Moorabool River fish survey – measuring the impact of dry inflow conditions

West Moorabool River at Hunts Bridge (December 2008)

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EXECUTIVE SUMMARY

The Moorabool River system is one of the most stressed river systems in Victoria and currently receives less than half of its annual natural flow, and even less in drought years. As a consequence the river system is suffering under prolonged periods of low flow, reduced median streamflows and lack of flow variability.

With low water levels in Lal Lal Reservoir, water authorities implemented a number of drought contingency measures to secure water supplies. An application by Central Highlands in November 2006 requested the Minister for Water, Environment and Climate Change to qualify rights to the Bulk Entitlement Conversion Order 1995. Two qualification of rights measures were granted – the temporary waiving of passing flows at Lal Lal Reservoir to retain water in storage for Ballarat, the other to secure Meredith's water supply.

This report summarises the findings of a fish survey which primarily targeted the reach between Lal Lal Reservoir and Sheoaks Weir, a reach that supports a high standard of riparian vegetation and a variety of instream habitats.

The results indicate that the exclusively freshwater native fish fauna of the middle reaches of the Moorabool River system has persisted despite few natural inflows and the cessation of passing flows from Lal Lal Reservoir since October 2006. A total of 1021 native fish from five different species and 1031 exotic fish from four different species were captured. Of particular note was the persistence of freshwater blackfish within the system. It, therefore, appears clear that environmental flow releases have been effective in maintaining water quality in the remnant pools between Lal Lal Reservoir and Sheoak Weir.

Most native aquatic fauna in the Moorabool River system are adapted to periods of flow cessation, as these conditions would naturally have occurred in the catchment. Unfortunately, the natural duration of the flow cessation period may have only been for weeks or months, not for years as the system is currently experiencing. It has been fortunate that the fish fauna between Lal Lal Reservoir and Sheoaks Weir currently remains intact, but there is no guarantee that this situation will remain unchanged into the future. Regular streamflow pulses are necessary to restore good water quality conditions to remnant pools.

The remaining 160 ML left in Lal Lal Reservoir for environmental entitlement is not sufficient for maintaining the West Moorabool River and downstream Moorabool River indefinitely. The existing allocation may be needed before the completion of 2009, if elevated water temperatures or salinity concentrations or low dissolved oxygen concentrations are triggered. With continuation of the drought further water allocations for the environment are needed, otherwise species like the river blackfish may not be capable of breeding and remnant pools may stagnate, and there is a possibility that the entire fish fauna could be lost.

The lower Moorabool River is in very poor ecological health. The current instream condition of remnant pools is expected to be severely degraded by low oxygen levels and elevated salinities. Some fish species may have already been lost from the remaining pools. Environmental flows are urgently required to prevent further loss of aquatic fauna and to restore the potential for migratory native fish to recolonise the system.

The confirmation of the nationally threatened Yarra pygmy perch is a supplementary outcome from this study. Given the species has not been recorded at any other location in the Moorabool River basin, protection of the small known reach of habitat in Sutherland Creek should be a priority management consideration.

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1.0 INTRODUCTION

The Moorabool River system is one of the most stressed river systems in Victoria (Corangamite Catchment Management Authority (CCMA), 2006). The Moorabool River currently receives less than half its annual natural flow, and even less in drought years (Sinclair Knight Merz (SKM), 2004).

This report summarises the findings of a fish survey which primarily targeted the reach between Lal Lal Reservoir and Sheoaks Weir, a reach that supports valued riparian vegetation and a variety of instream habitats (SKM, 2004). Prolonged periods of low flow, reduced median streamflows and lack of flow variability have been identified as primary issues affecting the reach (SKM, 2004). With cessation of passing flows at Lal Lal Reservoir in late 2006 the environmental condition of the West Moorabool River and Moorabool River could potentially have become further degraded. It is the intention of this report to determine whether diminished flows have been deleterious to the fish fauna between Lal Lal Reservoir and Sheoaks Weir.

A supplementary aspect of this investigation was to investigate a reported finding of Yarra pygmy perch (*Nannoperca obscura*) in Sutherland Creek (Bloink, pers. comm., 2008). Confirmation of this nationally threatened species is important, as there has been no other record of the species within the Moorabool River basin.

1.1 The study area

Figure 1 shows the Moorabool River basin. The study area included waterways in the middle of the catchment.

The West Moorabool River was surveyed between Lal Lal Reservoir and Morrisons and the Moorabool River between Morrisons and Batesford. The study area included an important ecological section of the Moorabool River catchment; the reach between Lal Lal Reservoir and Sheoaks Weir.

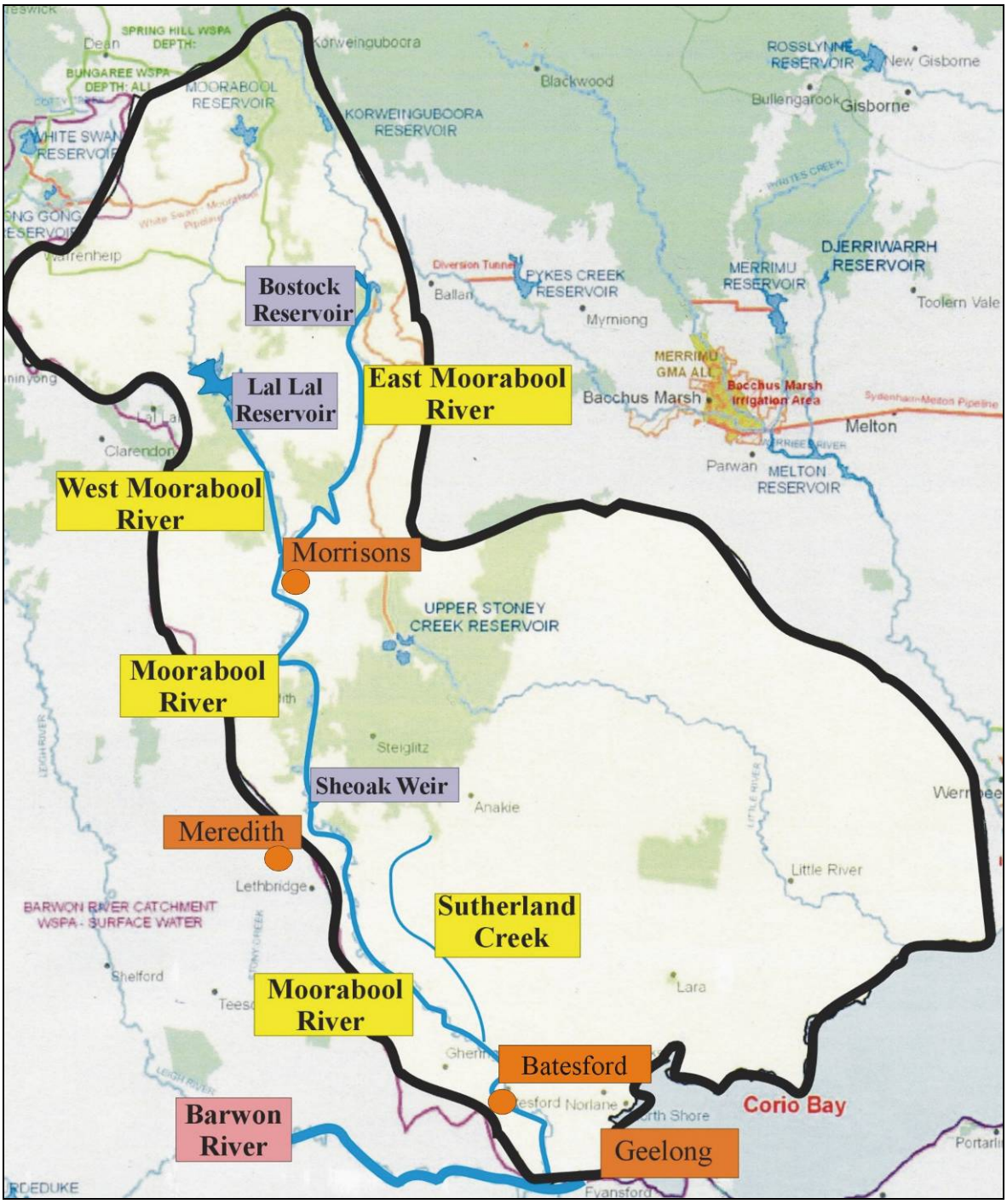
For comparison with the West Moorabool River, which has not received any passing flows from Lal Lal Reservoir since 2006, several locations on the East Moorabool River were surveyed. The East Moorabool River has a passing flow of approximately 1 ML/day released from Bostock Reservoir.

