# Environmental Flow Determination for the Maribyrnong River

# Final Recommendations

**Revision C**

July 2006

# Environmental Flow Determination for the Maribyrnong River

# FINAL RECOMMENDATIONS

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# Tables

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## Acknowledgements:

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

| | |
|---|---|
| Michael Aberton | Riparian vegetation |
| Chris Arnott | Chair of the technical panel |
| Tim Doeg | Macroinvertebrate ecology and Fish |
| Brian Finlayson | Geomorphology |
| Jeremy Hindell | Estuarine processes |
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The Earth Tech project management team consists of:

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| Chris Arnott | Project Manager |
| Amanda Wealands | Project Support |

The Technical Panel wishes to acknowledge the assistance of Christine Hughes (MW) and the Steering Committee and Advisory Group for their assistance in this phase of the project. The Steering Committee for the project consisted of:

| | |
|---|---|
| Jamie Ewert | Melbourne Water Corporation |
| Paul Louws | Western Water |
| Phil Mitchell | Department of Sustainability and the Environment |
| Cameron Welsh | Southern Rural Water |

The Advisory Group consisted of:

| | |
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| Wade Bland | Hume City Council |
| David Blicblau | Deep Creek Landcare |
| Christina Cheers | Friends of Emu Bottom Reserve |
| Garrett Hall | EPA |
| Gary Lawes | MW Diverter |
| Lachlan Milne | Shire of Macedon Ranges |
| Bill Mole | SRW Diverter |
| John Robinson | Port Phillip and Westernport Catchment Management Authority |
| Chris Ryan | SRW Diverter |
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| Ian Sutherland | Friends of Emu Bottom Reserve |
| Ian Taylor | Sunbury Landcare |
| Zoe Thomson | Brimbank City Council |
| Eddie Tsyrlin | Melbourne Water |

## Acronyms/Abbreviations used in this report:

| | |
|---|---|
| **CRC** | Co-operative Research Centre |
| **DSE** | Department of Sustainability and Environment |
| **EVC** | Ecological Vegetation Class |
| **EWR** | Environmental Water Requirements |
| **FLOWS** | The “Statewide Method for Determining Environmental Water Requirements” |
| **IFU** | Internal Floodplain Unit |
| **LWD** | Large Woody Debris |
| **MW** | Melbourne Water Corporation |
| **Technical Panel** | The Maribyrnong River Environmental Water Requirements Technical Panel |
| **VRHS** | Victorian River Health Strategy |
| **PPWCMA** | Port Phillip and Westernport Catchment Management Authority |

## Definitions:

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

| | |
|---|---|
| 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 |
| 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 bankfull flows are infrequent and a more frequent, upper bank wetting is required. |
| 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. |
| Internal Floodplain Unit | Refers to a generally horizontal and vegetated surface within the upper elevations of an incised stream channel which acts as a contemporary floodplain. Where a stream has incised (vertically degraded and enlarged |

the stream channel due to a temporary change in the sediment or flow dynamics of the channel), the historic floodplain is no longer engaged by regular flows. With greater flows contained within the incised channel a 'ledge' or IFU is created during the energy dissipation phase of channel incision. In recommending environmental flows for incised streams the IFU can serve as a substitute for many of the ecological processes previously provided by the historic floodplain, where flow recommendations for engaging the historic floodplain are not practicable.

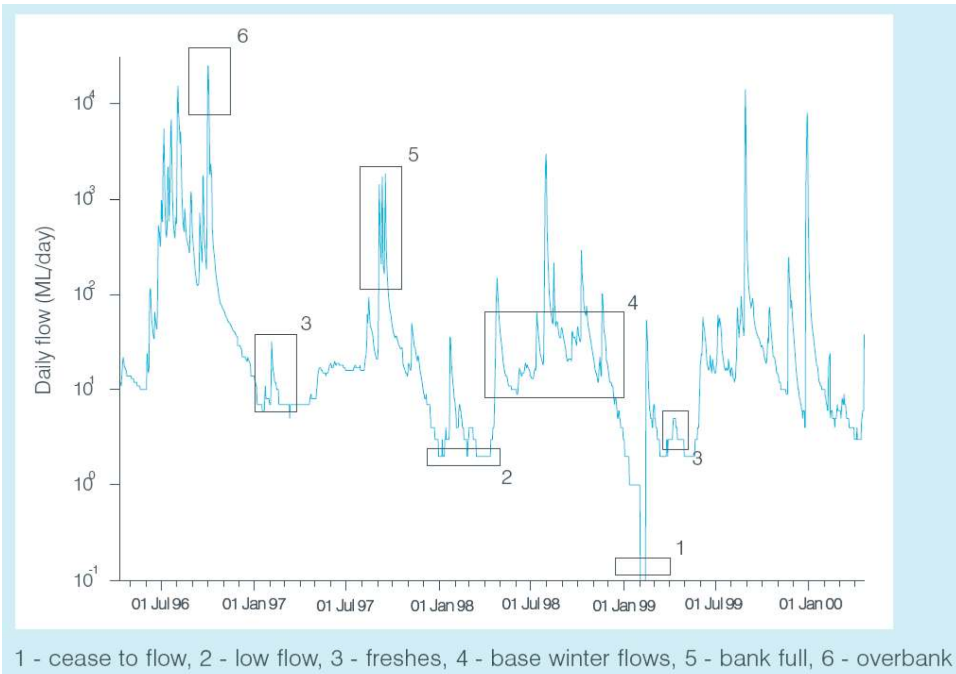



**Figure A Graphical example of flow components (DNRE, 2002)**

# 1 Introduction

Melbourne Water Corporation (Melbourne Water) has engaged Earth Tech to undertake an assessment of environmental flow requirements for the Maribyrnong River catchment.

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

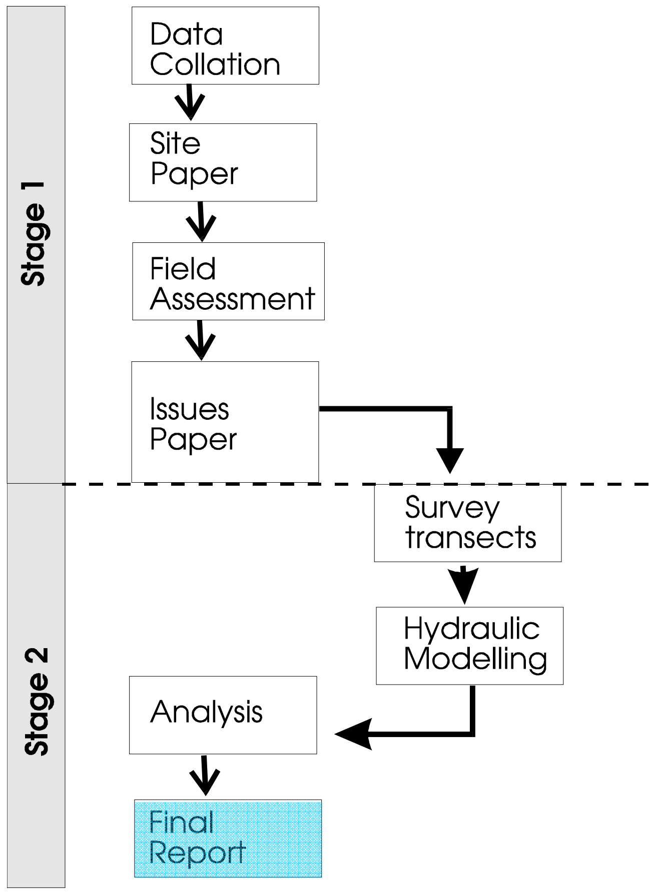



**Figure 1-1. Outline of the steps in the FLOWS method**

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. The key elements of the flows process include:

- An objective setting process that links environmental objectives to flow processes, components 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 are addressed in part by existing Melbourne Water and PPWCMA documents (i.e. River Health Strategy). The preparation of a Waterway Management Action Plan (WMAP) is likely to be a key future activity for identification of specific management actions that may alleviate some of the river health issues peripheral to the flow stresses identified in this report.

The Recommendations Paper 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 Maribyrnong 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 and should be read in conjunction with this final report.

This report identifies the recommendations for environmental water requirements for the Maribyrnong River catchment. The scope for the report does not include analysis of 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 will be used to inform the Central Region Sustainable Water Strategy, and will also be used in the development of the Upper Maribyrnong Stream Flow Management Plan.

## 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 environmental water requirements for this study and the limitations of the hydraulic analyses.

**Section 3** defines the environmental water requirements 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 six components:

- A summary of the reach condition, key values
- A vision for the reach;
- The environmental flow objectives for the reach;
- The flow processes and components linked to each environmental objective;
- Summary table of the recommendations; and
- Comparison table of the recommended flows to the current and natural flow regime.

**Section 4** discusses recommendations further investigation for the estuarine reach.

**Section 5** identifies a number of key supporting recommendations for the implementation of environmental flow recommendations in the Maribyrnong River catchment.

# The Maribyrnong River Catchment

The Maribyrnong River catchment is situated to the north west of the Melbourne central business district (CBD). The catchment is largely bounded by two major highways; the Hume Highway along the eastern edge and the Calder Freeway along the western edge of the catchment. Total catchment area is approximately 1,430km$^2$ and extends from Mt Macedon, Lancefield and Kilmore at the northern end of the catchment to the suburb of Yarraville and the river's confluence with the Yarra River, approximately 5.5km west of the Melbourne GPO, at the downstream end of the catchment.

The upper catchment of the Maribyrnong River is comprised of two main sub-catchments:

- Jacksons Creek that drains the western part of the catchment.
- Deep Creek that drains the central, northern and eastern part of the catchment.

Jacksons Creek rises to the west of Gisborne and flows in an easterly direction to its confluence with Riddells Creek to the south east of the township of Riddells Creek. The creek then turns south and flows through Sunbury, prior to meeting Deep Creek between the Organ Pipes National Park and Melbourne airport on the Melbourne urban fringe.

Rosslynne Reservoir is the only major on-stream storage within the Maribyrnong River catchment and is situated on the upper reaches of Jacksons Creek. Other minor tributaries of Jacksons Creek include Sandy, Dry, Longview, Kismet and Blind Creeks.

Deep Creek rises approximately 5km north east of Mt Macedon and flows in a northerly direction to the southern edge of the Cobaw State Forest. It then turns east, flowing to the north of Lancefield, before turning south and flowing past Romsey, Darraweit Guim, Konagaderra and Bulla before its confluence with Jacksons Creek to the west of Melbourne airport.

There are a raft of minor tributaries within this catchment, whilst the major tributaries are Boyd, Konagaderra and Emu Creeks.

The lower catchment of the Maribyrnong River extends from the confluence of Jacksons and Deep Creeks to the confluence with the Yarra River. Tributaries in this lower part of the catchment include Taylors, Steele and Stony Creek. Stony Creek enters the Yarra River approximately 1km downstream of the confluence with the Maribyrnong River, but is considered part of the Maribyrnong River catchment.

Approximately half of this lower catchment is estuarine extending from the Yarra River up to the Canning Street ford on the boundary between the suburbs of Avondale Heights and Maribyrnong.

More information on the catchment, reach break justification and condition of the representative sites discussed in this report can be found in the Site Paper and the Issues Paper. A map of the catchment showing reaches, representative sites and gauge locations can be found on the following page.

# 2 Environmental Flow Analysis

## 2.1 Surveys of selected reaches

Cross-sectional survey for the representative reaches of the Maribyrnong River catchment were undertaken by Earth Tech using a Total Station and differential GPS. Transects were identified and pegged by the Technical Panel and hydraulic modeller during the field inspection. Cross sections were chosen based upon the hydraulic requirements of the model, such as constrictions and riffles, and the ecological and geomorphologic points of interest such as deep pools and benches. Cross sections were surveyed perpendicular to the flow with a greater density of points within the low flow channel where finer detail is required and fewer points on the floodplain. The surveyors also surveyed water levels and photographed each section.

For Reach 8, the Maribyrnong River surveying was undertaken by Connell Wagner for a geomorphic study conducted by Gippel and Walsh (2000). Many cross sections were surveyed for this study at an approximate spacing of 100m and a sub sample of this (15 sections) was extracted for this study. The level of detail provided by these transects was considered suitable for this study given the scale of the river in this reach.

## 2.2 Hydraulic and Hydrologic Modelling

Hydraulic modelling of the representative sites was undertaken using HEC RAS, a one-dimensional steady state backwater analysis model. This model was designed by the United States Army Corps of Engineers (USACE) and has been extensively used for environmental flow studies in Victoria and to a much greater extent for hydraulic studies throughout the world.

The main input to HEC RAS is the *channel geometric* which represents the channel shape and is provided by the survey data. Therefore, the more reliable the survey data at each cross section and in representing the reach, the better the results in interpreting water levels in the model. There are two key parameters which alter the operation of the hydraulic model: the channel roughness and downstream boundary conditions (assuming subcritical flow). *Channel roughness* is the most important interpretive component in the model and is provided by Manning's *n* (a measure of channel roughness). The appropriate Manning's *n* for each part of each cross-section was identified through observations of the reach by the modeller during the field inspection, and identification of reach variability from photographs. The selection of appropriate Manning's values is based on interpretation from references (ie, Chow, 1959, pg. 110-113) and the experience of the modeller. The *downstream boundary condition* was chosen as 'normal depth' which utilises the water surface slope at steady uniform flow. In this case the slope for the models was determined through a combination of channel slope throughout the surveyed reach (riffle to riffle thalweg level), the valley slope and the observed water levels. In one case a rating curve from a nearby stream gauge has been utilised as a boundary condition. Calibration of the model is undertaken through relating known water surface elevations from surveying with the water surface elevations produced by the model for an equivalent flow as measured on the day of surveying at a proximal stream gauge.

