroinvertebrates, fish, benthic diatoms, macroalgae, platypus and an assessment of stream condition (particularly the quality of in-stream habitat and riparian vegetation). A brief explanation of the reasons why these environmental attributes were selected are presented in the methods section. Further details regarding how to assess river health are detailed by the River Basin Management Society (1997) and CRCFE (1997).

A limited assessment of water quality trends in these waterways is also presented. Water quality data have regularly been collected since 1977 from Corhanwarrabul Creek at Wellington Road, Ferny Creek at Glenfern Road and New Road and Monbulk Creek at Nixon Road.

This study is designed to provide a snapshot of the status of waterways in the Corhanwarrabul catchment. Scientifically rigorous methods are employed to assess waterway health, to ensure that they can be repeated in future surveys and enable a reasonable assessment to be made of how these systems change over time.

It is important to recognise the limitations of this study in order to clarify the objectives of this report. This study only provides a snapshot of the condition of the catchment, more extensive monitoring would be required to gather information about how the system changes between seasons and in relation to longer term fluctuations in the weather. For example, the first six months of 1997 have been exceptionally dry. Some different issues may have emerged if the weather had been wetter and cooler, such as what occurred in 1995/96. This report is not a concept plan, and therefore does not provide recommendations or action plans about future land uses. Furthermore, the focus of this report is on the health of the waterways. The riparian vegetation is only assessed in relation to how it may influence the waterway health. Other land management issues, such as the presence of rare plants and associated wildlife, are not considered.

Finally, we hope that this report will generate greater community interest and facilitate a greater understanding of the various issues that need to be managed. Community interest and awareness of these systems are required to ensure that these waterways and their distinct ecosystems are protected for future generations.

2. STUDY AREA

Corhanwarrabul Creek is a significantly modified waterway which drains a 74 km^2 catchment in the east of the Melbourne metropolitan area (Figure 1). The headwaters of Ferny Creek are located in the Tremont / Ferny Creek region on Mt. Dandenong, and the creek flows through the suburbs of Upwey, Upper Ferntree Gully, Ferntree Gully and Rowville. Ferntree Gully Creek, a major tributary in the headwaters of Ferny Creek, has a catchment almost entirely confined within the Dandenong Ranges National Park.

Monbulk Creek is located to the south of Ferny Creek. The headwaters of Monbulk Creek, and a major tributary called Clematis Creek, are located in the Sherbrooke Forest, Dandenong Ranges National Park. The lower catchment is within the City of Knox, and the upper portion of the catchment within the Yarra Ranges Shire.

Waterway conditions within the Corhanwarrabul Creek catchment reflect not only the mixture of urban and semi-rural uses in the catchment, but also an extensive historical background of waterway modifications. Corhanwarrabul Creek and the lower reaches of Ferny and Monbulk Creeks have been mostly straightened, and many stabilisation works have been carried out over several decades. Ferny Creek has been piped in sections downstream of the retarding basin at Gilmour Park and the majority of the catchment is urbanised. In comparison, the Monbulk Creek catchment has been less disturbed.

The stability problems in this catchment arise as a consequence of both the waterway modifications and the massive changes in hydrologic regime generated through urbanisation. Run-off volumes and peak flows have been significantly altered through increases in impervious areas as urbanisation has spread through the catchment.

There are three substantial retarding basins within the catchment. One is located on Monbulk Creek within Birds Land Reserve (the Monbulk Creek Retarding Basin), and two are located on Ferny Creek at Knox Park, Knoxfield, and at Gilmour Park, Upper Ferntree Gully. There are also several other barriers to fish movement: notably sections of Ferny Creek around Ferntree Gully are barrel drained and an on-stream impoundment is located on Monbulk Creek at Belgrave Lake Park.

Land Use

There is a mixture of urban and semi-rural uses within the catchment. Most of the lower section of the catchment along Corhanwarrabul and Monbulk Creeks are reserves. Corhanwarrabul Creek downstream of Stud Road flows through the Dandenong Creek floodplain: the majority of the catchment in this area consists of parkland managed by Parks Victoria. Other land is utilised as part of the Kingston Links Golf Course, the Carribean Gardens and for an industrial estate. Housing subdivisions are occurring in the Kellets Road area, Rowville. Ferny Creek and parts of the lower (around Karoo Road) and the upper catchment (around Belgrave) of Monbulk Creek, are urbanised. The majority of the Monbulk catchment is used for agricultural activities, particularly cattle grazing. The headwaters of Monbulk Creek are within the Dandenong Ranges National Park.

Figure 1 Corhanwarrabul Creek catchment

Further developments are planned in 3.2% of the catchment area over the next five years (1995/96 Land Release Forecast, Department of Infrastructure 1995). The majority of land for release is in the vicinity of lower Monbulk and Corhanwarrabul Creeks, and includes a proposed golf course development.

Geology and Soils

The soils of this catchment generally reflect the weathering effect on the volcanic lithology (predominantly rhyodacites) of the Dandenong Ranges and to a lesser extent, the granodirorite formations of the Lysterfield foothills, formed during the Devonian and Silurian epochs (416-446 million years ago).

The extensive floodplain in the catchment is primarily low-level alluvium. The middle and lower sections of the catchment (downstream of Napoleon Road, Rowville) are generically of a silt/clay profile with isolated exposed instances of siltstone and sandstone formations, symptomatic of the underlying Devonian Humevale Formation. These silty clays exhibit slight yellow mottles in the B horizon (Douglas and Ferguson 1988).

In terms of the stream bed composition, this is reflected in the cobbles and boulders of waterways in the upper reaches of the catchment, tending towards unconsolidated alluvial deposits downstream to the confluence with Dandenong Creek.

Population size and distribution

The major population is around the townships of Belgrave, Upwey and Tecoma near the headwaters of the catchment, and around the suburbs of Rowville and Scoresby in the lower catchment (Figure 2). Much of the Monbulk Creek catchment can be characterised as semi-rural, having a low proportion of urban areas. The headwaters of the catchment reside in the Dandenong Ranges National Park.

Status of sewering in the catchment

Most of the Corhanwarrabul Creek catchment is sewered, however, significant unsewered sections exist in the upper Monbulk Creek catchment above the Monbulk Creek Retarding Basin. A small section of the upper Ferny Creek, upstream of Tecoma, is also unsewered. The catchments of Ferntree Gully and Clematis Creeks are the least sewered, with the majority of their catchments within the Dandenong Ranges National Park.

Figure 2: Demographics distribution of the Corhanwarrabul catchment

3. METHODS

3.1 Stream condition assessment

The environmental condition of waterways in the Corhanwarrabul Creek catchment has a major influence on the health of these waterways. The major ways riparian zones influence waterway condition are:

- by providing shade (which influences the amount of photosynthesis),
- vegetative litter (representing a source of food for aquatic organisms),
- root structures (which affect bank stability) and the modification of channel structure by large woody debris, and in
- regulating nutrient flux between the stream and the terrestrial habitat along the bank (e.g. Cummins 1993).

Surveys of waterways in the Corhanwarrabul Creek catchment were conducted by S. Brizga & Associates (unpublished report) during early 1997. The entire length of Monbulk, Ferny and Corhanwarrabul Creeks were examined.

The method used to assess stream condition follows that used by Parks Victoria (MPW 1995). In essence, the environmental condition of each segment was assessed by considering the following variables:

- aquatic structure
- shading
- water quality
- bed stability
- bank stability
- verge/ floodplain stability
- bank vegetation
- verge vegetation
- noxious/ pest plants.

Variables are combined to provide an overall indicator of stream condition that is used to give each stream reach a rating.

3.2 Water Quality

A broad spectrum of water quality parameters was surveyed during base and high flows. There was a total of fourteen water quality sites. Two sites were from Corhanwarrabul Creek, five sites from Ferny Creek, fives sites from Monbulk Creek, one site from Clematis Creek and one site from Ferntree Gully Creek (Figure 3). All of these sites were sampled on seven occasions at roughly fortnightly intervals during base flows from January to April 1997. Sampling was only conducted if there had been less than 5 mm rain in the previous 24 hours, and no intense storms in the previous five days.

Storm flows are critical periods as the majority of sediment, nutrients and other materials are transported downstream during these periods. These surveys were intended to assess water quality when there was no surface run-off from the catchment, and to indicate whether there were any

Figure 3 Site locations in the Corhanwarrabul catchment.

significant water quality problems that were evident during these periods. It was intended that the water quality would be surveyed on three occasions, however, sampling was limited to only one sampling event on 26 June, as there was an extended period of dry weather during this study. A hydrograph from Blind Creek at High Street Road (the nearest continuous flow monitoring site) was obtained to determine what stage of the storm event was sampled.

A variety of physico-chemical parameters was surveyed at these sites during base flows. These parameters were dissolved oxygen, water temperature, electroconductivity, pH, biochemical oxygen demand, fluoride, chloride, total phosphorus, orthophosphate, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, *E. coli*, suspended solids and turbidity. The same set of parameters, except fluoride and chloride, were surveyed during the high flow surveys. Water samples were analysed by Australian Laboratory Services Pty. Ltd.

Heavy metals are considered to be the most toxic of environmental pollutants (Forstner and Muller 1976). They are generally found in sediments as most of them have low solubilities in water and are bound to sediment particles (Laws 1993). Methods used to collect the sediment samples and analyse the sediment for metals are detailed by Lewin (1997). Samples were analysed to determine concentrations of arsenic, cadmium, chromium, copper, lead, zinc and mercury.

Unfortunately, no environmental objectives exist in Australia for acceptable levels of these toxicants in waterway sediments. The results are compared to the lowest effect level (LEL) of the Ontario Ministry of the Environment (OME 1989) and Australian Level B guidelines (ANZECC 1992a). The Ontario LEL guidelines for these metals are based on the minimal concentrations known to affect aquatic organisms. In comparison, the Australian Level B guidelines are less stringent as they are intended for soil contamination and do not necessarily relate to more sensitive aquatic sediments and ecosystems (Lewin 1997). Only the sediment fraction less than 65 μm was used for these analyses. This standardised the fraction of sediments analysed and therefore facilitated a better comparison between sites.

3.3 Diatoms

Diatoms are the most abundant autotrophic organisms in rivers (Round 1993), and therefore, are an important component of lotic ecosystems. They are a major source of food for protozoa, invertebrates and juvenile fish and may considerably influence water chemistry, such as pH, dissolved oxygen and ion concentrations (Round 1993). Since the early part of this century it has been known that many diatom taxa have specific ecological requirements, optima and tolerance in respect to a variety of water quality indicators. Such knowledge enables a measure of water quality based upon the composition of a diatom community. Reid *et al*. (1995) have identified several advantages of using diatoms as water quality indicators. These include:

- relatively small samples are required to give reliable assessments of community composition;
- they are very sensitive to changes in water chemistry;
- they have short reproduction cycles and rapidly colonise new habitats (change in diatom communities represent recent environmental change);
- they are generally cosmopolitan in distribution (overseas information on the autecology of a species can be applied in Australia).

Diatoms are considered a valuable intermediate between the infrequent, discontinuous (‘snapshot’) nature of physico-chemical sampling, where short-term events can result in ecologically significant changes not being detected, and monitoring of higher organisms, which may have a tolerance of brief stresses or effective avoidance behaviour (Reid *et al*. 1995).

Benthic diatom communities were sampled at one site in Corhanwarrabul Creek at Wellington Road, two sites in Monbulk Creek (Karoo Road and Belgrave-Gembrook Road) and two sites in Ferny Creek (Rushdale Street and New Road) (Figure 3). Artificial substrata, with six roughened plastic slides (25 x 75 mm), were used to perform the sampling. Artificial substrata were chosen because they provide a standardised habitat and colonisation period to enable a quantifiable comparison between communities at each site. The disadvantages of artificial substrata are that the flora may, to some degree, be ‘unnatural’ and biased towards diatoms that are fast growing and can attach to flat, smooth surfaces (Round 1993). The plastic slides were roughened in an attempt to reduce the potential bias of smooth surfaces and to prevent sloughing of the diatom films (Round 1993). An important aspect to consider with artificial substrata is that the diatom community will only represent the environmental conditions during the colonisation period.

Colonisation of diatoms on artificial substrata generally takes two to four weeks to produce adequate growth (Round 1993), but colonisation has been known to take up to eight weeks in moderately nutrient enriched rivers (Biggs 1988). In this study, the substrata remained in the water at each site for seven weeks, from 5 March to 23 April. This was a compromise between the likelihood of adequate community colonisation and the risk of disruption from high flows, vandalism or grazing. To provide more reliable results, three substrata were placed at each site. These replicates were situated no more than five metres apart.

Sampling was restricted to locations with at least moderate flow (generally riffles) and placed so that the slides were parallel with the flow. This was to reduce the likelihood of silt accumulation on the substrata which could smother the diatom communities. Artificial substrata were positioned at a depth of around 30 to 45 cm to increase the chance that they would be permanently immersed.

After the seven-week colonisation period, diatoms were scraped into a separate sample jar for each substratum. Removal of diatoms from the slides and the preparation of samples for microscopic analysis followed the methods of Round (1993).

Slides were examined under oil immersion using Nomarsky Differential Interference Contrast at a magnification of x1000. For each slide a random transect was chosen and the first 200 frustules encountered were recorded. Where possible, identification was to species level.

3.4 Macroalgae

‘Macroalgae’ is a term used to describe algae which are macroscopically visible and typically filamentous. Entwisle (1989) identified several reasons for usefulness of macroalgae as bio-indicators:

- they are fixed to the substratum and are, therefore, unable to use avoidance behaviour to escape unfavourable conditions;
- they are usually easy to observe in the field;
- their abundance can be estimated in the field;
- they are totally submerged and thus, reflect the water quality better than many emergent plants; such as *Phragmites* and *Typha*, and
- most species are widespread.

For such reasons, macroalgae have the potential to be valuable indicators of water quality, but their application (particularly in Australia) has been retarded by the limited taxonomic and ecological information of many species (Entwisle 1989).

Macroalgal sampling was conducted at each site on a single occasion. Samples were only taken from macroscopically visible growths. All sites were shallow and fairly clear, enabling the collection of samples to the maximum depth. Samples were preserved at the time of collection with 10% Lugol's Iodine.

The composition of available algal habitat and its proportion to the total substrata was determined at each site, using a scale from 0 to 5 where: 0 = 0% of total site substrata, 1 = <10% of total site substrata, 2 = 10-35% of total site substrata, 3 = 35-65% of total site substrata, 4 = 65-90% of total site substrata and 5 = >90% of total site substrata. When algal samples were taken, the cover of each sample type on the various substrata was also estimated (using the same scale as above). At each site, a broad estimate of water surface shading was determined from low, moderate and high.

Where possible, the macroalgae were identified to species using a light transmission microscope. At least three sub-samples were used to identify the species present in each sample. A general abundance value from 1-3, based on the method of Entwisle (1989), was applied to each sample where: 1 = isolated plants, 2 = not common and 3 = common and easily observed.

Methods used to survey the macroalgal community in this catchment represent a balance between time and subjectivity. Because visual estimates of cover and shading were made, sampling was not statistically replicable, but many of the more objective methods may obscure the subtleties in community structures and the results they achieve are often no better than rapid visual estimates (Entwisle 1989).

3.5 Macroinvertebrates

Macroinvertebrates were qualitatively sampled using a rapid bioassessment technique in accordance with protocols defined in the River Bioassessment Manual (MRHI 1994). Invertebrates were collected from pool and riffle habitats at each site, except for Ferntree Gully Creek, Clematis Creek and Monbulk Creek at Belgrave-Gembrook Road (where there were no pools suitable to sample), and Corhanwarrabul Creek at Wellington Road and Monbulk Creek at Karoo Road (where there were no riffles). This method aims to collect as many taxa as possible within an *in situ* 30 minute live sort. Animals picked from the sample were preserved in alcohol and sent to Water Ecocience for identification. Further details regarding this technique and the laboratory processing of samples are detailed by Smith *et al.* (1997).

Invertebrate data are analysed in terms of faunal composition, diversity, key families as specified in the draft Schedule for the Yarra (EPA 1995), and by using a biotic index called the Stream Invertebrate Grade Number - Average Level, or SIGNAL. The pollution sensitivity grade numbers derived by Chessman *et al*. (1997) from the Hunter River catchment in NSW were used for calculating the SIGNAL index. Algorithms used to calculate pollution sensitivity grade numbers were also used to develop scores for Melbourne's waterways, using a database established by the CRC for Freshwater Ecology, Monash (Chris Walsh , personal communication).

3.6 Fish Surveys

Fish surveys were conducted in Corhanwarrabul Creek at Wellington Road, Ferny Creek at Hancock Drive and New Road, and Monbulk Creek at Karoo Road, Nixon Road and Belgrave-Gembrook Road. Each site was surveyed on one occasion to observe the type of fish fauna that inhabits these waterways and to identify those factors that may influence fish abundance and distribution.

Fish surveys were conducted by the Marine and Freshwater Resources Institute (MFRI) with some field assistance from MWC personnel. Fish were surveyed using a method, which would provide an estimate of fish densities and which could be repeated in further surveys.

The method involved collecting fish from a 100 m section of stream. Stop nets were positioned at each end of the sampling area and the fish were collected using a portable Smith-Root model 12 backpack electrofisher. Two electrofishing passes were conducted at each site, with the second run commencing a minimum of 30 minutes after the end of the first. Sampling was conducted during March and April 1997. All fish and freshwater crays captured were identified and a sub-sample of 20 individuals of each species was measured for length and weight. The bulk weight of fish at each site was also recorded. A visual assessment of flow type, substratum composition and in-stream habitat was also made, and was used to assist in site and aquatic faunal comparisons. Further details of this method are presented by Raadik & O'Connor (1997).

3.7 Platypus surveys

A survey was conducted as part of the Australian Platypus Conservancy/ Melbourne Water Urban Platypus Program, to determine the abundance and distribution of platypus in the study area, and to identify those factors that influence platypus ecology in urban waterways.

Two fyke nets were set at each site overnight, with one net facing downstream, and the other facing upstream. Each net is suspended partially out of the water to ensure that trapped platypus are able to breathe. Any other animals (ie. water rats, tortoises and fish) collected in these nets were also recorded. Further details regarding methods used in this survey are detailed in Serena and Williams (1997).

Platypus were surveyed from 38 sites in the study area between November 1996 to June 1997. Sites were located on Clematis Creek (one site), Monbulk Creek (16 sites), Ferny Creek (12 sites), Corhanwarrabul Creek (four sites) and Dandenong Creek within the vicinity of Corhanwarrabul Creek (five sites). Platypus surveys were also conducted in Monbulk and Corhanwarrabul Creeks during March 1996 (Serena and Williams 1996).

Eight platypus, consisting of three males, one sub-adult male, three adult or sub-adult females and one juvenile female, were fitted with radio-tags after being captured in Monbulk Creek. Movement of these animals was then monitored over the following four to 61 days, to gather detailed information on their range and to determine whether the platypus preferred some sections of waterways over others. Another interesting objective was to determine whether or not the drop structure below the Monbulk Retarding Basin was a barrier to the movement of platypus. Further details of this work are presented by Williams *et al*. (1997) and Serena *et al*. (1997).

4. RESULTS

4.1 Stream condition assessment

Corhanwarrabul Creek is in slightly better structural condition than the lower sections of Monbulk and Ferny Creeks. However, a number of rock chutes between the confluence of Ferny and Monbulk Creeks and Stud Road require repair. These problems have been created by poor rock grading, inadequate foundations and minimal tail-slope length. Increasing catchment development upstream of theses chutes will only increase the risk to these assets.

Corhanwarrabul Creek downstream of Stud Road is severely infested by willows (*Salix* spp) in-stream, and blackberries *(Rubus fruiticosis)* and gorse *(Ulex europeaus)* on the verges. A section of the waterway adjacent to the Caribbean Gardens has been cleared and the bank and verges adjacent to the Kingston Links Golf Course have been markedly upgraded, but the right bank remains in poor condition due to weeds and other exotic vegetation. A series of rock chutes have recently been built on the creek after willow removal along the golf course. Additional chutes are needed to cope with further drops in the bed and to reduce excessively steep tail-slopes on existing structures. Similar works are needed at intervals throughout the lower creek.

Figure 4: Bank erosion at a rock chute in Corhanwarrabul Creek

Ferny Creek - Overview

The lower section of Ferny Creek, between Corhanwarrabul Creek and the pipeline near Hancock Drive, has moderate to severe bed degradation and bank erosion problems. The worst section is below Knox Park, where existing rock chutes have been largely destroyed by a combination of hydraulic conditions and willow growth through the rocks. Whilst it may be viewed that the willows are assisting in resisting the bed degradation, their location in the channel creates major obstructions to flows. The levee bank and bike path on its crest are affected in places by bank wash-outs around the willow trees. Consideration should be given to the removal of these willows, given the potential threat to council assets (ie. the bike path) and the levee bank.

Figure 5: Willow obstruction and associated bank wash-out in Ferny Creek near Hancock Road

The section of Ferny Creek between the pipeline inlet near Waters Avenue (upstream of Glenfern Road) and the MWC Retarding Basin has incised to bedrock in places, but steep banks are still subject to erosion and possible slippage processes in places on the northern residential property frontages. The creek has high values and good stability upstream of the retarding basin through to Morris Road, but is marred by rubbish deposits and exotic understorey growth, especially sweet pittosporum (*Pittosporum undulatum)*. Weed eradication is required to ensure the existing values are maintained and enhanced.

Primary concerns for the stability of Ferny Creek in its upper reaches in Upwey and Tecoma are the many private access crossings and floodplain infills that have been built. The creek alignment is typically tortuous below the railway and there are numerous private retaining walls, landfills, culverts, and rubbish dumps which interfere with flows and degrade the creek environs in general. A similar pattern of interference with the creek and its over bank areas occurs upstream of the Burwood Highway through to its headwaters in the suburb of Ferny Creek.

The riparian buffer has been severely compromised by garden escapees. Ivy *(Hedera helix)* and other creepers and exotic understorey smother virtually all other understorey and groundcover growth, and often extend high into many of the canopy trees.

Figure 6: Noxious weed infestation in Ferny Creek

Monbulk Creek - Overview

Monbulk Creek (18.5 km in length) has similar, but less severe, stream condition problems than in Ferny Creek. Lateral instability is a typical characteristic of its tortuous middle reaches downstream of Belgrave-Hallam Road to Monbulk Creek Retarding Basin. Restoration of remnant riparian vegetation and revegetation is required to sustain the condition of the riparian zone. Stream bank

Figure 7: Monbulk Creek downstream of Nixon Road

stabilisation is not likely to be sustainable in this section, except to protect important assets (including major remnant overstorey trees).

Downstream of the Monbulk Creek Retarding Basin, Monbulk Creek is straight and dominated by exotic trees, principally willows. The stream has moderate bed and bank erosion downstream of Blackwood Park Road to the Ferny Creek confluence; a large section of this stream is proposed to be incorporated into a golf course development. This area also has a severe infestation of blackberries and there has been widespread dumping of refuse. The poor bed and bank condition of Monbulk and Ferny Creeks within the Knox Reserve are of concern and will need to be considered as part of any future development in the area.

