Assessment of Environmental Flow Requirements for the Latrobe River

AMENDED FINAL RECOMMENDATIONS REPORT

Revision D.6

March 2007

Assessment of Environmental Flow Requirements for the Latrobe River

AMENDED FINAL RECOMMENDATIONS – Final Report

L:\work\Jobs\6004116 Latrobe May06\Finalisation\Recommendations RevD v6.doc

Document History:

ISSUE DATE	REVISION NUMBER	AUTHOR	CHECKED	APPROVED	DESCRIPTION
15.09.2005	A	REH/ AW	R Hardie	Chris Arnott	Preliminary Draft for Comment
17.10.2005	B	A Wealands	R Hardie	R Hardie	Draft for Comment
02.12.2005	C	A Wealands R Hardie	R Hardie	R Hardie	Final Report for Comment
05.01.2006	C.1	A Wealands	C Arnott	C Arnott	Final Report
02.06.2006	D	C Stephenson	R Hardie	R Hardie	Amended Final Report (Rev D) Draft for Internal Comment
28.06.2006	D.3	C Stephenson	R Hardie	T Loffler	Amended Final Report (Rev D.3) Final Draft
04.08.2006	D.4			T Loffler	Final Report (RevD.4) includes Steering Committee comments
09.02.2007	D.5			T Loffler	Amended Final Recommendations Report (Rev. D.5) includes responses to TAP review
19.03.2007	D.6			T Loffler	Final Report approved by WGCMA

Natural Resources Group

Earth Tech Engineering Pty Ltd
ABN 61 089 482 888
Head Office 71 Queens Road
Melbourne VIC 3004
Tel +61 3 8517 9200

All Rights Reserved. No part of this document may be reproduced, transmitted, stored in a retrieval system, or translated into any language in any form by any means without the written permission of West Gippsland CMA.

Intellectual Property Rights

West Gippsland CMA retains copyright of all intellectual property and data generated by the project.

Contents

Contents i

Tables ii

Figures iii

1 Introduction 5

1.1 Background 5
1.2 Outline of this Report 7
1.3 Personnel 8
1.4 Acronyms and Abbreviations used in this Report 9
1.5 Definitions 9

2 Approach to EWR Analysis 11

2.1 Philosophy of Flow Determination 11
2.1.1 Introduction 11
2.1.2 Objective Setting Process 11
2.1.3 Technical Panel Process 11
2.2 Flow Components 12
2.3 Flow Analysis 13
2.4 Rates of Rise and Fall 14
2.5 Hydraulic Model Sensitivity Analysis 15
2.6 Peer Review 16
2.6.1 Flow Exceedence Thresholds 17
2.6.2 Flow Duration 17

3 Reach Recommendations 19

3.1 Reach 1 Summary Recommendations 25
3.2 Reach 2 Summary Recommendations 31
3.3 Reach 3 Summary Recommendations 37
3.4 Reach 4 Summary Recommendations 43
3.5 Reach 5 Summary Recommendations 49
3.6 Reach 8 Summary Recommendations 57
3.7 Reach 9 Summary Recommendations 63
3.8 Reach 10 Summary Recommendations 69
3.9 Reach 11 Summary Recommendations 75

4 Supporting Recommendations 77

5 Conclusion 80

6 References 81

Appendix A – Hydrology of the Latrobe River System 83

6.1 Hydrologic Data 83
6.2 Seasonality of Natural Flow Regime 84
6.3 Change in the Flow Regime 84
6.3.1 Reach 1 – Upper Latrobe River (upstream of Willow Grove) 85
6.3.2 Reach 2 – Latrobe River (Willow Grove to Lake Narracan) 87
6.3.3 Reach 3 – Latrobe River (Lake Narracan to Scarnes Bridge) 89
6.3.4 Reach 4 – Latrobe River (Scarnes Bridge to Rosedale) 91
6.3.5 Reach 5 – Latrobe River (Rosedale to Thomson River Confluence) 93
6.3.6 Reach 6 – Latrobe River (Thomson River confluence to Lake Wellington) 95
6.3.7 Reach 8 – Tanjil River 97
6.3.8 Reach 9 – Tyers River 99
6.3.9 Reach 10 – Morwell River 101
6.3.10 Reach 11 – Traralgon Creek 103

Appendix B – Hydraulic Modelling Report

Tables

Table 2-1 – Sensitivity Analysis Results – percentage change in flow to match "best-estimate" water level at upstream cross-section 15
Table 2-2 – Sensitivity Analysis Results – Upper and lower flow limits for a 25% change in boundary conditions and Manning's n for the recommended Low Flow and High Flow Fresh 16
Table 3-1 – Flow Processes and Components – Reach 1 22
Table 3-2 – Flow recommendations for Reach 1 – Upper Latrobe River (upstream of Willow Grove) .. 25
Table 3-3 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 26
Table 3-4 – Flow Processes and Components – Reach 2 28
Table 3-5 – Flow recommendations for Reach 2 – Latrobe River (Willow Grove to Lake Narracan)..... 31
Table 3-6 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 32
Table 3-7 – Flow Processes and Components – Reach 3 34
Table 3-8 – Flow recommendations for Reach 3 – Latrobe River (Lake Narracan to Scarnes Bridge) . 37
Table 3-9 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 38
Table 3-10 – Flow Processes and Components – Reach 4 40
Table 3-11 – Flow recommendations for Reach 4 – Latrobe River (Scarnes Bridge to Rosedale) 43
Table 3-12 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 44
Table 3-13 – Flow Processes and Components – Reach 5 46
Table 3-14 – Flow recommendations for Reach 5 – Latrobe River (Rosedale to Thomson River Confluence) 49
Table 3-15 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 50
Table 3-16 – Flow Processes and Components – Reach 8 54
Table 3-17 – Flow recommendations for Reach 8 – Tanjil River 57
Table 3-18 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 58
Table 3-19 – Flow Processes and Components – Reach 9 60
Table 3-20 – Flow recommendations for Reach 9 – Tyers River 63
Table 3-21 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 64
Table 3-22 – Flow Processes and Components – Reach 10 66
Table 3-23 – Flow recommendations for Reach 10 – Morwell River 69
Table 3-24 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 70
Table 3-25 – Flow Processes and Components – Reach 11 72
Table 3-26 – Flow recommendations for Reach 11 – Traralgon Creek 75
Table 3-27 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day) 76
Table 6-1 – Stream Gauge Data for the Latrobe River system provided by SKM. 83
Table 6-2 – Flow Seasons of the Latrobe River system 84

Figures

Figure 1-1 – Outline of the steps in the FLOWS method 5
Figure 1-2 – Graphical example of flow components (DNRE, 2002) 10
Figure 2-1 – HEC RAS model of Reach 2 (Willow Grove to Lake Narracan) 14
Figure 3-1 – Latrobe River Reach Breaks 20
Figure 6-1 – Flow Seasons of the Latrobe River system 84
Figure 6-2 – Reach 1 – Flow duration curve 85
Figure 6-3 – Reach 1 – Annual Flows 85
Figure 6-4 – Reach 1 – Mean monthly flows 86
Figure 6-5 – Reach 2 – Flow duration curve 87
Figure 6-6 – Reach 2 – Annual flows 87
Figure 6-7 – Reach 2 – Mean monthly flows 88
Figure 6-8 – Reach 3 – Flow duration curve 89
Figure 6-9 – Reach 3 – Annual flows 89
Figure 6-10 – Reach 3 – Mean monthly flows 90
Figure 6-11 – Reach 4 – Flow duration curve 91
Figure 6-12 – Reach 4 – Annual flows 91
Figure 6-13 – Reach 4 – Mean monthly flows 92
Figure 6-14 – Reach 5 – Flow duration curve 93
Figure 6-15 – Reach 5 – Annual flows 94
Figure 6-16 – Reach 5 – Mean monthly flows 94
Figure 6-17 – Reach 6 – Flow duration curve 95
Figure 6-18 – Reach 6 – Annual flows 96
Figure 6-19 – Reach 6 – Mean monthly flows 96
Figure 6-20 – Reach 8 – Flow duration curve 97
Figure 6-21 – Reach 8 – Annual flows 98
Figure 6-22 – Reach 8 – Mean monthly flows 98
Figure 6-23 – Reach 9 – Flow duration curves 99
Figure 6-24 – Reach 9 – Annual flows 100
Figure 6-25 – Reach 9 – Mean monthly flows 100
Figure 6-26 – Reach 10 – Flow duration curves 101
Figure 6-27 – Reach 10 – Annual flows 102
Figure 6-28 – Reach 10 – Mean monthly flows 102
Figure 6-29 – Reach 11 – Flow duration curve 103
Figure 6-30 – Reach 11 – Annual flows 103
Figure 6-31 – Reach 11 – Mean monthly flows 104

Please cite this document as:

Earth Tech (2007). ***Assessment of Environmental Flow Requirements for the Latrobe River and Wetlands of the Lower Latrobe River – Amended Final Recommendations Report Rev D.6***. Unpublished report to the West Gippsland Catchment Management Authority.

DISCLAIMER

This publication may be of assistance to you but the West Gippsland Catchment Management Authority and its employees and contractors do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purpose and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Due to the availability of additional technical information during the assessment and following a Technical Audit Panel Review changes have been made to produce this Amended Final Recommendations Report (Rev D.6) which may result in some inconsistencies between the Site Paper, Issues Paper and this Amended Final Recommendations Report. This Amended Final Recommendations Report (Rev D.6) supersedes all previous documentation and holds the most current and up to date information.

1 Introduction

1.1 Background

The West Gippsland Catchment Management Authority (WGCMA) engaged Earth Tech Engineering Pty Ltd (Earth Tech) to undertake an assessment of environmental flow requirements for the Latrobe River and selected. This report documents the investigations undertaken and the results obtained.

The environmental flow assessment has been undertaken in accordance with the FLOWS method – an established approach for the determination of environmental water requirements in Victoria (Figure 1-1) (DNRE, 2002).

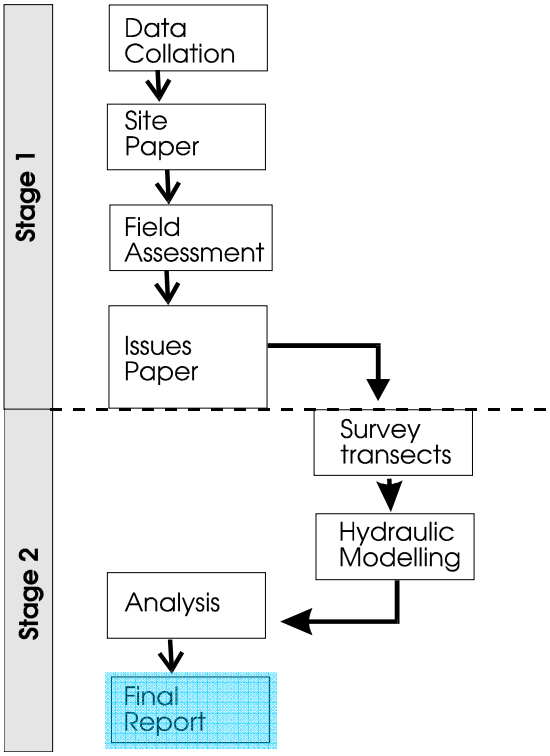


Figure 1-1 – Outline of the steps in the FLOWS method

The FLOWS method assists in the identification of critical flow components, as part of the total flow regime, to protect, sustain or restore specific flow dependent assets or values of a river system. The key elements of the flows process include:

- An objective setting process that links environmental objectives to flow objectives and recommendations.
- The use of an environmental flows Technical Panel.
- The use of hydrologic and hydraulic analysis tools in the interpretation and development of recommendations (DNRE, 2002).

The environmental flow assessment does not directly address non-flow related issues impacting on river health and management. These issues will be addressed

through priority actions identified in existing WGCMA documents (i.e. Regional River Health Strategy, WGCMA, 2005)

This Recommendations Report has been developed following the production of a Site Paper and an Issues Paper and forms part of the FLOWS method. The Site Paper (Earth Tech 2005a) provides background information on the Latrobe River including catchment descriptions, historic land use, water use, broad condition descriptions and recommended reaches for the investigations. Objectives for ecological river health, and the background information for the project are defined in the Issues Paper (Earth Tech 2005b). The Issues Paper is the culmination of literature reviews, anecdotal evidence, background knowledge and site visits by the Technical Panel. The Issues Paper provides further detail on the assets and conditions within each reach and details the development of the vision and objectives for each reach with reference to the West Gippsland Regional River Health Strategy (WGCMA, 2005). This Recommendations Report should be read in conjunction with the Issues Paper.

This Recommendations Report identifies the recommendations for environmental water requirements (EWR) for the Latrobe River and selected tributaries. The scope for the report does not include analysis of the operational impacts of the recommended flow regime or details of operational or infrastructure issues in relation to implementation of environmental water requirements. Recommendations from this report are to be analysed by the Department of Sustainability and Environment (DSE) to identify impacts of the recommendations on security of supply of water users. The results of this analysis will be used to inform the development of the Central Region Sustainable Water Strategy and any subsequent recommendations to improve the environmental water reserve and in any Streamflow Management Plan. Both the Strategy and any Streamflow Management Plan process, take into account all consumptive use on the Latrobe River system.

The recommendations report has been finalised following several iterations. These iterations have included:

- Rev A Draft Preliminary Recommendations. This report comprised the recommendations from the Technical Panel process, without significant review.
- Rev B Draft Recommendations. This report and recommendations introduced additional parameters and criteria to address preliminary comments.
- Rev C Final Recommendations. This report included the results of an informal peer review of aspects of the Rev B recommendations and additional analysis to address issues arising.
- Rev D Amended Final Recommendations (this report). This report includes outcomes from additional investigations undertaken as a result of the identification of irregularities in the hydraulic models used to develop previous recommendations. Further, the investigation has enabled review and refinement of analysis criteria used in the assessment of environmental water requirements, ensuring consistency between reaches..

The format of this Amended Final Recommendations Report is consistent with Rev C. The format provides improved linkages between identified river assets and processes, intended river health outcomes (vision and objectives) and flow recommendations to achieve these objectives.

This Amended Final Recommendations Report (Rev D.6) incorporates additional information provided to address questions raised by the Technical Audit Panel in their review undertaken in August 2006.

Due to the availability of additional technical information during the assessment and following a Technical Audit Panel Review changes have been made to produce this Amended Final Recommendations Report (Rev D.6) which may result in some inconsistencies between the Site Paper, Issues Paper and this Amended Final Recommendations Report. This Amended Final Recommendations Report (Rev D.6) supersedes all previous documentation and holds the most current and up to date information.

1.2 Outline of this Report

Section 1 identifies the background to this project.

Section 2 of this report presents an outline of the method used in determining the EWR for this study.

Section 3 defines the EWR recommendations for each reach. Each recommendation includes characteristics of the required flow events resulting from the hydrologic and hydraulic tools utilised and ecological justifications. The standard format for each reach includes four components:

- A summary of the reach condition (the major environmental issues in the reach);
- The environmental flow objectives for the reach;
- The flow processes and components linked to each environmental objective;
- Summary tables of the recommendations.

Appendix A provides a background to the hydrology of the Latrobe River system.

Appendix B summarises the hydraulic modelling works undertaken in support of this assessment.

Other background information can be found in the Issues Paper.

1.3 Personnel

The Latrobe River Environmental Water Requirements Technical Panel (the Technical Panel) consisted of (in alphabetical order, with fields of expertise):

Michael Aberton	Riparian vegetation
Paul Boon	Wetland ecology
Doug Hall	Fish
Ross Hardie	Geomorphology
Tim Loffler	Hydrology
Richard Marchant	Macroinvertebrate ecology

The Earth Tech project management team consisted of:

Ross Hardie	Project manager
Amanda Wealands	Project support

The Technical Panel wishes to acknowledge the assistance of Penny Neumann, Cath Paulet and Wayne Gilmour (WGCMA) and the Steering Committee for their assistance in this phase of the project. The Steering Committee for the project consisted of:

Duncan Malcolm	Chairman
Paul Bennett	DSE River Health Branch
Jodi Braszell	DSE River Health Branch
Shane Carruthers	IPM Loy Yang B
Russell Centre	Loy Yang A
Steve Dickson	Wellington Shire Council
Ray French	Yallourn Energy
Fiona Fullard/ Alison Taylor	Latrobe City Council
Isabelle Gabas	Southern Rural Water
Rebecca McGuigan/ Wayne Bath	EPA
Glen Morrison	Irrigator
Neville Penrose	DSE Region
David Pike	Irrigator
John Poppins	Environment Victoria
Andrew Schulz	Parks Victoria
Steve Shinners	Gippsland Water
Des Sinnott	WGCMA
Jenine Smith	Australian Paper
Tom Wallace	Irrigator

1.4 Acronyms and Abbreviations used in this Report

BE	Bulk water Entitlements
CMA	Catchment Management Authority
CRC	Co-operative Research Centre
d	Diadromous fish species
DSE	Department of Sustainability and Environment
E	Endangered species/community
e	Estuarine species
EVC	Ecological Vegetation Class
EWR	Environmental Water Requirements
FEM	The Flow Events Method
FLOWS	The "Statewide Method for Determining Environmental Water Requirements"
ISC	Index of Stream Condition
LWD	Large Woody Debris
SKM	Sinclair Knight Merz Pty Ltd.
SRW	Southern Rural Water
Technical Panel	The Latrobe River Environmental Flows Technical Panel
VRHS	Victorian River Health Strategy
WGCMA	West Gippsland Catchment Management Authority
WS	Water Surface

1.5 Definitions

Flow components used in this report and their descriptions are provided below together with a graphical representation of the components in Figure 1-2.

Cease-to-flow	No discernible flow in the river, or no measurable flow recorded at a gauge
Low Flow	Flow that generally provides a continuous flow through the channel
Low Flow Freshes	Small and short duration peak flow events that exceed the baseflow (low flow) and last for at least several days. Usually in summer and autumn in Victoria
High Flow	Persistent increases in the seasonal baseflow that remain within the channel
High Flow Freshes	Small and short duration peak flow events that exceed the baseflow (high flow) and last for at least several days. Usually in winter and spring in Victoria
Bankfull Flow	Completely fill the channel, with little flow spilling onto the floodplain

Overbank flows	These flows are greater than bankfull and result in surface flow on the floodplain habitats
Additional	Additional flow components are flows required specifically for sustaining an asset in the system which is not achieved by recommending other standard flow components. Such instances where an additional flow is appropriate include: - in an incised stream where overbank and bankfull flows are infrequent and a more frequent, upper bank wetting is required - for periodic wetting and drying of floodplain wetlands
or Natural	Refers to the minimum recommended flow or the natural flow occurring at that time. Therefore allowing for naturally occurring drought events to be sustained.

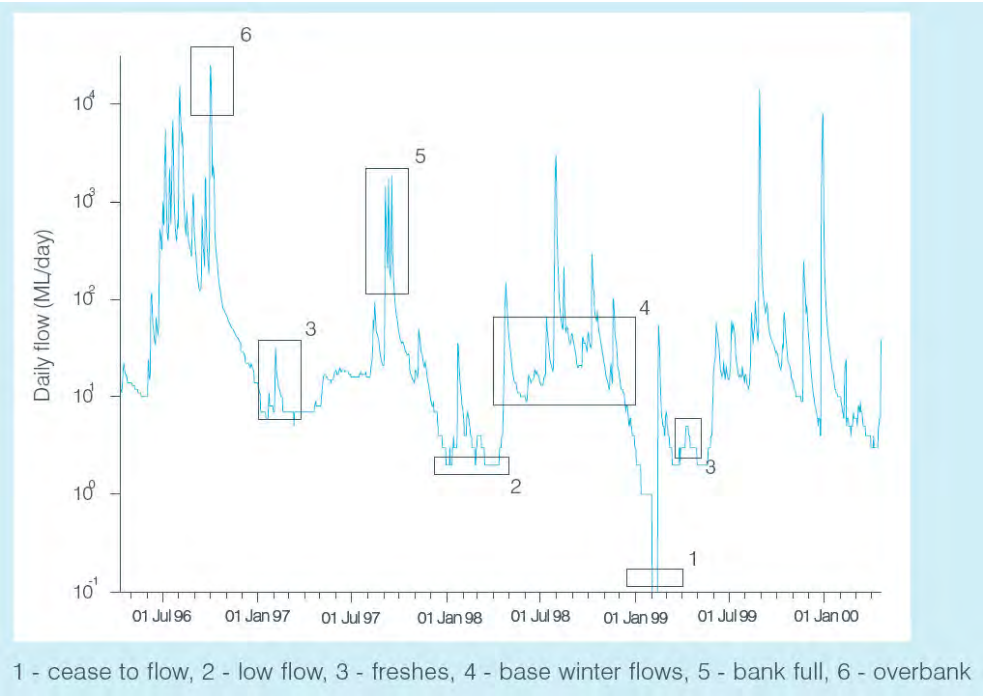


Figure 1-2 – Graphical example of flow components (DNRE, 2002)

2 Approach to EWR Analysis

2.1 Philosophy of Flow Determination

2.1.1 Introduction

The FLOWS method is based on the identification of the magnitude, duration frequency and timing of flow components (refer Section 1.5) necessary to maintain identified environmental assets and ecological processes. This approach places some risk on the environment as not all assets and processes may be identified. However, the recommendations provided in this report have been based on provision of a range of parameters and criteria that should protect not only the identified assets and processes, but other related processes not explicitly identified or for which suitable analysis and assessment criteria are not available.

2.1.2 Objective Setting Process

Environmental objectives for the Latrobe River were established during the development of the Issues Paper (April 2005). Broad environmental objectives for the Latrobe System were established prior to the development of reach specific objectives. The reach specific objectives take into consideration the current reach condition, constraints on change to reach condition (i.e. existing dams and storages) and potential improvements that can be realised through modification of the flow regime.

The reach specific objectives are not necessarily focussed on a return to “natural” conditions but aim to achieve improvements consistent with the broad environmental objectives for the system. As an example, in-stream channel features (benches and bars) are largely absent from Reach 5 due to past meander cut-off works. No specific objective has been set for watering of benches in this reach, rather the focus for this reach was on providing flows to connect to wetlands with ephemeral connections to the river.

Similarly, some objectives and associated flow components are set on the basis that existing constraints may be removed at some point in the future. As an example, Australian Grayling, a diadromous native fish species, is not currently found in Reach 2 due to the barrier imposed by the Lake Narracan weir wall. Flow objectives to provide conditions suitable for the Australian Grayling have however been set for Reach 2 assuming that fish passage beyond the weir wall may be provided in the future.

Further detail on the objective setting process is provided in the “Assessment of Environmental Flow Objectives for the Latrobe River and Wetlands of the Lower Latrobe River – Issues Paper” (Earth Tech, 2005 b). Some objectives were subsequently modified by the Technical Panel during the development of this Amended Final Recommendations Report, drawing on further analysis and in consideration of the Technical Panel Workshops.

2.1.3 Technical Panel Process

Recommended flow magnitudes are determined through a Technical Panel process drawing on:

- Expert knowledge and opinion to identify hydraulic or hydrologic measures which must be satisfied to maintain specific environmental assets and

ecological processes, based on the reach specific environmental objectives, such as:

  - the timing of fish migration and the minimum depth of flow required to enable movement of fish between different habitat zones
  - the flow velocity required to mobilise bed material or scour vegetation from channel bars
  - the frequency of floodplain watering required to enable survival and recruitment of floodplain vegetation
- Hydraulic modelling to identify flow magnitudes to achieve certain hydraulic measures within the reach such as:
  - minimum flow depth over riffles
  - inundation of benches
  - minimum velocities in pools
- Consideration of the frequency and duration of occurrence (via a Flow-Duration analysis) of certain flow magnitudes under natural and current conditions such as:
  - the recurrence interval of flows that overtop the river banks resulting in watering of floodplain vegetation
- Consideration of the typical period between, and duration of, certain flow events (via a Spells analysis) under natural and current conditions i.e:
  - the typical period (and maximum and minimum period) between events that result in flushing of pools, giving an indication of the likely ability of native species to cope with deteriorating water quality between events
  - the duration for which flows exceed the bankfull capacity, resulting in watering of floodplain vegetation
- Consideration of the seasonality of flows under natural and current conditions (based on monthly or seasonally averaged flows), allowing identification of changes to the timing of flood or low flow periods as a result of river regulation
- Time series graphs for particularly wet or dry periods in the flow record to provide an understanding of the characteristics of flow extremes

The Technical Panel process works iteratively drawing on the above techniques to assess the validity of the objectives, the hydrologic and hydraulic modelling and the resultant flow recommendations.

2.2 Flow Components

The flow regime recommended at the conclusion of the FLOWS process comprises of a set of flow components, as defined in Section 1.5, that have been identified as critical to the establishment, protection or enhancement of specific values within each reach. The components used to define the flow regime for each reach may be different, reflecting the sequence of flows which would naturally have occurred in a reach. Similarly, the magnitude, duration, frequency and timing of each flow component will vary from reach to reach, reflecting the objectives set for each reach,

the hydraulic characteristics of the reach and the hydrology of the catchment. The recommended flow regime will replicate certain features of the natural flow regime, focussing on elements of the regime critical to the identified reach objectives.

The recommended flow components are not mutually exclusive thus, a particular flow event can satisfy more than one component, provided that the timing, magnitude and duration satisfies the requirements for more than one component i.e:

- An overbank flow of 10,000 ML/D occurring between June and November and having a duration of 4 days can also be considered as a high flow fresh provided that:
    - the recommended magnitude for the high flow fresh is less than or equal to 10,000 ML/D
    - the recommended duration for the high flow fresh is less than or equal to 4 days and
    - the high flow fresh is specified to occur between June and November

Compliance with recommended low flows, high flows and low and high flow freshes will generally be achieved by management of storage releases, diversions and extractions. The occurrence of bankfull and overbank flows will generally be dependent on catchment generated flood events, however some level of management may be required to ensure passage of small to moderate flood peaks through much of the system to comply with the recommended flow regime.

2.3 Flow Analysis

Three hydraulic and hydrologic tools were utilised by the Technical Panel for the analysis:

- Digital terrain model – 12D
- Hydraulic model – HEC RAS, RAP
- Hydrologic analysis tool – RAP

The digital terrain modelling software, 12D, was used to interpret the survey of the representative sites and generate topographic data into a format suitable for input to and creation of a hydraulic model.

The hydraulic modelling software package HEC RAS was used to generate the hydraulic data required for analysis (Figure 2-1).

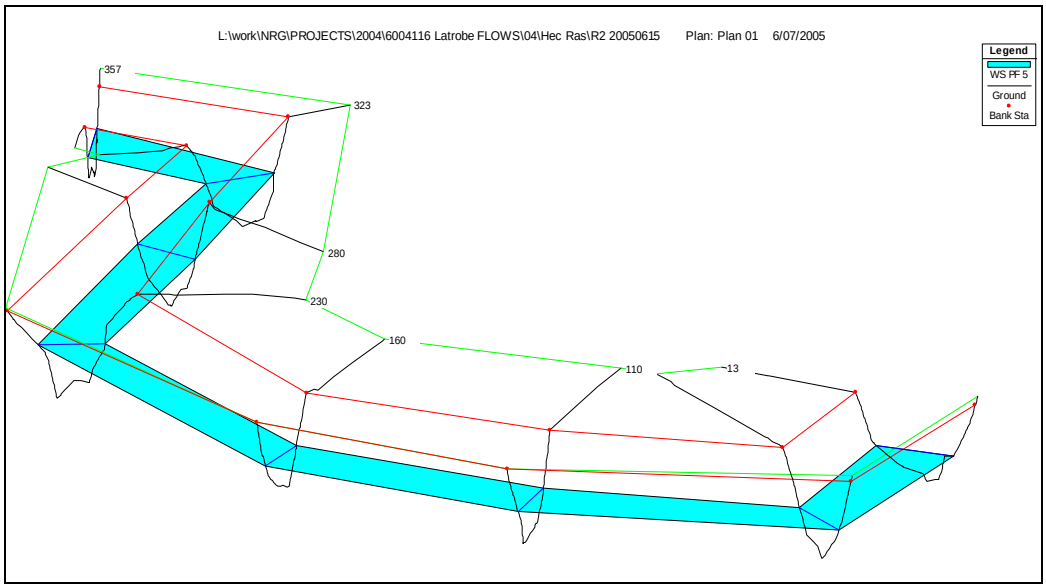


Figure 2-1 – HEC RAS model of Reach 2 (Willow Grove to Lake Narracan)

The RAP software package was used to interpret and visualise the hydraulic results and to analyse the hydrologic data. The hydraulic analysis component of RAP was used interactively to identify, represent and visually interpret the flow criteria. For example, to determine flow recommendations for fish passage a critical depth and location was defined and the flow corresponding to this depth determined subsequently through the hydraulic model. Similarly, for bench inundation, flows were adjusted until a particular selected bench was inundated.