Sutherland Creek, a small tributary in which the Yarra pygmy perch has been reported is a small ephemeral tributary of the Moorabool River in the lower part of the Moorabool River catchment.

1.2 Water resource management and environmental streamflow releases

Central Highlands Water manages Lal Lal Reservoir and has a 2/3 share of the water resource for supplying towns in the upper Moorabool River basin and the outskirts of Ballarat (Victorian Government, 2008). Barwon Water has the remaining 1/3 share of Lal Lal Reservoir for urban water supply to the Greater Geelong area (Victorian Government, 2008).

Under the Bulk Entitlement (Lal Lal Central Highlands) Conversion Order 1995 the passing flow rules at Lal Lal Reservoir is 20 ML/day for normal conditions and the lesser of 5 ML/day or natural flow under dry conditions (when the cumulative inflow over the previous 24 months is less than 43,00 ML).



Base map from Government of Victoria (2008).

Figure 1. Waters surveyed in the Moorabool River basin (labelled in yellow).

In 2006/07 rainfall in the Moorabool River basin ranged between 40% and 80% of the long term average, a reduction from the previous three years which experienced rainfall nearer the long term average (Victorian Government, 2008). Lal Lal Reservoir dropped from 16,600 ML to 3,300 ML, which is only 5.5% of capacity (Victorian Government, 2008).

With low water levels in Lal Lal Reservoir, water authorities implemented a number of drought contingency measures to secure water supplies. An application by Central Highlands in November 2006 requested the Minister for Water, Environment and Climate Change to qualify rights to the Bulk Entitlement (Lal Lal Central Highlands) Conversion Order 1995. Two qualification of rights measures were granted – the temporary waiving of passing flows at Lal Lal Reservoir to retain water in storage for Ballarat, the other to secure Meredith's water supply (Victorian Government, 2008).

After further application, the qualification of rights were renewal in 2007 and will apply for an indefinite period until Ballarat comes off Stage 4 water restriction.

As part of the Central Highlands 2006 application for qualification of rights, Corangamite CMA was granted an environmental flow qualification allocation of 240 ML to maintain water quality in remnant pool habitats between Lal Lal Reservoir and She Oaks Weir until spring 2007. Only three 80 ML pulses are available for the life of the qualification (Corangamite CMA, 2008).

A continuous water quality logger measuring water temperature, pH, dissolved oxygen and electrical conductivity at Cooper Crossing (Steiglitz Road) has been used to determine the trigger for the pulsed environmental flow releases (temperature greater than 25ºC, dissolved oxygen concentration less than 5 mg/L or electrical conductivity above 10,000 uS/cm).

The first 80 ML environmental entitlement commenced on 1 April 2008 and lasted for 11 days (Woolley, 2008). The release was triggered by a low dissolved oxygen levels recorded by the Coopers Crossing water quality logger and a matching trend in decreasing dissolved oxygen levels from manual monitoring (Woolley, 2008). Water released from Lal Lal Reservoir water took 3.5 days to reach Hunts Bridge (10 km downstream) 8 days to reach Morrisons (23.5 km downstream) and 15 days to reach Meredith pumping station (35 km downstream).

Apart from the qualification allocation, an additional 240 ML/year was provided by Central Highlands Water for summer 2008/09 to provide for 3 summer freshes of 80 ML as recommended in the FLOWS study (SKM, 2004). The objective of the summer freshes is to enhance connectivity between pools, allowing fish movement in the deeper channels and refuge in the shallower channels as well as improving water quality by flushing and mixing of pools (SKM, 2004).

When water was released from Lal Lal Reservoir to the Meredith pumping station to meet urban water supply in early December 2008, one of the summer freshes was also released from the reservoir. This fish study coincided with the combined flow release, which was hoped would provide streamflow downstream to Sheoaks Weir (unlike the April 2008 release which only reached 50 m past the Meredith pumping station). By combining the releases the larger overall volume and rate of flow is expected to provide a greater environmental benefit to the Moorabool River (Corangamite CMA, 2008).

1.3 Aquatic fauna

Table 1 lists the aquatic fauna recorded in the Moorabool River basin.

Twelve species of native freshwater fish, seven species of exotic fish, and four species of decapod crustacea have previously been recorded in the Moorabool River catchment (Ryan and McGuckin, 2008); Victorian Aquatic Fauna Database 2005 (not updated since 2003); Raadik and Koster, 2000).

Table 1 provides the relative distribution of fish, crustacea and aquatic mammals recorded in the Moorabool River. Three main reaches are used for the distribution, the West Moorabool River downstream of Lal Lal Reservoir, the Moorabool River between Morrisons and Batesford, and the Moorabool River between Batesford and the Barwon River. There is no known survey data for the East Moorabool River. Fish data for Sutherland Creek is also included in Table 1.

Two exclusively freshwater native fish species in the Moorabool River, the freshwater blackfish (*Gadopsis marmoratus*) and southern pygmy perch (*Nannoperca australis*), have been recorded throughout the Moorabool River system. Unconfirmed records include observations of mountain galaxias (*Galaxias olidus*) below Sheoaks Weir in 1987 and in Sutherland Creek in 1984 (Victorian Aquatic Fauna Database 2005) and Yarra pygmy perch in Sutherland Creek in 2005 (Bloink, pers. comm., 2008).

Two additional native fish species, the flat-headed gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*) are known to undertake opportunistic migrations, but are capable of persisting in either freshwater or estuarine environments. Both have been recorded in the Moorabool River.

There is six recorded native fish species which are known to migrate between estuarine and freshwater environments as part of their life cycles, namely short-finned eel (*Anguilla australis*), common galaxias (*Galaxias maculatus*), spotted galaxias (*Galaxias truttaceus*), short-headed lamprey (*Mordacia mordax*), Australian grayling (*Prototroctes maraena*) and tupong (*Pseudaphritis urvillii*). With the exception of the short finned eel, these species have generally only been found in the Moorabool River downstream of a series of instream barriers upstream of Batesford.

The Australian grayling is considered threatened in Victoria and Australia. The species is listed as vulnerable in Victoria (Department of Sustainability of Environment (DSE), 2003) and in Australia (Environment Protection and Biodiversity Conservation (EPBC) Act, 1999). The Australian grayling is also listed for protection under the Victorian Flora and Fauna Guarantee (FFG) Act, 1988. It has previously been recorded in the mid reach of the Moorabool River near Meredith in 1976 (Victorian Aquatic Fauna Database 2005) and more recently in the lower reach of the Moorabool River near the confluence of the Barwon River in 1998 (Raadik and Koster 2000a).

Of the seven exotic fish species recorded, redfin (*Perca fluviatilis*), brown trout (*Salmo trutta*), and tench (*Tinca tinca*) have widespread distributions. Goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), roach (*Rutilis rutilis*) and eastern gambusia (*Gambusia holbrooki)* have been recorded only in the lower reach of the Moorabool River, downstream of Batesford.

Other aquatic biota recorded include Southern Victorian spiny cray (*Euastacus yarraensis*) and freshwater shrimp (*Paratya australiensis*) which have been found downstream of Sheoaks Weir. An unidentified species of burrowing crayfish (*Engaeus* sp.) (Raadik and Koster, 2000) has also been recorded in the Moorabool River system.

Platypus (*Ornithorhynchus anatinus*) have been recorded in the Moorabool River in 1981 (Victorian Wildlife Database, 2005) and more recently, at Sharpe Road near Sheoaks Weir in 2007 (Ryan and McGuckin, 2008). Water rats (*Hydromys chryogaster*) have only been recorded near Fyansford in the lower reaches of the Moorabool River (Victorian Wildlife Database, 2005).

Table 1. Aquatic fauna recorded in the middle and lower reaches of the Moorabool River catchment.

