Thomson River Environmental Flows and Management Review

Flow Recommendations Paper

Report for West Gippsland CMA

June 2020

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Streamology and West Gippsland Catchment Management Authority would like to acknowledge and pay our respects to the Gunaikurnai as the Traditional Owners of the lands on which the project is based. We look forward to continuing to work collaboratively with the Gunaikurnai Land and Waters Aboriginal Corporation on achieving water for Traditional Owner cultural values and uses.

contents

Glossary

Amphidromous	Species of fish that spawn in the freshwater reaches of rivers and the eggs and larvae drift downstream with the current into the estuary and, ultimately, the sea.
Anadromous	Species of fish that undertake upstream adult migrations from the sea into the freshwater reaches of rivers to spawn.
Bankfull flows	These flows are of sufficient magnitude to reach bankfull condition with little flow spilling onto the floodplain (except from floodrunners that enter the waterway at a lower elevation than the banks). All benches are inundated, creating additional habitat for macroinvertebrates, plants and fish.
Baseflow	A continuous flow through the channel. The flow may be limited to a narrow area of the channel but will provide flow connectivity between habitats in the channel.
Catadromous	Species of fish that undertake downstream adult migrations out of the freshwater reaches of rivers to spawn in the estuary or sea.
Cease to flow	No discernible flow in the river
CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
EFTP	Environmental Flows Technical Panel. A multidisciplinary panel who provide the core team undertaking a FLOWS investigation
Environmental flows	Flows that describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems
EVC	Ecological Vegetation Class
FLOWS2	A method for determining environmental water requirements in Victoria
Fresh	A fresh is a small and short duration peak flow event. These are flows that exceed the baseflow and last for at least several days, often as a result of intensive, and sometimes localised, rainfall
GLaWAC	Gunaikurnai Land and Waters Aboriginal Corporation

High flow	The key characters that distinguish this flow component from freshes or other large flows are the persistent increases in the seasonal baseflow that remain within the channel. These flows are those which cover the bed of the stream and some of the lowest in-channel benches may be flooded, creating further habitat. High flows do not fill the channel to bankfull and are unlikely to provide substantial channel forming forces.
Low flow	The flow that provides a continuous current of water through the channel within the representative reach.
Non-diadromous	Species of fish that are generally restricted to freshwater reaches throughout their life history (although some species may occasionally stray into brackish or salty water).
Overbank flows	These flows overtop the river bank and result in inundation of some or all of the floodplain.
PAG	Project Advisory Group
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program
VEWH	Victorian Environment Water Holder
Water for the Environment	Water that is allocated and managed specifically to improve the health of rivers, wetlands and floodplains
WGCMA	West Gippsland Catchment Management Authority

1. Introduction

The Thomson River, known as the Carran Carran by Gunaikurnai people, flows from the slopes of the Baw Baw plateau in the Victorian Alps bioregion and discharges into the Latrobe River downstream of Sale in the Gippsland Plains bioregion. River flow is regulated by the Thomson Dam, which provides potable water for Melbourne, and the Cowwarr Weir, which provides water for the Macalister Irrigation District. Environmental water is managed via water holdings held in the Thomson Dam storage and in Lake Glenmaggie (on the Macalister River, to the east) for the reach downstream of the confluence with the Thomson River (Reach 6).

Streamology has been engaged to lead the updating of the 2003 Environmental Flow Recommendations for the Thomson River (EarthTech 2003) in this project, the Thomson River Environmental Flows Review. As part of work already completed on the project, an Issues Paper was produced which outlines what has changed in the Thomson system since 2003, drawing upon best available science and new knowledge developed since the first Environmental Flow Recommendations were devised. An Environmental Flows Technical Panel (EFTP) was convened and, after undertaking a site visit in late 2019, the Thomson River water dependent values and objectives were identified and described in the Issues Paper (Streamology 2020a).

The EFTP was convened for a second time during a two-day workshop in early February 2020 to review and update the original Environmental Flow Recommendations of 2003. This report − the Flow Recommendations Paper − outlines the outcomes and process towards arriving at the revised flow recommendations.

2. Project Objectives

The overarching objectives for the Thomson River Environmental Flows and Management Review project were to:

- Collate, review and update ecological information, objectives, stream condition (current and future trajectory) and conceptual models for the identified reaches of the Thomson River - covered in the Issues Paper (Streamology 2020a).
- **Review and update (where required) the 2003 Environmental Flow Recommendations (Earth Tech 2003), including their expansion to cover hydrological scenarios including current demand, unimpacted (natural), climate change (modest and extreme) and impact of irrigation modernisation (modest and extreme) - covered in this Flow Recommendations Paper.**
- Calculate the environmental water shortfalls for required scenarios, and assess the risks of not addressing, and conversely the benefits of addressing, these shortfalls. The risks and benefits should be presented qualitatively and be inclusive of environmental, social, cultural and economic values, covered in a separate Environmental Shortfalls and Risk Assessment Paper (Streamology 2020b).

This Flow Recommendations Paper addresses the second objective: updating the 2003 flow recommendations based on updated hydrology and best available science.

3. Vision, Values and Objectives

The Thomson River Environmental Flows Review project is based on the view that the river is a living entity, a connected and continuing river system from the headwaters in the mountains to the Gippsland Lakes and finally into the ocean. It is this vision that has formed the basis for Thomson River values, objectives and ultimately the flow recommendations (**Figure 1**).

Maintaining a consistent flow regime down the length of the river system is the principle driver of the flow recommendations that arise from the overarching vision of the Thomson River.

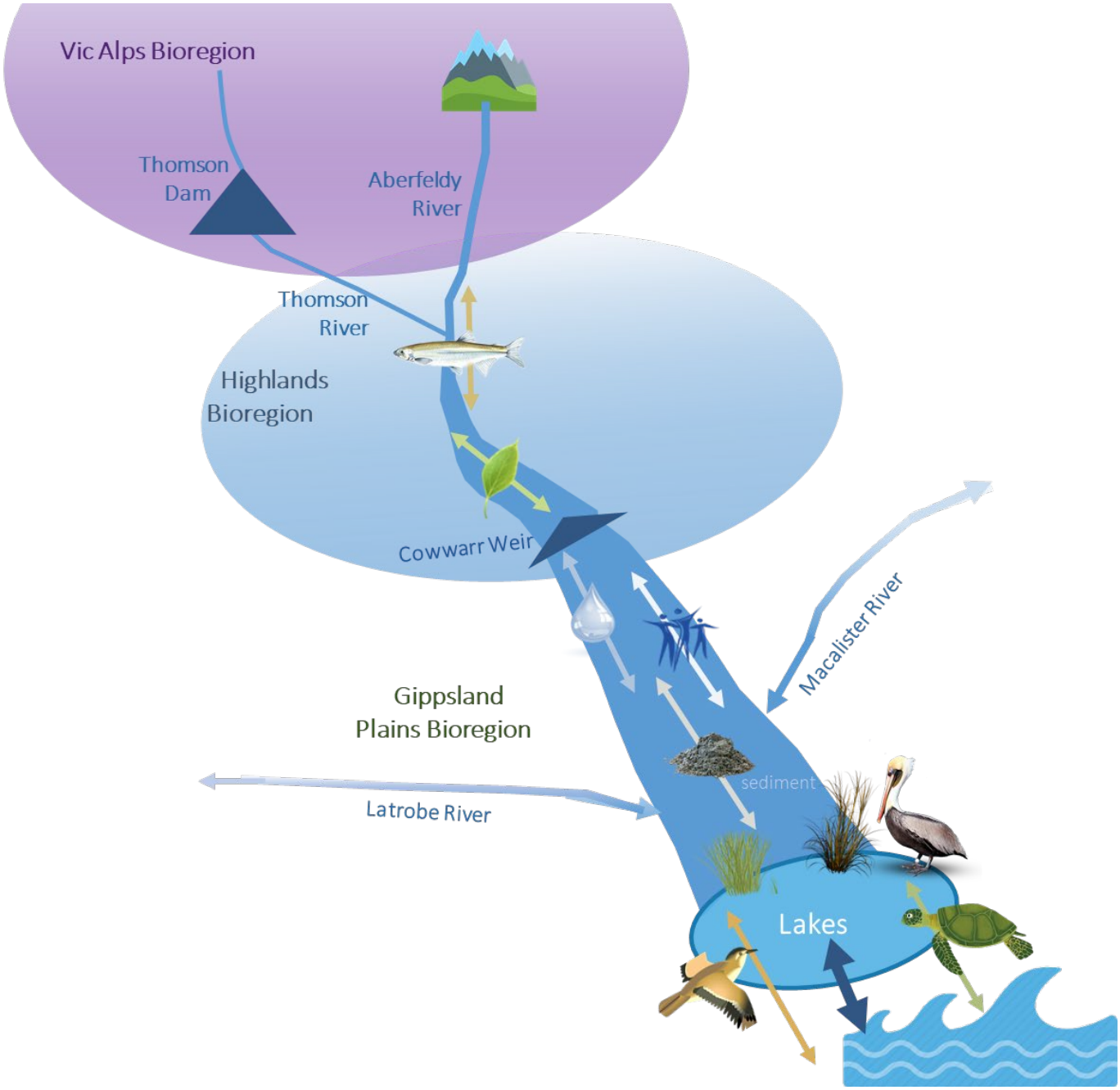


Figure 1: Thomson River vision: a continuous system part of an interconnected network of rivers flowing from the mountains to the sea

The Thomson River values and management objectives are detailed in the Issues Paper (Streamology 2020a).

