CAMPASPE RIVER

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

ASSESSMENT AREA: CAMPASPE RIVER, CAMPASPE WEIR TO MURRAY RIVER

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

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Front cover photo: Campaspe River, 6th October 2009, North Central CMA

The Campaspe River Environmental Watering Plan is a working document, compiled from the best available information. It will be subject to revision in the future as new information becomes available.

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EXECUTIVE SUMMARY

The Campaspe River Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to significant reductions in channel outfalls to the waterway.

This EWP refers to the Campaspe River from Campaspe Weir to confluence with the Murray River, or reaches 3 and 4 of the environmental flow recommendations. It also includes an assessment of the Campaspe Billabong and Unnamed Creek (Campaspe River Reach 4).

The following components are the primary means by which the commitment of no net environmental loss for the Campaspe River will be achieved for the NVIRP project. The main conclusions are summarised below.

Defining the environmental values of Campaspe River
The Campaspe River supports a range of environmental values and are described specifically for the lower Campaspe River (e.g. Golden Perch). In describing the waterway values, an emphasis has been placed on identifying listed flora and fauna species, and vegetation communities followed by the environmental flow recommendation that support and sustain the river (e.g. spring freshes to cue native fish movement).

Campaspe River environmental flow recommendations
The environmental flow recommendations for the Campaspe River were undertaken in 2006 and provide the environmental context that the mitigation water assessment was based on.

Campaspe Billabong and Unnamed creek
The contribution of channel outfalls to the Campaspe Billabong and Unnamed Creek is not likely to be significant and have been incorporated into the Campaspe River assessment.

Hydrology assessment)
The assessment of the impact of NVIRP (outfall reductions) on streamflow was undertaken for the long-term, recent (post 2000) and baseline year (2003-04 or 2004-05) conditions. The post NVIRP hydrology assessment has largely focused on the impact during the irrigation season (August to April), due to the influence of reduced outfalls over this time period.

Assessment of mitigation water requirement
Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values resulting from NVIRP. The outcomes from this assessment are summarised below:

- *Campaspe River Reach 3:* the assessment demonstrated that the **outfall water <u>does not</u> provide benefit** to the waterway. Therefore mitigation water is not required to maintain the environmental values of the waterway.
- *Campaspe River Reach 4:* the assessment demonstrated that the **outfall water <u>does not</u> provide benefit** to the waterway. Therefore mitigation water is not required to maintain the environmental values of the waterway.

Potential risks, limiting factors and adverse impacts associated with the recommended water regime
A number of potential risks, limiting factors and adverse impacts have been identified that may result from the provision of mitigation water as a portion of the recommended water regime. For example, this EWP is based on current operation of the Campaspe River, any significant changes to operation including water trade out this system will need to reviewed.

Adaptive management framework
An adaptive management approach (assess, design, implement, monitor, evaluate and adjust) has been incorporated into the EWP to ensure that it is responsive to changing conditions. The Campaspe River EWP has been developed using the best available information. However, a number of information and knowledge gaps which have been identified in the document may impact recommendations and/or information presented. These knowledge gaps will be addressed as part of the adaptive management approach outlined within the EWP as additional information becomes available.

Governance arrangements
A summary of the roles and responsibilities (e.g. land manager, environmental water manager, and system operator) relating to the development and implementation of EWPs has been defined.

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ACKNOWLEDGEMENTS

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The North Central Catchment Management Authority (CMA) acknowledges the assistance of the following people in preparing this EWP.

- Tony Cantwell and Sam Green (Goulburn-Murray Water)
- Rob O'Brien (Department of Primary Industries)
- Jason Lieschke, Stacey Parkinson and Stephen Adamthwaite (Environment Protection Authority Victoria)
- James Williams, Geoff Elliot, Denise Accocks, Frank Urbano, Brian Wearne and Kay Wearne
- Andrea Joyce, Paulo Lay and John Cooke (Department of Sustainability and Environment)
- Ross Plunkett and Chris Solum (NVIRP)
- Pat Feehan (Feehan Consulting)
- Andrew Sharpe, Erin Murrihy and Kate Austin (Sinclair Knight Merz)
- Professor Paul Boon (Dodo Environmental Pty Ltd)
- John McGuckin (Streamline Research Pty Ltd)
- NVIRP Technical Advisory Committee (TAC) (listed in Appendix A, Table A1)
- North Central CMA working group (listed in Appendix A, Table A2)
- Lyndall Rowley, Emer Campbell, Rebecca Horsburgh, Rebecca Lillie and Darren White (North Central CMA).

ABBREVIATIONS

ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BMW	Baseline Mitigation Water
BONN	Convention on the Conservation of Migratory Species
CAMBA	China–Australia Migratory Bird Agreement
CEWAG	Campaspe Environmental Water Advisory Group
DCFL	Department of Conservation Forests and Lands
DEWHA	Department of Environment, Water, Heritage and the Arts
DIWA	Directory of Important Wetlands
DPI	Department of Primary Industries
DPCD	Department of Planning and Community Development
DSE	Department of Sustainability and Environment
EPBC	*Environmental Protection and Biodiversity Conservation Act 1999*
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
FFG	*Flora and Fauna Guarantee Act 1988*
FSL	Full Supply Level
GIS	Geographic Information Systems
GL	Gigalitre (one billion litres)
GMID	Goulburn Murray Irrigation District
G-MW	Goulburn–Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
LTCE	Long-term Cap Equivalent
MWC	Mitigation Water Commitment
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEMP	Site Environmental Management Plan
TAC	Technical Advisory Committee
VEAC	Victorian Environmental Assessment Council
WCMF	Water Change Management Framework

1. Northern Victoria Irrigation Renewal Project

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover a long term average (LTCE) of 425 GL of water per year.

The GMID uses a number of natural carriers, rivers, lakes and wetlands for both storage and conveyance of water. While the water savings generated from the NVIRP are considered a 'loss' to the irrigation system, in some cases this operating regime provides incidental benefits to environmental assets (SKM 2008a).

1.1. Decision under the Environmental Effects Act 1978

On the 14 April 2009, the Victorian Minister for Planning made a decision that an Environment Effects Statement (EES) was not required for the NVIRP project under the Victorian *EES Act 1978*, although this decision was subject to several conditions (DPCD 2009). The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *development of a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister of Water.*

NVIRP have developed a Water Change Management Framework (NVIRP 2010) in response to this condition. The framework outlines the processes and methodologies for preparing Environmental Watering Plans to mitigate potential impacts on wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management (NVIRP 2010).

Condition 5: *Environmental Watering Plans (EWPs) are required for 'at risk' waterways and wetlands before operation of the relevant NVIRP work commences.*

The other relevant environmental legislation that the NVIRP need to be in compliance with is outlined in Appendix B.

1.2. Water Savings Protocol

The "Technical Manual for the Quantification of Water Savings" provides guidelines for the calculation of water savings from irrigation modernisation projects (DSE 2009).

1.2.1. Baseline year

To calculate water savings the Technical Manual has adopted a "baseline year" to establish the average asset condition and operation condition of the system prior to modernisation. The baseline year is representative of long term average system conditions (DSE 2009). The selected baseline year for the Campaspe and Rochester Irrigation Areas is 2003-04 and 2004-05 respectively[1] (NVIRP 2010).

1.2.2. Long Term Cap Equivalent Conversion Factor

The Long Term Cap Equivalent (LTCE) Conversion Factor converts the savings within any year to be equivalent to the expected long term average under the hydrological and operating conditions for the system (DSE 2009). Refer to Step 6 of Section 8 for how this applies to calculating mitigation water for waterways.

[1] The baseline year is selected for its representativeness (e.g. last 100% allocation year) and focuses the mitigation water assessment on NVIRP activities and excludes those system activities that happened before NVIRP (NVIRP 2010).

1.3. Water Change Management Framework

The Water Change Management Framework (WCMF) (NVIRP 2010) sets out the overarching principles with respect to environmental management for the operation of the modified GMID. These principles include:

- NVIRP will strive for efficiency in both water supply and farm watering systems.
- NVIRP will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.
- NVIRP will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these sites) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of or modification to operating protocols and operational arrangements.

While NVIRP has been established to implement the modernised works, it will have no ongoing role in the operation of the modified GMID or environmental management in the region. Therefore NVIRP will need to establish effective management arrangements to ensure that any management or mitigation measures are implemented on an ongoing basis, particularly in the EWPs (NVIRP 2010).

1.4. Environmental Referral Report

An Environmental Referrals process assessed Stage 1 (upgrade of the backbone and connections) of the NVIRP in relation to potential impacts on waterways, wetlands and regional groundwater from increased system efficiencies such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage (SKM 2008a).

As part of this, an assessment of the changes to river flow regimes for the Loddon, Campaspe, Goulburn and Broken rivers was undertaken. The results indicated that overall, the changes in river flow regimes post NVIRP are small, especially when examined in terms of the annual flow volume. For the Campaspe River, a small change in flow pattern was detected suggesting that both summer and winter flow regimes will move slightly towards natural which was found to be consistent with the environmental flow recommendations.

The preliminary impact assessment of reduced channel outfalls on waterways was found to be variable, depending on the timing and volume of channel outfalls and environmental values in the waterway. Further assessment was recommended for the Campaspe River with the following findings:

- Campaspe/Rochester Irrigation Area (Campaspe River Reach 3 and 4) –.further investigation was recommended due to the potential contribution that channel outfalls make to flows in low flow years.

1.5. Shortlisting of Environmental Watering Plans

Following the preliminary list of waterways requiring further investigation (SKM, 2008a), Feehan Consulting (2009) undertook a validation process (confirmation of environmental values and water supply to the site) to short-list the waterways requiring EWPs. The following four waterways with significant environmental values were identified as potentially impacted by an 85% reduction in channel outfalls across the GMID:

1. Campaspe River (downstream of Campaspe Weir to Murray River)
2. Loddon River (downstream of Loddon Weir to Murray River)
3. Twelve Mile Creek (anabranch of the Loddon River)
4. Broken Creek (NVIRP 2010).

1.6. Purpose and scope of Environmental Watering Plans

Where a site with high environmental values could be adversely affected due to the change in irrigation contribution by the implementation of NVIRP, or if uncertainty exists as to the materiality of impacts, an EWP is prepared (NVIRP 2010, p66). The purpose of EWPs is to assess the environmental values that may be impacted by an 85% reduction in channel outfall[2].

The EWPs recommend the required mitigation for any of the potential adverse impacts to the waterway due to the implementation of NVIRP and include:

- scoping and collation of background information
- defining the environmental values, ecological objectives and associated water requirements
- assessment of hydrology (natural and current)
- NVIRP impact assessment
- quantification of the required mitigation water
- identification of risks associated with NVIRP
- governance and adaptive management recommendations
- consultation and engagement with stakeholders and adjacent landholders.

This Waterway EWP is not a river restoration plan, therefore it is not intended to provide management guidance; rather it is aimed at providing a water supply protocol that can be agreed upon by the land, water and catchment managers.

Please note: This EWP is assessing the potential impact from NVIRP in relation to outfall water contribution

Please note: leakage and seepage from NVIRP works is difficult to quantify until works have been implemented. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been further assessed as part of this EWP.

NVIRP is responsible for managing and mitigating the significant environmental effects of its own activities. It is not responsible for managing and mitigating the effects of other activities or circumstances. NVIRP is not responsible for managing and mitigating the environmental effects of activities and circumstances beyond its control such as:

- reduced outfalls due to Government policy initiatives
- water trade
- drought and climate change
- management and modernisation programs carried out by others (NVIRP 2010).

NVIRP EWPs will be implemented in the context of

- an overarching wetland or waterway management plan (that considers integrated land, water and biodiversity management of the waterway), where available.
- Agency roles and responsibilities documented in the WCMF and the Northern Region Sustainable Water Strategy (DSE 2009a)
- Victorian and regional strategies for healthy rivers, estuaries and waterways (still in development).

[2] Channel outfalls are unscheduled flows that leave the irrigation system, they are variable being influenced by rainfall, water deliveries, system operations, irrigation demand, crops being irrigated and the length of the irrigation season (DSE, 2009).

1.7. EWP development process

The Campaspe River EWP (downstream of Campaspe Weir to Murray River) was developed in collaboration with key stakeholders (members of the NVIRP Technical Advisory Committee (TAC), Appendix A) including Goulburn-Murray Water (G-MW), NVIRP, the Department of Sustainability and Environment (DSE), Parks Victoria and the Department of Primary Industries (DPI) according to the process outlined in Figure 1.

This EWP recommends the management and mitigation measures appropriate for long-term implementation. It also includes the processes for monitoring, review and adaptive management (refer to Figure 1).

Following development, Waterway EWPs are reviewed by the Technical Reference Group (Section 1.7.3), NVIRP TAC, DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel prior to consideration by the Minister for Water.

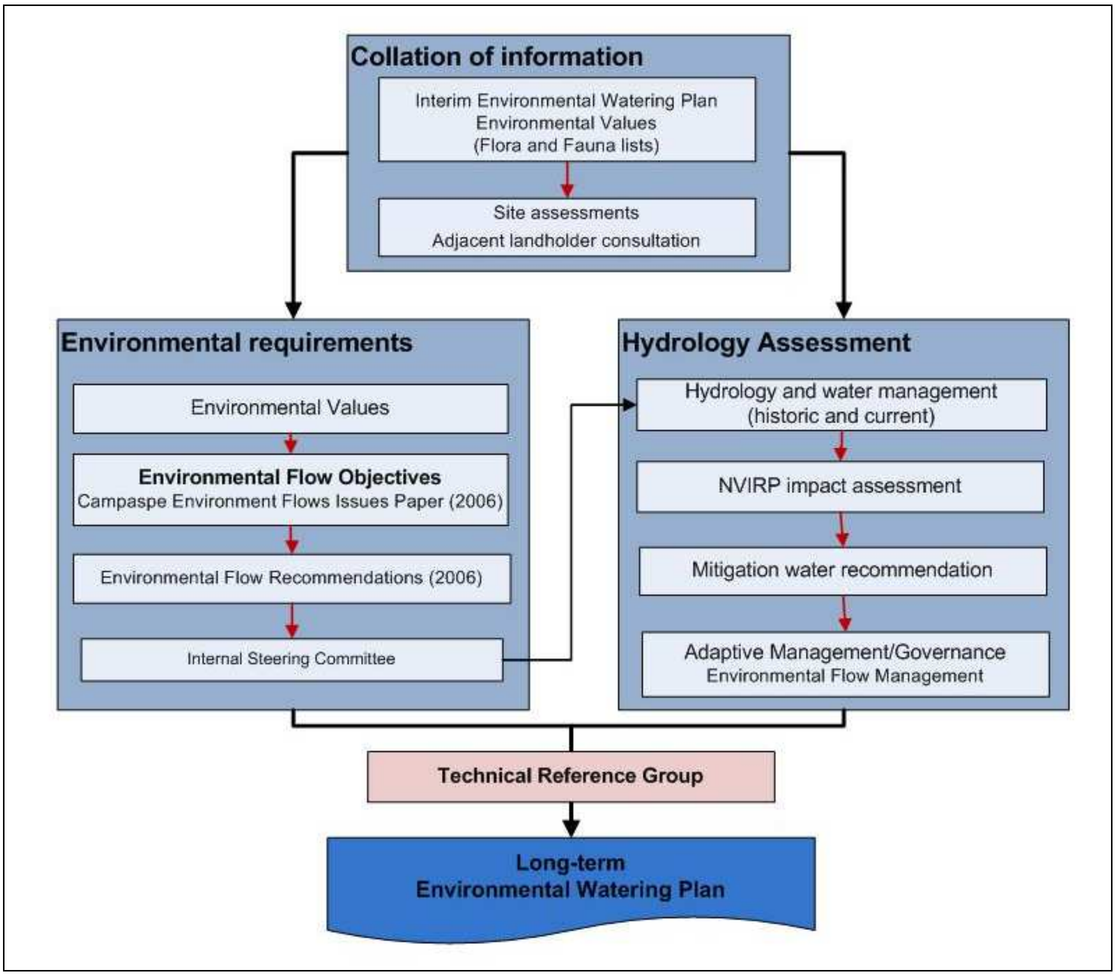

Figure 1: Waterway EWP development process

1.7.1. Interim Campaspe River EWP

An Interim Environmental Watering Plan for the Campaspe River (August 2009) considered the risk to the Campaspe River from the NVIRP 2009 winter works program. Conclusions from the Interim EWP for the Campaspe River are summarised below:

- The short-term risk of reducing the 2/1/3/14 channel outfall to the Campaspe River was considered to be low for both significant species and drought refuge. In isolation, the outfall is providing a minor contribution to the river. Cumulative impacts of reduced outfalls will need to be assessed for the longer term.
- It is unlikely that the No. 1/3/14 and No. 1/14 channel outfalls contribute flows to the Campaspe River, as they both outfall to a Campaspe anabranch which is not currently connected to the river and the sites assessed are used as reuse systems.

The risk assessment for these two outfalls focused on the direct area influenced by the outfall (Cahir's and Somerville's billabongs).

- The short-term risk of reducing No. 1/3/14 channel outfalls to Cahir's Billabong was considered to be Moderate for both significant species and drought refuge.
- The short-term risk of reducing No. 1/14 channel outfalls to Somerville's Billabong was considered to be Moderate for both significant species and drought refuge.
- The No. 2/1/3/14 channel outfall did not require mitigation actions for the 2009-10 irrigation season although a monitoring program was recommended.
- Considering the relatively poor condition of Cahir's and Somerville's billabongs (No. 1/3/14 and No. 1/14 channel outfalls) and the absence of significant species it was recommended that a monitoring program be implemented including an assessment of the occurrence of acid sulphate soils if the billabongs begin to dry out.