Common Name	Scientific name	West Moorabool River (Lal Lal Reservoir to Morrisons)	Moorabool River (Morrisons to Batesford)	Moorabool River (Batesford to Barwon River)	Sutherland Creek
Native fish					
short-finned eel **m**	*Anguilla australis*	X	X	X	
river blackfish	*Gadopsis marmaratus*		X	X	
common galaxias	*Galaxias maculatus*		X	X	
mountain galaxias	*Galaxias olidus*		X		
spotted galaxias	*Galaxias truttaceus*			X	
southern pygmy perch	*Nannoperca australis*		X	X	X
Yarra pygmy perch	*Nannoperca obscura*				
short headed lamprey**m**	*Mordacia mordax*			X	
flat headed gudgeon	*Philypnodon grandiceps*		X		X
Australian grayling **m**	*Prototroctes maraena***1 2 3**			X	
Australian smelt	*Retropinna semoni*		X	X	X
tupong	*Pseudaphritis urvillii*		X	X	
Exotic fish					
goldfish	*Carassius auratus*			X	
carp	*Cyprinus carpio*			X	
eastern gambusia	*Gambusia holbrooki*			X	
redfin	*Perca fluviatilis*	X	X	X	
brown trout	*Salmo trutta*	X	X	X	
roach	*Rutilis rutilis*			X	
tench	*Tinca tinca*	X	X	X	
Crustacea					
Southern Victorian spiny cray	*Euastacus yarriensis*		X	X	
burrowing cray	*Engaeus sp.*		X	X	
freshwater shrimp	*Paratya australiensis*		X	X	X
Aquatic mammals					
water rat	*Hydromys chryogaster*			X	
platypus	*Ornithorhynchus anatinus*		X		

1 listed as threatened in Australia (Environment Protection and Biodiversity Conservation Act, 1999)

2 listed as threatened fauna in Victoria (DSE, 2003)

3 listed under FFG Act, 1988

m migratory (between freshwater and estuarine environments)

2.0 FIELD STUDY

2.1 Survey sites

2.1.1 Moorabool River

A total of 14 sites were surveyed in the Moorabool River system between 8 – 11 December 2008.

Three locations were on the East Moorabool (sites 1-3), two on the West Moorabool River (sites 4 and 5) and nine on the Moorabool River between Morrisons and Batesford (6-14). Seven of the survey sites (4-10) were between Lal Lal Reservoir and Sheoak Weir.

The topographical map reference for each site is listed in Table 2. Figure 2 shows the location of the sampling sites.

Table 2. Sites surveyed in the Moorabool River catchment.

Waterway	Site Number	Date surveyed	Location	Topographical Map Reference			
				Map	Zone	East	North
East Moorabool River	1	8/12/2008	Pool at Bostock Reservoir spillway	7722 Bacchus Marsh	55	251708	5833248
	2	8-9/12/2008	Pools near Bostock Reservoir spillway	7722 Bacchus Marsh	55	251749	5833251
	3	8-9/12/2008	Egerton Bungeeltap Road	7722 Bacchus Marsh	55	250763	5825132
West Moorabool River	4	8/12/2008	Immediately below Lal Lal Reservoir	7722 Bacchus Marsh	55	242058	5825859
	5	8-9/12/2008	At Hunts Bridge on Elaine Egerton Road	7722 Bacchus Marsh	55	243917	5822295
Moorabool River	6	8-9/12/2008	Ballan - Meredith Road, Morrisons	7722 Bacchus Marsh	55	244980	5813990
	7	8-9/12/2008	Meredith Pump Station, Marchments Road, Meredith	7722 Bacchus Marsh	55	245275	5810240
	8	10-11/12/2008	Slate Quarry Road, Meredith	7722 Bacchus Marsh	55	246370	5809004
	9	10-11/12/2008	Steiglitz Road, Meredith (Coopers Crossing)	7722 Bacchus Marsh	55	247627	5805638
	10	9-10/12/2008	Sheoak Weir	7722 Bacchus Marsh	55	247442	5801926
	11	9-10/12/2008	Sharpe Road	7722 Bacchus Marsh	55	247436	5801564
	12	9-10/12/2008	Perdrisat Road, Maude	7722 Bacchus Marsh	55	249972	5795558
	13	9-10/12/2008	Parkers Road	7721 Geelong	55	253002	5789125
	14	9-10/12/2008	Bakers Bridge Road	7721 Geelong	55	257870	5784805

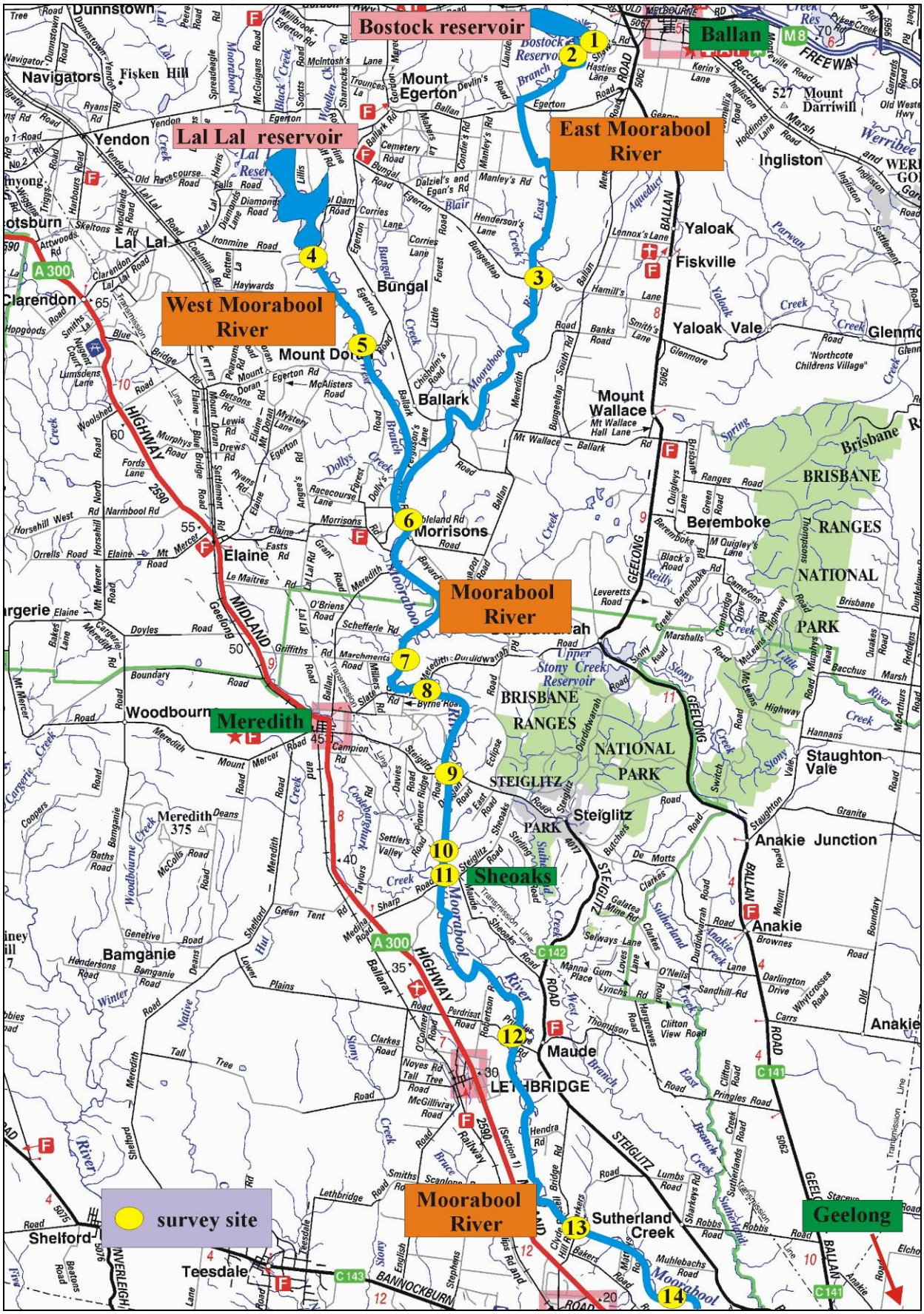
2.1.2 Sutherland Creek

A total of eight sites were investigated in the Sutherland Creek catchment on 10 - 11 December 2008. The four locations in the Sutherland Creek East Branch were disconnected pools (sites 15 to 18). The two locations observed in the Sutherland Creek West Branch were both dry (sites 19 and 20). In Sutherland Creek itself, one location was a shallow pool (site 21), the other a dry creek bed (site 22).