Table 1 provides a summary of the values, objectives, mechanisms and relevant identification number referred to later in the present report. These are categorised by ecological, physical or social values. The term 'Geomorphology' is used to describe the physical form and functioning of a river channel that supports ecological and social values.

Table 1: Summary of values and objectives

Value	Objective	Mechanism	ID
Macroinvertebrates	Restore or maintain natural macroinvertebrate community	Adequate and permanent inundated habitat for species and life stages	M1
		Maintenance of habitat quality, sediment	M2
		Maintenance of habitat quality - biofilms (flows able to disturb biofilms)	M3
		Maintenance of habitat quality - detritus (Flows to entrain leaf litter and DOC from riparian zone)	M4
		Provision of inundated habitat (LWD and edge of channel habitat)	M5
		Maintenance of food supply in edge and LWD habitats	M6
		Provide adequate water quality (DO and temp) through pools and riffles to facilitate respiration of macroinvertebrates	M7
		Entrainment of LWD into channel	M8
		Entrainment of leaf litter and DOC	M9
Fish	Diversity of instream habitat to support the whole native fish assemblage	Adequate habitat availability and LWD inundation for species and life stages with preference for pool habitat and complex woody structure	F1a
		Adequate habitat availability for species and life history stages with preference for run/glide habitats	F1b
		Adequate habitat availability for species and life history stages with preference for riffle habitats	F1c
	Connectivity to facilitate localised movement	Maintain continuous connectivity for localised movement between habitats for small-bodied species	F2
		Cue for downstream migration for adult Short-finned eel, adult Long-finned eel. Cue for upstream migration for juvenile Short-finned eel, juvenile long-finned eel, juvenile Australian bass, juvenile common galaxias.	F3

Value	Objective	Mechanism	ID
		Maintain occasional connectivity for localised fish movement between habitats for large-bodied species	
	Connectivity and environmental triggers for large-scale migrations by diadromous species	Cue for downstream migration for adult Australian Grayling, adult Short-finned eel, adult Long-finned eel, adult Australian bass, adult Common galaxias. Cue for upstream migration for juvenile Long-finned eel, spent adult Australian grayling.	F4
		Cue for downstream migration for adult Tupong, adult Australian bass, adult Common galaxias, adult and larval Australian grayling, larval Broad-finned galaxias. Cue for upstream migration for spent adult Australian grayling.	F5
		Extended connectivity for downstream migration by juvenile Short-headed lamprey, Pouched lamprey, adult Tupong, adult Australian bass, adult Common galaxias. Extended connectivity for upstream migration by adult Short-headed lamprey, adult Pouched lamprey.	F6
		Cue for downstream migration for juvenile Short-headed lamprey, adult Short-finned eel. Cue for upstream migration by adult Short-headed lamprey, adult Pouched lamprey, juvenile Short-finned eel, juvenile Tupong, adult and juvenile Australian bass, juvenile Common galaxias, juvenile Australian grayling, Broad-finned galaxias.	F7
	Lateral connectivity and habitat maintenance to support wetland specialist fish	Provide connectivity between main channel and low-lying freshwater wetlands for dispersal and recolonization by wetland specialists (Dwarf galaxias, Southern pygmy perch).	F8
Vegetation – Microbial biofilms	Maintain microbial biofilms on submerged surfaces (e.g. gravel, cobbles and coarse woody debris)	Adequate volume and flow of water in-stream to maintain existing biofilms Periodic higher flows to disturb substrata on which biofilms are attached, scour existing biofilms and generate new colonisation sites	V1

Value	Objective	Mechanism	ID
Vegetation – Submerged vascular plants	Maintain or where possible enhance native submerged vascular plants such as eelweed, milfoils, pondweeds and, possibly, Water Ribbon	Adequate volume and flow of water in-stream throughout the year to maintain obligately submerged taxa Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment	V2
Vegetation – **Non-woody fringing vascular plants**	Maintain or where possible enhance native non-woody fringing vegetation such as Common Reed, rushes, knotweeds, Leafy Flat-sedge, Swamp Club-sedge and River Club-sedge	Damp or wet substratum to maintain adult plants Flow variability to maintain zonation of vegetation according to elevation and flow requirements of individual taxa Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment	V3
Vegetation – **Woody and non-woody vegetation in channel, on benches and in lower riparian zone (prevention)**	Prevent colonisation of in-stream channel, low-lying benches and lower riparian zone by undesirable taxa, especially by terrestrial or weedy plant species intolerant of prolonged inundation	Periodic or permanent inundation of stream, low-lying benches and lower parts of the riparian zone to prevent encroachment of terrestrial weed taxa intolerant of prolonged submergence	V4
Vegetation – **Water-dependent woody riparian trees and shrubs**	Maintain water-dependent taxa of existing EVCs in riparian zones along river.	Damp or wet substratum to maintain adult plants Flow variability to maintain zonation of vegetation according to elevation and flow requirements of individual taxa Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment	V5

Value	Objective	Mechanism	ID
Vegetation – Maintain cool-damp valley microclimates required for surrounding terrestrial vegetation	Maintain local microclimates (especially lower air temperature and higher relative humidity) in valleys and gullies for surrounding terrestrial EVCs that require damp conditions	Presence of water in-stream creates a localised gully/valley microclimate with lower temperature and higher relative humidity in nearby terrestrial areas. The plant taxa in these EVCs are not directly water-dependent but do require the moderated climatic conditions generated by the presence of a nearby stream.	V6
Vegetation – Freshwater floodplain wetlands	Maintain and where possible enhance native vegetation in billabongs and other floodplain wetlands	Floodplain wetlands are inundated when connected to river via floodrunners etc below level of the top of bank (i.e. inundation of floodplain wetlands not requiring overbank flows)	V7
Vegetation – Floodplains	Enhance native floodplain vegetation (especially EVC 56 Floodplain Riparian Woodland)	Maintain adults and enhance recruitment of juvenile water-dependent plants on lower floodplain	V8
Platypus / Rakali	Increase abundance of Platypus / Rakali	Localised Platypus / Rakali movement between habitats to increase foraging opportunities and refuge from predators	P1
Birds, reptiles, amphibians	Support populations of birds, reptiles and amphibians	Inundate wetlands / low lying areas on floodplain to maintain habitat and increase food sources	FN1
Geomorphology*	Maintain / enhance physical form and functioning through refuge habitat provision	Maintain deep pools for refuge habitat (fish)	G1
Geomorphology*	Maintain / enhance physical form and functioning through slackwater habitat provision	Provide slow and shallow habitat for larval/juvenile fish and macroinvertebrates	G2

Value	Objective	Mechanism	ID
Geomorphology*	Maintain / enhance physical form and functioning through hydraulic habitat diversity	Provide velocity and depth diversity (runs, glides, pools) and maximise wetted perimeter	G3
Geomorphology*	Maintain / enhance physical form and functioning through woody debris habitat provision	Maintain depth over large woody debris for macroinvertebrates	G4
Geomorphology*	Maintain / enhance physical form and functioning through bank stability	Maintain toe vegetation to trap sediments and stabilise banks	G5
Geomorphology*	Maintain / enhance physical form and functioning through maintaining sediment substrate condition	Prevent sediment smothering by mobilising fine sediments	G6
Geomorphology*	Maintain / enhance physical form and functioning through maintaining sediment condition and diversity	Turnover sediment to maintain substrate condition and diversity	G7
Geomorphology*	Maintain / enhance physical form and functioning through bed disturbance, channel maintenance refuge habitat	Maintain channel form, depth diversity, prevent pool infilling (particularly Reach 4a)	G8
Geomorphology*	Maintain / enhance physical form and functioning through bar and bench maintenance	Maintain bars and benches by mobilising and depositing sediments on existing bars and benches	G9

Value	Objective	Mechanism	ID
Geomorphology*	Maintain / enhance physical form and functioning through bank condition	Deposit and drape sediments (and seeds) on riverbanks	G10
Geomorphology*	Maintain / enhance physical form and functioning through pool habitat maintenance	Maintain depth diversity through pool creation	G11
Geomorphology*	Maintain / enhance physical form and functioning through bar and bench formation	Build bars and benches by mobilising sediments	G12
Geomorphology*	Maintain / enhance physical form and functioning through recruiting OM, carbon and large wood	Inundate flood runners and anabranches (sub-bankfull)	G13
Social / economic	Maintain recreation opportunities in Cowwarr Weir (swimming, fishing, birdwatching, canoeing, picnicking)	Increased flow to increase the attractiveness of the environment	S1
	Maintain and enhance kayaking / canoeing opportunities along the river	Increased flow improves quality of experience	S2
	Maintain opportunities for camping (presence of running water or lake)	Increased flow to increase the attractiveness of the environment	S3

***Note that geomorphic objectives are commonly designed to be supportive of ecological and social values. Numerous links exist.**

4. How the Recommendations were derived

This project is a review of the existing Environmental Flow Recommendations identified in 2003 by EarthTech. As detailed in the Issues Paper (Streamology 2020a), changes to the system since 2003 were identified which formed the basis of discussion and ultimate updating of the recommendations by the EFTP members; Dr Geoff Vietz, Associate Professor David Crook, Professor Paul Boon and Steve Clarke, and Dr Stephanie Suter from the WGCMA.