Figure 8: Monbulk Creek upstream of the Monbulk Creek Retarding Basin

Figure 9: Ferny Creek Retarding Basin

4.2 Water Quality

4.2.1 The impact of Corhanwarrabul Creek on the water quality of Dandenong Creek

Corhanwarrabul Creek is a major tributary of Dandenong Creek that, on average, contributes about 32% of the flows in Dandenong Creek at Police Road (unpublished flow data). Therefore, the water quality of Corhanwarrabul Creek and its tributaries presumably will have a substantial impact on water quality in Dandenong Creek. Some water quality monitoring has been conducted in Dandenong and Corhanwarrabul Creeks since 1979, by MWC and the former Dandenong Valley Authority. Summary water quality and bacteriological data from Dandenong Creek upstream (Ferntree Gully Road) and downstream (Stud Road) of the Corhanwarrabul confluence, and data from Corhanwarrabul Creek near Wellington Road are presented in Table 1.

Corhanwarrabul Creek is the only major tributary between these monitoring sites on Dandenong Creek, although there are also several small waterways that drain urban areas to the east of Dandenong Creek. In addition, the Police Road Retarding Basin, which is located between these sampling sites, would also impact water quality in Dandenong Creek. It is also noteworthy that there are considerable differences in the number of samples collected from these three sites. Therefore these summary data only provide an indication of prevailing water quality at these sites, and more detailed analyses between data collected on the same date would be required to obtain more rigorous summary data.

Summary data in Table 1 indicate that there is a general improvement in the water quality of Dandenong Creek between Ferntree Gully and Stud Roads. In particular, there are reduced conductivities, nitrates, ammonia, orthophosphates, *E. coli* and BOD. In comparison to Dandenong

Creek at Ferntree Gully Road, Corhanwarrabul Creek has low conductivities, ammonia, orthophosphates, *E. coli* and BOD. This improvement would appear to be partly due to inflows of better quality water from Corhanwarrabul Creek, although improvements would also be due to microbial and other natural in-stream processes that would occur in these stable lowland sections of Dandenong and Corhanwarrabul Creeks .

Table 1: A comparison of median values of various water quality and bacteriological parameters collected from Dandenong Creek at Ferntree Gully Road and Stud Road between 1979 and 1994. The percentage change in median values between the two Dandenong Creek sites and summary data from the Corhanwarrabul Creek from Wellington Road are also presented. The numbers of samples collected for each parameter from these sites are provided in the parentheses.

Parameter	Dandenong Ck. at Ferntree Gully Rd.	Dandenong Ck. at Stud Rd.	% Change between sites	Corhanwarrabul Ck. at Wellington Rd.
Dissolved Oxygen	7.1 (144)	9.0 (313)	21	7.8 (32)
Water Temperature	13.9 (143)	14.0 (312)	0.7	13.2 (32)
Suspended Solids (Median)	20 (146)	18 (319)	-10	16 (33)
- 90%ile	92 (146)	75 (318)	-18	51.4 (33)
Turbidity	29 (147)	33 (318)	14	28 (33)
- 90%ile	90 (147)	90 (318)	0	55 (33)
Conductivity	645 (146)	520 (319)	-19	400 (33)
Nitrate	1.2 (140)	0.86 (313)	-28	1.1 (33)
Ammonia	0.18 (134)	0.1 (140)	-44	0.1 (33)
TKN	0.7 (17)	0.75 (186)	7	0.49 (7)
Orthophosphate	0.195 (144)	0.06 (311)	-69	0.09 (33)
Total Phosphorus	0.1 (25)	0.1 (184)	0	0.9 (7)
E. coli	3500 (132)	900 (300)	-74	1600 (28)
BOD	3 (138)	1.9 (243)	-37	2.2 (32)
Flow (ML/day)	37.5 (134)	47.5 (297)	20	15 (32)

These results indicate that Corhanwarrabul Creek contributes a large proportion of the flows and tends to improve the water quality in Dandenong Creek.

4.2.2 Water Temperature

Water temperature can have a substantial effect on many aquatic organisms. Physiological processes have thermal optima, and alterations to ambient temperatures may affect species in a variety of ways. However, there are currently insufficient data to recommend a guideline relating to reductions in temperature (ANZECC 1992).

Water temperatures recorded during base flow in January to April 1997 are illustrated in Figure 10. The median water temperatures were similar at all sites, ranging between 14.4 to 16.6 °C. The very hot weather that occurred during January to March 1997 would have created unusually high temperatures in the waterways. The highest water temperature of 25.6 °C was recorded from Monbulk Creek below Belgrave Lake on 19 February 1997. Almost all sites had their highest recorded water temperatures during this survey on 19 February, when maximum air temperatures exceeded 40 °C.

Figure 10: Water temperatures in Corhanwarrabul Creek and tributaries

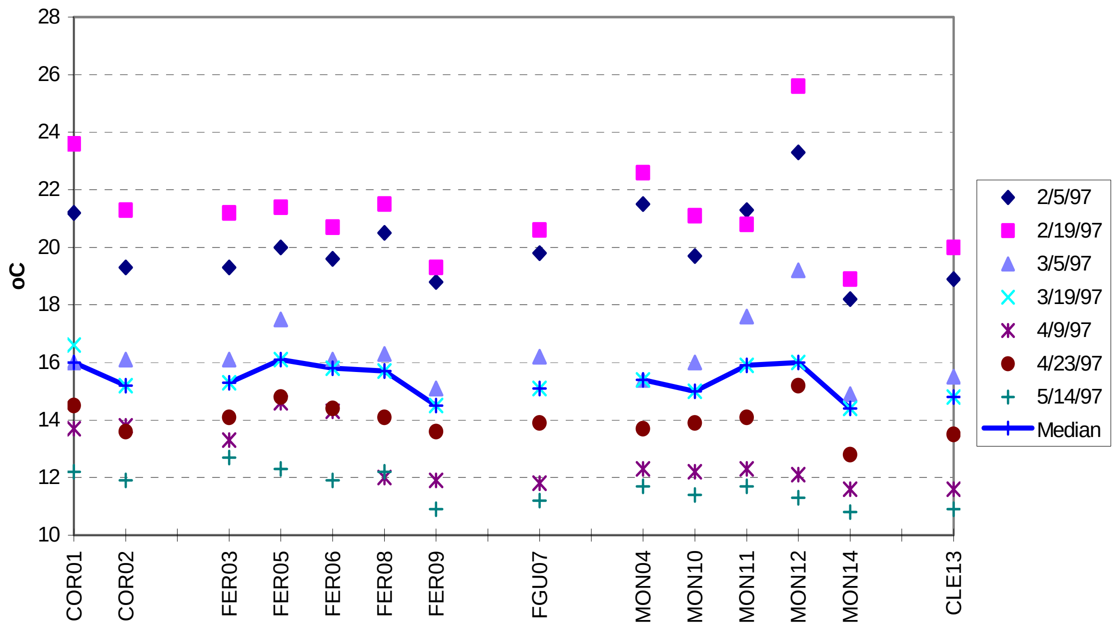
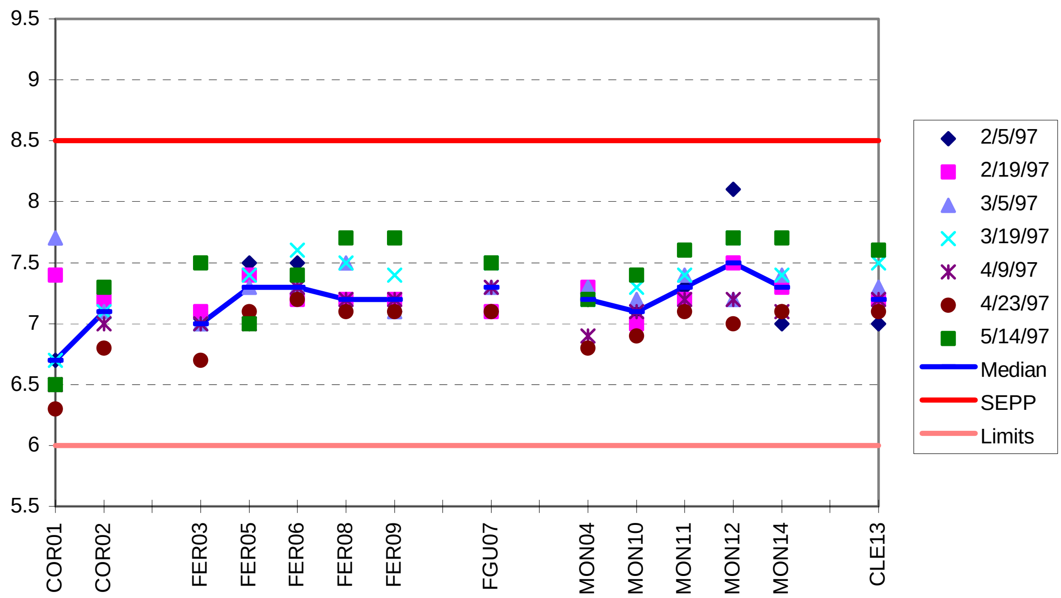


Figure 11: pH in Corhanwarrabul Ck. and tributaries.



4.2.3 pH

SEPP objectives for waters of Corhanwarrabul Creek and its tributaries state that pH should remain between 6.0 and 8.5 (Victorian Government 1988). The pH of waters at the study sites during base flows between January and April 1997 is illustrated in Figure 11. All fourteen sites were found to have pH values within the SEPP objective on all seven occasions they were sampled during base flows.

4.2.4 Fluoride

Fluoride concentrations are naturally low in most Australian soils and waterways. Streams in the Yarra catchment naturally have fluoride concentrations less than 0.1 mg/L (e.g. Brizga *et al*. (1994), Pettigrove & Coleman (1998) and Coleman & Pettigrove (1998)). Melbourne's water supplies are fluoridated to maintain average concentrations around 1.0 mg/L in drinking water (Shane Haydon, MWC, Water Supply Section, personal communication). Levels of fluoride in waterways can therefore, indicate the origin of the water in a stream. Water supplied through Melbourne's domestic water supply that discharges into local waterways will elevate fluoride concentrations, whereas direct run-off of other waters in the catchment will have low fluoride concentrations.

Fluoride concentrations in Corhanwarrabul Creek and tributaries are presented in Figure 12. Median concentrations of fluoride were 0.3 mg/L in Ferny Creek downstream of Lysterfield Road and in both sites on Corhanwarrabul Creek. In comparison, there was less fluoride present in Monbulk Creek, although 0.7 mg/L of fluoride was detected on one occasion at Puffing Billy Bridge and at Lysterfield Road. In comparison, low concentrations were detected in Ferntree Gully and Clematis Creeks.

The higher concentration of fluoride in sewered urban areas as opposed to unsewered low density urban areas (i.e upper Monbulk and upper Ferny Creeks), indicates that most base flows comes from urbanised sewered areas.

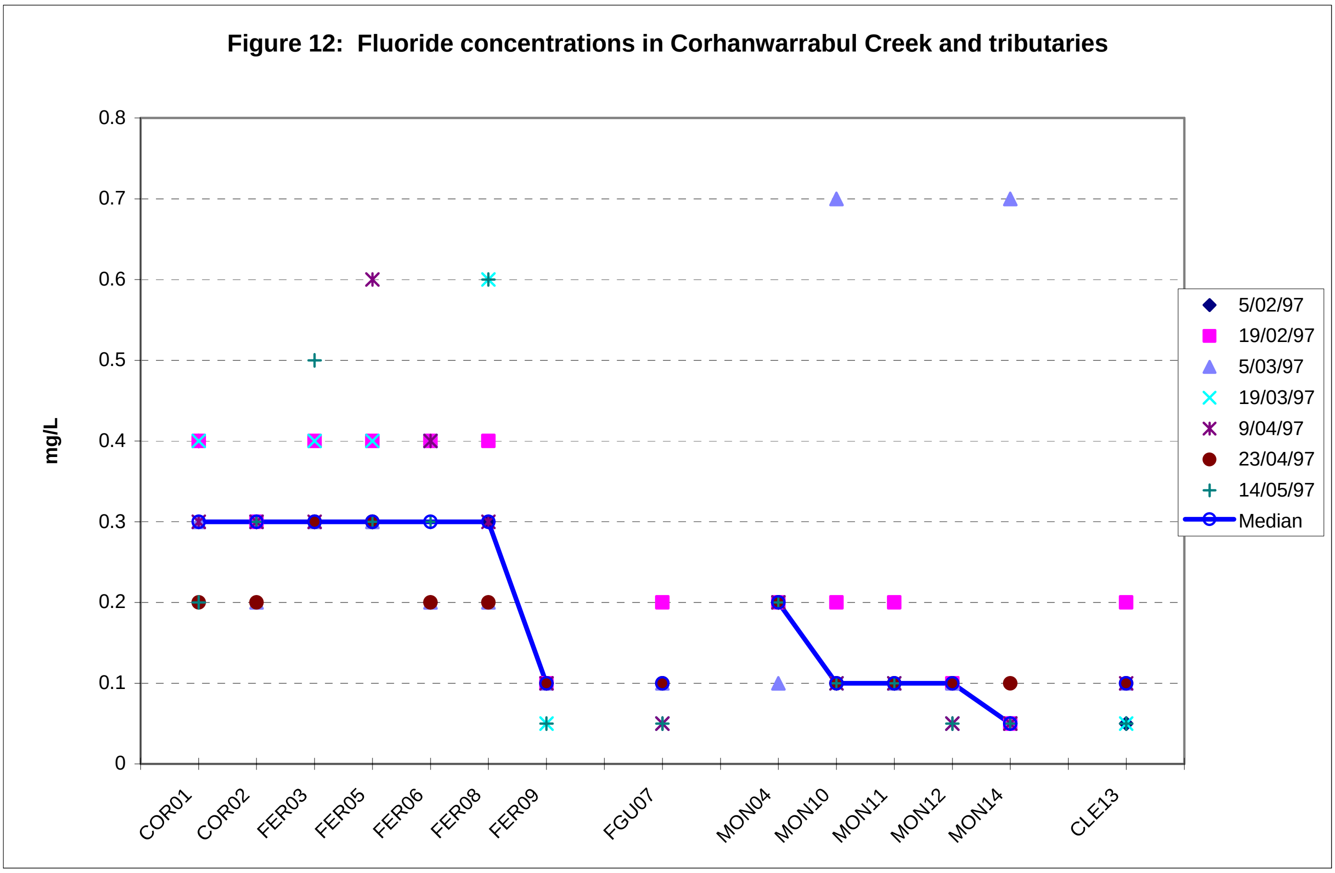


Figure 12: Fluoride concentrations in Corhanwarrabul Creek and tributaries
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
COR01
COR02
FER03
FER05
FER06
FER08
FER09
FGU07
MON04
MON10
MON11
MON12
MON14
CLE13
5/02/97
19/02/97
5/03/97
19/03/97
9/04/97
23/04/97
14/05/97
Median

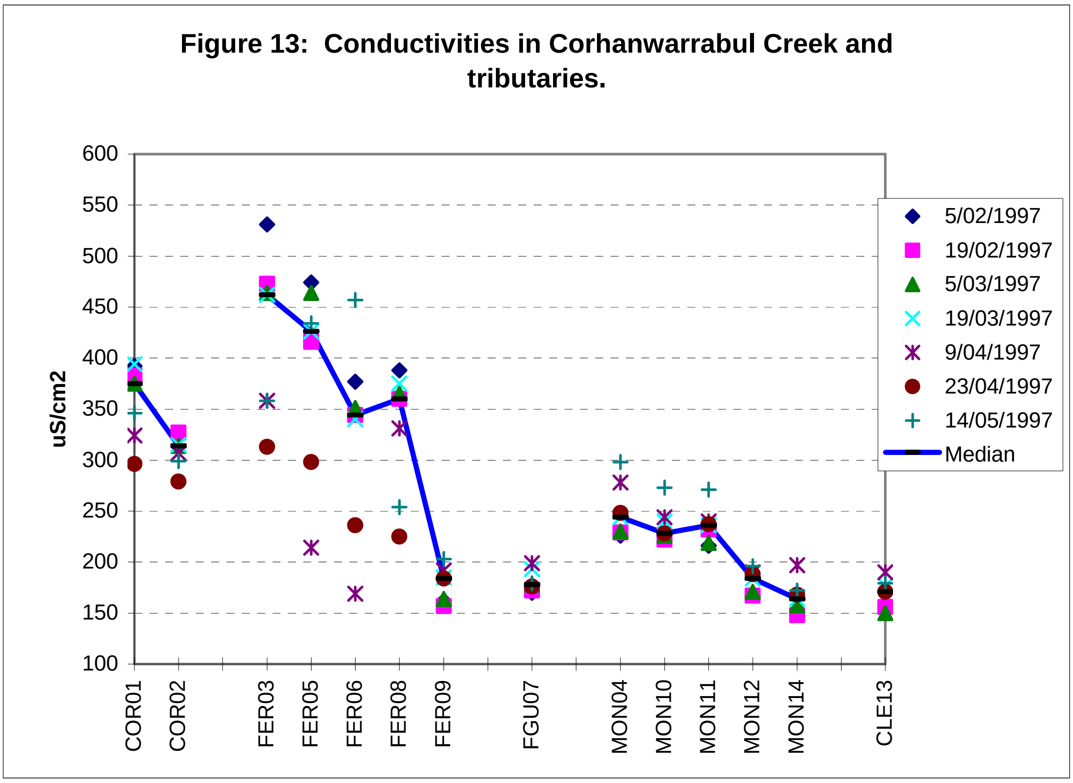


Figure 13: Conductivities in Corhanwarrabul Creek and tributaries.
uS/cm2
600
550
500
450
400
350
300
250
200
150
100
COR01
COR02
FER03
FER05
FER06
FER08
FER09
FGU07
MON04
MON10
MON11
MON12
MON14
CLE13
5/02/1997
19/02/1997
5/03/1997
19/03/1997
9/04/1997
23/04/1997
14/05/1997
Median

Results from this survey indicate that fluoridated water from urban areas contributes a substantial proportion of the flows in Ferny Creek downstream of Lysterfield Road and occasionally in Monbulk Creek during dry periods.

4.2.5 Conductivity

The SEPP objective for salinity in these waterways is that the 90th percentile of TDS (total dissolved solids) should not exceed 1,000 mg/L (Victorian Government 1988). This TDS concentration equates to about 1,500 μS/ cm^2 (ANZECC 1992).

Conductivities in Corhanwarrabul Creek and its tributaries during low flow periods are presented in Figure 13. They were all below the SEPP objective of 1500 μS/cm. There was a marked increase in conductivities in Ferny Creek downstream from a median value of 184 μS/cm at Sophia Street to 360 μS/cm at Lysterfield Road to 462 μS/cm at Rushdale Street. In comparison, there was only a slight increase in conductivities in Monbulk Creek moving downstream, and the highest median conductivity at Karoo Road was only 244 μS/cm. Conductivities in Ferntree Gully and Clematis Creeks were also low.

The difference in conductivities between the lower sections of Ferny and Monbulk Creeks probably reflect differences in land uses, with Ferny Creek catchment having a greater proportion of urban run-off.

It is possible to use the different conductivities from the lower section of Monbulk and Ferny Creeks to estimate the relative contribution of these streams to flows in Corhanwarrabul Creek during this study. The percentage contribution of flows from Monbulk Creek to flows in Corhanwarrabul Creek (x) can be calculated using the following equation:

$$x = 100 (Cc - Cf)/ (Cm - Cf)$$

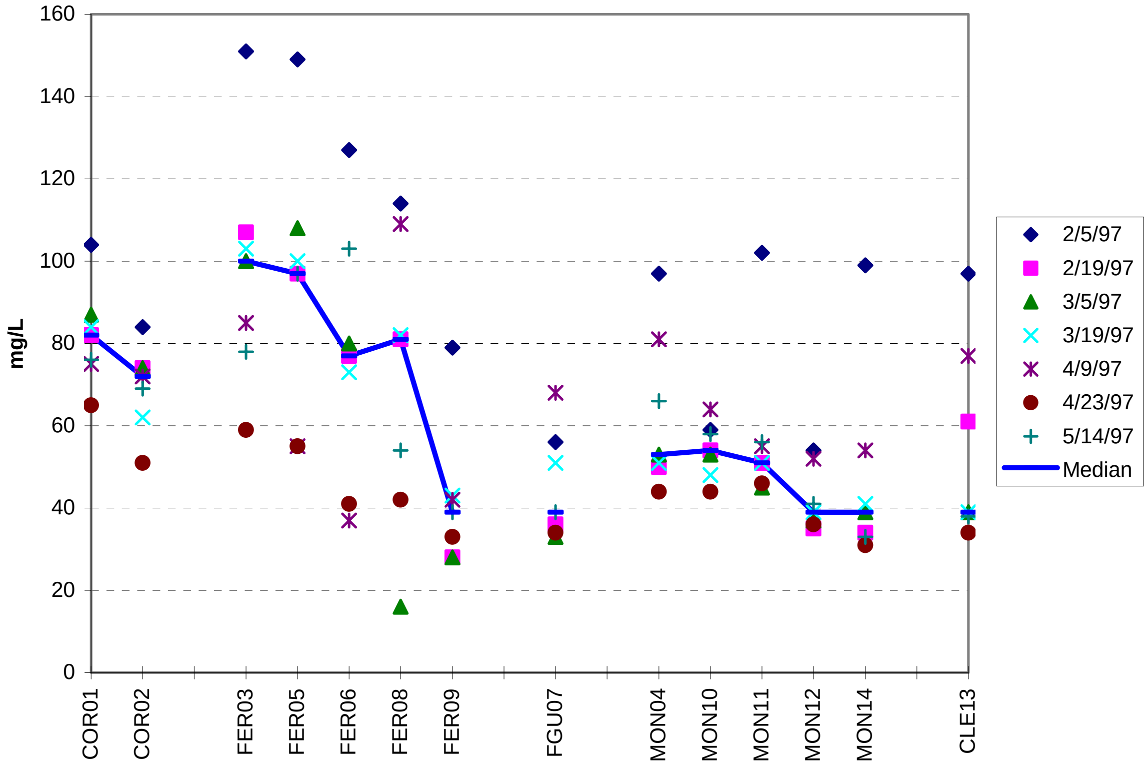
where: Cc is the conductivity in Corhanwarrabul Creek
Cf is the conductivity in Ferny Creek and
Cm is the conductivity in Monbulk Creek.

Results of this equation indicate that Monbulk Creek contributed between 60 and 68% (median 64%) of the flows in Corhanwarrabul Creek on five of the seven occasions it was sampled during this survey. On the other two occasions, conductivities in Monbulk and Ferny Creeks were similar, and therefore, it was not possible to make an estimate.