The topographical map reference for each site is listed in Table 3. Figure 3 shows the location of the sampling sites.

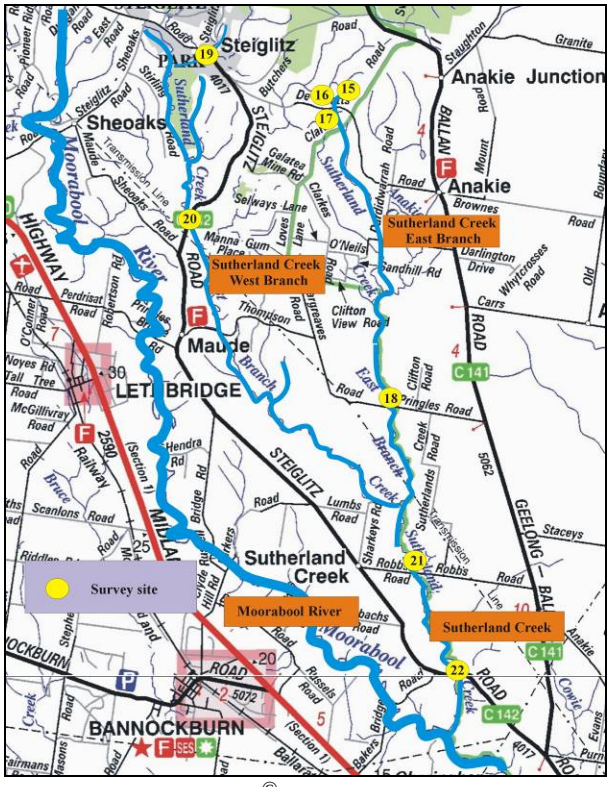
Table 3. Sites surveyed in Sutherland Creek system.

Waterway	Site Number	Date surveyed	Location	Topographical Map Reference			
				Map	Zone	East	North
Sutherland Creek East Branch	15	10/12/2008	Old dam (to the north of Steiglitz Anakie Road)	7721 Geelong	55	254200	5802955
	16	10/12/2008	Spring dam(to the north of Steiglitz Anakie Road)	7721 Geelong	55	253950	5802610
	17	10-11/12/2008	Hadlee property (wetland) (Steiglitz Anakie Road)	7721 Geelong	55	254218	5802313
	18	11/12/2008	To north of Pringle Bridge Road	7721 Geelong	55	252276	5795842
Sutherland Creek West Branch	19	11/12/2008	Steiglitz Road, Steiglitz	7721 Geelong	55	251400	580400
	20	11/12/2008	Steiglitz Maude Road,	7721 Geelong	55	251125	5798625
Sutherland Creek	21	10/12/2008	Robbs Road	7721 Geelong	55	258303	5788695
	22	10/12/2008	Steiglitz Road	7721 Geelong	55	259756	5785663



(Base map VicRoads GIS Dataset © VicRoads 2002 reproduced under licence)

Figure 2. Survey sites on the Moorabool River.



(Base map VicRoads GIS Dataset © VicRoads 2002 reproduced under licence)

Figure 3. Sites investigated in Sutherland Creek.

2.2 Fish sampling techniques

With the exception of one location on the East Moorabool River (site 1) and one location on the West Moorabool River (site 4) which could both be effectively electrofished, the overnight setting of fyke nets was considered the most appropriate technique to capture fish at the remaining survey sites in the Moorabool River system (sites 2, 3, 5-14). Fyke netting is an ideal fish capture technique in waters with elevated salinities and dense aquatic vegetation; characteristics found throughout the Moorabool River system. Fish observations were made at all survey sites and proved particularly important at several sites where fish were observed, but not captured (sites 7 and 9).

Sampling of pools in the Sutherland Creek system (sites 17-21) was conducted with a dip net. Fyke nets were also used at one location in the headwater in the Sutherland Creek East Branch (site 19).

At all survey sites, fish captured were identified and counted. The smallest and largest of each species was measured and weighed. Appendix 1 has a full listing of aquatic fauna captured at each survey site.

2.3 Water quality measurements

In situ water quality field measurements were made at all of the fish survey sites. Equipment included an Orion 230A pH meter, an Orion Model 130 conductivity meter, a YSI Model 51 B dissolved oxygen meter and a Orbeco Model 966 turbidity meter. All instruments were calibrated and used in accordance with NATA protocols.

Depth profiles of temperature dissolved oxygen and electrical conductivity was made at five locations. The sites were Egerton Bungeeltap Road on the East Moorabool River (site 3), and at Morrisons (site 6), Coopers Crossing (site 9), Sheoak Weir (site 10) and Parkers Road (site 13) on the Moorabool River.

3.0 RESULTS

3.1 Moorabool River system

There was five native fish species and four exotic fish species captured in the Moorabool River system (Table 4). The native fish captured were the short finned eel, river blackfish, southern pygmy perch, flat headed gudgeon and Australian smelt. Exotic fish included eastern gambusia, redfin brown trout and tench. All of the fish species captured have previously been captured in the Moorabool River system.

The total number of native fish (1021) was very similar to that of the exotic catch (1031). The most widespread species were the short finned eel and river blackfish which were in the East Moorabool River, the West Moorabool River and present at most sites in the Moorabool River. Southern pygmy perch were in low numbers in the Moorabool River upstream of Sheoak Weir (site 10) but abundant at sites surveyed further downstream (sites 12-14). The flat headed gudgeon was present in the West Moorabool River and also in the Moorabool River. Australian smelt were patchy in distribution and were only noted at two locations (sites 7 and 9).

Tench were the most widespread of the exotic fish species, being found in low numbers at most survey sites in the East Moorabool River, the West Moorabool River and also in the Moorabool River. Redfin were also found in low numbers throughout the Moorabool River system. The eastern gambusia was found at three locations in the East Moorabool River (sites 1-3) and one location in the Moorabool River (site 7). Where eastern gambusia were found, they were abundant. A single brown trout was observed in the Moorabool River (site 7), none were found in either the East Moorabool River or West Moorabool River.

Shrimp (*Paratya australiensis*) were found throughout the Moorabool River system. Platypus were captured at two locations in Moorabool River, at the Meredith pump station (site 7) and at Parkers Road (site 13).

Table 4. Aquatic fauna captured at Moorabool River catchment survey sites.

	East Moorabool River			West Moorabool River		Moorabool River									Total
Site Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Native fish species															
short-finned eel[m]	5	2	1	38	10	5	18	3	6	20	6	19	8	7	**148**
river blackfish			3	3	16	3	15	6	7		6	4			**63**
southern pygmy perch								1	2			27	81	24	**135**
flat headed gudgeon				5		39	82	27	26	141	15	9	46	17	**405**
Australian smelt							70		200						**270**
Exotic fish species															
eastern gambusia	500	100	306				50								**956**
redfin			1	6					1	8	1				**17**
brown trout							1								**1**
tench		1	8	1	31	1			2	5	7	3		4	**63**
Crustacea															
shrimp	25	400		400	15	9			8	40	12		26		**935**
Aquatic mammals															
platypus							1						1		**2**

m migratory (between freshwater and estuarine environments)

3. 2 Sutherland Creek

There was four native fish species and one exotic fish species captured in the Sutherland Creek system (Table 5).

The most significant species found was the Yarra pygmy perch which was only found in the East Branch of Sutherland Creek (site 18). Three additional native fish species, the short finned eel, southern pygmy perch and flat headed gudgeon were also found in the Sutherland Creek system.

The one exotic species captured was the eastern gambusia.

Shrimp were captured in the East Branch of Sutherland Creek.

Table 5. Aquatic fauna captured in the Sutherland Creek system.