Reach-based Environmental Flow Objectives were established for each reach of the Thomson River during a workshop with the EFTP members, held at WGCMA offices, on 3 and 4 February 2020.

4.1. The FLOWS method

The recommendations were developed using the framework of the standardised Statewide method for determining environmental water requirements in Victoria, referred to as the FLOWS method, Edition 2 (DELWP et al. 2013).

The flow regime of the River was categorised by the EFTP into three components - baseflows, freshes and bankfull flows, each of which are important for maintaining ecosystem health, functions and processes (refer to **Figure 2**). Each of the flow components were broken into seasonality; Summer / Autumn (December - May) and Winter / Spring (June - November) to more closely align with natural conditions pre regulation.

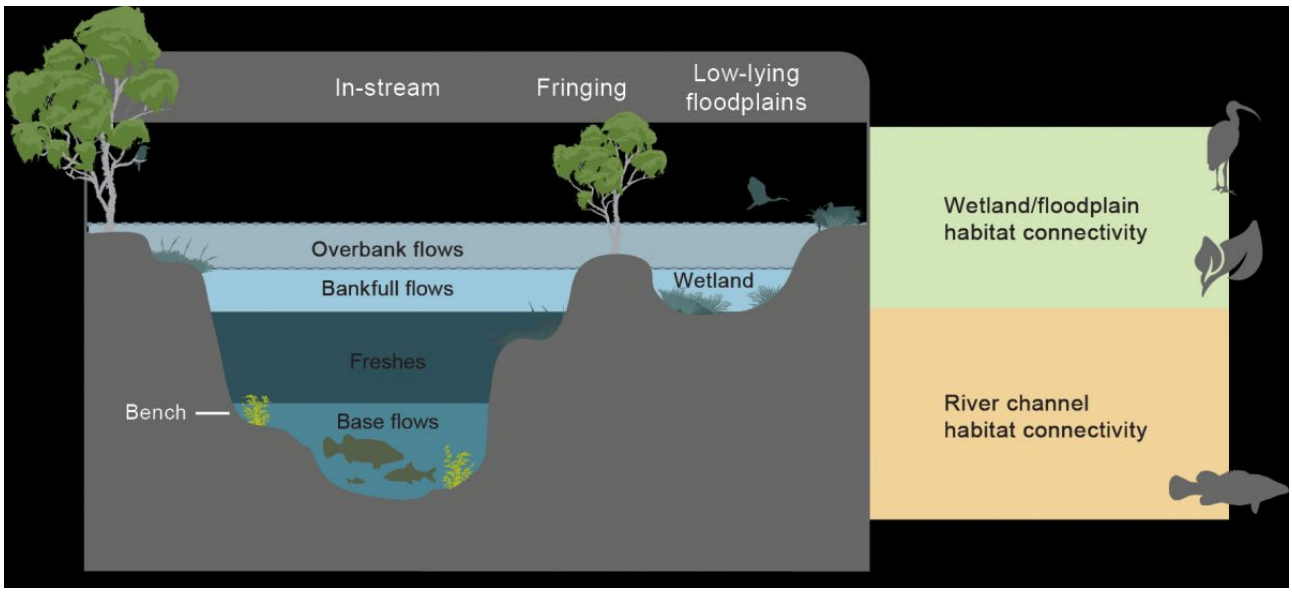


Figure 2: Flow components - important to the provision of environmental flows in rivers and floodplains (MDBA 2020)

4.2. Hydraulic modelling

The magnitude of the flows required to achieve the objectives were identified using previously developed hydraulic models. Resurveying reaches was not part of the project scope, therefore two existing models were used, which was deemed adequate:

- 2011 hydraulic models collected for the Thomson River Flood Study (Water Technology 2011).
- 2003 hydraulic models collected during the original Flow Recommendations Project (EarthTech 2003).

The one-dimensional hydraulic modelling package HEC RAS (Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System; US Army Corps of Engineers no date) was used interactively during the Flow Recommendations workshop to investigate the relationship between river discharge, river height and relevant flow criteria. For example, to determine flow recommendations for fish passage a critical depth over riffles was earlier defined, and the flow corresponding to this depth determined through iterative applications of the HEC RAS model.

4.3. Hydrologic modelling

The daily Thomson Macalister Source model (DELWP 2019) was used as the basis for hydrological modelling. The base model provided by the Department of Environment, Land, Water and Planning (DELWP) was subsequently updated to make it fit for purpose for this assessment. A summary of the updates undertaken on the model is provided below and outlined in HARC (2019):

- Historic irrigation outfalls embedded in the lower Thomson inflows were separated out and represented at current and future levels of development
- Environmental Flow node settings were updated to correct representation errors
- Environmental flow manager rules were established.

Unimpacted flows (pre regulation) were calculated from 1/7/1955 to 30/6/2018 from the Source model at the six Thomson River compliance points (**Table 2**) along with current flows. Flows were determined under historic climate, baseline climate and post 1997 climate.

Table 2: Compliance points per reach

Reaches		Compliance points
T2	Thomson Dam to Aberfeldy River junction	Downstream of Thomson Dam
T3	Aberfeldy River junction to Cowwarr Weir	Coopers Creek gauge
T4a	Thomson R: Cowwarr Weir to Rainbow Ck confluence	Thomson Heyfield gauge
T4b	Rainbow Ck: Cowwarr Weir to Thomson River confluence	Rainbow Heyfield gauge
T5	Rainbow Creek to Macalister River	Wandocka
T6	Macalister River to Latrobe River	Bundalaguah

The recommendations for frequency and duration of events were determined by examining the natural frequency and duration of events, pre regulation and by considering the ecological functions of particular flows (e.g., sufficient flow duration to facilitate long-distance migration by diadromous fish). A spells-analysis tool developed by Streamology was used to examine the frequency and duration of particular flows under natural conditions.

4.4. Rates of rise and fall

Although specific flow recommendations in terms of flow magnitude, frequency and duration are the most critical component of the recommendations outlined here, the rates of water-level rise and fall leading to and following on from a particular flow event are also important factors that need to be considered. Fluctuations in flow magnitude or rates of rise and fall serve important ecological and geomorphic functions in a river system. For example, excessive rates of water level fall after a fresh can result in fish being stranded in shallow, peripheral habitats. Also, if the drawdown phase of a floodplain wetland is too fast, habitat availability for birds that feed along the receding shoreline will be reduced. It is therefore important that rates of rise and fall are reflective of the rates that would have occurred under unimpacted (pre regulation) flows.

The method outlined in the 2003 study was followed for consistency of application, but with updated hydrology and a separate rate of rise and fall calculated for the reaches upstream of Cowwarr Weir (Reaches 2 and 3) and downstream of Cowwarr Weir (Reaches 4a, 4b, 5 and 6). In order to recommend maximum permissible rates of rise and fall, the differences between flows on individual days were divided into days when flows rose and days when flows fell. The ratio of the change in flow was calculated for each rise or fall. The maximum desirable rate of rise was selected as the 90th percentile value of all recorded rates of change (representing a fairly high rate that was recorded naturally) and the maximum desirable rate of fall was selected as the 10th percentile value of all recorded rates of change (**Table 3**).

Table 3: Rates of rise and fall

Reach/Site	Maximum rate of rise (proportion of previous day) 2020	Maximum rate of fall (proportion of previous day) 2020
Upstream Cowwarr Weir	0.82*	0.24**
Downstream Cowwarr Weir	0.68	0.20

*i.e. the flow on the following day may be a discharge value of 182% of the previous day's flow

**i.e. the flow on the following day may be 76% of the previous day's flow

5. Environmental Flow Recommendations

Environmental Flow Objectives were established for each reach of the Thomson River during a field visit and workshop held at WGCMA offices on 19 and 20 November 2019. Reach-based Environmental Flow Recommendations were established during a workshop held at WGCMA offices, on 3 and 4 February 2020.

The EFTP were able to determine specific flow components that were required to satisfy one or many of the objectives outlined in **Table 1**. Details of the objectives and criteria that were used by the EFTP to derive the flow recommendations for each value are presented in Table 20 of the Issues Paper (Streamology 2020a).