An EWP for the Campaspe River is still required to assess the impacts of NVIRP modernisation measures, including reduced outfalls, beyond this timeframe (NCCMA 2009a). Subsequent field visits over the 2009-10 season indicated that the short-term risk remained low (site did not dry out over this period).

1.7.2. Consultation and engagement

To assist in collating information for the Campaspe River EWP, a targeted community and agency engagement process was undertaken. Key groups consulted were the NVIRP Technical Advisory Committee (TAC), agency stakeholders, interest groups and adjoining landholders. An outline of the various groups' involvement is provided below.

The TAC was convened by the NVIRP to oversee the development of the EWPs to ensure quality, completeness and practicality. The committee included representation from CMAs, G-MW, DPI, NVIRP and DSE (Appendix A). A content template for the EWPs was developed and approved by the TAC in February 2010.

Consultation was also undertaken with adjoining landholders who have had a long association with the waterway and proven interest in maintaining its environmental value. A summary of the information sourced from this process is provided in Appendix C.

1.7.3. Technical Reference Group

In addition, key components (environmental values, hydrology and mitigation water assessments) of the EWP were presented and reviewed by an independent technical panel comprising of Dr Andrew Sharpe, Kate Austin (SKM), Prof Paul Boon (Dodo Environmental Pty Ltd) and John McGuckin (Streamline Research Pty Ltd) on 15 March 2010. This group have had practical and or consulting experience in the Campaspe River system (e.g. Environmental Flow Studies) and have provided technical expertise and scientific rigour for this EWP. Refer to Appendix G for paper outlining the recommendations made by the TRG.

2. Campaspe River

2.1. Catchment setting

The Campaspe catchment lies to the east of the North Central CMA region. The Campaspe River rises in the Great Dividing Range near Woodend and flows 150 km northwards to the Murray River at Echuca (Figure 2). The major waterways of the catchment are the upper Campaspe River and the Coliban River (both upstream of Lake Eppalock), and the lower Campaspe River (downstream of Lake Eppalock). Major tributaries are Axe, McIvor, Mount Pleasant, Wild Duck and Pipers creeks (NCCMA 2006).

Annual rainfall throughout the Campaspe River basin varies from 1080 mm on the Great Dividing Range in the south of the catchment to approximately 400-500 mm on the drier northern plains (Lorimer and Schoknecht 1987).

Flow throughout the catchment is regulated by water supply reservoirs, namely Lake Eppalock (downstream of the confluence of the Coliban and Campaspe rivers) and by the operation of the Campaspe Weir near Elmore and the Campaspe Siphon near Rochester (SKM 2006b).

Dryland farming (mainly cereal, beef cattle and wool) predominates in the southern part of the catchment, while irrigated crops (e.g. wheat, oats, barley) and horticulture (e.g. dairying, fruit, vines, tomatoes) are more common in the northern catchment. Other land uses, such as intensive animal industries and forestry, also occur at various locations throughout the catchment (NCCMA 2006).

2.2. Campaspe River EWP

This EWP is assessing the Campaspe River (downstream of Campaspe Weir to Murray River) and includes the Campaspe Billabong and an unnamed creek which is an anabranch of the Campaspe River Reach 4 (Figure 2).

The lower Campaspe catchment consists of the Campaspe and Rochester Irrigation Systems which provide water for irrigated agricultural practices, town and stock and domestic consumption (SKM 2006). The irrigation season is from mid-August to mid-May (approximately 270 days) which is when outfalls into the Campaspe River occur.

Irrigation outfalls currently contribute to flow in the lower Campaspe River. These outfalls provide additional flow to the waterway which may have some environmental benefit in the Campaspe River. The NVIRP is expected to significantly reduce losses from the Campaspe and Rochester Irrigation Areas (85% target), which may in turn lead to a number of hydrological changes in the Campaspe River (NVIRP 2010).

2.3. Cultural heritage

Traditionally, Indigenous people have a strong affinity with waterways and water bodies, as a vital source of food, water and camping sites in traditional lifestyles. The alluvial plain of the Campaspe River was first inhabited by a number of Indigenous groups.

The Campaspe River has been occupied by the Dja Dja Wurung and Yorta Yorta people. Rochester is the boundary area between Dja Dja Wurrung to the south and Yorta Yorta to the north. According to the Aboriginal Cultural Heritage sites register, there are fourteen sites of cultural significance along the Campaspe River Reach 4. These are predominantly shell deposits, scarred trees and mounds, with some artefact sites (DPCD 2008).

2.4. Recreation

The Campaspe River is a valuable recreation area in the North Central region. It supports the following recreational activities:

- camping and fishing (several small streamside reserves)
- swimming
- passive recreation (e.g. 3 km walking track along the Campaspe River banks, Echuca).

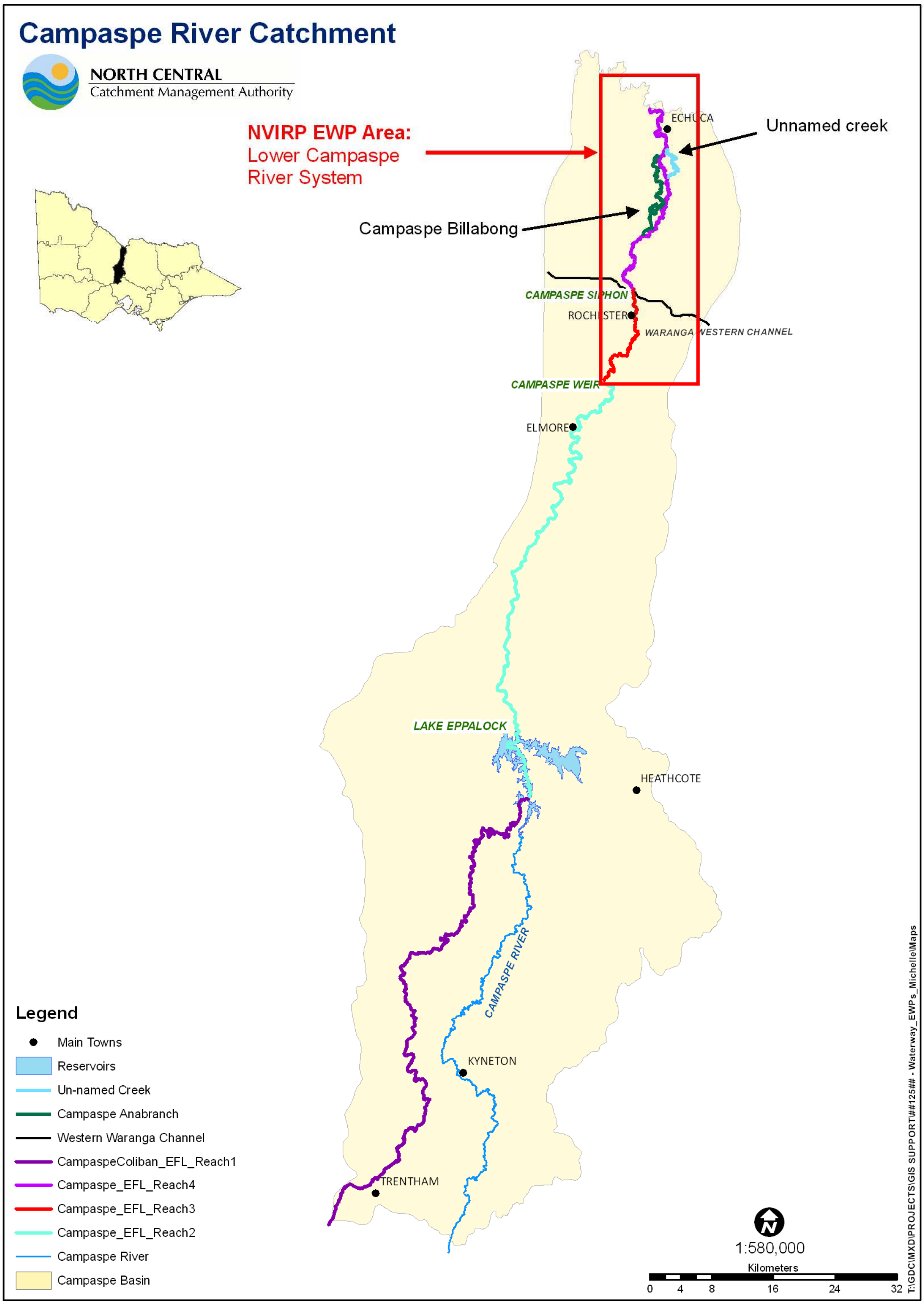

Figure 2: Campaspe River Catchment

3. Management objectives

Management objectives have been set for the Campaspe River in relation to the environmental flows (SKM 2006c). Environmental flow objectives set the direction and target for the environmental water releases and are clear statements of what outcomes should be achieved in providing environmental flows. The environmental flow recommendations provide the environmental framework in which the requirement for mitigation water is assessed (Section 8).

Trial environmental flow releases for the Campaspe River downstream of Lake Eppalock were recommended in 1995. In 1997, a scientific technical panel conducted an environmental flow assessment for the Campaspe River to help inform the Bulk Water Entitlement (BE) Conversion Process. The final BE flow provisions were less than the recommended flow requirements and reflect a decision that minimised impacts to consumptive supplies. The final BE recommendations specified passing flows for the Campaspe River below Lake Eppalock that varied depending on inflows to the lake, storage levels and season.

An updated environmental flows assessment was undertaken using the FLOWS method (DNRE 2002) in 2006 (SKM 2006a, 2006b and 2006c). The four environmental flow reaches are defined in Table 1 and shown in Figure 2.

Table 1: Campaspe River Environmental flow reaches (SKM 2006a)

Reach number	Description
Reach 1	Coliban River between Malmsbury Reservoir and Lake Eppalock
Reach 2	Campaspe River between Lake Eppalock and the Campaspe Weir
Reach 3a	Campaspe River between Campaspe Weir and Campaspe Siphon
Reach 4	Campaspe River between Campaspe Siphon and the Murray River

3.1. Lower Campaspe environmental flow reaches

The lower Campaspe River consists of the reaches of the Campaspe River downstream of Campaspe Weir to the Murray River. Reach 3 and 4 of the Campaspe River have high environmental values that could be adversely affected due to the changed irrigation contribution from the implementation of NVIRP.

The environmental flow recommendations (SKM 2006c) are presented in Section 5. These recommendations outline the desired watering regime for the Loddon River and are used as part of the calculations for mitigation water (Section 8). Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

Managing environmental water is dependent on the water resources available and the objectives for management, which change as the Campaspe system shifts from dry to wet seasons. The environmental flow recommendations (SKM 2006c) are presented in Section 5. These recommendations outline the desired watering regime for the Campaspe River and guide the mitigation water assessment (Section 8).

3.2. Previous relevant studies, projects and groups

There are a number of river health related projects and programs being implemented along the Campaspe River by government agencies, non-profit environmental organisations and Landcare groups. Various government agencies co-ordinate a number of projects and programs that feed into the management of water resources in the Campaspe River, these include:

- **Environmental Flow Management (2000 onwards) –** The right to water in the Campaspe River was defined in 2000 through the Bulk Entitlement (Campaspe System - Goulburn-Murray Water) Conversion Order. There is no separate Environmental Bulk Entitlement for the Campaspe River; however there are defined ‘passing flows’ within Goulburn-Murray Water’s Bulk Entitlements for Reach 4 (Table 2). This is based upon recommendations by an environmental flows scientific panel (Marchant *et al.* 1997). There are no passing flow requirements for Reach 3 (between the Campaspe Weir and the Campaspe Siphon).

Table 2: Reach 4 passing flow requirement

River reach	Lake Eppalock storage volume (ML)	Passing Flow (ML/day) (whichever is lower)
Campaspe River Reach 4 (Campaspe Siphon to Murray River)	≤ 200,000 ML	▪ 20 ML/day or modified natural flow[1] – July to Nov[2] ▪ 35 ML/day or modified natural flow – Dec to June
	> 200,000 ML	▪ 70 ML/day or modified natural flow

Note 1: Modified natural flow: The storage operator must estimate the modified natural flow in the Campaspe River immediately downstream of the Siphon based on water balance or a method based on gauged flow at Eppalock, Longlea & Runnymede (whichever provides the best estimate of daily flows).

Note 2: From Jul to Nov, the additional passing flow that would have been passed below the Siphon (up to 15ML/d) can be stored in an account and used anywhere along the Campaspe below Lake Eppalock from December to June.

In extreme dry years, the Minister for Water has emergency power to declare a water shortage and to qualify rights to water. This power is generally only used to meet critical human needs. The qualification of rights changes the water sharing rules, setting specific Bulk Entitlement requirements aside (NCCMA 2009b).

There have been two Qualification of Rights invoked by the Minister for Water for the Campaspe (including the Coliban) River system. The first Qualification of Rights covered the period July 2007 to June 2009. The second and current qualification covers the July 2009 to June 2011 period.

- **Campaspe Environmental Water Advisory Group (CEWAG) – the CEWAG** consists of key stakeholders and community representatives who provide advice on the best use of environmental water for the Campaspe River to the North Central CMA.
- **Loddon Campaspe Drought Response Group –** This group was established in 2004 to manage risks to river health during the prolonged drought conditions and to aid in the long term recovery of the Campaspe System. The group is co-chaired by Goulburn-Murray Water and the North Central CMA and comprises representatives from the Department of Sustainability and Environment, Department of Primary Industries, Coliban Water, Environment Protection Authority.
- **G-MW Management –** Bulk Entitlement (Campaspe System – Goulburn-Murray Water) Conversion Order 2005. Bulk entitlements define the amount, and the procedure by which, an authority is entitled to take and use water from a waterway.
- **Reach 4: Inter-Valley Transfer releases –** The Campaspe Inter Valley Transfer (IVT) provides water from the Goulburn River System (Lake Eildon) allocated to the Murray River to be delivered through the Waranga Western Channel via Reach 4 of the lower Campaspe River to reach its destination in the Murray River downstream of Echuca. This provides summer environmental flows for the lower Campaspe River (Reach 4). This IVT is negotiated on an annual basis with the system operator.
- **Saline Pools Study –** High salinity groundwater inflows have caused saline pools to form in deeper sections of the lower Campaspe River. Saline water collects in the base of the pools and, under low flow conditions, less dense freshwater passes over the top without mixing. This creates a strong vertical gradient in salinity, referred to as salt stratification. Salt stratification within these pools is often in combination with a similar stratification in Dissolved Oxygen (DO) and temperature levels, which can have adverse effects on aquatic biota (SKM 2008b).

  A monitoring program has been set up to better understand the process driving the formation of saline pools, quantify the behaviour of saline pools under different flow conditions and identify flows required to mix stratified pools. Key findings from this study include:

  - Stratification of pools is occurring, with three distinct zones (at flows of 10ML/d):
    - Surface to 60cm depth – low salinity and high DO
    - Depth 70cm to 120cm - transition zone is evident (deterioration of water quality)

    - Below 130cm - salinities and DO levels do not meet water quality guidelines with conditions anoxic and unsuitable for native fish populations
  - Flows greater than 25ML/d are required to get full mixing of stratified pools, although stratification reoccurs within a relatively short period (approximately 10 days)
  - Flows of 10ML/day provide a freshwater lens 60cm in depth, but do not mix the stratified pools (based on current groundwater levels).

  Further detail can be obtained from the Investigation of Saline Pools in the Lower Campaspe River (SKM 2008b).

- **Slackwater Review –** This study was commissioned to provide justification for the importance and protection of slackwater habitats in the Campaspe River. Flow versus velocity modelling was also performed at two sites to determine how specific flow magnitudes affected the availability of slackwater habitats in the Campaspe River. Slackwater habitats are particularly important for spawning and recruitment of ‘low-flow’ specialist species.

  Based on this review, it was concluded that the summer low flow recommendation for the Campaspe River maximises the availability of ecologically significant slackwater habitats for riverine species and should not be changed (SKM 2007).

4. Campaspe River current condition

The lower Campaspe River has supported a number of native fish species, including Murray Cod (*Maccullochella peelii peelii)*. However the recent drought, low flows and poor water quality has placed considerable pressure on these populations. Lippia (*Phyla canescens*) has also established on the riparian zone, dominating ground cover and outcompeting most native species.

Estimates of future climate change indicate that the Campaspe River catchment will be one of the most severely affected. Reductions in inflows of 31% under medium climate change conditions and 69% under a continuation of recent dry years by 2055 have been modelled (DSE 2008). If such conditions eventuate, the current low flow conditions and resulting channel drying may become more prevalent (Section 4.1 and 4.2). This would represent a considerable change to the hydrology of the lower Campaspe River.

The main objective for the watering arrangements during the current drought and low water availability is to maintain the presence of, and water quality in, aquatic habitats in the Campaspe River.

4.1. Reach 3

The current condition of the Campaspe River downstream of Campaspe Weir is moderate (Cottingham *et al*. 2007). Under the BE, this reach of the Campaspe River does not receive passing flows. During the 2008/09 season, zero irrigation allocation and therefore no availability of the environmental water reserve (EWR) under the Qualification of Rights, resulted in this reach receiving very little flow. A constant environmental flow of 5ML/day commenced in November 2009, the first managed release since 2005/06 season. This water was sourced from the Eppalock Passing Flows Account.