The key output from the modelling is a graphic presentation of each transect (Figure 2-1). In these, the black line (“Ground” in the legend) represents the ground surface, reflecting the channel shape at the cross-section. Small black squares on the ground line show the exact points where survey measurements were taken (note that these are more frequent within the channel than further out). Horizontal blue lines within the cross-section represent the water surface at the various flows (which are detailed in the legend). Long profiles can also be displayed (thalweg level plot), showing the maximum or minimum depths at each surveyed transect at different flows (Figure 2-2). Other than water levels, the hydraulic models also allow for interpretation of important hydraulic parameters such as velocity and shear stress.

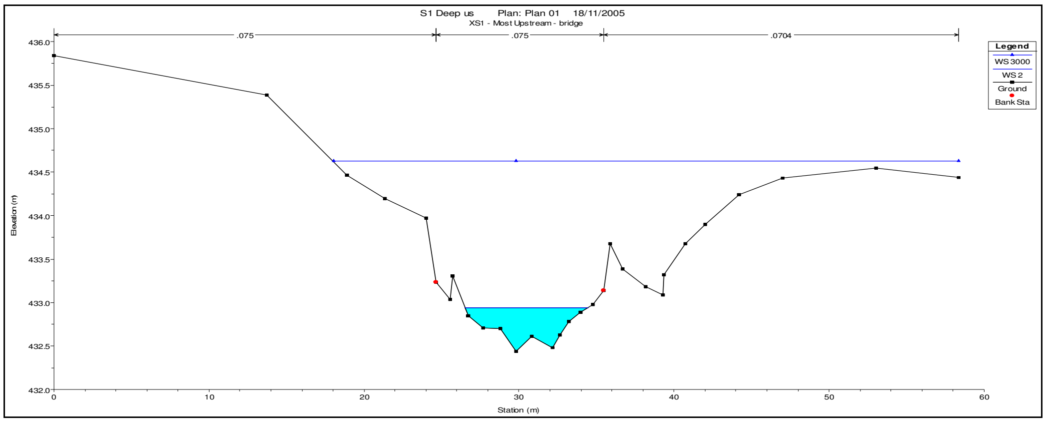



**Figure 2-1 Cross section displaying two flow levels**

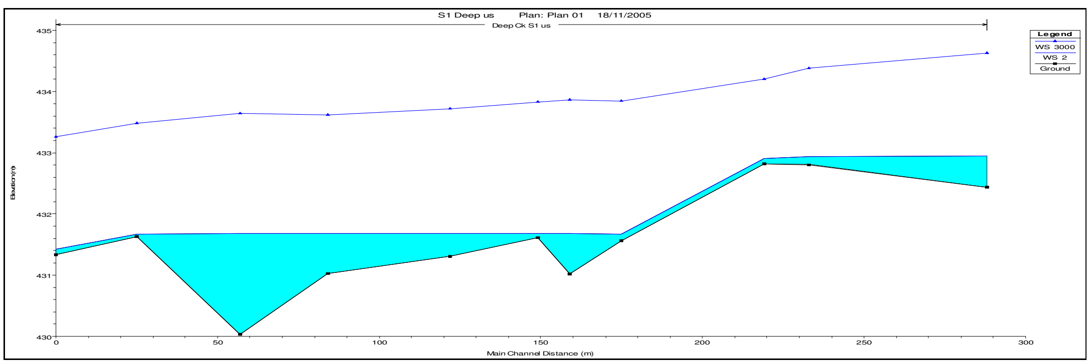



**Figure 2-2 Longitudinal section displaying two flow levels**

The RAP software package was then used to interpret and query the hydraulic modelling 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 entered and adjusted until a particular selected bench was inundated.

The recommendations for frequency and duration of events (e.g. freshes, bankfull) are based on the frequency and duration of the natural flow series. The time series analysis component of RAP was used to examine the frequency and duration of particular flows under natural conditions. The recommended frequency and duration was chosen from within the range of natural conditions (usually based on the average natural annual seasonal frequency and duration). An independence criteria of 10 days between events was adopted for the hydrologic analysis.

### 2.2.1 Representativeness of the Model

While the representativeness of the survey site or sections can not be easily verified, the changes to results from the hydraulic model due to parameter choice can be assessed. The two types of modeling error that can be assessed are flow regime and boundary condition selection.

All of the eight hydraulic models for this project are run on a sub-critical flow regime, where the flow conditions are determined by the conditions at the downstream boundary of each cross section. The conditions in all reaches, except Reach 8 (Maribyrnong River), would involve supercritical conditions at low flows, however supercritical conditions can not be modeled with the spacing of sections commonly used in environmental flow studies. This is best illustrated with an example from Riddells Creek.

Within the Riddells Creek representative site, several short steep drops existed. Sections were placed on the crest of a drop and eight meters downstream of this drop in the run (Figure 2-3).

**Figure 2-3 Steep drop at Riddells Creek (Reach 5) Section 2**

Even with this placement (much closer than in most environmental flow studies) the model can not compute supercritical flow as required. The model defaults to critical flow (Froude Number equal to 1). The results of this are that the low flow computations, such as those undertaken for fish passage at depths of 0.2m minimum depth, could be overestimated. The change in calculating water levels based on sub-critical flow (an influence by downstream conditions) and critical flow (at the threshold of supercritical flow) is a decrease in the minimum depth from 30cm to 25cm, and if we were able to model supercritical flow this would be greater (Figure 2-4).

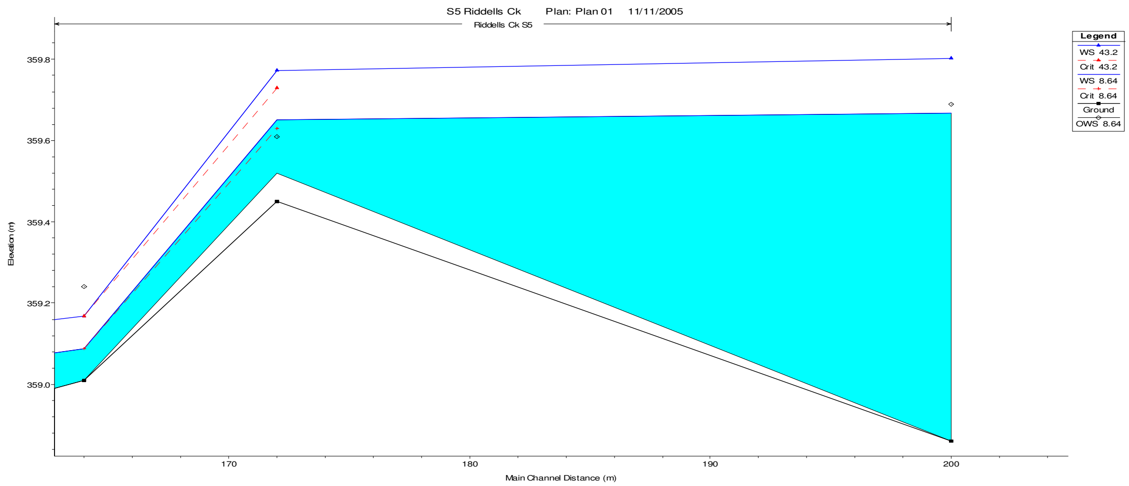



**Figure 2-4 Riddells Ck longitudinal section at flows of 8.6 and 43 ML/d with observed water levels identified by the small circles indicating the overestimate at the riffle crest (and underestimates downstream) where minimum fish passage is commonly defined**

There are two ways to overcome this problem;

1) collect more cross sections at a closer spacing or
2) duplicate cross sections through interpolation.

Considering the time and cost requirements involved in these tasks, it was considered that an awareness of the issues and limitations at these zones would provide a result close to the more detailed approaches. While it is important to understand these model inaccuracies at the finer level for which they are being used, for the purposes of this modeling exercise the results are generally adequate. It is most important that the technical panel is informed of these potential overestimates at low flows and as such conservative estimate is required. This was impressed upon the Technical Panel during the low flow analysis recommendations and recommended discharges were subjectively adjusted accordingly.

### 2.2.2 Hydraulic Model Sensitivity Assessment and Analysis

The sensitivity of the model to errors in determining the two key boundary conditions of roughness and downstream slope can be identified through a sensitivity analysis. The change in the water surface elevations for the lowest recommended flow (low flow) and highest recommended flow (bankfull flow) for an upstream site (Reach 1 Deep Ck upstream Boyd Ck) and a downstream site (Reach 4 Deep Ck upstream Jacksons Ck). The hydraulics for these sites were remodeled for a very significant difference of +/-25% change in the boundary conditions of roughness and downstream slope. The upper limits are based on decreased roughness and increased slope (lower water levels) and the lower limits are based on a 25% change for increased roughness and decreased slope (higher water levels) (Table 2-1). This analysis was undertaken for the most upstream cross section and as such the error in the selection of the roughness value has the most influence.

**Table 2-1 Upper and lower error limits for a 25% change in boundary conditions at the same water elevation for the recommended low flow and bankfull flow.**

| | Reach 1 Deep Ck upstream Boyd Ck | Reach 4 Deep Ck upstream Jacksons Ck |
|---|---|---|
| **Recommended Low Flow** | **2 ML/d** | **19 ML/d** |
| Upper Limit | 2.05 ML/d (+0.025%) | 19 ML/d (+0%) |
| Lower Limit | 1.95 ML/d (-0.025%) | 19 ML/d (-0%) |
| **Recommended Bankfull Flow** | **3000 ML/d** | **4000 ML/d** |
| Upper Limit | 3600 ML/d (+20%) | 5650 ML/d (+41%) |
| Lower Limit | 2300 ML/d (-24%) | 2800 ML/d) (-30%) |

The low flows in the model are most sensitive to topographic survey, which has not been verified here, show little change in water levels due to boundary condition selection. There is however a significant change in flows for the bankfull flow particularly for the larger channel section (Reach 4) with +/- 41/30%. While a 25% error in roughness should be outside the realm of an experienced hydraulic modeler this analysis serves to put extreme bounds on potential variability in flow recommendations and identify the importance of boundary conditions for higher flows. Conversely for low flows, the level of detail and section placement is extremely important for these flows.

## 2.3 Rates of Rise and Fall

In addition to the standard components of each flow recommendation (magnitude, frequency, duration and timing) the rates of rise and fall of each recommendation is also important both ecologically and geomorphologically. These rates prevent unnaturally rapid fluctuations from occurring. The approach is to separate the rise and fall components (e.g. what is the proportion of flow from one day to the next) from the natural, un-impacted flow record. For the Maribyrnong River catchment the maximum rate of rise was selected as the 90$^{th}$ percentile of all rates of natural rise and the rate of fall was selected as the 10$^{th}$ percentile of all the natural fall rates (Table 2-2).

The rationale for the percentiles is that while a rapid rate of rise was not seen as a significant concern (the 90$^{th}$ percentile is a significantly high rate) the allowable rate of fall is critical to prevent ecological concerns such as stranding of fish or geomorphic concerns such as bank slumping by surcharging. This method for determining rates of rise and fall was first utilised on the environmental flow investigation for the Loddon River and has been used subsequently on numerous FLOWS investigations.

**Table 2-2 Recommended maximum rates of rise and fall (expressed as a percentage of the previous days flow) for all reaches of the Maribyrnong River catchment.**

| Reach/Site | Maximum rate of rise (proportion of previous day) | Maximum rate of fall (proportion of previous day) |
|---|---|---|
| Reach 1 – Deep Ck u/s Boyd Ck | 2.88 | 0.61 |
| Reach 2 – Deep Ck u/s Emu Ck | 2.91 | 0.59 |
| Reach 3 – Emu Ck | 2.91 | 0.58 |
| Reach 4 - Deep Ck u/s Jacksons Ck | 2.58 | 0.62 |
| Reach 5 – Riddells Ck | 3.07 | 0.58 |
| Reach 6 – Jacksons Ck u/s Riddells Ck | 4.55 | 0.5 |
| Reach 7 – Jacksons Ck u/s Deep Ck | 3.40 | 0.58 |
| Reach 8 – Maribyrnong River | 2.49 | 0.64 |

# 3 Reach Recommendations

The flow recommendations for each reach are presented below in a standard format with six 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. This section also outlines the key values for each reach;
- **The Reach Vision**. An overall vision for the condition and function of each reach is identified. The vision helps to put the environmental objectives in context based upon the longer term target condition for the reach.
- **The Environmental Flow Objectives**. For each reach, the environmental flow objectives that apply to that reach, as defined by the Technical Panel, are presented. These objectives are defined as to either maintain, rehabilitate, remediate or restore a nominated asset.
    - *Maintain* refers to the preservation of the asset in its current condition, diversity and distribution.
    - *Rehabilitate* refers to an effort to artificially return the fundamental elements of the original stream, generally making the degraded asset closer to pre-European condition.
    - *Remediate* recognises the stream has changed so much that the original condition is no longer relevant and aims for some entirely new condition (Rutherfurd et.al., 2000)
    - *Restore* refers to reinstating the condition, diversity and distribution of the asset to natural conditions.
- **Flow Processes and Components**. For each reach the objectives are linked to the flow processes and flow components required to meet the objective.
- **Recommendation Summary Tables**. The recommendations are presented in a standard table format as used in the FLOWS method.
- **Comparison Tables**. For each reach, the recommended flows are compared to the natural and current flow regime.