The recommendations for the frequency and duration of events (such as freshes and bankfull flows, are based on the frequency and duration of the natural and current flow series. The time series component of RAP was used to examine the frequency and duration of particular flows under natural and current conditions. The recommended frequency and duration was chosen from within the range of natural and current conditions (usually based on the average natural annual seasonal frequency and duration) considered necessary to achieve the desired flow objective. An independence criteria of 7 days between spells was adopted for the purposes of the hydrologic analysis.

2.4 Rates of Rise and Fall

While specific flow recommendations (magnitude, timing, frequency and duration) are the most critical component of the recommendations, the maximum allowable rates of rise and fall leading up to the particular flow are also important. When managing flow events, the rate of decrease in flow should be gradual to ensure that aquatic organisms are not stranded on benches or banks. Setting maximum allowable rates of rise and fall therefore ensures rapid fluctuations greater than normal, do not occur.

The natural flow record (pre-development) was used to determine the average and maximum rates of rise and fall. In order to recommend maximum rates of rise and fall, the differences between flows on individual days were divided into days when flows rose and days when flows fell. The ratio of the change in flow was calculated on a daily basis for each rise or fall. The average desirable rates of rise and of fall

were selected as the average value of all recorded rates of change for each reach. The maximum desirable rates of rise and fall were selected as the average greatest value of all recorded rates of change. Tables detailing the recommended rise and fall for events within each reach are included in Section 4.

2.5 Hydraulic Model Sensitivity Analysis

Hydraulic modeling is used to provide an estimate of the hydraulic conditions expected within a river reach for various flow magnitudes. Modeling uncertainties arise in relation to the definition of river topography, the hydraulic conditions downstream of the river reach being modeled and the hydraulic roughness of the channel within the modeled reach. The relative significance of each of these factors varies with the flow magnitude. A sensitivity analysis provides a means to determine the likely range of results should some of the key modeling inputs vary. The analysis aims to identify limits on the potential variability in flow recommendations and highlights the importance of boundary conditions for higher flows.

A sensitivity analysis was undertaken by running the hydraulic models and varying two of the key parameters, hydraulic roughness (Manning's ***n***) and the downstream boundary condition (channel slope). The hydraulic roughness and boundary condition were varied by 25% either side of the estimated value. This magnitude of change is considered sufficiently large to fully encompass the limits of the likely modeling uncertainties. A variation of ±10% is considered a more realistic limit on modeling uncertainty and the sensitivity analysis is considered to be a conservative upper limit.

Sensitivity analyses were undertaken for the recommended low flow and the recommended high flow fresh for Reach 3 (Lake Narracan to Scarnes Bridge) and Reach 9 (Tyers River) (representative of the sensitivity of modeling for the Latrobe River and tributaries respectively). The flow required to achieve a water level at the upstream cross-section matching that obtained from the "best-estimate" model were determined and compared. Where the model was run with a decreased roughness and increased slope, an upper limit (flow) was produced. Conversely, where the model was run with an increased roughness and a decreased slope, a lower limit (flow) was produced. Results are shown in detail in Table 2-1 and summarised in Table 2-2.

Table 2-1 – Sensitivity Analysis Results – percentage change in flow to match "best-estimate" water level at upstream cross-section

Period		Reach 3 – Lake Narracan to Scarnes Bridge		Reach 9 – Tyers River	
Change in Manning's n	Change in slope	Low Flow	High Flow	Low Flow	High Flow
Increase 25%	Reduce 25%	-23%	-26%	-25%	-29%
Increase 25%	No change	-18%	-19%	-22%	-22%
No change	Reduce 25%	-4%	-8%	-5%	-9%
Reduce 25%	Increase 25%	+33%	+37%	+32%	+35%
Reduce 25%	No change	+30%	+30%	+26%	+29%
No change	Increase 25%	+3%	+6%	0%	+6%

Table 2-2 – Sensitivity Analysis Results – Upper and lower flow limits for a 25% change in boundary conditions and Manning's n for the recommended Low Flow and High Flow Fresh

Period	Reach 3 – Lake Narracan to Scarnes Bridge	Reach 9 – Tyers River
Recommended Low Flow	**560 ML/d**	**150 ML/d**
Upper Limit	743 ML/d (+33%)	199 ML/d (+32%)
Lower Limit	432 ML/d (-23%)	112 ML/d (-25%)
Recommended High Flow Fresh	**7780 ML/d**	**690 ML/d**
Upper Limit	10,627 ML/d (+37%)	933 ML/d (+35%)
Lower Limit	5789 ML/d (-26%)	492 ML/d (-29%)

The sensitivity analysis indicates:

- Results at the upstream end of the model are largely insensitive to changes in downstream boundary conditions (channel slope) – a maximum 9% change in flow is required to match the upstream water level
- Results at the upstream end of the model are more sensitive to changes in channel roughness – a maximum 30% change in flow required to match the upstream water level
- Reducing the roughness by 25% and increasing the downstream slope by 25% results in the maximum change in upstream flow , equivalent to a 37% increase
- The relative impact of modifications in channel roughness and downstream boundary condition is similar between the two reaches examined in the sensitivity analysis.

The recommended flow magnitudes quoted in this report are direct outputs from the hydraulic model investigation using "best estimate" parameters. Figures have not been rounded in the conversion from the modelled discharge (m^3/s) to ML/d however the inherent modelling uncertainties discussed above should be considered when developing a flow regime for implementation. The recommended flow magnitudes should not be assumed to have a degree of accuracy greater than that implied by the sensitivity analysis.

2.6 Peer Review

Specific components of the project have been subject to an informal peer review. The peer review was initiated to review two potential parameters and associated criteria not normally applied to the FLOWS method.

The peer review was conducted informally in October 2005 through discussions with the following academic staff of Melbourne University, experienced in the use of the FLOWS method and in assessment of stream processes:

- Dr Michael Stewardson,
- Dr John Tilleard, and

- Associate Professor Brian Finlayson

The additional parameters subject to review were: Flow Exceedence Thresholds and Flow Duration Criteria as discussed below.

2.6.1 Flow Exceedence Thresholds

Comment: Flow exceedence thresholds were adopted in the draft Recommendations Report (Revision B) to define a lower limit for Summer and Winter base flows. A 90 percentile flow was adopted for this purpose i.e., the flow that is exceeded 90% of the time. The purpose of this parameter was to prevent adoption of drought conditions to meet established criteria for identified assets.

Result of Review: The review endorsed the use of lower thresholds such as that provided by flow exceedence criteria. However the reviewers recommended that such thresholds be used for guidance only. The reviewers preferred that the reasons for avoiding persistent low flow conditions be explored and that parameters and criteria be identified and adopted to protect particular assets and or processes at risk.

Outcome: Flow parameters and acceptance criteria have been reviewed for a number of assets to protect these assets and processes. Examples of criteria include pool depth and depth of water within riffle/ runs on the Latrobe River to protect and restore populations of large bodied fish species.

2.6.2 Flow Duration

Comment: There is significant evidence linking changes in the flow regime with changes in channel shape and form in alluvial systems. Further, there is considerable evidence to suggest that this is associated with a change in the effective discharge and a change in the average annual excess energy expenditure in a stream system. Significant reductions and enlargements in channel size have been found to occur as a result of these. Ongoing accelerated channel adjustments are not a desirable outcome for stream systems of the Latrobe River. Such adjustments are inconsistent with the objectives for the river system and associated riverine assets.

The following flow duration criteria were adopted in the draft report as a means to protect the channel capacity from change resulting from extraction and regulation.

"In addition to the above flow component criteria there should be no more than a 10% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold".

This criteria does not relate to any one flow component and as such does not fit neatly into a process that concentrates on flow components.

Review: There was universal endorsement of the adoption of this parameter. However without detailed effective discharge analysis there is uncertainty over how much channel change will occur as a result of various changes to the flow regime. It was considered that a 10% variation to the natural duration of events that exceed the threshold of motion was unlikely to cause significant channel change and was a "safe bet". It was also agreed that a 40 to 50% change would cause significant channel change.

Outcome: A 20% threshold has been adopted for this parameter. This parameter and associated criteria have not been included in the recommendations for individual flow components. However the parameter and criteria have been

included as an additional recommendation for all alluvial reaches of the Latrobe River and Tributaries.

3 Reach Recommendations

The flow recommendations for each reach (excluding Reaches 6 and 7 as discussed below) are presented below in a standard format with four individual sections:

- **A Summary of the Reach Condition:** These are a very brief summary of the hydrology, water quality, geomorphology, macroinvertebrate, fish and vegetation condition in the reach. These are taken from information presented in the Issues Paper;
- **The Environmental Flow Objectives:** For each reach, the objectives and non-flow dependent issues are presented;
- **Flow Processes and Components:** For each reach the objectives are linked to the flow processes and flow components required to meet the objective;
- **Summary Tables:** The recommendations are presented in a standard table format as used in the FLOWS method.

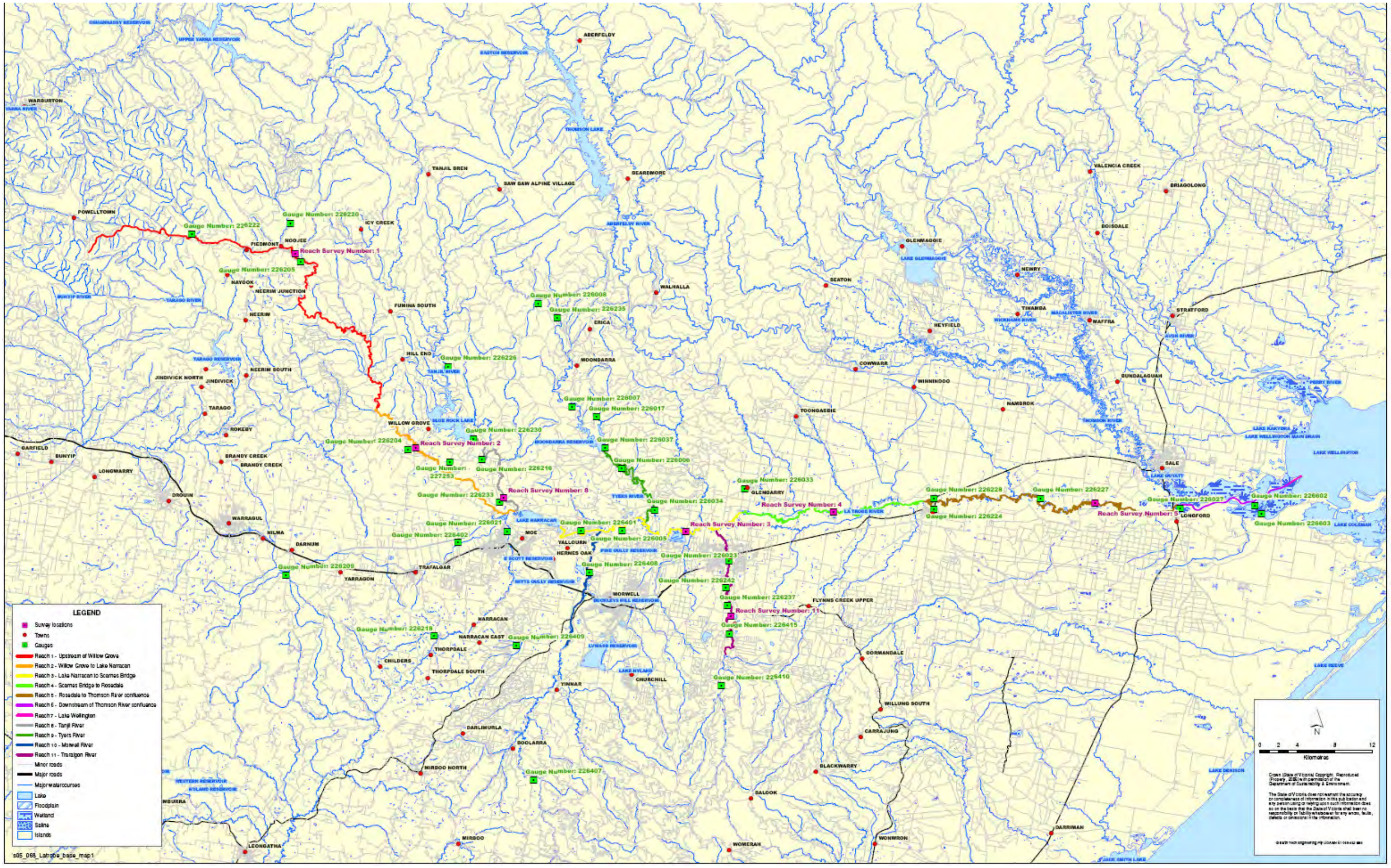
Figure 3-1 on the following page identifies the location of reach breaks, representative sites and gauges.

Reach 6 is considered to have the features and processes of an estuary. The FLOWS method was not developed for the assessment of environmental water requirements for estuaries. Estuarine water levels and ecological responses depend on the interaction between tidal and riverine processes which cannot be adequately assessed with the FLOWS method. The environmental water requirements for Reach 6 should be assessed in the future using the proposed “Estuary FLOWS Method” currently under development by DSE.

The Estuary FLOWS Method (currently under development) includes provisions for the assessment of wetlands adjoining estuary systems. The environmental water requirements for the Lower Latrobe Wetlands should be assessed in the future in conjunction with the Estuary FLOWS assessment for Reach 6.

Similarly, flow recommendations for Reach 7 (Lake Wellington) have not been assessed in the current study as it is an estuarine lake.

Figure 3-1 – Latrobe River Reach Breaks



Reach One – Upper Latrobe River (upstream of Willow Grove)

Reach One encompasses the headwaters of the Latrobe River and is unregulated although there are some licensed pumping extractions. The catchment of Reach One is generally forested, comprising Damp Forest, Wet Forest and Cool Temperate Rainforest in the upper catchment, grading to Damp Forest and Lowland Forest further downstream. Logging has been carried out within State Forests in the upper catchment. Near Noojee, cleared land is used primarily for grazing, however Riparian Forest generally persists in the immediate vicinity of the river. Agricultural activities (grazing, cropping and dairying) occur in the riparian corridor nearer Willow Grove. Reach One is identified as a representative river for south-central uplands river region with high environmental values (WGCMA, 2005).

This reach is largely intact and could be used as a template reach for restoration works in sand bed streams. The only significant impacts are associated with agricultural production near Noojee and include summer flow extractions and a decline in riparian vegetation condition. Protection of the hydrologic regime of this reach is a high priority for maintaining this part of stream in very good condition.

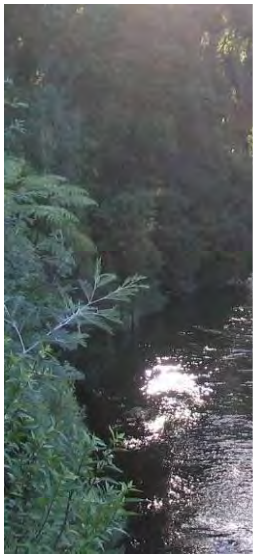
Key Values

- Representative river for south-central uplands river region
- Largely intact flow regime
- Barred galaxias (E), River blackfish, Short-finned eels (d), Australian smelt, Short-headed lamprey (d), Pouched lamprey (d), Spiny crayfish, Freshwater shrimp
- Present EVCs : Damp Forest (E), Wet Forest, Cool Temperate Rainforest, Lowland Forest

Reach Vision

A template 'ecologically healthy' reach with intact channel form and indigenous riparian vegetation that provides habitat and passage for species present prior to European settlement, resident and threatened aquatic fauna species.

Environmental Objectives



Physical Form

Provide suitable conditions to maintain the intact channel morphology

Fish

Maintain self sustaining populations of Barred galaxias, River blackfish, Australian smelt, Short-finned eels, Short-headed lampreys, Pouched lampreys, Spiny crayfish and Freshwater shrimp.

Provide suitable conditions for Australian grayling following removal of downstream fish barriers.

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to maintain in-stream and riparian vegetation abundance, diversity and structure, including watering of overbank vegetation

Floodplain Wetlands

No wetland objective set for Reach One due to absence of floodplain wetlands in confined valley setting

Table 3-1 – Flow Processes and Components – Reach 1

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Maintain self sustaining populations of macroinvertebrates.	1-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		1-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		1-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		1-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		1-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 1-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of Barred galaxias, River blackfish, Australian grayling, Australian smelt, Short-finned eels, Short-headed lampreys, Pouched lampreys, Spiny crayfish and Freshwater shrimp. Provide conditions suitable for establishment of new populations of Australian Grayling following provision of fish passage beyond Lake Narracan	1-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Grayling and Blackfish from birds of prey and overheating of pool in summer
		1-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Grayling and Blackfish species
		1-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling and Blackfish
		1-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs for Grayling and Blackfish
		1-F5	Regional scale migration	High flow	>0.4m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling migration
		1-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs for Grayling migration
		1-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match with other fish movement cues, such as lunar cycles.
		1-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		1-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							species over introduced species
Water Quality	Maintain water quality to meet SEPP (Waters of Victoria) objectives	1-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Reoxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	1-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Bar maintenance and provision of detritus for in-stream detrivores
		1-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		1-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		1- P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		1-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time	Maintain channel form through bed disturbance and scour hole formation
		1-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		1-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		1-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of events to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to maintain in-stream and riparian vegetation abundance, diversity and structure	1-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		1-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		1-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Dec – May	Watering of in-stream bar vegetation
		1-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		1-V5	Habitat inundation/ regeneration – provision of moisture and sediment to	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			benches				
		1-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		1-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		1-V8	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and overbank vegetation (within the confined valley setting overbank vegetation refers to infrequently inundated bank vegetation communities)

3.1 Reach 1 Summary Recommendations

Table 3-2 – Flow recommendations for Reach 1 – Upper Latrobe River (upstream of Willow Grove)

River		Latrobe River		Reach	Reach 1 – Upper Latrobe River (upstream of Willow Grove)
Compliance Point		Latrobe River at Noojee		Gauge No.	226 205
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >216 ML/d (or natural)	Continuous	Continuous	1-M1, 1-M2, 1-M3, 1-F1, **1-F2**, 1-V1	**Average depth of pools >0.4m for provision of habitat for Grayling and Blackfish**, inundation of bed for macroinvertebrate habitat
Dec – May	Low Flow Freshes >345 ML/d	4 per season	3 days	1-F3, 1-F4, 1-Q1, **1-P1**, 1-P3, 1-V2, **1-V3**	**Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation communities**, riffle thalweg >0.4m for movement of River Blackfish and Australian Grayling, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >345 ML/d (or natural)	Continuous	Continuous	1-F5, 1-F6, **1-P2**, 1-P8, **1-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.4m over thalweg between pools for migration of Grayling
June – Nov	High Flow Freshes >864 ML/d	1 per season	2 days	1-M4, 1-M5, 1-F7, 1-F8, 1-F9, **1-P4**, 1-P5, 1-P7, 1-P8, **1-V5**	**Bench inundation to maintain channel form and provide watering of bench vegetation**, pool velocity >1 m/s for scour hole formation and maintenance
June – Nov	Overbank Flow >1210 ML/d	1 every 2 years	2 days	**1-P6**, 1-P8, 1-V6, 1-V7, **1-V8**	**Channel maintenance, watering of floodplain vegetation,** protection of riparian vegetation diversity and structure

NOTES:

- 7 day independence is recommended between events
- In addition to the above flow component criteria there should be no more than a 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-3 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise		Rate of Fall	
		AVG rate	MAX rate	AVG rate	MAX rate
1 Latrobe River (upstream of Willow Grove)	Low Flow Freshes	45	280	30	205
	High Flow Freshes	80	440	50	290

Comments

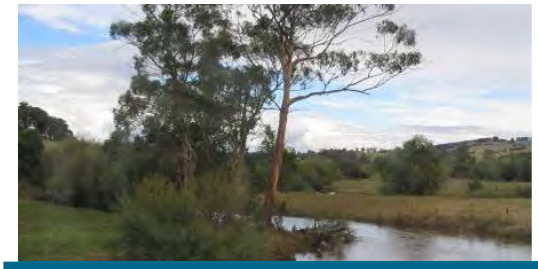
1. Australian Grayling, a diadromous native species, is not present in this reach. However this species could be expected to be present in this reach if Lake Narracan did not provide a barrier to fish passage. The flow recommendations for this reach have been assessed on the basis that Lake Narracan will be modified to enable passage of diadromous species such as Australian Grayling.
2. The impact of the Yallourn Barrel Weir (adjacent to Yallourn Power Station, downstream of Lake Narracan) on fish passage is unclear. Under low and normal flow conditions the drum gate is kept closed and all flow passes over the weir and it is likely that fish passage is limited. Modifications to the structure may be required to enable fish passage. This should be assessed in parallel with future works to provide fish passage at Lake Narracan.
3. The flow recommendations provided to meet the summer low flow criteria also meet the fish passage criteria associated with low flow freshes and high flows. As a consequence, adoption of the low flow recommendations will provide Blackfish and Grayling with some beneficial movement opportunities during summer low flows.

Reach Two – Latrobe River (Willow Grove to Lake Narracan)

Reach Two of the Latrobe River is unregulated although subject to licensed pumping extractions. The river emerges from a confined upland setting and flows through an extensively modified floodplain, with grazing and limited cropping becoming dominant. The floodplain and riparian corridor have been largely cleared of native vegetation although isolated remnants remain along the river channel. Willow infestation is locally significant. The Tanjil River enters the Latrobe River within the backwater zone of Lake Narracan, at the downstream end of Reach Two.

This reach has largely intact hydrology and stream bed form. However adjoining agricultural production has reduced the quality of riparian vegetation, floodplain wetlands, and impacted on in-stream ecology. The presence of Lake Narracan has resulted in the loss of access for some diadromous fish species from the reach and poses a threat for long term future of these species.

Key Values



- Largely intact flow regime
- River blackfish, Short-finned eels (d), Southern pigmy perch, Australian smelt, Short-headed lamprey (d)
- Good bed form
- EVCs present: Swamp Scrub, Valley Heathy Forest, Floodplain Riparian Woodland

Reach Vision

An 'ecologically healthy' reach providing sustainable passage, intact channel form and indigenous riparian vegetation cover.

Environmental Objectives

Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of small, non-migratory species

Maintain self sustaining populations of large, non-migratory species

Maintain self sustaining populations of migratory species

Provide suitable conditions for Australian grayling following removal of downstream fish barriers

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure, including watering of remnant overbank vegetation

Floodplain Wetlands

No wetland objective set for Reach Two as wetland condition is compromised due to grazing

Table 3-4 – Flow Processes and Components – Reach 2

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Maintain self sustaining populations of macroinvertebrates.	2-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		2-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		2-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		2-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		2-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 2-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of small, non-migratory species Maintain self sustaining populations of large, non-migratory species Maintain self sustaining populations of migratory species. Provide conditions suitable for establishment of new populations of Australian Grayling following provision of fish passage beyond Lake Narracan	2-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Grayling and Blackfish from birds of prey and overheating of pool in summer
		2-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Grayling and Blackfish species
		2-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling and Blackfish
		2-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs for Grayling and Blackfish
		2-F5	Regional scale migration	High flow	>0.4m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling migration
		2-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs for Grayling migration
		2-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match with other fish movement cues, such as lunar cycles.
		2-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		2-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Water Quality	Maintain water quality to meet SEPP (Waters of Victoria) objectives	2-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Reoxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	2-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Bar maintenance and provision of detritus for in-stream detrivores
		2- P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		2-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		2-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		2-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time	Maintain channel form through bed disturbance and scour hole formation
		2-P6	Channel disturbance	Near bankfull	Flow nearing bankfull capacity	Any time	Enables ongoing channel evolution
		2-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		2-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to maintain in-stream and riparian vegetation abundance, diversity and structure	2-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		2-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		2-V3	Habitat regeneration –inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		2-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		2-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
		2-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Bankfull	Commence overbank flooding	June – Nov	Inundation of upper banks to prevent vegetation encroachments
		2-V7	Delivery of seed from upper catchment	Freshes	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds

3.2 Reach 2 Summary Recommendations

Table 3-5 – Flow recommendations for Reach 2 – Latrobe River (Willow Grove to Lake Narracan)

River		Latrobe River		Reach	Reach 2 – Latrobe River (Willow Grove to Lake Narracan)
Compliance Point		Latrobe River at Willow Grove		Gauge No.	226 204
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >200ML/d (or natural)	Continuous	Continuous	2-M1, 2-M2, 2-M3, 2-F1, **2-F2**, 2-V1	**Average depth of pools >0.4m for provision of habitat for Grayling and Blackfish**, inundation of bed for provision of macroinvertebrate habitat
Dec – May	Low Flow Freshes >345ML/d	5 per season	11 day average	2-F3, 2-F4, 2-Q1, 2-V2, **2-V3**, **2-P1**, 2-P3	**Inundation of bars to maintain channel form and provide watering for vegetation communities**, riffle thalweg >0.4m for movement of River Blackfish and Australian Grayling, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >345 ML/d (or natural)	Continuous	Continuous	2-F5, 2-F6, **2-P2**, 2-P8, **2-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.4m over thalweg between pools for migration of Grayling
June – Nov	High Flow Freshes >1300ML/d	3 per season	3 day average with variation between 2 and 4 days	2-M4, 2-M5, 2-F7, 2-F8, 2-F9, **2-V5**, **2-P4,** 2-P5, 2-P7, 2-P8	**Bench inundation to maintain channel form and provide watering of bench vegetation**, pool velocity >1 m/s for scour hole formation and maintenance
Sep – Nov	Near Bankfull Flow >2073 ML/d	1 per season	2 days	**2-P6**, 2-P8, **2-V6**, 2-V7	**Channel maintenance and Inundation of upper banks to prevent vegetation encroachment**

NOTES:

- 7 day independence is recommended between events
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-6 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
2 Latrobe River (Willow Grove to Lake Narracan)	Low Flow Freshes	70	505	45	295
	High Flow Freshes	145	935	90	545

Comments

1. Australian Grayling, a diadromous native species, is not present in this reach. However this species could be expected to be present in this reach if Lake Narracan did not provide a barrier to fish passage. The flow recommendations for this reach have been assessed on the basis that Lake Narracan will be modified to enable passage of diadromous species such as Australian Grayling.
2. The impact of the Yallourn Barrel Weir (adjacent to Yallourn Power Station, downstream of Lake Narracan) on fish passage is unclear. Under low and normal flow conditions the drum gate is kept closed and all flow passes over the weir and it is likely that fish passage is limited. Modifications to the structure may be required to enable fish passage. This should be assessed in parallel with future works to provide fish passage at Lake Narracan.
3. This reach is disconnected from the floodplain. Further, the floodplain vegetation has been significantly altered as a result of grazing limiting ecological value and function. No specific overbank flood recommendation is made for this essentially unregulated reach.

Reach Three – Latrobe River (Lake Narracan to Scarnes Bridge)

Reach Three commences at the Lake Narracan weir wall. The Lake Narracan weir wall is a concrete structure with four vertical lift (undershot) gates, retaining a weir pool approximately 5 m deep. Reach Three is therefore a regulated reach with the Narracan weir wall (operated to provide a constant water level in Lake Narracan) attenuating the passage of flood flows to the reach.