	Sutherland Creek East Branch				Sutherland Creek West Branch		Sutherland Creek		
Site Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**Total**
Native fish species									
short-finned eel[m]			2						**2**
southern pygmy perch		12	182						**194**
Yarra pygmy perch[1 2 3]				11					**11**
flat headed gudgeon							4		**4**
Exotic fish species									
eastern gambusia				12					**12**
Crustacea									
shrimp		20		30					**50**

1 listed as threatened in Australia (Environment Protection and Biodiversity Conservation Act, 1999)

2 listed as threatened fauna in Victoria (DSE, 2003)

3 listed under FFG Act, 1988

m migratory (between freshwater and estuarine environments)

3.3 Water quality

Under the variation to the State Environment Protection Policy (SEPP) for the Waters of Victoria (Environment Protection Authority (EPA), 2003), the middle and lower reaches of the Moorabool River system is within the Cleared Hills and Coastal Plains Segment.

Table 6 lists the surface water quality for the fish survey sites in the Moorabool River catchment.

Water quality in both the East Moorabool River and the West Moorabool River generally met the SEPP guidelines (EPA, 2003), which was expected, given that water was being released from both Bostock Reservoir and Lal Lal Reservoir at the time of this study.

In the Moorabool River, the measured pH, temperature, dissolved oxygen and turbidity were all suitable for supporting aquatic fauna. The elevated electrical conductivity downstream of Morrisons suggests that the released streamflow from Lal Lal Reservoir that commenced at the end of November 2008, had not effectively flushed pools as far downstream as Sheoak Weir. It is hoped that this occurred with the continuation of the streamflow in mid December 2008.

There was no indication that streamflow from Lal Lal Reservoir was reaching very far downstream of Sheoak Weir at the time of this study. The dissolved oxygen levels was just 44 % at Parkers Road (site 13) and 27% at Bakers Bridge Road (site 14). Both sites also had elevated electrical conductivities (5350 and 7790 µS/cm respectively). Poor water quality may be one of the reasons that a lower diversity of fish was found at these sites than further upstream.

For Sutherland Creek, data provides an indication of the water quality conditions in the pools supporting the Yarra pygmy perch.

Table 6. Water quality data.

Waterway	Site Number	Date	pH	Temperature (ºC)	Dissolved oxygen (% saturation)	Electrical conductivity (µS/cm)	Turbidity (NTU)
East Moorabool River	1	8/12/2008	7.0	19.0	78	1032	103
	2	8/12/2008	7.0	18.9	74	1078	3.5
	3	8/12/2008	7.1	17.0	79	1651	
West Moorabool River	4	8/12/2008	7.7	17.5	82	890	21
	5	9/12/2008	7.7	18.5	91	902	3.9
Moorabool River	6	9/12/2008	7.6	17.0	88	1026	3.3
	7	9/12/2008	7.9	21.1	76	1900	3.5
	8	9/12/2008	8.4	20.6	90	2650	
	9	9/12/2008	8.2	17.0	81	3140	2.0
	10	9/12/2008	7.9	19.0	106	2940	4.0
	11	9/12/2008	8.1	17.0	79	3200	1.5
	12	10/12/2008	7.8	15.0	83	3250	4.4
	13	10/12/2008	7.7	17.5	44	5350	3.2
	14	10/12/2008	8.0	15.4	27	7790	
Sutherland Creek East Branch	18	11/12/2008	8.8	22.0	103	3420	8.9

Vertical profiles of temperature, dissolved oxygen and electrical conductivity for five pools in the Moorabool River system are shown in Figure 4. Water depth was 2.1 m in the East Moorabool River at Egerton Bungeeltap Road (site 3). In the Moorabool River water depth was 1.8 m at Morrisons (site 6), 2.1 m at Coopers Crossing (site 9), 4.3 m at Sheoak Weir (site 10) and 2.0 m at Parkers Road (site 13).

There was no discernible difference in top to bottom water temperature at any of the surveyed sites. Oxygen levels dropped to around 40% saturation in the lower 0.5 m of the pool at Egerton Bungeeltap Road (site 3), which was similar to the dissolved oxygen levels found throughout the water column in the pool at Parkers Road (site 13). No halocline was found at any of the surveyed sites, although pool conductivity was higher with distance downstream, reaching a maximum of 5400 µS/cm at Parkers Road (site 13).

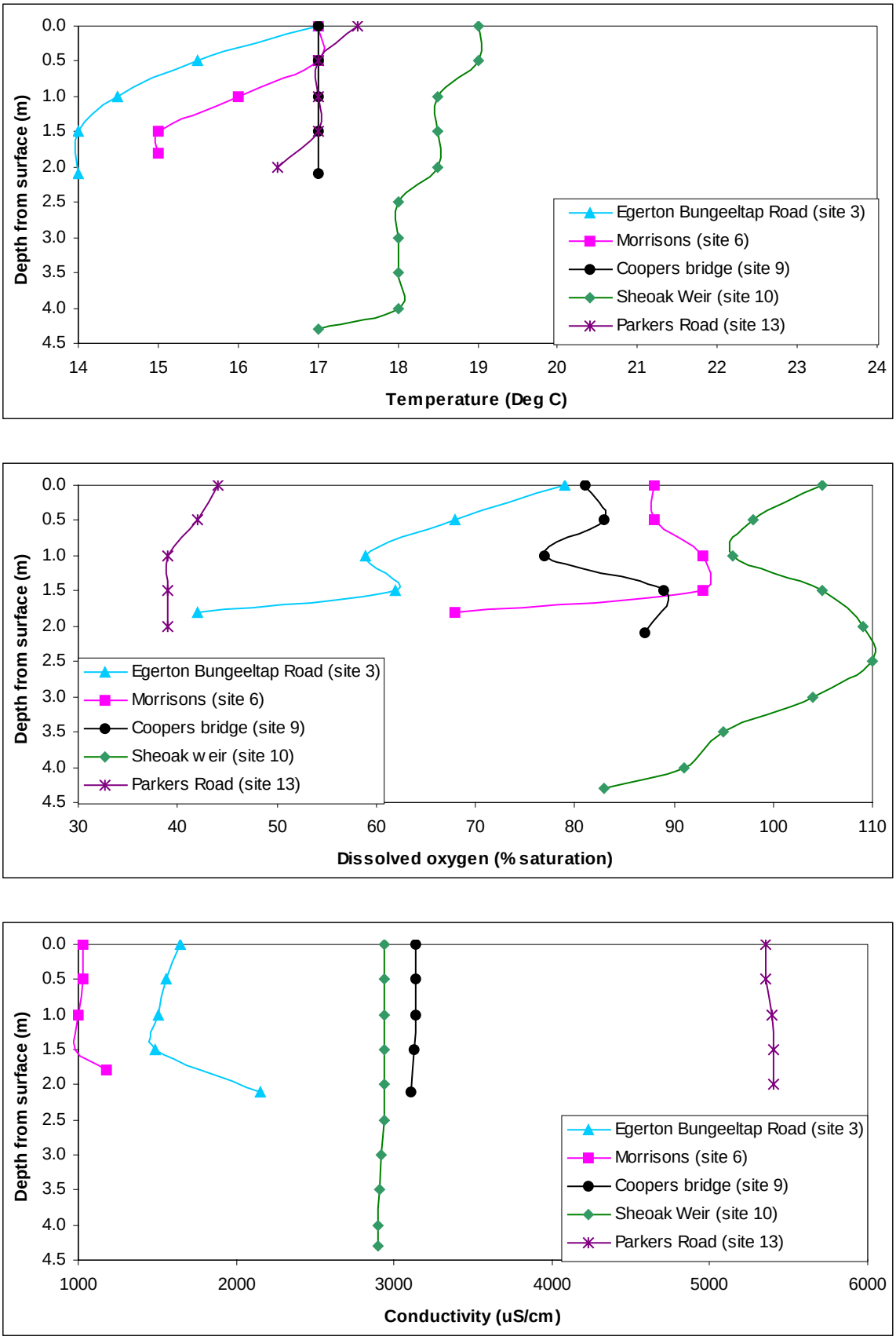


Figure 4. Vertical profiles of temperature, dissolved oxygen and electrical conductivity.