NOTES:

- Flow recommendations for *Reach Nine – Maribyrnong River Estuarine Reach* were not developed. Freshwater recommendations to sustain the assets of the estuary, as identified in the Issues Paper, are discussed in Section 4 – Estuary Recommendations.
- It is considered that flows suitable for large-bodied fish and those required by the macroinvertebrate community (the major food source) in the Maribyrnong River would be adequate for platypus. Therefore, no specific criteria for platypus have been included in this study.

## Reach One – Deep Creek Upper Catchment

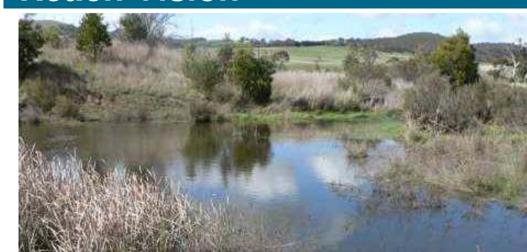
Reach 1 encompasses the headwaters of Deep Creek. There are some licensed pumping extractions and water supply reservoirs (Lancefield No.1 (Garden Hut) Reservoir and diversion weir to Lancefield No.2 Reservoir on Monument Creek). Tributaries include Dry Creek, Long Gully Creek, Garden Hut Creek, Monument Creek and Five Mile Creek. The catchment of Reach 1 is forested in the upper reach and has a poor riparian cover in the lower reach. Logging has been carried out within the Cobaw State Forest in the upper catchment. Near Lancefield, cleared land is used primarily for grazing. Agricultural activities (grazing and cropping) occur in the riparian corridor in the lower reaches.

There is not a significant change from natural conditions to the current flow regime in the upper reach of Deep Creek. Significant *chain of ponds* channel morphology dominates the upper reach which is primarily threatened by riparian land use and physical channel intervention. Macroinvertebrate and fish habitat in low flow periods is in disconnected pools. Water quality in these pools is critical during this period. Instream vegetation in Reach 1 is of high quality, however land clearing and agriculture has depleted much of the riparian vegetation.

## Key Values

- Significant channel morphology
- High quality instream vegetation
- Yarra Pygmy Perch present in reach
- Largely intact flow regime

## Reach Vision



***An 'ecologically healthy' reach with chain of ponds channel form and an intact indigenous riparian vegetation cover that provides habitat and passage for resident and threatened aquatic fauna species.***

## Environmental Objectives

### Physical Form

Provide suitable conditions to maintain channel morphology

Maintain sediment accession onto the floodplain

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of Yarra Pygmy Perch, small bodied fish and macroinvertebrates

Maintain water quality to ensure all environmental flow objectives are met

### Vegetation

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

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

**Table 3-1 Flow Processes and Flow Components for Reach One – Deep Creek Upper Catchment**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 1-M1 | Habitat availability (pool/run) | Low flow (edge vegetation inundated) | All year | Macroinvertebrate habitat availability |
| | | 1-M2 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | Any time | Habitat inundation variability |
| | | 1-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Food and habitat provided for macroinvertebrates |
| | | 1-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish and Yarra Pygmy Perch | 1-F1 | Habitat availability | Low flow (pool depth >0.2m in edge vegetation areas) | All year | Pool habitat available for small bodied fish and Yarra Pygmy Perch during low flow period |
| | | 1-F2 | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools) | Dec-May | Local movement between habitats (small bodied fish and Yarra Pygmy Perch) |
| | | 1-F3 | Spawning and migration trigger | High flow fresh (duration >3 days) | Sep-Nov | Spawning trigger provided for resident fish species |
| | | 1-F4 | Regional scale migration | High flow (>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |
| | | 1-F5 | Entrain terrestrial carbon/woody debris on benches | refer to 1-M3 | | |
| | | 1-F6 | Disturb habitat | High flow fresh (median depth over run >0.2m) | Jun-Nov | Fish habitat disturbed |
| | | 1-F7 | Shelter for Yarra Pygmy Perch | Low flow | All year | Continual provision of Shelter from birds of prey and temperature increase for Yarra Pygmy Perch |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 1-Q1 | Flushing of pools | Low flow fresh (every 4-6 weeks) | Summer | No decline in water quality |
| Physical Form | Provide suitable conditions to maintain channel morphology | 1-P1 | Disturbance | High flow | Any time | Inundation of main channel to prevent terrestrial vegetation encroachment |
| | | | | High flow fresh (average velocity 1.5m/s) | | Channel form disturbed and maintained |
| | | | | Bankfull (top of bank wetted) | | |
| | | 1-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh (median depth over run >0.1m, velocity approximately 0.5m/s) | Any time with sufficient duration | Accumulations of fine sediments removed |
| | | 1-P3 | Scour biofilms | High flow (average velocity >0.5m/s over run) | Winter/Spring | Biofilms scoured |
| | | 1-P4 | Prevent vegetation encroachment in channel | Refer to 1-V3 | | |
| | Maintain sediment accession onto the floodplain | 1-P6 | Disturbance and deposition of sediment | Bankfull | Anytime | Sediment disturbed and deposited on the floodplain |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 1-V1 | Instream vegetation inundation | Low flow (pool depth >0.1m) | All year | Continual inundation of instream submerged vegetation over summer/autumn dry period. |
| | | | | Low flow (run depth >0.1m) | | |
| | | 1-V2 | Instream vegetation disturbance | Low flow fresh (inundation of fringing vegetation) | Summer/Autumn | Regeneration of diverse instream vegetation communities |
| | | 1-V3 | Prevent vegetation encroachment in channel | High Flow | Winter/Spring | Inundation of main channel to prevent terrestrial vegetation encroachment |
| | Provide suitable conditions to restore riparian vegetation abundance diversity | 1-V4 | Riparian habitat inundation | High flow fresh | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment |
| | | 1-V5 | Riparian habitat disturbance | High flow fresh | Spring | Disturbance of vegetation |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | and structure | | | Bankfull | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 1-V6 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 1-V7 | Stimulate regeneration of seed | Bankfull | Spring | Regeneration of endangered EVC 83 – Swampy Riparian Woodland |

# Reach One Summary

**Table 3-2. Flow Recommendations for Reach One – Deep Creek Upper Catchment**

| River | | Deep Creek | | Reach | Reach 1 – Deep Creek Upper Catchment |
|---|---|---|---|---|---|
| Compliance Point | | Deep Creek @ Bolinda | | Gauge No. | 230 232 |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec – May | Low Flow<br>2 ML/d (or natural) | Continuous | Continuous | 1-M1, 1-M2, 1-F1, **1-F7**, 1-V1 | Edge vegetation inundated greater than 0.2m deep providing shelter for Yarra Pygmy Perch and macroinvertebrate habitat availability. |
| Dec – May | Low Flow Freshes<br>20 ML/d | 5 per period<br>(or natural) | 4 days<br>(or natural) | **1-F2**, 1-Q1, 1-P2, 1-V2 | Shallowest point on the downstream run greater than 0.12m with an average velocity of 0.5m/s allowing localised fish movement between pool habitats |
| Jun – Nov | High Flow<br>20 ML/d (or natural) | Continuous | Continuous | 1-F4, 1-P1, 1-P3, **1-P4**, **1-V3**, 1-V5 | Bench inundation to prevent terrestrial vegetation encroachment during the high flow season |
| Jun – Nov | High Flow Freshes<br>370 ML/d | 3 per period<br>(or natural) | 4 days<br>(or natural) | 1-M2, 1-M3, 1-M4, 1-F3, 1-F5, 1-F6, **1-P1**, 1-V4, 1-V5, 1-V6 | Channel velocity >1.5m/s for disturbance processes. |
| Late Spring | Bankfull Flow<br>3000 ML/d | 1 per 2 years<br>(or natural) | 1 day<br>(or natural) | **1-P1, 1-P6, 1-V5, 1-V7** | Bankfull flow at upstream cross-section providing a wetted riparian width greater than 20m |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- The ‘or natural’ qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.

**Table 3-3 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach One**

| Flow Component | Flow Recommendation | Natural occurrence of *value during period | Current occurrence of * value during period |
|---|---|---|---|
| Low Flow | 2 ML/d* or natural | 86% of time value is exceeded | 51% of time value exceeded |
| Low Flow Fresh | 20 ML/d*<br>(5/period, 4 day duration or natural) | 5 times per period, 6 day mean duration | 3 times per period, 6 day mean duration |
| High Flow | 20 ML/d* or natural | 78% of time value is exceeded | 65% of time value is exceeded |
| High Flow Fresh | 370 ML/d*<br>(3/period, 4 day duration or natural) | 6 times per period, 3 day mean duration | 6 times per period, 3 day mean duration |
| Bankfull | 3000 ML/d*<br>(1/2 years, 1 day duration or natural) | 26 events in 40 year period, 1 day mean duration | 24 events in 40 year period, 1 day mean duration |

## Reach Two – Deep Creek Mid Catchment

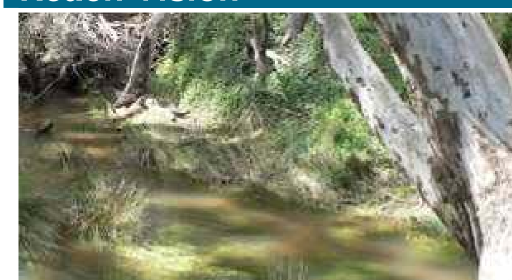
Reach 2 covers the middle reach of Deep Creek, downstream of Boyd Creek. Similar to upstream, this is an unregulated reach impacted by local extractions and farm dams. Agricultural impacts are greater in this reach in comparison to upstream.

The magnitude of low flows is reduced in Reach 2, and the occurrence of cease to flow periods increased. Water quality in these extended periods is a concern. The channel is incised and instream diversity is generally attributed to large woody debris. Riparian vegetation is dominated by native over-storey and a weedy under-storey, however instream vegetation diversity is good. Australian Grayling may be present in this reach.

## Key Values

- Good instream habitat and diversity (large wood)
- Potential habitat for Australian Grayling and Blackfish
- Good instream vegetation diversity
- Endangered EVC – Riparian Woodland

## Reach Vision



***An 'ecologically healthy' condition for the mid catchment of Deep Creek. Utilise the stream's incised form as a basis for protection of existing instream assets and enhancement of riparian values***

## Environmental Objectives

**Physical Form**

Provide suitable conditions to maintain channel morphology

**Aquatic Ecology and Water Quality**

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Restore self sustaining populations of Australian Grayling and Blackfish

Maintain water quality to ensure all environmental flow objectives are met

**Vegetation**

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

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

**Table 3-4 Flow Processes and Flow Components for Reach Two – Deep Creek Mid Catchment**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 2-M1 | Habitat availability (pool/run) | Low flow (inundation of channel substrate) | All year | Macroinvertebrate habitat availability |
| | | | | Low flow (median depth >0.1m over run) | | Fast flowing habitat available upstream of pool for macroinvertebrates |
| | | 2-M2 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | Any time | Habitat inundation variability |
| | | 2-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 2-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish.<br>Restore self sustaining populations of Australian Grayling and Blackfish. | 2-F1a | Habitat availability | Low flow (pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 2-F1b | | Low flow (pool depth >0.4m) | | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 2-F2a | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 2-F2b | | Low flow fresh (>0.2 m over shallowest point between pools, every 8 weeks) | | Localised fish movement between habitats (Australian Grayling, Blackfish) |
| | | 2-F3 | Spawning and migration trigger/ larval transport | Low flow fresh (duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 2-F4 | Regional scale migration | High flow (>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |
| | | | | High flow (>0.2 m over shallowest point) | Sep-Oct | Regional scale fish movement between habitats (Blackfish) leading up to the spawning season |
| | | 2-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 2-M3 | | |
| | | 2-F6 | Disturb habitat | High flow fresh | Jun-Nov | Pool habitat disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 2-Q1 | Flushing of pools | Low flow fresh (every 4-6 weeks) | Summer | No decline in water quality |
| Physical Form | Provide suitable conditions to maintain channel morphology | 2-P1 | Disturbance | High flow | Any time | Channel form maintained |
| | | | | Additional | | Maintain and disturb channel form |
| | | 2-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh | Any time | Accumulations of fine sediments removed. |
| | | | | High flow fresh (duration >3 days) | | Elevated flow with scour suitable for moving large cobble particles |
| | | 2-P3 | Scour biofilms, turning of bed sediments | High flow fresh (duration >3 days) | Any time | Bed sediment disturbed |
| | | 2-P4 | Prevent vegetation encroachment in channel | Refer to 2-V3 | | |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 2-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over riffle >0.1m) | | |
| | | 2-V2 | Instream habitat disturbance | Low flow fresh (bench wetting) | Summer/Autumn | Zonation of riparian vegetation communities |
| | | 2-V3 | Prevent vegetation encroachment in channel | High Flow | Winter/Spring | Inundation of main channel to prevent terrestrial vegetation encroachment |
| | Provide suitable conditions to enhance riparian vegetation abundance diversity | 2-V4 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment |
| | | 2-V5 | Riparian habitat disturbance | High flow fresh | Spring | Regeneration niches provided and riparian vegetation disturbed |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | and structure | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 2-V6 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 2-V7 | Stimulate regeneration of seed | Additional | Spring | Succession of endangered EVC 641 – Riparian Woodland |

# Reach Two Summary

### Table 3-5. Flow Recommendations for Reach Two – Deep Creek Mid Catchment

| River | | Deep Creek | | Reach | Reach 2 – Deep Creek Mid Catchment |
|---|---|---|---|---|---|
| Compliance Point | | Deep Creek @ Konagaderra | | Gauge No. | 230 107 |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec – May | Low Flow 3 ML/d (or natural) | Continuous | Continuous | **2-M1**, 2-M2, 2-F1b, 2-V1 | Inundation of channel substrate for macroinvertebrate habitat availability. |
| Dec - May | Low Flow Freshes 17 ML/d | 5 per period * (or natural) | 4 days (or natural) | 2-F2b, 2-F3, 2-Q1, 2-P2, **2-V2** | Bench wetting to prevent terrestrial vegetation from colonising on benches<br>* One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun – Nov | High Flow 70 ML/d (or natural) | Continuous | Continuous | 2-F3, 2-F4, 2-P1, **2-P4**, **2-V3**, 2-V6 | Inundation of channel up to location of change in bank vegetation to prevent vegetation encroachment. |
| Jun – Nov | High Flow Freshes 1000 ML/d | 3 per period (or natural) | 3 days (or natural) | 2-M2, **2-M3**, 2-M4, 2-F3, **2-F5**, 2-F6, 2-P2, 2-P3, 2-V4, 2-V5, 2-V6 | Upper bank wetting to entrain terrestrial carbon and woody debris. |
| Late Spring | Additional Flow 3800ML/d | 1 per year (or natural) | 2 days (or natural) | **2-P1, 2-V5, 2-V6** | Inundation of the internal floodplain to maintain channel form and provide suitable regeneration conditions for the endangered EVC – Riparian Woodland. |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- The ‘or natural’ qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.