The Lake Narracan weir wall is located in a confined (gorge) setting with limited public access and generally intact riparian vegetation. A small weir (the Yallourn Barrel Weir) is located on the Latrobe River immediately downstream of the Yallourn Power Station (Refer Reaches 1 and 2). The floodplain width increases rapidly downstream of the Yallourn Mine as the Morwell River (south bank) and Tyers River (north bank) enter the Latrobe River within a distance of approximately 5 km. Downstream of the Morwell River confluence the Latrobe River floodplain has an average width of 2-3 km. Much of the floodplain in Reach Three has been cleared and is used for beef and dairy grazing. Wetland features comprise cut-off meanders. The Australian Paper Mill plant at Maryvale lies immediately south of the Latrobe River floodplain upstream of Traralgon. Traralgon Creek enters the Latrobe River approximately 3 km upstream of Scarnes Bridge.

Key Values

- Australian Grayling (d, E), River blackfish, Southern pigmy perch, Australian smelt, Tupong (d), Short-finned eel (d), Long-finned eel (d), Short-headed lamprey (d)
- EVCs present: Damp Forest, Plains Grassy Woodland, Plains Grassy Forest, Swampy Riparian Woodland
- Water Supply - Lake Narracan

Reach Vision

An 'ecologically healthy' working reach that provides connectivity with reaches upstream and downstream whilst recognising the social and economic value of Lake Narracan.

Environmental Objectives

Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of Australian grayling

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Water Quality and Macroinvertebrates

Rehabilitate self sustaining populations of macroinvertebrates

Rehabilitate water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to rehabilitate floodplain wetland connectivity and condition

Table 3-7 – Flow Processes and Components – Reach 3

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Rehabilitate self sustaining populations of macroinvertebrates	3-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		3-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		3-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		3-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		3-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 3-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of Australian grayling Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species	3-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Grayling and Blackfish from birds of prey and overheating of pool in summer
		3-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Grayling and Blackfish species
		3-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling and Blackfish
		3-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs for Grayling and Blackfish
		3-F5	Regional scale migration	High flow	>0.4m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling migration
		3-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs
		3-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							each season to ensure match with other fish movement cues, such as lunar cycles.
		3-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		3-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Rehabilitate water quality to meet SEPP (Waters of Victoria) objectives	3-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Re-oxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	3-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Bar maintenance and provision of detritus for in-stream detrivores
		3-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		3-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		3-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	Dec – May	Maintain channel form
		3-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time	Maintain channel form through bed disturbance and scour hole formation
		3-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		3-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		3-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to rehabilitate in-stream and riparian vegetation abundance, diversity and structure	3-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		3-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		3-V3	Habitat regeneration –	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			inundation of in-stream bars				vegetation
		3-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		3-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		3-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		3-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
Floodplain Wetlands	Provide suitable conditions to rehabilitate floodplain wetland connectivity and connection	3-W1	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation

3.3 Reach 3 Summary Recommendations

Table 3-8 – Flow recommendations for Reach 3 – Latrobe River (Lake Narracan to Scarnes Bridge)

River		Latrobe River		Reach	Reach 3 – Latrobe River (Lake Narracan to Scarnes)
Compliance Point		Latrobe River @ Scarnes Bridge		Gauge No.	226 033
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >560 ML/d (or natural)	Continuous	Continuous	**3-M1, 3-M2**, **3-M3**, 3-F1, 3-F2, 3-V1	**Inundation of bed for provision of macroinvertebrate habitat**, average depth of pools >0.4m for provision of habitat for Grayling and Blackfish
Dec – May	Low Flow Freshes >1380 ML/d	3 per period	6 days	3-F3, 3-F4, 3-Q1, **3-P1**, 3-P3, 3-V2, **3-V3**	**Inundation of in-stream bars to maintain channel form and provide watering of vegetation**, riffle thalweg >0.4m for movement of River Blackfish, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >1380 ML/d (or natural)	Continuous	Continuous	3-F5, 3-F6, **3-P2**, 3-P8, **3-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.4m over thalweg between pools for migration of Grayling
June – Nov	High Flow Freshes >7780 ML/d	2 per season	3 days	3-M4, 3-M5, 3-F7, 3-F8, 3-F9, **3-P4**, 3-P5, 3-P7, 3-P8, **3-V5**	**Bench inundation to maintain channel form and provide watering of bench vegetation**, pool velocity >1m/s for scour hole formation and maintenance
June – Nov	Overbank Flow >17300 ML/d	1 every 2 years	2 days average duration with variation between 1 and 3 days	**3-P6**, 3-P8, 3-V6, 3-V7, **3-W1**	**Channel maintenance and watering of floodplain and wetland vegetation**

NOTES:

- 7 day independence is recommended between events
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-9 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
3 Latrobe River (Lake Narracan to Scarnes Bridge)	Low Flow Freshes	335	2745	190	1760
	High Flow Freshes	990	6285	575	4065

Comments

1. Reach 3 is a transition reach with considerable internal variability. The reach comprises a gorge immediately downstream of Lake Narracan transitioning to an alluvial meandering stream in the lower reaches.
2. No Australian Bass have been recorded in this reach. This reach is on the southern recorded limit of Australian Bass and while Bass may on occasion be present, no specific recommendations have been made for this species in Reach 3.
3. The flow recommendations provided to meet the summer low flow criteria also meet the fish passage criteria associated with low flow freshes (Grayling and Blackfish) and high flows (Blackfish). As a consequence, adoption of the low flow recommendations will provide blackfish and grayling with some beneficial movement opportunities during summer low flows.

Reach Four – Latrobe River (Scarnes Bridge to Rosedale)

Reach Four traverses undulating agricultural land. Historically, this reach has been impacted by de-snagging and meander cut-off practices and by upstream water quality issues. Between Scarnes Bridge and Rosedale the conditions in the Latrobe River are impacted by a range of factors including:

- Grazing and agricultural activities on the floodplain, resulting in significant clearing and modification to vegetation communities. Isolated remnants (Floodplain Riparian Woodland EVC56) and floodplain wetlands (cut-off meanders) remain.
- Modified flows resulting from river regulation at Lake Narracan and regulation of major tributaries (Tanjil River and Tyers River)
- Past river management works including extensive channel straightening through construction of artificial meander cut-offs, leading to major channel incision, bank erosion and channel widening.
- Upstream industrial discharges and local nutrient inputs from agricultural activities and bank erosion

Key Values

- Australian Grayling (d, E), Australian bass (d), Macquarie Perch (E), Australian smelt, Southern pigmy perch, Short-finned eel (d), Long-finned eel (d), Tupong (d), Common galaxias (d)
- EVCs present: Lowland Forest, Damp Forest, Swamp Scrub, Estuarine Swamp Scrub, Plain Grassy Woodland

Reach Vision

An 'ecologically healthy' working reach, providing sustainable passage and connectivity with the floodplain.

Environmental Objectives

Physical Form

Provide suitable conditions to rehabilitate channel morphology

Fish

Maintain self sustaining populations of Australian grayling

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Water Quality and Macroinvertebrates

Rehabilitate self sustaining populations of macroinvertebrates

Rehabilitate water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to maintain floodplain wetland condition

Table 3-10 – Flow Processes and Components – Reach 4

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component, (Parameter and criteria)	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Rehabilitate self sustaining populations of macroinvertebrates	4-M1	Habitat availability (pool/run)	Low flow	Inundation of low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		4-M2	Habitat availability (riffle)	Low flow	Inundation of low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		4-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		4-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		4-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 4-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of Australian grayling Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species	4-F1	Habitat availability	Low flow	>1.5 m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Bass from birds of prey and overheating of pool in summer
		4-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 1.0m	All year	Provision of suitable pool habitat volume of adequate depth to support Bass
		4-F3	Local movement between habitats	Low flow freshes	>0.5m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Bass
		4-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.5m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs for Australian bass
		4-F5	Regional scale migration	High flow	>0.5m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Bass migration
		4-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.5m (*)	June – Nov	Provision of fish passage over riffles and runs for Australian bass
		4- F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component, (Parameter and criteria)	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							migration. Several required each season to ensure match with other fish movement cues, such as lunar cycles
		4-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		4-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Rehabilitate water quality to meet SEPP (Waters of Victoria) objectives	4-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Reoxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to rehabilitate channel morphology	4-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Bar maintenance and provision of detritus for in-stream detrivores
		4- P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		4-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		4- P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		4-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time	Maintain channel form through bed disturbance and scour hole formation
		4-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		4-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		4-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form.
Vegetation	Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure	4-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		4-V2	Habitat inundation – variability to provide	Low flow freshes	No quantitative criteria	Any time (with natural	Watering of bank vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component, (Parameter and criteria)	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			zonation			rate of rise and fall)	
		4-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		4-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		4-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		4-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		4-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		4-V8	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation
Floodplain Wetlands	Provide suitable conditions to maintain floodplain wetland condition	4-W1	Wetland inundation and carbon exchange	Wetland watering flow	Inundate connections to floodplain wetlands	June – Nov	Watering of floodplain and wetland vegetation

3.4 Reach 4 Summary Recommendations

Table 3-11 – Flow recommendations for Reach 4 – Latrobe River (Scarnes Bridge to Rosedale)

River		Latrobe River		Reach	Reach 4 – Latrobe River (Scarnes Bridge to Rosedale)
Compliance Point		Latrobe River at Rosedale (anabranch) and (main stream)		Gauge	Sum of 226 224 and 226 228
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >520 ML/d (or natural)	Continuous	Continuous	**4-M1, 4-M2**, **4-M3**, 4-F1, 4-F2, 4-V1	**Inundation of bed for provision of macroinvertebrate habitat**, average depth of pools >1.0 m for provision of habitat for Bass
Dec – May	Low Flow Freshes >1470ML/d	3 per season	7 days	4-F3, 4-F4, 4-Q1, **4-P1**, 4-P3, 4-V2, **4-V3**	**Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation**, riffle thalweg >0.5m for movement of Bass, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >1470ML/d (or natural)	Continuous	Continuous	4-F5, 4-F6, **4-P2**, 4-P8, **4-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, riffle thalweg >0.5m for migration of Bass
June – Nov	High Flow Freshes >6900ML/d	3 per season	5 days-	4-M4, 4-M5, 4-F7, 4-F8, 4-F9, 4-P4, **4-P5**, 4-P7, 4-V5	**Maintain channel form through bed disturbance and scour hole formation**
June – Nov	Overbank Flow >12960ML/d	1 per season	2 days	**4-P6**, 4-P8, 4-V6, 4-V7, **4-V8**	**Channel maintenance and watering of floodplain and wetland vegetation**
June – Nov	Wetland Watering Flow >8640ML/d	2 per season	3 days	**4-W1**	**Wetland inundation**

NOTES:

- 7 day independence between events is recommended
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-12 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
4 Latrobe River (Scarnes Bridge to Rosedale)	Low Flow Freshes	370	3105	190	1485
	High Flow Freshes	1065	6950	605	3900

Comments

1. Australian Bass have not been recorded in this reach. However this reach is very similar in structure to Reach 5 where Bass have been recorded. Recommendations for Reach 4 have included assessment of habitat and movement criteria for Australian Bass. These habitat and passage criteria for Australian Bass were not the controlling criteria for this reach.
2. Benches and bars were largely absent from the representative site. This is likely to be associated with ongoing channel adjustments following the large scale meander cut off program implemented in the Latrobe River. To assist with the analysis, the cross sectional survey for the site was extended using existing cross section data for the Latrobe River, held by the West Gippsland CMA. Adoption of this data enabled survey effort at the site to concentrate on data necessary to assess inundation of the meander cut-off at the site that now forms a floodplain wetland.
3. The flow recommendations provided to meet the summer low flow criteria also meet the fish passage criteria adopted for low flow freshes. As a consequence, adoption of the low flow recommendations is likely to provide Grayling and Bass with some beneficial movement opportunities during summer low flows.

Reach Five – Latrobe River (Rosedale to Thomson River)

Reach Five traverses undulating agricultural land and displays similar conditions to Reach Four although remnants of Floodplain Riparian Woodland (EVC56) adjacent to the river are larger and more continuous. The quality of riparian vegetation is generally better than that found in Reach Four, with a greater cover of retained native vegetation and fewer areas dominated by willows. The reach has been impacted by de-snagging and meander cut-offs and by upstream water quality issues from high nutrient discharges from adjacent irrigation districts. The condition of existing billabongs in cut-off meanders would be enhanced by improved hydrological connectivity with the river.

Key Values

- EVCs present: Swamp Scrub, Estuarine Swamp Scrub, Floodplain Riparian Woodland, Latrobe Valley Plains Grassland, South Gippsland Plains Grassland
- Short-finned eel (d), Australian bass (d), River blackfish, Short-headed lamprey (d), Non-parasitic lamprey (d), long-finned eel (d), Southern pigmy perch, Australian smelt

Reach Vision

An 'ecologically healthy' working reach, providing sustainable passage and connectivity with the floodplain.

Environmental Objectives

Physical Form

Provide suitable conditions to rehabilitate channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Water Quality and Macroinvertebrates

Rehabilitate self sustaining populations of macroinvertebrates

Rehabilitate water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to maintain and improve floodplain wetland condition

Table 3-13 – Flow Processes and Components – Reach 5

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Rehabilitate self sustaining populations of macroinvertebrates	5-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		5-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		5-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		5-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		5-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species	5-F1	Habitat availability	Low flow	>1.5m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Bass from birds of prey and overheating of pool in summer
		5-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 1.0m	All year	Provision of suitable pool habitat volume of adequate depth to support Bass
		5-F3	Local movement between habitats	Low flow freshes	>0.5m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Bass
		5-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.5m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs for Australian bass
		5-F5	Regional scale migration	High flow	>0.5m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Bass migration
		5-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.5m (*)	June – Nov	Provision of fish passage over riffles and runs for Australian bass
		5- F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							with other fish movement cues, such as lunar cycles.
		5-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		5-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Rehabilitate water quality to meet SEPP (Waters of Victoria) objectives	5-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Re-oxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to rehabilitate channel morphology	5-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Maintain channel form and provision of detritus for in-stream detrivores
		5- P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		5-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		5-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		5-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time	Maintain channel form through bed disturbance and scour hole formation
		5-P6	Channel disturbance	Overbank	Commence overbanks flooding	Any time	Enables ongoing channel evolution
		5-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		5-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure	5-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		5-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		5-V3	Habitat regeneration – inundation of in-stream	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			bars				
		5-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		5-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		5-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		5-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		5-V8	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation
Floodplain Wetlands	Provide suitable conditions to maintain and improve floodplain wetland condition	5-W1	Wetland inundation and carbon exchange	Wetland Watering Flow	Inundate connections to floodplain wetlands	June – Nov	Watering of floodplain and wetland vegetation

3.5 Reach 5 Summary Recommendations

Table 3-14 – Flow recommendations for Reach 5 – Latrobe River (Rosedale to Thomson River Confluence)

River		Latrobe River		Reach	Reach 5 – Latrobe River (Rosedale to Thomson River Confluence)
Compliance Point		Latrobe River at Kilmany South		Gauge	226 227
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >690 ML/d (or natural)	Continuous	Continuous	**5-M1, 5-M2**, **5-M3**, 5-F1, 5-F2, 5-V1	**Inundation of bed for provision of habitat to macroinvertebrates**, average depth of pools >1.0 m for provision of habitat for Bass
Dec – May	Low Flow Freshes >1296ML/d	3 per season	7 days	5-F3, 5-F4, 5-Q1, 5-P1, **5-P3**, 5-V2, 5-V3	Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation, riffle thalweg >0.5m for movement of Bass, **minimum reach velocity >0.3m/s for bed disturbance**
June – Nov	High Flow** >1470ML/d (or natural) (refer comment No. 3)	Continuous	Continuous	5-F5, 5-F6, **5-P2**, 5-P7, 5-P8, **5-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment (based on upstream reach)**, riffle thalweg >0.5m for migration of Bass
June – Nov	High Flow Freshes >6900ML/d	3 per season-	5 days-	5-M4, 5-M5, 5-F7, 5-F8, 5-F9, 5-P3, **5-P5**, 5-V5	**Maintain channel form through bed disturbance and scour hole formation**
June – Nov	Overbank Flow >12960ML/d	1 per season	2 days	**5-P6**, 5-P8, 5-V6, 5-P7, 5-V7, **5-V8**	**Channel maintenance and watering of floodplain and wetland vegetation**
Sep – Nov	Wetland Watering Flow >8640ML/d	2 per season	3 days	**5-W1**	**Wetland inundation**

NOTES:

- 7 day independence between events is recommended
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-15 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
5 Latrobe River (Rosedale to Thomson River Confluence)	Low Flow Freshes	370	3104	189	1484
	High Flow Freshes	1065	6951	605	3902

Comments

1. Australian Bass have been recorded in this reach. Recommendations for this reach have included assessment of habitat and movement criteria for Australian Bass.
2. Benches and bars were largely absent from the representative site. This is likely to be associated with ongoing channel adjustments following the large scale meander cut off program implemented in the Latrobe River. To assist with the analysis, the cross sectional survey for the site was extended using existing cross section data for the Latrobe River, held by the West Gippsland CMA. Adoption of this data enabled survey effort at the site to concentrate on data necessary to assess inundation of the meander cut-off at the site that now forms a floodplain wetland.
3. The absence of benches and bars in this reach has meant that all relevant high flow criteria for this reach are met at very low recommendations. The adopted high flow recommendation of 1470 ML/d for this reach is based on the Reach 4 (upstream) high flow recommendation. Provision of this flow will assist in the maintenance of bars at this level as they form during the process of channel recovery.
4. The flow recommendations provided to meet the summer low flow criteria also meet the fish passage criteria adopted for low flow freshes. As a consequence, adoption of the low flow recommendations is likely to provide Australian Bass with some beneficial movement opportunities during summer low flows.

Reach Six – Latrobe River (Thomson River to Lake Wellington)

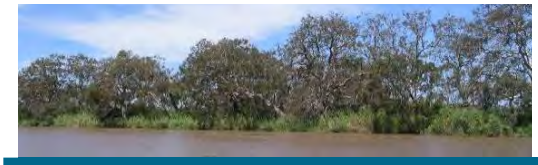
The Latrobe River within Reach Six is bordered by a floodplain wetland system comprising Sale Common and Heart Morass to the north and Dowd Morass to the south. Sale Common and Dowd Morass are managed by Parks Victoria as environmental and recreational assets. Approximately three quarters of Heart Morass is privately owned and used for cattle grazing while the eastern (downstream) portion lies within the Heart Morass Game Reserve. Conditions within each of these wetlands have been modified by increased salinity (from Lake Wellington) and reduced river flows in both the Thomson and Latrobe Rivers. Water levels and wetting and drying regimes in the wetlands are partially controlled by operation of gated culverts and regulators (operated by Parks Victoria) between the wetlands and the Latrobe River. The riparian vegetation along the Latrobe River in this reach is generally in fair to good condition.

The river in this reach is increasingly impacted by salinity impacting on vegetation communities. There appears to have been no significant change to physical form in this reach.

Key Values

- Ramsar listed Gippsland Lakes and adjoining wetlands
- EVC present: Swamp Scrub
- Southern pigmy perch, Australian smelt, Small-mouthed hardyhead, short-finned eel (d), long-finned eel (d), Australian bass, Striped gudgeon (e), Bridled goby (e), Estuary perch (e), Black bream (e), Luderick (e)
- Reach provides key link between Gippsland Lakes and the Macalister, Thomson and Latrobe systems

Reach Vision



An 'ecologically healthy' reach, providing the Thomson and Latrobe systems with sustainable passage and connectivity with the highly significant Gippsland Lakes and adjoining wetlands.

Environmental Objectives

Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to restore in-stream and riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to maintain and improve the adjoining freshwater and brackish wetlands including Sale Common and the Dowd and Heart Morass

Comments

This reach has been found to have the attributes of an estuary. Criteria adopted for the FLOWS method and applied to upstream reaches of this investigation were found to be inappropriate and not relevant to this reach.

A method is currently being developed for the assessment of environmental water requirements for estuaries within Victoria. The environmental flow requirements for this reach should be assessed during the trials and or “roll out” of this Estuary FLOWS assessment method.

As a consequence no specific flow recommendations are made for this reach.

Reach Eight – Tanjil River

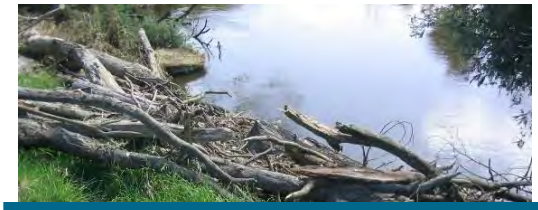
Reach Eight is regulated by the operation of Blue Rock Reservoir at the upstream end of the reach. Blue Rock Reservoir is operated by Southern Rural Water, providing water for industrial, irrigation and domestic uses. Releases from Blue Rock Reservoir are made to ensure compliance with Bulk Entitlement specifications that include minimum flows of 90-150 ML/D (seasonal variation) are achieved in the Latrobe River immediately upstream of the confluence with the Morwell River. Downstream of Blue Rock Reservoir, the Tanjil River flows through a short confined reach before emerging onto a broader floodplain approximately 1-2 km wide. The floodplain is subject to agricultural pressures including grazing and dairying. Much of the native vegetation has been cleared from the river channel and floodplain and willow is widespread. The Tanjil River enters the Latrobe River (Reach Two) in the backwater zone of Lake Narracan.

Much of the Tanjil River is subject to grazing pressure and its condition reflects this use.

Key Values

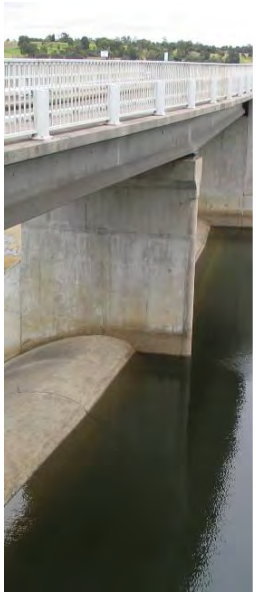
- Largely intact bed form
- Water Supply – Blue Rock Lake
- River blackfish, Australian smelt, Flathead gudgeon, Short-finned eel (d), Short-headed lamprey (d)
- EVCs present: Swamp Scrub, Lowland Forest, Damp Forest, Estuarine Swamp Scrub, Plains Grassy Forest, Floodplain Riparian Woodland

Reach Vision



An 'ecologically healthy' working reach, providing intact channel form, indigenous vegetation cover and sustainable passage.

Environmental Objectives



Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Provide suitable conditions for Australian grayling following removal of downstream fish barriers

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to maintain riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to maintain floodplain wetland condition

Table 3-16 – Flow Processes and Components – Reach 8

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Maintain self sustaining populations of macroinvertebrates	8-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		8-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		8-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		8-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		8-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 8-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species Provide conditions suitable for establishment of new populations of Australian Grayling following provision of fish passage beyond Lake Narracan	8-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Grayling and Blackfish from birds of prey and overheating of pool in summer
		8-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Grayling and Blackfish species
		8-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling and Blackfish
		8-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs
		8-F5	Regional scale migration	High flow	>0.4m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling migration
		8-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs
		8-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							with other fish movement cues, such as lunar cycles.
		8-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		8-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Maintain water quality to meet SEPP (Waters of Victoria) objectives	8-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Re-oxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	8-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Maintain channel form and provision of detritus for in-stream detrivores
		8-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		8-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		8-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		8-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time with sufficient duration	Maintain channel form through bed disturbance and scour hole formation
		8-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		8-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		8-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to maintain riparian vegetation abundance, diversity and structure	8-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		8-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		8-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		8-V4	Prevent vegetation	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			encroachment in channel				of drowning encroaching vegetation
		8-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		8-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		8-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		8-V8	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation
Floodplain Wetlands	Provide suitable conditions to maintain floodplain wetland condition	8-W1	Overbank species regeneration	Overbank	Commence overbank flooding	June – Nov	Watering of floodplain and wetland vegetation

3.6 Reach 8 Summary Recommendations

Table 3-17 – Flow recommendations for Reach 8 – Tanjil River

River	Tanjil River			Reach	Reach 8 – Tanjil River
Compliance Point	Tanjil River @ Tanjil South			Gauge	226 216
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >140 ML/d (or natural)	Continuous	Continuous	**8-M1, 8-M2**, **8-M3**, 8-F1, 8-F2, 8-V1	**Inundation of bed for provision of macroinvertebrate habitat**, average depth of pools >0.4m for provision of habitat for Grayling and Blackfish
Dec – May	Low Flow Freshes >432ML/d	2 per season	4 days	8-F3, 8-F4, 8-Q1, **8-P1**, 8-P3, 8-V2, **8-V3**	**Inundation of bars to maintain channel form and provide watering of vegetation communities**, riffle thalweg >0.4m for movement of River Blackfish and Australian Grayling, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >432ML/d (or natural)	Continuous	Continuous	8-F5, 8-F6, **8-P2**, 8-P8, **8-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.4m over thalweg between pools for migration of Grayling
June – Nov	High Flow Freshes >1035ML/d	2 per season (including additional high flow fresh >1470 ML/d)	3 days (including additional fresh of 1470 ML/d for 2 days)	8-M4, 8-M5, 8-F7, 8-F8, 8-F9, 8-P4, **8-P5**, 8-P7, 8-P8, 8-V5	Bench inundation to maintain channel form and provide watering of bench vegetation, **pool velocity >1m/s for scour hole formation and maintenance**
June – Nov	Overbank Flow >3024ML/d	1 every 2 years	2 days	**8-P6**, 8-P8, 8-V6, 8-V7, **8-V8**, 8-W1	**Channel maintenance and watering of floodplain and wetland vegetation**

NOTES:

- 7 day independence between events is recommended
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-18 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
8 Tanjil River	Low Flow Freshes	95	820	40	320
	High Flow Freshes	165	1340	80	485

Comments

1. Australian Grayling, a diadromous native species, is not present in this reach. However this species could be expected to be present in this reach if Lake Narracan did not provide a barrier to fish passage. The flow recommendations for this reach have been assessed on the basis that Lake Narracan will be modified to enable passage of diadromous species such as Australian Grayling.

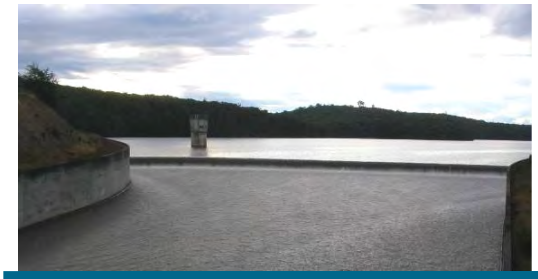
Reach Nine – Tyers River

Flows in Reach Nine are regulated by the operation of Moondarra Reservoir at the upstream end of the reach. Moondarra Reservoir is operated by Gippsland Water and is used primarily to supply water to industry in the Latrobe Valley. Moondarra Reservoir is a small reservoir and flood releases via the spillway are frequent however there is significant attenuation of small to medium floods.

The Tyers River downstream of the reservoir flows through the Boola State Forest and Tyers Regional Park. Much of the catchment is very steep and public access is low and as a result the majority of the river and immediate catchment are in excellent condition. Near the downstream end of Reach Eight, there is a low concrete weir (Wirilda Park Weir) and associated pumping station providing emergency water supply. Downstream of the pumping station (approximately 1 km upstream of the Tyers Road) grazing is dominant on the floodplain of the Tyers River and the Latrobe River and vegetation is generally cleared or degraded. The Tyers River enters the Latrobe River (Reach Three) a short distance upstream of the Australian Paper Mill plant at Maryvale.

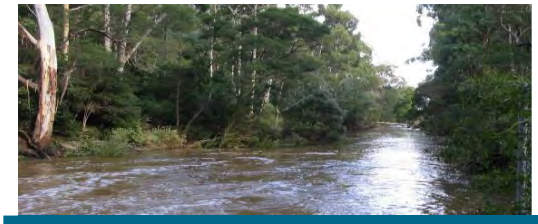
Much of this reach is within forest and is in excellent condition. The presence of a downstream weir limits fish migration, as does Moondarra Reservoir.