4.0 DISCUSSION

4.1 Instream conditions

4.1.1 East Moorabool River

There has not previously been any fish survey work conducted in the East Moorabool River. Two native fish species were recorded in this study, the short finned eel and river blackfish. The lack of smaller individuals of these species indicates limited recruitment within this reach. Exotic fish included redfin, eastern gambusia and tench. The eastern gambusia was the most widespread exotic species and when present was found in large numbers. The capture a small tench in this reach is indicative of a self sustaining population.

The East Moorabool River has a number of deep pools immediately downstream of Bostock Reservoir (near the spillway) all of which appear poorly oxygenated. Further instream degradation is expected to be due to flocculant from the reservoir which has smothered the substrate in the area.

The gorge area further downstream could potentially provide a number of deep pools that could have good instream value and may support a population of river blackfish, unfortunately, poor access prevented observation or sampling.

The passing flow of 1 ML/day from Bostock Reservoir is inadequate in providing connectivity of the pools throughout the East Moorabool River. No discernible streamflow was observed at Ballan Egerton Road and further downstream poor mixing was evident in the pool at Egerton Bungeeltap Road.

Of ecological value is the presence of a river blackfish population in the East Moorabool River. Continued streamflows from Bostock Reservoir are necessary to preserve water quality in pools where this species may occur.

4.1.2 West Moorabool River

The native fish fauna in the West Moorabool River has not been lost as a result of reduced streamflows from Lal Lal Reservoir. The remnant pools in the West Moorabool River may only be 1 to 3 metres in depth, but have, to date, maintained fish stocks. The capture of five fish species immediately downstream of Lal Lal Reservoir is indicative of fish moving from remnant pools into the habitat made available by streamflows. When streamflows cease, fish will again move back into remnant pools.

Numerous short finned eels were captured from 120 to 600 mm in length, indicating that the species may have been attracted into the West Moorabool River by environmental releases.

The absence of brown trout in the West Moorabool River is probably due to low oxygen concentrations since the cessation of passing flows from Lal Lal Reservoir. The species has a higher oxygen dependency than the other fish species that are found in the West Moorabool River. The species was not recorded in the current study, but was present in July 2007 (Ryan and McGuckin, 2008). Disconnectivity of pools and falling oxygen levels over the past 18 months are expected to have resulted in the loss of most, if not all, of the brown trout that formally were found in the West Moorabool River. The observation of just one fish in this study (at Meredith in the Moorabool River) may indicate that the species might disappear from the entire Moorabool River system if no or low streamflows persist in the future.

Tench ranging between 105 and 264 mm in length suggests that this is a self sustaining population. The capture of small redfin shows recent recruitment of this species.

4.1.3 Moorabool River

The exclusively freshwater fish fauna of the Moorabool River is consistent with the species previously recorded in the system (Raadik and Koster, 2000; Ryan and McGuckin, 2008). The short finned eel, river blackfish, southern pygmy perch and flat headed gudgeon and Australian smelt were all present.

Short finned eels ranged between 120 and 900 mm in length which shows some recruitment into the Moorabool River has occurred in recent years. River blackfish ranged between 135 and 506 mm, which may indicate that the species has not had successful recruitment in the last 12 months. Southern pygmy perch were captured at most sites, but were more abundant downstream of Sheoak Weir (sites 12, 13 and 14). The size of southern pygmy perch was between 18 to 77 mm in length and suggestive of a self sustaining population. The flat headed gudgeon ranged between 26 and 91 mm which also is indicative of a self sustaining population.

The distribution of Australian smelt can often be patchy, with no fish found in some areas and large populations located elsewhere in the same system. Although the species was not captured at any of the surveyed sites, large shoals were observed at the Meredith pumping station (site 7) and at Coopers Crossing (site 9). It is unknown why maintaining a self sustaining population and movement of this species has been singled out as a justification of summer freshes (SKM, 2004). This species, with southern pygmy perch, flat headed gudgeon and juvenile river blackfish could all potentially benefit from summer freshes.

Tench was the dominant exotic fish species being recorded over a wide range of sites and sizes from 54 to 469 mm. Redfin also appear to be widespread species with evidence of recent recruitment at Sheoak Weir (site 10).

The current drought has resulted in the discontinuity of streamflow, particularly downstream of Sheoak Weir. With a series of instream barriers present near Batesford (Raadik and Koster, 2000) migratory species like Australian grayling, the common galaxias, spotted galaxias, tupong and the short headed lamprey have had no opportunity for movement into the middle reaches of the Moorabool River. With the exception of the short finned eel, no native migratory fish were captured in this investigation.

Water levels in the Moorabool River between Meredith and Sheoak Weir are expected to have been much lower in the past 2 years than those observed in this study. The Sheoak Weir pool, for instance was in excess of 4 m in depth at the time of this investigation but was totally dry in early 2008 (John McKewon, pers. com., 2009).

4.1.4 Sutherland Creek

This study has confirmed the presence of the Yarra pygmy perch in Sutherland Creek. Eleven fish were found in several pools to the north of Pringle Bridge Road, near Maude (Figure 5).

The pools, which had depths to 2m are found within a deeply incised channel and are expected to persist as a result of groundwater interception. The surrounding farmland is highly degraded.

The distribution of the Yarra pygmy perch in the Sutherland Creek system is not likely to be very extensive, as it appears to have a unique localised habitat.

Further investigation is needed to determine the extent of the pools supporting Yarra pygmy perch in Sutherland Creek and to develop an appropriate management strategy for the species.

Figure 5. Yarra pygmy perch habitat in Sutherland Creek.

4. 2 River blackfish

River blackfish were recorded in the East and West Moorabool Rivers and in the Moorabool River downstream to Perdrisat Road, Maude (site 12). Figure 6 shows the length distribution of the 63 fish captured during this study. The size range of fish was between 96-506 mm with a variety of size classes present. Overall, the data suggests a healthy population of river blackfish in the Moorabool River system. The presence of small fish (around 100 mm in length) shows that recruitment of river blackfish has occurred over the past few years, particularly in the West Moorabool River, despite little or no streamflow. The larger length frequency classes indicate that more successful recruitment events have occurred 4 to 7 years ago.

If periodic environmental streamflows are not provided from Lal Lal Reservoir to Sheoak Weir, river blackfish populations could be threatened by rising salinities.

The finding of river blackfish immediately downstream of Lal Lal Reservoir (in an area that was until recently dry) shows that the species will move from remnant pools into other instream environments when streamflows allow, a useful survival technique which will assist recolonisation if permanent streamflows can be reinstated at some stage in the future.

The finding of river blackfish in the East Moorabool River has not previously been documented. Further investigation of the inaccessible reaches downstream of Bostock Reservoir may locate some additional remnant pools that are important to supporting the population in the East Moorabool River.

Downstream of Sheoak Weir, there is a possibility that the range of river blackfish has contracted in recent years. In 1998, the species was found in the Moorabool River as far downstream as Batesford (Raadik and Koster, 2000). In July 2007, one river blackfish was captured at Russells Bridge (Ryan and McGuckin, 2008), whereas, in this study no river blackfish were captured at nearby Parkers Road (site 13) or downstream at Bakers Bridge Road (site 14).