Initially, the basic ecological conditions of the reach (including impacts arising from river regulation) and the previously determined ecological objectives (from the Issues Paper) were summarised and reviewed. Photos and field notes taken during the field inspection were examined, and hydraulic model transects were viewed to identify key environmental features of the reach.

Note that Reach 1, upstream of the Thomson Dam (**Figure 1**) is not considered in this assessment.

5.1. Reach 2 - Thomson Dam Wall to Aberfeldy River Junction

Reach 2 of the Thomson River begins at the wall of the Thomson Dam and continues to the junction with the Aberfeldy River. This reach contains high-value water-dependent vegetation, and since 2019 has had fish connectivity restored through the installation of the Horseshoe Bend Fishway on Reach 3. Anecdotal evidence suggests increasing vegetation encroachment in the channel over the last ~15 years, despite increased environmental flows.

The flow recommendations (**Table 4**) were derived for Reach 2 using the 2003 HEC RAS sections and models. This adaptation of the earlier findings was possible because Reach 2 is characterised by stable bedrock-controlled channels within a confined setting, and so it is safe to assume that it has not changed significantly in the ~20 years since the original flows investigation was undertaken.

Table 4: Reach 2 flow recommendations

Timing	Flow component	Reach 2: Thomson Dam Wall to Aberfeldy Junction		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	125 ML/d Continuous	**125 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, V1, V2, V3, V4, V5, V6, M1, M7, P1, S3**
	Fresh	230 ML/d, Dec-Apr, 7/year, 3 days	**350 ML/d** – 1 x yr 7 days, December / Jan	**G2, G3, G4, G5, G6, V1, V2, V3, V4, V5, S2, M2**
			230 ML/d – 1 x yr 7 days, Feb / March	**G2, G3, G4, G5, G6, F3, V1, V2, V3, V4, S2, M2**
			800 ML/d – 1 x yr 7 days, April	**G3, G5, G6, G7, G8, G9, G10, V1, V2, V3, V4, V5, F4, S2, M2**
Winter / Spring	Baseflow	230 ML/d, May-Nov, continuous	**230 ML/d** Continuous	**G1, G2, G3, G4, F1a, F1b, F1c, F2, F6, V1, V2, V3, V4, V5, V6, M1, M7, P1, S3**
	Fresh	800 ML/d, May-Nov, 5/year, 4 days	**800 ML/d** – 1 x yr 7 days, May	**G3, G6, G7, G8, G9, G10, F5, V3, V4, V5, M3, M2, S2**
			800 ML/d – 1 x yr 7 days, Sep	**G3, G6, G7, G8, G9, G10, V3, V4, V5, M3, M2, S2**
			800 ML/d – 1 x yr 7 days, Oct / Nov	**G3, G6, G7, G8, G9, G10, F7 (V1, V2, V3, V4, V5) M3, M2, S2**
	Bankfull / sub bankfull	2,000 ML/d, Any time, 1 in 2 yrs, 3 days	**2,000 ML/d** – every 2 yrs 1 day, anytime*	**G11, G12, G13, V7, V8, M4, FN1**

*Ideally June - August to limit impact on Platypus

5.1.1. Summer / Autumn Baseflow

The EFTP agreed with the 2003 Summer / Autumn Baseflow recommendation and could not justify any changes to the original recommendations. The main hydraulic criteria for this Baseflow was fish passage of at least 20 cm over riffles, maintaining a wetted central zone of the streambed for macroinvertebrates, maintaining permanently wet conditions in the channel for obligately aquatic

plants and to prevent encroachment by terrestrial plant species, and promoting habitat diversity more generally. The likely role of a constant baseflow in Reach 2 in maintaining adjacent cool/damp microclimates also cannot be dismissed (Objective V6).

Under baseline conditions (reflecting pre-dam hydrology), a flow of 125 ML/d was exceeded 90% of the time in summer and Autumn (and only dropped below this volume 10% of the time in extreme drought), indicating that the flow should not be reduced further.

5.1.2. Summer / Autumn Freshes

Three Summer/Autumn freshes of different magnitudes are recommended for Reach 2. The primary purpose of the 350 ML/d fresh in December or January is to inundate fringing (woody and non-woody) vegetation during the typically dry summer months. The earlier Issues Paper (Streamology 2020) has shown the benefits that accrue to fringing vegetation from periodic freshes and other fluctuations in water level. The second (230 ML/d in Feb/March) and third (800 ML/d in April) fresh of the season are primarily fish migration cues, with the 800 ML/d fresh also acting to scour the bed and banks and microbial biofilms from rocks and other submerged surfaces. Although directed primarily at fish, they will also have benefits for water-dependent vegetation. The original flow recommendation fresh duration of 3 days was extended to 7 days, as research conducted since 2003 has shown that a time period of 7 days is more appropriate for facilitating large-scale downstream migration to the spawning grounds in the lower reaches (Koster et al. 2013; 2018; Amtstaetter et al. 2016). Longer duration Summer/Autumn freshes will also benefit kayakers.

5.1.3. Winter / Spring Baseflow

The EFTP agreed with the 2003 Winter / Spring Baseflow recommendation of 230 ML/d and could not justify any changes.

Furthermore, a Baseflow of 230 ML/d will assist with Platypus movement along the reach and reduce the risk of individuals being predated upon during the critical pre-breeding feeding months.

5.1.4. Winter / Spring Freshes

Three winter freshes of 800 ML/d are recommended for Reach 2. The primary purpose of these freshes is to act as fish migration cues, as well as meeting vegetation, geomorphic and macroinvertebrate objectives. Vegetation is posited to benefit most from the large May and September freshes but may benefit to a lesser extent from the October/November event (and this is why those vegetation objectives are shown in parentheses).

5.1.5. Bankfull / Sub Bankfull

The EFTP agreed with the 2003 Bankfull / Sub Bankfull recommendation of 2,000 ML/d and could not justify any changes. This type of flow will disturb the entire aquatic system in Reach 2 and the shear stress associated with the high flows will be adequate to move sand from pools.

Although it is recommended that a flow of this magnitude be delivered, the EFTP noted that this may affect downstream landholders. Therefore, if this flow cannot be delivered due to system constraints, it is recommended that the September fresh be increased to 900 ML/d to provide as

much disturbance as possible including mobilise sand in pools and mobilise gravel-sized sediments between 7 to 10 cm (~7 to 10 N/m^2).

5.2. Reach 3 – Aberfeldy River Junction to Cowwarr Weir

Reach 3 is defined as the section of the Thomson River from the Aberfeldy River Junction to the Cowwarr Weir. Inflows from the Aberfeldy augment flows into this reach, also contributing sediment from higher in the catchment. Connectivity with lower reaches has been improved since 2003 via the installation of a fishway at Cowwarr Weir and since 2019 with the installation of a fishway at Horseshoe Bend. The flow recommendations (**Table 5**) were derived for Reach 3 using the 2003 HEC RAS models.

Table 5: Reach 3 flow recommendations

Timing	Flow component	Reach 3: Aberfeldy River Junction to Cowwarr Weir		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	125 ML/d Continuous	**125 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, V1, V2, V3, V4, V5, V6, M1, M7, P1, S1, S3**
	Fresh	230 ML/d, Dec-Apr, 7/year, 3 days	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**G2, G3, G4, G5, G6, V1, V2, V3, V4, V5, S2. M2**
			230 ML/d – 1 x yr 7 days, Feb / March	**G2, G3, G4, G5, G6, F3, V1, V2, V3, V4, S2, M2**
			800 ML/d – 1 x yr 7 days, April	**G3, G5, G6, G7, G8, G9, G10, V1, V2, V3, V4, V5, F4, S2, M2**
Winter / Spring	Baseflow	230 ML/d, May-Nov, continuous	**350 ML/d** Continuous	**G1, G2, G3, G4, F1a, F1b, F1c, F2, F6, V1, V2, V3, V4, V5, V6, M1, M7, P1, S1, S3**
	Fresh	800 ML/d, May-Nov, 5/year, 4 days	**800 ML/d** – 1 x yr 7 days, May	**G3, G6, G7, G8, G9, G10, F5, V3, V4, V5, M3, M2, S2**
			800 ML/d – 1 x yr 7 days, Sep	**G3, G6, G7, G8, G9, G10, V3, V4, V5, M3, M2, S2**
			800 ML/d – 1 x yr 7 days, Oct / Nov	**G3, G6, G7, G8, G9, G10, F7 (V1, V2, V3, V4, V5) M3, M2, S2**
	Bankfull / sub bankfull	2,000 ML/d, Any time, 1 in 2 yrs, 3 days	**3,000 ML/d** – 1 x yr 1 day, anytime*	**G11, G12, G13, V7, V8, M4, FN1**

*Ideally June - August to limit impact on Platypus

5.2.1. Summer / Autumn Baseflow

The EFTP agreed with the 2003 Summer / Autumn Baseflow recommendation and could not justify substantive changes. Under baseline conditions (reflecting pre-dam hydrology), a flow of 125 ML/d was exceeded 90% of the time in Summer and Autumn.