Key Values



- Largely intact physical form
- Water Supply – Moondarra Reservoir
- EVCs present: Swamp Scrub, Damp Forest, Estuarine Swamp Scrub, Floodplain Riparian Woodland, Plains Grassy Forest, Swampy Riparian Woodland, Swampy Woodland
- Gippsland Spiny Cray

Reach Vision



An 'ecologically healthy' working reach, preserving intact channel form and indigenous vegetation cover while providing sustainable passage.

Environmental Objectives

Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of diadromous species

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to maintain riparian vegetation abundance, diversity and structure, including overbank vegetation

Floodplain Wetlands

No wetland objective set due to absence of wetlands in gorge setting and degraded wetland condition in floodplain reach

Table 3-19 – Flow Processes and Components – Reach 9

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Maintain self sustaining populations of macroinvertebrates	9-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		9-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		9-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		9-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel benches	June – Nov	Provision of food source to macroinvertebrate community
		9-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 9-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species	9-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Grayling and Blackfish from birds of prey and overheating of pool in summer
		9-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Grayling and Blackfish species
		9-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling and Blackfish
		9-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs
		9-F5	Regional scale migration	High flow	>0.4m over thalweg between pools	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Grayling migration
		9-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs
		9-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match with other fish movement cues, such as lunar cycles.
		9-F8	Entrain terrestrial	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			carbon/woody debris on benches				
		9-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Maintain water quality to meet SEPP (Waters of Victoria) objectives	9-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Reoxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	9-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Maintain channel form and provision of detritus for in-stream detrivores
		9-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		9-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		9-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		9-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time with sufficient duration	Maintain channel form through bed disturbance and scour hole formation
		9-P6	Channel maintenance	Channel maintenance flow	Inundate to observed flood cut	Any time	Enables ongoing channel evolution and maintenance of open channel
		9-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
Vegetation	Provide suitable conditions to maintain riparian vegetation abundance, diversity and structure	9-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		9-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		9-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		9-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
		9-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		9-V6	Inundation of bank and benches to disadvantage terrestrial species	Terrace inundation	Inundation of terrace	June – Nov	Inundation of benches to prevent vegetation encroachments
		9-V7	Inundation of observed vegetation community	Terrace inundation	Inundation of terrace	Any time	Maintenance and watering of terrace vegetation

3.7 Reach 9 Summary Recommendations

Table 3-20 – Flow recommendations for Reach 9 – Tyers River

River		Tyers River		Reach	Reach 9 – Tyers River
Compliance Point		Tyers River @ McMillan Highway		Gauge	226 034
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >150 ML/d (or natural)	Continuous	Continuous	**9-M1, 9-M2, 9-M3**, 9-F1, 9-F2, 9-V1	Average depth of pools >0.4m for provision of habitat for Grayling and Blackfish, **inundation of bed for macroinvertebrate habitat**
Dec – May	Low Flow Freshes >432ML/d	2 per season	3 days	9-F3, 9-F4, 9-Q1, 9-P1, **9-P3**, 9-V2, 9-V3	Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation communities, riffle thalweg >0.4m for movement of River Blackfish, **minimum reach velocity >0.3m/s for bed disturbance**
June – Nov	High Flow >345ML/d (or natural)	Continuous	Continuous	9-F5, 9-F6, **9-P2**, **9-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.4m over thalweg between pools for migration of Grayling
June – Nov	High Flow Freshes >690ML/d	2 per season	3 days	9-M4, 9-M5, 9-F7, 9-F8, 9-F9, **9-P4**, 9-P5, 9-P7, 9-P8, **9-V5**	**Bench inundation to maintain channel form and provide watering of bench vegetation,** pool velocity >1 m/s for scour hole formation and maintenance
June – Nov	Channel maintenance flow >2070ML/d	1 per 2 years	2 days	**9-P6**	**Enables ongoing channel evolution and maintenance of open channel**
June – Nov	Terrace Inundation >3456ML/d	1 per 5 years	1 days	9-V6, **9-V7**	Maintenance and watering of terrace vegetation

NOTES:

- 7 day independence between events is recommended.
- The flow magnitudes for the High Flow Freshes, Channel Maintenance Flows and Terrace Inundation flows cannot be met by operational releases from Moondarra Reservoir as the maximum release from Moondarra Reservoir (excluding spillway flows) is 200 ML/d. Flows of greater magnitude will occur only following significant storm events in the Tyers River catchment and cannot be controlled by deliberate management actions at the reservoir.

Table 3-21 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
9 Tyers River	Low Flow Freshes	85	740	40	290
	High Flow Freshes	140	1095	75	515

Comments

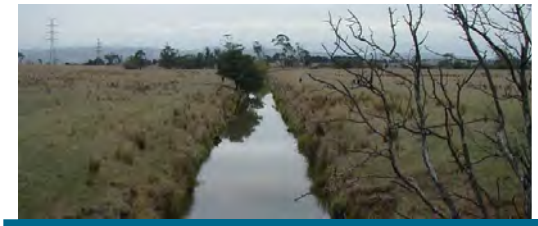
1. Australian Grayling, a diadromous native species, has not been recorded in this reach. However this species could be expected to be present in this reach if an existing weir in the lower reaches of the Tyers River (Wirilda Park Weir) did not present a barrier to fish passage. The flow recommendations for this reach have been assessed on the basis that this weir will be modified to enable passage of diadromous species such as Australian Grayling.
2. The flow recommendations provided to meet the summer low flow criteria also meet the fish passage criteria associated with low flow freshes and high flows. As a consequence, adoption of the low flow recommendations will provide Blackfish and Grayling with some beneficial movement opportunities during summer low flows.

Reach Ten – Morwell River

The headwaters of the Morwell River lie in the Strzelecki Ranges to the south of the Latrobe Valley. The upper catchment is forested, however agricultural pressures increase downstream of Mirboo. Within Reach Ten (downstream of Eel Hole Creek), the Morwell River has been subject to pipe and floodway style stream diversions that have enabled access to the underlying brown coal reserves. A new Morwell River Diversion at Yallourn has now been completed, replacing one of these piped diversions. The river now flows through an above ground meandering channel with pools and riffles and complementary ground cover and middle story riparian vegetation. Construction of a similar pool and riffle style watercourse to replace the existing piped diversion at the Hazelwood mine has now commenced. This diversion will include complementary riparian and floodplain vegetation and associated features. The end result of the recently completed and proposed works will be the reinstatement of in-stream and riparian connectivity between the Latrobe River and the upper reaches of the Morwell River and a significantly improved waterway environment.

There are only short remnant sections of river within Reach Ten and the riparian vegetation is generally degraded although some high value remnants, including natural and re-constructed wetlands, are found around the Princes Freeway. The Morwell River enters the Latrobe River (Reach Three) adjacent to the Yallourn Mine development.

Key Values

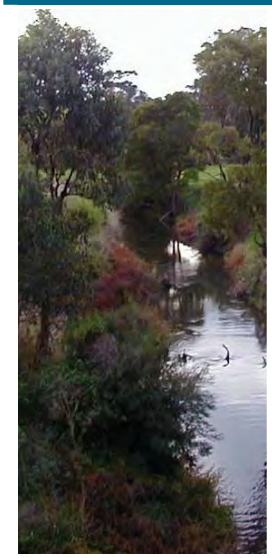


- River blackfish, Southern pigmy perch, Flathead gudgeon, Australian smelt, Tupong (d), Short-finned eel (d), Long-finned eel (d), dwarf galaxias
- EVCs present: Swamp Scrub, Swampy Riparian Complex

Reach Vision

An 'ecologically healthy' working reach, providing intact channel form, an indigenous vegetation cover, sustainable passage and connectivity with the floodplain.

Environmental Objectives



Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of small-bodied diadromous species

Water Quality and Macroinvertebrates

Rehabilitate self sustaining populations of macroinvertebrates

Rehabilitate water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to rehabilitate riparian vegetation abundance, diversity and structure

Floodplain Wetlands

Provide suitable conditions to maintain floodplain wetland condition

Table 3-22 – Flow Processes and Components – Reach 10

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Rehabilitate self sustaining populations of macroinvertebrates	10-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		10-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		10-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		10-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		10-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 10-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of diadromous species	10-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Blackfish from birds of prey and overheating of pool in summer
		10-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Blackfish
		10-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Blackfish
		10-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs
		10-F5	Regional scale migration	High flow	>0.4m thalweg depth over riffles	June – Nov	Provision of suitable fish passage over riffles and runs with suitable depth of cover for migration of small-bodied diadromous species
		10-F6	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs
		10-F7	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match with other fish movement cues,

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							such as lunar cycles.
		10-F8	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		10-F9	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native species over introduced species
Water Quality	Rehabilitate water quality to meet SEPP (Waters of Victoria) objectives	10-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec – May	Re-oxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	10-P1	Bar formation and disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Maintain channel form and provision of detritus for in-stream detrivores
		10-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		10-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		10-P4	Bench formation and disturbance	High flow freshes		June – Nov	Maintain channel form
		10-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time with sufficient duration	Maintain channel form through bed disturbance and scour hole formation
		10-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		10-P7	Scour biofilms	High flows freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		10-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to rehabilitate riparian vegetation abundance, diversity and structure	10-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		10-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		10-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		10-V4	Prevent vegetation	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			encroachment in channel				of drowning encroaching vegetation
		10-V5	Habitat inundation/ regeneration – provision of moisture and sediment to benches	High flow freshes	Inundate channel bench	June – Nov	Watering of bench vegetation
		10-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Prolonged bankfull and overbank flow	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		10-V7	Delivery of seed from upper catchment	Bankfull and Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		10-V8	Overbank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation
Floodplain Wetlands	Provide suitable conditions to maintain floodplain wetland condition	10-W1	Wetland watering and regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and wetland vegetation

3.8 Reach 10 Summary Recommendations

Table 3-23 – Flow recommendations for Reach 10 – Morwell River

River		Morwell River		Reach	Reach 10 – Morwell River
Compliance Point		Morwell River at Yallourn		Gauge	226 408
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >60 ML/d (or natural)	Continuous	Continuous	**10-M1, 10-M2, 10-M3**, 10-F1, 10-F2, 10-V1	Average depth of pools >0.4m for provision of habitat for Blackfish, **inundation of bed for macroinvertebrate habitat**
Dec – May	Low Flow Freshes >260ML/d	2 per season	3 days	10-F3, 10-F4, 10-Q1, **10-P1**, 10-P3, 10-V2, **10-V3**	**Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation communities**, riffle thalweg >0.4m for movement of River Blackfish, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >260ML/d (or natural)	Continuous	Continuous	10-F5, 10-F6, **10-P2**, 10-P8, **10-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**, >0.3m over thalweg between pools for migration of small-bodied diadromous species
June – Nov	High Flow Freshes >1380ML/d	4 per season	4 days	10-M4, 10-M5, 10-F7, 10-F8, 10-F9, 10-P4, **10-P5**, 10-P7, 10-P8, 10-V5	Bench inundation to maintain channel form and provide watering of bench vegetation, **pool velocity >1 m/s for scour hole formation and maintenance**
June – Nov	Overbank Flow >3456ML/d	1 per year	2 days	**10-P6**, 10-P8, 10-V6, 10-V7, **10-V8**, 10-W1	**Channel maintenance and watering of floodplain and wetland vegetation**

NOTES:

- 7 day independence between events is recommended
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.
- Compliance point recommended for Reach 10 is Morwell River at Yallourn (Gauge Number 226 408). This gauge currently measures only water quality. Due to the unsuitability of the other flow gauge on the Morwell River, it is recommended that this gauge be reinstated to measure discharge at this point.

Table 3-24 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
10 Morwell River	Low Flow Freshes	45	420	30	350
	High Flow Freshes	300	2215	190	1620

Comments

1. Australian Grayling have not been recorded in the Morwell River. Low flow and low flow fresh recommendations are based on provision of habitat for and local movement of Blackfish (recorded in the Morwell River). The recommendation for high flow has included analysis of small-bodied fish migration. However, the controlling criteria for high flow is inundation of bars and not fish migrations. Based on the controlling criteria, the high flow recommendation would meet the migration requirements of both small-bodied diadromous species and Australian Grayling (if this species was present).

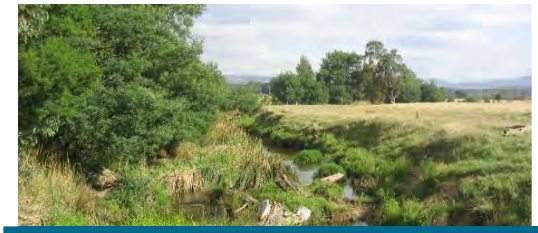
Reach Eleven – Traralgon Creek

Traralgon Creek rises to the south of the Loy Yang Power development at Traralgon South. It is an unregulated stream but receives significant licensed industrial discharges from the Loy Yang operations (Total industrial discharge to Latrobe system of 54 GL/yr between Morwell River and Traralgon Creek). Much of the floodplain and creek channel downstream of Mattingley's Hill Road has been cleared for grazing and heavy willow infestations are present. Recent willow control works have resulted in the clearing and revegetation of major reaches of the creek however some heavy infestations remain. Traralgon Creek runs through the centre of Traralgon and receives significant stormwater runoff from the urban area. Poor water quality has been reported in Traralgon Creek downstream of Traralgon. Traralgon Creek enters the Latrobe River floodplain (Reach Three) immediately downstream of Traralgon.

Key Values

- River blackfish, Southern pigmy perch, Flathead gudgeon, short-finned eels (d), Long-finned eels (d), Tupong (d), Common galaxias (d), Short-headed lamprey (d), Australian smelt, Pouched lamprey (d), Non-parasitic lamprey (d)
- Damp Forest EVC

Reach Vision



A reach that is managed to protect current channel form, remnant vegetation and resident aquatic biota, thereby minimising current and potentially threatening processes on the ecological health of downstream reaches.

Environmental Objectives

Physical Form

Provide suitable conditions to maintain channel morphology

Fish

Maintain self sustaining populations of non-migratory species

Maintain self sustaining populations of small-bodied diadromous species

Water Quality and Macroinvertebrates

Maintain self sustaining populations of macroinvertebrates

Maintain water quality to meet SEPP (WoV) SF5 (Waters of Latrobe and Thomson River Basins, and Merrimans Creek catchment) objectives

Vegetation

Provide suitable conditions to rehabilitate riparian vegetation abundance, diversity and structure

Floodplain Wetlands

No wetland objective set for reach as wetlands are largely absent. Small floodplain depressions exist but do not support wetland vegetation

Table 3-25 – Flow Processes and Components – Reach 11

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
Macroinvertebrates	Maintain self sustaining populations of macroinvertebrates	11-M1	Habitat availability (pool/run)	Low flow	Inundate low flow channel	All year	Provision of habitat to wide diversity of macroinvertebrate types
		11-M2	Habitat availability (riffle)	Low flow	Inundate low flow channel	All year	Provision of habitat to full diversity of macroinvertebrate types
		11-M3	LWD inundation (habitat)	Low flow	Inundate lower parts of LWD	All year	Provision of habitat to full diversity of macroinvertebrate types
		11-M4	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source to macroinvertebrate community
		11-M5	Disturb habitat	Low flow freshes	Refer geomorphology criteria 11-P3	Dec – May	Scour and regeneration of macroinvertebrate community
Fish	Maintain self sustaining populations of non-migratory species Maintain self sustaining populations of small diadromous species	11-F1	Habitat availability	Low flow	>1.0m depth at deepest point in pool thalweg (*)	All year	Provision of deep pool suitable for cover protection of Blackfish from birds of prey and overheating of pool in summer
		11-F2	Habitat availability	Low flow	Pool cross-sections having an average depth > 0.4m	All year	Provision of suitable pool habitat volume of adequate depth to support Blackfish
		11-F3	Local movement between habitats	Low flow freshes	>0.4m thalweg depth over riffles	Dec – May	Provision of suitable fish passage over riffles and runs with suitable depth of cover for Blackfish
		11-F4	Local movement between habitats	Low flow freshes	Riffle cross-sections having an average depth >0.2m (*)	Dec – May	Provision of unconfined fish passage over riffles and runs
		11-F5	Regional scale migration	High flow	Riffle cross-sections having an average depth >0.2m (*)	June – Nov	Provision of fish passage over riffles and runs
		11-F6	Migration cue	High flow freshes	No quantitative criteria	June – July	Provision of cue for fish migration. Several required each season to ensure match with other fish movement cues, such as lunar cycles.
		11-F7	Entrain terrestrial carbon/woody debris on benches	High flow freshes	Inundate channel bench	June – Nov	Provision of food source for fish
		11-F8	Disturb habitat	High flow freshes	No quantitative criteria	June – Nov	Provides advantages to native

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
							species over introduced species
Water Quality	Maintain water quality to meet SEPP (Waters of Victoria) objectives	11-Q1	Flushing of pools	Low flow freshes	No quantitative criteria	Dec - May	Re-oxygenation of water, introduction of carbon and nutrients
Physical Form	Provide suitable conditions to maintain channel morphology	11-P1	Bar disturbance	Low flow freshes	Inundation of in-stream bar	Dec – May	Maintain channel form and provision of detritus for in-stream detrivores
		11-P2	Bar formation and disturbance	High flow	Inundation of in-stream bar	June – Nov	Maintain channel form
		11-P3	Bed disturbance	Low flow freshes	Reach velocity >0.3m/s	Dec – May	Detritus movement in pool riffle systems
		11-P4	Bench formation and disturbance	High flow freshes	Inundate channel bench	June – Nov	Maintain channel form
		11-P5	Substrate scour to remove accumulations of fine sediment	High flow freshes	Pool velocity >1m/s	Any time with sufficient duration	Maintain channel form through bed disturbance and scour hole formation
		11-P6	Channel disturbance	Overbank	Commence overbank flooding	Any time	Enables ongoing channel evolution
		11-P7	Scour biofilms	High flow freshes	No quantitative criteria	June – Nov	Provision of surface for fresh/new biofilm establishment
		11-P8	Prevent channel encroachments	All flow components in excess of low flow fresh	Maintain duration and frequency of event to within 20% of natural flow regime	Always	Protection and restoration of channel shape and form
Vegetation	Provide suitable conditions to rehabilitate riparian vegetation abundance, diversity and structure	11-V1	Habitat inundation – low flow channel inundation	Low flow	Inundate low flow channel	Dec – May	Watering of in-stream vegetation
		11-V2	Habitat inundation – variability to provide zonation	Low flow freshes	No quantitative criteria	Any time (with natural rate of rise and fall)	Watering of bank vegetation
		11-V3	Habitat regeneration – inundation of in-stream bars	Low flow freshes	Inundate in-stream bar	Any time	Watering of in-stream bar vegetation
		11-V4	Prevent vegetation encroachment in channel	High flow	Inundate in-stream bar	June – Nov	Inundation of bars as a means of drowning encroaching vegetation
		11-V5	Habitat inundation/ regeneration – provision of moisture	High flow freshes	Bench wetting	June – Nov	Watering of bench vegetation

Asset	Environmental Objective	No.	Flow Process/Function	Flow Component	Parameter and Criteria (* = indicative criteria for reference only)	Timing	Comments / Expected Response
			and sediment to benches				
		11-V6	Prolonged inundation of bank and benches to disadvantage terrestrial species	Overbank	Commence overbank flooding	June – Nov	Inundation of benches to prevent vegetation encroachments
		11-V7	Delivery of seed from upper catchment	Overbank	Commence overbank flooding	Any time	Dispersal of riparian and floodplain seeds
		11-V8	Upper bank species regeneration	Overbank	Commence overbank flooding	Any time	Watering of floodplain and overbank vegetation

3.9 Reach 11 Summary Recommendations

Table 3-26 – Flow recommendations for Reach 11 – Traralgon Creek

River		Traralgon Creek		Reach	Reach 11 – Traralgon Creek
Compliance Point		Traralgon Creek at Traralgon (Princes Highway)		Gauge	226 023B
Flow				Rationale	
Period	Magnitude	Frequency	Duration	Objectives	Controlling Criteria and Discussion
Dec – May	Low Flow >35 ML/d (or natural)	Continuous	Continuous	11-M1, 11-M2, 11-M3, 11-F1, **11-F2**, 11-V1	Inundation of bed for provision of macroinvertebrate habitat, **average depth of pools >0.4m for provision of habitat for Blackfish**
Dec – May	Low Flow Freshes >210ML/d	1 per season	3 days	**11-F3**, 11-F4, 11-Q1, 11-P1, 11-P5, 11-V2, 11-V3	Inundation of in-stream bars to maintain channel form and provide watering of aquatic vegetation, **riffle thalweg >0.4m for movement of River Blackfish**, minimum reach velocity >0.3m/s for bed disturbance
June – Nov	High Flow >130ML/d (or natural)	Continuous	Continuous	11-F5, 11-F5, **11-P2**, 11-P8, **11-V4**	**Inundation of in-stream bars to maintain channel form and prevent vegetation encroachment**
June – Nov	High Flow Freshes >520ML/d	3 per season	3 days	11-M4, 11-M5, 11-F6, 11-F7, 11-F8, **11-P4**, **11-P5**, 11-P7, 11-P8, **11-V5**	**Bench inundation to maintain channel form and provide watering of bench vegetation**, pool velocity >1 m/s for scour hole formation and maintenance
June – Nov	Overbank Flow >1555ML/d	1 per 2 years	2 days	**11-P6**, 11-P8, 11-V6, 11-V7**, 11-V8**	**Channel maintenance and watering of floodplain and wetland vegetation**

NOTES:

- 7 day independence between events is recommended
- No more than 20% variation to the natural duration of events that exceed the threshold of motion of the weakest component of the bed and bank material. The low flow fresh is adopted as this threshold.

Table 3-27 – Recommended average and maximum rates of rise and fall (expressed as the change in discharge of the event divided by the length of the event, ML/day/day)

Reach/Site	Flow Component	Rate of Rise (ML/day/day)		Rate of Fall (ML/day/day)	
		AVG rate	MAX rate	AVG rate	MAX rate
11 Traralgon Creek	Low Flow Freshes	30	200	10	90
	High Flow Freshes	90	550	40	235

Comments

1. Australian Grayling have not been recorded in Traralgon Creek. Low flow and low flow fresh recommendations are based on provision of habitat for and local movement of Blackfish (recorded in Traralgon Creek). The recommendation for high flow has included analysis of small-bodied fish migration. However, the controlling criteria for high flow is inundation of bars and not fish migrations. Based on the controlling criteria, the high flow recommendation would meet the migration requirements of small-bodied diadromous species.

4 Supporting Recommendations

There are a number of key supporting recommendations for the implementation of EWR in the Latrobe River catchment, which include:

a. Implement the West Gippsland Regional River Health Strategy actions for the Latrobe River catchment

The WG RRHS identifies and addresses the complementary non-flow related options to restore river health such as stock exclusion, riparian revegetation, willow and weed control, in-stream habitat restoration and floodplain connectivity. The implementation of these works is inherent in achieving the vision and expected outcome sought within the flow recommendations for each reach.

This investigation has identified significant impacts associated with past meander cut offs. This has included channel incision (deepening). Flow recommendations included in this report have been based on provision of flows necessary to water these cut offs and the adjoining floodplain on the assumption that these meanders remain cut off from the primary flows within the Latrobe River. The environmental flow requirements for the Latrobe River identified in this investigation would be significantly less if these cut-off meanders were reinstated as the primary flow path. However reinstatement of the meander cut-offs would be a substantial project and could have significant impacts on the operation of adjoining agricultural land. Any project aimed at meander reinstatement would require significant investment in investigations and community consultation.

b. Examine the removal or provision of passage over fish barriers (such as Lake Narracan, Blue Rock Lake, Moondarra Dam, Wirilda Park Weir and Morwell River diversions)

The environmental flow recommendations contained within this report have been based on the return of fish passage through the Latrobe River system. Fish passage provision over the wall at Narracan Reservoir is a critical factor in the success of the environmental flow recommendations of this study. Fish passage in the Morwell River will be addressed with the decommissioning of the current piped diversion following the completion of the construction of the geomorphically designed 5th Morwell River Diversion at Hazelwood Mine. The attainment of the outcome sought for the Tyers River will be dependant on the provision of fish passage over the Wirilda Park weir. It is recommended that investigations be undertaken into the feasibility of the provision of fish ladders, fish locks and other means of fish passage over these existing in-stream barriers.

c. Manage water quality inputs to the system

Water quality in the Latrobe River is impacted to some extent by industrial discharges and urban and agricultural runoff. These inputs are addressed through EPA licensed discharges and best management practice. Ongoing programs will be required to address water quality issues in the Latrobe River system and the Gippsland Lakes catchment.

d. Community engagement regarding meander cut-off management and floodplain wetland connectivity

Removal of barriers (i.e., levees) and the sustainable management of the Latrobe River floodplain are required to rehabilitate the condition of floodplain wetlands.

This requires community engagement to encourage and facilitate such land management practices.

e. Undertake stream rehabilitation activities to complement environmental flow provisions

The environmental flow assessment identifies key environmental assets of the Latrobe River system and recommends a flow regime to meet defined condition objectives for these assets into the future. The benefits of environmental flow implementation will be maximised by undertaking stream rehabilitation activities to address non-flow dependent condition limits. Works such as restoration of in-stream habitat (i.e. large woody debris), fencing and revegetation activities and measures to improve water quality are addressed in the West Gippsland River Health Strategy. Continued strategic implementation of such works will provide additional habitat, food, shade and shelter and improved riparian connectivity for flora and fauna species which colonise the system in response to the modified flow regime.

f. Develop and implement a monitoring and evaluation program

A robust monitoring program will be required to assess whether the improvements expected from flow regime change are in fact being achieved. If the objectives expected of the flow regime are not being achieved over time, the flow regime will require adjustment. It is important to note that time frames for expected improvements may vary and improvements may not be immediate. In the same way that processes that lead to a degraded river system may occur over time frames ranging from days to years, in cases where degrading processes are widespread and persistent, it is highly likely that the effect of rehabilitation efforts will take many years to become apparent. It is also possible that river condition will continue to decline for some time even after rehabilitation actions have been undertaken. The ability of the monitoring and evaluation program to identify ecological changes, quantify changes, detect time frames expected and adjust actions accordingly will be critical to the adaptive management approach that is necessary for the environmental flow regime.

g. Investigate the environmental flow requirements of the Gippsland Lakes and surrounding wetlands

The Gippsland Lakes and wetlands are a key environmental asset. Flows in these systems are dependent on inflows from contributing catchments (including the Latrobe River catchment). These systems were not included in the scope of this study however the flow recommendations developed could be utilised in a future assessment of the environmental water requirements of the Lakes and surrounds. In particular the flow recommendations for the Latrobe River have not included the identification of volumetric requirements to adequately water the adjoining wetlands. It is recommended that further investigation be undertaken to identify the volume of water required to adequately water these wetland systems

Further and in this regard, Reach 6, the reach of the Latrobe River downstream of the Thomson River confluence can be considered to be an estuary reach. The reach comprises deep continuous pool over a length of approximately 10km. The reach is also subject to some saline intrusions as a result of a number of influences including but not limited to the permanent opening of the Gippsland Lakes to the marine environment at Lakes Entrance. Key issues in such systems are the salt balance, stratification, and the location of saline wedges and intrusions. The commonly applied approaches established for the analysis of environmental water requirements for freshwater stream systems are not appropriate for the analysis of

these estuary processes. As a consequence it is recommended that the environmental flow recommendations for Reach 6 be reviewed as a component of a review of environmental water requirements for the Gippsland Lakes estuary system.

5 Conclusion

Recommendations presented in this report identify the flow regime required to sustain ecological and geomorphic assets and processes of the Latrobe River. The recommendations have been developed by a Technical Panel using the FLOWS method. In particular the recommendations are based on satisfying ecological requirements for fish, macroinvertebrates, riparian vegetation, water quality, wetlands, and geomorphologic requirements as determined by the Technical Panel. The recommendations are also based on some limited hydrologic criteria to secure the long term ecological sustainability of the Latrobe River system.