### Table 3-6 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach Two

| Flow Component | Flow Recommendation | Natural occurrence of *value during period | Current occurrence of *value during period |
|---|---|---|---|
| Low Flow | 3 ML/d* or natural | 42% of time value is exceeded | 24% of time value exceeded |
| Low Flow Fresh | 17 ML/d*<br>(5/period, 4 day duration or natural) | 6 times per period, 10 day mean duration | 5 times per period, 7 day mean duration |
| High Flow | 70 ML/d* or natural | 56% of time value is exceeded | 48% of time value is exceeded |
| High Flow Fresh | 1000 ML/d*<br>(3/period, 3 day duration or natural) | 4 times per period, 2 day mean duration | 4 times per period, 2 day mean duration |
| Additional | 3800 ML/d*<br>(1/year, 2 day duration or natural) | 36 events in 40 year period, 1 day mean duration | 35 events in 40 year period, 1 day mean duration |

## Reach Three – Emu Creek

Emu Creek is an unregulated reach with irrigation extractions located centrally within the Deep Creek sub-catchment. There are two diversions in this catchment – diversion weir on Bolinda Creek to Romsey Reservoir and diversion weir on Main Creek to Wright and Forster reservoir). Tributaries include Dry Creek, Sandy Creek, Duck Hole Creek, Charlies Creek and Bolinda Creek. Some of the headwater tributaries (eg. Charlies Creek) form in the forested valleys of the Macedon Ranges, however Emu Creek is generally characterised by poor riparian vegetation and heavy grazing.

Emu Creek is subject to reduced low flow magnitude and duration. The bedrock controlled channel meanders across a confined floodplain. Water quality within pools is a key concern. Riparian vegetation is highly modified and prevalence of Spiny Rush indicates salinity.

## Key Values

- Instream vegetation
- Endangered EVC (Creekline Grassy Woodland)

## 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

Maintain sediment accession onto the floodplain

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Maintain water quality to ensure all environmental flow objectives are met

### Vegetation

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

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

**Table 3-7 Flow Processes and Flow Components for Reach Three – Emu Creek**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 3-M1 | Habitat availability (pool/run) | Low flow<br>(median depth >0.1m over run) | All year | Variety of habitats available for macroinvertebrates, from fast flowing habitat on runs to still pools |
| | | 3-M2 | LWD inundation (habitat) | Low flow<br>(lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh<br>(LWD submerged) | Any time | |
| | | 3-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into the river maintained |
| | | 3-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish | 3-F1 | Habitat availability | Low flow<br>(pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 3-F2 | Local movement between habitats | Low flow fresh<br>(>0.12 m over shallowest point between pools) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 3-F3 | Spawning trigger | High flow fresh<br>(duration >3 days) | Sep-Nov | Spawning trigger provided for resident fish species |
| | | 3-F4 | Entrain terrestrial carbon/woody debris on benches | Refer to 3-M3 | | |
| | | 3-F5 | Disturb habitat | High flow fresh<br>(median depth over riffle >0.2m) | Jun-Nov | Fish habitat disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 3-Q1 | Flushing of pools | Low flow fresh | Summer | No decline in water quality and/or no adverse impact on other environmental objectives |
| Physical Form | Provide suitable conditions to maintain channel morphology | 3-P1 | Disturbance | High flow | Any time | Channel form maintained |
| | | | | Additional | | Channel form disturbed and maintained |
| | | 3-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh<br>(duration >3 days) | Any time | Accumulations of fine sediments removed |
| | | | | High flow fresh | | |
| | | 3-P3 | Scour biofilms | High flow | Any time | |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | 3-P4 | Prevent vegetation encroachment in channel | Refer to 4-V3 | | |
| | Maintain sediment accession onto the floodplain | 3-P5 | Disturbance and deposition of sediment | Additional | Any time | Sediment disturbed and deposited on floodplain |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 3-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over run >0.1m) | | |
| | | 3-V2 | Instream habitat disturbance | Low flow fresh (bench wetting) | Summer/Autumn | Zonation of riparian vegetation communities |
| | Provide suitable conditions to restore riparian vegetation abundance diversity and structure | 3-V3 | Prevent vegetation encroachment in channel | High Flow | Winter/Spring | Inundation of main channel to prevent terrestrial vegetation encroachment |
| | | 3-V4 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment |
| | | 3-V5 | Riparian habitat disturbance | High flow fresh | Spring | Regeneration niches provided and riparian vegetation disturbed |
| | | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 3-V6 | Stimulate regeneration of seed | Additional | Spring | Succession of endangered EVC 68 Creekline Grassy Woodland |

# Reach Three Summary

### Table 3-8. Flow Recommendations for Reach Three – Emu Creek

| River | | Emu Creek | | Reach | Reach 3 – Emu Creek |
|---|---|---|---|---|---|
| Compliance Point | | Emu Creek @ Clarkfield | | Gauge No. | 230 101 |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec – May | Low Flow<br>6 ML/d<br>(or natural) | Continuous | Continuous | **3-M1**, 1-M2, 3-F1, 3-V1 | Median depth >0.1m over run to provide macroinvertebrate habitat and continual inundation of instream submerged vegetation. |
| Dec - May | Low Flow Freshes<br>14 ML/d | 6 per period<br>(or natural) | 4 days<br>(or natural) | **3-F2**, 3-Q1, 3-P2, 3-V2 | Shallowest point between pools >0.12m to provide local movement of small bodied fish species during the low flow period. |
| Jun – Nov | High Flow<br>14 ML/d (or natural) | Continuous | Continuous | 3-P1, 3-P3, **3-P4**, **3-V3** | Disturbance and prevention of terrestrial vegetation encroachment. |
| Jun – Nov | High Flow Freshes<br>50 ML/d | 6 per period<br>(or natural) | 3 days<br>(or natural) | 3-M2, 3-M3, 3-M4, 3-F3, 3-F4, 3-F5, **3-V4**, **3-V5** | Bench wetting and inundation of all vegetation in the low flow channel to provide regeneration niches and prevent terrestrial vegetation encroachment. |
| Late Spring | Additional Flow<br>1000ML/d | 1 per 2 years<br>(or natural) | 1 day<br>(or natural) | **3-P1, 3-P5, 3-V5, 3-V6** | Inundation of gross channel and internal floodplain unit for seed dispersal to support the regeneration of endangered EVC – Creekline Grassy Woodland. |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- The 'or natural' qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.

### Table 3-9 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach Three

| Flow Component | Flow Recommendation | Natural occurrence of * value during period | Current occurrence of * value during period |
|---|---|---|---|
| Low Flow | 6 ML/d* or natural | 47% of time value is exceeded | 20% of time value exceeded |
| Low Flow Fresh | 14 ML/d*<br>(6/period, 4 day duration or natural) | 7 times per period, 3 day mean duration | 3 times per period, 2 day mean duration |
| High Flow | 14 ML/d* or natural | 59% of time value is exceeded | 43% of time value is exceeded |
| High Flow Fresh | 50 ML/d*<br>(6/period, 3 day duration or natural) | 7 times per period, 4 day mean duration | 5 times per period, 4 day mean duration |
| Additional | 1000 ML/d*<br>(1/2 years, 1 day duration or natural) | 21 events in 40 year period, 1 day mean duration | 20 events in 40 year period, 1 day mean duration |

## Reach Four – Deep Creek Lower Catchment

The lower reach of Deep Creek encompasses the area downstream of Emu Creek through to the confluence with Jacksons Creek. This reach flows through agricultural land and is impacted by an increasing level of catchment urbanisation.

In lower Deep Creek, the current flow regime is characterised by a decrease in low flow magnitude in comparison to the natural regime. The channel in this reach is incised into granite bedrock. Water quality during the low flow period in this reach is not as critical due to a deeper pools in the incised channel. The riparian vegetation of the representative site is classed as the vulnerable Streambank Shrubland EVC.

## Key Values

- Vulnerable EVC (*Streambank Shrubland*)
- Habitat for Australian Grayling and Blackfish
- Provision of connectivity between Maribyrnong River and the large catchment areas of Deep Creek and Emu Creek

## Reach Vision

***An ecologically healthy reach that provides passage to upstream and downstream catchment areas.***

## Environmental Objectives

### Physical Form

Provide suitable conditions to maintain channel morphology

Maintain sediment accession onto the floodplain

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Restore self sustaining populations of Australian Grayling and Blackfish

Maintain water quality to ensure all environmental flow objectives are met

### Vegetation

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

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

## Table 3-10 Flow Processes and Flow Components for Reach 4 – Deep Creek Lower Catchment

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 4-M1 | Habitat availability (pool/run) | Low flow (median depth >0.1m in low flow channel of run) | All year | Variety of habitats available for macroinvertebrates, from fast flowing habitat on runs to still pools. |
| | | 4-M2 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | Any time | |
| | | 4-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 4-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish. Restore self sustaining populations of Australian Grayling and Blackfish | 4-F1a | Habitat availability | Low flow (pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 4-F1b | | Low flow (pool depth >0.4m) | | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 4-F2a | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 4-F2b | | Low flow fresh (>0.2 m over shallowest point between pools, every 8 weeks) | | Localised fish movement between habitats (Australian Grayling, Blackfish) |
| | | 4-F3 | Spawning and migration trigger/ larval transport | Low flow fresh (duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 4-F4 | Regional scale migration | High flow (>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |
| | | | | High flow (>0.2 m over shallowest point) | Sep-Oct | Regional scale fish movement between habitats (Blackfish) leading up to the spawning season |
| | | 4-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 4-M3 | | |
| | | 4-F6 | Disturb habitat | High flow fresh | Jun-Nov | Pool habitat disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 4-Q1 | Flushing of pools | Low flow fresh | Summer | No decline in current water quality and/or no adverse impact on other environmental objectives. |
| Physical Form | Provide suitable conditions to maintain channel morphology | 4-P1 | Disturbance | High flow | Any time | Channel form maintained during high flow period |
| | | | | Additional | | Channel form disturbed and maintained. |
| | | 4-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh (velocity >0.5m/s, duration >3 days) | Any time | Accumulations of fine sediments removed |
| | | | | High flow fresh (velocity >1m/s) | | |
| | | 4-P3 | Scour biofilms | High flow (average velocity over riffle >1.0m/s) | Any time | Biofilms scoured |
| | | 4-P4 | Prevent vegetation encroachment in channel | Refer to 4-V3 | | |
| | Maintain sediment accession onto the floodplain | 4-P5 | Disturbance and deposition of sediment | Additional (inundate internal floodplain) | Any time | Sediment disturbed and deposited on floodplain |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 4-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | 4-V2 | Instream habitat disturbance | Low flow fresh | Summer/Autumn | Zonation of riparian vegetation communities |
| | Provide suitable conditions to restore | 4-V3 | Prevent vegetation encroachment in channel | High Flow | Winter/Spring | Terrestrial species not present on benches |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | riparian vegetation abundance diversity and structure | 4-V4 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment, sediment deposited on benches. Variation of vegetation types up the bank of the channel. |
| | | 4-V5 | Riparian habitat disturbance | High flow fresh | Spring | Regeneration niches provided and riparian vegetation disturbed |
| | | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 4-V6 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 4-V7 | Stimulate regeneration of seed | Additional | Spring | Succession of vulnerable EVC – Streambank Shrubland present |

# Reach Four Summary

### Table 3-11. Flow Recommendations for Reach Four – Deep Creek Lower Catchment

| River | | Deep Creek | | Reach | Reach 4 – Deep Creek Lower Catchment |
|---|---|---|---|---|---|
| Compliance Point | | Deep Creek @ Bulla | | Gauge No. | 230 205 |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec – May | Low Flow 6 ML/d (or natural) | Continuous | Continuous | **4-M1**, 4-M2, 4-F1b, 4-V1 | Median depth >0.1m in low flow channel of run to provide macroinvertebrate habitat |
| Dec - May | Low Flow Freshes 100 ML/d | 3 per period * (or natural) | 4 days (or natural) | **4-F2b**, 4-F3, 4-Q1, 4-P2, 4-V2 | Shallowest point between pools >0.2m to provide local movement of Australian Grayling and Blackfish during the low flow season.<br>* One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun – Nov | High Flow 100 ML/d (or natural) | Continuous | Continuous | 4-F3, 4-F4, 4-P1, **4-P3**, 4-P4, 4-V3, 4-V6 | Average velocity over riffle >1.0m/s to scour biofilms and turn over sediment. |
| Jun – Nov | High Flow Freshes 1000 ML/d | 2 per period (or natural) | 4 days (or natural) | 4-M2, 4-M3, 4-M4, 4-F3, 4-F5, 4-F6, 4-P2, 4-V4, 4-V5, **4-V6** | Inundation of root zone of large trees to rehabilitate the health of large riparian vegetation |
| Late Spring | Additional Flow 4000 ML/d | 1 per year (or natural) | 2 days (or natural) | **4-P1, 4-P6, 4-V5, 4-V7** | Inundation of internal floodplain unit to support regeneration and rehabilitation of vulnerable EVC – Streambank Shrubland. |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2
- 10 day independence is recommended between events.
- The 'or natural' qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.