Due to the dry conditions, the low flow releases are essentially the only flows that have flowed down the reach apart from some minor flows from rainfall events and some ongoing leakage through the weir structure. In 2009 (prior to the 5 ML/day release) CEWAG members' field observations reported stagnant river pools with bad water odour in some areas along the length of the reach due to a lack of flow. This was a concern for local stock and domestic users along this reach with strong concerns conveyed to G-MW (NCCMA 2009b).

Isolated refuge pools fringed by *Phragmites australis* with some snags and submerged patches of *Valisneria sp.* still occur along the reach. The pool depths vary between one to two metres in places. Phragmites growth is expanding due to the low flow conditions.

4.2. Reach 4 (including Campaspe Billabong and Unnamed Creek)

The current condition of the Campaspe River downstream of the Campaspe Siphon is moderate to good (Cottingham *et al*. 2007). The combination of a minimum flow (10 ML/day) and freshes (100 ML/day, 3 per year, 6 days, during summer and autumn) is helping maintain the environmental values in Reach 4 as per the environmental objectives outlined in Section 5.2.3. During the 2008/09 season, passing flows to this reach were suspended under the Qualification of Rights. Without the provision of the IVT, this reach of the Campaspe River would have been severely flow stressed, as there was no other water available to supply this reach (NCCMA 2009b).

The absence of winter flows in Reach 4 has resulted in increasing salinity, reduced native fish recruitment and a build up of organic matter (increasing the likelihood of blackwater events occurring).

5. Campaspe River environmental values

All environmental values associated with the lower Campaspe River have been documented and recorded in this report. All listed values have been presented in this section with a full species list provided in Appendix E.

The primary purpose of this EWP is to assess and mitigate potential impacts of NVIRP on the Campaspe River's high environmental values. While it is recognised that this waterway provides a number of broader ecological and landscape values (i.e. floodplain processes), high environmental values have previously been defined by the conservation significance of the waterway or species at an international, national or state level (SKM 2008a; NVIRP 2010) (refer to Appendix B).

As such, in describing the waterway values in the sections below, an emphasis has been placed on identifying significant flora and fauna species and vegetation communities, followed by the environmental flow recommendation that support and sustain the river.

The FLOWS method (DNRE 2002) was used to determine environmental flow recommendations for the Campaspe River system. The method has been specifically developed for determining environmental water requirements in Victoria and is based on the concept that key flow components of a natural flow regime influence various biological, geomorphological and physicochemical processes in waterways (SKM 2006b). All listed values have been presented in this section with full species lists provided in Appendix E.

5.1. Campaspe River Reach 3

Reach 3 of the Campaspe River flows for approximately 30 km from Campaspe Weir to Campaspe Siphon. There are no tributary inflows between the Campaspe Weir and Campaspe Siphon. The main land uses in this reach include open grazing and cropping farmland (SKM 2006b).

5.1.1. Fauna

Ten native fish species have been recorded in this section of the Campaspe River (Appendix E), including two significant species (Table 3). Of the native fish species, one (Murray Cod, *Maccullochella peelii peelii)* is listed under the federal *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and one (Golden Perch, *Macquaria ambigua*) listed for protection under the Victorian *Flora and Fauna Guarantee (FFG) Act 1988.* Golden Perch are stocked at Campaspe Weir (DPI 2009). Macroinvertebrate fauna have moderate diversity (some filter feeders, although mainly collector/gatherers); however the reach is dominated by taxa that indicate pollution (SKM 2006b).

Table 3: Significant fish species recorded in Reach 3 of the Campaspe River

Common Name	Scientific Name	EPBC	FFG	VROTS
Golden Perch*	*Macquaria ambigua*			VU
Murray Cod*	*Maccullochella peelii peelii*	VU	L	EN

Conservation Status:
Environment Protection and Biodiversity Conservation (EPBC) *Act 1999* Listed: VU – Vulnerable
FFG listing: L – listed as threatened
Victorian Rare or threatened Species (VROTS): EN – Endangered, CR – Critical, VU – Vulnerable, DD – Data Deficient
* Migratory

Source: (DSE 2009c)

Thirty-nine bird species have been recorded in Reach 3 (Appendix E), including three significant species (Table 4). From this list, two are listed under the Victorian *FFG Act 1988.* Both the Diamond Firetail and Hooded Robin are considered to be flood-dependent (VEAC 2008).

Table 4: Significant bird species recorded in Reach 3 of the Campaspe River

Common Name	Scientific Name	International Agreements	EPBC	FFG	VROTS
Brown Treecreeper	*Climacteris picumnus*				NT
Diamond Firetail	*Stagonopleura guttata*			L	VU
Hooded Robin	*Melanodryas cucullata cucullata*			L	NT

Conservation Status:
- J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn international agreements
- FFG listing: L – listed as threatened
- VROTS: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened

Source: (DSE 2009c)

5.1.2. Flora

Campaspe River Reach 3 occurs within the Victorian Riverina Bioregion. All four EVCs modelled in the pre-1750 mapping still occur, with Floodplain Riparian Woodland being the most extensive. The remainder of EVCs occupy far less area along the reach (Table 5).

The two flood-dependent EVCs are Floodplain Riparian Woodland and Wetland Formation (VEAC 2008).

Table 5: EVCs at Campaspe River Reach 3

EVC No.	EVC Name	Bioregional Conservation Status	pre-1750[1] (ha)	2005[1] (ha)
56	Floodplain Riparian Woodland	Vulnerable	300	165
132	Plains Grassland	Endangered	1.7	0.2
803	Plains Woodland	Endangered	75	26
74	Wetland Formation	Endangered	8	4

Note 1: Modelled EVC information pre 1750 and 2005 within Campaspe River Reach 3.
Source: (DSE 2009d and 2009e)

No flora species listed under the *EPBC Act* have been recorded in Reach 3 of the Campaspe River. One species is listed under the *FFG Act 1988* (Table 6). Wetland Blown-grass is considered to be flood-dependent and is also likely to respond to rainfall induced run-off (DNRE 2002; VEAC 2008).

Table 6: Significant flora species at Campaspe River Reach 3

Common Name	Scientific Name	EPBC	FFG	VROTS
Buloke	*Allocasuarina luehmannii*		L	
Wetland Blown-grass	*Lachnagrostis filiformis* var.2			k

Conservation Status:
- L = Listed under the *Flora and Fauna Guarantee Act 1988*
- VROTS: v- vulnerable in Victoria, r - rare in Victoria, k – poorly known in Victoria

Source: (DSE 2009b)

5.1.3. Environmental Flow Recommendations

The environmental flow recommendations for Reach 3 are summarised in Table 7. Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

Summer/autumn low flow and freshes aim to maintain flow through the reach, prevent further deterioration of water quality at the surface of pools and preserve slackwater habitats for developing fish larvae and juvenile fish. The winter low flow magnitude was primarily set to address water quality issues. The winter/spring bankfull flow will fill the channel, mobilise sediment and help scour Typha. Some floodplain sections along Reach 3 contain remnant River Red Gum forest and an overbank flow is recommended to help promote regeneration in these areas. Cease to flow events would have naturally, however, no cease to flow period was recommended as this is likely to exacerbate high salinity levels, nutrient enrichment and low dissolved oxygen levels, which would create an unnatural level of stress to aquatic biota throughout this reach (SKM 2006c).

Table 7: Campaspe River Reach 3 environmental flow recommendations (SKM 2006c)

Season and component	Reach 3 Campaspe Weir to the Campaspe Siphon	Justification
Summer low flow	10 ML/day (Not more than 20ML/day), 1 per year, duration 6 months	**Fish community:** • Maintain habitat and re-instate backwaters **Water Quality** • Maintain connecting flow **Macroinvertebrate community:** • maintain aquatic habitat **Vegetation:** • Maintain aquatic vegetation
Summer freshes	100 ML/day, 3 per year (Feb to May*), duration 6 days	**Fish community:** • Provide longitudinal connectivity during low flow period **Water Quality** • Flush and mix pools **Macroinvertebrate community:** • Inundate additional snags and flush sediments off biofilms **Vegetation:** • Maintain riparian and in channel recruits
Winter low flow	200 ML/day (or natural), 1 per year, duration 6 months	**Fish community:** • Provide longitudinal connectivity **Water Quality** • Maintain connecting flow **Macroinvertebrate community:** • Maintain aquatic habitat
Winter high flow	1,500 ML/day, 2 per year (or natural), duration 4 days	**Fish community:** • Cue fish movement and allow movement between upstream and downstream reaches **Water Quality** • Flush and mix pools **Macroinvertebrate community:** • Inundate additional snags and flush sediments off biofilms **Vegetation:** • Reduce encroachment of exotics and terrestrial species
Winter Bankfull flow	8,000 ML/day, 2 per year (or natural), duration 2 days	**Fish community:** • Cue fish movement and allow movement between upstream and downstream reaches **Geomorphology** • Channel forming processes **Vegetation:** • Scour Typha from middle of channel
Winter Overbank flow	12,000 ML/day, 1 per year, duration 1 day	**Vegetation:** • Inundate wetlands and connect main channel and enhance River Red Gum recruitment above bank
Rise and fall	Rise 230% and fall 65%	

*Note: Additional freshes may be released in December and January if water quality in the reach deteriorates.

5.2. Campaspe River Reach 4

Reach 4 of the Campaspe River flows for approximately 45 km from Campaspe Siphon to Murray River. The floodplain continues to be confined between high terraces, however this reach opens out into flood runners and other secondary channels. The main land uses in this reach are open grazing and cropping farmland.

5.2.1. Fauna

Ten native fish species have been recorded in this section of the Campaspe River (Appendix E), including 5 significant species (Table 8). Of the native fish species, three are considered migratory, three are threatened in Victoria and three are listed for protection under the *FFG Act 1988*. Murray Cod and Golden Perch are also stocked in Reach 4 (DPI 2009). Only one threatened bird species is recorded in Reach 4 and is listed as near threatened in Victoria (Table 8, refer to Appendix E for complete list). Brown Treecreeper is not considered to be flood-dependent.

Table 8: Significant fish and bird species recorded in Campaspe River Reach 4

Fauna	Common Name	Scientific Name	EPBC	FFG	VROTS
Fish	Golden Perch*	*Macquaria ambigua*			VU
	Murray Cod*	*Maccullochella peelii peelii*	VU	L	EN
	Silver Perch*	*Bidyanus bidyanus*		L	CR
	Trout Cod	*Maccullochella macquariensis*	EN	L	CR
Birds	Brown Treecreeper	*Climacteris picumnus victoriae*			NT

Conservation Status:

- *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999* Listed: VU – Vulnerable, EN - Endangered
- FFG listing: L – listed as threatened
- Victorian Rare or threatened Species (VROTS): CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened
- * Migratory

Source: (DSE 2009c)

Note: Trout Cod last recorded in 1970.

As part of the Victorian Biological Assessment Program three sites in Reach 4 of the Campaspe River are monitored for macroinvertebrates. The three sites are located at Cox's Reserve, Lock Lomon and at Schoeffel Road. Lowland communities have been recorded featuring a lower diversity of species than would naturally be expected (EPA 2008).

5.2.2. Flora

Campaspe River Reach 4 falls entirely within the Victorian Riverina Bioregion. All of the modelled pre-1750 Ecological Vegetation Classes (EVCs) are still present in the reach (Table 9), and the dominant EVC is still Floodplain Riparian Woodland, which is characterised by River Red Gum and Yellow Box woodland with a groundlayer of amphibious and aquatic herbs and sedges. Silver Wattle is often present. This EVC is subject to periodic flooding and inundation, and according to the benchmark should experience episodic flooding in order to remain viable (DSE 2004).

All of the EVCs are flood-dependent, except for EVC nos. 106, 132, 803 and 235 (VEAC 2008).

Table 9: EVCs occurring in Campaspe River Reach 4

EVC No.	EVC Name	Bioregional Conservation Status	pre-1750[1] (ha)	2005[1] (ha)
168	Drainage-line Aggregate	Endangered	<1	<1
56	Floodplain Riparian Woodland	Vulnerable	740	538
106	Grassy Riverine Forest	Depleted	24	23
823	Lignum Swampy Woodland	Vulnerable	1	<1
132	Plains Grassland	Endangered	59	36
267	Plains Grassland/Plains Grassy Woodland/Gilgai Wetland Mosaic	Endangered	3	<1
803	Plains Woodland	Endangered	10	4

EVC No.	EVC Name	Bioregional Conservation Status	pre-1750[1] (ha)	2005[1] (ha)
235	Plains Woodland/Herb-rich Gilgai Wetland Mosaic	Endangered	30	17
103	Riverine Chenopod Woodland	Vulnerable	12	7
295	Riverine Grassy Woodland	Vulnerable	10	10
814	Riverine Swamp Forest	Depleted	1	1

Note 1: Modelled EVC information pre 1750 and 2005 within Campaspe River Reach 4.
Source: (DSE 2009d and 2009e)

No flora species listed under the *EPBC Act 1999* or the *FFG Act 1988* has been recorded in Reach 4 of the Campaspe River. However two species threatened within Victoria have been recorded (Table 10). Both species are considered to be flood-dependent (DNRE 2002; VEAC 2008).

Table 10: Significant flora species found in Campaspe River Reach 4

Common Name	Scientific Name	EPBC	FFG	VROTS
Pale Flax-lily	*Dianella sp. aff. longifolia* (Riverina)			v
Wetland Blown-grass	*Lachnagrostis filiformis* var. 2			k
Conservation Status: VROTS: v- vulnerable in Victoria, k – poorly known in Victoria				

Source: (DSE 2009b)

5.2.3. Environmental Flow Recommendations

Table 11 outlines the environmental flow recommendations and associated ecological objectives for Reach 4 of the Campaspe River. Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

The recommended summer low will maintain flow and aquatic habitat, including slackwaters for juvenile fish, throughout the reach. High flows in late winter and spring will enhance River Red Gum and other native plant regeneration within the channel and cue fish movement. Most of the floodplain in Reach 4 has been extensively cleared to the top of the riverbank and therefore no features were identified that would substantially benefit from an overbank flow in the Campaspe River. Similar to Reach 3, cease to flow events have not been recommended (likelihood to exacerbate high salinity levels and low dissolved oxygen levels, particularly near Echuca) (SKM 2006c).

Table 11: Campaspe River Reach 4 environmental flow recommendations (SKM 2006c)

Season and component	Reach 4 Campaspe Siphon to the Murray River	Justification
Summer low flow	10 ML/day (Not more than 20ML/day), 1 per year, duration 6 months	**Fish community:** • Maintain habitat and re-instate backwaters **Water Quality** • Maintain constant flow **Macroinvertebrate community:** • maintain aquatic habitat **Vegetation:** • Maintain aquatic vegetation
Summer freshes	100 ML/day, 3 per year (Feb to May*), duration 6 days	**Fish community:** • Provide longitudinal connectivity during low flow period and cue fish movement from the Murray River **Water Quality** • Flush and mix pools **Macroinvertebrate community:** • Inundate additional snags and flush sediments off biofilms **Vegetation:** • Maintain riparian and in channel recruits

Season and component	Reach 4 Campaspe Siphon to the Murray River	Justification
Winter low flow	200 ML/day (or natural), 1 per year, duration 6 months	**Fish community:** • Provide longitudinal connectivity **Water Quality** • Maintain constant flow **Macroinvertebrate community:** • Maintain aquatic habitat
Winter high flow	1,500 ML/day, 2 per year (or natural), duration 4 days	**Fish community:** • Cue fish movement and allow movement between upstream and downstream reaches **Water Quality** • Flush and mix pools **Macroinvertebrate community:** • Inundate additional snags and flush sediments off biofilms **Vegetation:** • Reduce encroachment of exotics and terrestrial species • Enhance River Red Gum recruitment
Winter Bankfull flow	9,000 ML/day, 2 per year (or natural), duration 2 days	**Fish community:** • Cue fish movement and allow movement between upstream and downstream reaches **Geomorphology** • Channel forming processes **Vegetation:** • Scour Typha from middle of channel
Rise and fall	Rise 230% and fall 65%	

*Note: Additional freshes may be released between December and February to manage water quality if required.

5.3. Campaspe billabong and Unnamed Creek

5.3.1. Campaspe Billabong

The Campaspe Billabong is situated along an anabranch (high flow section) of the Campaspe River. This anabranch leaves the Campaspe River upstream of the Strathallan Road and re-joins the Campaspe River upstream of Echuca.

The condition of the two outfall sites on this waterway was assessed in October 2009 (Campbell *et al*. 2009) and the following water regime was recommended to maintain the environmental values of this billabong.

"Flood billabong 1 in 3 to 5 years to a depth sufficient to inundate the fringing River Red Gums on the lower slopes of the creek banks. Allow the billabong to dry completely between inundation events".

There is one species listed for protection under the *FFG Act 1988* at the Campaspe Billabong (Table 12). The Squirrel Glider (*Petaurus norfolcensis)* relies on a consistent, highly productive habitat; and while this species is not dependent on permanent water being present, soil moisture influences site productivity through the health of the vegetation (Rowley 1997). In addition, VEAC (2008) found that the Squirrel Glider is flood-dependent.