4.2.6 Chloride

Chlorine concentrations during low flow periods in waters of Corhanwarrabul Creek are illustrated in Figure 14. These results closely correlate to the conductivity results, thus indicating that chlorine is a major ion contributing to conductivities in these waterways.

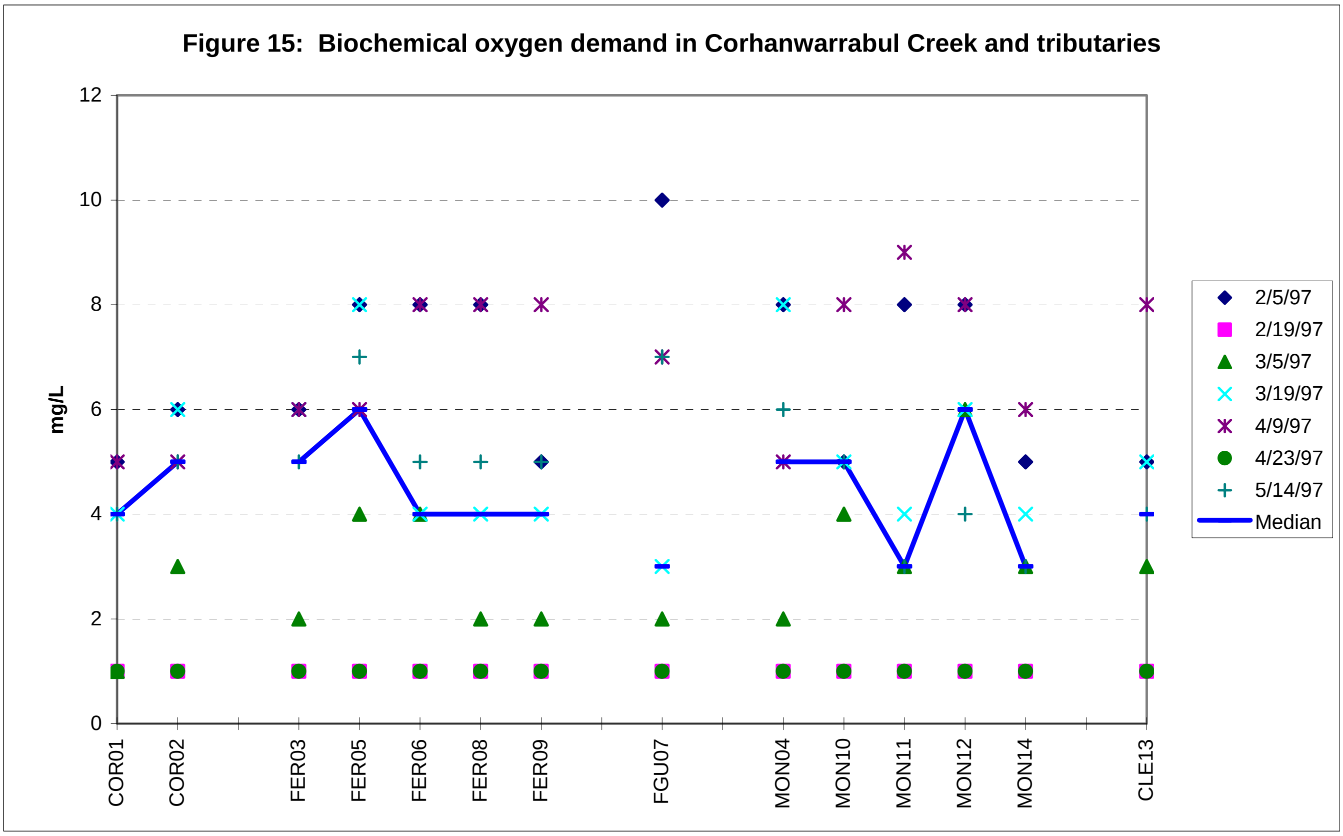
Figure 14: Chloride concentrations in Corhanwarrabul Creek and tributaries.



4.2.7 Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) test provides a measurement of the quantities of oxygen consumed during biological oxidation of organic waste matter under controlled conditions. It is possible to interpret the BOD data semi-quantitatively in terms of gross concentrations of organic matter, as well as in terms of the amount of oxygen in the stream that is likely to be consumed by organisms feeding on organic material (e.g. Nancy & Weber 1971). There are no SEPP or ANZECC objectives for BOD, but BOD levels in natural streams and lakes are generally less than 5 mg/L (SER 1988).

Median BOD levels ranged between 3 to 6 mg/L at all sites (Figure 15), indicating moderate levels of organic enrichment (SER 1988). BOD levels were similar between sites during any particular sampling event and varied more in relation to sampling events than between sites. For example, the BOD were below the detection limit of 2 mg/L at all sites during 19 February and 23 March 1997. In contrast, BOD concentrations were about 5 to 9 mg/L at all sites during 9 April 1997. The most elevated BOD (10 mg/L) was collected from Ferntree Gully Creek during 5 February, two weeks after a large section of this catchment had been burnt by a bushfire during mid-January 1997.

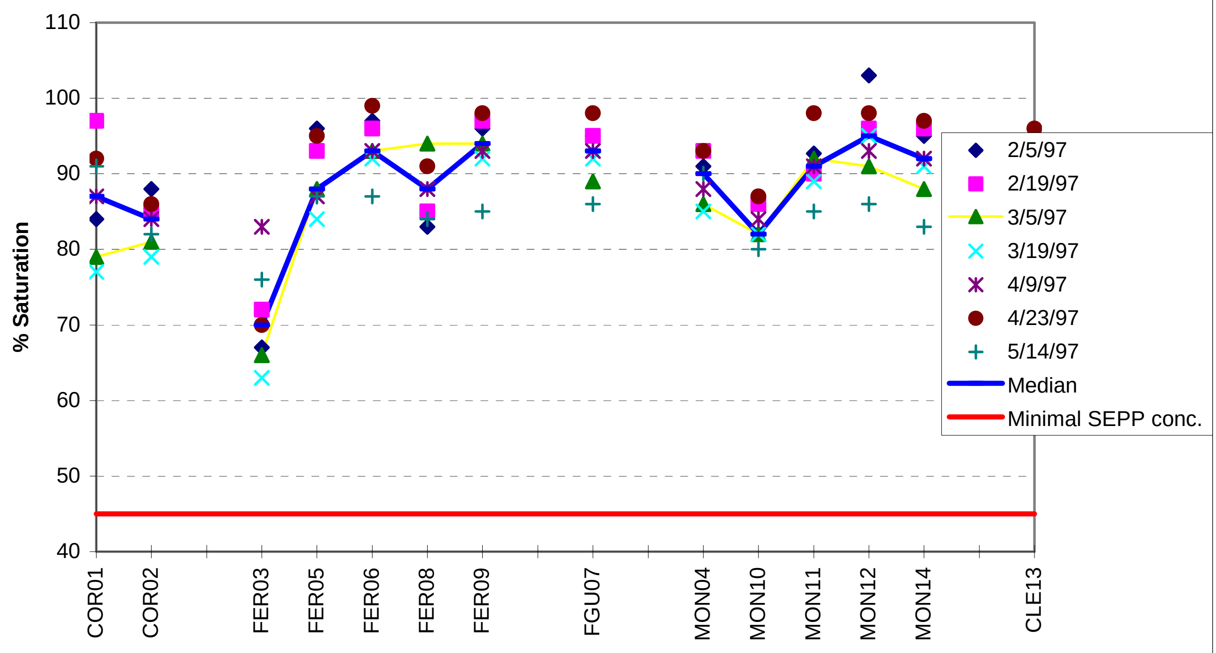


4.2.8 Dissolved Oxygen

Low concentrations of dissolved oxygen (DO) can have a major impact on the types of organisms that can inhabit waterways. The SEPP objective for waters of the Corhanwarrabul catchment states the minimal DO concentration should exceed 4.5 mg/L or 45% saturation (Victorian Government 1988). DO levels below this level can stress many freshwater fish (e.g. Koehn & O'Connor 1990) and many macroinvertebrate taxa (e.g. Hynes, 1971).

DO results during base flows are illustrated in Figure 16. All sites met the SEPP objective on all occasions they were sampled during low flows. Furthermore, all sites, except Ferny Creek at Rushdale Street, usually had DO concentrations greater than 80% saturation. The lower DO levels in Ferny Creek may be due to a lack of riffle habitats, which would aerate waters, and additional microbial respiration that would deplete DO concentrations.

Figure 16: Dissolved oxygen levels in Corhanwarrabul Creek and tributaries.



4.2.9 Nutrients

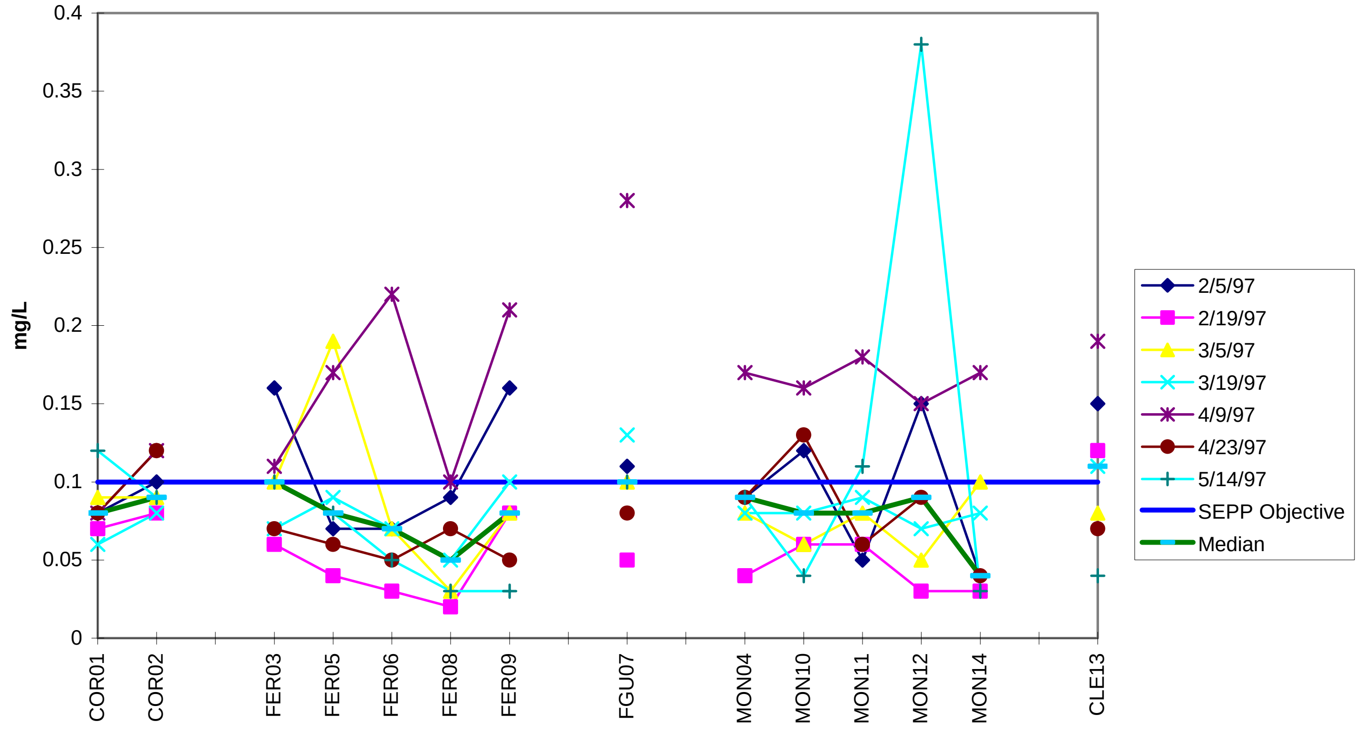
Phosphorus

The SEPP nutrient objective for waters of the Corhanwarrabul catchment is that "nutrients and other growth stimulants shall not be present in quantities sufficient to cause excessive or nuisance growths of algae or other aquatic plants in these segments or in downstream waters" (Victorian Government 1988). There is no quantitative SEPP objective for phosphorus in the Dandenong Valley, however an interim maximum objective of 0.1 mg/L has been proposed for urban tributaries, such as those in the Corhanwarrabul catchment (Tiller & Newall 1995).

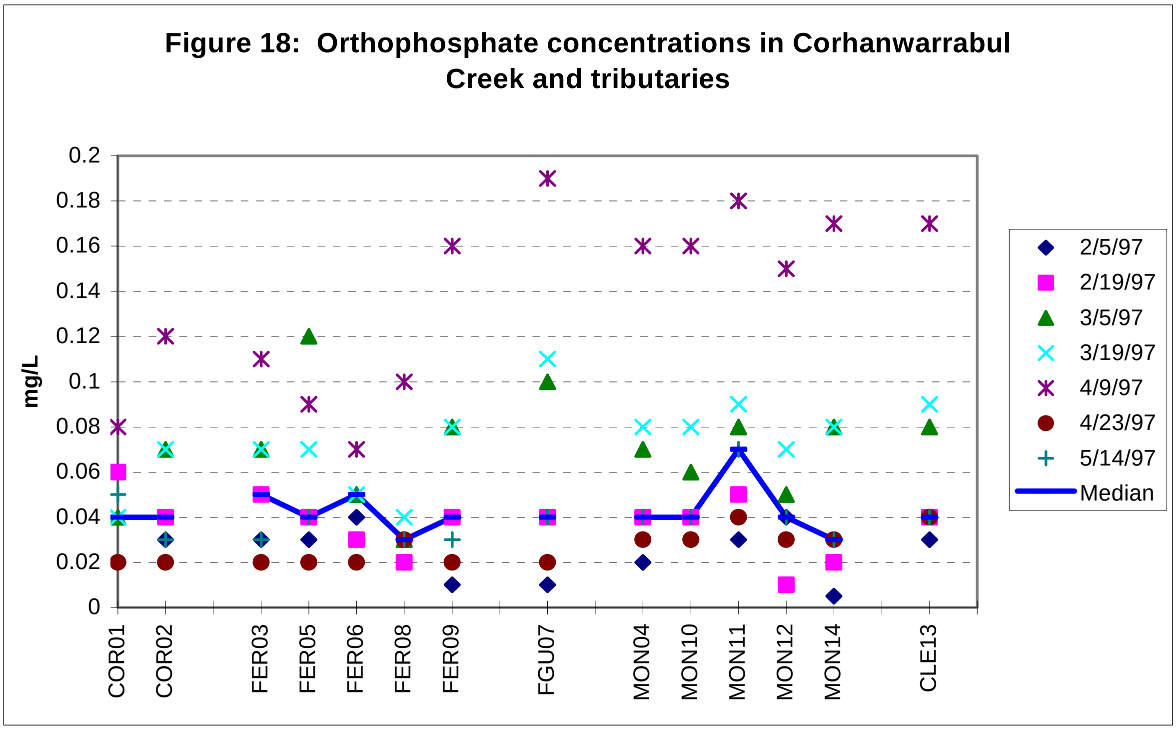
Total phosphorus concentrations during base flows in the Corhanwarrabul catchment are presented in Figure 17. All sites exceeded the 0.1 mg/L total phosphorus maximum on at least one of the seven occasions they were sampled during base flows, but the sites were below 0.1 mg/L on most occasions. Median total phosphorus ranged from 0.04 mg/L in Monbulk Creek at the Puffing Billy Bridge, to 0.11 mg/L in Clematis Creek. Total phosphorus concentrations also varied in relation to sampling period. For example, the highest concentrations at most sites were detected during 9 April, whereas low concentrations occurred during 23 April 1997.

These total phosphorus concentrations were good when compared to other urban waterways. For example, the median total phosphorus levels in Dandenong Creek between Stud Road and Pillars Crossing during 1996/97 ranged between 0.11 and 0.12 mg/L (Coleman *et al.* 1998).

Figure 17: Total phosphorus concentrations in Corhanwarrabul Ck. and tributaries. The interim EPA total phosphorus objective for urban tributaries is also presented



Orthophosphate concentrations during base flows are presented in Figure 18. Orthophosphates tended to co-vary with total phosphorus. For example, orthophosphate concentrations were high in 9 April and low during 23 April. There was little spatial variation during the survey, with the median concentrations ranging from 0.03 mg/L in Monbulk Creek at the Puffing Billy Bridge and Ferny Creek at Lysterfield Road, to 0.07 mg/L in Monbulk Creek at Nixon Road.



The ratio of orthophosphate to total phosphorus can indicate the relative richness, or bioavailability, of the phosphorus that is present in a stream. Orthophosphate is readily assimilated by organisms, therefore elevated levels of this form of phosphorus in a waterway usually indicate that there is a local, rich source of phosphorus entering the waterway.

Table 2: The ratio of median orthophosphate to median total phosphorus in Corhanwarrabul Creek and tributaries

Creek	Location	Code	Ratio
Corhanwarrabul	Wellington Road	COR01	0.50
Corhanwarrabul	Henderson Road	COR02	0.44
Ferny	Rushall St.	FER03	0.50
Ferny	Hancock Dve.	FER05	0.50
Ferny	Lysterfield Road	FER06	0.71
Ferny	New Road	FER08	0.60
Ferny	Sophia Grove	FER09	0.50
Ferntree Gully	Mt. Dandenong Tourist Road	FGU07	0.40
Monbulk	Karoo Road	MON04	0.44
Monbulk	Napoleon Road	MON10	0.50
Monbulk	Nixon	MON11	0.88
Monbulk	d/s Belgrave Lake	MON12	0.44
Monbulk	Puffing Billy Bridge	MON14	0.75
Clematis	Belgrave-Gembrook Road	CLE13	0.36

Median ratios of orthophosphate to total phosphorus during base flows at the study sites are presented in Table 2. The ratio ranged from 0.36 at Clematis Creek to 0.88 at Monbulk Creek at

Nixon Road. Ten of these sites had a ratio between 0.40 to 0.60, whereas the ratio was also high in Monbulk Creek at Puffing Billy Road and in Ferny Creek at Lysterfield Road.

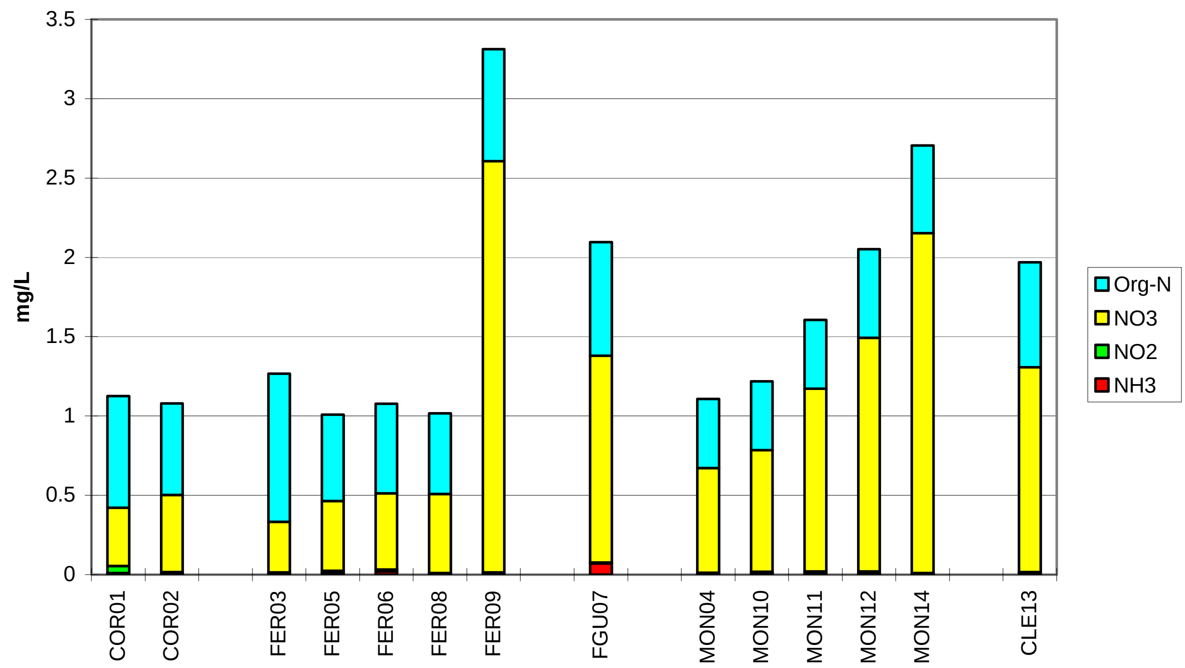
Nitrogen

There is currently no quantitative SEPP objective for nitrogen in waters of Corhanwarrabul Creek, however, an interim maximum objective for total nitrogen in such urban waterways is that total nitrogen should not exceed 1.0 mg/L (Tiller and Newall 1995).

Median nitrogen concentrations in Corhanwarrabul Creek and its tributaries during base flows are presented in Figure 19. The interim maximum guideline of 1.0 mg/L of total nitrogen was exceeded at all fourteen sites. Concentrations of total nitrogen tended to be highest in the headwaters of Ferny and Monbulk Creeks and became progressively lower downstream. Nitrogen levels were also elevated in Ferntree Gully Creek, particularly in the earlier part of the study when the catchment had just been extensively burnt from a bushfire. Nitrates from groundwater would appear to be a major source of nitrogen entering these waterways.

Most of the nitrogen present in the upper catchment was as soluble nitrate ions. For example, 78% of the total nitrogen in Ferny Creek at Sophia Street was as nitrate. Nitrate was also the predominant form of nitrogen throughout Monbulk Creek and Corhanwarrabul Creek, whereas the lower sites on Ferny Creek had a larger proportion of organic nitrogen.

Figure 19: Median nitrogen concentrations in Corhanwarrabul Creek and tributaries



Ammonia is a rich form of nitrogen that is readily adsorbed by plants. Elevated levels of ammonia can be acutely toxic to aquatic organisms, particularly fish. Salmonoid fish (e.g. trout) are particularly sensitive to ammonia. There is some general acceptance that undissociated ammonia should not exceed 0.02 to 0.03 mg/L in Australian waters. Given the prevailing pH during this survey was between 7.0 and 7.5 (Figure 11), and the water temperature was between 12 and 24 ^{o}C (Figure 10), a conservative recommended (ANZECC 1992b) guideline for total ammonia in waters of the Corhanwarrabul catchment would be 0.7 mg/L. However, a value of up to 2.2 mg/L would be acceptable with cooler water temperatures (less than 15 ^{o}C) that usually occur outside normal summer conditions.

Only low levels of ammonia were detected in this survey. The highest ammonia concentration detected was 0.47 mg/L from Ferntree Gully Creek, the second highest concentration was 0.1 mg/L from Ferny Creek. On all other occasions, ammonia concentrations were 0.4 mg/L or less. Therefore, ammonia levels were sufficiently low to not be a toxic threat to aquatic life.

Historical nutrient data

Some nutrient data have been collected from Monbulk, Ferny and Corhanwarrabul Creeks since 1978 by the former Dandenong Valley Authority (DVA) and MWC. Most of the data were collected two to four times per annum.