5.2.2. Summer / Autumn Freshes

Maintaining a consistent flow regime down the entire length of the Thomson River below the dam wall is a key principle that arises from the overarching vision of the Thomson River outlined in the Issues Paper (Streamology 2020a) and shown schematically in **Figure 1**. Therefore, the Summer / Autumn Freshes defined for Reach 2 need to be carried into Reach 3, with the 350 ML/d fresh primarily for wetting vegetation during the typically warm and dry summer period, and the 800 ML/d April fresh to scour pools and promote fish migration, as well as to wet upper benches etc. As for Reach 3, the 800 ML/d April fresh will also benefit kayakers during the Easter period (800 ML/d is in the low-to-good range for kayaking according to the Whitehorse Canoe Club).

5.2.3. Winter / Spring Baseflow

The EFTP determined that the Winter / Spring Baseflow of 230 ML/d defined in 2003 was too small to continue to prevent encroachment by terrestrial vegetation along this reach. The EFTP therefore defined a new Baseflow of 350 ML/d, which will also wet more of the stream bed and thus increase the area of wetted bed for macroinvertebrates.

Furthermore, a Baseflow of 350 ML/d will assist with Platypus movement along the reach and reduce the risk of individuals being predated upon during the critical pre-breeding feeding months.

Note: the current environmental watering rules enable the altering of passing flow volumes in July / August to accrue water to be used at a later stage. Given the change in flow recommendation as a result of this study, this approach may no longer be appropriate moving forward.

5.2.4. Winter / Spring Freshes

Consistent with Reach 2, three winter freshes of 800 ML/d are recommended for Reach 3. Again, as for Reach 2, the primary purpose of these freshes is to act as a cue for fish migration as well as assisting in maintaining the vertical zonation and successful recruitment of water-dependent fringing plants and meet various geomorphic and macroinvertebrate objectives. The receding waterfront after the freshes is important for vegetation recruitment, reed and rush establishment and the transport of sexual propagules of plants, as shown in the conceptual model for vegetation provided in the Issues Paper.

If the Bankfull recommendation outlined below cannot be met due to system constraints, the EFTP recommend providing the maximum permissible volume as a fresh in September (900 ML/d).

5.2.5. Bankfull / Sub Bankfull

The EFTP recommend a Bankfull / Sub Bankfull delivery of 3,000 ML/d once per year, an increase in volume from the 2003 recommendation. This flow primarily serves geomorphological objectives, but will also meet vegetation objectives V7 and V8, which relate to wetland and floodplain features in this reach. In particular, this large once-a-year flow will mobilise organic and inorganic material in the system and the bed shear stress associated with the flow will be adequate to mobilise sand, cobbles and gravels.

It is recommended that a flow of this magnitude be delivered, however, the EFTP note that this may affect downstream landholders. Therefore, if this flow cannot be delivered due to system constraints, then it is recommended that the September fresh be increased to 900 ML/d.

5.1. Reach 4a – Thomson River, Cowwarr Weir to Rainbow Creek Confluence

Reach 4a runs from Cowwarr Weir to the confluence with Rainbow Creek and is the older channel of an avulsion. It is geomorphologically 'perched' (i.e. higher in the landscape, therefore is a losing channel) and it is likely to be further aggrading (i.e. filling and raising the level of the stream through accumulation of sediments). This process is reducing channel capacity and causing fine-grained sediments (e.g. sand and silts) to dominate the substratum. The channel is continuing to develop floodrunners onto the floodplain between Reaches 4a and 4b, which themselves are prone to avulsion (e.g. during a period of high flow). The EFTP discussed the management of Reaches 4a and 4b at length during the recommendations workshop in February 2020 with WGCMA staff to ensure that the updated flow recommendations were consistent with the Avulsion Management Plan (WGCMA, 2019) as well as the overall Thomson River Vision (as developed by the team for this project in the Issues Paper). The EFTP, in consultation with the WGCMA, developed flow recommendations (**Table 6**) based on the documented need to maintain Reach 4a as the preferred flow path for the Thomson River, despite the current trajectory of likely change in geomorphology and river path. The inference is that the EFTP defining geomorphically-focused flows that, within existing operational constraints, may reduce the risk of complete capture of flow by Rainbow Creek, i.e. outflanking of Cowwarr Weir. This approach is based on the WGCMA (2019b) statement that:

The Thomson and Rainbow system is managed to reduce the risk of avulsion and improve waterway health with benefits for agriculture, the community and the Gippsland Lakes.

Because of these considerations, the new flow recommendations devised for Reaches 4a and 4b are in most aspects quite unlike those recommended in the original (2003) investigation (**Table 6**).

Table 6: Reach 4a flow recommendations

Timing	Flow component	Reach 4a: Thomson River, Cowwarr Weir to Rainbow Creek Confluence		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	20 ML/d, Dec-Apr, continuous	**75 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, V2, V3, V4, V5, M1, M5, M7, P1**
	Fresh	45 ML/d, 4/yr, Dec-Apr, 7 days	**300 ML/d**– 1 x yr 7 days, Dec / Jan	**G2, G3, G4, G5, G6, V2, V3, V4, V5, M6, M2**
			180 ML/d - 1 x yr 7 days, Feb / Mar	**G2, G3, G4, G5, G6, F3, V2, V3, V4, M6, M2**
			750 ML/d – 1 x yr 7 days, April	**G3, G5, G6, G7, G8, G9, G10, V2, V3, V4, V5, F4, M6, M2**
Winter / Spring	Baseflow	45 ML/d, May-Nov, continuous	**300 ML/d** Continuous	**G1, G2, G3, G4, F1a, F1b, F1c, F2, F6, V2, V3, V4, V5, M1, M5, M7, P1**
	Fresh	260 ML/d, May-Nov, 1/yr 4 days	**750 ML/d** – 1 x yr 7 days, May	**G3, G6, G7, G8, G9, G10, F5, V3, V4, V5, M6, M2, M3**
			750 ML/d – 1 x yr 7 days, Sep	**G3, G6, G7, G8, G9, G10, V3, V4, V5, M6, M2, M3**
			750 ML/d – 1 x yr 7 days, Oct / Nov	**G3, G6, G7, G8, G9, G10, (V2, V3, V4, V5) M6, M2, M3**
	Bankfull / sub bankfull	2,000 ML/d, May-Nov, 1/yr, 4 days	**5,000 ML/d** – every 2 yrs, 1 day, anytime*	**G11, G12, G13, V7, V8, M8, M9, FN1**

*Ideally June - August to limit impact on Platypus

5.1.1. Summer / Autumn Baseflow

Consistent with the overarching vision for the Thomson River (Streamology 2020) and with the management imperatives for Reaches 4a and 4b outlined in the Avulsion Management Plan (WGCMA 2019b), the EFTP determined that Baseflows moving through Reach 4a should be increased from the original recommendations (20 ML/day) to 75 ML/day in order to provide a dominant and attractant flow for fish connectivity. The fundamental reason for this revision is that

fish moving up Reach 4b eventually reach a 'dead end' at the distal part, whereas fish moving up Reach 4a can continue up the Thomson River past the fish ladder on Cowwarr Weir and eventually into the Aberfeldy River (and Reach 2 of the Thomson River), thus maintaining a continuum for the ocean to the headwaters of the river system in the Victorian Alps.

A Baseflow of 20 ML/d is thus inappropriate for Reach 4a, and increases the risk that this part of the river system will avulse. The EFTP, therefore, recommend splitting the incoming 125 ML/d baseflow from Reach 3 into a baseflow of 75 ML/d for Reach 4a (and a baseflow of 50 ML/d for 4b - outlined in Section 5.2).

5.1.2. Summer / Autumn Freshes

The EFTP recommend three Summer / Autumn Freshes, in keeping with the connected river vision, with each Fresh acting as a migration cue or for wetting fringing and riparian vegetation. The volumes of the Freshes are continuous from Reach 3, with the baseflow removed at the Cowwarr Weir flow split. The December / January fresh of 300 ML/d will mobilise sand in pools (based on the two pools in the model), the February / March Fresh of 180 ML/d will mobilise sand in pools for half the reach (i.e. not maintaining some pool depth). The April Fresh of 750 ML/d will mobilise gravel-sized sediments between 7 to 10 cm (~7 to 10 N/m^2).

5.1.3. Winter / Spring Baseflow

The EFTP determined that the Winter / Spring Baseflows moving through Reach 4a need to be increased over the original recommendation, in order to provide a dominant and attractant flow for fish connectivity. As for the Summer/Autumn period, baseflow of 45 ML/d is no longer appropriate for this reach, and increases the risk that the system will avulse. Therefore, the EFTP recommend splitting the incoming 350 ML/d baseflow from Reach 3 into a baseflow of 300 ML/d for Reach 4a (and a baseflow of 50 ML/d for Reach 4b - outlined in Section 5.2).