Analysis of non-flow related options to improve river health has not been the focus of this report and should be addressed in the implementation of the West Gippsland Regional River Health Strategy actions for the Latrobe River catchment. The focus of this report has been identifying flow regime requirements for ecological health, and not the physical, social or economic impacts of implementing these recommendations.

No recommendations have been provided for Reach 6. Additional investigations will be required to identify appropriate environmental flow requirements for this reach and the adjoining wetlands.

The report forms a component of the implementation of environmental flows for the Latrobe River. The impacts of the recommendations are to be analysed through hydrologic modelling by DSE to determine the allocation of water for environmental recommendations and consumptive users. The results of this process, and additional information, will be utilised in the decision making process, determining water allocation along the Latrobe River for environmental and consumptive uses.

6 References

Department of Natural Resources and Environment (2002). FLOWS – a method for determining environmental water requirements in Victoria, State Government of Victoria

Department of Natural Resources and Environment (2004). Victorian River Health Strategy. State Government of Victoria

Department of Sustainability and Environment (2003). Gippsland Lakes Ramsar site. Strategic management plan.

Earth Tech (2003). Heart Morass health improvement works. Stage 1. Report and draft operating agreement. Report to West Gippsland Catchment Management Authority, Project 6003018.

Earth Tech (2005 a). Assessment of Environmental Flow Requirements for the Latrobe River and Wetlands of the Lower Latrobe River – Site Paper. Report to West Gippsland Catchment Management Authority.

Earth Tech (2005 b). Assessment of Environmental Flow Requirements for the Latrobe River and Wetlands of the Lower Latrobe River – Issues Paper. Report to West Gippsland Catchment Management Authority.

Nash, N (1991). Lake Wellington catchment wetlands salinity study. Department of Conservation and Environment.

Parks Victoria (1997). Lake Wellington wetlands. Draft management plan.

Sinclair Knight Merz (2001). Lake Wellington catchment salinity management plan. Wetland monitoring project. Part A. Analysis and interpretation of wetland monitoring data. Report to Department of Natural Resources and Environment.

Sinclair Knight Merz (2003). Lake Wellington catchment salinity management plan. Dowd Morass salt and water balance and the impact of management options. Report to Parks Victoria.

Sinclair Knight Merz (2005). Current and Natural daily Flows in the Latrobe River Catchment. Report to West Gippsland Catchment Management Authority.

WGCMA (2004). West Gippsland Regional Catchment Strategy 2004-2009. West Gippsland Catchment Management Authority.

WGCMA (2005). West Gippsland Regional River Health Strategy February 2005. West Gippsland Catchment Management Authority.

Appendix A

Hydrology of the Latrobe River System

Appendix A – Hydrology of the Latrobe River System

The Latrobe River system supplies water to local urban and industrial users, private diverters and farm dams. The river has an average annual runoff of 887,000 ML/year (WGCMA, 2004) and displays a high degree of variability in flow ranging from low flows to widespread overbank inundation.

Water resources in the Latrobe River system have been highly developed. There are three main regulating structures– Lake Narracan, Blue Rock Lake on the Tanjil River and Moondarra Reservoir on Tyers River. These storages provide the large local industry and townships with security of supply. Discharges from industry have also impacted on the flow regime of the Latrobe River system, with discharges from Loy Yang, Yallourn and Hazelwood power stations increasing the flows in Traralgon Creek and the Morwell River.

6.1 Hydrologic Data

WGCMA commissioned SKM to provide current and 'natural' daily flows for the period from 1 January 1957 to 30 June 2004 in the study reaches of the Latrobe River system.

'Natural' flows in the catchment were defined as ***streamflows that would have occurred over the historical climate sequence without extractions and discharges of water in the catchment*** (SKM, 2005). These flows do not account for other effects of land use changes such as urbanisation (SKM, 2005).

'Current' flows are ***streamflows that would have occurred over the historical climate sequence with the current level of development in the catchment*** (SKM, 2005).

Table 6-1 – Stream Gauge Data for the Latrobe River system provided by SKM.

Reach	Gauge No.	Gauge Name	Start Date	End Date
1	226 205	Latrobe River at Noojee	6 March 1957	17 August 2005
2	226 204	Latrobe River at Willow Grove	24 October 1924	25 July 2005
3	n/a	Latrobe River downstream of Tyers River Junction		
4	226 224 (anabranch) and 226 228 (main stream)	Latrobe River at Rosedale	20 December 1936 2 December 1936	26 July 2005 26 July 2005
5	226 227	Latrobe River at Kilmany South	16 December 1976	26 July 2005
6	226 027	Latrobe River at Swing Bridge (Sale)	unknown	
7	**Reach not assessed**			
8	226 216	Tanjil River at Tanjil South	6 April 1955	17 August 2005
9	226 006	Tyers River at Boola	1 January 1958	31 December 1986
10	226 408	Morwell River at Yallourn	2 March 1943	31 December 1986
11	226 023	Traralgon Creek at Traralgon	2 January 1962	1 December 2005

The process undertaken to disaggregate the flow series from REALM models of the catchment to daily flows for the Latrobe River system is detailed in SKM, 2005.

6.2 Seasonality of Natural Flow Regime

The Latrobe River system exhibits similar seasonal characteristics to other south eastern Australian rivers with a winter/spring high flow period and a summer/autumn low flow period. Flow seasons for the Latrobe River system are shown in Figure 6-1 and Table 6-2.

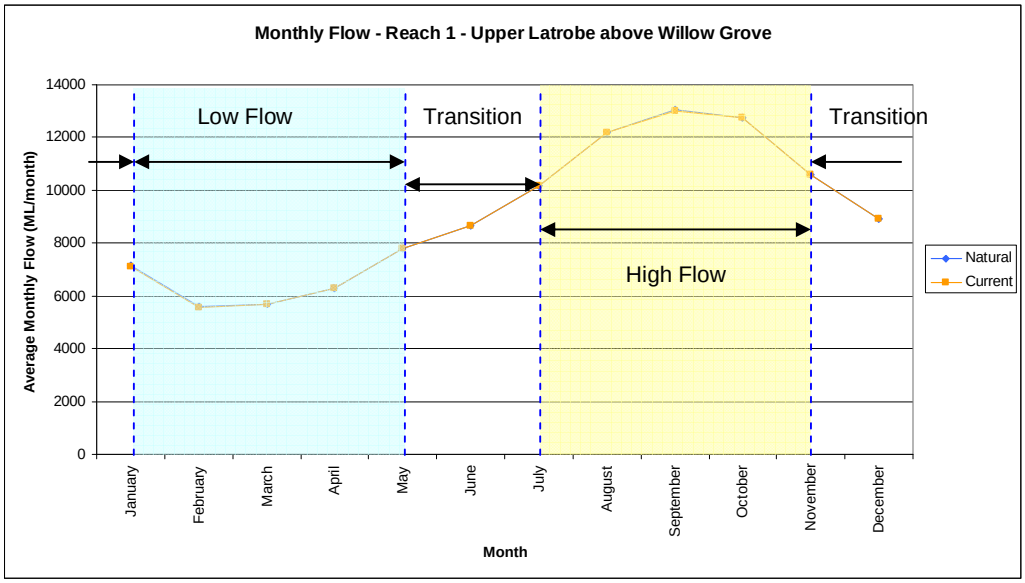


Figure 6-1 – Flow Seasons of the Latrobe River system

Table 6-2 – Flow Seasons of the Latrobe River system

Flow Component	Period/Season
Low flow	January to May
Transition low to high flow	June
High flow	July to November
Transition high to low flow	December

For the purpose of this investigation, the following seasons have been adopted:

- Low Flow – December to May inclusive
- High Flow – June to November inclusive

6.3 Change in the Flow Regime

Changes in the flow regime were identified from graphical flow data representation and analysis. Plots of flow data used include:

- Flow duration curves
- Annual flow
- Mean monthly flow

6.3.1 Reach 1 – Upper Latrobe River (upstream of Willow Grove)

Comparison of modelled natural and current daily flows illustrates no discernable impact of development on the flow regime in this reach. There is a slight decrease in the current flow regime from the developed scenario during January and February when stock and domestic extraction from the upper Latrobe River would most likely occur (Figure 6-2, Figure 6-3, Figure 6-4).

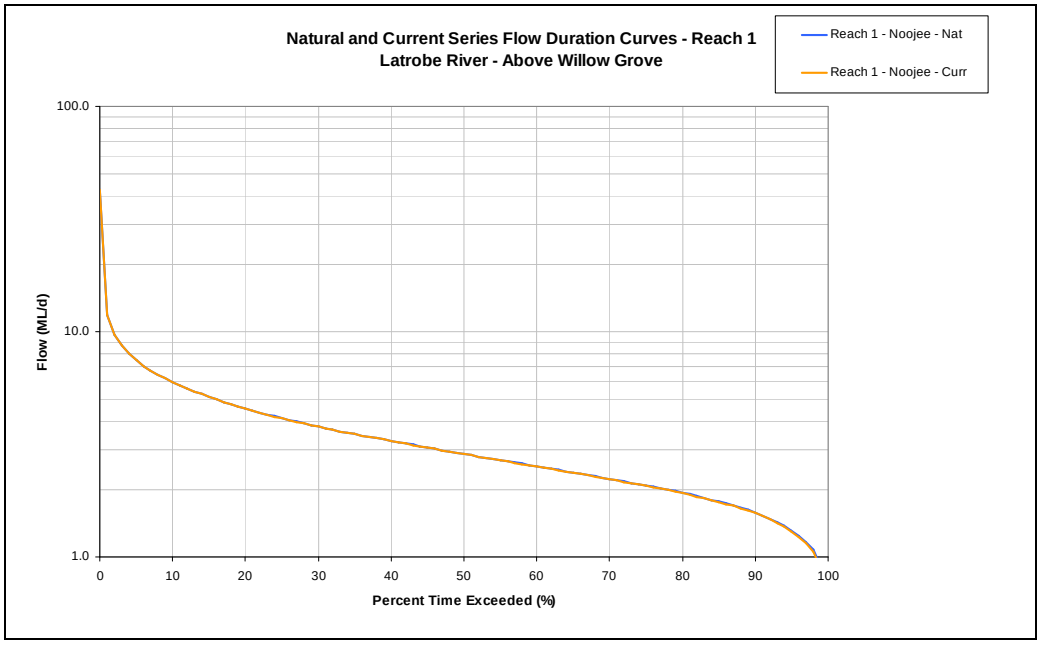


Figure 6-2 – Reach 1 – Flow duration curve

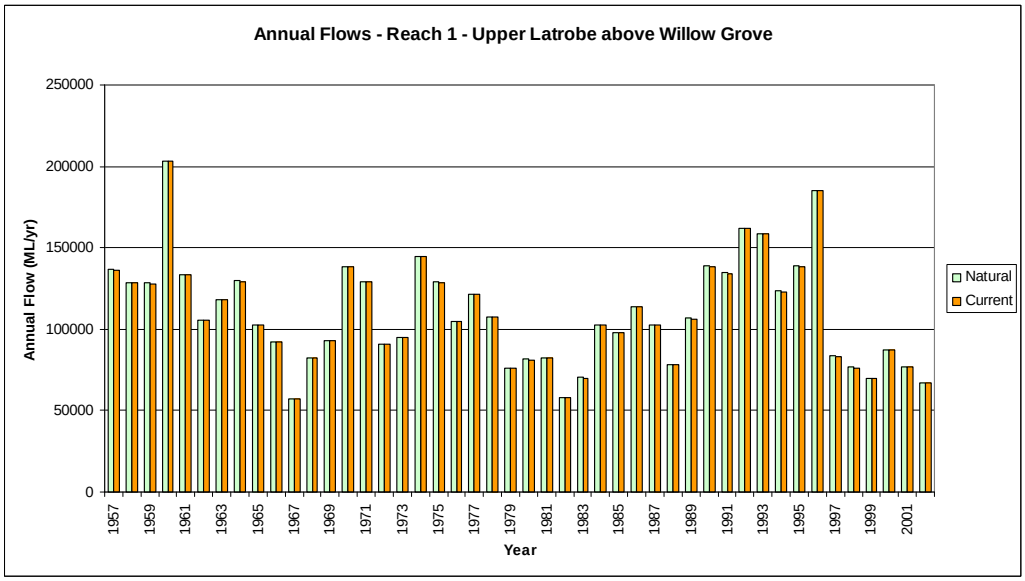


Figure 6-3 – Reach 1 – Annual Flows

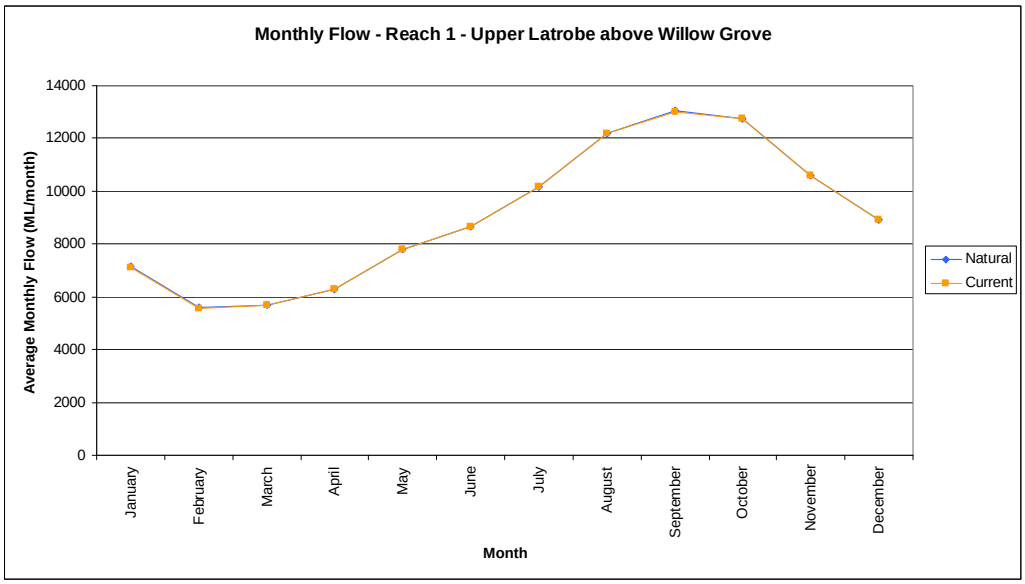


Figure 6-4 – Reach 1 – Mean monthly flows

6.3.2 Reach 2 – Latrobe River (Willow Grove to Lake Narracan)

Reach 2 has very similar flow conditions to Reach 1. There is a more sizeable reduction in January and February mean monthly flows in Reach 2 under developed conditions (Figure 6-7) due to a greater number of farm dams and stock and domestic licences. The flow series however, remains largely intact (Figure 6-5, Figure 6-6).

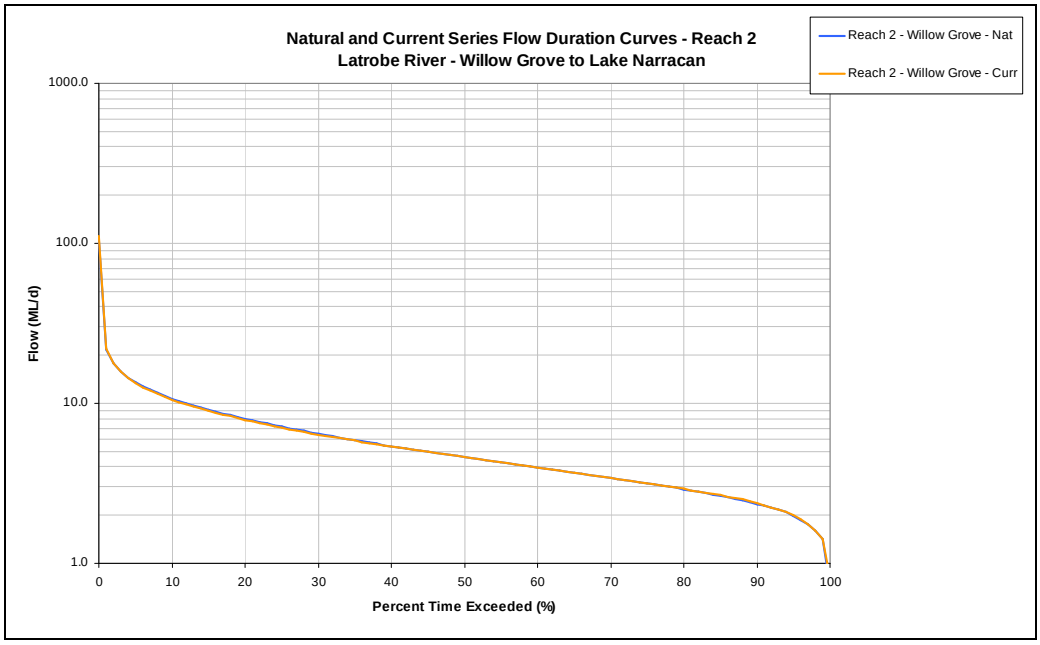


Figure 6-5 – Reach 2 – Flow duration curve

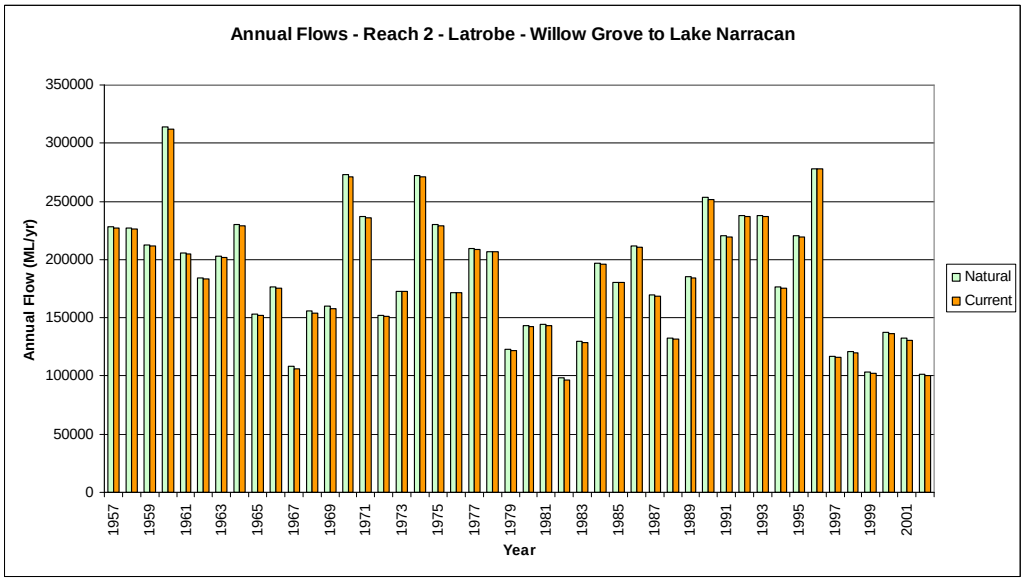


Figure 6-6 – Reach 2 – Annual flows

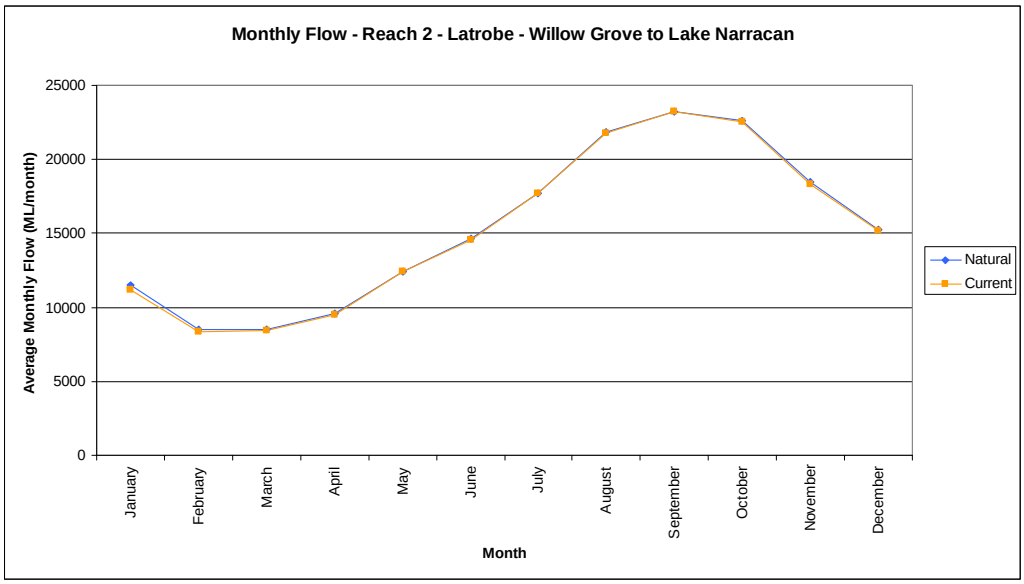


Figure 6-7 – Reach 2 – Mean monthly flows

6.3.3 Reach 3 – Latrobe River (Lake Narracan to Scarnes Bridge)

Downstream of Lake Narracan, there is a considerable impact on the current flow regime, compared to natural. A consistent reduction in flows over all months is evident, in the order of 10,000ML/month over summer months, to 20,000ML/month during winter high flows.

From the flow duration curve (Figure 6-8) it is evident that variability in flow has been maintained. The curve however, also shows a significant decrease in the magnitude of events exceeded greater than 40% of days.

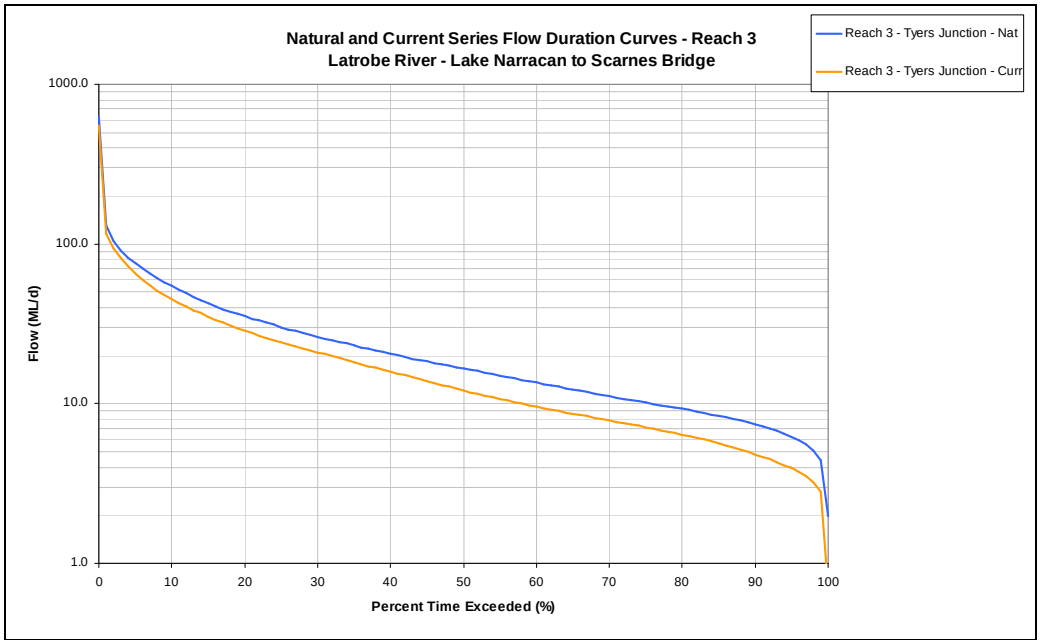


Figure 6-8 – Reach 3 – Flow duration curve

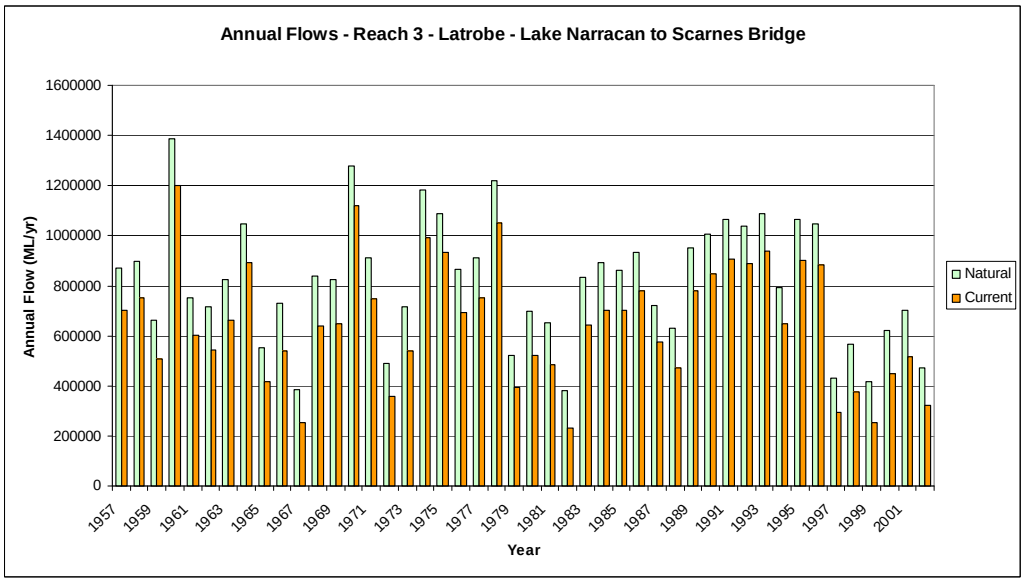


Figure 6-9 – Reach 3 – Annual flows

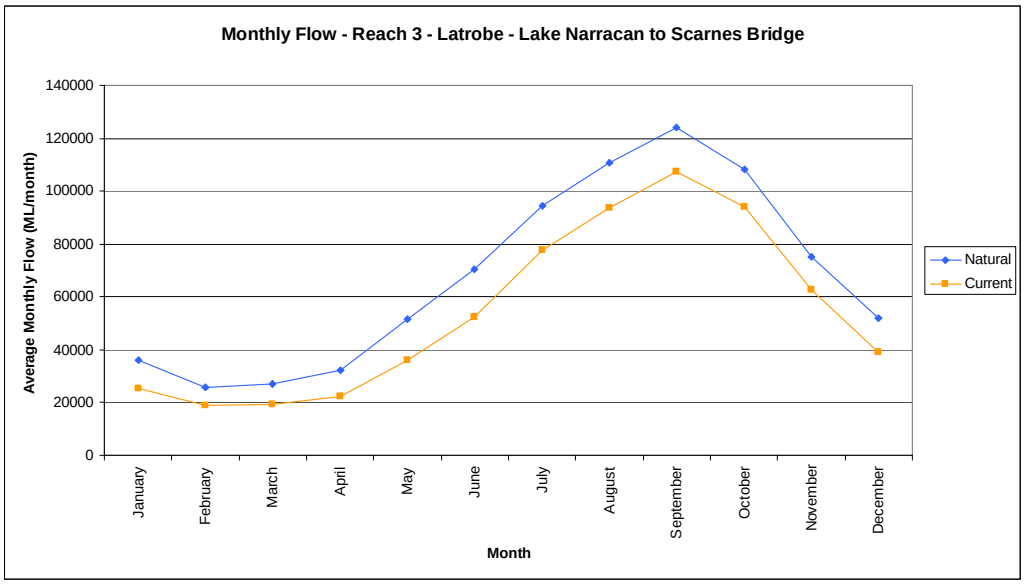


Figure 6-10 – Reach 3 – Mean monthly flows

6.3.4 Reach 4 – Latrobe River (Scarnes Bridge to Rosedale)

There is a general reduction in current daily flows in Reach 4 of the Latrobe River in comparison to the natural flow series. The variability of the flow series in maintained, however the base flow magnitude is significantly reduced (Figure 6-11).