### Table 3-12 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach Four

| Flow Component | Flow Recommendation | Natural occurrence of * value during period | Current occurrence of * value during period |
|---|---|---|---|
| Low Flow | 6 ML/d* or natural | 84% of time value is exceeded | 50% of time value exceeded |
| Low Flow Fresh | 100 ML/d*<br>(3/period, 4 day duration or natural) | 3 times per period, 4 day mean duration | 2 times per period, 3 day mean duration |
| High Flow | 100 ML/d* or natural | 52% of time value is exceeded | 44% of time value is exceeded |
| High Flow Fresh | 1000 ML/d*<br>(2/period, 4 day duration or natural) | 4 times per period, 2.5 day mean duration | 3 times per period, 2.5 day mean duration |
| Additional | 4000 ML/d*<br>(1/ year, 2 day duration or natural) | 40 events in 40 year period, 1.6 day mean duration | 38 events in 40 year period, 1.6 day mean duration |

## Reach Five – Riddells Creek

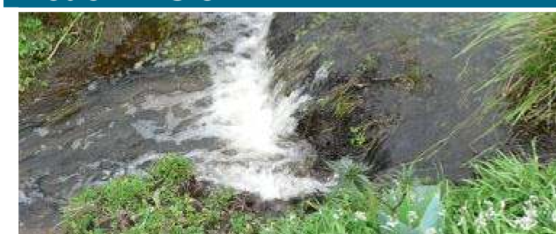
Riddells Creek rises in the forested upper reaches in the Macedon Ranges and discharges into Jacksons Creek. Major tributaries include Turitable Creek, Willimigongon Creek, Barringo Creek and Dry Creek. Flow in the creek flows through the township of Riddells Creek. There are a number of reservoirs and diversions in the catchment, including Diversion weir on Barringo Creek to Pierce Reservoir; Stoney Creek weir, Orde Hill Reservoir and Willimigongon Reservoir on Willimigongon Creek; Andersons and McDonalds reservoirs, and Chapman's and Gillespies weirs on Turitable Creek; Kitty English and Little Kitty English reservoirs on Riddells Creek.

The current flow regime of Riddells Creek is characterised by a decrease in high flows. The bedrock controlled channel form is dominated by a pool and cascade sequence. Depth of water in the reach is not the limiting factor during low flow events and therefore water quality is unlikely to be a key concern. Quality of instream vegetation is good, however the presence of willows has altered channel form and flow.

## Key Values

- High quality instream vegetation
- Connectivity with high quality, forested catchment areas upstream of the township of Riddells Creek
- Largely intact flow regime
- Remnant, endangered *Riparian Woodland* EVC

## Reach Vision



***An ecologically healthy unregulated reach providing high value instream and riparian habitat.***

## Environmental Objectives

## Physical Form

Provide suitable conditions to maintain channel morphology

Maintain sediment accession onto the floodplain

## Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Restore self sustaining populations of Australian Grayling and Blackfish (subject to provision of fish passage at downstream barriers)

Maintain water quality to ensure all environmental flow objectives are met

## Vegetation

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

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

**Table 3-13 Flow Processes and Flow Components for Reach 5 – Riddells Creek**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 5-M1 | Habitat availability (pool/run) | Low flow | All year | Macroinvertebrate habitat availability |
| | | 5-M2 | Habitat availability (riffle) | Low flow (median depth >0.1m over riffle) | All year | Fast flowing habitat available for macroinvertebrates |
| | | 5-M3 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | Jun-Nov | |
| | | 5-M4 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 5-M5 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish. Restore self sustaining populations of Australian Grayling and Blackfish | 5-F1a | Habitat availability | Low flow (pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 5-F1b | | Low flow (pool depth >0.4m) | All year | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 5-F2a | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 5-F2b | | Low flow fresh (>0.2 m over shallowest point between pools, every 8 weeks) | Dec-May | Localised fish movement between habitats (Australian Grayling, Blackfish) |
| | | 5-F3 | Spawning and migration trigger/ larval transport | Low flow fresh (duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 5-F4 | Regional scale migration | High flow (>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | High flow (>0.2 m over shallowest point) | Sep-Oct | Regional scale fish movement between habitats (Blackfish) leading up to the spawning season |
| | | 5-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 5-M4 | | |
| | | 5-F6 | Disturb habitat | High flow fresh | Jun-Nov | Fish habitat disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 5-Q1 | Flushing of pools | Low flow fresh | Summer | No decline in current water quality and/or no adverse impact on other environmental objectives. |
| Physical Form | Provide suitable conditions to maintain channel morphology | 5-P1 | Disturbance | High flow | Any time | Channel form maintained |
| | | | | Additional | | Channel form disturbed and maintained |
| | | 5-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh (duration >3 days) | Any time | Accumulations of fine sediments removed |
| | | | | High flow fresh (>0.5m/s) | Winter/Spring | |
| | | 5-P3 | Scour biofilms | High flow | Winter/Spring | Biofilms scoured |
| | | 5-P4 | Prevent vegetation encroachment in channel | Refer to 5-V3 | | |
| | Maintain sediment accession onto the floodplain | 5-P5 | Disturbance and deposition of sediment | Additional | Any time | Sediment disturbed and deposited on floodplain |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 5-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over riffle >0.1m) | | |
| | | 5-V2 | Instream habitat disturbance | Low flow fresh (bench wetting) | Summer/Autumn | Regeneration of instream vegetation communities |
| | Provide suitable conditions to restore riparian vegetation abundance diversity and structure | 5-V2 | Prevent vegetation encroachment in channel | High Flow | Winter/Spring | Terrestrial vegetation not present in channels |
| | | 5-V3 | Habitat inundation – provision of moisture to benches | High flow fresh (>0.1m depth over bench) | Spring | Vegetation establishment and delivery of seed from upper catchment |
| | | 5-V4 | Riparian habitat disturbance | High flow fresh | Spring | Regeneration niches provided and riparian vegetation disturbed. |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 5-V5 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 5-V6 | Stimulate regeneration of seed | Additional | Spring | Succession of endangered EVC641 – Riparian Woodland species |

# Reach Five Summary

**Table 3-14. Flow Recommendations for Reach Five – Riddells Creek**

| River | | Riddells Creek | | Reach | Reach 5 – Riddells Creek |
|---|---|---|---|---|---|
| Compliance Point | | Riddells Creek @ Riddells Creek | | Gauge No. | 230 204 |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec – May | Low Flow 2 ML/d (or natural) | Continuous | Continuous | 5-M1, **5-M2**, 5-M3, 5-F1b, 5-V1 | Depth over riffle >0.1m to provide habitat for macroinvertebrates. |
| Dec -May | Low Flow Freshes 10 ML/d | 6 per period * (or natural) | 5 days (or natural) | **5-F2b**, 5-F3, 5-Q1, 5-P2, 5-V2 | Shallowest point over riffle >0.2m to provide local movement of Australian Grayling and Blackfish during the low flow period.<br>* One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun, Sep - Oct | High Flow 10 ML/d (or natural) | Continuous | Continuous | 5-F3, **5-F4**, 5-P1, 5-P3, 5-P4, 5-V3, 5-V6 | Shallowest point over riffle >0.2m to provide regional scale movement between habitats for Australian Grayling and Blackfish |
| Jul – Aug, Nov | High Flow 5 ML/d (or natural) | Continuous | Continuous | 5-P1, 5-P3, **5-P4**, **5-V3**, 5-V6 | Bench wetting to prevent terrestrial vegetation encroachment and inundate instream vegetation. |
| Jun – Nov | High Flow Freshes 80 ML/d | 6 per period (or natural) | 3 days (or natural) | 5-M3, 5-M4, 5-M5, 5-F3, 5-F5, 5-F6, **5-P2**, 5-V4, 5-V5, 5-V6 | Velocity approx 0.5m/s in riffle cross section to disturb channel substrate |
| Late Spring | Additional Flow 400 ML/d | 2 per year (or natural) | 1 day (or natural) | **5-P1, 5-P5, 5-V5, 5-V7** | Inundation of the flood channel to promote seed dispersal and regeneration of endangered EVC – Riparian Woodland. |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2
- 10 day independence is recommended between events.
- 'or natural' qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.
- Achievement of the environmental objective for self sustaining populations of Australian Grayling in this reach is contingent on the provision of fish passage at the Salesian College weir and the Old Flour Mill Bluestone weir.

**Table 3-15 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach Five**

| Flow Component | Flow Recommendation | Natural occurrence of * value during period | Current occurrence of * value during period |
|---|---|---|---|
| Low Flow | 2 ML/d* | 71% of time value is exceeded | 55% of time value exceeded |
| Low Flow Fresh | 10 ML/d* (6/period, 5 day duration) | 6 times per period, 6 day mean duration | 5 times per period, 4 day mean duration |
| High Flow | 10 ML/d* | June: 73% of time value is exceeded | June: 36% of time value is exceeded |
| | | September: 90% of time value is exceeded | September: 76% of time value is exceeded |
| | | October: 77% of time value is exceeded | October: 63% of time value is exceeded |
| | 5ML/d* | July: 96% of time value is exceeded | July: 71% of time value is exceeded |
| | | August: 97% of time value is exceeded | August: 85% of time value is exceeded |
| | | November: 77% of time value is exceeded | November: 67% of time value is exceeded |
| High Flow Fresh | 80 ML/d* (6/period, 3 day duration) | 6 times per period, 3 day mean duration | 3 times per period, 3 day mean duration |
| Additional | 400 ML/d* (2/year, 1 day duration) | 91 events in 40 year period, 1.7 day mean duration | 59 events in 40 year period, 1.6 day mean duration |

## Reach Six – Jacksons Creek Upper Catchment

Rosslynne Reservoir is located at the upstream boundary of Reach 6 – Jacksons Creek Upper Catchment. The reach extends from the reservoir to the confluence with Riddells Creek. The reservoir and its associated spillway provide a significant barrier to fish migration and sediment movement. This reach is characterised by poor continuity of riparian vegetation and is modified in urban areas (Gisborne).

Willows dominate the reach, impacting on physical form, water quality and aquatic habitat.

There is a significant seasonal reversal of flows experienced in Reach 6 due to the presence of the reservoir. Prior to the commissioning of Rosslynne Reservoir in 1973, this reach experienced extended periods of cease to flow. Since then, baseflow has been continuously maintained downstream of the reservoir. Due to continuing irrigation releases from the reservoir, Jacksons Creek will continue to operate in this manner and the vision for the reach reflects this operational requirement.

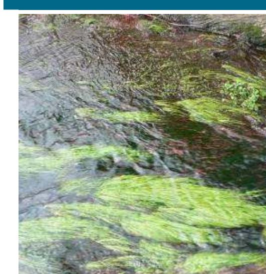
## Key Values

- Water supply - Rosslynne Reservoir
- Vulnerable EVC – Streambank Shrubland

## Reach Vision

***A reach that is remediated over time to achieve an ecologically healthy permanent stream, recognising the presence and influence of Rosslynne Reservoir.***

## Environmental Objectives



### Physical Form

Provide suitable conditions to remediate channel morphology

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Restore self sustaining populations of Australian Grayling and Blackfish (subject to provision of fish passage at downstream barriers)

Remediate water quality to meet environmental objectives of a permanent stream

### Vegetation

Provide suitable conditions to remediate instream vegetation abundance, diversity and structure

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

**Table 3-16 Flow Processes and Flow Components for Reach Six – Jacksons Creek Upper Catchment**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 6-M1 | Habitat availability (pool/run) | Low flow (median depth >0.1m over run) | All year | Variety of habitats available for macroinvertebrates, from fast flowing habitat on runs to still pools. |
| | | 6-M2 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | | |
| | | 6-M3 | Entrain terrestrial carbon/woody debris | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 6-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish.<br>Restore self sustaining populations of Australian Grayling and Blackfish. | 6-F1a | Habitat availability | Low flow (pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 6-F1b | | Low flow (pool depth >0.4m) | | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 6-F2a | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 6-F2b | | Low flow fresh (>0.2 m over shallowest point between pools, every 8 weeks) | | Localised fish movement between habitats (Australian Grayling, Blackfish) |
| | | 6-F3 | Spawning and migration trigger/ larval transport | Low flow fresh (duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 6-F4 | Regional scale migration | High flow (>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | High flow (>0.2 m over shallowest point) | Sep-Oct | Regional scale fish movement between habitats (Blackfish) leading up to the spawning season |
| | | 6-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 6-M3 | | |
| | | 6-F6 | Disturb habitat | High flow fresh | Jun-Nov | Pool habitat disturbed |
| Water Quality | Remediate water quality to meet environmental objectives | 6-Q1 | Flushing of pools | Low flow fresh (every 4-6 weeks) | Dec-May | No decline in current water quality and/or no adverse impact on other environmental objectives. |
| Physical Form | Provide suitable conditions to remediate channel morphology | 6-P1 | Disturbance | High flow | Any time | Channel form maintained |
| | | | | Additional | | Channel form disturbed and maintained |
| | | 6-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh | Any time with sufficient duration | Accumulations of fine sediments removed |
| | | | | High flow fresh (velocity >1m/s) | | |
| | | 6-P3 | Scour biofilms | High flow | Any time | Biofilms scoured |
| | | 6-P4 | Prevent vegetation encroachment in channel | Refer to 6-V2 | | |
| Vegetation | Provide suitable conditions to remediate instream vegetation abundance, diversity and structure | 6-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over run >0.1m) | | |
| | | 6-V2 | Instream habitat disturbance | Low flow fresh | Summer/Autumn | Regeneration of instream vegetation communities |
| | Provide suitable conditions to rehabilitate riparian vegetation abundance diversity and structure | 6-V3 | Prevent vegetation encroachment in channel | High Flow (bench wetting) | Winter/Spring | Terrestrial vegetation not present in channels |
| | | 6-V4 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment, sediment deposited on benches. Variation of vegetation types up the bank of the channel |
| | | 6-V5 | Riparian habitat disturbance | High flow fresh (>0.1m depth over bench) | Any time | Regeneration niches provided and riparian vegetation disturbed. |
| | | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | 6-V6 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 6-V7 | Stimulate regeneration of seed | Additional | Any time | Succession of vulnerable EVC – Streambank Shrubland species present. |