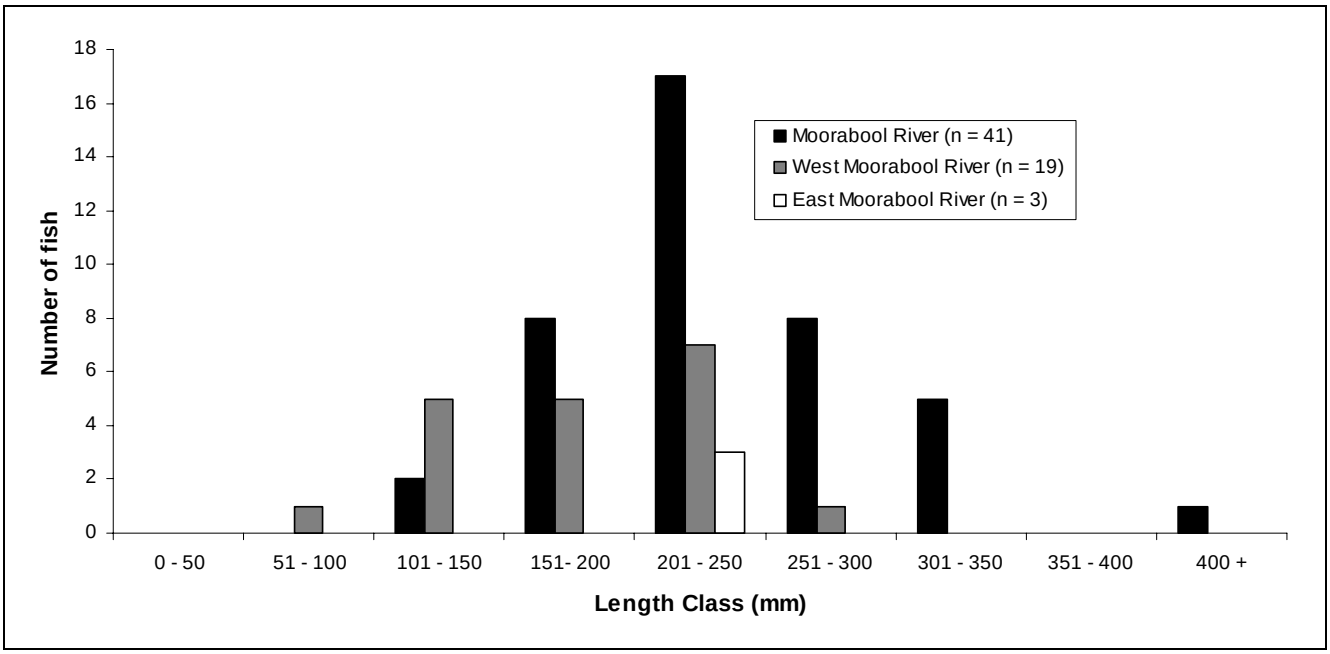


Figure 6. River blackfish lengths.

It is suspected that elevated salinities, reduced dissolved oxygen and available habitat in the Moorabool River downstream of Maude may have affected river blackfish populations and that few fish remain in the lower reach of the river. Eggs and larvae of river blackfish have an upper known threshold of around 8800 µS/cm (Bacher and Garner, 1992), which is not that much higher than the 7700 µS/cm recorded at Bakers Bridge Road during this study (Figure 7).

A flushing flow is urgently needed to freshen remnant pools in the lower reach of the Moorabool River downstream of Sheoak Weir. Without a significant flow event, instream salinities will continue to rise in remnant pools and total loss of river blackfish throughout the reach may occur.

Figure 7. Remnant pools downstream of Bakers Road (impacted by elevated salinity and depleted dissolved oxygen).

4.3 Environmental flows

The FLOWS study conducted in 2004 (SKM, 2004) identified a number of flow components that are necessary for the protection of environmental values in the reach between Lal Lal Reservoir and Sheoaks Weir.

The objectives for the Moorabool River basin are to provide benefits for a range of biota including fish, macroinvertebrates and vegetation communities. The FLOWS method also includes determinations for maintaining water quality, appropriate wetting/drying cycle of wetlands, nutrient cycling processes and the preservation of instream habitat.

Flows are allocated to maintain adequate habitat for the survival of aquatic biota. The flows are designed to provide connectivity between shallow and deeper habitats for fish and macroinvertebrates. Freshes provide mixing in pools and scour biofilms from surfaces (Biggs *et al.*, 1999) and prevent stagnation. Seasonal wetting and drying is needed for maintaining channel form of banks and exposed benches. Winter flows assist with suppressing encroaching vegetation and assist spawning of fish.

The 6 main flow components considered applicable for the reach between Lal Lal Reservoir and Sheoaks Weir based on the FLOWS study are:

1. cessation of streamflow for no more than 10 consecutive days annually
2. a summer low flows minimum of 20 ML/day
3. 3 summer freshes of >31 ML/day for 10 consecutive days
4. a winter low flows minimum of 83 ML/day
5. 3 winter freshes of >162 ML/day for 10 consecutive days
6. winter high flow of >3,000 ML for 1-2 day consecutive days

With continuation of the drought within the Moorabool River basin, potential compliance with the recommended streamflows has not been possible. Securing town water supplies has been a priority and this is the reason for the qualification of rights which have effectively waived passing flows at Lal Lal Reservoir. The qualification of rights has meant that environmental flow components 1, 2 and 4 have not been attained since prior to 2006. Furthermore, absence of stored water in Lal Lal Reservoir means that environmental flow components 5 and 6 are not even possible.

From the 240 ML allocated to the environment as compensation (which was initially only to be until spring 2007), 80 ML was used in April 2008, after a 18 month period of no flow from Lal Lal Reservoir. The remaining 160 ML is all that is now available until Ballarat is taken off Stage 4 water restrictions. The development of an environmental emergency contingency plan (Corangamite CMA, 2008) is a solid basis for using the allocation appropriately. Findings from this investigation are supportive that the existing strategy has, to date, protected instream habitat and aquatic fauna between Lal Lal Reservoir and Sheoaks Weir (as there has been no major loss of the native fish fauna in the reach).

The provision of three summer freshes (80 ML for each) is the only recommended component of the FLOWS study (SKM, 2004) which is currently being provided to the reach between Lal Lal Reservoir and Sheoaks Weir. The first of these freshes occurred in December 2008, another occurred in late January 2009 and the third is planned for February 2009.

Operational changes made by Barwon Water to provide streamflow for the Meredith town supply via the East Moorabool River has a positive environmental benefit to the reach between Lal Lal Reservoir and Sheoaks Weir. Not only does the initial release allow for the wetting of the channel but when combined with a summer fresh allows a small streamflow to pass downstream of Sheoak Weir (as

noted in the December releases). This is a vast improvement to the petering out of streamflow near the Meredith pump station which occurred when 80 ML was released to a dry channel in April 2008 (Corangamite CMA, 2008a).

Although the necessary recommended flow components for the reach between Lal Lal Reservoir and Sheoaks Weir have not been achieved in recent years, the native aquatic fauna has shown a resilience to persist under the current low flow conditions. Although this is a positive finding, there is no certainty that low streamflows that have occurred since 2006 will continue to support the aquatic fauna indefinitely into the future.

The challenge for Corangamite CMA is to recognise when to use the remaining water allocation of 160 ML. Too early may mean there is no further water available, but too late could be catastrophic to the aquatic fauna in the reach. Existing water quality triggers (temperature greater than 25ºC, dissolved oxygen concentration less than 5 mg/L or electrical conductivity above 10,000 uS/cm) appear to be appropriate for ensuring early warning signs of water quality deterioration. If any of the triggers are met, the environmental flow allocation should be used. Further environmental flow allocations should be sought if the drought continues.

4. 4 Duration of flow cessation

The duration of no streamflow before the first environmental flow release in May 2008 was 18 months and another 8 months before the December 2008 pulsed fresh release. The period of no flow could potentially be an additional trigger used for environmental flow releases. Fortunately, the existing triggers are likely to occur before the period of no streamflow becomes catastrophic.

There is no known information on the period of flow cessation in which the system can naturally maintain the fish fauna. Presumably, if the duration between streamflow events is too long, water quality will deteriorate and water depths may become critically low and the remaining remnant pools may become unsuitable as refuge habitat. Loss of suitable habitat will result in the loss of aquatic species, species which are needed for future recolonisation, if streamflows are eventually reinstated.

The environmental streamflow releases at Lal Lal Reservoir may potentially maintain habitat and aquatic species in the Moorabool River downstream to Sheoak Weir, but do little or nothing towards maintaining the habitat of the system between Sheoak Weir and the Barwon River. Without improved water quality conditions in the lower Moorabool River, migratory native fish will no longer venture into the system and there could be consequences which affect the Barwon River.

5.0 CONCLUSION

The exclusively freshwater native fish fauna of the middle reaches of the Moorabool River system has persisted in recent times, despite few natural inflows and the cessation of passing flows from Lal Lal Reservoir since October 2006. Environmental flow releases have been effective in maintaining water quality in the remnant pools between Lal Lal Reservoir and Sheoak Weir.