Table 12: Significant fauna species recorded at the Campaspe Billabong

Common Name	Scientific Name	EPBC	FFG	VROTS
Squirrel Glider	*Petaurus norfolcensis*		L	EN

Conservation Status:
FFG listing: L – listed as threatened
Victorian Rare or threatened Species (VROTS): CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened

The original record of Squirrel Glider was in 2001, however it was recently observed in December 2009 at the Somerville's site on the Campaspe Billabong (outfall site 1/14). VEAC (2008) has listed this species as flood dependent (reliant or utilises flood dependent EVCs). Figure 3 below illustrates the close proximity of this site to the Campaspe River and the condition of the riparian zone for both the Campaspe Billabong and Campaspe River. This species has been found on the Campaspe River as well as the adjacent billabong.

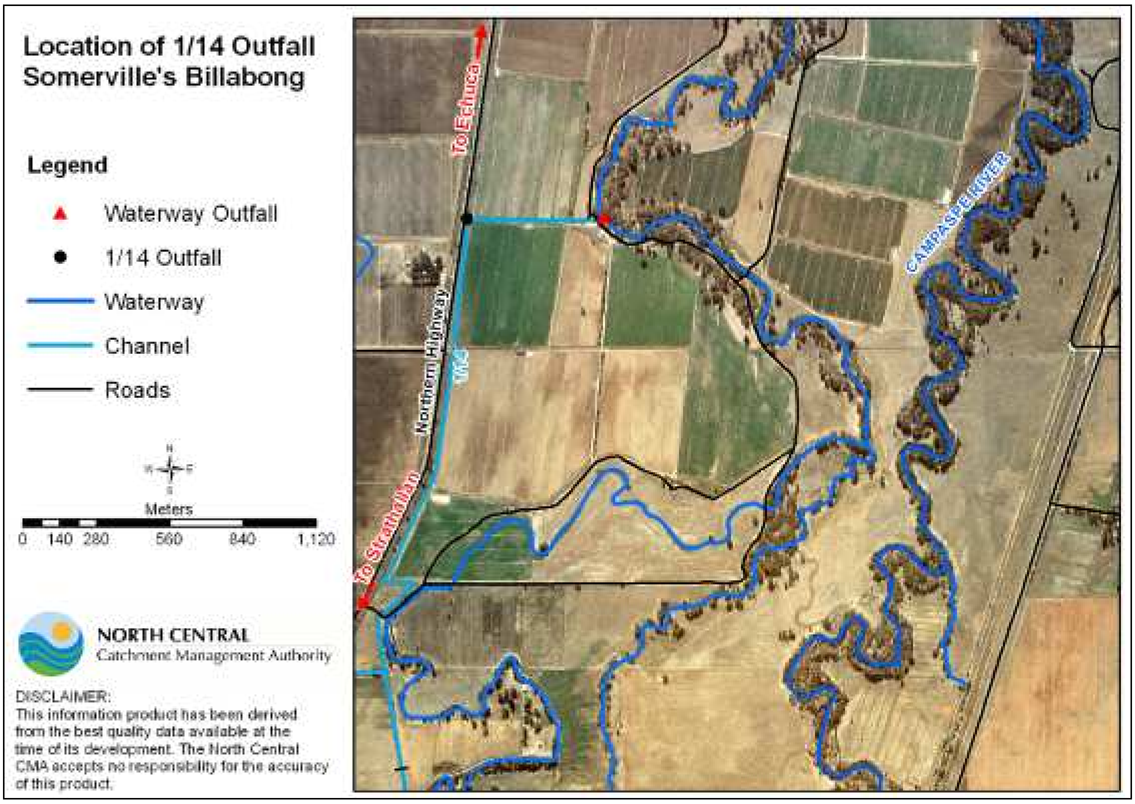

Figure 3: Aerial map of No. 1/14 outfall site

5.3.2. Unnamed Creek

This unnamed creek is on the eastern side of the Campaspe River Reach 4. A condition assessment was undertaken at the 2/11 outfall, where it enters a section of the unnamed creek upstream of the Campaspe River. The creek meanders for a further 2.6 km before entering the Campaspe River.

No threatened species have been recorded at this site, however, Lignum Swampy Woodland Ecological Vegetation Class (EVC) was observed by Campbell *et al.* (2009) in the unnamed creek. This EVC is listed by DSE as Vulnerable in the Victorian Riverina Bioregion (DSE 2007).

Campbell *et al.* (2009) recommended the following water regime to maintain the environmental values of this creek:

"Provide sufficient water 1 in 3 to 5 years to inundate the Lignum Swampy Woodland and Floodplain Riparian Woodland downstream of the 2/11 Outfall."

6. Hydrology

6.1. Natural water regime

Prior to European settlement, streams in the middle and lower Campaspe River catchment would have had low energy, contained fine grained sediments and had occasional rocky outcrops. Most of the streams would have had incised channels, with deep pools, infrequent riffles over gravel, boulders or logs and an abundance of large woody debris (SKM 2006b).

Flows would have been seasonally variable, with high flows in winter and spring and low or no flow in summer and autumn (McGuckin and Doeg 2001). However, the construction of reservoirs and weirs for potable supply and irrigation has substantially reduced flows throughout the catchment and reversed seasonal flow patterns in the lower reaches.

Under natural conditions the highest daily flows generally occurred in September and the lowest flows occur between January and May (SKM 2006b).

6.2. Current water regime (pre-NVIRP)

The Campaspe River is now a regulated river, supplying water for irrigation and urban demands. In 1882, the Campaspe Weir was constructed 12 km south of Rochester with a capacity of 2,700 ML and delivers irrigation water through the east and west channels. In 1902, the Campaspe Siphon was constructed 2 km north of Rochester. The Western Waranga Channel (WWC) crosses the river at this point and the siphon structure allows water from the Goulburn River to flow down the river, or continue its flow to the western irrigation districts (SKM 2006b).

The most significant structure on the Campaspe River is Lake Eppalock (completed in 1964 with a capacity of 312,000 ML). Lake Eppalock was constructed to secure water for the Campaspe Irrigation Area, to safeguard the Coliban Supply system and allow increased development of urban areas (NCCMA 2009b).

The hydrological regime of the Campaspe River has changed markedly since the construction and operation of Lake Eppalock. Irrigation releases from the reservoir have substantially reversed seasonal flow patterns in the Campaspe River downstream of the Campaspe Weir and the Campaspe Siphon (SKM 2006b). Prior to the 2005-06 change in river operations due to the drought constant high flows occurred during the irrigation season (August to May).

Regulation throughout the Campaspe River catchment diverts approximately 50% of mean annual discharge for irrigation, stock and domestic use. Irrigation releases elevate autumn flows downstream of the Campaspe Weir and the Campaspe Siphon (Marchant *et al.* 1997).

The Campaspe catchment has seen unprecedented dry conditions over several years. This has been reflected in zero allocation to Campaspe irrigators for the past three years, Qualification of Rights and the development of Dry Flow Contingency Plans and Annual Watering Plans (NCCMA 2009b and G-MW 2009).

6.2.1. Reach 3

Prior to the current drought and Qualification Rights (2005-06), irrigation diversions at Campaspe Weir ensured that flow at Bryant's Lane was lower than natural from late November to early February, but transfer flows between the Campaspe Weir and Campaspe Siphon elevate flows above natural conditions from late February to the end of April. Flow through the reach increases through winter, but the magnitude of these flows is less than natural and floods only occur if storages higher in the catchment spill (SKM 2006b).

Due to the dry conditions experienced in this reach, the weir releases are essentially the only flows that have flowed down the reach apart from some minor flows (5 ML/day flow commenced in November 2009 from the Eppalock Passing Flows Account) from rainfall events and some ongoing leakage through the weir structure.

6.2.2. Reach 4

Flows in the Campaspe River downstream of the Campaspe Siphon are characterised by longer periods of low flow and shorter periods of high flow compared to natural. The current flow regime through this reach generally retains this seasonal pattern, but the high flow period persists through all of spring rather than peaking in September. Floods only occur in this reach when storages higher in the catchment spill, and therefore occur much less frequently compared with the natural flow regime (SKM 2006b).

The Campaspe River below the siphon has largely relied on the IVT since 2005-06 to maintain flows during the summer and autumn, i.e. no flows in late winter/early spring (Figure 4 and Section 4.2).

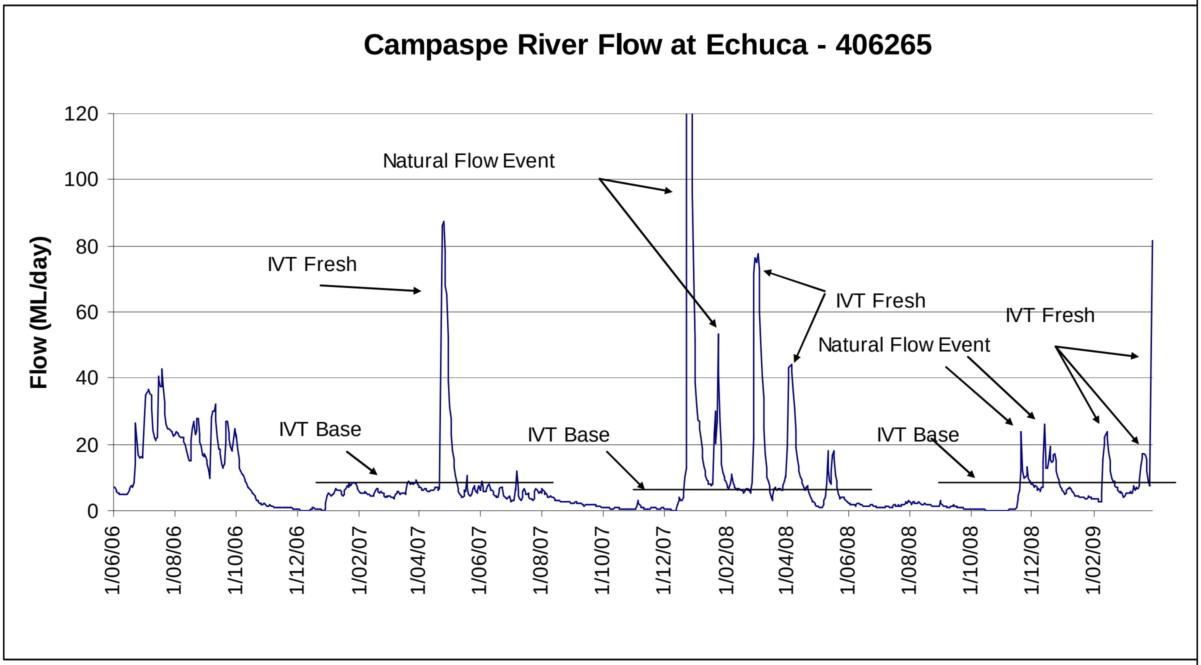

Figure 4 Campaspe River flow at Echuca (2006 onwards)

7. NVIRP impact assessment

Irrigation outfalls currently contribute to flow in the lower Campaspe River. These outfalls (Table 13) contribute to an artificial flow regime which may be beneficial for some water dependent values identified in Section 5).

To quantify the impact of irrigation outfalls on flow along the lower Campaspe River, SKM (2010d) have undertaken a hydrology impact assessment. This includes:

- determining the magnitude and pattern of irrigation outfalls to the lower Campaspe River, based on available records of irrigation outfalls
- quantifying the magnitude and pattern of change in outfalls to the lower Campaspe River due to reduced outfalls
- assessing the impact of the reduction in outfalls on flow in the lower Campaspe River.

The outcomes of this investigation are presented in section 7.4.1 and 7.4.2 and have been used to inform the mitigation water assessment (Section 8).

7.1. Campaspe River outfall sites

Channel outfalls that result from operation of the system and that directly or indirectly outfall to the Campaspe River have been identified and are presented in Table 13 and Figure 5. Refer to Appendix F for waterway site descriptions.

Table 13 Location of Campaspe River outfalls that will be impacted by the NVIRP

Outfall	Irrigation area	Road Reference	Connection
Campaspe River Reach 3			
No. 2 Accocks ST032783	Campaspe	Bonn Rd	Off the Campaspe No. 2 main channel to a drain, then to the river (less than 1 km of drain)
No. 1 ST032729	Campaspe	Spencer Rd	Off the bottom of the No. 1/1 channel I to drain 7 then to the river (~1.5 km of drain)
Campaspe River Reach 4			
No. 12 ST051358	Rochester	McColl Rd	Off the No. 14 channel, direct to the river
No. 2/1/3/14 ST033397	Rochester	Fehring Lane	Outfalls from the No. 2/1/3/14 channel to a short drain and then a short creek (~ 0.5 km) before flowing into the Campaspe
No. 1/3/14 ST033384	Rochester	Cahir's Rd	Outfalls from the No. 1/2/14 channel to a billabong on the Campaspe anabranch (via a short drain ~ 100 m)
No. 5/3/14 ST033461	Rochester	near Mount Terrick Rd	Outfalls from the No. 5/3/14 to a drain (~1.5 km) then to a forested flood basin
Campaspe Billabong			
No. 1/14 ST065860	Rochester	Somerville's Property	Outfalls from the No. 1/14 to a Billabong on the Campaspe anabranch. ~1.5 km of drain, then ~ 7 or 8km of anabranch (does not flow under normal conditions)
No. 1/4/3/14 ST033425	Rochester	near Crumpler Rd	Outfalls from the No. 1/4/3/14 to the same creek as above, but via ~ 2 km of drain
Unnamed Creek			
No. 2/11 ST033111	Rochester	on Echuca-Nanneela Rd, near McKenzie Rd	Outfalls from the No. 2/11 channel to a drain, then to a creek. Returns to the river just upstream of Echuca.

The contribution of channel outfalls at each individual site (Appendix F) is considered to be low. This is mainly due to the variable nature[3] of outfalls and the Campaspe River outfall sites not being hydrologically connected. Therefore the outfalls have been cumulatively assessed for each reach (Section 7.4).

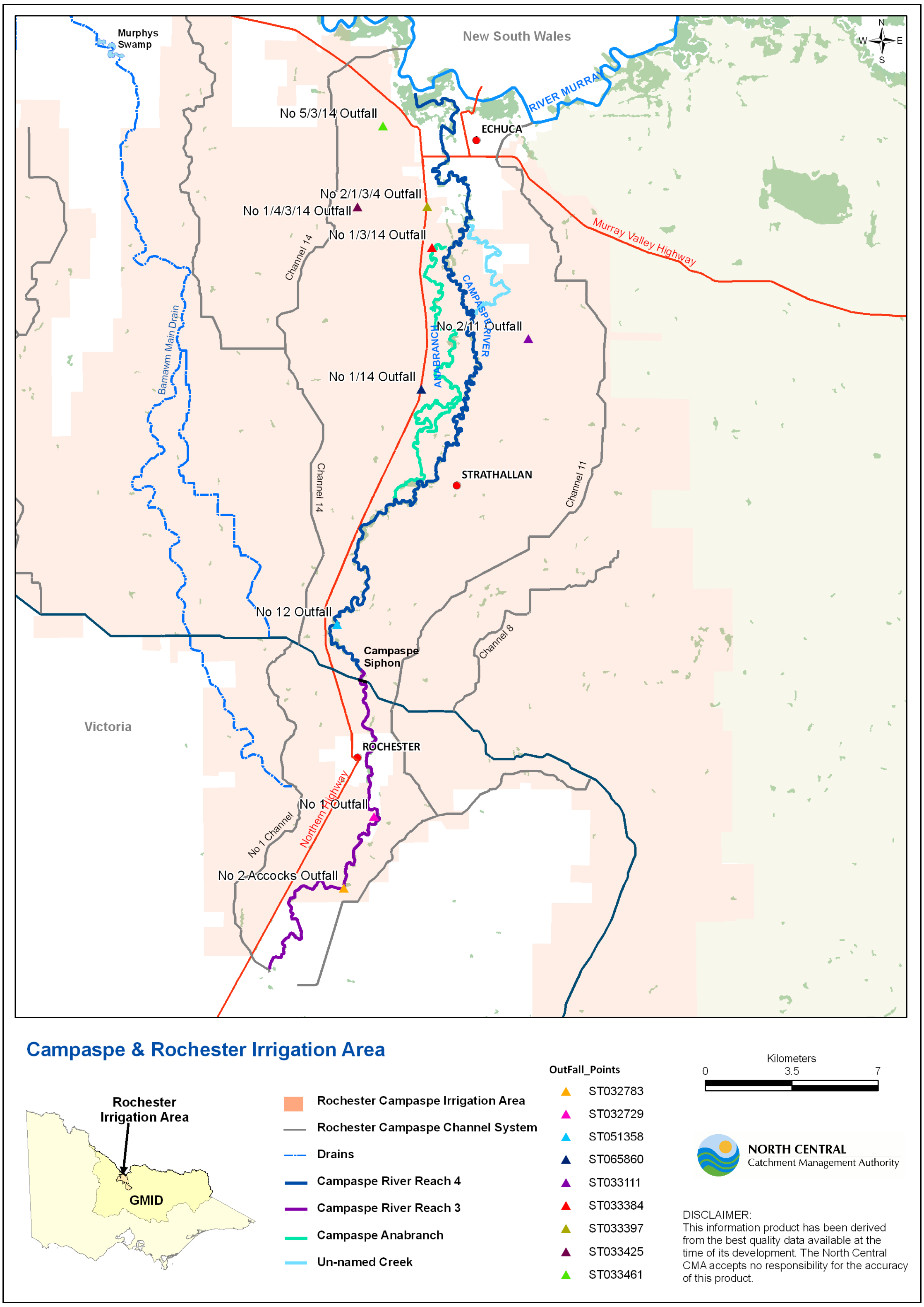

Figure 5: Lower Campaspe River outfall locations

[3] Whilst the discharge from outfalls from an irrigation district are driven by irrigation deliveries and climatic factors, the discharge from an individual outfall can be significantly influenced by a wide range of factors, many of which are essentially random (i.e. an irrigator mistiming the opening of their gate).