# Reach Six Summary

**Table 3-17. Flow Recommendations for Reach Six – Jacksons Creek Upper Catchment**

| River | | Jacksons Creek | | Reach | Reach 6 – Jacksons Creek Upper Catchment |
|---|---|---|---|---|---|
| Compliance Point | | Jacksons Creek @ Gisborne | | Gauge No. | 230 206C |
| Flow | | | | Rationale | |
| Period | Magnitude | Frequency | Duration | Objectives | Evaluation |
| Dec –May | Low Flow<br>4 ML/d | Continuous | Continuous | **6-M1**, 6-M2, 6-F1b, 6-V1 | Median depth over riffle >0.1m to provide macroinvertebrate habitat and instream vegetation inundation. |
| Dec – May | Low Flow Freshes<br>15 ML/d | 5 per period * | 4 days | 6-F2b, 6-F3, **6-Q1**, 6-P2, **6-V2** | Bench wetting to provide regeneration niches for the rehabilitation of riparian vegetation. Occurs every 4-6 weeks to refresh water quality in pools.<br>* One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun – Nov | High Flow<br>15 ML/d | Continuous | Continuous | 6-F3, 6-F4, 6-P1, 6-P3, **6-P4, 6-V3**, 6-V6 | Bench wetting to prevent terrestrial vegetation encroachment and rehabilitate channel form. |
| Jun – Nov | High Flow Freshes<br>200# ML/d | 3 per period | 3 days | 6-M2, 6-M3, 6-M4, 6-F3, 6-F5, 6-F6, **6-P2**, 6-V4, **6-V5**, 6-V6 | Full bench inundation (Figure 3-1) for substrate scour and to provide regeneration niches for riparian vegetation. |
| Late Spring | Additional Flow<br>1400# ML/d | 1 per year | 1 day | **6-P1, 6-V5, 6-V7** | Inundation of internal floodplain unit for regeneration of vulnerable EVC – Streambank Shrubland |

NOTES:

- # Due to current limitations of storage infrastructure these flows cannot be met. Currently the reservoir is capable of releasing approximately 30 ML/day.
- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- Achievement of the environmental objective for self sustaining populations of Australian Grayling in this reach is contingent on the provision of fish passage at the Salesian College weir and the Old Flour Mill Bluestone weir.

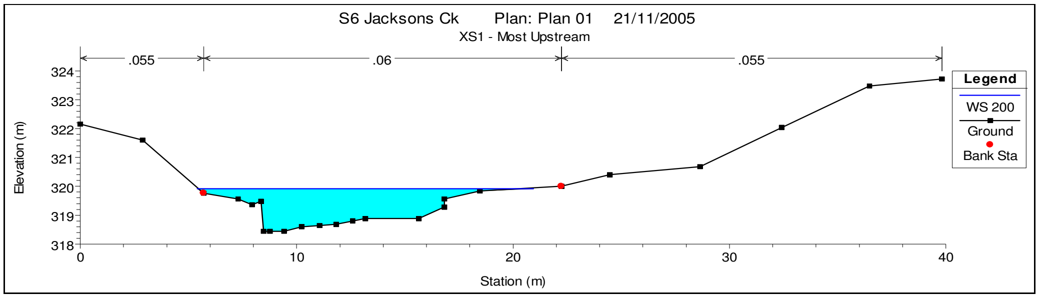



**Figure 3-1 Recommended High Flow Fresh at Cross-section 376**

**Table 3-18 Comparison of Flow Recommendations to Current Flow Regime – Reach Six**

| Flow Component | Flow Recommendation | Current occurrence of * value during period |
|---|---|---|
| Low Flow | 4 ML/d* | 83% of time value exceeded |
| Low Flow Fresh | 15 ML/d*<br>(5/period, 4 day duration) | 2 times per period, 7 day mean duration |
| High Flow | 15 ML/d* | 31% of time value is exceeded |
| High Flow Fresh | 200 ML/d*<br>(3/period, 3 day duration) | 1 time per period, 3 day mean duration |
| Additional | 1400 ML/d*<br>(1/ year, 1 day duration) | 21 events in 40 year period, 1.5 day mean duration |

NOTE:

- Comparison to natural flow regime is not demonstrated as the flow recommendations are based on a deviation from natural ephemeral conditions to a permanent stream.

## Reach Seven – Jacksons Creek Lower Catchment

Reach 7 encompasses the lower reach of Jacksons Creek from Riddells Creek to the confluence with Deep Creek. Tributaries include Longview Creek, Kismet Creek and Blind Creek. Lower Jacksons Creek is a regulated reach due to Rosslynne Reservoir. Water quality in this reach is generally degraded due to agricultural practices and urbanisation. Prior to meeting Deep Creek to form the Maribyrnong River, Jacksons Creek flows through the Organs Pipes National Park.

The impact of Rosslynne Reservoir on flows in Reach 7 decreased from upstream reach due to significant inflows from major and minor tributaries. Channel modifications in urban areas are evident. Physical form generally consists of a pool/riffle sequence. Water quality during low flow periods is a key concern. Remnants of endangered EVC are present and require flooding for regeneration.

*Note: the site analysed for the flow recommendations was approximately 2km upstream of the site described in the Issues Paper. This move was due to access issues. The site chosen was sufficiently homogeneous to the site described in the Issues Paper.*

## Key Values

- Vulnerable EVC – Streambank Shrubland
- Water supply for surrounding agriculture and townships

## Reach Vision

***An ecologically healthy 'working' reach that provides sustainable habitat connectivity and protection of existing ecological values.***

## Environmental Objectives

### Physical Form

Provide suitable conditions to maintain channel morphology

Maintain sediment accession onto the floodplain

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Restore self sustaining populations of Australian Grayling and Blackfish (subject to provision of fish passage at downstream barriers)

Maintain water quality to ensure all environmental flow objectives are met

### Vegetation

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

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

## Table 3-19 Flow Processes and Flow Components for Reach 7 – Jacksons Creek Lower Catchment

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 7-M1 | Habitat availability (pool/riffle) | Low flow<br>(median depth >0.1m over riffle) | All year | Variety of habitats available for macroinvertebrates, from fast flowing habitat on runs to still pools. |
| | | 7-M2 | LWD inundation (habitat) | Low flow<br>(lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh<br>(LWD submerged) | | |
| | | 7-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 7-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish.<br>Restore self sustaining populations of Australian Grayling and Blackfish | 7-F1a | Pool habitat availability | Low flow<br>(pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 7-F1b | | Low flow<br>(pool depth >0.4m) | | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 7-F2a | Local movement between habitats | Low flow fresh<br>(>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement between habitats (small bodied fish) |
| | | 7-F2b | | Low flow fresh<br>(>0.2 m over shallowest point between pools, every 8 weeks) | | Localised fish movement between habitats (Australian Grayling, Blackfish) |
| | | 7-F3 | Spawning and migration trigger/ larval transport | Low flow fresh<br>(duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 7-F4 | Regional scale migration | High flow<br>(>0.12 m over shallowest point) | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | | Sep-Oct | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |
| | | | | High flow (>0.2 m over shallowest point) | Sep-Oct | Regional scale fish movement with complete connectivity between habitats (Blackfish) leading up to the spawning season |
| | | 7-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 7-M3 | | |
| | | 7-F6 | Disturb habitat | High flow fresh | Jun-Nov | Pools disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 7-Q1 | Flushing of pools | Low flow fresh | Summer | No decline in current water quality and/or no adverse impact on other environmental objectives. |
| Physical Form | Provide suitable conditions to maintain channel morphology | 7-P1 | Disturbance | High flow | Any time | Channel form maintained |
| | | | | Additional | | Channel form disturbed and maintained |
| | | 7-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh | Any time with sufficient duration | Accumulations of fine sediments removed |
| | | | | High flow fresh | | |
| | | 7-P3 | Scour biofilms | High flow | Any time | Biofilms scoured |
| | | 7-P4 | Prevent vegetation encroachment in channel | Refer to 7-V2 | | |
| | Maintain sediment accession onto the floodplain | 7-P5 | Disturbance and deposition of sediment | Additional | Any time | Sediment disturbed and deposited on the floodplain |
| Vegetation | Provide suitable conditions to maintain instream vegetation abundance, diversity and structure | 7-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | All year | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over riffle >0.1m) | | |
| | | 7-V2 | Instream habitat disturbance | Low flow fresh (bench wetting) | Summer/Autumn | Regeneration of instream vegetation communities |
| | Provide suitable conditions to rehabilitate | 7-V2 | Prevent vegetation encroachment in channel | High Flow (depth >0.4m at pool edge) | Winter/Spring | No increase in phragmites encroachment |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | riparian vegetation abundance diversity and structure | 7-V3 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment, sediment deposited on benches. Variation of vegetation types up the bank of the channel. |
| | | 7-V4 | Riparian habitat disturbance | High flow fresh (bench wetting) | Spring | Regeneration niches provided |
| | | | | Additional | | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 7-V5 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 7-V6 | Simulate regeneration of seed | Additional | Spring | Succession of vulnerable EVC – Streambank Shrubland present |

# Reach Seven Summary

**Table 3-20. Flow Recommendations for Reach Seven – Jacksons Creek Lower Catchment**

| **River** | | **Jacksons Creek** | | **Reach** | **Reach 7 – Jacksons Creek Lower Catchment** |
|---|---|---|---|---|---|
| **Compliance Point** | | **Jacksons Creek @ Sunbury** | | **Gauge No.** | **230 202** |
| **Flow** | | | | **Rationale** | |
| **Period** | **Magnitude** | **Frequency** | **Duration** | **Objectives** | **Evaluation** |
| Dec – May | Low Flow 6ML/d (or inflows) | Continuous | Continuous | **7-M1**, 7-M2, 7-F1b, 7-V1 | Depth over riffle >0.1m to provide habitat for macroinvertebrates and instream vegetation. |
| Dec – May | Low Flow Freshes 17 ML/d (or inflows) | 5 per period * | 4 days | **7-F2b**, 7-F3, 7-Q1, 7-P2, 7-V2 | Shallowest point between pools >0.2m to provide local movement opportunities for Australian Grayling and Blackfish. * One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun – Nov | High Flow 40 ML/d (or inflows) | Continuous | Continuous | 7-F3, 7-F4, 7-P1, 7-P3, **7-P4, 7-V3**, 7-V6 | Depth >0.4m at edge of pools to prevent encroachment of phragmites (Figure 3-2). |
| Jun – Nov | High Flow Freshes 250 ML/d (or inflows) | 3 per period | 3 days | 7-M2, 7-M3, 7-M4, 7-F3, 7-F5, 7-F6, 7-P2, 7-V4, **7-V5**, 7-V6 | Bench inundation to maintain channel and disturb vegetation. |
| Late Spring | Additional Flow 1400 ML/d | 1 per year | 1 day | **7-P1, 7-P5, 7-V5, 7-V7** | Inundation of internal floodplain unit to support regeneration of vulnerable EVC Streambank Shrubland |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- Achievement of the environmental objective for self sustaining populations of Australian Grayling in this reach is contingent on the provision of fish passage at the Salesian College weir and the Old Flour Mill Bluestone weir.
- 'Or inflows' refers to the combination of complying inflows from reaches 5 and 6. This recognises the operational implications of meeting flow recommendations while preserving the ecological assets in reach 7.

**Figure 3-2 Phragmites encroachment at Reach 7 Representative Site**

**Table 3-21 Comparison of Flow Recommendations to Current Flow Regime – Reach Seven**

| Flow Component | Flow Recommendation | Current occurrence of * value during period |
|---|---|---|
| Low Flow | 6 ML/d* (or inflows) | 90% of time value exceeded |
| Low Flow Fresh | 17 ML/d* (or inflows)<br>(5/period, 4 day duration) | 7 times per period, 8 day mean duration |
| High Flow | 40 ML/d* (or inflows) | 48% of time value is exceeded |
| High Flow Fresh | 250 ML/d* (or inflows)<br>(3/period, 3 day duration) | 3 times per period, 4 day mean duration |
| Additional | 1400 ML/d*<br>(1/ year, 1 day duration) | 56 events in 40 year period, 2 day mean duration |

NOTE:

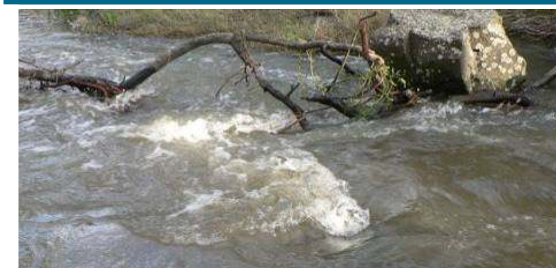
- Comparison to natural flow regime is not demonstrated as the flow recommendations are based on a deviation from natural ephemeral conditions to a permanent stream.