Current minimum daily flow for the whole record in Reach 3 (59.8 ML/day), upstream of Scarnes Bridge are greater than that experienced in Reach 4 (36.1 ML/day), downstream of Scarnes Bridge. This is due to industrial extraction, private diverters and farm dams upstream.

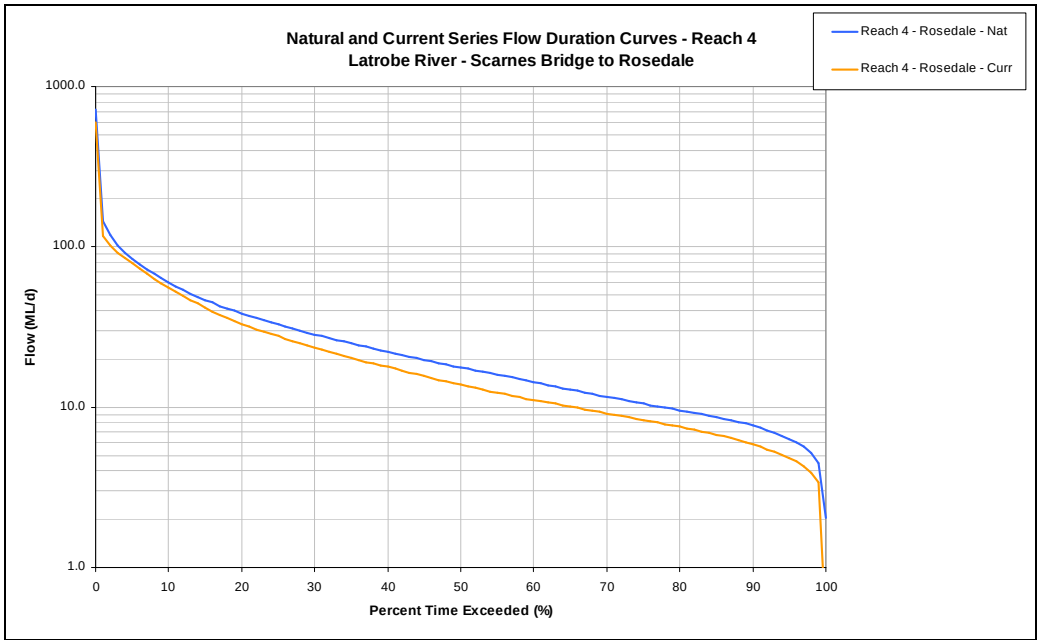


Figure 6-11 – Reach 4 – Flow duration curve

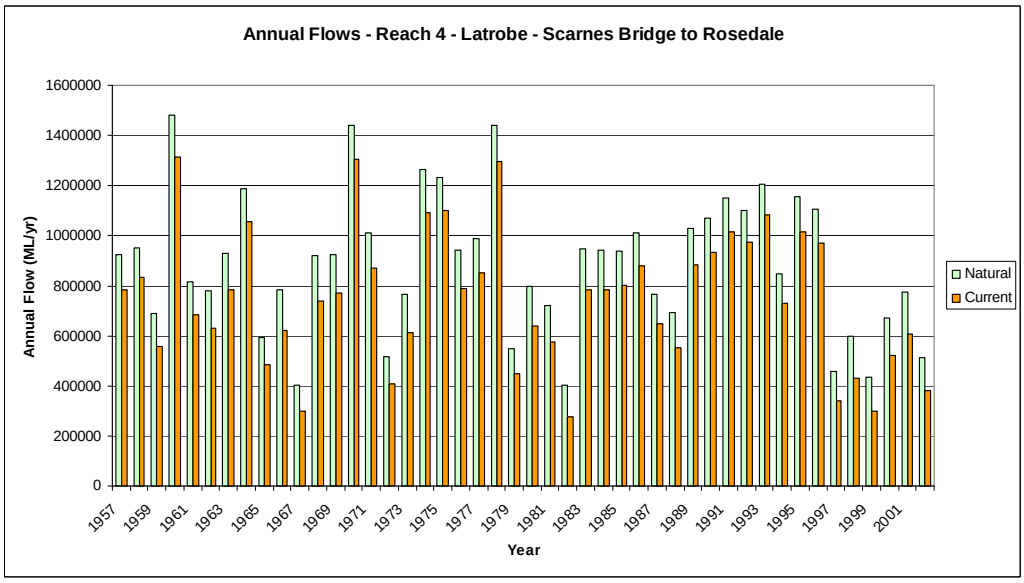


Figure 6-12 – Reach 4 – Annual flows

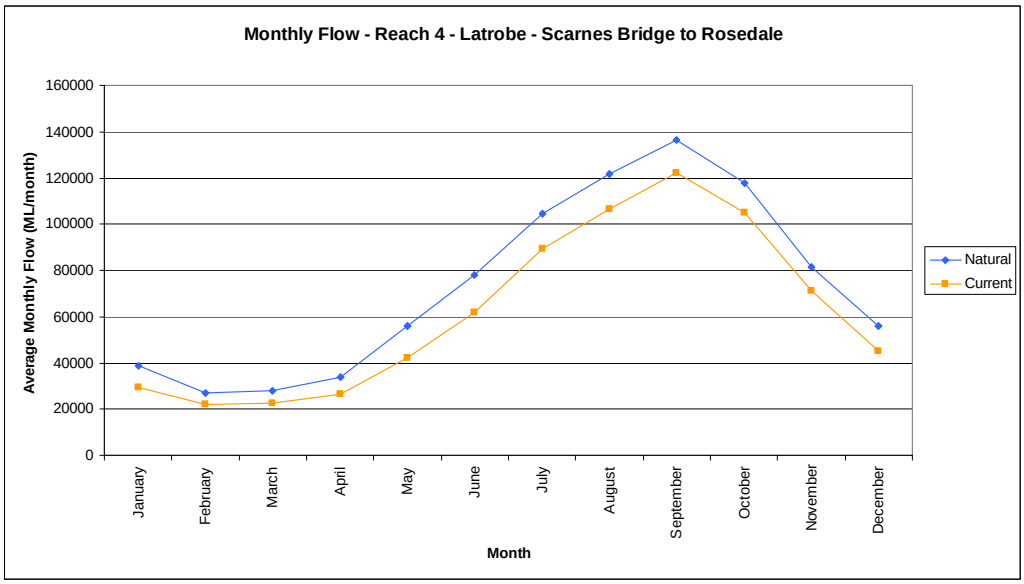


Figure 6-13 – Reach 4 – Mean monthly flows

6.3.5 Reach 5 – Latrobe River (Rosedale to Thomson River Confluence)

Current flows in the Reach 5 of the Latrobe River show a decrease in magnitude in comparison to the natural flow series. This is likely due to industrial extractions and discharges, private diverters and farm dams.

There is a reduction in the magnitude of all events, however the variability of these events are maintained, as demonstrated in the flow duration curve (Figure 6-14). The relative impact of flow regulation and consumptive use has been most significant for low flows.

Seasonality of the natural flow regime is preserved in this reach (Figure 6-16).

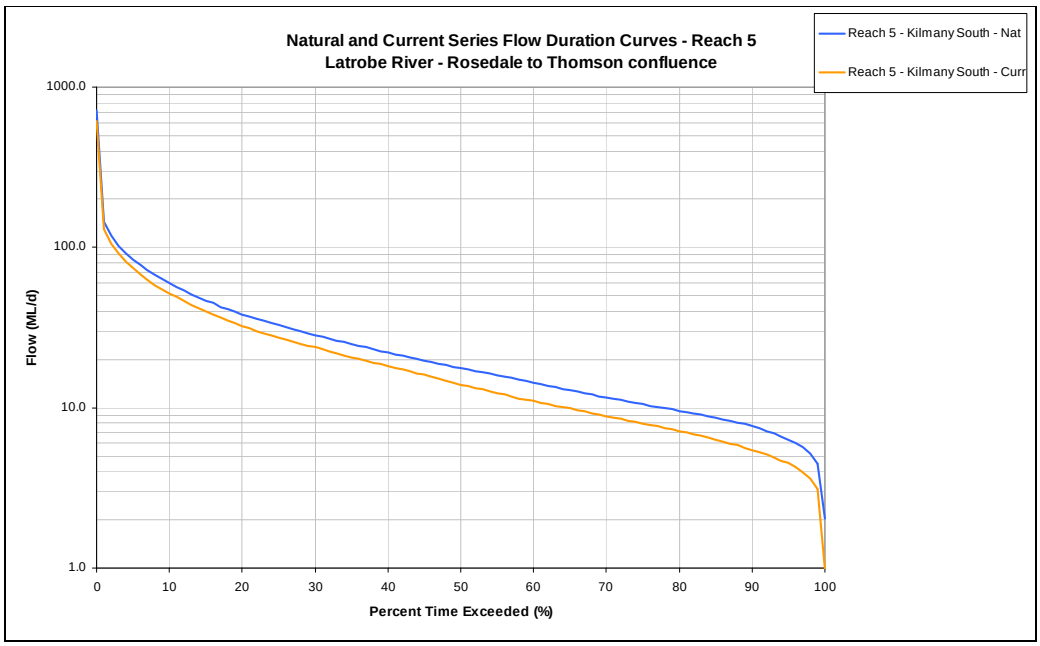


Figure 6-14 – Reach 5 – Flow duration curve

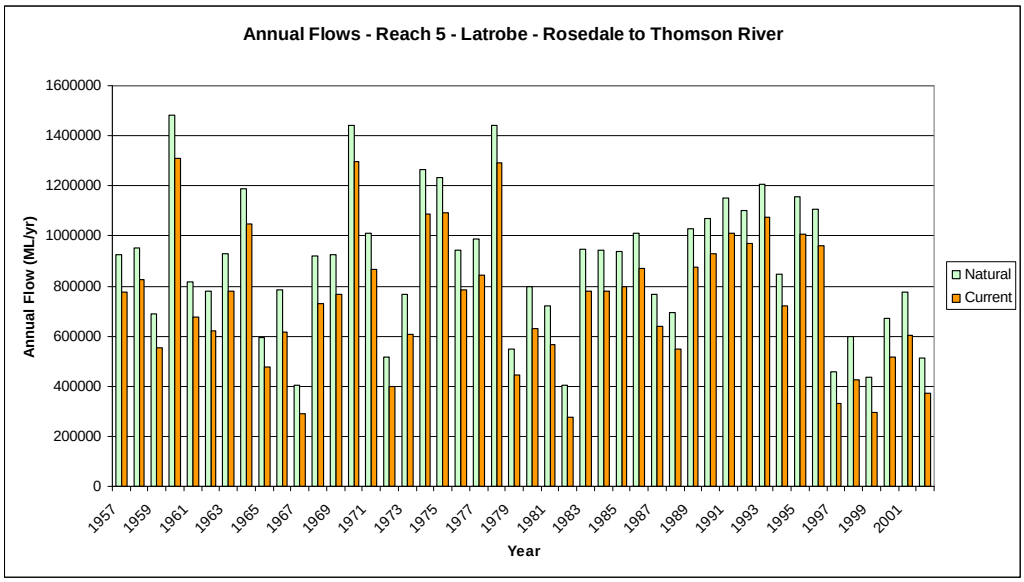


Figure 6-15 – Reach 5 – Annual flows

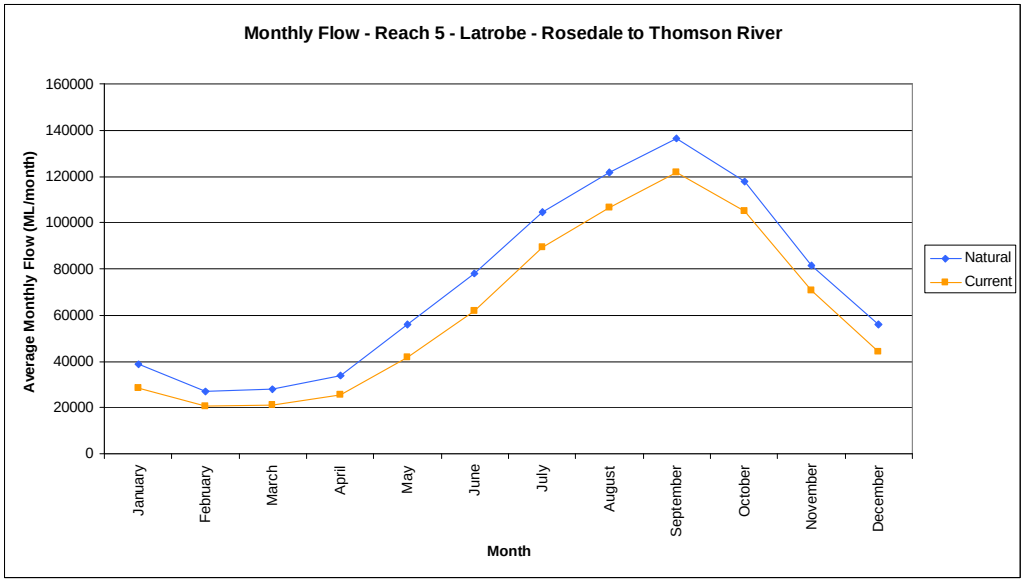


Figure 6-16 – Reach 5 – Mean monthly flows

6.3.6 Reach 6 – Latrobe River (Thomson River confluence to Lake Wellington)

Downstream of the Thomson River confluence, the natural flow series has been reduced under current development conditions (Figure 6-18). This is likely to be a result of upstream diversions by industry, private diverters and farm dams upstream of Sale (SKM, 2005).

Current flows in the Latrobe River maintain variability (Figure 6-17), however high flows during winter are much lower in magnitude than those under natural conditions (Figure 6-19).

Natural seasonality of the flow regime is preserved under current flow conditions.

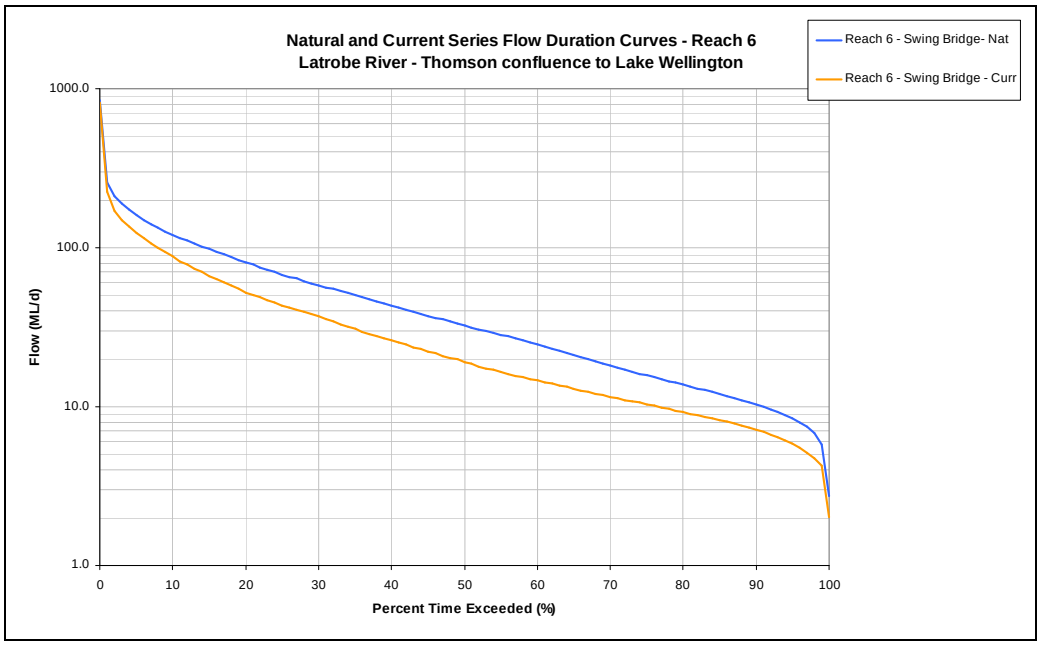


Figure 6-17 – Reach 6 – Flow duration curve

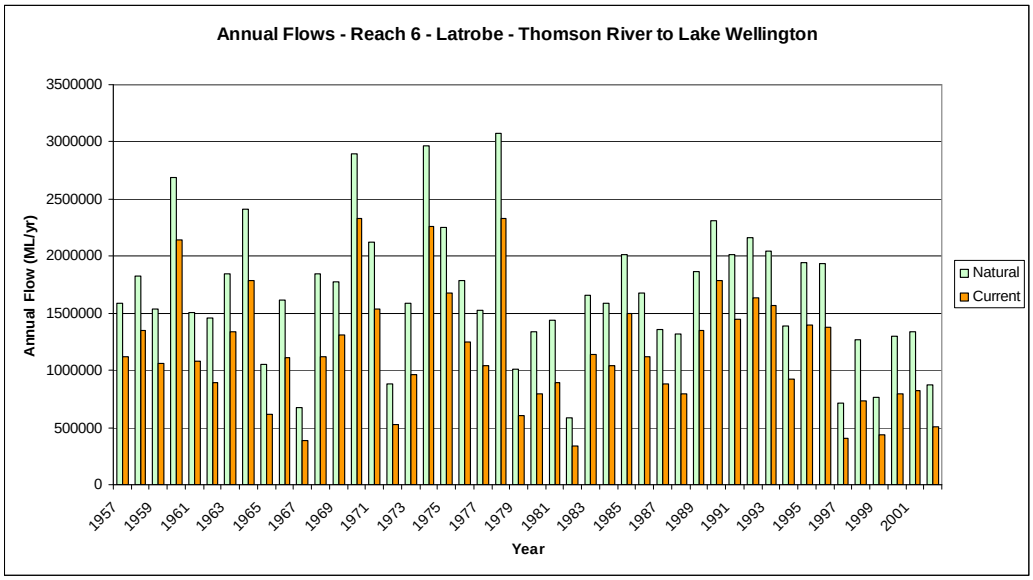


Figure 6-18 – Reach 6 – Annual flows

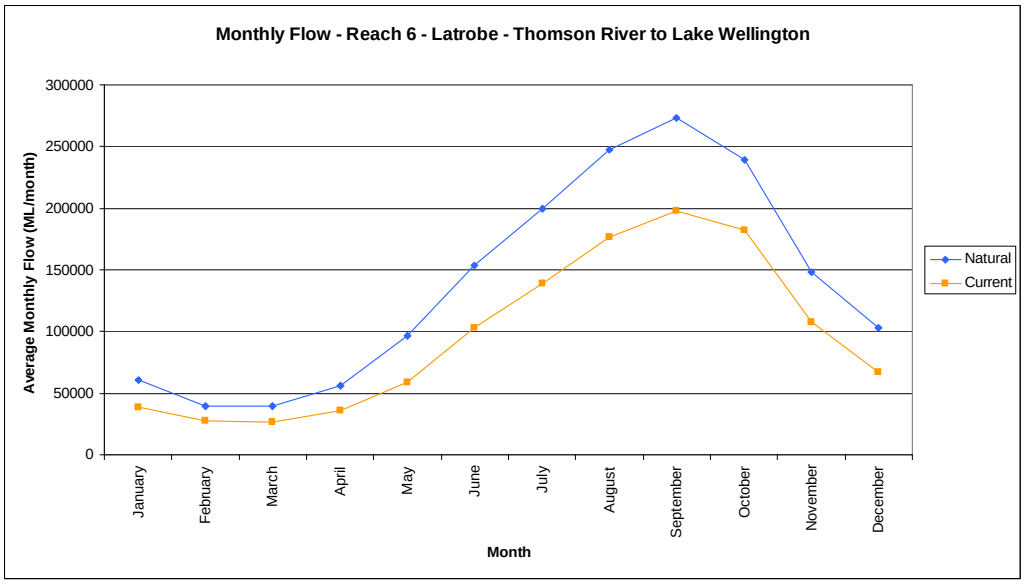


Figure 6-19 – Reach 6 – Mean monthly flows

6.3.7 Reach 8 – Tanjil River

In the Tanjil River the current flow series displays larger low flow events and smaller high flow events than natural conditions (Figure 6-20). There is lower variability in flow for events exceeded between 20% and 50% of days in current flow series. The flow duration curve also displays a constant low flow discharge from Blue Rock Lake Reservoir.

The average monthly flows (Figure 6-22) show an increase in the magnitude of summer low flows due to irrigation releases over the dry months. A decrease in winter high flows is also noted and is primarily due to refilling of Blue Rock Dam over the higher rainfall months.

Throughout the flow record, the natural annual flows (Figure 6-21) in the Tanjil River are sometimes exceeded by current flows, however this is not true for all years.

Seasonal variability of the Tanjil River has been shifted by a couple of months (Figure 6-22) and under current conditions, the low flow period is from March to July.

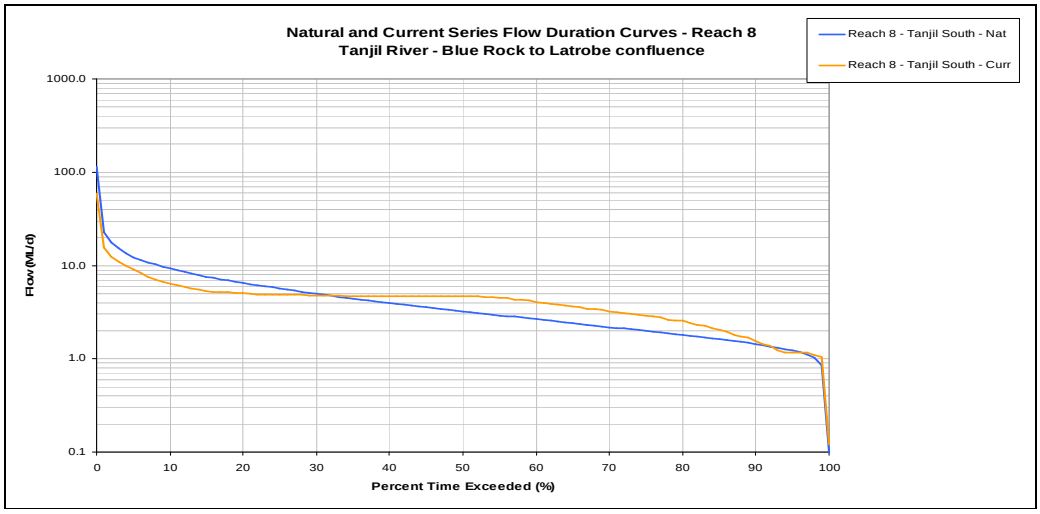


Figure 6-20 – Reach 8 – Flow duration curve

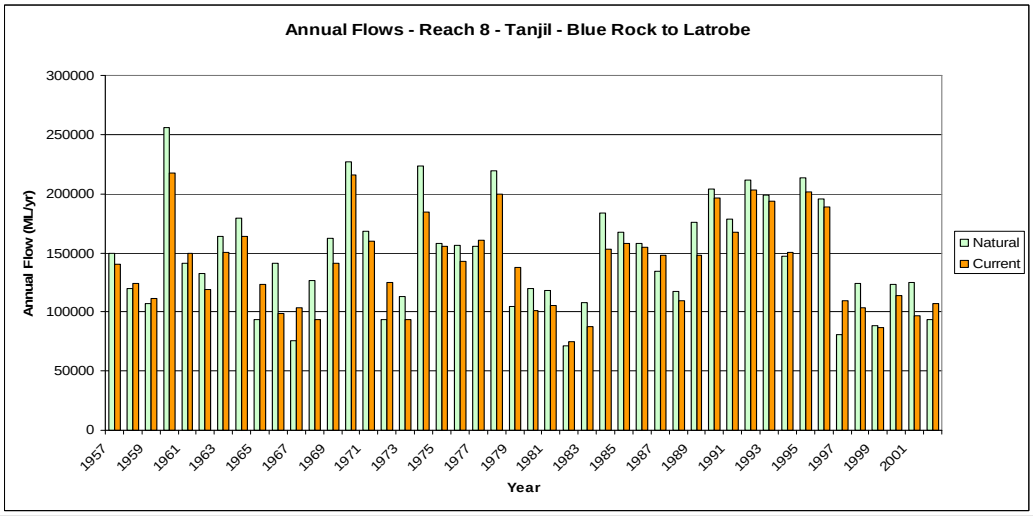


Figure 6-21 – Reach 8 – Annual flows

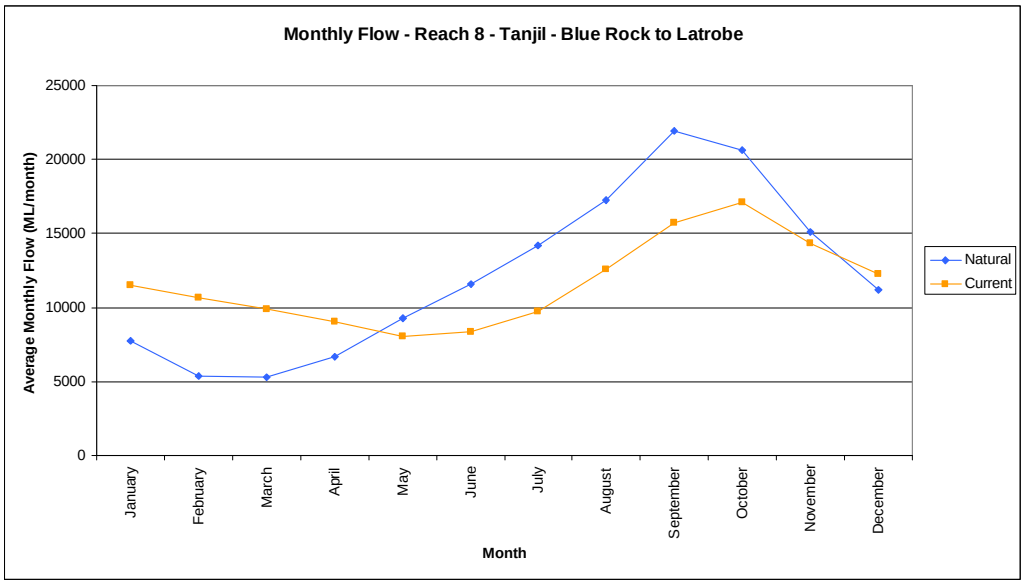


Figure 6-22 – Reach 8 – Mean monthly flows

6.3.8 Reach 9 – Tyers River

Moondarra Reservoir, the upstream extent of this reach, is used to supply water to the Australian Paper Mills, Loy Yang power stations, Hazelwood power station and other local industry (SKM, 2005). The current flow series displays an overall reduction in flows from natural conditions due to these water supply uses.

The flow duration curve (Figure 6-23) depicts low variability in daily flows exceeded between 50% and 80% of days. Cease to flow events were not present in the natural flow series of the Tyers River, however under current conditions, zero flow occurs on average 2.3 days annually.

There is a consistent reduction in flows (Figure 6-25) over each month, with the greatest magnitude of extraction occurring in winter. Seasonality of the natural flow regime is preserved.