7.1.1. Outfall losses

The indicative loss is the proportion of the outfall volume which is lost between the outfall site and the Campaspe River. The indicative loss has been estimated from a desktop review of the outfall location and destination and is not based on measurements or site inspections. Estimates of indicative losses were based on:

- length of drain or creek between the outfall site and the main river channel
- the presence of drainage diversion schemes on the drain or creek
- whether or not the drain or creek would be expected to flow under 'average' flow conditions.

Actual losses are extremely variable. In the absence of recorded losses, these indicative losses have been adopted for this investigation (SKM 2010d). Refer to Table 14 for calculated indicative losses.

Table 14: Indicative losses for Campaspe River outfalls

Outfall	Outfall loss assessment[1&2]	Outfall Volume (ML)	Indicative loss	Estimated Outfall (ML)
Campaspe River Reach 3[3]				
No. 2 Accocks ST032783	• No outfall volume was recorded for this outfall.	0	0 %	0
No. 1 ST023729	• Indicative loss = (1.5 km of channel * 12 ML/year of loss per km of channel) / 74 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 20% (with rounding).	92	20 %	74
	Sub Total	**92**		**74**
Campaspe River Reach 4[4]				
No. 12 ST051358	• Outfall is direct to river, indicative loss set to zero.	0	0 %	0
No. 2/1/3/14 ST033397	• Indicative loss = (0.5 km of channel * 12 ML/year of loss per km of channel) / 55 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 10% (with rounding).	60	10 %	54
No. 1/3/14 ST033384	• This outfall discharges to a billabong on the Campaspe Anabranch. This billabong is used as a storage/re-use system by the adjacent landholder. • Additionally, the Campaspe Anabranch does not flow into the Campaspe River under low or average flow conditions. This means that the outfall would be unlikely to contribute flow to the river. • Therefore the indicative loss was set to 100%.	13	100 %	0
No. 1/14 ST065860	• The indicative loss was set to 100% for the same reasons as outfall No 1/3/14 (ST033384) above.	204	100 %	0
No. 1/4/3/14 ST033425	• Indicative loss = (2 km of channel * 12 ML/year of loss per km of channel) / 51 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 50% (with rounding). This is relatively high loss, but was determined to be appropriate drainage diverters.	62	50 %	31

No. 5/3/14 ST033461	• Indicative loss due to channel = (1.5 km of channel * 12 ML/year of loss per km of channel) / 177 ML of average outfall for 2004/05 period which equates to 10% (with rounding). • Additionally, an allowance was made for losses through the Wharparilla forest basin. It was assumed that approximately two-thirds of the flow would be lost through this forest (70% with rounding). • Therefore the indicative loss was set to 80%.	213	80 %	43
No. 2/11 ST033111	• The combination of: long distance between the outfall and the river (~10km), multiple (large) drainage diverters on the drain and multiple impounding weirs on the Unnamed Creek means that the outfall would be unlikely to contribute flow to the Campaspe River. • Therefore the indicative loss was set to 100%.	91	100 %	0
	Sub Total	643		**128**

Note 1: The loss rate of 12ML/year per km of channel has been used (SKM 2008)

Note 2: The average outfall volume for 2004/05 was based on the average outfalls for the three year period surrounding the relevant outfall year to allow for annual variations (Appendix F).

Note 3: Baseline year for Campaspe Irrigation District is 2003/04

Note 4: Baseline year for Rochester Irrigation District is 2004/05

7.1.2. Streamflow measurement

Flow in the lower Campaspe River is measured at few locations, with little or no measurement of tributary flows. Flow data is measured at two locations suitable for this study (Table 15).

Table 15: Available flow gauging stations throughout the study area

Gauge No.	Gauge Name	Period of Record
406202	Campaspe River at Rochester	January 1951 to current
406265	Campaspe River at Echuca	April 1991 to current

Campaspe River Reach 3
To quantify the contribution of irrigation outfalls for Campaspe River Reach 3, the Rochester gauge was used to estimate the streamflow reduction in outfalls from Campaspe Irrigation Area. This site was selected as the most downstream flow gauging station within the assessment area (SKM 2010).

Campaspe River Reach 4
To quantify the contribution of irrigation outfalls for Campaspe River Reach 4, the Echuca gauge was used to estimate the streamflow reduction in outfalls from both the Campaspe and Rochester Irrigation Areas (Reach 4 would be expected to be impacted by all upstream changes). This site was selected as the most downstream flow gauging station within the assessment area (SKM 2010).

7.2. Campaspe Billabong and Unnamed Creek

Due to the lack of gauged flow data (refer to Section 7.1.2) on the tributaries of the Campaspe River, it has not been possible to quantify the impact of the reduction in outfalls due to NVIRP on the Campaspe Billabong.

The condition assessments undertaken at the outfall sites (Section 5.3 and Appendix F) and overall dependency of the values on outfall water is low. Therefore adding these outfalls to the cumulative impact assessment for the Campaspe River Reach 4 is considered adequate in assessing the environmental impact of NVIRP (Section 7.4.2).

Campaspe Billabong
The contribution of channel outfalls to the Campaspe Billabong is not likely to be significant and have been incorporated into the Campaspe River assessment due to:

- Recommended water regimes for the two billabongs are to flood *1 in 3 to 5 years to a depth sufficient to inundate the fringing River Red Gums on the lower slopes of the creek banks*
- Both billabongs are currently receiving annual watering and have been operated as permanent wetlands (sites along the billabong used (and will continue to be used) as reuse system)
- Reducing channel outfalls will result in less inundation for less duration, which will allow for the billabong to have a more ‘natural’ wetting and drying cycle.

This assessment has assumed that these systems will continue to be operated as reuse systems by the adjacent land owner. A further assessment of this site may be required if this situation changes in the future.

Unnamed creek
The Campaspe unnamed creek receives outfalls from the ST033111 outfall from the No. 2/11 channel. Water from this outfall passes through approximately 2.9 km of drain and approximately 2.6 km of creek. An indicative loss of 100% was calculated for this outfall on Campaspe River Reach 4.

An assessment was undertaken to estimate the volume of water entering the unnamed creek (SKM 2010). It has been concluded that no mitigation water is required specifically for the Unnamed Creek due to:

- high losses in 2.9km of drain prior to entering the unnamed Creek (40% indicative loss).
- low outfall volumes
- recommended desired watering regime of 1 in 3 year flooding frequency
- timing of flooding in winter (not relevant for outfalls) and spring.

A summary of the analysis is provided in Appendix H.

Mitigation water assessment is not required specifically for the Campaspe Billabong or Unnamed Creek

7.3. Hydrology modelling

The assessment of the impact of NVIRP on streamflow was undertaken for the long-term, recent (post 2000) and baseline year conditions (2003/04 and 2004/05) (SKM 2010).

Long-term assessment
For the long-term assessment (1891 to 2009), pre-NVIRP streamflow data was sourced directly from the Goulburn Simulation Model (GSM) REALM model. Regressions were derived for each outfall assessment area using multiple linear regression analysis, based on deliveries to the relevant irrigation supply area, allocation and local climate (rainfall) data. All regressions were developed on a monthly basis based on available total historical outfalls to the relevant irrigation district and then scaled (using annual factors) for the outfalls that will be impacted by NVIRP (SKM 2010). Post-NVIRP streamflow data was derived:

Post NVIRP Streamflow = Pre NVIRP Streamflow – Reduction in Outfalls

The two streamflow series were compared using flow duration curves and the results are discussed in the Section 7.4.1 and 7.4.2.

Recent conditions assessment
For the recent conditions assessment, pre-NVIRP streamflow data for July 2000 to June 2009 was sourced as recorded historical data. Recorded outfall data was used where available (pre-NVIRP outfalls), with post-NVIRP outfalls set to 15% of the recorded pre-NVIRP outfalls. Post-NVIRP streamflow data was derived as above.

As for the long-term assessment, the two streamflow series were compared using flow duration curves and are discussed in the Section 7.4.1 and 7.4.2.

NVIRP baseline year assessment
Time series plots of pre- and post- NVIRP streamflow and of pre- and post-NVIRP outfalls for the baseline year are assessed in Section 7.4.1 and 7.4.2.

7.3.1. Hydrology modelling limitations and uncertainty

The hydrology assessment (SKM 2010) presented in this report is affected by a number of limitations and sources of uncertainty including:

- the small amount of historical outfall data available, which limits the calibration of the regression equations used for the long-term assessment
- the limited recorded streamflow data for the lower Campaspe River (two assessment points).
- the application of regional scaling factors to scale the regression from the region to the outfalls of interest, which means that whilst the average results can be expected to be reasonable accurate, the results for individual years may be over or underestimated
- the determination of regional scaling factors based on a limited number of years, which may or may not be representative of long-term regional factors
- the lack of information about losses between the outfall site and the main river channel, which means that losses may be over or underestimated
- the application of a single generic factor for the expected impact of NVIRP (85% reduction), which while appropriate at a regional scale, may not be appropriate for individual outfalls.

Each of these limitations introduces a source of uncertainty into the assessment, the magnitude of which is very difficult to quantify. It has not been possible to quantify the magnitude of the uncertainty within the scope of this investigation.

Despite this, the assessment has been based on the best available information, and is believed to be fit-for-purpose for developing environmental watering plans for the Loddon and Campaspe Rivers, provided the limitations and uncertainties are considered.

7.4. Water regime (post NVIRP)

The results of the hydrology assessment undertaken as part of the development the Campaspe EWP is presented below. The post NVRIP hydrology assessment has largely focused on the impact during the irrigation season (August to April), due to the influence of reduced outfalls over the irrigation season (SKM 2010).

7.4.1. Reach 3

Overall the results show that based on both the long-term and recent conditions assessment, the reduction in Reach 3 outfalls due to NVIRP is expected to have a limited impact on flow (less than 5%) at Rochester (refer to Table 16). Figure 6 illustrates the streamflow reduction for irrigation season months (August to April) at Rochester (SKM 2010).

Table 16: Percent reduction in flow at Rochester (Reach 3) (pre-NVIRP flow for each percentile also shown)

Flow*	Percent Reduction in Flow for an Equivalent Percentile (Pre-NVIRP Flow- ML/month)			
	All Months		Irrigation Season Months	
	Long Term	Recent	Long Term	Recent
Very low flows (90th Percentile)	3% (580)	0% (110)	5% (580)	0% (180)
Low Flows (75th Percentile)	2% (1,230)	1% (380)	2% (1,260)	1% (430)
Median Flows (50th Percentile)	1% (2,380)	1% (580)	2% (2,340)	2% (590)
High Flows (25th Percentile)	0% (6,380)	1% (1,000)	1% (5,700)	1% (1,020)
Very High Flows (10th Percentile)	0% (29,720)	1% (1,630)	1% (28,790)	1% (2,230)

*- the percent reduction in flow for each key percentile is based on the average reduction in flow for percentiles ± 5% of the specified percentile. This is to avoid results being skewed by a single, non-representative change. For example, the change reported for 90th percentile flows is based on the change for flows between the 85th and 95th percentiles.

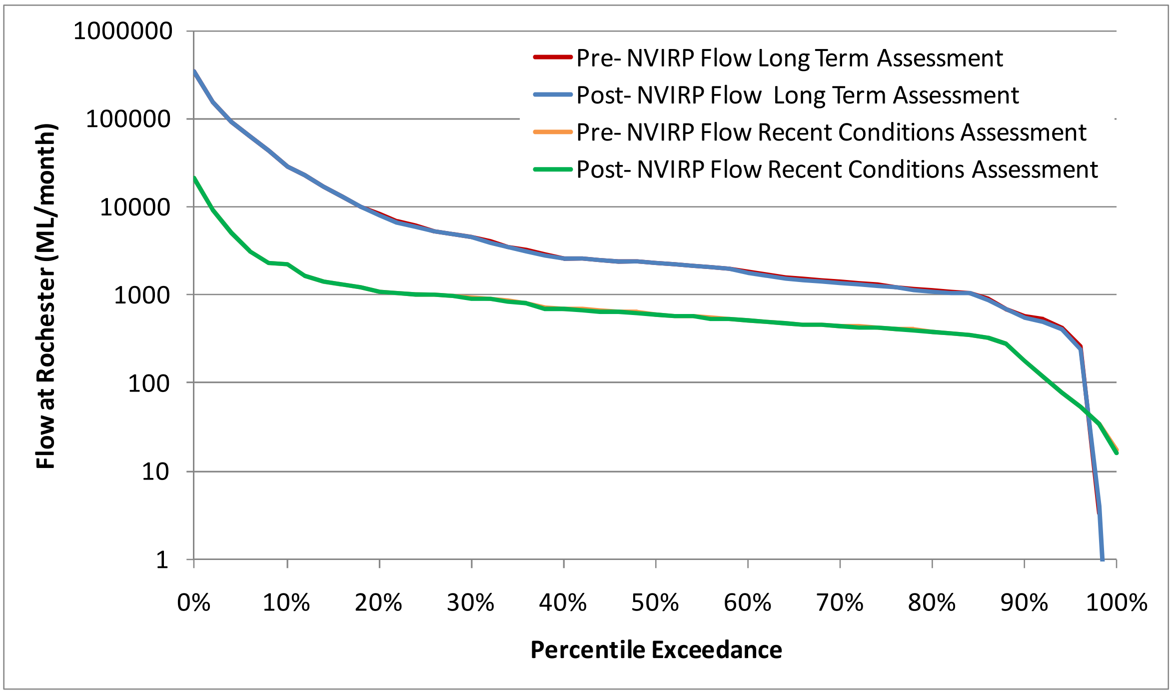

Figure 6: Flow duration curve of pre- and post-NVIRP streamflow for irrigation season months (August to April) at Rochester (Reach 3)

Long-Term Assessment
The long-term assessment of the impact over the irrigation season (August to April) indicates that low flows will be most affected with a reduction in flow for an equivalent percentile of 5% for very low flows (90th percentile flows, 580 ML/month pre-NVIRP) and 2% for low flows (75th percentile flows, 1,260 ML/month pre-NVIRP).

Recent Conditions Assessment
Based on the recent conditions assessment indicates a 1% reduction in both low (25th percentile, 430 ML/month pre-NVIRP) and high (75th percentile, 1,020 ML/month pre-NVIRP) flows.

Baseline Year Assessment
Figure 7 shows a time series plot of pre- and post- NVIRP flow for the baseline year (2003-04), illustrating the minimal change in the pre-NVIRP flow over the irrigation season (7,360 ML).

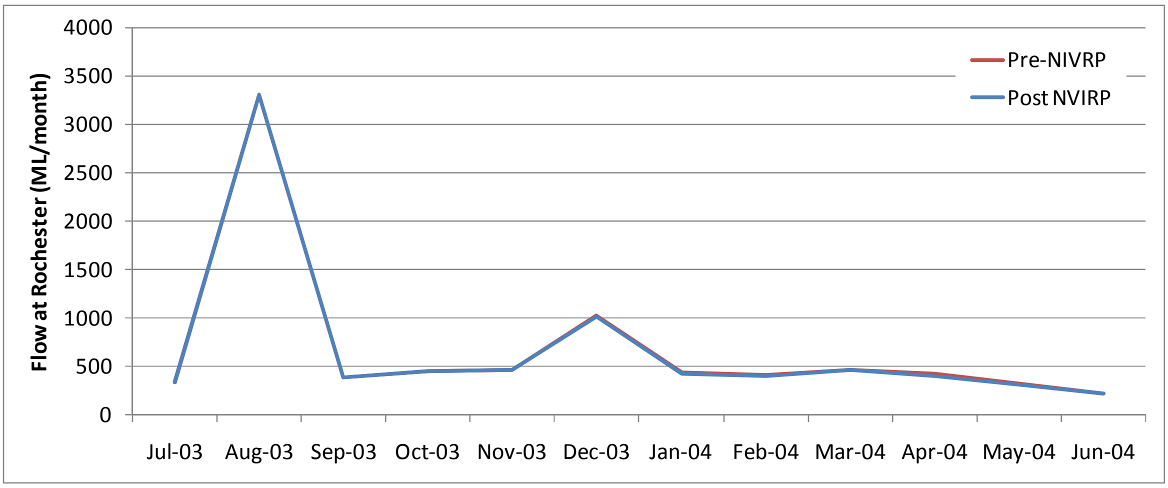

Figure 7: Time series plot of pre- and post-NVIRP flow at Rochester (Reach 3) for 2003/04 (the baseline year)

Figure 8 illustrates the low contribution of channel outfall to the streamflow at Rochester.