## Reach Eight – Maribyrnong River Freshwater Reach

Reach 8 encompasses the freshwater reach of the Maribyrnong River downstream of the Jacksons Creek/Deep Creek confluence. This reach flows through market garden areas near Keilor and the catchment is subject to increasing levels of urbanisation. Major tributaries Arundel Creek and Taylors Creek flow into the Maribyrnong in this reach. The headwaters of the Arundel creek originate in the Tullamarine Airport area.

Seasonality of the natural flow regime is preserved under current conditions in the freshwater reach of the Maribyrnong River. A small decrease in all flow components is evident in this reach. There is no evidence of urbanisation impacting on the physical form of the channel at the representative site, however this would be more likely to occur further downstream of the site. Australian Grayling is potentially present in this reach. Water quality, especially during low flow periods is a key concern. Riparian vegetation community at the representative site is the endangered *Floodplain Riparian Woodland* which requires periodic flooding to trigger vegetation recruitment.

## Key Values



- Endangered flow dependent EVC - Floodplain Riparian Woodland
- Australian Grayling, Blackfish
- Connection with estuary
- Social connection with intensive urban development

## Reach Vision

***Recognising its proximity to high intensity urban development, the reach will be managed as a crucial link to upstream waterways and the estuary downstream.***

## Environmental Objectives


### Physical Form

Provide suitable conditions to maintain channel morphology

Maintain sediment accession onto the floodplain

### Aquatic Ecology and Water Quality

Maintain self sustaining populations of small bodied fish and macroinvertebrates

Rehabilitate self sustaining populations of Australian Grayling and Blackfish

Maintain fish passage

Maintain water quality to ensure all environmental flow objectives are met

### Vegetation

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

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

**Table 3-22 Flow Processes and Flow Components for Reach 8 – Maribyrnong River Freshwater Reach**

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| Macroinvertebrates | Maintain self sustaining populations of macroinvertebrates | 8-M1 | Habitat availability (pool/run) | Low flow (median depth >0.1m over run) | All year | Variety of habitats available for macroinvertebrates, from fast flowing habitat on runs to still pools. |
| | | 8-M2 | LWD inundation (habitat) | Low flow (lower parts of LWD inundated) | All year | Habitat inundation variability provided for macroinvertebrates |
| | | | | High flow fresh (LWD submerged) | | |
| | | 8-M3 | Entrain terrestrial carbon/woody debris on benches | High flow fresh | Jun-Nov | Carbon/litter cycling into stream maintained |
| | | 8-M4 | Disturb habitat | High flow fresh | Jun-Nov | Macroinvertebrate habitat disturbed |
| Fish | Maintain self sustaining populations of small bodied fish.<br>Rehabilitate self sustaining populations of Australian Grayling and Blackfish.<br>Maintain fish passage. | 8-F1a | Pool habitat availability | Low flow (pool depth >0.2m) | All year | Pool habitat available for small bodied fish during low flow period |
| | | 8-F1b | | Low flow (pool depth >0.4m) | All year | Pool habitat available for Australian Grayling and Blackfish during low flow period |
| | | 8-F2a | Local movement between habitats | Low flow fresh (>0.12 m over shallowest point between pools, every 4-6 weeks) | Dec-May | Local movement of resident fish species between habitats (small bodied fish) |
| | | 8-F2b | | Low flow fresh (>0.2 m over shallowest point between pools, every 8 weeks) | Dec-May | Local movement of resident fish species between habitats (Australian Grayling, Blackfish) |
| | | 8-F3 | Spawning and migration trigger/ larval transport | Low flow fresh (duration >3 days) | Apr-May | Spawning trigger for Australian Grayling |
| | | | | High flow | May-Jun | Regional scale Australian Grayling larval transport |
| | | | | High flow fresh | Sep-Nov | Spawning trigger for small bodied resident fish species |
| | | 8-F4 | Regional scale migration | High flow (>0.12 m over shallowest | June | Regional scale movement between habitats (small bodied fish) following the Low Flow season |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | | | | point) | Jul-Nov | Regional scale fish movement between habitats (small bodied fish) leading up to the spawning season |
| | | | | High flow (>0.2 m over shallowest point) | Jun-Nov | Regional scale fish movement with complete connectivity between habitats (Blackfish) leading up to the spawning season |
| | | 8-F5 | Entrain terrestrial carbon/woody debris on benches | Refer to 8-M3 | | |
| | | 8-F6 | Disturb habitat | High flow fresh | Jun-Nov | Fish habitat (pools) disturbed |
| Water Quality | Maintain water quality to ensure all environmental flow objectives are met | 8-Q1 | Flushing of pools | Low flow fresh | Summer | No decline in current water quality and/or no adverse impact on other environmental objectives. |
| Physical Form | Provide suitable conditions to maintain channel morphology | 8-P1 | Disturbance | High flow | Any time | Channel form maintained continuously during high flow period |
| | | | | Additional | | Channel form disturbed and maintained |
| | | 8-P2 | Substrate scour to remove accumulations of fine sediment | Low flow fresh | Any time with sufficient duration | Accumulations of fine sediments removed |
| | | | | High flow fresh (velocity >1.5 m/s) | | |
| | | 8-P3 | Scour biofilms | High flow | Any time | Biofilms scoured |
| | | 8-P4 | Prevent vegetation encroachment in channel | Refer to 8-V3 | | |
| | Maintain sediment accession onto the floodplain | 8-P5 | Disturbance and deposition of sediment | Additional | Any time | Sediment disturbed and deposited on floodplain |
| Vegetation | Provide suitable conditions to rehabilitate instream vegetation abundance, diversity and structure | 8-V1 | Instream habitat inundation | Low flow (pool depth >0.2m) | Summer/Autumn | Continual inundation of instream submerged vegetation for survival |
| | | | | Low flow (depth over run >0.1m) | | |
| | | 8-V2 | Instream habitat disturbance | Low flow fresh (bench wetting) | Any time (with natural rate of rise and fall) | Regeneration of diverse instream vegetation communities |
| | Provide suitable conditions to | 8-V3 | Prevent terrestrial vegetation encroachment | High Flow | Winter/Spring | Terrestrial vegetation not present in channel or benches. |

| Asset | Environmental Objective | No. | Flow Process/Function | Flow Component | Timing | Expected Response |
|---|---|---|---|---|---|---|
| | rehabilitate riparian vegetation abundance diversity and structure | 8-V4 | Riparian habitat inundation | High flow fresh (>0.1m depth over bench) | Winter/Spring | Vegetation establishment and delivery of seed from upper catchment, sediment deposited on benches. Variation of vegetation types up the bank of the channel. |
| | | 8-V5 | Riparian habitat disturbance | High flow fresh (bench inundation) | Spring | Regeneration niches provided and riparian vegetation disturbed. |
| | | | | Additional | Spring | Restore disturbance processes ensuring vegetation diversity and structure. |
| | | 8-V6 | Watering of canopy tree root zone | High flow | Any time | Prolonged/continuous provision of water to root zone of large trees, enhancing the health of large riparian vegetation |
| | | | | High flow fresh | | Periodic inundation of root zone of large trees, enhancing the health of large riparian vegetation |
| | | 8-V7 | Stimulate regeneration of seed | Additional | Spring | Succession of Endangered EVC – Floodplain Riparian Woodland species present. |

# Reach Eight Summary

**Table 3-23. Flow Recommendations for Reach Eight – Maribyrnong River Freshwater Reach**

| River | | Maribyrnong River | | Reach | Reach 8 – Maribyrnong River Freshwater Reach |
|---|---|---|---|---|---|
| **Compliance Point** | | **Maribyrnong River @ Keilor** | | **Gauge No.** | **230 200** |
| **Flow** | | | | **Rationale** | |
| **Period** | **Magnitude** | **Frequency** | **Duration** | **Objectives** | **Evaluation** |
| Dec – May | Low Flow 30 ML/d (or natural) | Continuous | Continuous | **8-M1**, 8-M2, 8-F1b, 8-V1 | Depth greater than 0.1m over run to provide habitat for macroinvertebrates |
| Dec - May | Low Flow Freshes 100 ML/d | 3 per period * (or natural) | 4 days (or natural) | 8-F2b, **8-F3**, 8-Q1, 8-P2, 8-V2, | Depth over the shallowest point between pools >0.2m providing periodic local fish passage during low flow period. * One low flow fresh required during April-May as a spawning trigger for Australian Grayling. |
| Jun – Nov | High Flow 100 ML/d (or natural) | Continuous | Continuous | 8-F3, **8-F4**, 8-P1, 8-P3, 8-P4, 8-V3, 8-V6 | Depth over the shallowest point between pools >0.2m providing fish passage throughout the entire high flow period. |
| Jun – Nov | High Flow Freshes 800 ML/d | 2 per period (or natural) | 4 days (or natural) | 8-M2, 8-M3, 8-M4, 8-F3, 8-F5, 8-F6, 8-P2, 8-V4, 8-V5, **8-V6** | Inundation of benches and root zone to enhance the health of large canopy trees. |
| Late Spring | Additional Flow 9600 ML/d | 1 per 2 years (or natural) | 1 day (or natural) | **8-P1, 8-P5, 8-V5, 8-V7** | Inundation of the internal floodplain unit (Figure 3-3) to maintain channel form and provide suitable regeneration conditions for endangered EVC – Floodplain Riparian Woodland. |

NOTES:

- Objective number shown in **bold** relates to the controlling criteria for the flow component
- Rates of rise and fall as identified in Table 2-2.
- 10 day independence is recommended between events.
- The ‘or natural’ qualification on low flow recommendation will ensure natural cease to flow frequency and duration in this reach.

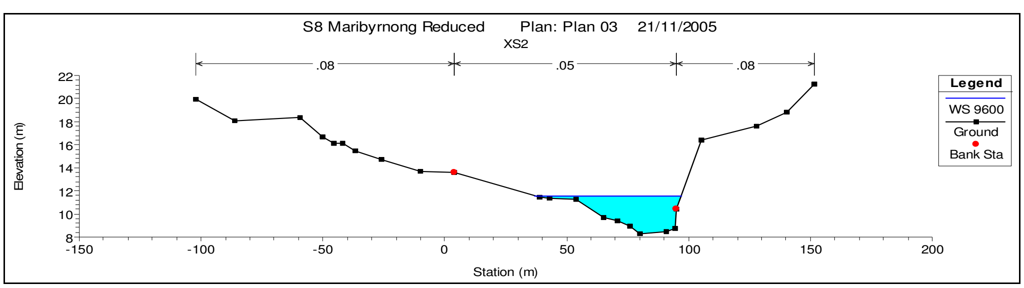



**Figure 3-3 Recommended Bankfull Flow at Cross-section 6633**

**Table 3-24 Comparison of Flow Recommendations to Current and Natural Flow Regimes – Reach Eight**

| Flow Component | Flow Recommendation | Natural occurrence of * value during period | Current occurrence of * value during period |
|---|---|---|---|
| Low Flow | 30 ML/d* or natural | 43% of time value is exceeded | 32% of time value exceeded |
| Low Flow Fresh | 100 ML/d* (3/period, 4 day duration or natural) | 3 times per period, 5 day mean duration | 2 times per period, 4 day mean duration |
| High Flow | 100 ML/d* or natural | 61% of time value is exceeded | 53% of time value is exceeded |
| High Flow Fresh | 800 ML/d* (2/period, 4 day duration or natural) | 5 times per period, 4 day mean duration | 5 times per period, 4 day mean duration |
| Additional | 9600 ML/d* (1/2 years, 1 day duration or natural) | 23 events in 40 year period, 1 day mean duration | 17 events in 40 year period, 1 day mean duration |

## 3.1 Estuary Recommendations

A temperate, drowned river valley estuary, the Maribyrnong is permanently open to Port Phillip Bay through a largely unconstricted, but highly modified mouth (Digby et al. 1999). With inputs from both tidal inundation and terrestrial runoff, the main drainage line is an unbranched channel with branching terminal drainage lines. The Yarra and Maribyrnong rivers together represent the greatest source of freshwater input to Port Phillip Bay and drain 56% of the total catchment area (Beckett, 1982).

The estuary is influenced substantially by the Canning Street ford, which largely restricts the landward incursion tides and potentially mediates the impacts of freshwater flows. These restrictions result in an estuarine system that is dominated by a combination of tides and wind. During low flow conditions tidal processes dominate, with local wind conditions playing an import role in the stratification of the system. In high flow conditions the system is more flow dominated, however the transition point from flow to tide domination is unknown.

The current form of the Maribyrnong estuary bears little resemblance to its natural form. During the second half of the nineteenth century, the area adjacent to the river and estuary was developed into the '*central powerhouse of Melbourne's industrial wealth*' (Maribyrnong City Council, 2003). During this period, the Maribyrnong River became an industrial corridor, resulting in a severe decline in environmental condition. In recent times, due to the decline in the manufacturing industry in the 1960s and 1970s, the lower Maribyrnong River has become the waterfront to large residential developments.