5.1.4. Winter / Spring Freshes

Consistent with flows upstream in Reaches 2 and 3 (with the baseflow for Reach 4b removed at Cowwarr Weir), three winter freshes of 750 ML/d are now recommended for Reach 4a. Again, the primary purpose of these freshes is to act as a cue for fish migration, but they will also serve in maintaining recruitment and vertical zonation of plants, as well as meeting geomorphic and macroinvertebrate objectives.

5.1.5. Bankfull / Sub Bankfull

The EFTP recommend a Bankfull / Sub Bankfull delivery of 5,000 ML/d every two years, an increase in volume from the 2003 recommendation but with a decrease in duration.

5.2. Reach 4b – Rainbow Creek, Cowwarr Weir to Thomson River Confluence

Based on the Avulsion Management Plan developed by WGCMA (WGCMA 2019b), as well as the overarching vision for the Thomson River developed in the earlier phases of this project, the environmental flow recommendations focus on and give priority to Reach 4a over Reach 4b. Reach 4a has higher ecological value due to its role in providing ecological connectivity between headwater and lacustrine/estuarine reaches via the fishway at Cowwarr Weir. The outlet at Cowwarr Weir for Reach 4b is a low-level offtake valve and there is no fishway in Reach 4b. Cowwarr Weir therefore represents a complete barrier to the migration of fish and other aquatic fauna in Reach 4b and also inhibits the transport of sediment and plant propagules through this reach. The flow recommendations are therefore not trying to restore the full functionality of Reach 4b; rather, they are aimed at simply maintaining the channel and preventing encroachment by terrestrial vegetation. Due to the flow split at Cowwarr Weir, increasing flow down Reach 4b will have an impact on Reach 4a.

The EFTP note that the 2019 WGCMA Avulsion Management Plan vision is short-term focussed to maintain the *status quo* of system. In the longer term, however, this vision is likely to be highly problematic: maintaining the *status quo* of the system increases the risk of an unmanaged and possibly highly destructive avulsion occurring in the future.

As outlined in the Issues Paper, the EFTP is managing Reach 4a and 4b to maintain current conditions, but also identifying recommendations that may assist with the preparation of the channels to support altered conditions in the case of significant channel change through this reach. Recommendations therefore consider sediment scouring flows through Reach 4a, and complementary actions (outlined in Section 8) such as delivery of sediment to Reach 4b. Both of these aspects require monitoring and further consideration.

Table 7 outlines the original (2003) and revised (2020) flow recommendations for Reach 4b.

Table 7: Reach 4b Flow Recommendations

Timing	Flow component	Reach 4b: Rainbow Creek, Cowwarr Weir to Thomson River Confluence		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	50 ML/d, Dec-Apr, continuous	**50 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, (V2, V3), V4, M1, G3**
	Fresh	250 ML/d, Dec-Apr, 4/yr, 7 days	**NA**	**NA**
				NA
				NA
Winter / Spring	Baseflow	250 ML/d, May-Nov, continuous	**50 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, F6 (V2, V3), V4, M1, G3**
	Fresh	2,500 ML/d, May-Nov, 1/yr, 4 days	**NA**	**NA**
				NA
				NA
	Bankfull / sub bankfull	13,000 ML/d, May-Nov, 1 in 3 yrs, 2 days	**5,000 ML/d** – every 2 yrs, 1 day, anytime*	**G11, G12, G13, V7, V8, M4, FN1**

*Ideally June - August to limit impact on Platypus

5.2.1. Summer / Autumn Baseflow

The EFTP recommend a low baseflow of 50 ML/d to achieve two objectives: (1) prevent terrestrialisation of the waterway (Objective V4) and (2) to simply maintain the channel (Objective G3).

5.2.2. Summer / Autumn Freshes

The EFTP does not recommend delivery of Summer / Autumn Freshes because of the adverse impact that delivering Freshes to Reach 4b would have on hydrological connectivity and ecological values in Reach 4a. A 50 ML/d Baseflow equates to velocities of 0.07 up to 0.5 m/s which is sufficient for sediment movement to maintain water quality within pools and prevent floating plants such as *Azolla* accumulating within the waterway.

5.2.3. Winter / Spring Baseflow

The EFTP recommend a Winter / Spring Baseflow of 50 ML/d to help prevent terrestrialisation and to maintain the channel.

5.2.4. Winter / Spring Freshes

Again, the EFTP does not recommend delivery of Winter / Spring Freshes, because of the adverse impact that delivering Freshes to Reach 4b would have on values in Reach 4a. A 50 ML/d Baseflow equates to velocities of 0.07 up to 0.5 m/s which is sufficient for sediment movement to maintain water quality within pools and will not allow *Azolla* to accumulate within this reach.

5.2.5. Bankfull / Sub Bankfull

The EFTP recommend a Bankfull / Sub Bankfull delivery of 5,000 ML/d every two years, an increase in volume from the 2003 recommendation but with a decrease in duration. A volume of 5,000 ML/d will keep the channel open and help prevent the system from avulsing.

5.3. Reach 5 – Reach 4a / 4b Confluence to Macalister River Confluence

Reach 5 begins at the confluence of Reaches 4a and 4b and extends to the confluence of the Thomson River with the Macalister River. Reach 5 consists of a meandering sand bed with high sinuosity and abandoned channels. Native fish assembly is largely intact, with Reach 5 having the highest abundance of large-bodied fish, but introduced fish species are also abundant. Flow recommendations are outlined in **Table 8**.

Table 8: Reach 5 flow recommendations

Timing	Flow component	Reach 5: 4a/4b Confluence to Macalister River Confluence		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	70 ML/d, All year, continuous	**125 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, V2, V3, V4, V5, V6, M1, M5, P1**
	Fresh	230 ML/d, Dec-Apr, 3/yr, 4 days	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**G2, G3, G4, G5, G6, V2, V3, V5, M2, M6**
			230 ML/d – 1 x yr 7 days, Feb / March	**G2, G3, G4, G5, G6, F3, V2, V3, M2, M6**
			800 ML/d – 1 x yr 7 days, April	**G3, G5, G6, G7, G8, G9, G10, V2, V3, V5, F4, M2, M6**
Winter / Spring	Baseflow	70 ML/d, All year, continuous	**350 ML/d** Continuous	**G1, G2, G3, G4, F1a, F1b, F1c, F2, F6, V2, V3, V4, V5, V6, M1, M5, P1**
	Fresh	300 ML/d, May-Nov, 7/yr, 4 days	**800 ML/d** – 1 x yr 7 days, May	**G3, G6, G7, G8, G9, G10, F5, V3, V5, M2, M3, M6**
			800 ML/d – 1 x yr 7 days, Sep	**G3, G6, G7, G8, G9, G10, V3, V5, M6, M2, M3**
			800 ML/d – 1 x yr 7 days, Oct / Nov	**G3, G6, G7, G8, G9, G10, F7 (V2, V3, V5) M6, M2, M3**
	Bankfull / sub bankfull	5,000 ML/d, any time, 2/yr, 4 days	**5,000 ML/d** – 1 x yr 1 day, Oct/Nov	**F8, G11, G12, G13, V7, V8, M8, M9, FN1**

5.3.1. Summer / Autumn Baseflow

The EFTP recommended a Summer / Autumn Baseflow of 125 ML/d to maintain consistency in Baseflow along the length of the Thomson River. A Baseflow of 125 ML/d also inundates former bars, inhibiting or removing terrestrial vegetation, maintains a diversity of habitat types and allows for connectivity between pools.

Under baseline conditions (reflecting pre-dam hydrology), a flow of 125 ML/d was exceeded 95% of the time, further justifying the need to increase the Baseflow in Reach 5 from the 70 ML/d recommended in 2003.

5.3.2. Summer / Autumn Freshes

Maintaining a consistent flow regime down the length of the river system is the principle objective that arises from the overarching vision of the Thomson River. In keeping with this ideal, the Summer / Autumn Freshes defined for Reach 5 are a continuation of, and consistent with, those to be delivered for Reaches 3 and 4 (combined 4a and 4b):

- 800 ML/d mobilises silts from the stream bed, fish migration cue, recharge soil moisture at high banks, maintains plant zonation and plants along the riparian zone
- 230 ML/d acts as a downstream migration cue, upstream migration cue for Bass, eels and large bodied fish
- 350 ML/d is primarily directed to the maintenance of fringing vegetation and its vertical zonation, as without it such a fresh this vegetation band will undergo a 3-month period over Summer without inundation.

5.3.3. Winter / Spring Baseflow

The EFTP recommend a significant increase in Winter / Spring Baseflow from the original 70 ML/day to 350 ML/d, for continuity in flow along the river. A baseflow of 350 ML/d was exceeded 90% of the time in Winter and Spring, further justifying the need to increase the original 2003 Baseflow recommendation of 70 ML/d.

Furthermore, a Baseflow of 350 ML/d will assist with Platypus movement along the reach and reduce the risk of individuals being predated upon during the critical pre-breeding feeding months.