Orthophosphate concentrations recorded between 1978 and 1994 at four sites in the Corhanwarrabul catchment are presented in Figure 20. The data indicate a substantial reduction in orthophosphate concentrations since about 1984. This reduction correlates to large sections of the catchment being connected to a reticulated sewerage system.

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Ammonia concentrations in Monbulk, Ferny and Corhanwarrabul Creeks between 1978 and 1994 are presented in Figure 21. There is a similar trend to that illustrated by the orthophosphate data, as there is a substantial reduction in ammonia concentrations in the mid 1980s. Therefore, the elevated ammonia concentrations prior to 1984 seem to be due to sewage and sullage entering these waterways.

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Moving averages of nitrate concentrations in Corhanwarrabul, Monbulk and Ferny Creeks between 1978 and 1994 are illustrated in Figure 22. Nitrate concentrations have remained constant in Monbulk Creek at Nixon Road since 1978. Figure 22 also indicates that nitrate concentrations were high in the mid 1980s in Corhanwarrabul Creek at Wellington Road and in Ferny Creek at New Road and Glenfern Roads. There is no clear temporal trend in nitrates in Ferny Creek, but there has been a progressive reduction in Corhanwarrabul Creek at Wellington Road since 1978.

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4.2.10 *E. coli*

E. coli is widely used to provide an indication of faecal contamination and hence the potential for water to contain pathogenic organisms (EPA 1995). The SEPP objective for *E. coli* in waters of the Corhanwarrabul catchment is that the geometric mean should not exceed 1000 organisms/100 mL, nor shall 20% of samples exceed 2000 organisms/100 mL (Victorian Government, 1988). The geometric mean can only be based on a minimum of five samples collected during a period of not more than 42 days. This SEPP objective is intended to protect human secondary contact (such as fishing and wading) within these waterways.

Geometric means of *E. coli* in waters of the Corhanwarrabul catchment during base flows are presented in Figure 23. These means are only based on seven sampling events conducted during base flows between February and May 1997 (99 days). Sampling events do not fit the conditions specified in the SEPP to enable a correct assessment of compliance. This is because the samples were not randomly collected during any flows and the time span for comparisons is too long. However, the results are compared to these objectives to illustrate their suitability to secondary and passive forms of recreational contact within the waterway during base flows.

Figure 23: Geometric means of *E. coli* in Corhanwarrabul Creek and tributaries

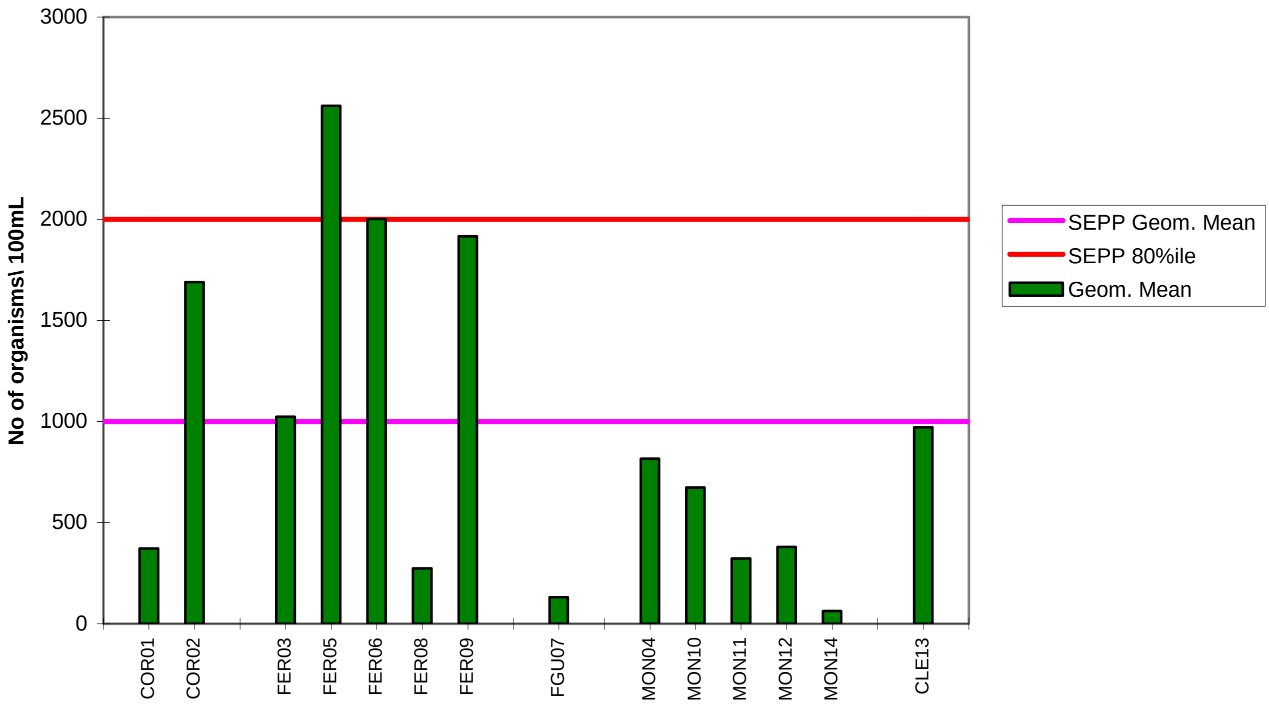
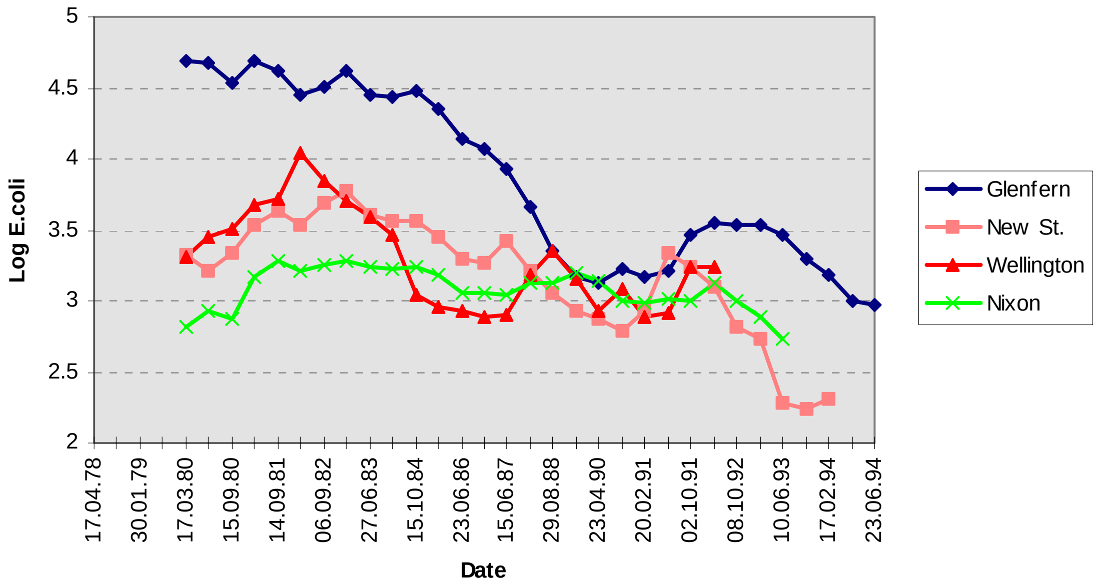


Figure 24: Moving averages of *E.coli* from Corhanwarrabul (Wellington Rd.), Ferny (New St. and Glenfern St.) and Monbulk Creeks (Nixon Rd.) between 1978 and 1994.



E. coli levels exceeded the SEPP for the geometric mean objective in Ferny Creek at Sophia Grove, Lysterfield Road, Hancock Drive and Rushdale Street, and in Corhanwarrabul Creek at Hendersons Road. All sites on Monbulk Creek had acceptable *E. coli* levels, although they tended to increase downstream. Ferny Creek sites also tended to exceed the 80th percentile objective more often than at the Monbulk Creek sites. *E. coli* levels in Ferny Creek at Hancock Drive exceeded 2000 organisms/100 mL on three of the seven occasions it was surveyed. Corhanwarrabul Creek at Hendersons Road also exceeded 2000 organisms/100 mL on three occasions but the levels declined downstream at Wellington Road to be below 1000 organisms/100 mL.

Historical E. coli data

Some E. *coli* data were collected since 1978 by MWC and the former DVA. Generally, two to four samples were collected every year. Figure 24 presents a moving average of the data collected since 1978 from Corhanwarrabul Creek at Wellington Road, Ferny Creek from New Road and Glenfern Street and Monbulk Creek from Nixon Road.

Figure 24 illustrates that there has been a reduction in *E. coli* in Ferny Creek and possibly in Corhanwarrabul Creek. The biggest reduction occurred in Ferny Creek at Glenfern Street where concentrations dropped from about 30,000 organisms/ 100 mL between 1978 and 1983 to about 3,000 organisms/ 100 mL in the past decade. This improvement in *E. coli* levels corresponds to sections of the catchment, particularly in the Ferny Creek sub-catchment, being connected to a reticulated sewerage system.

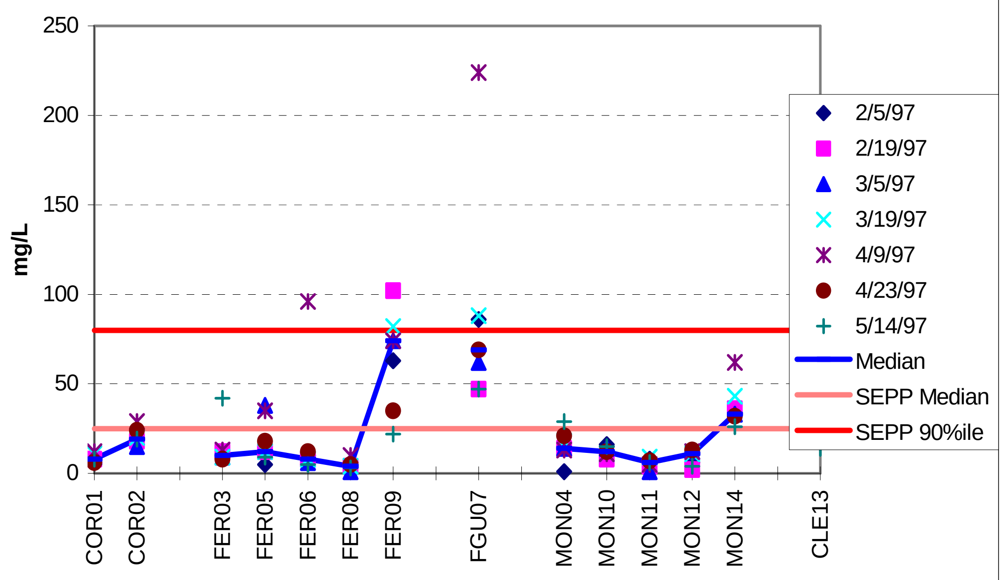
4.2.11 Water clarity

Suspended solids

The SEPP objectives for suspended solids concentrations in waters of Corhanwarrabul Creek is an annual median of 25 mg/L and a 90 percentile of 80 mg/L (Victorian Government 1988). Suspended solids results, presented in Figure 21, are compared to the SEPP objective. It should be noted, however, that the SEPP objectives are intended to encapsulate a variety of flows over a 12 month period, not just the base flows that were sampled. Given that more elevated suspended solids would normally occur during elevated flows, the base flows measured during this survey would be expected to yield lower than average levels.

Median suspended solids concentrations exceeded the SEPP objective in the four headwater streams, that is, Ferntree Gully Creek (69 mg/L), Ferny Creek at Sophia Street (74 mg/L), Clematis Creek (33 mg/L) and Monbulk Creek at the Puffing Billy Bridge (33 mg/L). The 90th percentile was exceeded at Ferntree Gully Creek (three occasions), Ferny Creek at Sophia Street (two occasions) and at Lysterfield Road (one occasion). Elevated suspended solids concentrations in Ferntree Gully Creek and possibly in other parts of the upper catchment of Ferny Creek, were probably caused by the January 1997 bushfires.

Figure 25: Suspended solids concentrations in Corhanwarrabul Creek and tributaries

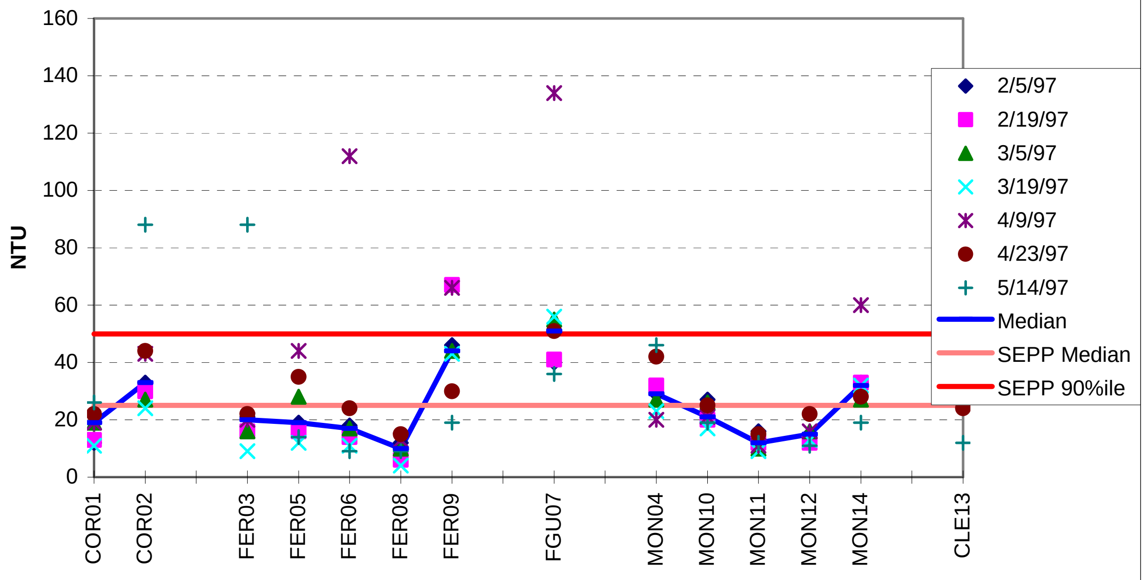


Turbidity

The SEPP objective for turbidities in waters of the Corhanwarrabul catchment are a median of 25 FTU and a 90 percentile of 50 FTU. The turbidities during base flows for all sampling sites are presented in Figure 22. For the purposes of an assessment with the SEPP objectives, the

Nephelometric Turbidity Unit (NTU) is considered to be equivalent to the Formazin Turbidity Unit (FTU) used in the SEPP.

Figure 26: Turbidities in Corhanwarrabul Ck. and tributaries.



The SEPP objective for median turbidity was exceeded in six of the fourteen sites surveyed. Headwater streams tended to have elevated turbidities, which declined in the middle sections of Ferny and Monbulk Creeks but again increased in the lower catchment near the confluence of Corhanwarrabul Creek. Very high turbidities in Ferntree Gully Creek and Ferny Creek at Sophia Street are probably due to run-off from areas burnt by the 21 January 1997 bushfires. Elevated turbidities in Ferny Creek at Rushdale Street and in Corhanwarrabul Creek at Henderson Road during 14 April were caused by a milky pollutant in these waterways at the time of sampling. The source of this pollutant could not be located. The 90th percentile was also exceeded in Ferny Creek at Sophia Street (two occasions) and Hancock Drive (one occasion), Ferntree Gully Creek (three occasions), Clematis Creek (one occasion) and in Monbulk Creek near the Puffing Billy Bridge (one occasion).

Generally, there were elevated turbidities in the study area during base flows. Recent bushfires would have led to turbid waters in the upper catchment of Ferny and Ferntree Gully Creek, but the elevated levels elsewhere would appear to be due to land disturbances within the catchment. These waterways would be expected to have an even poorer level of compliance during the wetter months of the year when there is greater surface run-off.

Historical water clarity data

Summary water clarity data irregularly collected from some waterways in the Corhanwarrabul catchment since 1977 are presented in Table 3. These results indicate that the turbidities and suspended solids have been generally acceptable over the past 20 years. All four sites complied with the SEPP objective for median suspended solids (25 mg/L), but the median SEPP objective for turbidities (25 NTU) was slightly exceeded at three sites.

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Table 3: Summary turbidity and suspended solids data collected from Corhanwarrabul, Ferny and Monbulk Creeks

	Corhanwarrabul	Ferny	Ferny	Monbulk
Site	**Wellington Road**	**Glenfern Road**	**New Road**	**Nixon Road**
Date	Apr. 1978 - Oct. 1996	Apr.1978 - Jul. 1994	Dec. 1977 - Aug. 1993	Feb.1978 - Oct. 1991
	SUSPENDED SOLIDS (mg/L)			
n	33	36	36	34
25%ile	12	10	8	13
Median	16	19	12	19
75%ile	32	70	20	28.75
90%ile	51.4	155	44	39.9
	TURBIDITY (NTU)			
n	33	36	36	33
25%ile	20	18	15	22
Median	28	25.5	21	30
75%ile	40	67	30	40
90%ile	55	102.5	49	53.6

Results also indicate that there are considerable increases in Ferny Creek in the 90th percentiles of suspended solids and turbidity between the New Road and Glenfern Road sites. High suspended solids and turbidities occurred in Ferny Creek at New Road and Glenfern Road in the early 1980s and between 1988 and 1990 (Figures 27 and 28). These elevated levels may be due to land disturbance from housing developments, the construction of the Ferny Creek Retarding Basin or any other large scale land disturbances. Suspended solids concentrations and turbidity were also consistently higher in Ferny Creek at Glenfern Road, than at the New Road site further upstream. The section of stream between these sites flows through eroded sections in the foothills of Mt. Dandenong.

The suspended solids concentrations and turbidities in Corhanwarrabul Creek at Wellington Road closely mimicked trends that occurred in Monbulk Creek at Nixon Road; although Ferny Creek appeared to contribute to elevated 90th percentiles of suspended solids and turbidity in Corhanwarrabul Creek. These results illustrate that Monbulk Creek has the most impact on water quality in Corhanwarrabul Creek. The slightly lower values in Corhanwarrabul Creek may be attributed to a small fraction of sediments depositing between these sites.

Figure 27: Moving average of suspended solids in Corhanwarrabul (Wellington Rd.), Monbulk (Nixon Rd.) and Ferny (New St. and Glenfern Rd.) between 1978 and 1994

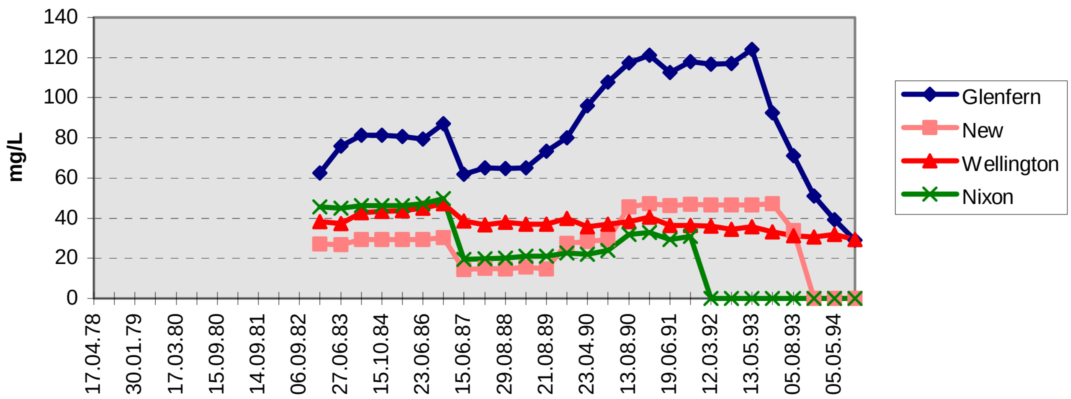
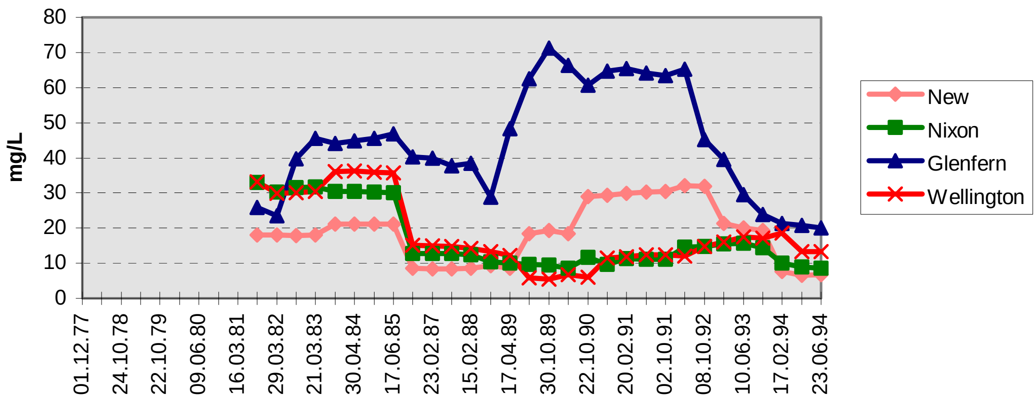
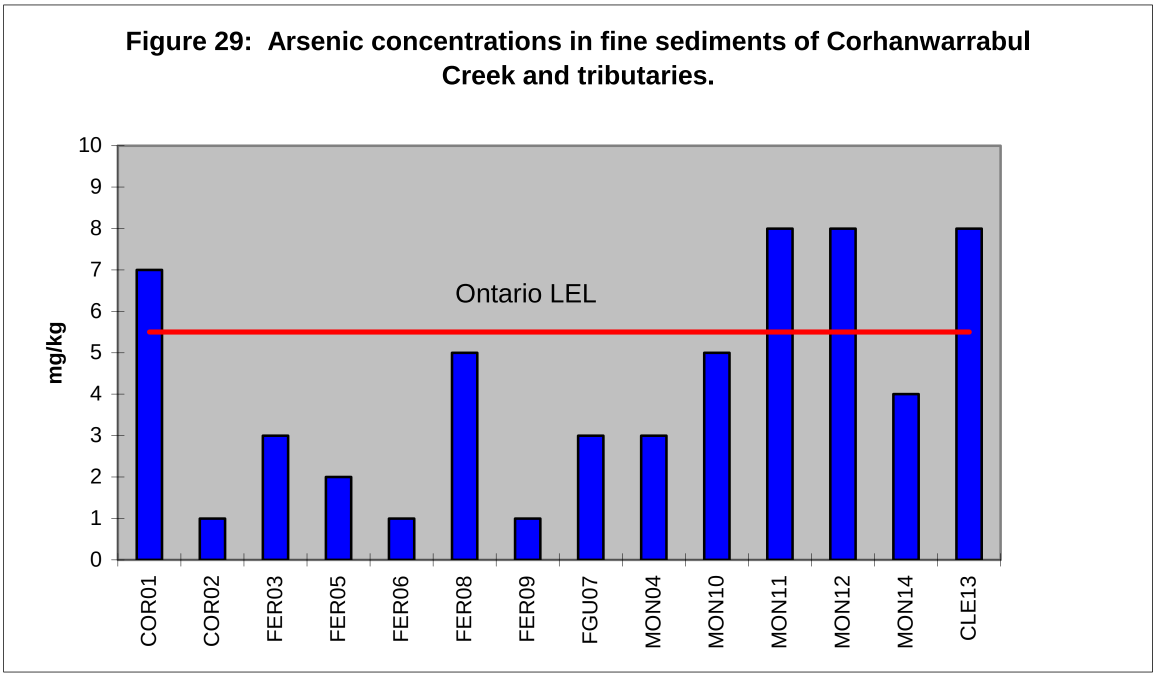