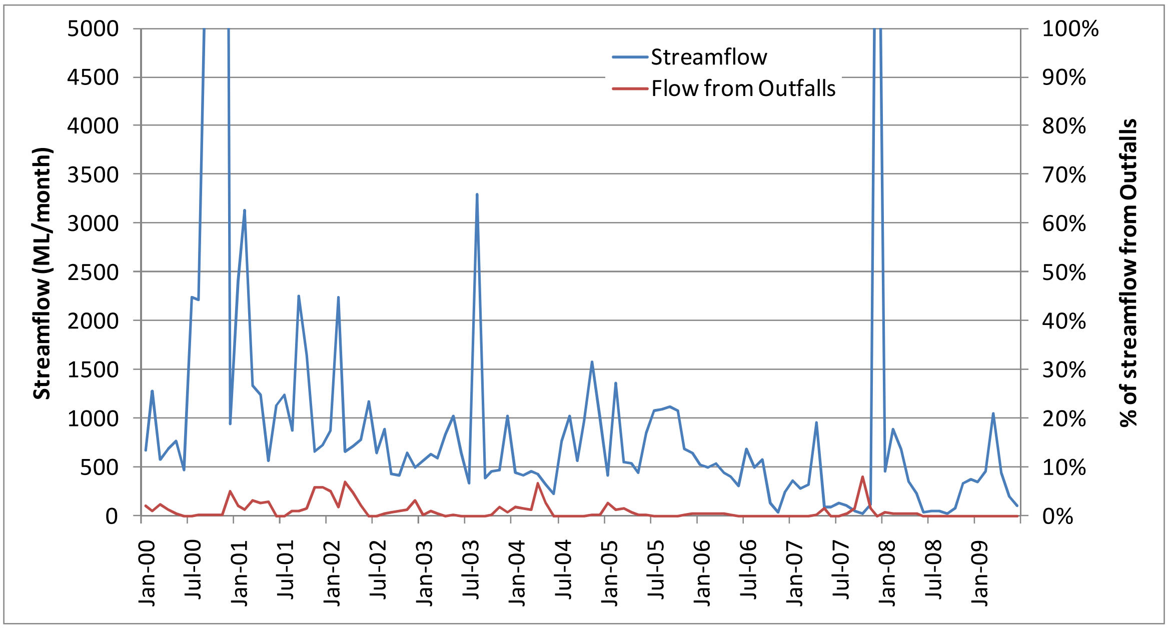

Figure 8: Time series plots showing the proportion of streamflow from outfalls for Rochester

From the above analysis the reduction in Campaspe River Reach 3 outfalls due to NVIRP is expected to have a limited impact on flow at Rochester.

7.4.2. Reach 4

The results show that based on both the long-term and recent conditions assessment, the reduction in Reach 3 and 4 outfalls due to NVIRP is expected to lead to a reduction in flow over the irrigation period at Echuca (refer to Table 17). Figure 9 illustrates the streamflow reduction for irrigation season months (August to April) at Echuca.

Table 17: Percent reduction in flow at Echuca (Reach 4) (pre-NVIRP flow for each percentile also shown)

Flow*	Percent Reduction in Flow for an Equivalent Percentile (Pre-NVIRP Flow- ML/month)			
	All Months		Irrigation Season Months	
	Long Term	Recent	Long Term	Recent
Very low flows (90th Percentile)	7% (490)	14% (40)	10% (480)	16% (60)
Low Flows (75th Percentile)	3% (1,060)	6% (150)	5% (1,050)	5% (150)
Median Flows (50th Percentile)	2% (2,170)	2% (470)	3% (2,100)	4% (460)
High Flows (25th Percentile)	1% (7,270)	2% (920)	1% (7,060)	2% (900)
Very High Flows (10th Percentile)	0% (30,580)	1% (1,320)	0% (30,640)	2% (1,310)

*- the percent reduction in flow for each key percentile is based on the average reduction in flow for percentiles ± 5% of the specified percentile. This is to avoid results being skewed by a single, non-representative change. For example, the change reported for 90th percentile flows is based on the change for flows between the 85th and 95th percentiles.

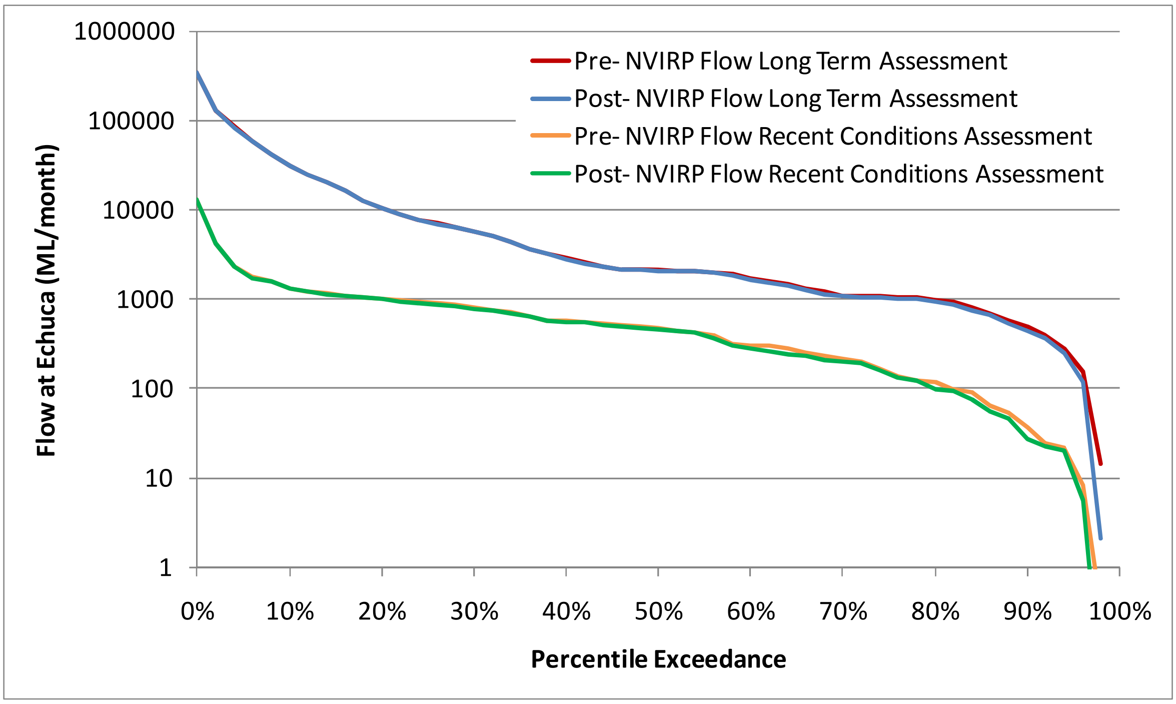

Figure 9: Flow duration curve of pre- and post-NVIRP streamflow for irrigation season months (August to April) at Echuca (Reach 4).

Long-Term Assessment
The long-term assessment of the impact over the irrigation season (August to April) indicates that low flows will be most affected with a reduction in flow for an equivalent percentile of 10% for very low flows (90th percentile flows, 480 ML/month pre-NVIRP) and 5% for low flows (75th percentile flows, 1,050 ML/month pre-NVIRP). High flows will also be slightly affected, with a reduction in flow for an equivalent percentile of 1% for high flows (25th percentile flows, 7,060 ML/month pre-NVIRP) (SKM 2010).

Recent Conditions Assessment
Similarly, the recent conditions assessment of the impact over the irrigation season (August to April) indicates that low flows with be most affected, though high flows will still be slightly affected. The results indicate that there will be a reduction in flow for an equivalent percentile of 16% for very low flows (90th percentile flows, 60 ML/month pre-NVIRP) and 5% for low flows (75th percentile flows, 150 ML/month pre-NVIRP) reducing to 2% for high flows (75th percentile flows, 900 ML/month pre-NVIRP).

Baseline Year Assessment
Figure 10 shows a time series plot of pre- and post-NVIRP flow for the baseline year (2004/05[4]).

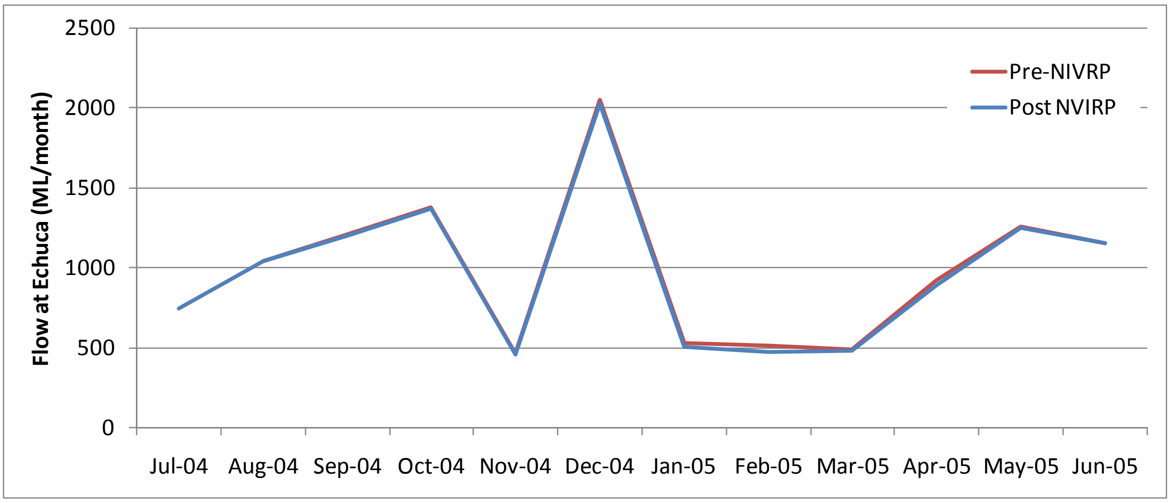

Figure 10: Time series plot of pre- and post-NVIRP flow at Echuca (Reach 4) for 2004/05 (the baseline year)

Figure 11 highlights the contribution of channel outfall to the streamflow at Echuca.

[4] The baseline year for Reach 4 outfalls (Rochester Irrigation District) is 2004-05, however the baseline year for Reach 3 outfalls (Campaspe Irrigation District) is 2003-04. As flow at Echuca is impacted by both Reach 3 and 4 outfalls the baseline year for assessment is not clear. For the purposes of this investigation, 2004/05 has been assessed as the baseline year, as Reach 4 outfalls are larger (by volume) than Reach 3 outfalls and thus have a more significant affect on flow at Echuca.

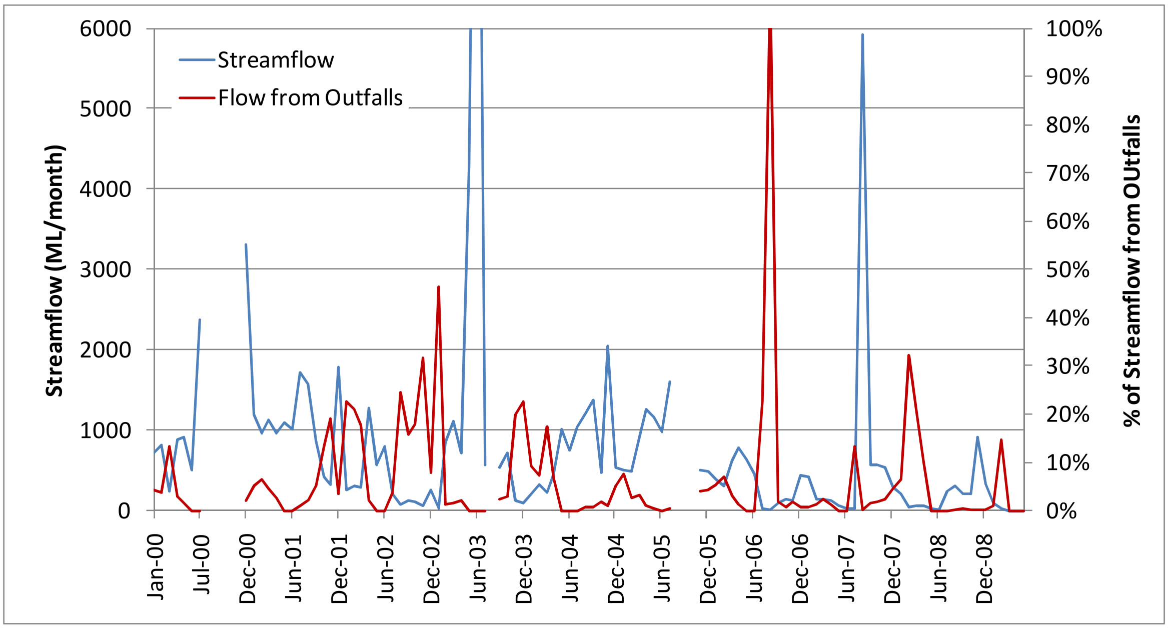

Figure 11: Time series plots showing the proportion of streamflow from outfalls for Echuca

From the above analysis the reduction in Campaspe River Reach 4 outfalls due to NVIRP is expected to lead to a small reduction in irrigation season flow at Echuca.

7.4.2.1. Inter Valley Transfer for Reach 4

The Campaspe Inter Valley Transfer (IVT) provides water from the Goulburn River System (Lake Eildon) allocated to the Murray River to be delivered through the Waranga Western Channel via Reach 4 of the lower Campaspe River to reach its destination in the Murray River downstream of Echuca. This provides summer environmental flows for the lower Campaspe River (Reach 4). This IVT is negotiated on an annual basis with the system operator and has been effectively used in the past four extreme dry years.

Under the current extreme conditions (with zero allocation in the Campaspe) all losses associated with delivery of IVT to Reach 4 is accounted for by the environment. During all other years when irrigation allocations are greater than 1%, all losses are accounted for as part of the Campaspe BE, as Reach 4 is part of the regulated system. Hence, the only environmental impact from reduced outfalls is during the last few extreme drought years where allocations have remained at 0% for the year.

The Northern Sustainable Water Strategy background report “Impact of future water availability scenarios on reliability of supply in regulated systems” modelled the impact of climate change on the water resources of the Campaspe Basin. The modelled results from this analysis indicated that zero allocations in the Campaspe Basin were still a rare event over the modelling period (greater than 100 years), as summarised below:

- Base case (long-term average) - zero allocations occur 1 year in 100
- Medium climate change at 2055 - zero allocations occur 1 year in 100
- Continuation of low inflows (July 1997 to June 2007) - zero allocations occur 5 years in 100.

The contribution of outfall to deliver of IVT has not been assessed any further due to:

- the rare occurrence that Reach 4 of the Campaspe relies solely on IVT (zero allocations) (i.e. 5 years in 100 under continuation of low inflows above).
- small outfall volumes and uncertainty being of similar magnitude to volume of water being considered.

7.4.3. Outfall Pattern Analysis

The TRG highlighted (refer to Appendix G) that it is important to understand how channel outfalls vary over time in order to fully assess the impact that reduced outfalls are likely to have on environmental values. Therefore an analysis was undertaken to better understand the pattern of the outfalls entering Reach 3 and Reach 4 of the Campaspe River.

Flow from outfall structures can be due to general operational practice which is generally related to the amount of demand being supplied in a channel system or due to rain rejection events which are influenced by the amount of rainfall and the level of demand being supplied in the channel system prior to the rainfall event.

Outfalls which are predominately demand driven are most likely to provide a relatively steady contribution to stream flow throughout the year. This type of outfall is most likely to support base (low) flow components of the flow regime. Outfalls which are predominately driven by rainfall are most likely to provide highly variable contributions to streamflow with a high proportion of the outfall volume occurring in a few short bursts. This type of outfall is more likely to support fresh and high flow components of the flow regime.

The multi-linear regression analysis for channel outfalls (Refer Section 7.3 and SKM 2010) was used to develop a relationship between irrigation demand, rainfall and irrigation allocation. An outfall pattern analysis using regression analysis information, actual outfalls and rainfall was undertaken for three years of record (2002/03, 03/04 & 04/05). Discussion with G-MW Rochester staff was also undertaken. Conclusion from the outfall pattern analysis is:

- The majority of the outfall volume and variation could be explained by irrigation deliveries to the region with climate variables (rainfall) less influential
- Average weekly outfall volumes were low through out the irrigation season (1.4 to 3 ML/wk) (Refer Table 18)
- Higher outfall volumes are relatively rare with outfalls exceeding 10ML/wk for Campaspe reach 3 & 4 on four and three occasions respectively (over the 3 years assessed). (Refer to Figure 12 & 13)
- Overall, these results suggest that the outfalls have historically been supporting the base or low flow components of the flow regime at relatively low outfall volumes, and that higher flows are relatively rare. (This summary was supported by T. Cantwell G-MW Rochester, pers comm.).