5.3.4. Winter / Spring Freshes

Consistent with Reaches 2, 3 and 4 (4a and 4b combined) three Winter / Spring Freshes of 800 ML/d are recommended for Reach 5. The primary purpose of these Freshes is to act as a cue for fish migration, as well as maintaining recruitment of plants, meeting geomorphic and macroinvertebrate objectives. The receding waterfront after the Freshes is important for vegetation recruitment, rush and reed establishment and the downstream transport of plant propagules.

5.3.5. Bankfull / Sub Bankfull

The EFTP agreed with the 2003 Bankfull recommendation and, on the basis of the HEC RAS modelling and the spells analysis, could not justify any substantial changes in volume or timing.

If Bankfull flows are able to be delivered in October / November, the 800 ML/d fresh in October / November is not required.

5.4. Reach 6 – Macalister River Confluence to the Latrobe River

Reach 6 extends from the confluence with the Macalister River to the confluence of the Thomson River with the Latrobe River, just downstream of the town of Sale. Reach 6 contains ecologically significant freshwater wetlands which are currently hydrologically disconnected from the river. Environmental Flow Recommendations for Reach 6 are provided in **Table 9**.

Table 9: Reach 6 flow recommendations

Timing	Flow component	Reach 6: Macalister River Confluence to the Latrobe River		
		2003 recs	2020 recs	Objectives met
Summer / Autumn	Baseflow	100 ML/d, all year, continuous	**125 ML/d** Continuous	**G1, G2, G3, G4, G5, F1a, F1b, F1c, F2, V2, V3, V4, V5, V6, M1, M5, P1**
	Fresh	355 ML/d, Dec-Apr, 3/yr, 4 days	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**G2, G3, G4, G5, G6, V2, V3, V5, M2, M6, S2**
			230 ML/d – 1 x yr 7 days, Feb / March	**G2, G3, G4, G5, G6, F3, V2, V3, M2, M6, S2**
			800 ML/d – 1 x yr 7 days, April	**G3, G5, G6, G7, G8, G9, G10, V2, V3, V5, F4, M2, M6, S2**
Winter / Spring	Baseflow	100 ML/d, all year, continuous	**350 ML/d** Continuous	**G1, G2, G3, G4, F1a, F1b, F1c, F2, F6, V2, V3, V4, V5, V6, M1, M5, P1**
	Fresh	2,200 ML/d, May-Nov, 3/yr, 10 days	**800 ML/d** – 1 x yr 7 days, May	**G3, G6, G7, G8, G9, G10, F5, V3, V5, M6, M2, M3, S2**
			800 ML/d – 1 x yr 7 days, Sep	**G3, G6, G7, G8, G9, G10, V3, V5, M6, M2, M3, S2**
			800 ML/d – 1 x yr 7 days, Oct / Nov	**G3, G6, G7, G8, G9, G10, F7, (V2, V3, V5) M6, M2, M3, S2**
	Bankfull / sub bankfull	9,500 ML/d, May-Nov, 2/yr*, 4 days	**9,500 ML/d,** 1 x yr, 2 days, Oct/Nov	**F8, G11, G12, G13, V7, V8, M8, M9 FN1**
			18,000 ML/d, every 4th yr, 2 days, Oct/Nov	**F8, G11, G12, G13, V7, V8, M8, M9, FN1**

5.4.1. Summer / Autumn Baseflow

The EFTP recommend an increase in Summer / Autumn Baseflow from 100 ML/day to a flow of 125 ML/d in order to maintain consistency in Baseflow along the various reaches of the river system. This baseflow also contributes to preventing encroachment of the salt wedge into the freshwater

reach – particularly with ongoing and possibly increasing rates of eustatic sea-level rise. (Gross et al. 2015).

5.4.2. Summer / Autumn Freshes

Three Freshes of different magnitudes are recommended for Reach 6. The primary purpose of the 350 ML/d Fresh in December or January is to wet vegetation during the seasonally dry summer months. The second (230 ML/d) and third (800 ML/d) Fresh of the season primarily serve as fish migration cues, with the 800 ML/d Fresh also acting to scour the bed and banks. The original flow recommendation Fresh duration of 3 days was extended to 7 days, as research conducted since 2003 has shown that a time period of 7 days is more appropriate to facilitate the long-distance migration of diadromous species (Koster et al. 2013, 2018; Amtstaetter et al. 2016).

These Freshes will also contribute to flushing the Upper Thomson Estuary, leading to water quality benefits and assisting with preventing encroachment of the salt wedge into the freshwater reach.

5.4.3. Winter / Spring Baseflow

The EFTP determined that the Winter/Spring Baseflow of 100 ML/d defined in 2003 is insufficient and recommend an increased Baseflow of 350 ML/d. A flow of 350 ML/d will inundate fringing woody vegetation (e.g. Swamp paperbark, *Melaleuca ericifolia*) and maintain damp conditions in these mid-bank zones. This baseflow also contributes to preventing encroachment of the salt wedge into the freshwater reach – particularly with ongoing and possibly increasing rates of eustatic sea-level rise. (Gross et al. 2015).

Furthermore, a Baseflow of 350 ML/d will assist with Platypus movement along the reach and reduce the risk of individuals being predated upon during the critical pre-breeding feeding months.

5.4.4. Winter /Spring Freshes

Consistent with Reaches 2, 3, 4 (4a and 4b combined) and 5, three Winter/Spring Freshes of 800 ML/d are recommended for Reach 6. The primary purpose of these Freshes is to act as a cue for fish migration, as well as maintaining recruitment of plants, meeting geomorphic and macroinvertebrate objectives. The receding waterfront after the Freshes is important for vegetation recruitment, rush and reed establishment and the downstream transport of plant propagules.

Similarly to the Summer/Autumn Freshes, the Winter/Spring Freshes will also have positive outcomes for the Upper Thomson Estuary.

5.4.5. Bankfull / Sub Bankfull

Two different Bankfull flows are recommended for Reach 6: 9,500 ML/d once per year for a period of 2 days in Oct / Nov; and 18,000 ML/d every fourth year for a period of 2 days in October or November. The smaller 9,500 ML/d flow is primarily designed to act as a disturbance mechanism as well as inundating upper-bank woody vegetation. The larger 18,000 ML/d event aims to inundate wetlands along the reach, thus providing a period of connectivity with the main channel. **Figure 3** shows the commence-to-flow volumes for some of the wetlands located along Reach 6. The diagram clearly shows a point of inflection at around 18,000 ML/d whereby 11 wetlands are inundated and the falling effectiveness of higher flows, which add progressively fewer sites to those expected to

experience filling. The increase from 25,000 ML/day to 45,000 ML/day, for example, results in only an additional four floodplain wetlands being inundated.