Figure 28: Moving average of turbidities in Corhanwarrabul (Wellington Rd.), Monbulk (Nixon Rd.) and Ferny (New St. and Glenfern Rd.) between 1978 and 1993



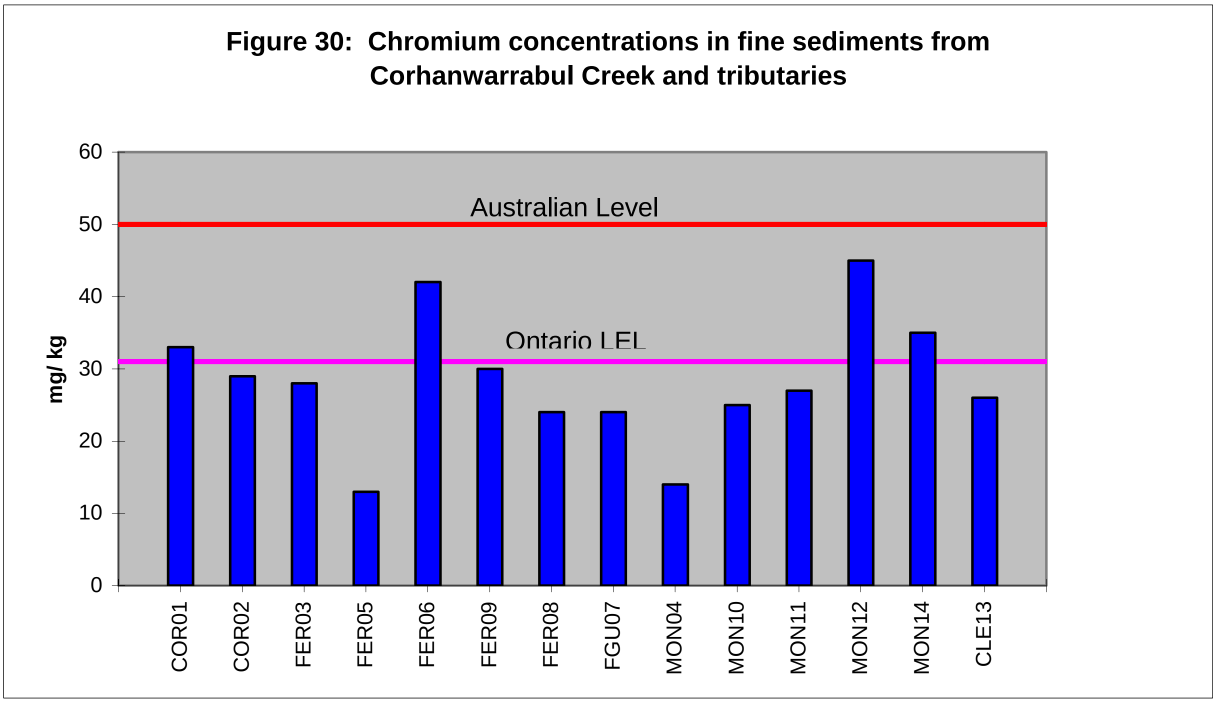
4.2.12 Toxicants in sediments

Arsenic concentrations in sediments from Corhanwarrabul Creek and tributaries are presented in Figure 29. They were all below the Australian Level B objective of 20 mg/kg, but the Ontario LEL objective was exceeded in Corhanwarrabul Creek at Wellington Road, Clematis Creek and Monbulk Creek at Nixon Road and Napoleon Road. Arsenic concentrations tended to be greater in Monbulk Creek than in Ferny Creek. Arsenic can be naturally high in Australian soils and in gold bearing quartz (e.g. Metzeling & Pettigrove 1988), however, arsenic in the upper Monbulk Creek may also come from phosphate fertilisers, herbicides and insecticides (Lewin 1997), which are typically used in agricultural areas.



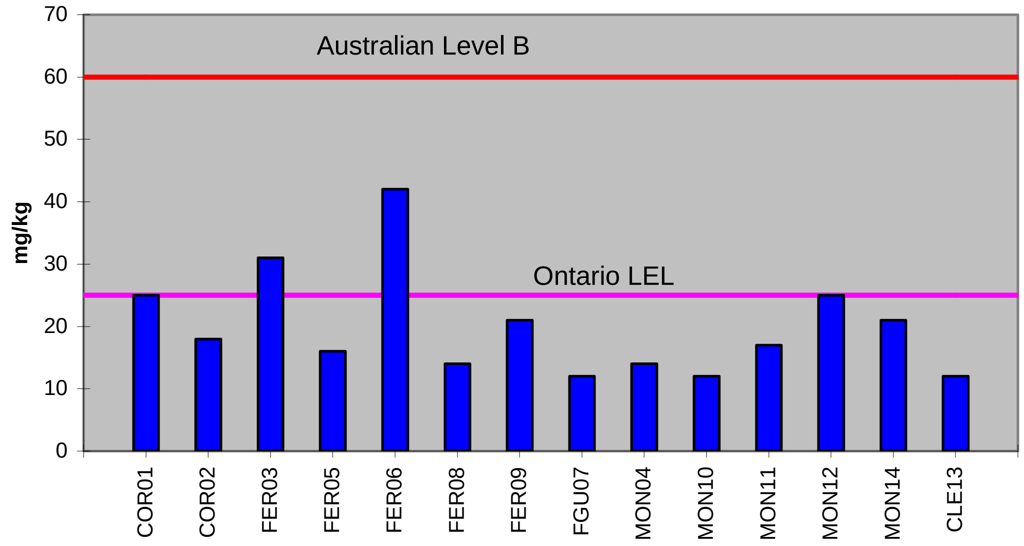
Cadmium concentrations in sediments were below the detection limit of 2 mg/kg at all of the 14 sites monitored, and were therefore all less then the Australian Level B objective. Similarly, mercury concentrations were all below the detection limit of 0.2 mg/kg and, therefore, below the Australian Level B objective of 1 mg/kg. It was not possible to compare the mercury and cadmium concentrations to the Ontario LEL, as the detection limits were greater than the objectives.

The chromium concentrations in sediments from the study sites are presented in Figure 30. All sites met the Australian Level B objective, but the Ontario LEL was exceeded in Ferny Creek at Lysterfield Road and in Monbulk Creek at the Puffing Billy Bridge and downstream of Belgrave Lake.



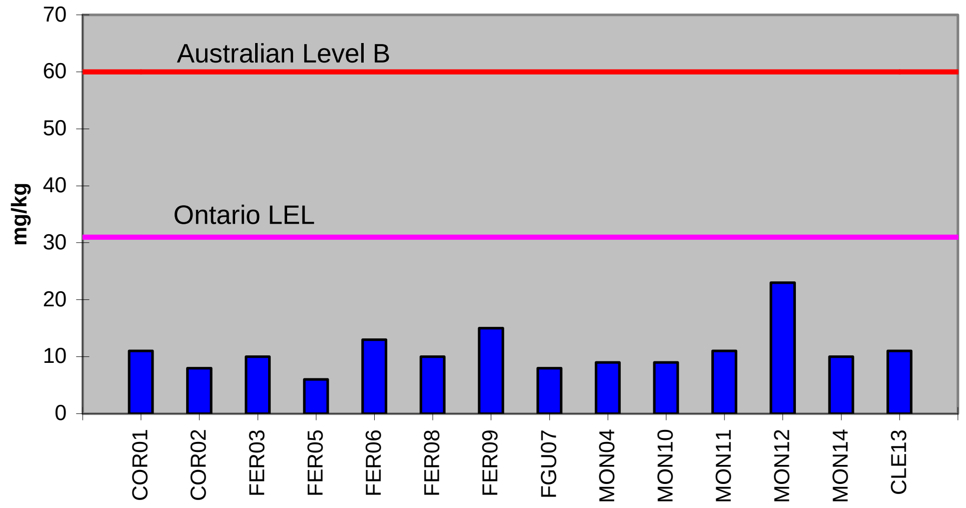
The copper concentrations in sediments from Corhanwarrabul Creek and its tributaries are presented in Figure 30. All sites met the Australian Level B objective but the Ontario LEL was exceeded in Ferny Creek at Rushdale Street and at Lysterfield Road.

Figure 31: Copper concentrations in fine sediments from Corhanwarrabul Creek and tributaries



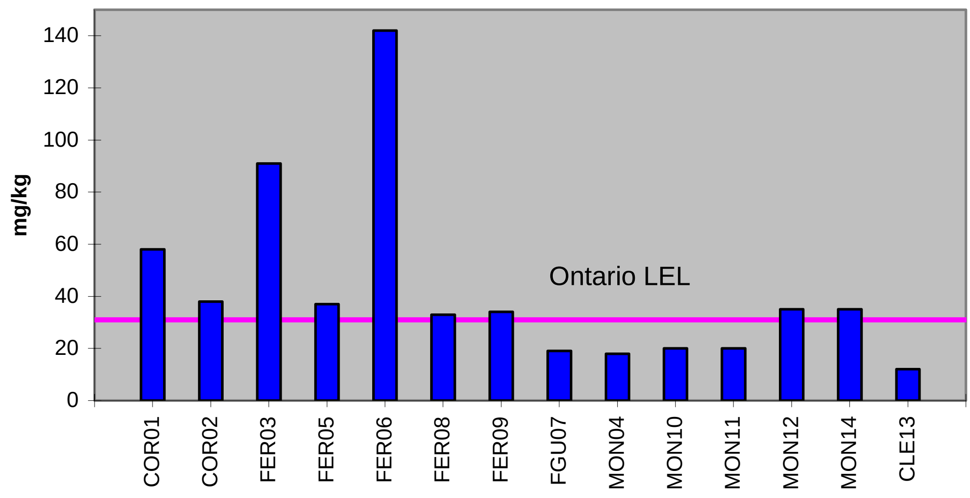
Nickel concentrations in sediments from Corhanwarrabul Creek and its tributaries are presented in Figure 32. All sites met both the Australian Level B and the Ontario LEL objectives.

Figure 32: Nickel concentrations in fine sediments from Corhanwarrabul Creek and tributaries.



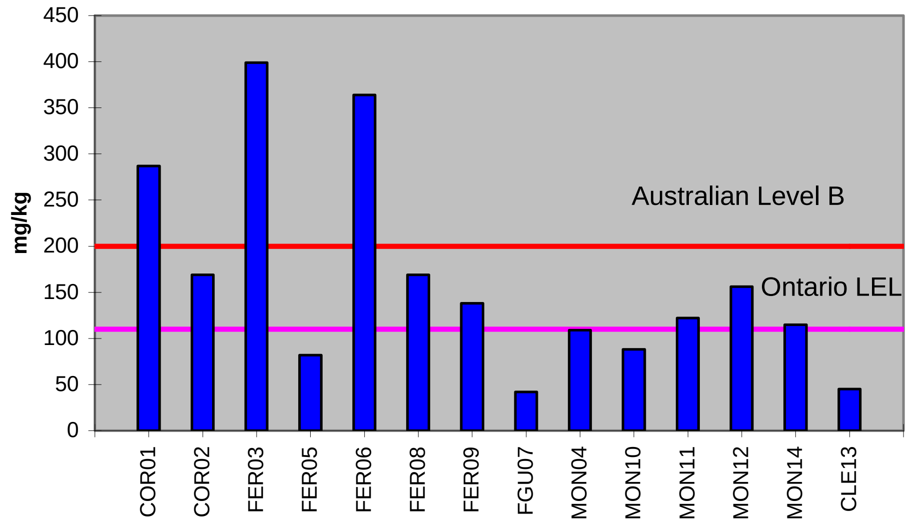
Lead concentrations in fine sediments collected from the study sites are presented in Figure 33. All sites had lead concentrations below the Australian Level B of 300 mg/kg, but lead concentrations exceeded the Ontario LEL in the lower sections of Ferny Creek (at Lysterfield Road, Hancock Drive and Rushdale Street), both sites in Corhanwarrabul Creek and in headwaters of Monbulk Creek (Puffing Billy Bridge and downstream of Belgrave Lake Park).

Figure 33: Lead concentrations in fine sediments from Corhanwarrabul Creek and tributaries



Zinc concentrations in fine sediments collected from Corhanwarrabul Creek and its tributaries are presented in Figure 34. Almost all sites exceeded the Ontario LEL objective of 110 mg/kg: the only sites which met this objectives were Ferny Creek at Hancock Road, Ferntree Gully Creek, Clematis Creek and Monbulk Creek at Napoleon Road and Karoo Court. The Australian Level B objective of 200 mg/kg was exceeded in Corhanwarrabul Creek at Wellington Road and in Ferny Creek at Lysterfield and Rushdale Street.

Figure 34: Zinc concentrations in fine sediment from Corhanwarrabul Creek and tributaries



Concentrations of zinc, copper and lead tended to more elevated in the sediments of waterways where the catchment was mostly urbanised. Similarly, elevated concentrations of these three metals have also been detected in other urban streams around Melbourne (Lewin 1997). There would be many potential sources of these metals in urban areas. Major contributors probably are motor vehicles (ie a greater density of vehicles are usually present in urban areas), pavement degradation and water pipe and roof erosion (Lewin 1997).

4.3 Storm Flow Water Quality

Storm flow sampling was only conducted on June 26. It was intended that three high flow events would be sampled, but the lack of rainfall during the study restricted sampling to one event. It is not possible to know from this one event whether results are typical conditions experienced in this catchment during high flows. The event sampled was a small, intense storm that produced 9 to 10 mm of rain. During the sampled high flow event, flows from the nearest continuous flow station in Blind Creek at High Street Road (a small tributary of Dandenong Creek) reached a maximum of about 1,166 ML/d, with a base flow about 4 ML/d (unpublished data). The response of Blind Creek to the rainfall was short and intense. The samples appeared to be collected at the end of the storm, when flows were declining.

Results from this sampling event are illustrated in Figure 35 as the deviation from median base flow concnetrations. These storm flows had more elevated suspended solids, turbidities, ammonia, nitrite, total phosphorus and *E. coli* than found during base flows. *E. coli* levels ranged between 1,600 and 5,200 organisms/100 mL. All sites had low levels of ammonia, organic nitrogen and orthophosphate, but had elevated levels of suspended solids, turbidity, nitrate and total phosphorus. Poorest water quality was detected in Monbulk Creek at Karoo Road. This was probably because the peak of the storm was captured at this site, but was missed at the other sites.

These water quality changes reflect increased run-off of sediment and contaminants from the catchment into the waterways.

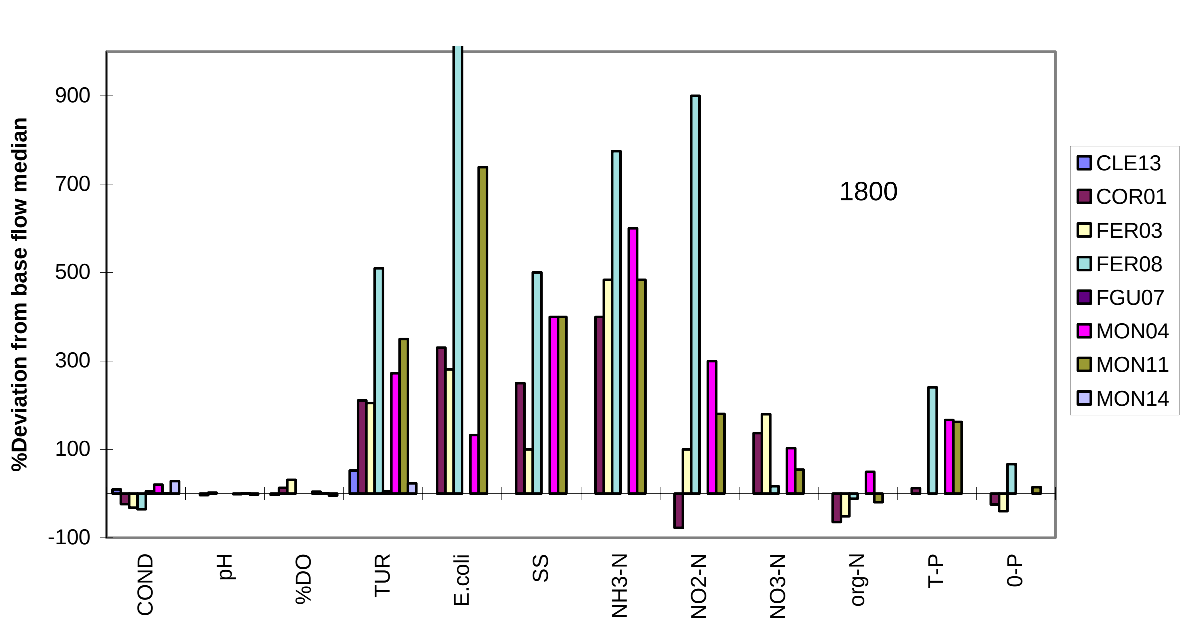
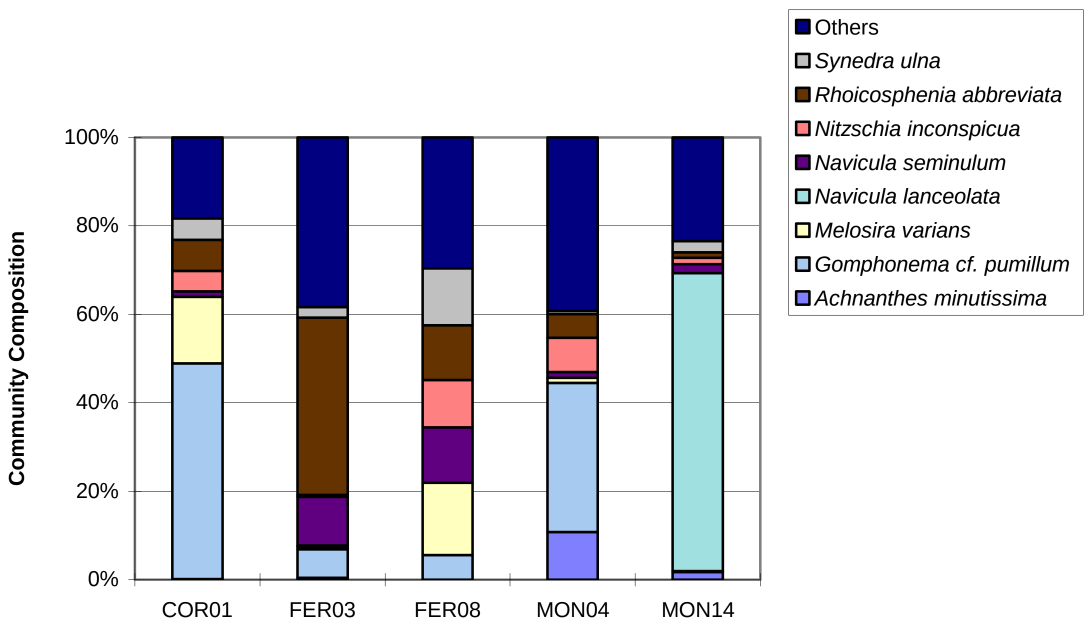


Figure 35: Deviation from base flow levels of physico-chemical parameters during high flow in the Corhanwarrabul Creek catchment

4.4 Diatoms

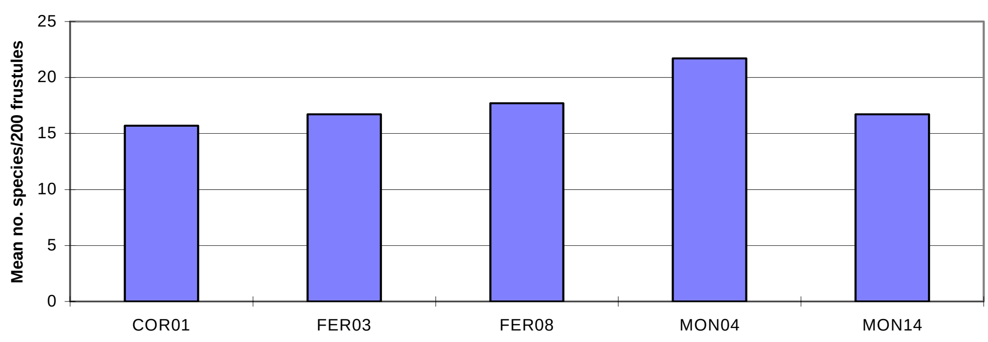
A list of all identified taxa and their mean percentage composition at each site is given in Appendix 8.2. Of the 48 taxa identified, eight were dominant (ie. mean percentage composition greater than 10%) at one or more sites. These common species were *Achnanthes minutissima*, *Gomphonema cf. pumillum*, *Melosira varians*, *Navicula lanceolata*, *Navicula seminulum*, *Nitzschia inconspicua*, *Rhoicosphenia abbreviata* and *Synedra ulna*. The mean percentage composition of the dominant species at each site is illustrated in Figure 36.