Table 18: Key statistics for weekly outfalls

Outfall Group	Average Yearly Outfall Volume (ML)	Average Weekly Volume (ML/week)	Median Weekly Volume (ML/week)	Peak Weekly Volume (ML/week)
Group 1 (Campaspe Reach 3	55.1	1.4	0.3	12.0
Group 2 (Campaspe Reach 3 & 4)	116.8	3.0	2.8	19.5

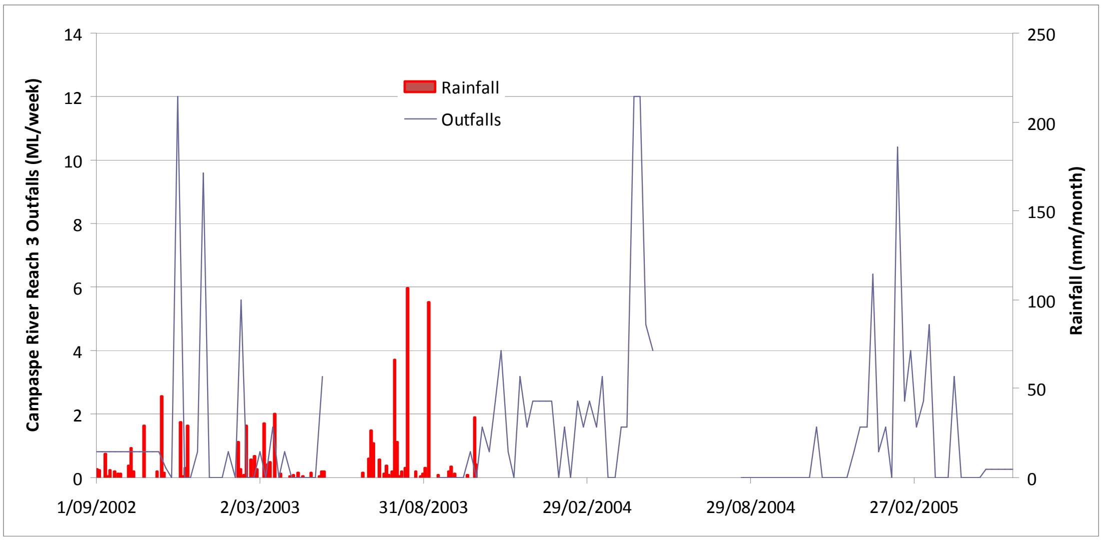

Figure 12: Time series plot of weekly Campaspe Reach 3 Channel Outfalls and rainfall

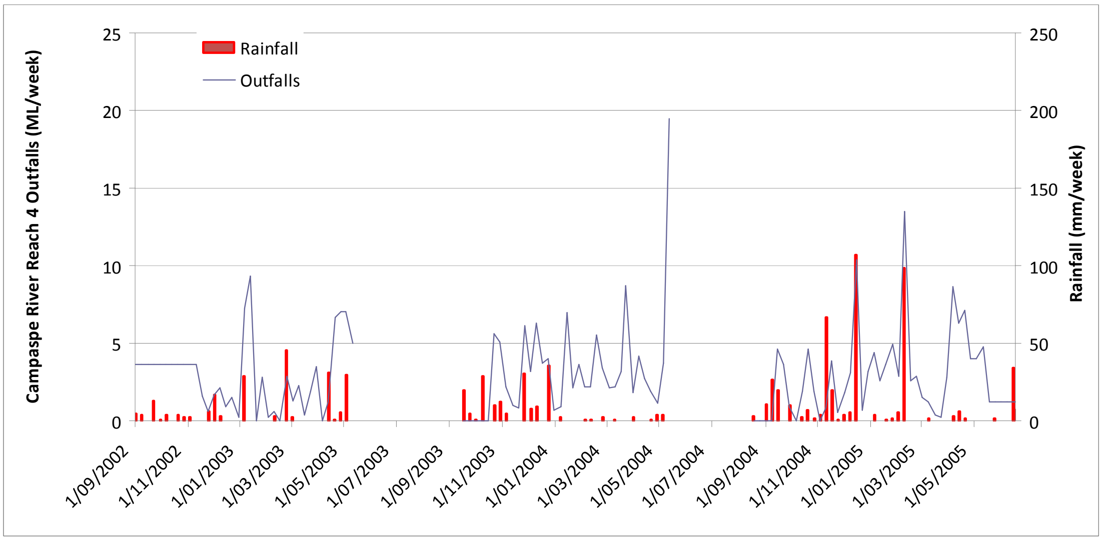

Figure 13: Time series plot of weekly Campaspe Reach 4 Channel Outfalls and rainfall

8. Mitigation water assessment

The volume of water that is required to offset the impact of NVIRP on waterways that have become reliant on this water to support high environmental values is termed ‘mitigation’ water. The potential impact of NVIRP considered in the Campaspe River EWP is related mainly to a reduction in outfalls. Other potential impacts to the waterway will be managed through the Water Change Management Framework (NVIRP 2010) and Site Environmental Management Plans.

Guiding principles for mitigation water based on government policy have been defined by the Water Change Management Framework and are:

1. Water savings are the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values
2. Using the same baseline year (2003-04 or 2004–05) as that used to quantify savings, taking into account the long-term average annual patterns of availability
3. The mitigation water will be deployed according to the EWP
4. Sources of mitigation water will be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the EWPs. Water quality will need to be considered for all sources of water to ensure it is appropriate.

In the majority of cases, actual outfall volumes will be less than what is required to support all water-dependent environmental values of a particular waterway. Therefore, the outfall water only forms part of the overall volume required to provide the watering regime of the waterway. The watering regime supports processes and systems which in turn provide suitable conditions for defined ecological values (e.g. spring freshes to cue breeding and migratory movements for native fish). Consequently, the mitigation water will be calculated based on a qualitative assessment supported by data and information on the values that a waterway supports, and the hydrological information available at the time.

A process for calculating mitigation water based on the best available information has been developed and involves the application of a series of steps that includes:

Step 1: Describe the desired environmental flow regime

Step 2: Determine the baseline year incidental water contributions

Step 3: Assess dependency on baseline mitigation water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

NVIRP have assumed an overall 85 % reduction in channel outfalls across the entire GMID. This has been reflected in the hydrology modelling undertaken for this EWP and is appropriate for assessing system wide impacts. Given the uncertainty in estimating the actual reduction in individual outfalls (i.e. it is expected that each system operator will be aiming to reduce channel outfall to zero) it is appropriate to use 100% reduction in channel outfalls in the mitigation water calculation.

8.1. Reach 3 mitigation water assessment

Step 1: Describe the desired environmental flow regime

The environmental flow recommendations for Reach 3 describe a permanently flowing waterway (Section 5.1.3), the flow components are outlined below:

1. **Summer low flow:** 10 ML/day (not more than 20ML/day), 1 per year, duration 6 months
2. **Summer freshes:** 100 ML/day, 3 per year (Feb to May**), duration 6 days
3. **Winter low flow:** 200 ML/day (or natural), 1 per year, duration 6 months
4. **Winter high flow:** 1,500 ML/day, 2 per year (or natural), duration 4 days
5. **Winter bank-full flow:** 8,000 ML/day, 2 per year (or natural), duration 2 days
6. **Winter Overbank flow:** 12,000 ML/day, 1 per year, duration 1 day

There are no 'cease to flow recommendations' as it was determined that this would potentially exacerbate high salinity levels, nutrient enrichment and low dissolved oxygen levels, which would create an unnatural level of stress to aquatic biota throughout this reach (SKM 2006c).

Step 2: Determine the baseline year incidental water contribution[5]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage. As outlined in Section 1.6, leakage and seepage from NVIRP works is difficult to quantify until works have been implemented[6]. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been accounted for within the following steps.

Therefore, only one hydrological connection (waterway outfalls) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year loss contribution is the amount of water received by the waterway from outfalls. The baseline year (2003-04) outfall recorded was 98 ML, the portion of water that reached the waterway equates to 74 ML (Table 19 and SKM 2010).

Table 19: Determination of the baseline year contribution at Campaspe River Reach 3

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Baseline year incidental water contribution at the waterway (Net) (ML)
ST032783	0	0	0
ST023729	92	18	74
TOTAL	**92 ML/year**	**18 ML/year**	**74 ML/year**

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Campaspe River Reach 3 with the results presented in Table 20.

[5] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel to the waterway.

[6] If future NVIRP actions are likely to impact the potential for leakage and seepage in Reach 4 (i.e. lining the main supply channel or decommissioning other channels), it is recommended that a more detailed analysis is undertaken.

Table 20: Reach 3 Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between outfall water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	There is a hydraulic connection, indicative losses have been calculated.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Outfall water reaches waterway (losses have been calculated).
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	The waterway is dependent on the outfall water, particularly under recent conditions (reduced flows downstream of Campaspe Weir)
2.2 That occurs at a time that is detrimental to the environmental values	The timing of outfalls maintains water quality in permanent pools for fish
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Irrigation water in the Campaspe Irrigation Area is of good quality, therefore outfall water is not detrimental to environmental values in the Reach 3 (refer to Appendix I)
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Reach 3 has water dependent values that may benefit from outfall (e.g. native fish)
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	**The outfall volume is small (74ML after losses), removal of outfall water would not reduce flows significantly and therefore is not likely to increase the risk to environmental values**
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	**The outfall volume is very small compared to the required flow magnitude.**

The above assessment demonstrates that the **outfall water does not provide benefit to Campaspe River Reach 3.** Therefore **mitigation water is not required to maintain the environmental values of the waterway.**

The hydrology assessment for Reach 3 (Section 7.4.1, Table 16) indicates that based on both the long-term and recent conditions assessment, the reduction in Reach 3 outfalls due to NVIRP is expected to have a limited impact on flow (less than 5%) at Rochester. Due to the low volumes of outfall water supplied to the reach 3 over the past 10 years in comparison to the volumes required to support the Reach 3 environmental values, it is reasoned that outfalls are not supporting high environmental values at the waterway.

The outfall pattern analysis outlined in Section 7.4.3 concluded that the majority of the outfall volume and variation could be explained by irrigation deliveries to the region, with climate variables (rainfall) found to be less influential and that average weekly outfall volumes are low. This analysis also indicated that higher outfall volumes are rare and not likely to significantly influence flows in Campaspe Reach 3. Therefore reducing channel outfalls for Reach 3 is not likely to increase the risk to environmental values within the reach.

Please note: due to the recommendation above Steps 4, 5 and 6 do not need to be calculated.

8.2. Reach 4 mitigation water assessment

Step 1: Describe the desired filling frequency

The environmental flow recommendations for Reach 4 describe a permanently flowing waterway (Section 5.2.3), the flow components are outlined below:

1. **Summer low flow:**10 ML/day (not more than 20ML/day), 1 per year, duration 6 months
2. **Summer freshes:** 100 ML/day, 3 per year (Feb to May**), duration 6 days
3. **Winter low flow:** 200 ML/day (or natural), 1 per year, duration 6 months
4. **Winter high flow:** 1,500 ML/day, 2 per year (or natural), duration 4 days
5. **Winter bank-full flow: 9**,000 ML/day, 2 per year (or natural), duration 2 days

As in Reach 3, cease to flow events were not recommended. While they would have naturally occurred in Reach 4, re-introducing cease to flow events was seen to exacerbate high salinity levels and low dissolved oxygen levels, particularly near Echuca (McGuckin 1990).

Step 2: Determine the baseline year incidental water contribution[7]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage. As outlined in Section 1.6, leakage and seepage from NVIRP works is difficult to quantify until works have been implemented[8]. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been accounted for within the following steps.

Therefore, only one hydrological connection (waterway outfalls) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year loss contribution is the amount of water received by the waterway from outfalls. The baseline year (2004-05) outfall recorded was 643 ML, the portion of water that reached the waterway equates to 128 ML (Table 21 and SKM 2010).

Table 21: Determination of the baseline year contribution at Campaspe River Reach 4

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Baseline year incidental water contribution at the waterway (Net) (ML)
ST051358	0	0%	0
ST033397	60	10%	54
ST033384	13	100%	0
ST065860	204	100%	0
ST033425	62	50%	31
ST033461	213	80%	43
ST033111	91	100%	0
TOTAL	**643 ML/year**		**128 ML/year**

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. The criteria have been assessed for Campaspe River Reach 4 with the results presented in Table 22.

[7] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel to the waterway.

[8] If future NVIRP actions are likely to impact the potential for leakage and seepage in Reach 4 (i.e. lining the main supply channel or decommissioning other channels), it is recommended that a more detailed analysis is undertaken.

Table 22: Reach 4 Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between outfall water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	There is a hydraulic connection, indicative losses have been calculated.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Outfall water reaches waterway (losses have been calculated)
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	The waterway is dependent on the outfall water, particularly in relation to offsetting against losses in providing the Campaspe IVT
2.2 That occurs at a time that is detrimental to the environmental values	The timing of outfalls maintains water quality in permanent pools for fish
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Irrigation water in the Rochester Irrigation Area is of good quality, therefore outfall water is not detrimental to environmental values in the Reach 4 (refer to Appendix I)
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Reach 4 has water dependent values that directly benefit from outfall (e.g. native fish)
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	The outfall volume is small (146ML after losses), removal of outfall water would not reduce flows significantly and therefore is not likely to increase the risk to environmental values (see discussion below).
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	Under current conditions the Environmental Water Manager would need to secure more water to cover the losses in providing the Campaspe IVT, although this will be a rare event and has not been assessed any further

The above assessment demonstrates that the **outfall water <u>does not</u> provide benefit to Campaspe River Reach 4.** Therefore **mitigation water is not required to maintain the environmental values of the waterway.**

The hydrology assessment for Reach 4 (Section 7.4.2, Table 17) indicates that during recent conditions there is a percentage reduction in flow of 16% during very low river flows (90th percentile, 60ML/month or approximately 2 ML/day). This indicates that outfalls contribute a greater proportion of flow during these very low river flow events. Given the very small volumes of water in both the river and outfall, level of uncertainty in relation to model outputs and the low volumes of water compared to the volumes required to support the Reach 4 environmental values this reduction is not considered significant.

The Outfall Pattern Analysis outlined in Section 7.4.3 concluded that the majority of the outfall volume and variation could be explained by irrigation deliveries to the region with climate variables (rainfall) found to be less influential and that average weekly outfall volumes are low. This analysis also indicated that higher outfall volumes are rare and not likely to significantly influence flows in Campaspe Reach 4. These conclusions were supported by G-MW Rochester operations staff (pers comm. T. Cantwell).

Campaspe Reach 4 is also influenced by saline groundwater with saline pool stratification occurring in the reach (Refer to Section 3.2 and SKM 2008b). A key finding from the Saline Pools Study (SKM 2008b) was that flows of 10ML/day provide a freshwater lens 60cm in depth, but do not mix the stratified pools (based on current groundwater levels) and flow of greater than 25ML/day are required to get full mixing of the pool. This assessment is based on current groundwater conditions, further investigation may be required if groundwater condition change significantly.

Given the findings from the saline pools investigation and the outcomes from the Outfall Pattern Analysis (Section 7.4.3) the following summary can be made:

- Average weekly outfall volumes were low throughout out the irrigation season (1.4 to 3 ML/wk) (Refer Table 18).
- Higher outfall volumes are relatively rare with outfalls exceeding 10ML/wk for Campaspe reach 3 & 4 on four and three occasions respectively (over the 3 years assessed). (Refer to Figure 7 & 8).
- Flows of 10ML/day only provide a freshwater lens of 60cm in depth and flow greater than 25ML/day is required to get full mixing.
- Reduction in Outfall will have an insignificant impact on saline pools due to the low volumes, although there is likely to be a small, localised and short-lived benefit to water quality from the outfall water.

Therefore reducing channel outfalls for Reach 4 is not likely to increase the risk to environmental values within reach 4, due to:

- the low volumes of outfall water supplied to the Reach 4 over the past 10 years in comparison to the volumes required to support the Reach 4 environmental values
- pattern of outfall water is generally small and influenced by irrigation demand and less influenced by rainfall
- reduction in outfall volumes is likely to have an insignificant impact on the saline pools of the Lower Campaspe River.

Please note: due to the recommendation above Steps 4, 5 and 6 do not need to be calculated.

9. Other environmental water sources

The calculated mitigation water only represents a small portion of the total volume of water required to provide the desired watering regime. As such, it is important to secure additional sources of water for the Campaspe River. The most likely additional sources of water will be existing and future environmental entitlements. The most likely additional sources of environmental water will be existing and future environmental entitlements. Potential sources of water available for the Campaspe River are discussed below.

9.1. 75GL environmental entitlement

Water savings generated by NVIRP will provide up to 75 GL to be vested in the Minister for Environment and Climate Change as an Environmental Water Entitlement. This environmental water is in addition to Government's commitments to provide water for the Living Murray process and will be used to help improve the health of stressed wetlands and waterways in Northern Victoria and the River Murray (NVIRP 2010).

In addition, the Australian Government may co-invest in Stage 2 of NVIRP which will generate up to 100 GL of water savings, some of which will be allocated to the environment. This water will be available for use across the Murray Darling Basin.

9.2. Commonwealth environmental water

Under Water for the Future the Australian Government has committed $3.1 billion to purchase water in the Murray-Darling Basin over 10 years. The program will complement a range of other measures to address sustainable water management in the Basin. The Commonwealth Environmental Water Holder, in DEWHA, will manage the Commonwealth's environmental water.

The *Water Act 2007* provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements” (DEWHA 2008).

9.3. Murray Darling Basin Plan

The Murray-Darling Basin Authority is currently in the process of developing the first Murray-Darling Basin Plan as required by the *Water Act 2007*. The Basin Plan aims to establish Sustainable Diversion Limits for key environmental assets within the Murray-Darling Basin and is anticipated to commence in 2011 (MDBA 2010).

Sources of Commonwealth environmental water for the Campaspe River will be influenced by the outcomes of the Basin Plan. The Campaspe River has been nominated as a key environmental asset for which Sustainable Diversion Limits are likely to be established.

10. Opportunities to deliver water

The following section outlines the opportunities to deliver water including any infrastructure requirements to deliver mitigation and/or environmental water in the lower Campaspe River (downstream of Campaspe Weir to the Murray River).