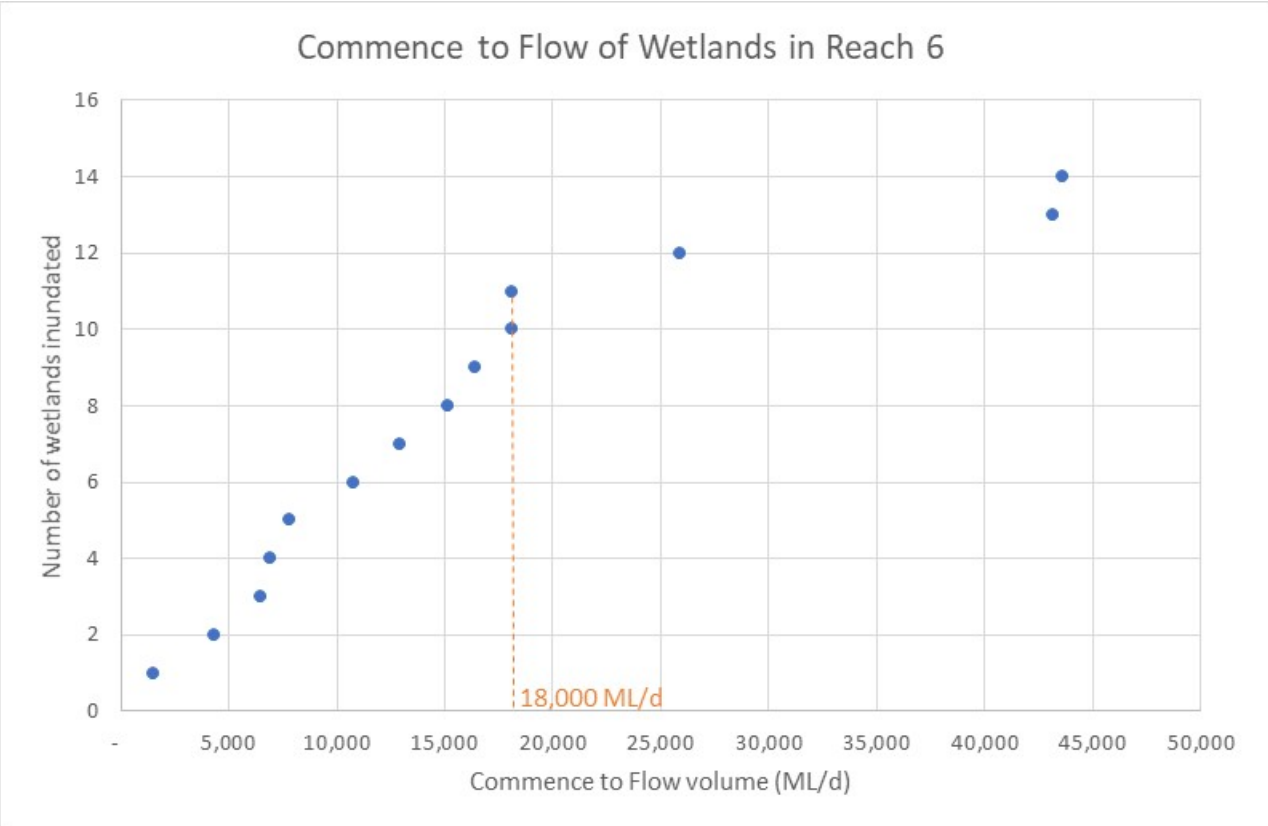
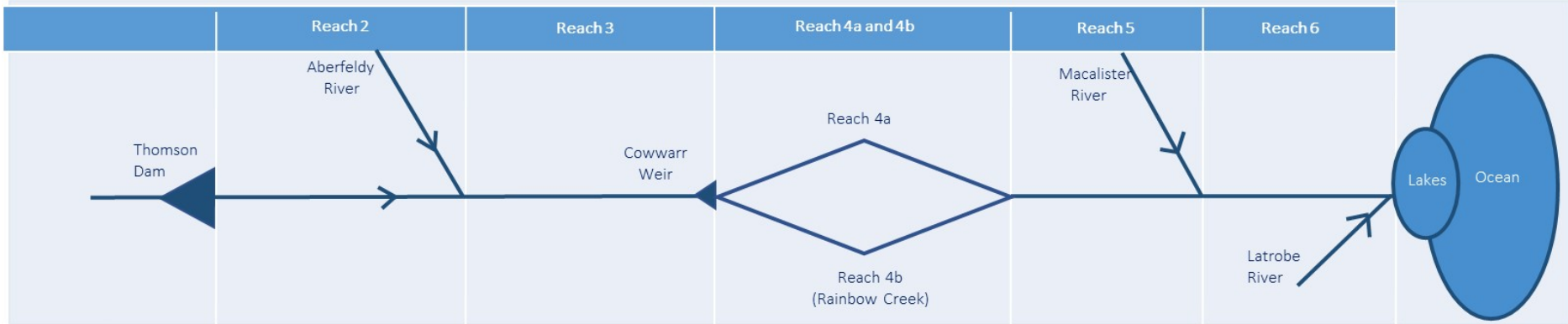


Figure 3: Commence to flow (CTF) for wetlands in Reach 6 (note: two wetlands are in the very lowest portion of Reach 5)

6. Recommendations Summary

The EFTP has recommended a flow regime that is consistent with the overall vision of the Thomson River, creating a consistent flow regime along the length of the river. **Table 10** outlines the flow recommendations per reach.

Table 10: Flow recommendations for the Thomson River



Timing	Flow component	Reach 2	Reach 3	4a	4b	Reach 5	Reach 6
Summer / Autumn	Baseflow	**125 ML/d** Continuous	**125 ML/d** Continuous	**75 ML/d** Continuous	**50 ML/d** Continuous	**125 ML/d** Continuous	**125 ML/d** Continuous
	Fresh	**350 ML/d** – 1 x yr 7 days, December / Jan	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**300 ML/d**– 1 x yr 7 days, Dec / Jan	**NA**	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**350 ML/d** – 1 x yr 7 days, Dec / Jan
		230 ML/d – 1 x yr 7 days, Feb / March	**230 ML/d** – 1 x yr 7 days, Feb / March	**180 ML/d** - 1 x yr 7 days, Feb / Mar		**230 ML/d** – 1 x yr 7 days, Feb / March	**230 ML/d** – 1 x yr 7 days, Feb / March
		800 ML/d – 1 x yr 7 days, April	**800 ML/d** – 1 x yr 7 days, April	**750 ML/d** – 1 x yr 7 days, April		**800 ML/d** – 1 x yr 7 days, April	**800 ML/d** – 1 x yr 7 days, April
Winter / Spring	Baseflow	**230 ML/d** Continuous	**350 ML/d** Continuous	**300 ML/d** Continuous	**50 ML/d** Continuous	**350 ML/d** Continuous	**350 ML/d** Continuous
	Fresh	**800 ML/d** – 1 x yr 7 days, May	**800 ML/d** – 1 x yr 7 days, May	**750 ML/d** – 1 x yr 7 days, May	**NA**	**800 ML/d** – 1 x yr 7 days, May	**800 ML/d** – 1 x yr 7 days, May
		800 ML/d – 1 x yr 7 days, Oct / Nov	**800 ML/d** – 1 x yr 7 days, Oct / Nov	**750 ML/d** – 1 x yr 7 days, Oct / Nov		**800 ML/d** – 1 x yr 7 days, Oct / Nov	**800 ML/d** – 1 x yr 7 days, Oct / Nov
		800 ML/d – 1 x yr 7 days, Sep	**800 ML/d** – 1 x yr 7 days, Sep	**750 ML/d** – 1 x yr 7 days, Sep		**800 ML/d** – 1 x yr 7 days, Sep	**800 ML/d** – 1 x yr 7 days, Sep
	Bankfull / sub bankfull Flow	**2,000 ML/d** – every 2 yrs 1 day, anytime	**3,000 ML/d** – 1 x yr 1 day, anytime	**5,000 ML/d** – every 2 yrs, 1 day, anytime	**5,000 ML/d** – every 2 yrs, 1 day, anytime	**5,000 ML/d** – 1 x yr 1 day, anytime	**9,500 ML/d,** 1 x yr, 2 days, anytime
							18,000 ML/d, every 4th yr, 2 days, anytime

7. Tools to Manage Flow Recommendations

Recommendations provided by this study are intended to adaptive. To assist the WGCMA to utilise these recommendations Streamology, in the third phase of this project, identifies shortfalls and develops a tool that can be used to adapt flow delivery to achievement of critical values. This tool, Flowcaster, is outlined in the next phase (Streamology 2020c).

8. Complementary Measures

A number of complementary measures are recommended to be considered for implementation in conjunction with the flow recommendations. These include:

- Consideration be given to inundating floodplain wetlands through direct pumping, if climatic considerations warrant it
- Modifying wetland connectivity in order to improve inundation frequency, particularly in order to reduce commence-to-flow levels
- Fishway maintenance at Reach 4a Cowwarr Weir and Horseshoe Bend to ensure that ecological connectivity is maintained at all times.
- Examine potential for provision of fish passage at Rainbow Creek. This is aimed to redress concerns over flows >1,000 ML/d attracting fish to migrate up Rainbow Creek
- Sediment management – Flushing from Cowwarr weir into Rainbow Creek – investigate desilt operations
- Monitor geomorphic channel changes in Reaches 4a and 4b. This would require field-based (beyond the Lidar comparison) to ensure the resolution and timescales are appropriate to assessing changes in channel bed and bank morphology.
- Fencing – Reaches 4, 5 and 6
- Control of weeds, both introduced and native 'out-of-balance' taxa – Reaches 4, 5 and 6, particularly Reaches 4a and 5
- Introduction of native vegetation through revegetation schemes – Reaches 4, 5, 6, particularly 4b (preparing Rainbow Creek)
- Carp control – Previous recommendation for drying carp eggs via water level manipulation not supported by strong field evidence. Control options such as direct removal (harvesting) and future biological controls (e.g., carp herpes virus) may be appropriate.
- Introduced brown trout are likely to have detrimental impacts on native fish in the system (especially Australian grayling and galaxiids). Engagement with the Victorian Fisheries Authority to develop trout stocking strategies that are sensitive to the requirements of native fish would limit this threat.
- Consideration be given to re-introducing large woody debris into the stream channel to provide fish habitat and hard surfaces for primary production – Reaches 5 and 6

- Monitoring for information gaps – e.g. Fish migration responses to volumes of water less than 800 ML/d.

9. Conclusions

The revised flow recommendations presented in this report, determined by the EFTP in collaboration with staff from the WGCMA, identify the flow types, frequency, magnitude, duration, timing and seasonality required to sustain a healthy Thomson River that runs as a continuum for the headwaters in the mountains to the Gippsland Lakes and, eventually, to the sea. The recommendations have been developed by the Thomson River Environmental Flows Technical Panel according to the State-endorsed FLOWS 2 method. Recommendations are based on satisfying agreed ecological objectives for fish, macroinvertebrates, vegetation, Platypus, and geomorphology, and should help in ensuring that the Vision for the Thomson River system is achieved.

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