Figure 36: Mean percentage composition of dominant benthic diatoms at each site

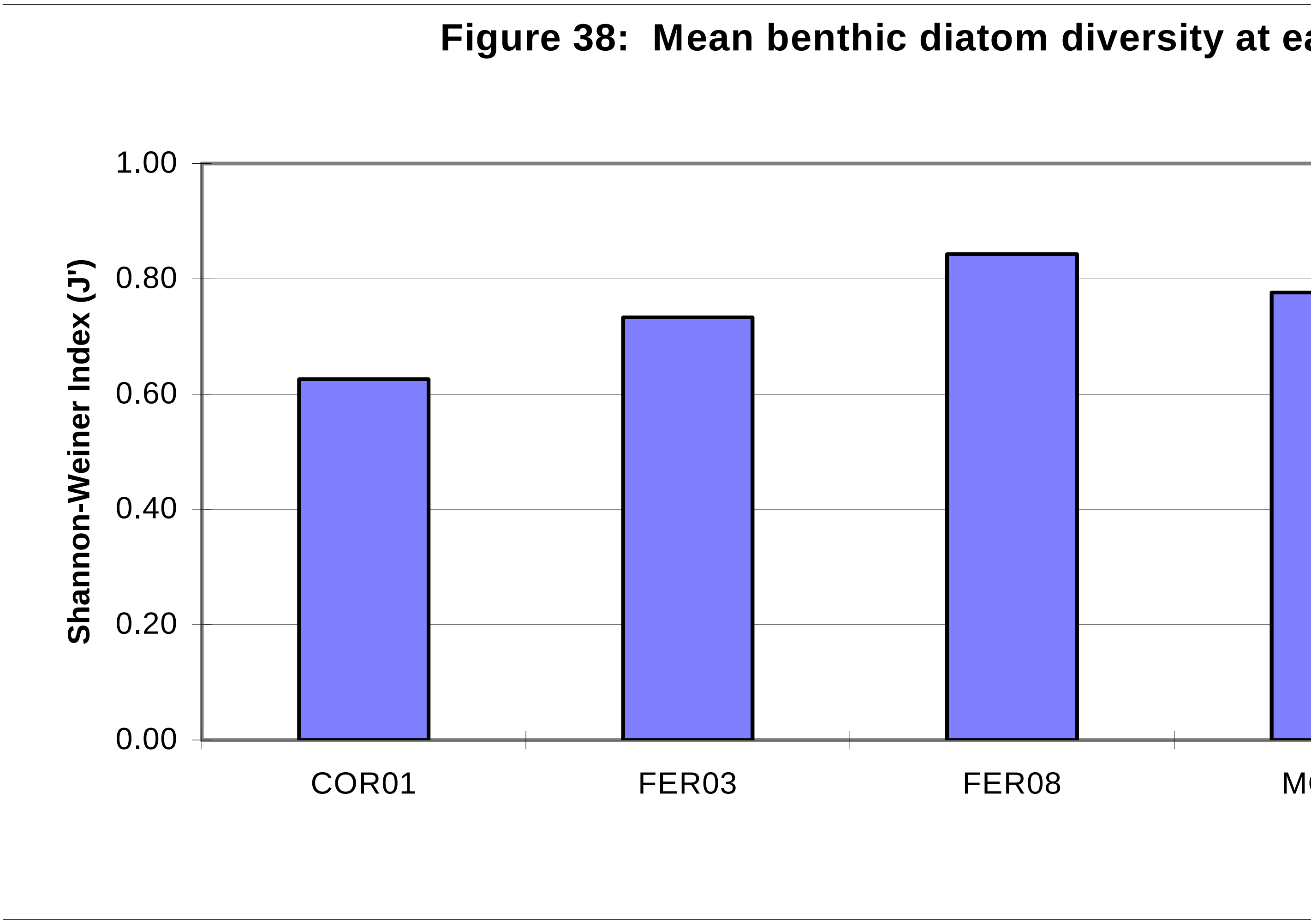


The known ecological requirements and pollution tolerance of the benthic diatoms collected in this study are summarised in Appendix 8.3. Mean species richness showed little variation throughout the catchment, with most sites having 16 to 18 different taxa (Figure 37). Monbulk Creek at Karoo Road (M0N04) had the richest diatom community, with a mean species richness of 22.

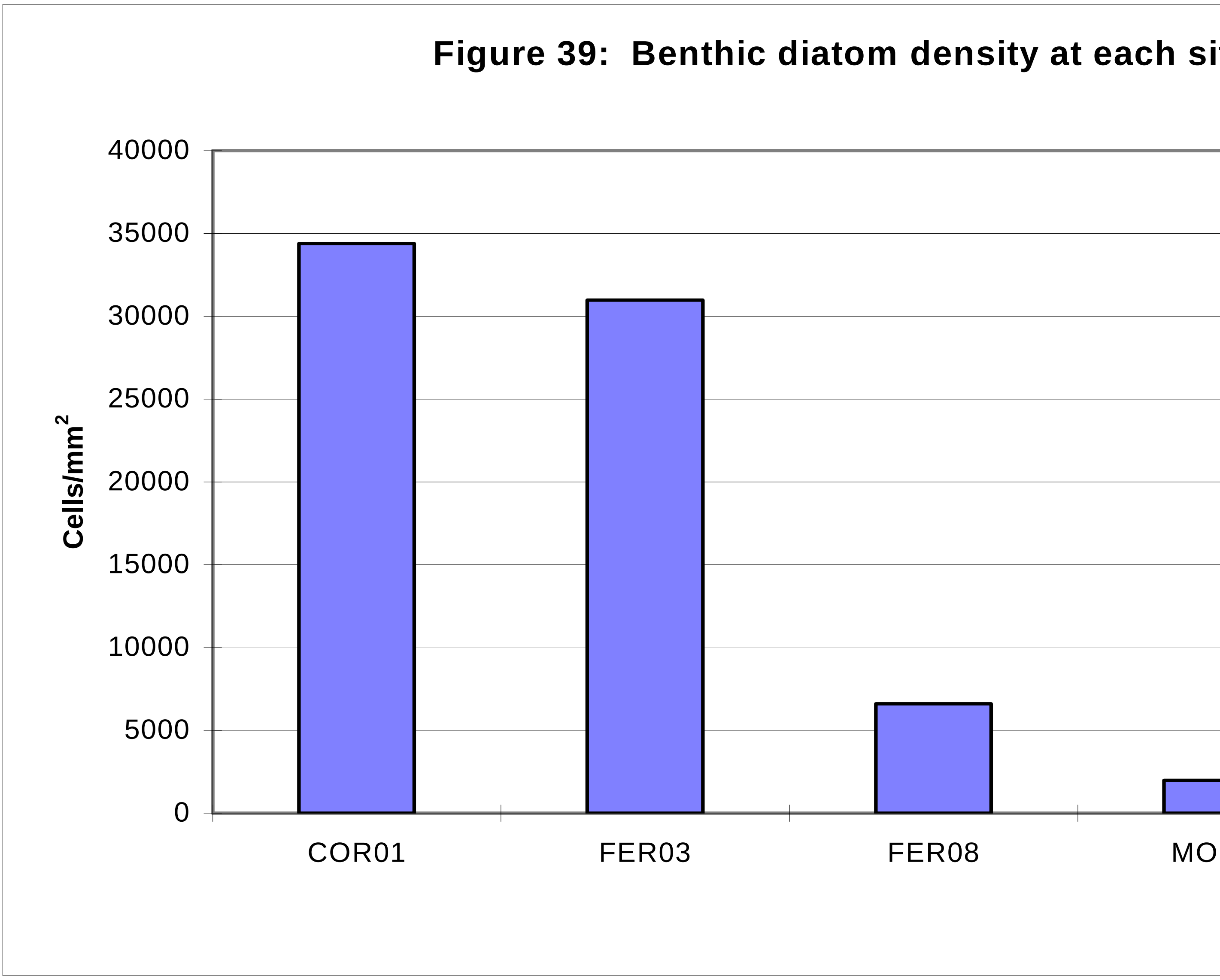
Figure 37: Benthic diatom species richness at each site



The relative diversity of the benthic diatom communities (J') at each site (Figure 38) was calculated using the Shannon-Weiner Index of diversity (H') and dividing this by the maximum possible diversity (H'max). Diatom diversity was greatest in Ferny Creek at New Road (FER08) and lowest in Monbulk Creek at Belgrave-Gembrook Road (MON14). There was a downstream decrease in diversity in Ferny Creek, and an downstream increase in diversity in Monbulk Creek. Corhanwarrabul Creek at Wellington Road (COR01) had a slightly lower diversity than the lower sections of Monbulk and Ferny Creeks.



The density of benthic diatoms was greatest in Corhanwarrabul Creek at Wellington Road (COR01) and lowest in Monbulk Creek at Karoo Road (MON04) (Figure 39). Diatom densities increased downstream in Ferny Creek, but decreased downstream in Monbulk Creek.



Results for the DAIpo index [Watanabe et al, 1988], Saprobity and Trophic state indices (Reid 1996) at each site are presented in Table 4. The DAIpo index gives a value from 0 to 100, where 100 indicates no organic pollution and 0 indicates gross organic pollution. The Saprobity index also gives an indication of organic pollution, but a higher value suggests more organic pollution. The Trophic index indicates the concentration of inorganic nitrogen and phosphorus; the greater the value, the greater the nutrient concentrations. Both the Saprobity and Trophic state indices were calculated using the following equation:

Trophic or Saprobity state = $\Sigma(X_{(i)}A_{(j)})/\ \Sigma A_{(j)}$

Where,
X is the numerical saprobity or trophic state class assigned by Van Dam *et al*. (1994) to a particular taxon $_{(i)}$
A is the abundance of taxon $_{(I)}$ in sample $_{(j)}$

Values calculated for the DAIpo index were similar throughout the catchment and indicated moderate organic pollution. Sites on Ferny Creek had slightly lower values (ie. were more organically polluted) than the other sites (Table 4). Values calculated for the Saprobity index were also similar throughout the catchment and indicated moderate organic pollution. The Saprobity values for Corhanwarrabul Creek (COR01) and Monbulk Creek at Karoo Road (MON04) were not accepted because of the low percentage of communities included in their calculations (% counts). Trophic values were consistently high in the catchment, which indicates inorganic nutrient enrichment. Trophic values were greatest in Corhanwarrabul Creek (COR01) and lowest in Monbulk Creek at Belgrave-Gembrook Road (MON14).

Table 4: Mean organic pollution and inorganic nutrient levels at each site, as calculated by the DAIpo (organic), Saprobity (organic) and Trophic (nutrients) indices. % count = the percentage of the total community used for the calculation.

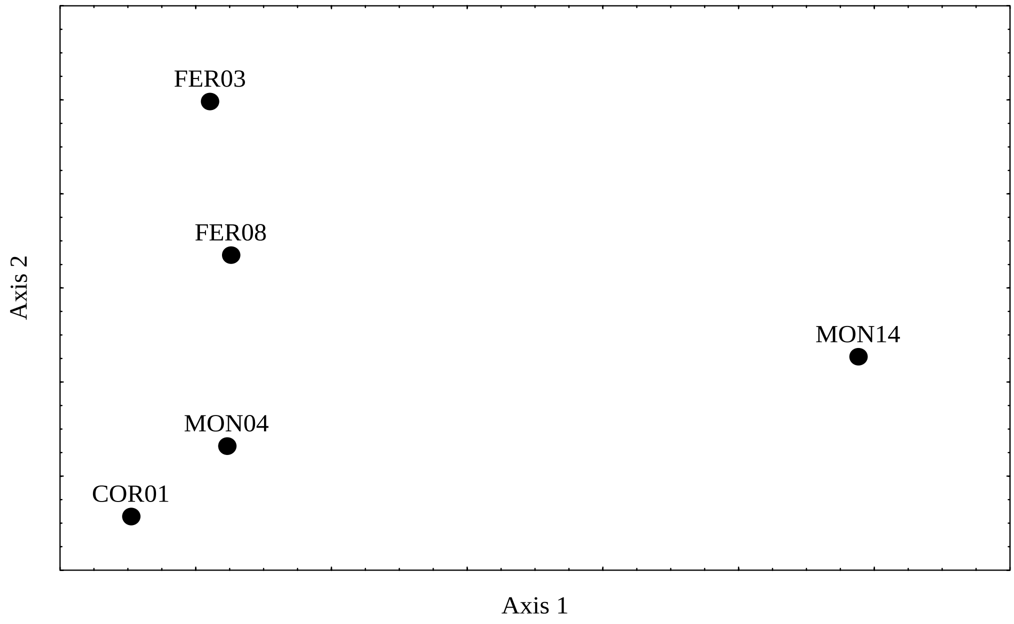
Site	DAIpo	Saprobity	% Count	Trophic	% Count
COR01	49.38		47	6.12	95
FER03	48.32	2.57	90	5.04	97
FER08	45.08	2.93	92	5.29	97
MON04	49.30		57	6.06	91
MON14	49.90	2.97	98	4.95	99

An ordination of the diatom assemblages using multi-dimensional scaling is presented in Figure 40. Corhanwarrabul Creek (COR01) and Monbulk Creek at Karoo Road (MON04) had a similar diatom flora and Ferny Creek at Rushdale Street (FER03) and New Road (FER08) had similar communities. Monbulk Creek at Belgrave-Gembrook Road (MON14) had the most unique diatom assemblage of the five sites surveyed.

The dominant species at each site tended to vary through the catchment, but generally indicated neutral to alkaline conditions, with low to moderate conductivities, high nutrient levels and moderate organic pollution.

In waters with moderate organic pollution (ie. BOD_5 ranging from 2.5 to 10 mg/L), species richness and diversity tend to increase with decreasing organic pollution (Watanabe *et al.* 1986, and Watanabe 1988). Therefore, the results indicate that there is a downstream increase in organic

Figure 41: Ordination of diatom communities using multi-dimensional scaling.
(Stress = 0.00)



pollution in Ferny Creek and a downstream decrease in organic pollution in Monbulk Creek. In contrast, the DAIpo and Saprobity values show little variation throughout the catchment.

Primary factors affecting density of diatom communities are light, temperature, nutrients and grazing (Stevenson 1996). Water temperatures were similar at all sites (Figure 10) and most sites were moderately shaded (Appendix 8.1). Therefore, the downstream increase in diatom density along Ferny Creek could reflect an increase in nutrients. Similarly, the downstream decrease in diatom density along Monbulk Creek could indicate a decline in nutrient concentrations. Values calculated from the Trophic index suggest that the whole catchment is enriched, with no significant differences between sites.

Diatom assemblage in Corhanwarrabul Creek and Monbulk Creek at Karoo Road were similar, which suggests they have similar water quality. Ferny Creek sites would also be expected to have similar water quality to each other. The diatom community in Monbulk Creek at Belgrave-Gembrook Road is composed of different taxa compared to the other sites, but these diatoms have similar ecological requirements and pollution tolerances to the other communities and therefore, do not necessarily reflect a difference in water quality.

4.5 Macroalgae

A total of 12 macroalgal taxa was collected from the Corhanwarrabul catchment. Macroalgae identified are:
Anabaena aff. *planktonica*
Batrachospermum antipodites
Cladophora glomerata
Melosira varians
Microspora flocculosa
Oedogonium sp. BFG (Broad-Filament Group)

Oedogonium sp. MFG (Medium-Filament Group)
Phormidium sp.
Spirogyra aff. *ellipsospora*
Spirogyra sp. MFG (Medium-Filament Group)
Spirogyra sp. SCG (Squat-Cell Group)
Vaucheria sp.

Information on ecological requirements and pollution tolerances of the identified taxa are presented in Appendix 8.4.

The number of taxa ranged from no macroalgae in Ferntree Gully Creek, Clematis Creek and Ferny Creek at Sophia Street, to six taxa in Corhanwarrabul Creek at Wellington Road and Ferny Creek at New Road (Appendix 8.5).

Table 5 lists the habitat and light available for macroalgal growth at each site. Habitat and shading of sites in this catchment was quite variable between and within streams.

Table 5: Habitat and light available for algal growth at each site. Where values refer to proportion of the total site substrata ie. 0 = 0% of total site substrata, 1 = <10% of total site substrata, 2 = 10 - 35% of total site substrata, 3 = 35 - 65% of total site substrata, 4 = 65 - 90% of total site substrata & 5 = >90% of total site substrata.

Site	Bedrock/ Boulders	Cobbles/ Pebbles	Gravel/ Sand	Instream Debris	Vegetation	Other	Type of other substrate	Shading of Stream
COR01	0	0	2	0	1	4	clay	low
COR02	4	2	2	1	1	1	litter	low
FER03	2	3	1	1	1	0		mod
MON04	0	1	5	0	2	0		low
FER05	4	1	2	1	1	0		low
FER06	2	4	2	2	3	2	litter	mod
FGU07	2	2	1	1	0	0		high
FER08	2	3	1	2	1	0		mod
FER09	1	4	2	2	1	0		high
MON10	4	2	3	1	1	0		mod
MON11	4	1	3	1	1	0		mod
MON12	3	3	1	1	1	0		low
CLE13	1	1	4	1	1	0		high
MON14	2	2	3	0	1	0		mod

A high macroalgal coverage occurred in Corhanwarrabul Creek at Wellington Road, Ferny Creek at Hancock Drive and Ferny Creek at New Road (Table 5). No macroalgal growth was visible in Ferntree Gully Creek, Clematis Creek and Ferny Creek at Sophia Street. Where macroalgae were present, they covered more than 35% of the stream bed.

The most frequently dominant taxa were *Cladophora glomerata, Oedogonium* sp. BFG and *Vaucheria* sp. *Cladophora glomerata* was dominant at various sites in Monbulk and Ferny Creek, and *Oedogonium* sp. BFG was common in Ferny Creek and in Monbulk Creek at Karoo Road. *Vaucheria* sp. was widespread in Monbulk Creek and in Corhanwarrabul Creek at Henderson Road.

Macroalgae observed in the Corhanwarrabul Creek catchment indicate that the catchment is neutral to alkaline and has low-moderate conductivities (Appendix 8.2). Macroalgae present indicate that the levels of nutrients and organic pollution tended to be more variable between sites.

The site in Corhanwarrabul Creek at Wellington Road (COR01) was dominated by *Melosira varians* and *Spyrogyra* spp., suggesting that this site experiences moderate to high nutrients and, perhaps, moderate organic pollution. Although the lack of shade would encourage algal growth, the high cover of algae at this site supports other evidence for high nutrient levels. The other site on Corhanwarrabul Creek at Henderson Road (COR02) appears to be less eutrophic and organically polluted than Wellington Road, with the dominance of *Vaucheria* sp. and *Spirogyra* sp. MFG. This is supported by the low to moderate cover of algae at this site, even though there is little shading.

Ferny Creek at Rushdale Street (FER03) was dominated by *Cladophora glomerata*, which implies the presence of high nutrient levels, but also, little heavy metal pollution. The dominance also of *Vaucheria* sp., could mean that the levels of nutrients are slightly lower than if *C. glomerata* was dominating on its own (but the well oxygenated riffle from which the *Vaucheria* sp. was collected may have enabled it to survive higher pollution levels). Ferny Creek at Hancock Drive (FER05) was dominated by *Cladophora glomerata* and *Oedogonium* sp. BFG., with some *Vaucheria* sp. This would suggest these two sites have similar water quality. The greater coverage of algae at this site compared to the site at Henderson Road is probably due to differences in shading.

Ferny Creek at Lysterfield Road (FER06) was dominated by *Oedogonium* sp. BFG, with a low to moderate algal coverage. This site may receive a lower level of nutrients and organic pollution than other sites on Ferny Creek, however, there is little information on this taxon. Ferny Creek at New Road was dominated by *Oedogonium* sp. BFG and *Melosira varians* and *Microspora flocculosa*. The presence of these taxa suggest that this site may have moderate inputs of nutrients.

Monbulk Creek at Karoo Road (MON04) had a moderate to high coverage of *Cladophora glomerata*, indicating that the site is eutrophic, and has low levels of heavy metals. Other sites on Monbulk Creek were dominated by *Vaucheria* sp., which implies that these sites experience lower levels of nutrients (supported by their cover). The low amount of shading at these sites would have enabled more pollution tolerant species to occur, such as *Cladophora glomerata*, to occur if the stream was enriched with nutrients. The presence of *Vaucheria* sp. throughout the middle and upper parts of Monbulk Creek is consistent with it being widespread in agricultural areas. The *Batrachospermum* species at Belgrave-Gembrook Road could mean that this site has slightly better water quality than the other sites.

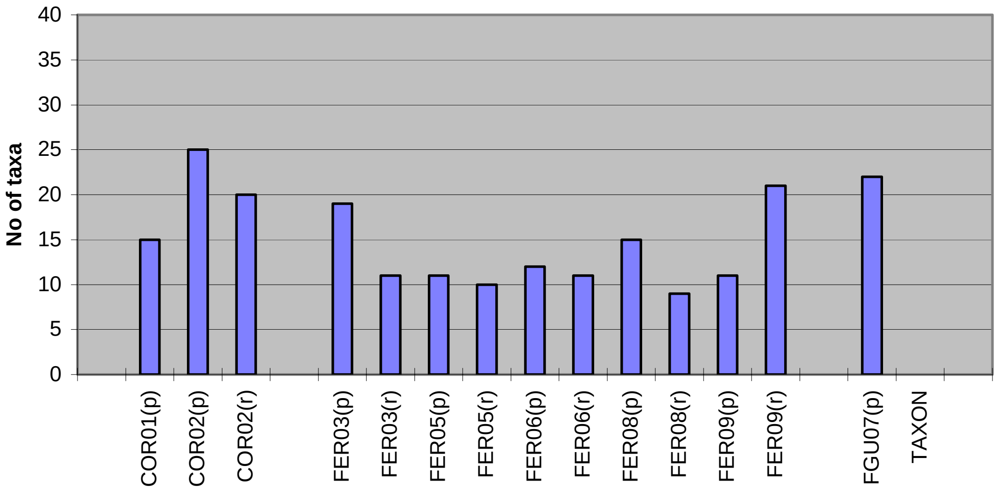
The absence of obvious macroalgal growth in Ferntree Gully Creek (FGU07), Clematis Creek (CLE13) and Ferny Creek at Sophia Street (FER09) is most likely the result of a lack of sunlight and stable habitat.

4.6 Macroinvertebrates

Raw data collected from waters of the Corhanwarrabul catchment are presented in Appendices 8.5 to 8.6. A total of 138 taxa were collected from the 14 sites surveyed during February 1997. The fauna was represented by caddisflies (26 taxa), chironomids (25 taxa) and other true flies (16 taxa), mayflies (11 taxa), beetles (14 taxa) and true bugs (16 taxa).

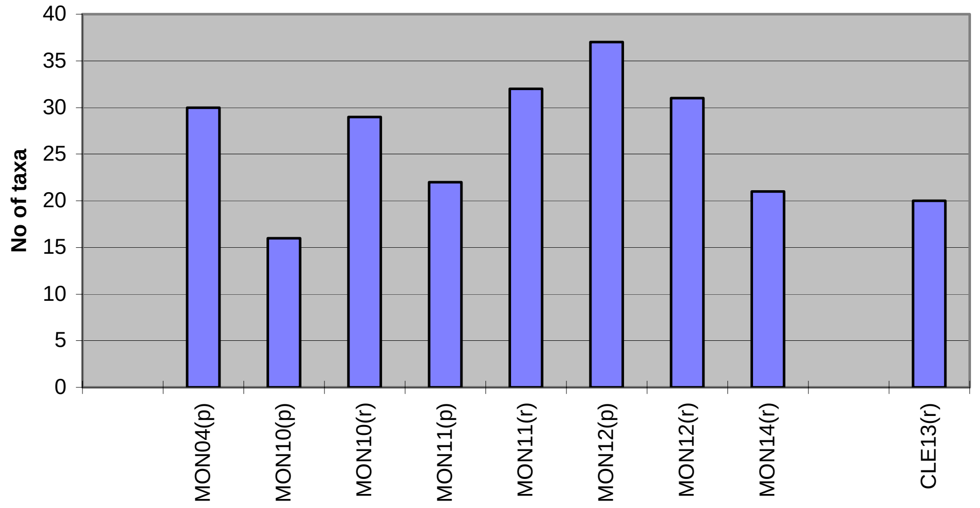
The total number of taxa collected from each habitat in Corhanwarrabul, Ferny and Ferntree Gully Creeks is presented in Figure 41. Similarly, the numbers of macroinvertebrate taxa collected from pool and riffles in Monbulk and Clematis Creeks are presented in Figure 42. The greatest number of taxa was collected from the pool habitat in Monbulk Creek near Belgrave Lake. This site also had the most diverse riffle fauna of all the sites surveyed.