Environmental impacts to the Maribyrnong estuary of these land use practices include:

- **Altered physical form**

  The lower estuary is part of the Port of Melbourne with about 0.5km dredged to a depth of 10m (Beckett, 1982). Banks of the estuary have also been 'stabilised' with rock walls and incoming waterways have been diverted from their original course and piped to allow for industrial and residential development to occur.

  This has resulted in altered hydraulic characteristics, loss of habitat, bed disturbance and a reduction in the carbon/litter cycling to the estuary.

- **Stormwater inflows and other direct discharges**

  The volume of stormwater runoff discharged to the estuary has increased due to a reduction in permeable surfaces in the local catchment area. This runoff would contain higher suspended sediment and nutrient loads.

  Licensed and illegal industrial discharges may also contribute to degraded water quality, however it has been found that higher concentrations found adjacent to discharge points do not appear to be impacting the river as a whole. Water quality of the Maribyrnong estuary is 'consistent with those expected for an industrialised port area at the bottom of a large catchment'(EPA, 2006), suggesting a deviation from a natural system that is not necessarily threatening the current use of the area.

- **Vegetation communities**

  Pre-European settlement EVC mapping of the area depicts a diverse range of vegetation present, ranging from brackish grasslands to swamp scrub. In comparison, mapping of the current EVC extent shows an almost complete removal of indigenous vegetation (Figure 3-4).

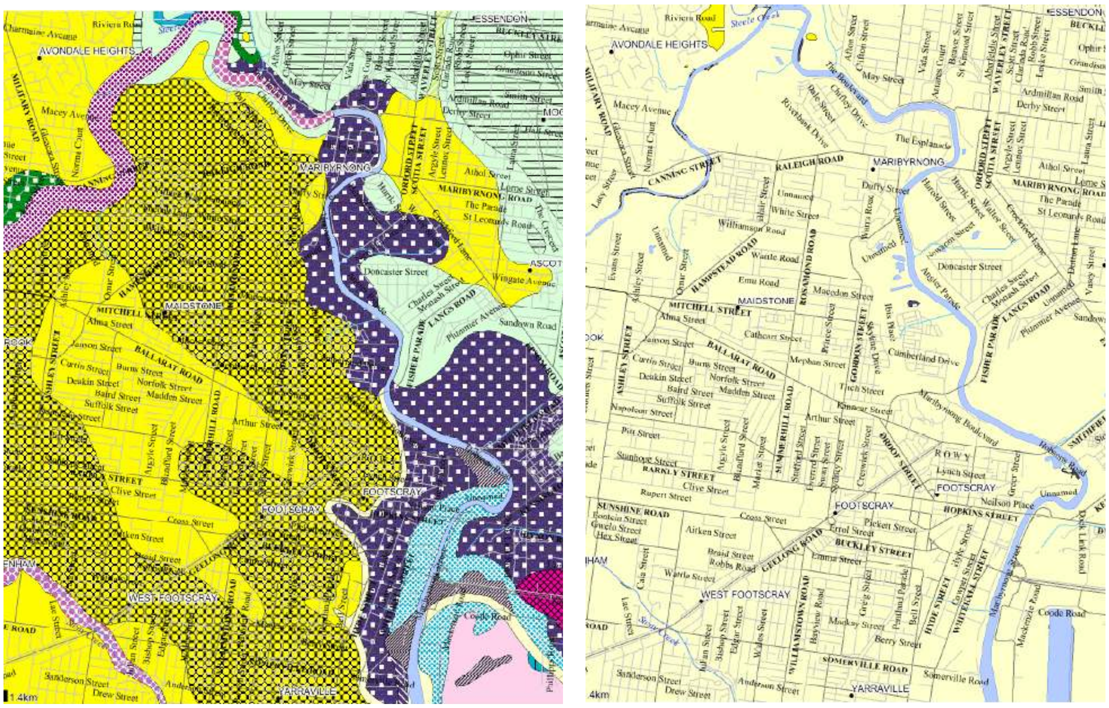



**Figure 3-4 Comparison of EVC extent, depicting the extensive modification and clearing from pre-1750 (left) to current EVC extent (right)**

This deviation from natural has primarily resulted in an extensive loss of habitat for aquatic fauna and reduction in carbon/litter cycling.

- **Aquatic ecology**

The most common fish species present in the Maribyrnong estuary are the Blue Spot Goby, Silversides, Common Galaxias and Tamar River Goby (ARI, 2005). Many species use the estuary for feeding (Mullet, Luderick, Western Australian Salmon, Mulloway and Flathead) and for spawning (Black Bream, Tupong and Common Galaxias,). Australian Grayling, a significant species identified in upper reaches have not been recorded in a recent survey of the estuary. As the larvae of Australian Grayling travel from the upper reaches and utilise the brackish estuary waters as a nursery prior to moving up into the freshwater reaches when they are approximately 6 months old, it would be expected that such a species would exist in the lower Maribyrnong.

A study undertaken by Melbourne Water on contaminant levels within recreationally caught fish species of the Maribyrnong estuary found that fish caught in the estuary contain contaminants. A sample of fish were tested for metals/metaloids and organic compounds and while most levels were below Australian Food Standards, one short finned eel sampled in the Maribyrnong showed concentrations of PCBs three times greater than the stated maximum (Melbourne Water, 2006).

One of the key processes, aside from the physical modifications, that may be threatening the health of the Maribyrnong estuary is a reduction in freshwater inflows due to regulation and diversion from the waterway upstream. It is also anticipated that freshwater inflows may also change as a consequence of changes in climate (due to changes in the distribution, magnitude and frequency of rainfall events in the catchment), land use patterns, water extraction volumes (due to further urbanisation and farming) and drainage schemes.

Freshwater inflows are the main source of sediment, nutrients and silica for estuaries. These inflows can also impact on temperature, pH and turbidity. Changes to magnitude, frequency and duration of freshwater inputs to the estuary can impact on estuarine biota by altering migration cues, areal extent of habitat, growth, development and movement patterns. The relative risk of changes to flow patterns from changes to one or all of the listed factors is high.

In the freshwater reach of the Maribyrnong River (Reach 8), the seasonality of the natural flow regime is preserved under current conditions (Figure 3-5). As a result of water harvesting upstream in the catchment, the river currently experiences a minor increase in low flow event occurrence and a minor reduction in high flows.

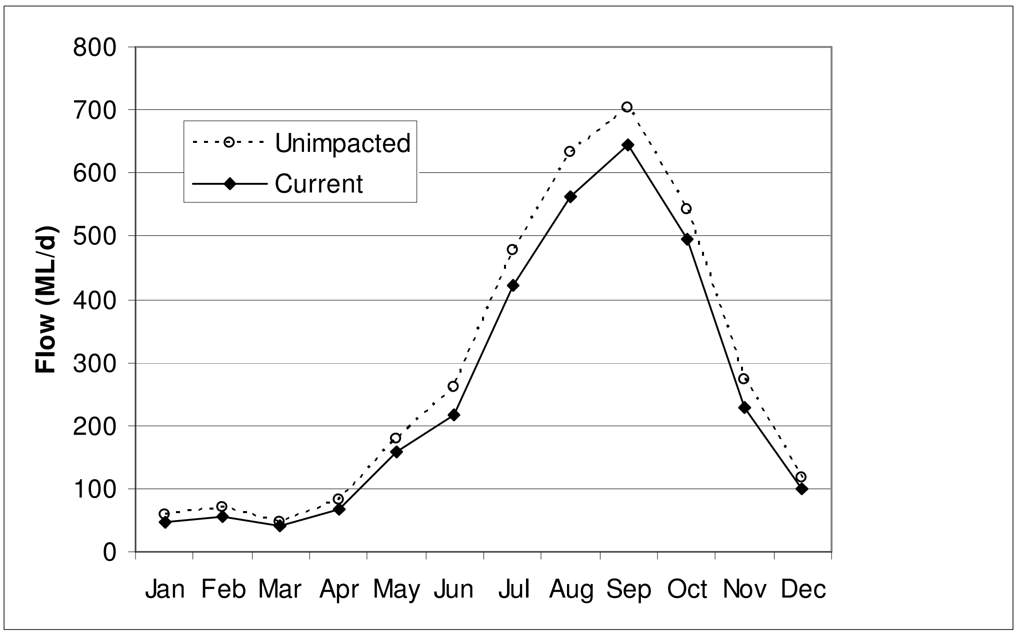



**Figure 3-5 Comparison of natural and current mean daily flows for each month in Reach 8**

Flow recommendations for Reach 8 (discussed in previous section) show an increase in the magnitude and occurrence of summer and winter base flows from the current flow regime. These base flows primarily determine the location of the salt wedge over the flow period. Due to the physical barrier to salt water intrusion at Canning Street, heavily modified river inflows may affect the saltwater/freshwater mixing of the estuary thereby impacting on the health and diversity of aquatic flora and fauna present.

Summer freshes are of similar frequency and duration to the natural time series, however the recommended frequency of winter freshes is lower than both current and natural conditions in Reach 8. Freshes act as spawning and migration triggers for many fish species, and also have the ability to refresh water quality. Due to the lower frequency of freshes during the winter period (June to November), the timing of when they occur will be critical to ensure spawning trigger requirements of fish species (eg. Black Bream) are met.

Compared to other estuaries in Victoria, there is ‘little known about the biological health of the Maribyrnong estuary’ (Melbourne Water, 2006). To manage the impact of freshwater flows on the assets of the Maribyrnong estuary, while acknowledging its modified form, further investigation into the ecological and physical processes occurring in the system is recommended to determine environmental flow objectives and freshwater recommendations.

The objective of further investigations would be to determine how the quality of the water in the estuary (salinity, dissolved oxygen, temperature etc) varies according to magnitude, frequency and duration of freshwater inflows. The following studies are recommended to meet this objective:

**1. Measure water quality.**

A measure of the quality of water would provide information relating to the location of the salt wedge and concentration levels of nutrients and pollutants in the estuary.

**Recommendation One:**

Establish and undertake a water quality monitoring and evaluation program at a number of sampling sites in the Maribyrnong estuary and surrounds.

**2. Investigate how the current populations and distribution of aquatic fauna and habitat are impacted by water quality.**

Further research into the impact of water quality on the life cycles of estuarine aquatic fauna would provide vital information to determine the amount of change in abundance and diversity expected with changes in water quality. This study would also determine and quantify the influence of water quality on spawning, dispersal, recruitment, growth, mortality and movement processes.

**Recommendation Two:**

Investigate and research the role that water quality has on habitat and resident fauna of the Maribyrnong estuary.

**3. Develop a hydrodynamic model to quantify the freshwater influence on water quality.**

Little is currently known about the hydrodynamics of the Maribyrnong estuary. Freshwater inflows play a role in stratification and salt wedge dynamics, thereby having an influence on the water quality in the estuary. Ecological and biological processes dependent on freshwater inflows, as identified in Recommendation Two, could be quantified through modelling the hydrodynamics of the estuary.

This modelling would require, as an input, quantification of the relationship between stormwater and river inflows to the estuary. An assessment of where and when the freshwater inflow components originate will quantify the amount of estuarine inflows originating from the Maribyrnong River itself.

There have been some studies conducted on the water movement and salinity of the Maribyrnong estuary previously by Beckett et al. (1982). This work was undertaken only during low flow events and sampling was limited to no further than the Maribyrnong Road bridge.

This assessment is required to assist in quantifying the relative influence of the magnitude, frequency and duration of freshwater inflows on the current and target health of the estuary.

**Recommendation Three:**

Develop a model with the ability to measure the effect of the magnitude, frequency and duration of freshwater inflows originating in the Maribyrnong River on the water quality of the estuary.

Findings of these investigations can then be used to develop freshwater environmental flow recommendations to ensure sustainable management of estuarine habitat and the provision of appropriate triggers to maintain or rehabilitate the life cycle of aquatic fauna.

It should also be noted that DSE is currently developing a standardised approach for the analysis of Victorian estuaries and the determination of their environmental water requirements.

# 4 Supporting Recommendations

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

**a. Develop a Waterway Management Action Plan for the Maribyrnong River catchment**

The WMAP will identify and address the complementary non-flow related options to restore river health such as stock exclusion, riparian revegetation, willow and weed control and instream habitat restoration. The implementation of these works are inherent in achieving the vision and expected outcome sought within the flow recommendations for each reach.

**b. Examine the removal or provision of passage over fish barriers (such as Salesian College weir and the Old Flour Mill Bluestone weir)**

The environmental flow recommendations contained within this report have been based on the return of fish passage through the Maribyrnong River system. It is recommended that investigations be undertaken into the feasibility of the provision of fish ladders and other means of fish passage over existing instream barriers.

**c. Manage water quality inputs to the system**

Water quality in the Maribyrnong 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 Maribyrnong River.

**d. 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 leading 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.

# 5 Conclusion

Recommendations presented in this report identify the flow regime required to sustain ecological and geomorphic assets and processes of the Maribyrnong River . The recommendations have been developed by the Technical Panel utilising the FLOWS method (DNRE, 2002b). In particular the recommendations are based on satisfying ecological requirements for fish, macroinvertebrates, riparian vegetation, water quality and geomorphologic requirements as determined by the Technical Panel. The recommendations are also based on a hydraulic criteria to guarantee the long term ecological sustainability of the Maribyrnong River system.

Analysis of non-flow related options to improve river health has not been the focus of this report and will need to be addressed in a Waterway Management Activity Plan. 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.

The report forms a component of the implementation of environmental flows for the Maribyrnong River. The impacts of the recommendations on the reliability of supply for consumptive users are to be analysed through hydrologic modelling. The results of this process will be utilised in the decision making process of determining water allocation along the Maribyrnong River for the various environmental and consumptive uses.

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