The iconic river blackfish is present at Perdrisat Road in the middle reach of the Moorabool River and has a good distribution further upstream. The species could, however, be under threat if current instream conditions continue indefinitely. Downstream of Perdrisat Road, it is likely that river blackfish have already disappeared as a result of low oxygen levels and rising salinities. There is also some evidence of poor recruitment in the reaches where river blackfish are still found. Continued recruitment failure could lead to the extinction of the species in the Moorabool River.

Migratory native fish inclusive of Australian grayling, tupong, common galaxias, spotted galaxias and short headed lamprey have all formerly been recorded in the Moorabool River near Batesford (Raadik and Koster, 2000). Unfortunately, movement of these species into the Moorabool River system has been severely restricted in recent years. Discontinuity of streamflow, instream barriers and a lack of attraction flows to the Barwon River have all been contributing factors. With the exception of the short finned eel, no native migratory fish species were recorded in Moorabool River upstream of Batesford in this study.

One recreational species, the exotic brown trout, is no longer found in the West Moorabool River and is expected to disappear from the Moorabool River system if the current drought persists.

Most native aquatic fauna in the Moorabool River system are adapted to periods of flow cessation, as these conditions would naturally have occurred in the catchment. Unfortunately, the natural duration of the flow cessation period may have only been for weeks or months, not for years as the system is currently experiencing. It has been fortunate that the fish fauna between Lal Lal Reservoir and Sheoaks Weir currently remains intact, but there is no guarantee that this situation will remain unchanged into the future. Regular streamflow pulses are necessary to restore good water quality conditions to remnant pools.

The remaining 160 ML left in Lal Lal Reservoir for environmental entitlement is not sufficient for maintaining the West Moorabool River and downstream Moorabool River indefinitely. The existing allocation may be needed before the completion of 2009, if elevated water temperatures or salinity concentrations or low dissolved oxygen concentrations are triggered. With continuation of the drought further water allocations for the environment are needed, otherwise species like the river blackfish may not be capable of breeding and remnant pools may stagnate, and there is a possibility that the entire fish fauna could be lost.

The lower Moorabool River is in very poor ecological health. The current instream condition of remnant pools appears to be severely degraded by low oxygen levels and elevated salinity. Some fish species may have already been lost from the remaining pools. Environmental flows are urgently required to prevent further loss of aquatic fauna.

The confirmation of the Yarra pygmy perch in Sutherland Creek is a supplementary outcome from this study. Given the species has not been recorded at any other location in the Moorabool River basin, protection of the small known reach of habitat in Sutherland Creek should be a management consideration. More extensive investigations are needed to determine whether saline groundwater intrusion is responsible for maintaining water levels in the pools where the Yarra pygmy perch are found. Enhancement of remnant instream habitat could be made by revegetating degraded riparian fringes.

6.0 RECOMMENDATIONS

- Corangamite CMA should seek additional water for further environmental flows between Lal Lal Reservoir and Sheoaks Weir. Water should also be sought for an environmental flow release for the lower Moorabool River.

- environmental flows from Lal Lal Reservoir should continue to accompany streamflows released for supplying town water to Meredith. The approach provides the best possible benefit to the aquatic environment of the Moorabool River given the low volume of water being released.

- the fish fauna between Lal Lal Reservoir and Sheoak Weir should be resurveyed if cessation of streamflow at Lal Lal Reservoir continues throughout 2009.

- further research is needed on the Yarra pygmy perch population in Sutherland Creek. It is necessary to determine the extent of the pools which support the species and the key aspects maintaining suitable instream conditions.

7.0 ACKNOWLEDGEMENTS

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APPENDIX 1. FISH SURVEY DATA - MOORABOOL RIVER SYSTEM

Waterway	Site No.	Technique	Fish captures (common name)	No. of fish	Length (mm)	Weight (g)	Bycatch
East Moorabool River	**1**	electrofished (15 min)	short finned eel *eastern gambusia	5 500#	350-450		25 shrimp
	2	4 fyke nets (14 hours)	short finned eel *tench	2 1	600-800 42	 0.9	400 shrimp
		observation	*eastern gambusia	100#			
	3	4 fyke nets (14 hours)	short finned eel river blackfish *eastern gambusia *redfin *tench	1 3 6 1 8	400 213-220 162 163-273	 75-99 55 68-319	no shrimp
		observation	*eastern gambusia	300#			
West Moorabool River	**4**	electrofished (50 min)	short finned eel river blackfish flat headed gudgeon *redfin *tench	38 3 5 6 1	120-600 107-241 42-90 36-38 144	 9-110 0.6-7.0 0.4-0.5 59	400 shrimp
	5	electrofished (50 min)	short finned eel river blackfish	6 12	300-500 135-288	 20-184	15 shrimp
		2 fyke nets (14 hours)	short finned eel river blackfish *tench	4 4 31	350-550 96-218 105-264	 8-86 21-296	
Moorabool River	**6**	4 fyke nets (13 hours)	short finned eel river blackfish flat headed gudgeon *tench	5 3 39 1	120-450 224-245 26-91 135	 90-124 0.1-6.6 42	9 shrimp
	7	4 fyke nets (17 hours)	short finned eel river blackfish flat headed gudgeon	18 15 82	400-750 135-315 42-85	 24-273 0.3-4.4	1 female platypus no shrimp
		observation	Australian smelt *eastern gambusia *brown trout	70 50 1	30-40# 350#		
	8	4 fyke nets (15 hours)	short finned eel river blackfish southern pygmy perch flat headed gudgeon	3 6 1 27	350-550 188-506 45 38-76	 66-405 1.3 0.8-3.3	no shrimp
	9	4 fyke nets (14 hours)	short finned eel river blackfish southern pygmy perch flat headed gudgeon *redfin *tench	6 7 2 26 1 2	250-650 176-287 18-25 45-88 362 335-350	 48-225 0.01-0.02 0.8-6.3 775 648-733	8 shrimp
		observation	Australian smelt	200	25-40#		
	10	4 fyke nets (15 hours)	short finned eel flat headed gudgeon *redfin *tench	20 141 8 5	120-600 34-87 49-53 443-469	 0.2-5.6 1.4-1.8 1409-1845	40 shrimp
	11	4 fyke nets (13 hours)	short finned eel river blackfish flat headed gudgeon *redfin *tench	6 6 15 1 7	400-500 155-308 35-70 165 205-465	 46-258 0.1-2.6 73 137-1597	12 shrimp
	12	4 fyke nets (14 hours)	short finned eel river blackfish southern pygmy perch flat headed gudgeon *tench	19 4 27 9 3	120-500 198-243 18-58 58-88 54-365	 78-127 0.1-3.1 1.8-6.1 2.0-857	no shrimp
	13	4 fyke nets (13 hours)	short finned eel southern pygmy perch flat headed gudgeon	8 81 46	200-550 37-77 44-74	 0.8-6.8 0.4-3.3	1 male platypus 26 shrimp
	14	4 fyke nets (12 hours)	short finned eel southern pygmy perch flat headed gudgeon *tench	7 24 17 4	300-900 22-71 58-74 216-415	 <0.1-5.2 1.5-3.6 172-1158	6 shrimp

*exotic species
estimated

APPENDIX 1. FISH SURVEY DATA - SUTHERLAND CREEK SYSTEM

Waterway	Site No.	Technique	Fish captures (common name)	No. of fish	Length (mm)	Weight (g)	Bycatch
Sutherland Creek East Branch	**15**	dip netted (20 minutes)	no fish				
	16	dip netted (20 minutes)	southern pygmy perch	12			20 shrimp
	17	dip netted (20 minutes) 2 fyke nets (14 hours)	southern pygmy perch short finned eel southern pygmy perch	8 2 174	 600-800 22-78	 0.1-6.9	 30 shrimp
	18	dip netted 60 minutes)	Yarra pygmy perch *eastern gambusia	11 12			50 shrimp
Sutherland Creek East Branch	**19**		dry				
	20		dry				
Sutherland Creek	**21**	dip netted 60 minutes)	flat headed gudgeon	4	35-50		
	22		dry				

*exotic species