Figure 42: The number of macroinvertebrate taxa collected from pool (p) and riffles (r) in Corhanwarrabul, Ferny and Ferntree Gully Creeks in February 1997.



Monbulk Creek had a much greater diversity of macroinvertebrates than Ferny Creek sites (Figure 42). The four pools on Monbulk Creek had more taxa than the five pools sampled on Ferny Creek. In addition, there were from 20 to 37 taxa collected from the five riffles sampled on Monbulk Creek whereas only 9 to 12 taxa were collected from the riffles in Ferny Creek (excluding the Sophia Grove riffle). Corhanwarrabul Creek at Henderson Road had a similar diversity of taxa to that present throughout Monbulk Creek. The lower site near Wellington Road had a low diversity of taxa similar to Ferny Creek.

Figure 43: The number of macroinvertebrate taxa collected from pools (p) and riffles (r) in Monbulk and Clematis Creeks during February 1997



Total numbers of macroinvertebrate taxa collected from the pool and riffle habitats at each site during the survey in February 1997 are presented in Table 6. Of those sites that had pools and riffles, Ferny Creek sites had between 17 to 27 taxa and the Monbulk Creek sites had between 37 to 59 taxa. These results again highlight that Monbulk Creek has a considerably more diverse fauna than in Ferny Creek.

Table 6: The total number of macroinvertebrate taxa collected from each site from a survey conducted in February 1997

Waterway	Site	Pool	Riffle	Total
Corhanwarrabul Ck.	Wellington Rd.	15	-	15
Corhanwarrabul Ck..	Henderson Rd.	25	20	37
Ferny Ck.	Rushdale St.	19	11	23
Monbulk Ck.	Karoo Rd.	30	-	30
Ferny Ck.	Hancock Dr.	11	11	17
Ferntree Gully Ck.	Mt. Dandenong Tourist Rd.	-	22	22
Ferny Ck.	Lysterfield Rd.	12	11	17
Ferny Ck.	New Rd.	15	9	19
Ferny Ck.	Sophia Gve.	11	21	27
Monbulk Ck.	Napoleon Rd.	16	29	37
Monbulk Ck.	Nixon Rd.	22	32	45
Monbulk Ck.	d/s Belgrave Lake	37	31	59
Clematis Ck.	Gembrook Rd.	-	20	20
Monbulk Ck.	Puffing Billy Bridge	-	21	21

Biotic indices calculated for each habitat from each site using the SIGNAL HU97 B pollution sensitivity grades and environmental quality ratings derived by Chessman *et al* (1997) are presented in Figures 43 and 44. These figures also present rating based on species scores calculated by Walsh (unpublished data), using the formulae suggested by Chessman *et al* (1997) and data collected from the Melbourne region.

The ratings using the grades of Chessman *et al* (1997) and Walsh (unpublished data) produce different environmental quality ratings. The Walsh scores tend to rate all the sites higher than Chessman scores. In this instance, the Walsh ratings are preferred to the Chessman ratings, as the Walsh ratings appear to be more suited to assess streams with urbanised catchments.

Figure 44: Environmental ratings using riffle (r)and pool (p) macroinvertebrates from Corhanwarrabul, Ferny and Ferntree Gully Creeks.

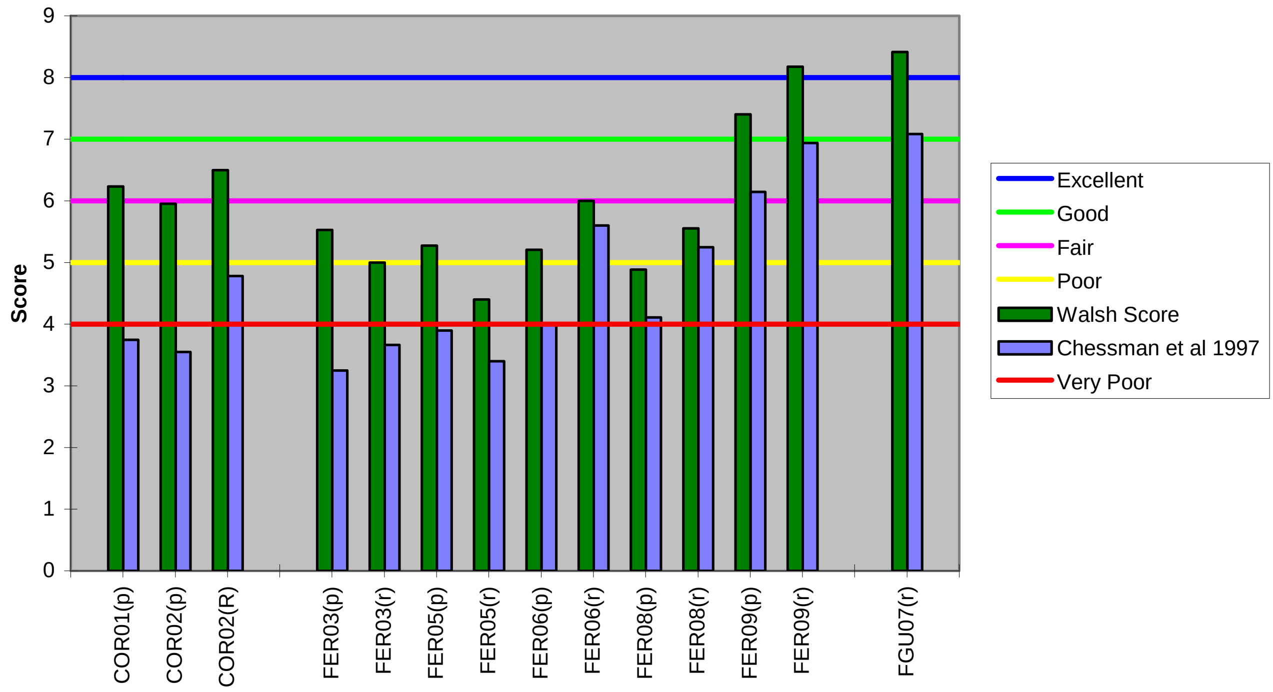
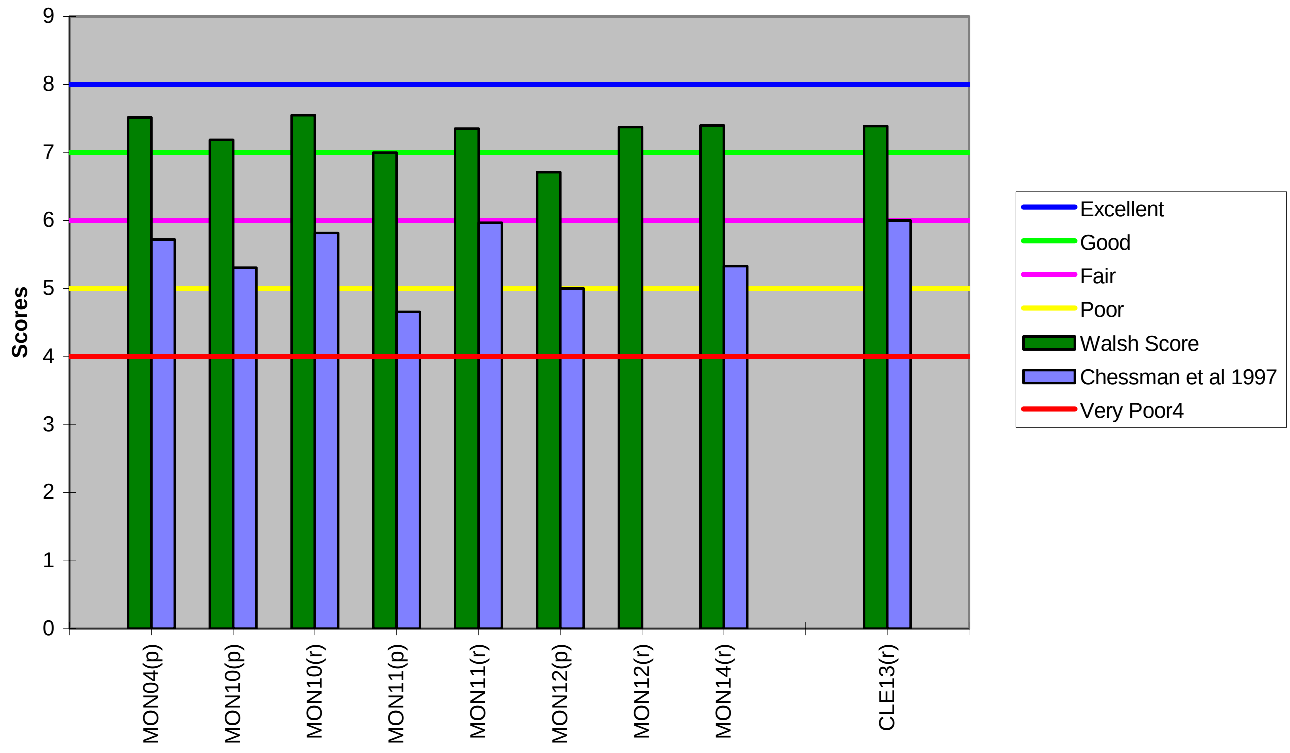


Figure 45: Environmental ratings using the macroinvertebrates from pools and riffles in Monbulk and Clematis Creeks.



Using the Walsh scores, the environmental quality ratings for the study sites are:

Corhanwarrabul Ck., at Wellington Rd.	Fair condition
Corhanwarrabul Ck., at Henderson Rd.	Poor to fair condition
Ferny Ck., at Rushdale St.	Poor condition
Ferny Ck., at Hancock Dve.	Very poor to poor condition
Ferny Ck., Lysterfield Rd.	Poor condition
Ferny Ck., New Rd.	Very poor to poor condition
Ferny Ck., Sophia Gve.	Good to excellent condition
Ferntree Gully Ck.	Excellent condition
Monbulk Ck., Karoo Rd.	Good condition
Monbulk Ck., Napoleon Rd.	Good condition
Monbulk Ck., Nixon Rd.	Good condition
Monbulk Ck., d/s Belgrave Lake	Fair to good condition
Monbulk Ck., Puffing Billy Bridge	Good condition
Clematis Ck., Belgrave-Gembrook Rd.	Good condition

The type of fauna present in Ferntree Gully Creek indicated that this stream was in excellent condition. This was an interesting result given that a large part of the catchment had recently been burnt by a bushfire and the water was usually turbid. It is possible that the fauna at this site may have changed over the following months as the burnt material and sediment was washed into the waterway.

The SIGNAL-based environmental ratings again illustrate a considerable difference in the condition of the macroinvertebrate assemblages in Ferny and Monbulk Creeks. All the Monbulk Creek sites and Clematis Creek were rated as being in good condition. Ferny Creek at Sophia Grove had an excellent riffle fauna and a good pool fauna, but all other sites on Ferny Creek were rated as being in very poor to poor condition.

Analyses of the diversity of macroinvertebrates and SIGNAL scores clearly indicated that Monbulk Creek is in good condition and that Ferny Creek is in poor condition. The condition of Ferny Creek deteriorates between Sophia Grove, Tecoma and New Road, Upper Ferntree Gully. Corhanwarrabul Creek is rated as being in fair condition, which represents a slight deterioration in stream health, when compared to Monbulk Creek.

4.7 Fish

The fish and crayfish were surveyed from three sites on Monbulk Creek, one on Corhanwarrabul Creek, two on Ferny Creek and from wetlands near Corhanwarrabul Creek. A species list collected during a survey conducted in March 1997, including scientific names, conservation status and whether species are migratory, is presented in Table 7. A total of 10 species of fish (five native and five exotic) and two cray species were collected from this survey. All the native fish were common species.

Table 7: Common and scientific names of fish species recorded in this study, including their conservation status (DCNR 1995) and whether they migrate

Common Name	Scientific Name	Conservation Status	Migratory
FISH			
Common native species			
Broadfinned Galaxias	*Galaxias brevipennis*	Common	Yes
Common Galaxias	*Galaxias maculatus*	Common	Yes
Shortfinned Eel	*Anguilla australis*	Common	Yes
Southern Pygmy Perch	*Nannoperca australis*	Common	No
Flatheaded Gudgeon	*Philypnodon grandiceps*	Common	No
Exotic Species			
Brown Trout	*Salmo trutta*	-	-
Rainbow Trout	*Oncorhynchus mykiss*	-	-
Mosquitofish	*Gambusia holbrooki*	-	-
Roach	*Rutilus rutilus*	-	-
Goldfish	*Carassius auratus*	-	-
DECAPODS			
Burrowing Cray	*Engaeus sp.*	-	-
Central Highlands Spiny Cray	*Euastacus woiwuru*	Common	-

4.7.1 Corhanwarrabul Creek and adjacent wetlands

A wetland located just north of Corhanwarrabul Creek on the Dandenong Creek floodplain was sampled to ascertain the presence of the threatened native dwarf galaxias (*Galaxias pusilla*). Only a brief survey was conducted in three wetlands about 50 to 100m north to north west of the survey site COR01 on Corhanwarrabul Creek. A list of the fish collected are presented in Table 8.

Table 8: A list of the fish and the numbers collected from on a survey of unnamed wetlands near Corhanwarrabul Creek and Welling ton Road and in Corhanwarrabul Creek near Wellington Road.

	Unnamed wetlands near Corhanwarrabul Ck.			Corhanwarrabul Ck. at Wellington Rd.		
	Run 1	Run 2	Total	Run 1	Run 2	Total
Shortfinned eel	-	-	15	10	8	18
Flatheaded Gudgeon	-	-	20	4	2	6
Common Galaxias	-	-	-	1	-	1
Sth. Pygmy Perch	-	-	20	2	1	3
Goldfish	-	-	40	2	-	2
Mosquitofish	-	-	200	57	43	100
Roach	-	-	-	1	2	3
Total			295			133

No dwarf galaxias were collected, but their presence cannot be discounted, given their cryptic nature, the low sampling effort and the large proportion of wetlands in the area that have not been surveyed.

Seven species of fish (four native and three exotic) were collected from the survey of Corhanwarrabul Creek upstream of Wellington Road. The fish assemblage was numerically dominated by mosquitofish, while the shortfinned eel was the most abundant native fish. The catch per unit effort (CPUE) of 145 fish/hour was relatively high, due to the high abundance of juvenile mosquitofish.

4.7.2 Monbulk Creek

The fish populations in Monbulk Creek were surveyed from Karoo Road, Nixon Road and near the Puffing Billy Bridge. A list of the fish collected from these sites is presented in Table 9. The only fish collected were shortfinned eels, brown trout and roach. The Central Highlands Spiny Cray was

Table 9: A list of the fish and the numbers collected from on a survey of Monbulk Creek at Karoo Road, Nixon Road and near the Puffing Billy Bridge

SITE	Karoo Rd.			Nixon Rd.			Puffing Billy Bridge		
	Run 1	Run 2	Total	Run 1	Run 2	Total	Run 1	Run 2	Total
Shortfinned eel	4	3	7	8	11	19	2	-	2
Brown Trout	6	-	6	3	2	5	13	9	22
Roach	8	2	10	210	108	318	-	-	-
Burrowing Cray sp.	-	1	1	-	-	-	-	-	-
Central High-lands Spiny Cray	-	-	-	-	-	-	10	4	14
Total			23			367			38

also collected from the site near the Puffing Billy Bridge and a burrowing cray was sighted in the Karoo Road site. Roach was the most dominant species in the two sites downstream of the Monbulk Retarding Basin, whereas brown trout was the most abundant species near the Puffing Billy Bridge. The largest fish (excluding eels) collected during these surveys was a 1.21 kg brown trout collected from Nixon Road.

4.7.3 Ferny Creek

Fish populations in Ferny Creek were surveyed from Hancock Drive and New Road, above the retarding basin. A list of the fish collected from these sites is presented in Table 10. Five species of fish (2 native and three exotic) were collected from Hancock Drive. The fauna was numerically dominated by shortfinned eels and goldfish. The CPUE at Hancock Drive of 61.5 fish/ hour was relatively low. The Hancock Drive site was rated by Raadik and O'Connor (1997) as being the most degraded, as it provided little in-stream fish cover.

The fish fauna at the New Road site was extremely poor, only two shortfinned eels were collected.

Table 10: A list of the fish and the numbers collected from on a survey of Ferny Creek at Hancock Drive and New Road

	Hancock Dve.			New Rd.		
	Run 1	Run 2	Total	Run 1	Run 2	Total
Shortfinned eel	14	11	25	2	-	2
Broadfinned Galaxias	1	3	4	-	-	-
Goldfish	12	12	24	-	-	-
Mosquitofish	2	-	2	-	-	-
Roach	1	-	1	-	-	-
Total			56			2

4.7.4 An assessment of the fish assemblages

This one-off fish survey of seven sites in the Corhanwarrabul catchment provides a limited amount of information. More intensive surveys would be required to determine how the fauna varies seasonally and to identify what other fish species are present. Although acknowledging the limitations of this survey, Raadik and O'Connor (1997) provided a tentative assessment of the health of the fauna based on the:

- percentage of the expected native taxa recorded, and
- the percentage abundance of exotic species in the community.

A summary of the expected native taxa recorded and the percentage abundance of exotic species are presented in Table 11. The expected number of taxa at each site was partly generated from distributional information from the Victorian Fish Database (NRE) and from expert knowledge of the distribution of fish in the state (Raadik and O'Connor 1997). A collection of 50% or more of the expected taxa was considered to be high and the numbers of exotic fish low if they comprised less than 10% of the total fish abundance.

Given these criteria, the health of the fish and cray community would be rated as being poor in all waterways surveyed. The major reason for the poor diversity and abundance of native fish would appear to be barriers to fish movement. There are several barriers in the Dandenong Valley, including weirs at the Police Retarding Basin, Pillars Crossing on Dandenong Creek, the National Water Sports Centre on Patterson River and long sections of concrete-lined channels along Dandenong Creek in the vicinity of the City of Dandenong. The relative significance of these barriers in limiting fish movement is currently unclear. Barriers have been effective in preventing the upstream movement of migratory fish and hence the native fish fauna upstream has become impoverished (Raadik and O'Connor 1997). Two concrete-piped drop structures associated with the Monbulk and Ferny Creeks Retarding Basins further restrict fish movement in these systems.

Pillars Crossing impedes the upstream movement of approximately 62% of the migratory fish species that naturally occur in the system. Tupong (*Pseudaphritis urvilli*), the rare spotted galaxias (*Galaxias truttaceus*), and the threatened Australian grayling (*Prototroctes maraena*) are totally prevented from moving upstream past the barrier and the populations have become extirpated upstream. The common galaxias (*Galaxias maculatus*), the broadfinned galaxias (*Galaxias brevipennis*) and the common short-headed lamprey (*Mordacia mordax*), are occasionally able to negotiate the weir in small numbers (Raadik and O'Connor 1997).

The majority of the migratory fish species found upstream of Pillars Crossing weir (ie shortfinned eel, broadfinned galaxias and short-headed lamprey) have some ability to circumvent in-stream barriers by either climbing over them or by moving past them overland (Raadik and O'Connor 1997).

Table 11: The percentage of expected native taxa sampled at each site and the abundance of exotic species in the fauna

STREAM	Site	% of Expected	% Exotic Abundance
Corhanwarrabul Ck.	Wetlands	37	64
Corhanwarrabul Ck.	Wellington Rd.	33	80
Monbulk Ck.	Karoo Rd.	9	67
	Nixon Rd.	11	95
	Puffing Billy Bridge	16	58
Ferny Ck.	Hancock Dve.	18	48
	New Rd.	11	0

4.7.5 Dwarf Galaxias

Dwarf galaxias is one of Australia's more attractive and unusual fish species. It occurs in still or gently flowing waters in the shallows around the margins of creeks, drains and swamps, usually heavily overgrown with aquatic macrophytes or emergent plants. The fish may take refuge in yabby burrows when frightened. Its habitat may dry up seasonally (autumn to early winter) and it seems likely to be able to aestivate (ie. spend dry periods in a torpor) for several months when this happens, possibly again in association with yabby burrows (McDowall 1996). Unlike many other native fish that inhabit southern Victorian streams, dwarf galaxias spend their entire life cycle in inland waterways.

Dwarf galaxias is distributed in the southern part of the south-east coast drainage division from Gippsland to Mt. Gambier, and are also present on Flinders Island and the north-east of Tasmania (Merrick and Schmida 1984). Although this species is often locally abundant, it has a patchy distribution within this range and appears to have suffered from pervasive wetland drainage, which has variously destroyed, reduced or fragmented habitats (McDowall 1996). It is listed as vulnerable in Victoria, and is listed under the Victorian Fauna and Flora Guarantee Act 1988 and hence all populations are provided legal protection (DCNR 1995).

Dwarf galaxias has been recorded from parts of the Dandenong Creek system (Table 12), including Corhanwarrabul Creek. This population is probably the second largest of this species outside of the Grampians National Park (Raadik and O'Connor 1997). Very little survey effort has been directed to determine the specific distribution of this threatened fish species within the Dandenong Creek system. The only major survey of this species was conducted as part of a more general fish survey of the Dandenong Valley by Koehn (1986). A specific survey of a dwarf galaxias population in Tirhatuan Park wetlands was conducted by Breen (1989). A recent brief survey of the wetlands of Jells Park by MFRI for Parks Victoria, which targeted dwarf galaxias, located an additional, previously unknown population (Raadik, unpublished data).

Table 12: Location details of populations of the dwarf galaxias in the Dandenong Creek valley. Source: Victorian Fish Database, DNRE.

Stream	Location	AMG
Blind Ck.	near Timothy Dve., Wantirna South	7922 436068
Corhanwarrabul Ck.	just upstream of former junction with Dandenong Creek	7922 423011
Dandenong Creek	Police Rd., Mulgrave	7922 433993
	Tirhatuan Park wetlands	7922 433993
	Wetland in Jells Park Reserve, Wheelers Hill	7922 420039

Koehn (1986), Breen (1989) and Raadik and O'Connor (1997) provided similar comments on the future survival of dwarf galaxias in the Dandenong catchment. The population is under great pressure from increasing urbanisation and other developments, which is resulting in the loss of wetland habitat critical to its survival. An example is the loss of wetland habitat in a newly constructed housing estate in Wantirna South. A population of dwarf galaxias is present in a small dam formerly fed by run-off from paddocks. A housing estate has been built over most of the paddocks eliminating the run-off area to the dam, and isolating it on the corner of Timothy Drive and Jenola Parade. This population may completely disappear if this corner block is also developed.