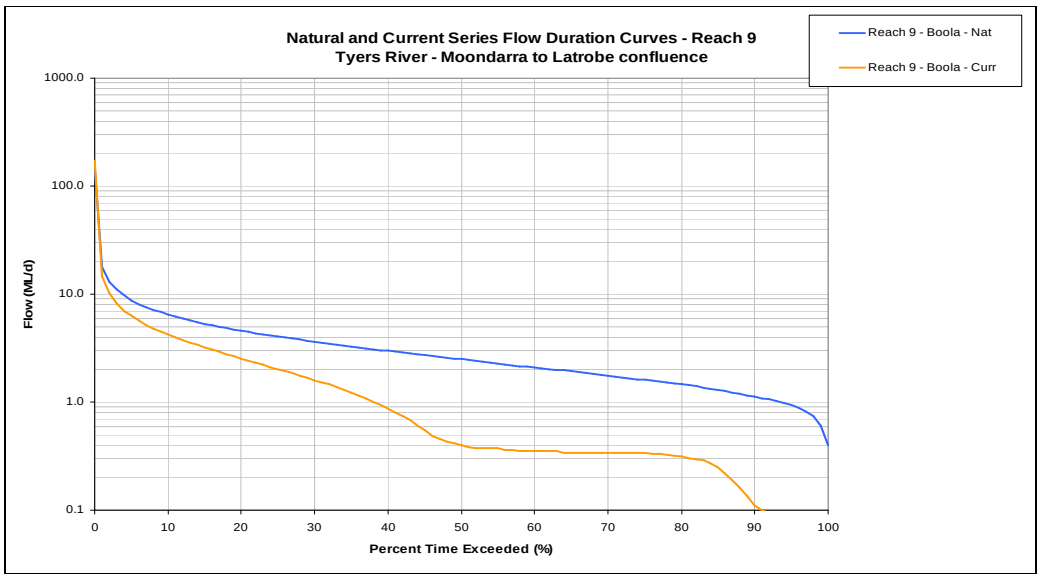


Figure 6-23 – Reach 9 – Flow duration curves

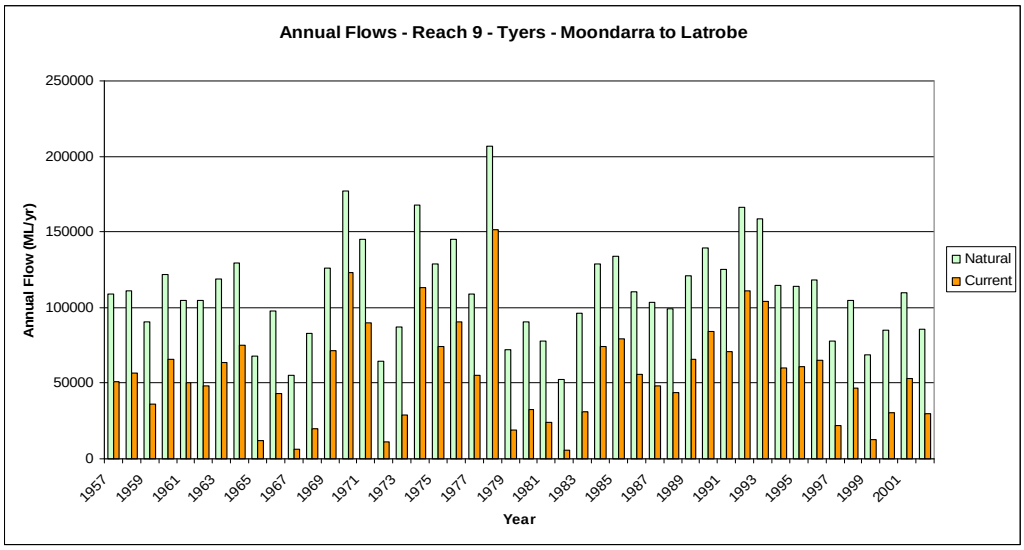


Figure 6-24 – Reach 9 – Annual flows

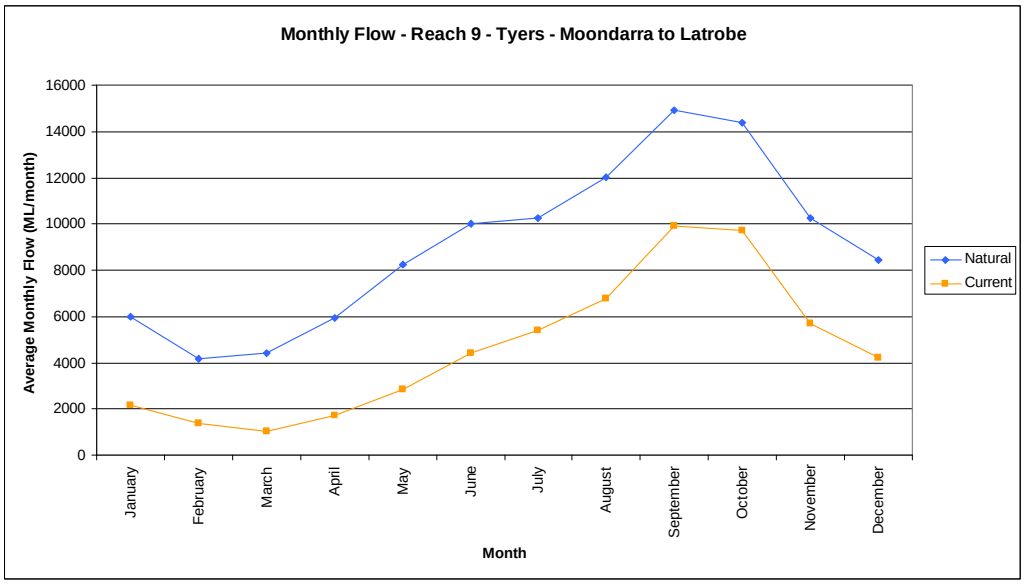


Figure 6-25 – Reach 9 – Mean monthly flows

6.3.9 Reach 10 – Morwell River

The increase in current flows in the Morwell River is due to discharges from the Yallourn and Hazelwood power stations. This development has resulted in a reduction in zero flow days in the Morwell River and an increase in the magnitude of flows occurring more than 95% of days. The flow duration curve (Figure 6-26) shows this increase in current flow conditions. The magnitude of low flow events is larger under current conditions with the 90th percentile flow approximately 20 ML/day greater than natural. The magnitude of high flows has also increased due to development.

Seasonality of the natural flow regime is preserved. Average daily flows during summer are least affected by current catchment conditions (Figure 6-28) and the current average flows during January are slightly less than natural conditions.

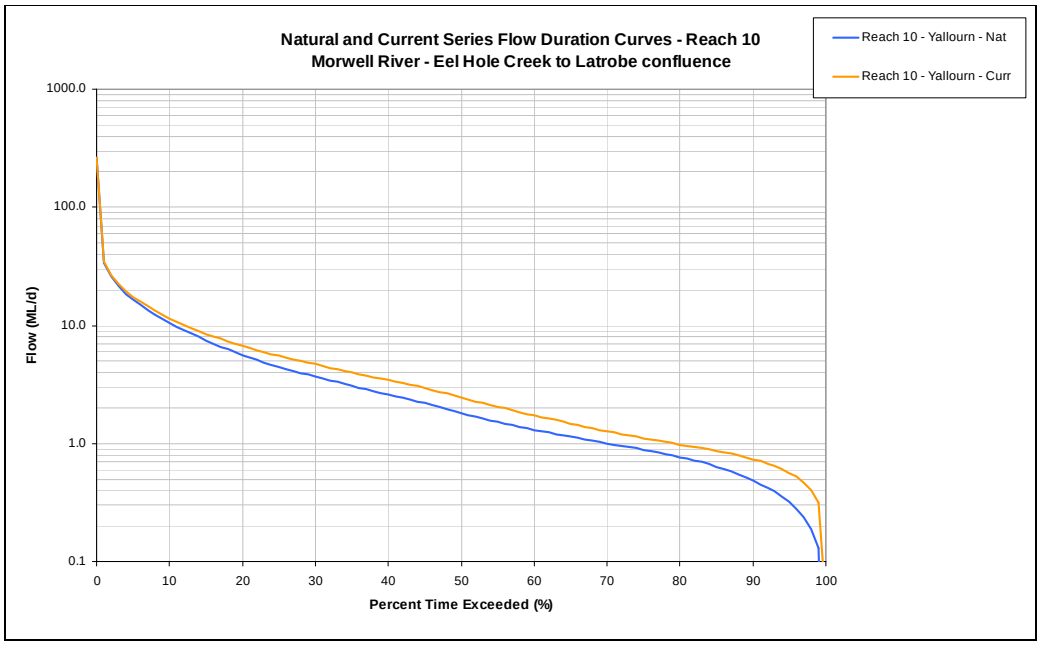


Figure 6-26 – Reach 10 – Flow duration curves

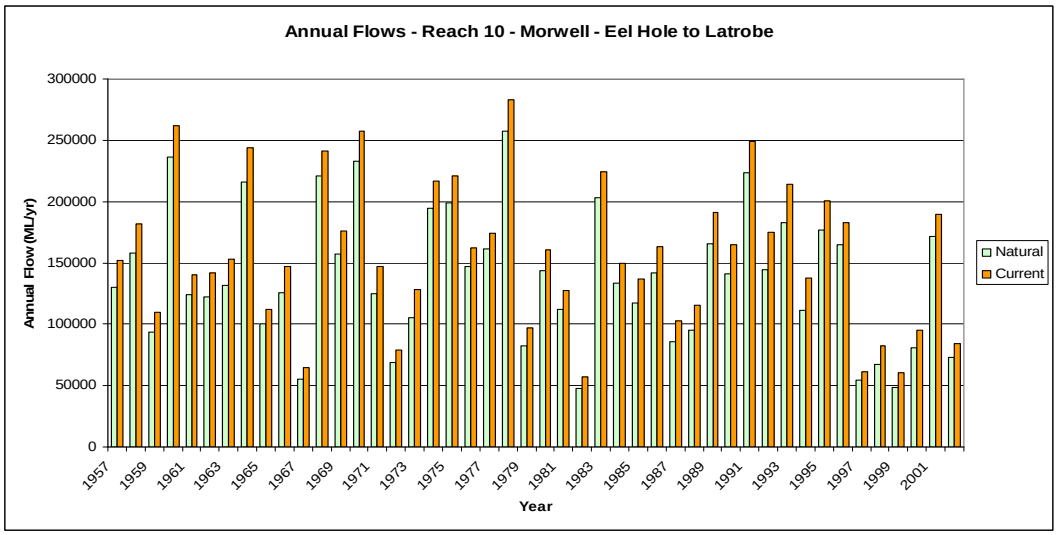


Figure 6-27 – Reach 10 – Annual flows

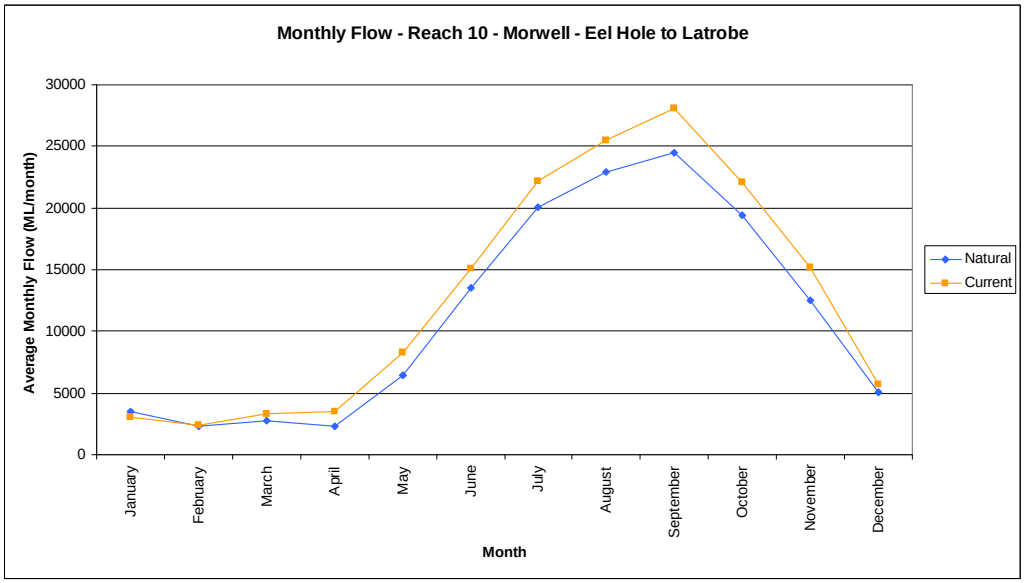


Figure 6-28 – Reach 10 – Mean monthly flows

6.3.10 Reach 11 – Traralgon Creek

Figure 6-30 and Figure 6-31 show a marked increase in the current annual and monthly average flows compared to the natural flow series in Traralgon Creek. This can be attributed to discharges from Loy Yang power station. The flow duration curve (Figure 6-29) highlights a 20% reduction in 'zero flow days' under current conditions, however the frequency and magnitude of extreme high flow events appear relatively unimpacted.

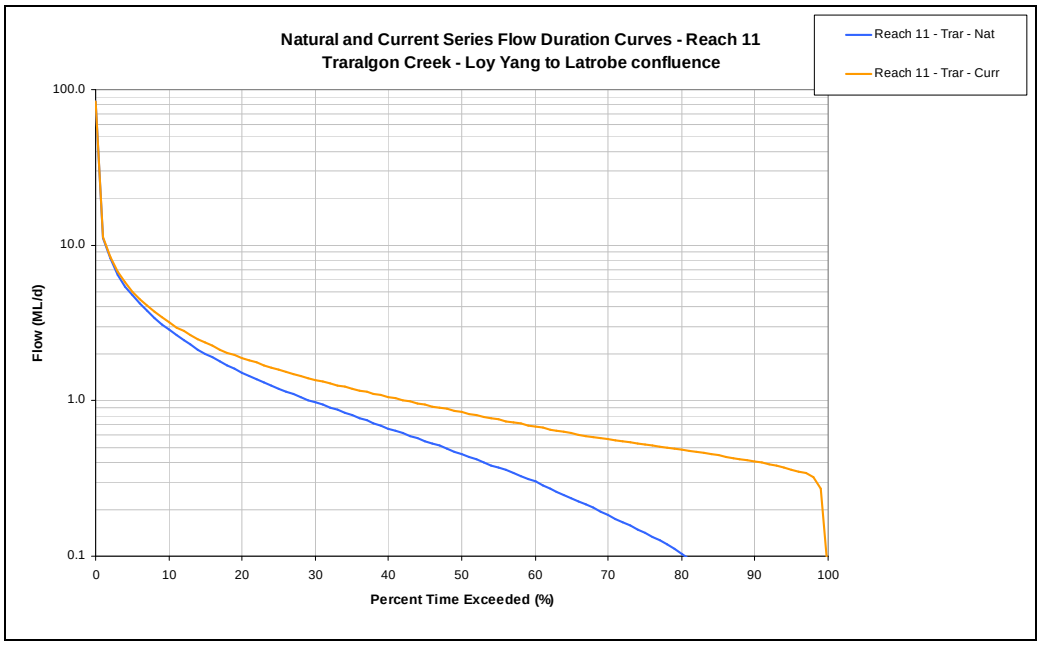


Figure 6-29 – Reach 11 – Flow duration curve

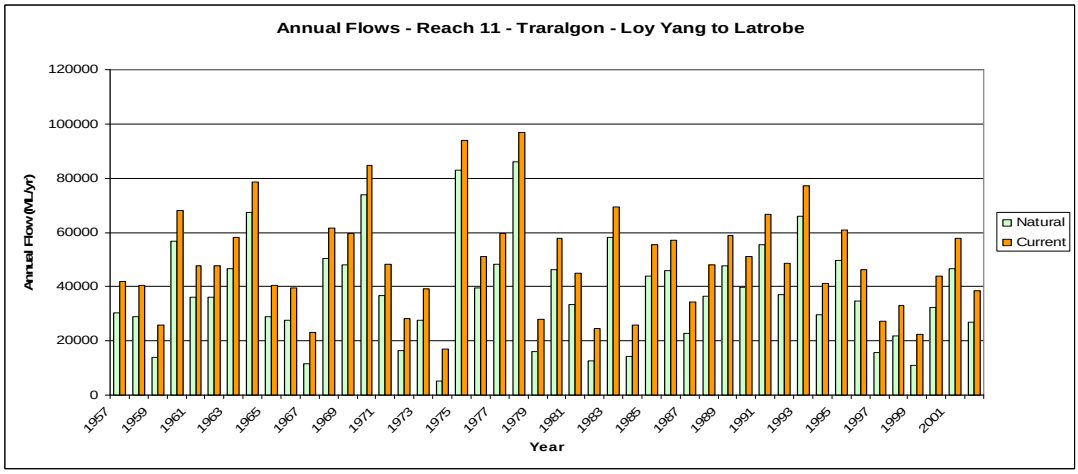


Figure 6-30 – Reach 11 – Annual flows

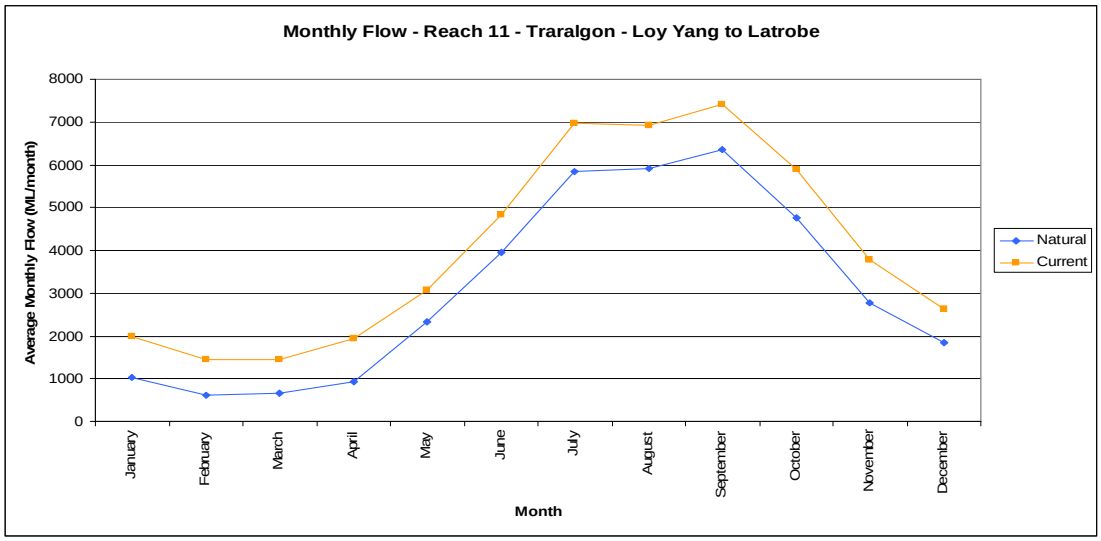


Figure 6-31 – Reach 11 – Mean monthly flows

Appendix B

Hydraulic Modelling Report

Assessment of Environmental Flow Requirements for the Latrobe River

HYDRAULIC MODELLING

Revision 2
March 2007

Assessment of Environmental Flow Requirements for the Latrobe River

HYDRAULIC MODELLING

L:\work\Jobs\6004116 Latrobe May06\Finalisation\Rev D Hydraulics v2.doc

Document History:

ISSUE DATE	REVISION NUMBER	AUTHOR	CHECKED	APPROVED	DESCRIPTION
13/06/2006	1 (Recs Paper Rev D)	TL	R Hardie	R Hardie	For Release
19/03/2007	2 (Recs Paper Rev D.6)	TL			Inclusion in Amended Final Recs Report

Natural Resources Group

Earth Tech Engineering Pty Ltd
ABN 61 089 482 888
Head Office 71 Queens Road
Melbourne VIC 3004
Tel +61 3 8517 9200

All Rights Reserved. No part of this document may be reproduced, transmitted, stored in a retrieval system, or translated into any language in any form by any means without the written permission of West Gippsland CMA.

Intellectual Property Rights

West Gippsland CMA retains copyright of all intellectual property and data generated by the project.

Contents

Contents i
Tables i
1 Introduction 2
2 Reaches and Modelling Approach 3
2.1 Reaches 3
2.2 Modelling Approach 5
3 Hydraulic Model Details 6
4 References 16

Tables

Table 2-1 – Reach Breaks and Features 3

1 Introduction

The West Gippsland Catchment Management Authority (WGCMA) has engaged Earth Tech Engineering Pty Ltd (Earth Tech) to undertake an assessment of environmental flow requirements for the Latrobe River and selected tributaries and the Lower Latrobe wetlands (the Latrobe River system).

The environmental flow requirements have been assessed in accordance with the FLOWS methodology (DNRE, 2002). This report outlines the methodology and summarises the results of the hydraulic modelling undertaken to support the FLOWS assessment.

2 Reaches and Modelling Approach

2.1 Reaches

The selection of reaches for the environmental flow assessment is discussed in the Site Paper prepared by Earth Tech (Earth Tech, 2005). The identification of reach breaks included consideration of the following attributes:

- Geomorphology – channel and floodplain morphology
- Hydrology – major tributaries, extractions and gauging station locations
- Land use
- Riparian zone vegetation
- Water quality, macroinvertebrate and fish communities

Reach breaks are generally located such that each of these attributes are relatively consistent within each reach. For each reach, a minimum of one representative site has been identified to assist in characterisation of the features of the reach.

A total of 11 reaches were identified as summarised in Table 2-1.

Table 2-1 – Reach Breaks and Features

Reach	Extents	Description
1	Upper Latrobe River (upstream of Willow Grove)	Encompasses the headwaters of the Latrobe River and is unregulated although there are some licensed pumping extractions. The catchment is generally forested, comprising Damp Forest, Wet Forest and Cool Temperate Rainforest in the upper catchment, grading to Damp Forest and Lowland Forest further downstream. Logging has been carried out within extensive State Forests in the upper catchment. Near Noojee, cleared land is used primarily for grazing however Riparian Forest generally persists in the immediate vicinity of the river. Agricultural activities (grazing, cropping and dairying) occur in the riparian corridor nearer Willow Grove.
2	Latrobe River – Willow Grove to Lake Narracan	Unregulated although subject to licensed pumping extractions. The river emerges from a confined upland setting and flows through an extensively modified floodplain, with grazing and limited cropping becoming dominant. The floodplain and riparian corridor have been largely cleared of native vegetation although isolated remnants remain along the river channel. Willow infestation is locally significant. The Tanjil River enters the Latrobe River within the backwater zone of Lake Narracan, at the downstream end of Reach Two.
3	Latrobe River – Lake Narracan to Scarnes Bridge	Commences at the Lake Narracan weir wall. The Lake Narracan weir wall is a concrete structure with four vertical lift (undershot) gates, retaining a weir pool approximately 5m deep. Reach Three is therefore a regulated reach with the Narracan weir wall (operated to provide a constant water level in Lake Narracan) attenuating the passage of flood flows to the reach. The Lake Narracan weir wall is located in a confined (gorge) setting with limited public access and generally intact riparian vegetation. A small weir (the Yallourn Weir) is located on the Latrobe River immediately downstream of the Yallourn Power Station. The floodplain width increases rapidly downstream of the Yallourn Mine as the Morwell River (south bank) and Tyers River (north bank) enter the Latrobe River within a distance of approximately 5km. Downstream of the Morwell River confluence the Latrobe River floodplain has an average width of 2-3 km over most of Reach Three. The Australian Paper Mill plant at Maryvale lies immediately south of the Latrobe River floodplain upstream of Traralgon. Traralgon Creek enters the Latrobe River approximately 3 km upstream of Scarnes Bridge. Much of the floodplain in Reach Three is heavily utilised for grazing.

Reach	Extents	Description
4	Latrobe River – Scarnes Bridge to Rosedale	Reach Four traverses undulating agricultural land. Historically, this reach has been impacted by de-snagging and meander cut-off practices and by upstream water quality issues. Between Scarnes Bridge and Rosedale the conditions in the Latrobe River are impacted by a range of factors including: • Grazing and agricultural activities on the floodplain • Modified flows resulting from river regulation at Lake Narracan and regulation of major tributaries (Tanjil River and Tyers River) • Past river management works including extensive channel straightening through construction of artificial meander cut-offs, leading to major channel incision, bank erosion and channel widening. • Upstream industrial discharges and local nutrient inputs from agricultural activities and bank erosion
5	Latrobe River – Rosedale to Thomson River	Reach Five traverses undulating agricultural land and displays similar conditions to Reach Four. The reach has been impacted by de-snagging and meander cut-offs and by upstream water quality issues from high nutrient discharges from adjacent irrigation districts. The quality of riparian vegetation is generally better than that found in Reach Four, with a greater cover of retained native vegetation and fewer areas dominated by willows.
6	Latrobe River – Thomson River to Lake Wellington	The Latrobe River within Reach Six is bordered by a floodplain wetland system comprising Sale Common and Heart Morass to the north and Dowd Morass to the south. Sale Common and Dowd Morass are managed by Parks Victoria as environmental and recreational assets. Approximately three quarters of Heart Morass is privately owned and used for cattle grazing while the eastern (downstream) portion lies within the Heart Morass Game Reserve. Conditions within each of these wetlands have been modified by increased salinity (from Lake Wellington) and reduced river flows in both the Thomson and Latrobe Rivers. The riparian vegetation along the Latrobe River in this reach is generally in fair to good condition. The river in this reach is increasingly impacted by salinity impacting on vegetation communities. There appears to have been no significant change to physical form in this reach.
7	Lake Wellington	
8	Tanjil River	Reach Eight is regulated by the operation of Blue Rock Reservoir at the upstream end of the reach. Blue Rock Reservoir is operated by Southern Rural Water, providing water for industrial, irrigation and domestic uses. Releases from Blue Rock Reservoir are made to ensure that minimum flows of 90-150 ML/D (seasonal variation) are achieved in the Latrobe River immediately upstream of the confluence with the Morwell River. Downstream of Blue Rock Reservoir, the Tanjil River flows through a short confined reach before emerging onto a broader floodplain approximately 1-2 km wide. The floodplain is subject to intense agricultural pressures including grazing and dairying. Much of the native vegetation has been cleared from the river channel and floodplain and willow infestation is widespread. The Tanjil River enters the Latrobe River (Reach Two) in the backwater zone of Lake Narracan. Much of the Tanjil River is subject to grazing pressure and its condition refects this use.
9	Tyers River	Flows in Reach Nine are regulated by the operation of Moondarra Reservoir at the upstream end of the reach. Moondarra Reservoir is operated by Gippsland Water and is used primarily to supply water to industry in the Latrobe Valley. Moondarra Reservoir is a small reservoir and flood releases via the spillway are frequent however there is significant attenuation of small to medium floods. The Tyers River downstream of the reservoir flows through the Boola State Forest and Tyers Regional Park. Much of the catchment is very steep and public access is low and as a result the majority of the river and immediate catchment are in excellent condition. Near the downstream end of Reach Eight, there is a low concrete weir (Wiralda Park Weir) and associated pumping station providing emergency water supply. Downstream of the pumping station (approximately 1 km upstream of the Tyers Road) grazing is dominant on the floodplain of the Tyers River and the Latrobe River. The Tyers River enters the Latrobe River (Reach Three) a short distance upstream of the Australian Paper Mill plant at Maryvale. Much of this reach is within forest and is in excellent condition. The presence of a downstream weir limits fish migration, as does Moondarra Dam

Reach	Extents	Description
10	Morwell River	The headwaters of the Morwell River lie in the Strzelecki Ranges to the south of the Latrobe Valley. The upper catchment is forested, however agricultural pressures increase downstream of Mirboo. Within Reach Ten (downstream of Eel Hole Creek), the Morwell River has been subject to a number of past stream diversions designed to enable access to the underlying brown coal reserves. Two of these diversions included large (3m diameter) pipelines to carry all but the largest river flows. The Yallourn diversion has recently been replaced with an open channel diversion incorporating meanders, pools/riffles and riparian vegetation and replacement of the remaining piped diversion (Hazelwood) has recently commenced. The end result will be reinstated connectivity between the Latrobe and the upper reaches of Morwell River and a vastly improved waterway environment. There are only short remnant sections of river within Reach Ten and the riparian vegetation is generally degraded although some high value remnants, including natural and re-constructed wetlands, are found around the Princes Freeway. The Morwell River enters the Latrobe River (Reach Three) adjacent to the Yallourn Mine development.
11	Traralgon Creek	Traralgon Creek rises to the south of the Loy Yang Power development at Traralgon South. It is an unregulated stream but receives some licensed industrial discharges from the Loy Yang operations. Much of the floodplain and creek channel downstream of Mattingley's Hill Road has been cleared for grazing and heavy willow infestations are present. Recent willow control works have resulted in the clearing and revegetation of major reaches of the creek however some heavy infestations remain. Traralgon Creek runs through the centre of Traralgon and receives significant stormwater runoff from the urban area. Poor water quality has been reported in Traralgon Creek downstream of Traralgon. Traralgon Creek enters the Latrobe River floodplain (Reach Three) immediately downstream of Traralgon.