Raadik and O'Connor (1997) recommend that it would be prudent to adopt a conservative view and assume that dwarf galaxias are present in all waterways (creeks and wetlands) within the valley unless otherwise disproved. They argue that such an approach would avoid further indiscriminate loss of populations and habitat, ensuring areas are assessed for the presence of this species prior to any proposed developments. The value of this conservative approach can be illustrated by a recent survey conducted by Koster (1997). He recently surveyed several wetlands in the Dandenong Valley as part of a thesis for an Honours Degree. Dwarf galaxias were collected from the wetland surveyed near Corhanwarrabul Creek upstream of Wellington Road, that was surveyed by Raadik and O'Connor (1997) without success.

4.8 Platypus

MWC, with the support of the Australian Platypus Conservancy, has been conducting a study on the platypus populations that inhabit waterways in the Melbourne region. The aims of this study are to describe the current distribution and abundance of platypus in Melbourne's waterways and to identify those factors which influence their survival. As part of this program two survey were conducted in 1996 to determine whether platypus occurred in Monbulk and Corhanwarrabul Creeks. These surveys confirmed that platypus inhabit Monbulk Creek near the Puffing Billy Bridge downstream to Blackwood Park Road, Ferntree Gully. No platypus were collected from two other sites surveyed further downstream in Monbulk Creek at Karoo Road and Corhanwarrabul Creek at Hendersons Road. Further details regarding these surveys are reported by Serena (1996).

More surveys have since been conducted and radio-tracking has also been used to monitor the movement of platypus within these streams. A total of 86 site-nights (1 site-night = 1 pair of nets set overnight) of survey effort in the period from 12 November 1996 to 27 June 1997. These surveys were conducted in:

- Monbulk Creek upstream of the Monbulk Retarding Basin - 22 site-nights,

- Monbulk Creek downstream of the Monbulk Retarding Basin - 22 site-nights,
- Ferny Creek - 25 site-nights,
- Corhanwarrabul Creek - 8 site-nights, and
- Dandenong Creek in the vicinity of Corhanwarrabul Creek - 9 site-nights.

The denning and foraging preferences and other movements of platypus were also monitored by using radio-tracking devices. Further details regarding sites sampled, methods used and results of this work are detailed elsewhere (Serena *et al.* 1997; Williams *et al.* 1997). These recent surveys have increased our understanding of the platypus populations in the study. Some significant findings are:

- Platypus were collected from Monbulk Creek and Corhanwarrabul Creek. The lower distribution of platypus appears to be around the Caribbean Gardens below Stud Road.
- One male platypus was collected from Ferny Creek immediately upstream of the Ferny Creek Retarding Basin. No other platypus were collected in Ferny Creek downstream of this retarding basin, so it is possible that the one or more platypus existing in the upper section of Ferny Creek are somewhat isolated from the Monbulk Creek population.
- The only juvenile platypus present occurred in Monbulk Creek upstream of Lysterfield Road. Areas outside this range may therefore have sub-optimal conditions for platypus.
- Eight platypus collected from Monbulk Creek and Corhanwarrabul Creek were radio-tagged and their movements were monitored between February and June 1997. The platypus were found to travel considerable distances within one night. For example, one platypus was found to travel about 11 km within one night.
- Radio-tracking also provided valuable information regarding how platypus can travel through piped sections. Results indicate that platypus are able to at least travel through short sections of piped waterway. For example, platypus were able to travel through a steep, piped section of waterway below the Monbulk Creek Retarding Basin (immediately upstream of Nixon Road).
- Platypus also appeared to concentrate their foraging to a small percentage of their home range. This finding indicates that the type of stream habitat may be important in determining how much food is available for the platypus.

Further research will be conducted during 1997/98 to determine whether the platypus distribution in the study area is restricted by the amount of food (typically macroinvertebrates) available and to determine the link between the amount of food and the type of stream habitat present.

Further platypus surveys and radio-tracking is scheduled in the Monbulk Creek during early 1998 as part of the Urban Platypus Program.

5. DISCUSSION

Waterways within the Corhanwarrabul system are valuable environmental resources that are some of the few waterways in the Dandenong Valley that are in reasonably good condition. Therefore, these important waterways need to be diligently managed to ensure that the rich aquatic ecosystem present is protected and enhanced.

Obviously, it is important to maintain reasonably good water quality, stream condition and habitats to support healthy aquatic ecosystems in the Corhanwarrabul catchment. This study addresses the difficult task of prioritising management objectives in the catchment, by providing a snapshot of the health of these waterways and utilising all available information to determine the factors that most affect stream health. It should also be appreciated that the Corhanwarrabul system also plays a vital role in supporting a healthy aquatic ecosystem in Dandenong Creek. For example, historical water quality data illustrates that Corhanwarrabul Creek contributes to an observed improvement in Dandenong Creek water quality. Therefore, a deterioration in the condition of the Corhanwarrabul Creek could also produce a substantial detrimental impact on Dandenong Creek.

Water quality in Dandenong Creek and tributaries has gradually deteriorated from a pristine state last century as a result of urban development, grazing, clearing and drainage. In the 1970s, following the gazettal of the Environment Protection Act (Victorian Government 1970), industrial and sewage discharges were gradually controlled. As a result, the water quality dramatically improved in the 1980s as the majority of point sources were removed. This improvement in water quality also led to an increased diversity of macroinvertebrates and a reduction in pollution-tolerant species (Nuttall 1983). Further urbanisation in the catchment has again led to deterioration of water quality in Dandenong Creek since the late 1980's (State Government of Victoria undated report).

These predominantly urban waterways have a reasonably good aquatic fauna, including platypus, some native fish, freshwater crayfish and trout. Platypus inhabit Monbulk Creek, the upper section of Corhanwarrabul Creek and at least one male inhabits Ferny Creek around New Road. The greatest density of platypus occurs in Monbulk Creek upstream of the Monbulk Retarding Basin. Moderate numbers of platypus occur in the lower section of Monbulk Creek and at least two platypus spent the majority of their time in Corhanwarrabul Creek between the Caribbean Gardens and the confluence of Monbulk and Ferny Creeks. It is very interesting to note that platypus were not found in the lower section of Ferny Creek, even though the lower section would be easily accessed by platypus in Monbulk and Corhanwarrabul Creeks. This indicates that the distribution of platypus in Ferny Creek is restricted by some other attribute (ie water quality, suitable food supply or physical condition) of the waterway.

Few native fish species occur in the Corhanwarrabul catchment, as they are unable to move past several fish barriers in the lower Dandenong Creek. These barriers have prevented the upstream movement of 62% of migratory fish which would have naturally occurred in this system (Raadik and O’Connor 1997). Of these native fish, tupong, the rare spotted galaxias and Australian grayling are totally prevented from moving through Pillars Crossing. Common galaxias and the short-headed lamprey are able to negotiate the weir in small numbers. Considerable improvements in the native fish fauna in the Dandenong Valley could potentially occur if fish barriers are removed. Therefore, further investigations should be conducted to identify these barriers and to suggest how they may be removed.

The most significant aquatic species that potentially occurs in the Corhanwarrabul catchment is the dwarf galaxias (*Galaxiella pusilla*). This species has been recommended by the Scientific Advisory Committee for listing under the Flora and Fauna Guarantee Act 1988 (FFG Nomination No. 141). Dwarf galaxias are primarily threatened by further drainage of wetlands and other human-induced damage, predation from redfin and possibly disturbance from introduced mosquitofish. The small dwarf galaxias population in the Dandenong Valley is probably the second largest of this species outside the Grampians National Park (Raadik and O'Connor, 1997). The limited surveys conducted indicate that they occur in Tirhatuan Wetlands Conservation Reserve near the confluence of Dandenong and Corhanwarrabul Creeks, and in Jells Park. It is likely that further surveys will confirm the presence of this species in wetlands in the Corhanwarrabul catchment, if suitable habitat still remains. Developments planned for areas in the Corhanwarrabul and lower sections of Monbulk and Ferny Creeks floodplains should ensure that suitable wetland habitat is retained, or even created, to protect this vulnerable species.

Water Quality

The limited historical water quality data available indicates that there have been substantial improvements in water quality in Ferny and Corhanwarrabul Creeks over past decades, whereas the reasonably good water quality in Monbulk Creek has remained constant over the same period. In particular, there was a substantial reduction in nutrients (ammonia and orthophosphate) and *E. coli* in Corhanwarrabul and Ferny Creeks after 1984. This improvement may be due to large numbers of residential properties being connected to a reticulated sewerage system during this period. The historical data also suggest that there may have been a reduction in turbidity and suspended solids in Ferny and Monbulk Creeks since the early 1990s, however, further monitoring will be required to substantiate these trends.

Base flow water quality in Monbulk and Clematis Creeks is generally good. These waterways have low levels of faecal contamination and usually moderate nutrient levels, although there are some exceptions: total phosphorus concentrations tend to be elevated in Clematis Creek, total nitrogen (predominantly as nitrate) is elevated in Monbulk Creek, particularly downstream of Belgrave Lake. Clematis Creek and Monbulk Creek near the Puffing Billy Bridge are often turbid and have elevated suspended solids, even during base flows. Water quality in Monbulk Creek downstream of Nixon Road was generally clear and mildly enriched. Turbidities increase downstream of Nixon Road and are elevated at Karoo Road. The diatom flora indicated that the amount of organic pollution in Monbulk Creek decreased downstream.

The water quality in Ferny Creek was generally poor. Ferny Creek at Sophia Street, Tecoma, tended to have high concentrations of total nitrogen (particularly nitrate) and elevated turbidities and suspended solids, even during base flows. There was a considerable change in water quality between Sophia Street and New Road, upstream of the Ferny Creek Retarding basin. Fluoride results indicate that urban run-off constitutes a low proportion of the flows in Ferny Creek at Sophia Street, but contribute a large proportion of flows downstream from New Road. As the contribution of urban run-off increases downstream of New Road, there are increases in conductivities, total phosphorus and the concentrations of some heavy metals in stream sediments. The greatest deterioration in water quality in Ferny Creek occurs at Lysterfield Road, as this site had high total phosphorus concentrations, conductivities and elevated levels of lead and zinc in the sediments. The diatom flora indicated that the amount of organic pollution in Ferny Creek increased downstream. The increased nutrient enrichment in the lower section of Ferny Creek did impact the aquatic flora. There were high densities of diatoms present and the filamentous alga *Cladophora glomerata*, which is indicative of high nutrient levels, dominated the macroalgal flora at the Hancock Drive and Rushdale Street sites.

Ferntree Gully Creek had poor water quality during this survey. The stream has high suspended solids and was usually very turbid, with the median value exceeding the SEPP 90th percentile objective of 50 NTU. In addition, the stream had elevated total nitrogen, total phosphorus and occasionally ammonia concentrations. Ferntree Gully Creek, however, still had very low *E. coli*, BOD and conductivity levels. Unusually poor water quality in Ferntree Gully Creek can be attributed to a large proportion of the catchment being burnt by a bushfire in January 1997. A small proportion of catchment headwaters of Ferny Creek was also burnt during these fires.

The contrasting water qualities in Ferny and Monbulk Creeks have an interesting impact on water quality in Corhanwarrabul Creek. Monbulk Creek contributes the majority (about 67%) of base flows to Corhanwarrabul Creek and, therefore, the water quality in Corhanwarrabul Creek would be predicted to be most influenced by Monbulk Creek. In addition, the diatom flora from Corhanwarrabul Creek was very similar to that present in Monbulk Creek at Karoo Road. However, the slightly poorer water quality in Ferny Creek does have a measurable impact on the water quality in Corhanwarrabul Creek, and a detectable impact on the aquatic biota. Ferny Creek had elevated *E. coli* and conductivities in the water and zinc and lead concentrations in sediments. Monbulk and Ferny Creeks contributed similar nutrient concentrations to Corhanwarrabul Creek. Total nitrogen concentrations were slightly higher in Monbulk Creek than in Ferny Creek. The form of nitrogen present differed between these waterways; Ferny Creek had a large proportion of organic nitrogen, whereas Monbulk Creek had a large proportion of nitrogen as nitrate. Lower sections of Monbulk and Ferny Creeks had similar concentrations of total phosphorus and orthophosphate.

Stream condition

Most waterways have very degraded riparian zones. Willows dominate the riparian vegetation in Ferny Creek downstream of Ferntree Gully, reducing hydraulic capacity in some sections. The riparian zone has also been compromised by a variety of other exotic plants. Sweet pittosporum is a dominant part of the undergrowth in a section of stream downstream of the Ferny Creek Retarding Basin. Ivy and other creepers and exotic understorey vegetation have smothered all other understorey and groundcover growth in many areas, particularly around Tecoma. Monbulk Creek downstream of Nixon Road is also dominated by willows and rampant blackberry growth. Large sections of Corhanwarrabul Creek are also infested with willows, although willow removal has occurred in some areas. Downstream of Stud Road, the majority of the waterway is severely infested by willows in the channel, and on the verges by blackberries and gorse. Stands of willows act as effective litter traps and have collected large amounts of litter and other rubbish, which create visual pollution and occasional odour problems.

Severe bed degradation and bank erosion occurs in parts of Corhanwarrabul, Ferny and Monbulk Creeks. Some rock chutes in Corhanwarrabul and Ferny Creeks have been damaged by a combination of hydraulic conditions and willow growth through the rocks. Bank erosion is evident, particularly around the foothills of Ferny Creek, and along Monbulk Creek between Belgrave Lake and the Monbulk Retarding Basin.

Nuttall (1982) reported that Ferny, Monbulk and Corhanwarrabul Creeks contained large deposits of unstable silt, sand and gravel on the stream bed. He also observed that the numbers and diversity of animals and plants were significantly reduced in stretches of waterway which had undergone stream improvement, when compared to natural sections throughout the catchment. The aim of these "stream improvement" works was to improve drainage and mitigate flooding in urban areas. Many sections of watercourses in areas that were prone to flooding were transformed into underground pipe drains (DVA 1975), including large sections of Ferny Creek around the foothills of the Dandenong Ranges in Ferntree Gully.

Major factors influencing stream health

Analyses of the macroinvertebrate assemblages indicate that fauna in Monbulk Creek is in good condition and in Ferny Creek poor condition. The biotic condition in Ferny Creek deteriorates between Sophia Grove, Tecoma and New Road, Upper Ferntree Gully. Corhanwarrabul Creek is rated as being in fair condition, which represents a slight deterioration in stream health, when compared to Monbulk Creek. Another significant faunal difference between these waterways, is that platypus are widely distributed in Monbulk Creek but are virtually absent in Ferny Creek. Significantly lower numbers of platypus occur in Monbulk Creek downstream of the Monbulk Creek Retarding Basin than further upstream. This difference in numbers is likely to be due to changes in the types and condition of in-stream habitats.

Differences in biota that inhabit Monbulk and Ferny Creeks primarily appear to be influenced by the physical attributes of the waterway and catchment land uses, rather than water quality. This survey indicates that Monbulk and Ferny Creeks have similar water quality. Ferny Creek does have higher levels of *E. coli*, organic nitrogen, conductivities in water, and zinc and lead concentrations in sediments, but Monbulk Creek had slightly higher total nitrogen and nitrate concentrations. Both waterways have similar phosphorus (total phosphorus and orthophosphate) concentrations, suspended solids and turbidities.

A major reason for observed differences could be that a large proportion of the Ferny Creek catchment is urbanised compared to Monbulk Creek. This increased level of urbanisation alters flows by increasing the impervious area in the catchment and by increasing the hydraulic efficiency within drainage lines and receiving waterways (Stormwater Committee, 1998). Therefore, the higher proportion of urbanisation in Ferny Creek, compared to Monbulk Creek, can lead to considerable changes in the biota (P. Breen, personal communication). Draft best practice guidelines for managing flow have been developed for the Stormwater Committee (1988). These guidelines recommend maintaining natural drainage systems, the construction of small storages throughout the catchment to help reduce peak flow rates, designing channels that both protect aquatic ecosystems and provide flood mitigation and control run-off from impervious surfaces. Numerous techniques are also presented for treating urban run-off. These best practices guidelines need to be followed in the Corhanwarrabul catchment to minimise the impact of further urbanisation in the catchment. A detailed strategy for controlling urban stormwater run-off from the Ferntree Gully area would also improve the water quality and return storm flows to more natural levels.

Aquatic ecosystems in the catchment could also be enhanced by improving riparian zones and stream beds and banks. Eradication of willows, control of other exotics and revegetation of the riparian zones with native species, will provide a constant source of food for many aquatic animals and help create some diversity in in-stream habitats, rather than having a shallow stream flowing over willow root mats. Stream bed and bank erosion will also need to be controlled to minimise sedimentation within the stream.

6. CONCLUSIONS

Monbulk and Ferny Creeks have an important role in maintaining the water quality and health of the Dandenong Creek, as well as supporting significant aquatic ecosystems in their own right. Historical data demonstrate that there has been considerable improvements in water quality over past decades, presumably as residential areas have been connected to Melbourne's sewerage system. Waterways in the catchment now have reasonably good water quality.

The health of waterways in the Corhanwarrabul catchment can be enhanced by restoring and protecting an adequate riparian zone, with indigenous vegetation, stabilising eroding banks and by creating more in-stream habitat. Differences in macroinvertebrates, fish and platypus that inhabit Ferny and Monbulk Creeks primarily appear to be due to difference in the physical condition of these waterways and the amount and type of land use activities in the catchment, rather than due to water quality. The future management of these waterways should focus on improving stream condition and by adopting best practice guidelines for treating urban run-off and reducing the impact of storm flows from urbanised areas.

There are few native fish in the Corhanwarrabul catchment. Concrete channels and weirs in the lower Dandenong Valley are barriers to fish movement of diadromous species, such as grayling and galaxias. Removal or modification of these barriers would improve the variety of native fish that would inhabit the Corhanwarrabul waterways downstream of the retarding basins on Ferny and Monbulk Creek, and greatly contribute to improved ecosystem health in these waterways.

The dwarf galaxias is the most significant aquatic vertebrate species occurring in the Dandenong Valley, as it is listed by the Scientific Advisory Committee under the Victorian Fauna and Flora Guarantee 1988. This species can be protected in the Dandenong Valley by ensuring that floodplain wetlands are conserved.

Developments planned for areas in the Corhanwarrabul catchment and in the lower sections of Monbulk and Ferny Creeks should ensure that suitable wetlands are conserved, or even created, to protect this vulnerable species. Furthermore, adequate vegetated riparian zones should be retained along all watercourses to provide habitat and a constant source of food to aquatic ecosystems.

The health of these waterways can only be enhanced, even maintained, with the cooperation of land owners, MWC, the Cities of Knox and Yarra Ranges, and other agencies that impact catchment condition.

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Appendix 8.x: Macroalgal species abundance and habitat at each site. * 'A'= abundance value from 0-3, where 0 = absent, 1 = isolated plants, 2 = not common & 3 = common and easily observed (as in Entwisle 1989). 'Cover' refers to the cover of the sample on the substrata, where 0 = 0%, 1 = <10%, 2 = 10-35%, 3 = 35-65%, 4 = 65-90% & 5 = >90%.

Site	**Species in Sample 1**	**A***	**Habitat**	**Substrata Attached**	**Cover**	**Sample 2**	**A***	**Habitat**	**Substrata Attached**	**Cover**	**Sample 3**	**A***	**Habitat**	**Substrata Attached**	**Cover**	**Total Algal Cover**
COR01	*Spirogyra* sp. MFG *Spirogyra* sp. SCG *Melosira varians* *Phormidium* sp. *Anabaena aff. planktonica*	3 3 3 1 1	Pool	Other	5	*Spirogyra* sp. MFG *Oedogonium* sp. MFG *Melosira varians*	3 1 1	Run	Vegetation	2						High
COR02	*Vaucheria* sp. *Spirogyra* sp. MFG	3 1	Riffle	Bedrock/Boulders	2											Low-Moderate
FER03	*Cladophora glomerata* *Vaucheria* sp. *Oedogonium* sp. BFG *Melosira varians*	3 1 1 1	Riffle	Bedrock/Boulders Cobbles/Pebbles	1	*Cladophora glomerata* *Oedogonium* sp. MFG *Oedogonium* sp. BFG *Melosira varians* *Vaucheria* sp.	3 2 2 2 1	Riffle	Bedrock/Boulders Cobbles/Pebbles	1	*Cladophora glomerata* *Vaucheria* sp. *Oedogonium* sp. BFG	3 3 1	Riffle	Bedrock/Boulders Cobbles/Pebbles	2	Moderate
MON04	*Cladophora glomerata* *Oedogonium* sp. BFG *Spirogyra* sp. MFG	3 3 3	Run	Cobbles/Pebbles Gravel/Sand	3	*Spirogyra* sp. MFG	3	Run	All	2						Moderate-High
FER05	*Oedogonium* sp. BFG *Spirogyra* sp. MFG	3 1	Riffle	Bedrock/Boulders	2	*Vaucheria* sp. *Oedogonium* sp. BFG *Melosira varians*	2 1 1	Riffle	Bedrock/Boulders	1	*Cladophora glomerata* *Oedogonium* sp. BFG *Spirogyra* sp. MFG	3 2 1	Riffle	Bedrocks/Boulders	3	High
FER06	*Oedogonium* sp. BFG *Spirogyra* sp. MFG	3 2	Riffle	Bedrock/Boulders Cobbles/Pebbles Vegetation	2											Low-Moderate
FGU07	No macroalgae observed															None
FER08	*Oedogonium* sp. BFG	3	Pool	Cobbles/Pebbles	1	*Cladophora glomerata* *Oedogonium* sp. MFG *Oedogonium* sp. BFG *Microspora flocculosa*	3 1 1 1	Pool	Bedrock/Boulders Cobbles/Pebbles	1	*Oedogonium* sp. BFG *Melosira varians* *Spirogyra* sp. MFG	3 3 1	Pool	All	3	High
FER09	No macroalgae observed															None
MON10	*Vaucheria* sp.	3	Riffle	Bedrock/Boulders	2	*Vaucheria* sp.	3	Riffle	Bedrock/Boulders	1						Moderate
MON11	*Vaucheria* sp. *Oedogonium* sp. BFG	3 2	Riffle	Bedrock/Boulders Cobbles/Pebbles	2	*Cladophora glomerata* *Vaucheria* sp. *Oedogonium* sp. BFG	3 3 3	Riffle	Bedrock/Boulders Cobbles/Pebbles	1						Moderate
MON12	*Vaucheria* sp. *Melosira varians*	3 1	Riffle	Bedrock/Boulders Cobbles/Pebbles	3	*Oedogonium* sp. BFG *Oedogonium* sp. MFG *Spirogyra aff. ellipsospora* *Vaucheria* sp. *Melosira varians*	3 3 2 1 1	Riffle	Bedrock/Boulders Cobbles/Pebbles	1						Moderate
CLE13	No macroalgae observed															None
MON14	*Batrachospermum* sp.	3	Run	Bedrock/Boulders	1	*Vaucheria* sp.	3	Riffle	Bedrock/Boulders	1	*Vaucheria sp.*	3	Run	All	2	Low-Moderate