2.2 Modelling Approach

Hydraulic modelling for this project was undertaken using the Hec Ras one dimensional, steady state, backwater, hydraulic modelling package. Survey data used for this project included both new survey and existing survey. Survey data was imported into the 12D digital terrain modelling package before being exported to create Hec Ras geometry files.

Downstream controls for each hydraulic model have been based on topographic plans, the survey data and a review of streambed longitudinal profiles in north East Victoria (refer Hardie 1993).

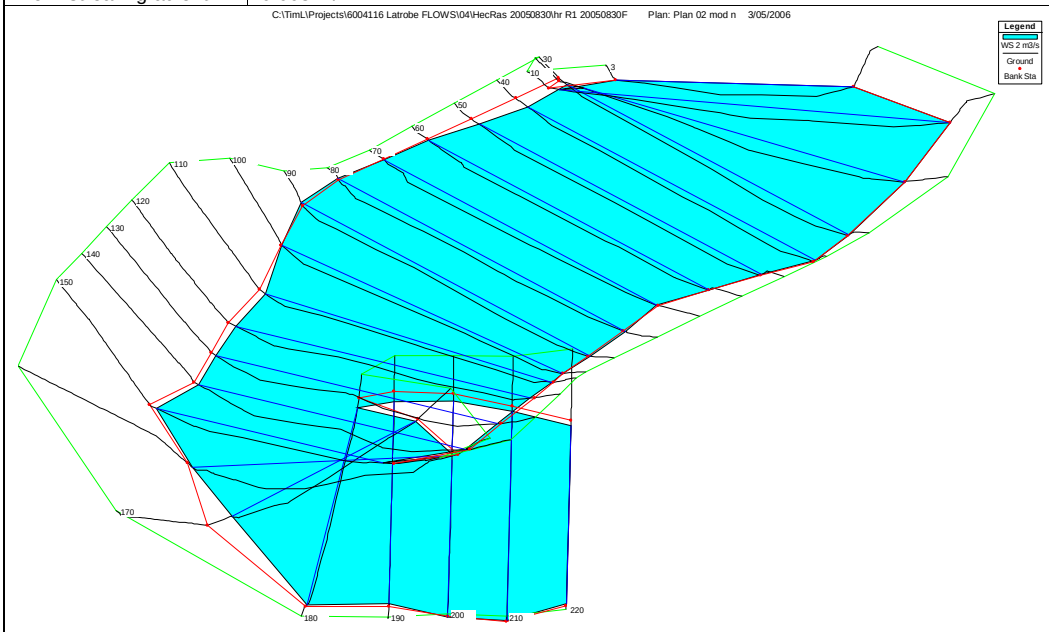
Manning's roughness adopted for this project have been based on field observations and, the experience of the project team, and Hicks and Mason (1991).

3 Hydraulic Model Details

Reach 1 – Features of Representative Site

Reach	Site Location	Description
1 – Upper Latrobe River (upstream of Willow Grove)	Noojee township	Eucalypt forest with shrubby understorey. Dense vegetation fringing the river. River has sand bed and significant quantities of large woody debris.

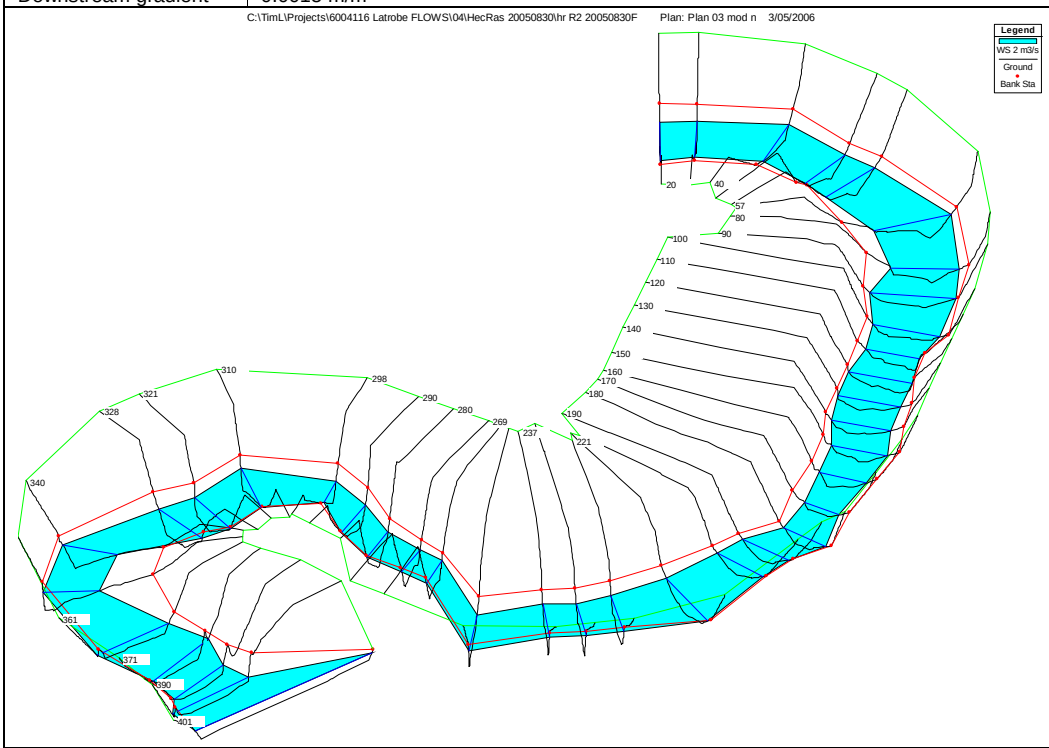
Survey length and type	230 m feature survey, extending downstream from private bridge
Channel form / size	Intact channel form – nom. 12 m base width, nom. 12 m top width, 1-2 m depth.
Manning's n (stream roughness) Channel Floodplain	0.065 – fringing channel vegetation, variable channel form, in-stream woody debris 0.1 – dense riparian forest
Downstream gradient	0.003 m/m



Reach 2 – Features of Representative Site

Reach	Site Location	Description
2 – Latrobe River – Willow Grove to Lake Narracan	Upstream and downstream of Willow Grove Road	Generally cleared grazing land, scattered remnant eucalypts, stands of dense willow. Sand bed and local bank erosion.

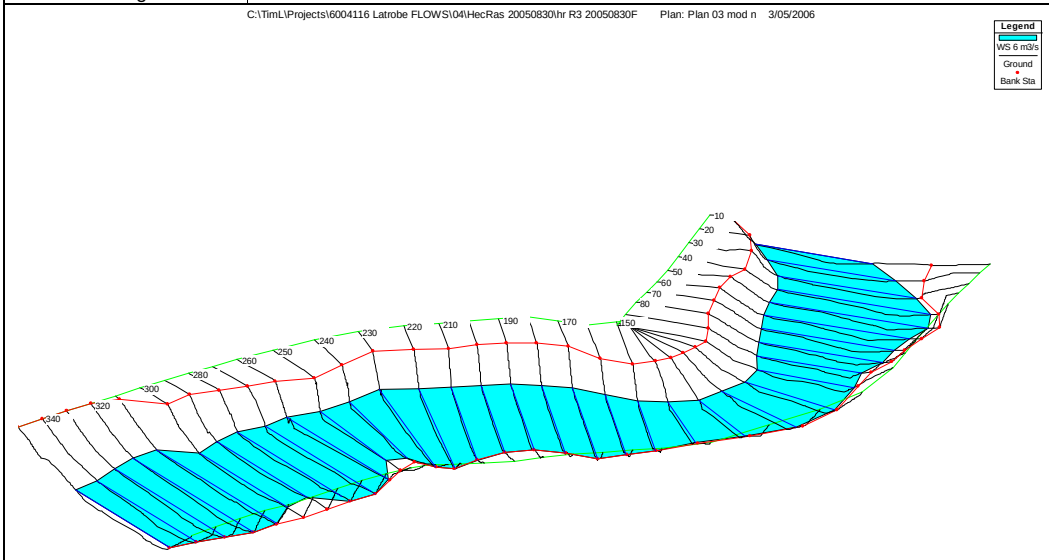
Survey length and type	270 m upstream and 140 m downstream of Willow Grove Road
Channel form / size	Nom. 8 m base width, 20-25 m top width, 4 m depth.
Manning's n (stream roughness) Channel Floodplain	0.045 – moderate in-channel vegetation, moderate channel variability 0.035 – generally cleared and grazed floodplain with scattered trees
Downstream gradient	0.0015 m/m



Reach 3 – Features of Representative Site

Reach	Site Location	Description
3 – Latrobe River – Lake Narracan to Scarnes Bridge	Sandbanks Reserve, upstream of Tyers Road, north of Traralgon	Recreation reserve, scattered trees on bench and floodplain, locally dense willow infestations

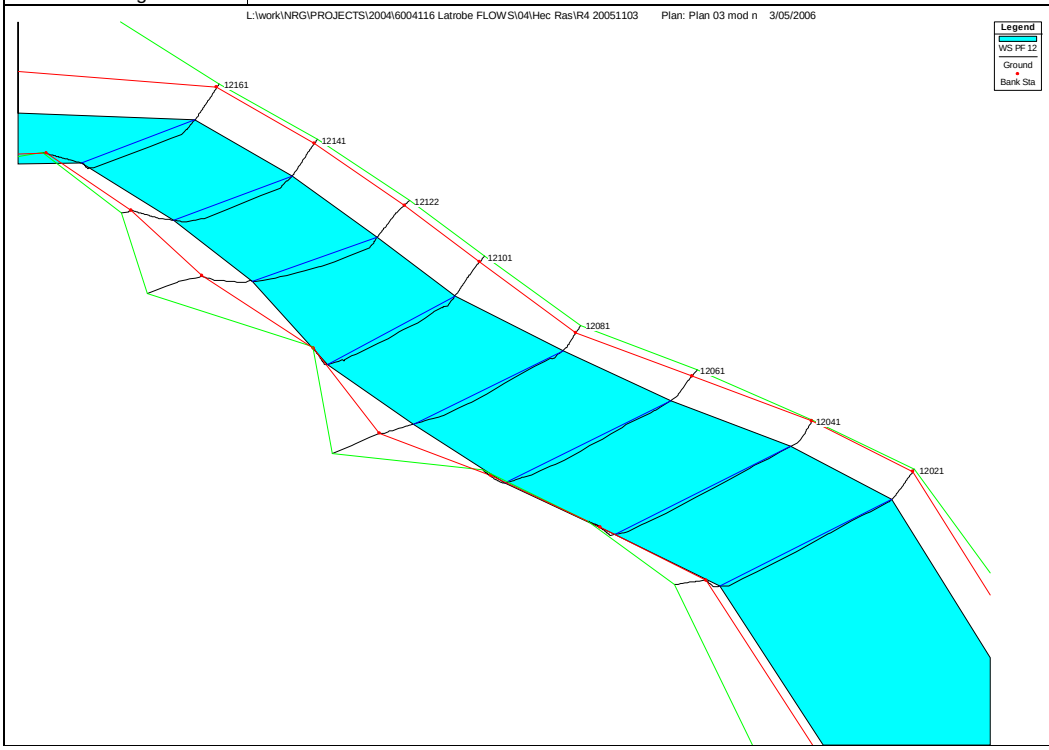
Survey length and type	360 m feature survey, upstream of Tyers Road
Channel form / size	20-25 m base width, 40-45 m top width, 5 m depth, sand bars
Manning's n (stream roughness) Channel Floodplain	0.045 – moderate in-channel vegetation, moderate channel variability 0.045 – scattered trees
Downstream gradient	0.0007 m/m



Reach 4 – Features of Representative Site

Reach	Site Location	Description
4 – Latrobe River – Scarnes Bridge to Rosedale	End of Stuckeys Lane, off Princes Highway	Cleared grazing land on both banks. Scattered floodplain vegetation, wattle regeneration on river banks. Stock tracking and local slumping. Billabong with upstream and downstream connections on river right bank.

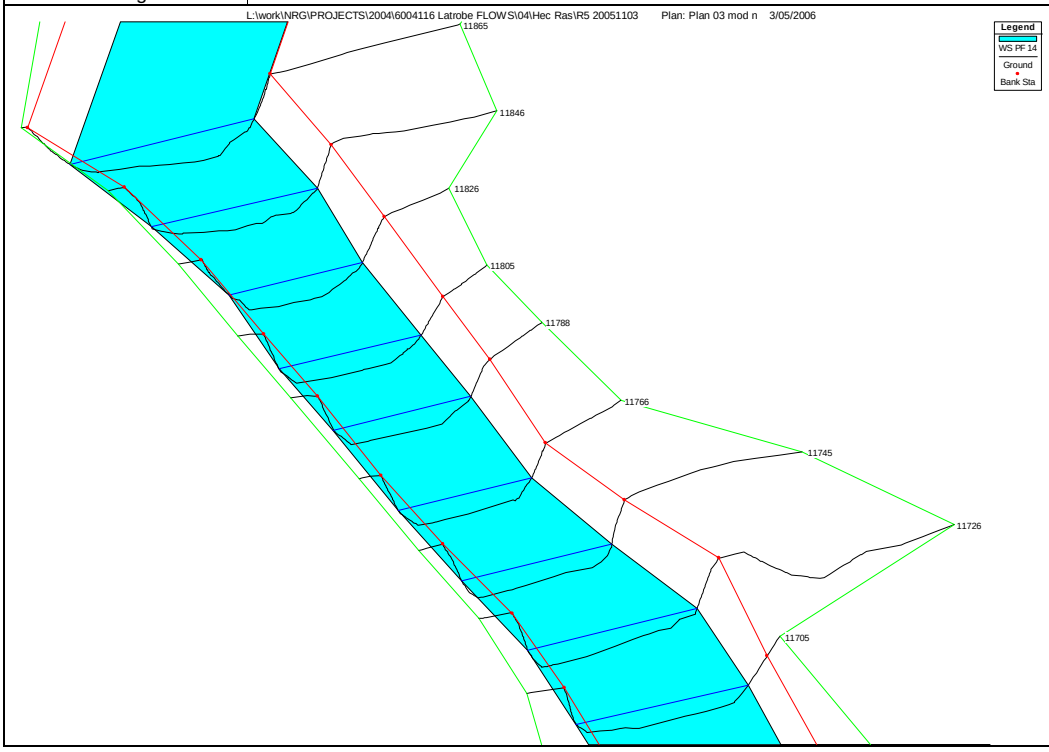
Survey length and type	170 m feature survey + feature survey of billabong connections Survey supplemented with WGCMA cross section survey over approx 14km length
Channel form / size	16-30 m base width, 30-40 m top width, 4 m depth, few in-channel features
Manning's n (stream roughness) Channel Floodplain	0.045 – moderate in-channel vegetation 0.045 – scattered trees
Downstream gradient	0.0002 m/m



Reach 5 – Features of Representative Site

Reach	Site Location	Description
5 – Latrobe River – Rosedale to Thomson River	Off Lower Settlement Road, approximately 8 km west of Sale	Straight channel with steep banks. Phragmites, Melaleuca and Eucalypt vegetation with some stock impacts. Cut-off meander with upstream and downstream connections on river left bank.

Survey length and type	200 m feature survey + feature survey of billabong connections Survey supplemented by WGCMA stream cross section survey over approx 12km length
Channel form / size	14-20 m base width, nom. 25 m top width, 3 m depth, few in-channel features
Manning's n (stream roughness) Channel Floodplain	0.045 – moderate in-channel vegetation, some large woody debris 0.06 – scattered trees and pockets of remnant vegetation + cut-off meander feature
Downstream gradient	0.0002 m/m



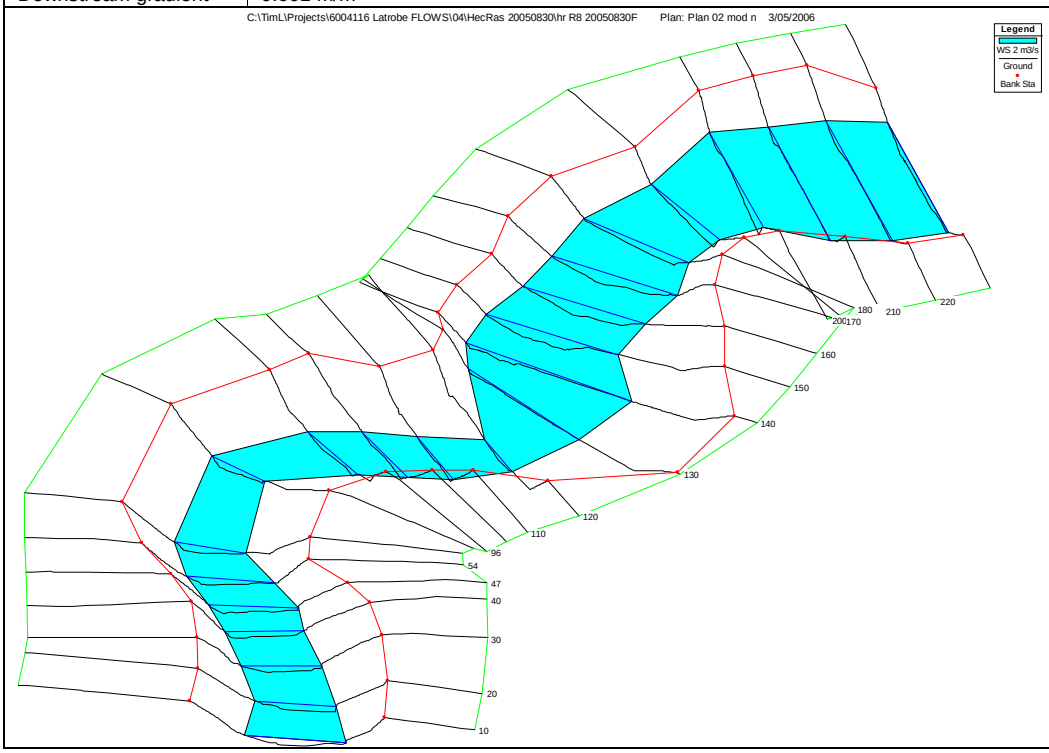
Reach 6 – Features of Representative Site

Reach	Site Location	Description
6 – Latrobe River – Thomson River to Lake Wellington	Downstream of Princes Freeway / Swing Bridge – between Dowd Morass and Sale Common / Heart Morass	Typha and phragmites beds in variable condition + scattered Eucalypt and Melaleuca fringing the wetland features
Survey length and type	12 km modelled reach comprising cross-sections at approx. 200 m spacing. In channel features from hydrographic survey.	
Channel form / size	60-100 m top width, typical >7 m depth (channel base at approx –RL6)	
Manning's n (stream roughness) Channel Floodplain	0.04 0.035	
Downstream gradient	Fixed downstream boundary condition – water surface at RL0	

Reach 8 – Features of Representative Site

Reach	Site Location	Description
8 – Tanjil River	Upstream of Moe-Rawson Road, to north of Moe-Willowgrove Road	Meandering river channel through generally cleared grazing land. Some bank slumping.

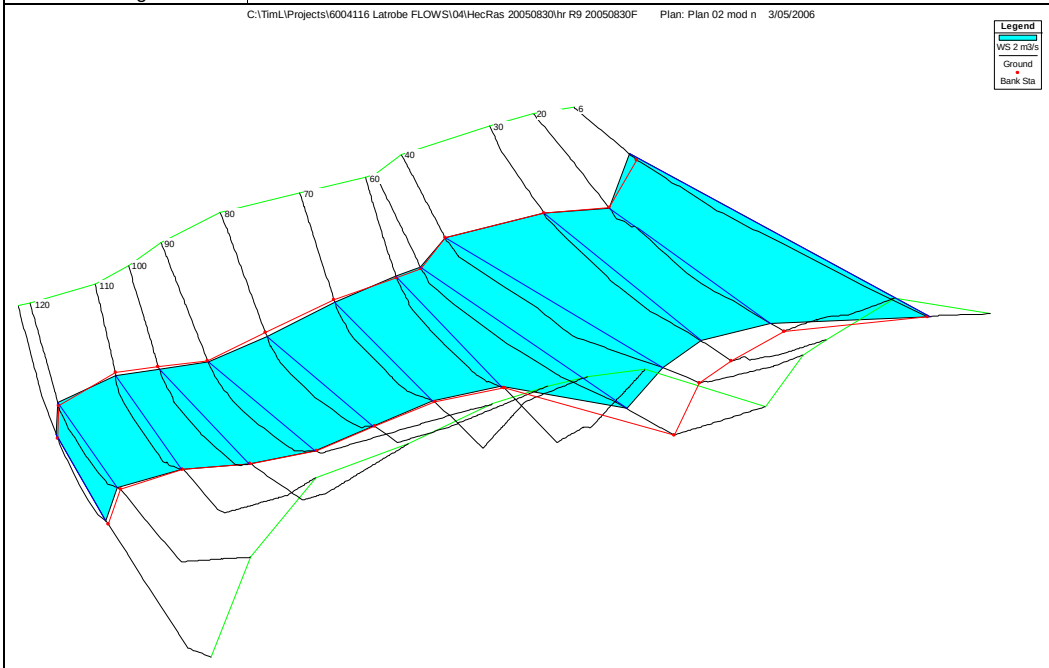
Survey length and type	225 m feature survey
Channel form / size	5-7 m base width, 20—25 m top width, 4 m depth
Manning's n (stream roughness) Channel Floodplain	0.045 0.045
Downstream gradient	0.001 m/m



Reach 9 – Features of Representative Site

Reach	Site Location	Description
9 – Tyers River	Immediately downstream of pipe bridge crossing (McMillans Bridge)	Straight gorge reach with bedrock riffles. Some bench formation but channel generally abuts hillslope. Intact riparian vegetation.

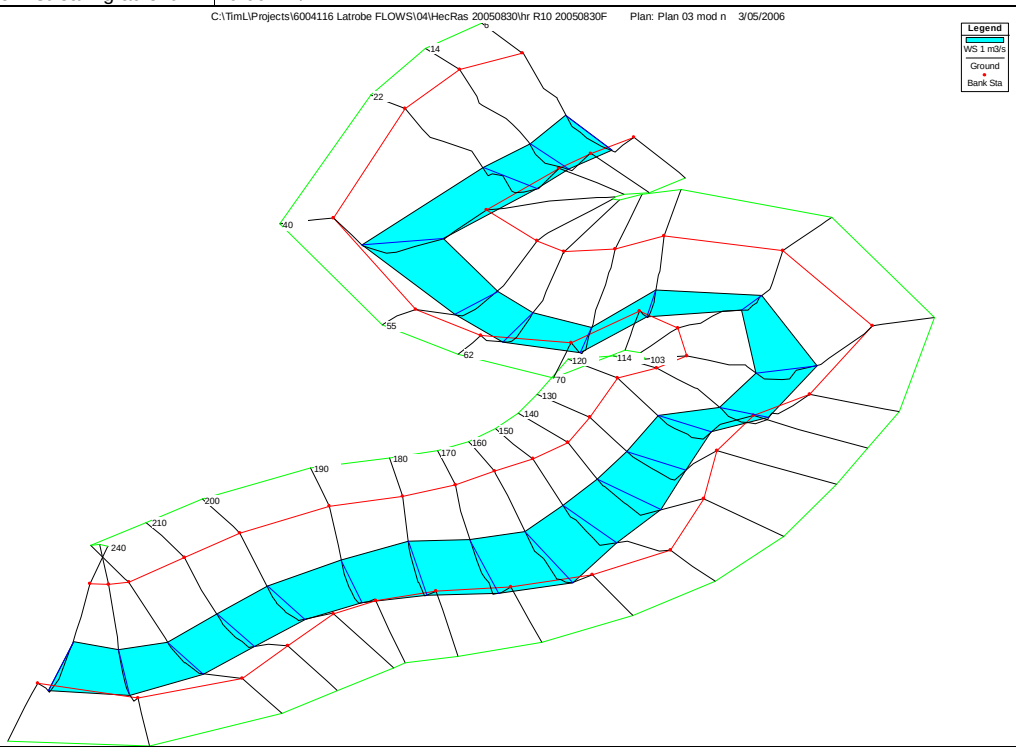
Survey length and type	130 m feature survey
Channel form / size	20 – 25 m valley floor width rising immediately into hill slopes
Manning's n (stream roughness) Channel Floodplain	0.06 0.1 (dense riparian vegetation above low water level)
Downstream gradient	0.003 m/m



Reach 10 – Features of Representative Site

Reach	Site Location	Description
10 – Morwelll River	Immediately upstream of Princes Freeway bridge crossing (adjacent to Morwell River Wetlands)	Meandering channel with sand benches. Revegetation works undertaken on right floodplain, generally clear on left bank.

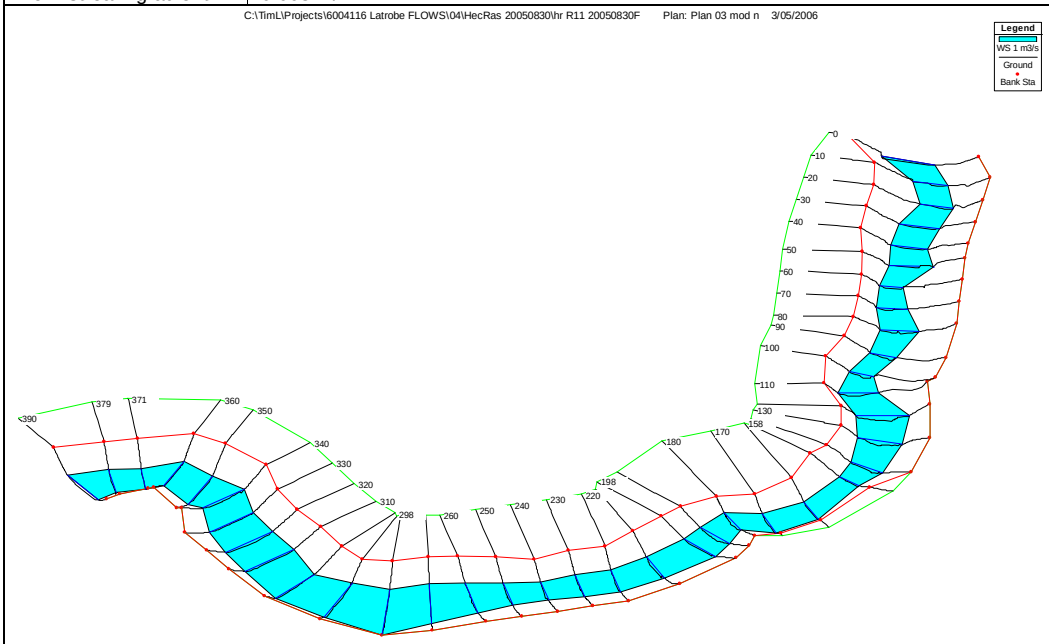
Survey length and type	240 m feature survey (survey undertaken in 2004)
Channel form / size	4-6 m base width, 15 m top width, 3.5 m depth
Manning's n (stream roughness) Channel Floodplain	0.045 0.035 (left), 0.045 (right)
Downstream gradient	0.001 m/m



Reach 11 – Features of Representative Site

Reach	Site Location	Description
11 – Traralgon Creek	Approx. 400 m upstream of Mattingley Hill Road	Generally uniform channel geometry with some vegetated benches. Left floodplain generally clear, right floodplain densely vegetated.

Survey length and type	390 m feature survey
Channel form / size	5-8 m base width, 15-20 m top width, 3 m depth
Manning's n (stream roughness) Channel Floodplain	0.045 0.035 (left), 0.06 (right)
Downstream gradient	0.003 m/m



4 References

Department of Natural Resources and Environment (2002). Flows – a method for determining environmental water requirements in Victoria, State Government of Victoria.

Earth Tech (2005). Assessment of Environmental Flow Requirements for the Latrobe River and Wetlands of the Lower Latrobe River – Site Paper. Report to West Gippsland Catchment Management Authority.

Hardie, R, (1993) ***Review of Stream Profile Information for Catchments of North East Victoria***. Masters Thesis, University of New England, New South Wales.

Hicks and Mason (1991). ***Roughness Characteristics of New Zealand Rivers***. Water Resources Survey, DSIR Maine and Freshwater.