Campaspe River Reach 3

Environmental flow recommendations in Campaspe River Reach 3 are delivered via the Campaspe Weir, however the following recommendations would enhance the delivery of the desired flow regime:

- Campaspe Weir: investigations have recommended a remediation option to strengthen the Campaspe Weir and extend its weir life a further 20 years. Any works undertaken will need to consider environmental water uses both upstream and downstream of the weir (e.g. the weir pool is an important environmental refuge).
- To provide the Winter Bankfull flow component to Campaspe River Reach 3 there is a constraint at the Lake Eppalock outlet capacity at less than FSL (maximum 1,850 ML/day). Recommendations to modify Eppalock releases and piggyback on high tributary inflows have been made (SKM 2006d).

Campaspe River Reach 4

Environmental flow recommendations in Campaspe River Reach 4 are delivered via the Campaspe Siphon. The following constraints exist for this reach of the Campaspe River:

- To provide the Winter Bankfull flow component to Campaspe River Reach 4 the same constraint at the Lake Eppalock outlet capacity as described for reach 3 above applies. The outfall capacity at the Waranga Western Channel is also limited to 1,470 to 2,300 ML/day (SKM 2006d).

Campaspe Billabong and Unnamed Creek

The Campaspe Billabong receives annual watering and is operated as a permanent system (outfall sites along the billabong provide supply to landholders and is operated as a reuse system). A further assessment of this system may be required if this situation changes in the future (e.g. channel rationalisation, preventing water delivery to the Campaspe Billabong).

No additional delivery infrastructure or upgrades are required for the management of the Unnamed Creek (Section 7.2). The values in this waterway require a 1 in 3 year flooding frequency in winter/spring and the waterway is connected to the Campaspe River.

11. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired watering regime. Table 23 outlines the risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired watering regime that need to be considered by NVIRP in conjunction with the environmental water manager.

Mitigation measures have been recommended to minimise the likelihood or the risk occurring and/or its potential impact.

Table 23: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to the Campaspe River EWP area

Risk/limiting factors	Impacts	Mitigation measures
NVIRP		
Mitigation water was not calculated correctly	Underestimation of the mitigation water commitment Loss of environmental values	Review Campaspe River EWP recommendations in 2012
Error in quantifying the outfall losses (desktop analysis – Section 7.1.1)	May result in an underestimation of the impact and hence the need for mitigation water	Review Campaspe River EWP recommendations in 2012
Opportunistic diversion licences (unregulated)[1]	Artificial lowering of water level threatening environmental flow objectives Use of environmental and mitigation water for consumptive use	Investigate options for alternative supply
Rationalisation of the Campaspe and Rochester Irrigation Districts	E.g. Change to Campaspe Weir operation impacting on environmental values of the waterway	Infrastructure rationalisation as part of NVIRP will need consider the implications to any recommendations outlined in the Campaspe EWP
Reach 3 and 4		
Outfall water has provided environmental benefits to this waterway	Loss of environmental values	Monitoring (Appendix J) will identify any issues on the Campaspe River
EWP is based on current operating system. Any significant changes to operations (including water trade out of the Campaspe System) will need to assess the implications on the EWP prior to proceeding	EWP Assessment may require review	Assess impacts on EWP
Reach 4		
Changes to the groundwater level impacting on the level of saline stratification	Potential impact on aquatic biota	Monitor groundwater levels and interaction with River. If significant changes, then review influence of channel outfalls.

Note 1: G-MW stage 5 roster suspensions on diversions are currently in place. These are to remain in place, or appropriate restrictions implemented if not already in place, to ensure that any mitigation water delivered to wetlands and waterways is protected until such time more permanent measures are established. The roster suspensions may be temporarily lifted to allow extraction to occur where there are demonstrable alternative water supplies entering the waterway or wetland (e.g. as a result of flood).

12. Adaptive management framework

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, NVIRP 2010).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 24 shows how the adaptive management approach will be applied in the context of this EWP.

Table 24: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When (Sections 15 and 19, NVIRP 2010)
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (NVIRP)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Agencies as appropriate)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal. (NVIRP – to resource or coordinate monitoring to meet its reporting obligations, Other agencies – monitoring to inform assessment of achievement of environmental objectives).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (NVIRP, until responsibilities transferred to other Agencies)	2012, 2015, 2020, 2025, etc
Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (NVIRP, until responsibilities transferred to other Agencies)	2012, 2015, 2020, 2025, etc

12.1. Monitoring and reporting

Mitigation water is not currently recommended for the Campaspe River, therefore there is no requirement for NVIRP to report, annually, on the contribution, or provision, of "NVIRP Mitigation Water" towards achieving the water regime as with other EWPs (Section 18, NVIRP 2010).

It is expected that the environmental water holder will monitor environmental water delivery (i.e. quantity, timing, duration and frequency) and implement a detailed monitoring program to enable assessment of ecological condition. NVIRP will not implement a detailed monitoring program.

It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the desired water regime in achieving ecological objectives and the overall environmental flow regime.

NVIRP (2010, p73) states that "monitoring requirements will be designed to be consistent with the Catchment Management Authorities' existing monitoring programs".

There is already an ongoing environmental flow, water resource planning and water quality monitoring program for the Campaspe River conducted by the North Central CMA and Goulburn-Murray Water. This monitoring program is seen as sufficient and will be used to inform the outcomes of the use of mitigation water (refer to Appendix J).

The recommendations within this EWP (including the requirement of mitigation water and reporting) will be regularly reviewed as outlined in Section 12.2 below.

12.2. Review

Periodic reviews provide the opportunity to evaluate monitoring results in terms of compliance, ecological objectives and to learn from implementation.

It is expected this EWP will be reviewed in 2012, 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for Environment Protection (Sections 15 and 19, NVIRP 2010).

12.3. Adjustment

Adjustments may be made to:

- operational management
- management hypotheses and, perhaps, to ecological objectives
- cope with unexpected issues.

These adjustments will be incorporated into the EWP.

13. Management and governance arrangements

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 25 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 25: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• Identify and account for water savings, subject to audit by DSE accredited auditor • Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. • Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. • Retain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Technical Advisory Committee. • Convene the Expert Review Panel	• Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. • Provides resources to enable monitoring and review of management and mitigation measures • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to improve management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water • Work closely with system operator.
Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
Land Manager (Public and private as relevant)	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
	implementation of NVIRP.	of NVIRP.
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in section 9. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve. • Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered. • Work closely with NVIRP
DSE	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures. • Develop policies to address relevant issues (assuming that other agencies will participate policy development).	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs. • Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the *Water Act 1989*. The process will allow: • The balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions. • The need for the obligation reviewed based on the environmental values at the time of the review.
Environmental Water Holder (to be established) **DSE pending appointment of the Environmental Water Holder**	Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.	• Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. • Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements. • Participate in the periodic review of relevant EWPs. • Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

13.1. Framework for operational management

The obligation to annually reserve and supply mitigation water will be established in one of two ways:

- by amendment to the River Murray and Goulburn System Bulk Entitlements held by G-MW; or
- by agreement (contract) between the Minister for Environment and G-MW, under section 124(7) of the Water Act 1989.

Both arrangements are legally binding and reflect the commitments of the NVIRP to provide water to mitigate potential impacts to high value environmental assets. The arrangements require G-MW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved EWP.

Mitigation water will be able to be carried over in line with other entitlements and will only be supplied to those wetlands where a mitigation water requirement has been identified. The specification of the volume and use of mitigation water will be the same regardless of whether it is established via bulk entitlement or contract.

There is no mitigation water recommended for the Campaspe River, however the environmental water manager will need to provide information into the review of this EWP, as outlined in Section 12.2.

Delivery of environmental water to the Campaspe River requires the coordination of information, planning and monitoring among a number of agencies. The main components are:

- Assessment of current conditions i.e. water resource outlook, water quality, and season.
- Annual Water Planning under the Campaspe BE.
- Identification of ‘other’ potential water sources and preparation of relevant information for submission of water bid.
- Coordination of the environmental water delivery and adaptive management process.

14. Knowledge gaps

The Campaspe River EWP has been developed using the best available information. However, a number of information and knowledge gaps exist which may impact on recommendations and/or information presented in the EWP. These are summarised below.

14.1. Works program

Further information on the NVIRP works program in the vicinity of Campaspe River needs to be confirmed to more specifically assess the potential impacts on the waterway.

14.2. Mitigation water

No mitigation water has been recommended for the Campaspe River.

14.3. Roles and responsibilities

The roles and responsibilities of key agencies in the operational management of mitigation water (and other sources of environmental water) have not yet been clearly defined. A process has been recommended (Section 12). However, in light of changes recommended in the Northern Region Sustainable Water Strategy (Victorian Environmental Water Holder) and the Land and Biodiversity White Paper, roles and responsibilities will need to be reviewed.

15. References

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Appendix A: NVIRP TAC and TRG Workshop Attendees

Table A1: NVIRP TAC members

Name	Organisation and Job title
Anne Graesser	Manager – Water Systems Health Goulburn-Murray Water
Emer Campbell	Manager – NRM Strategy North Central CMA
Jen Pagon	Catchment and Ecosystem Service Team Leader Department of Primary Industries
John Cooke	Manager Sunraysia Department of Sustainability and Environment
Carl Walters	Shepparton Irrigation Region Executive Officer Goulburn Broken CMA
Ross Plunkett	Executive Manager Planning NVIRP
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria

Table A2: TRG Workshop Attendees

Name	Organisation and Job title
Dr Andrew Sharpe	Senior Ecologist Sinclair Knight Merz
Emer Campbell	Manager – NRM Strategy North Central CMA
Erin Murrihy	Hydrologist Sinclair Knight Merz
Geoff Earl	Northern Victoria Environmental Flows Coordinator Goulburn Broken CMA
John McGuckin	Consultant – Aquatic Ecology Streamline Research
Kate Austen	Senior Hydrologist Sinclair Knight Merz
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Pat Feehan	Representing NVIRP Feehan Consulting
Prof Paul Boon	Senior Lecturer Victoria University
Rohan Hogan	Science and Strategy Leader North Central CMA

Appendix B: Legislative framework

B1 International agreements

Australia is a signatory to the following international migratory bird agreements:

- Japan–Australia Migratory Bird Agreement (JAMBA)
- China–Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention).

The Campaspe River (reaches 3 and 4) is known to support species protected by each of the above international migratory bird agreements (Section 5).

B2 Federal legislation

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance[9].

The Campaspe River (reaches 3 and 4) is known to support a species listed under the *EPBC Act* (Section 5). Actions that may significantly impact any of these matters of national environmental significance are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The NVIRP works program is also subject to assessment and approval under the *EPBC Act 1999*. A Public Environment Report documenting and assessing the potential impacts of the NVIRP on matters of national environmental significance was submitted to the Department of the Environment, Water, Heritage and the Arts (DEWHA) on 6 January 2010.

B3 State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The *Flora and Fauna Guarantee (FFG) Act 1988* aims to protect a number of identified threatened species and communities within Victoria. The Campaspe River (reaches 3 and 4) is known to support a number of species both protected[10] and listed under the *FFG Act* (Section 5). Disturbance or collection of any of these threatened species will require a permit from the DSE.

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under the *Environmental Effects Act 1978*. As such, the NVIRP works program and any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 1.1).

Planning and Environment Act 1987

The removal or disturbance to native vegetation within Victoria is controlled by the implementation of a three-step process of avoidance, minimisation and offsetting under the *Planning and Environment Act 1987*. Any proposed removal or disturbance to native vegetation associated with the NVIRP works program will require the implementation of the three-step process, assessment and approval under the Act.

Water Act 1989

The *Water Act 1989* is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

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[9] There are seven MNES that are protected under the EPBC Act, these are: World Heritage properties, National Heritage places, wetlands of international importance, listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, and nuclear actions (including uranium mines) (DEWHA 2009).

[10] Includes plant taxa belonging to families or genera protected by the Act (DSE 2005).

Aboriginal Heritage Act 2006
All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). The Campaspe River is known to support sites of Aboriginal cultural significance (Section 5.4).

Other - Threatened Species Advisory Lists
Threatened species advisory lists for Victoria are maintained by the DSE and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the Victorian FFG Act. There are no legal requirements or consequences that flow from inclusion of a species in advisory lists. However, some of the species in these advisory lists are also listed as threatened under the FFG Act. The Campaspe River (reaches 3 and 4) is known to support flora and fauna species that are included on advisory lists however are not protected by additional state or federal legislation.

Appendix C: Community Engagement

Community Engagement purpose

Environmental Watering Plans (EWPs) are currently being developed for the lower Loddon and Campaspe rivers to determine the ecological impact of the current irrigation outfall (surplus water). An important component of this work involves identifying the environmental objective and environmental flow requirements for each of the river reaches potentially impacted by NVIRP. This requires an understanding of physical attributes, the history and the main environmental and hydrological processes associated with each of the river systems.

There have been various levels of planning and monitoring on the waterways currently being studied. To assist in collating all relevant information on each waterway it is important to capture and record information from the local community. In many cases adjoining landholders have had a long association with a waterway and have developed good understanding that is useful to include in the development of the EWP. This is particularly important if only limited monitoring records exist.

This process is also useful to increase community ownership and acceptance of the EWP, particularly if ongoing work involves onground works.

Similar to the Wetland EWPs completed in association with the Campaspe River EWP, a targeted community/agency engagement process was developed where a list of people with a good technical understanding of the river reach being assessed was developed by the technical working group.

This list included key adjoining landholders who have had a long association with the waterway and proven interest in maintaining its environmental value. A minimum of two landholders were invited to provide input for each river reach.

The information is captured in brief dot point form and only technical information and observations have been noted that will add value to the development of the EWP.

A list of participants has been recorded; however, comments for each river reach have been combined so individual comments are not referenced back to individuals.

It is important that the people approached for this information have a brief, straight summary of the purpose of the EWPs and type of information that will be useful to include in the planning process. Refer to summary below:

Method

A targeted community/agency engagement process was developed for the first round of EWPs developed in early 2009. A list of people with a good technical understanding of each waterway was developed by the technical working group (DPI, DSE and North Central CMA representatives).

This list included key adjoining landholders that have had a long association with the wetland and proven interest in maintaining its environmental value. A minimum of 2 landholders were invited to provide input for each river reach.

The method of obtaining information was informal and occurred at the site (e.g. oral histories, interviews). The information has been captured in brief dot point form and only technical information and observations are to be noted that will add value to the development of the EWP.

A list of participants has been recorded however all the comments have been combined for each of the waterways so individual comments are not referenced back to individuals.

List of community and agency participants
Campaspe River Reach 3 (including Twelve Mile Creek)

- James Williams
- Geoff Elliot
- Denise Accocks

Campaspe River Reach 5

- Frank Urbano
- Brian Wearne
- Kay Wearne

Information provided to participants

We are currently completing a study for NVIRP. It involves completing plans for the lower Loddon and Campaspe rivers:

1. Campaspe River (downstream of Campaspe Weir to Murray River)
2. Loddon River (downstream of Loddon Weir to Murray River)
3. Twelve Mile Creek (anabranch of the Loddon River)

As part of this, it would be valuable to gather information that is broadly described below with a focus on the water regime and associated waterway values. It is recognised that these waterways have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how they influenced and altered the waterways is important. It is particularly important to collate information or observations over more recent times, such as the last 30–50 years.

- What was the original (pre-European settlement) condition of this section of the Campaspe River, including any detail of the water regime and environmental values?
- What connection did the Campaspe River have to the floodplain areas creek lines and wetlands and there behaviour in both flood and dry times?
- What broad changes to river management have occurred as part of European Settlement and agricultural development?
- What function did the river have in the development of the irrigation supply system?
- What changes occurred to the environmental values as part of increased river regulation?
- More recently what changes have occurred to the water regime and health of the Campaspe River since the mid 1900's?
- Describe notable plants and animals that utilised the river over time?
- What influence do the artificial structures have on river flow or health?
- Given the history and current condition what water regime would be needed to achieve the best environmental results for the river and adjacent floodplain?
- What role does outfall from the G-MW channel have?
- Given the history and current condition, what type of water regime would be needed to achieve the best environmental results for the waterway?

Comments and feedback from participants for the Campaspe River
Campaspe River Reach 3

Campaspe River natural/pre European settlement condition

- High winter/spring flows (August to October), there were a lot of floods in October
- The river ran dry in 1939 with only a few deep holes remaining in the river
- The river use to be a strong hold for Macquarie Perch and Platypus
- Fine white river washed sands on the banks were present along the reach

Changed Campaspe River regulation and management over time

- To secure water supply, channels were made around Rochester which decreased the amount of water in the Campaspe River
- “Trust channel” that use to deliver water to properties, summer fill basis for dams (1950s onwards)
- The establishment of the Rural Finance and Settlement Scheme, 100 acre dairy farms with 100ML water rights providing farmers with loans with 4% interest (1967/68). This led to some areas being irrigated which maybe shouldn’t have
- The river had a lot of water with diverters (dairy and tomatoes).
- Sheep are creatures of habit – return to the same spot on the river
- Slumped river banks, sand bars are not building up like they use to (due to lack of high flushing flows)
- Re-stocking of Murray Cod and Yellow Belly for the anglers.
- Swimming at Englishes Bridge use to be great, “the river had life”
- Salinity was a real issue (water logging) in the 1980/90s, bringing about drainage plans and “Salt Mitigation Plans”
- Salinity pumps were also used to transfer off the river and shandy the poor quality (salty) water.
- 1974 was a big flood year with all the tributaries of the Campaspe River running
- In good years – over 100% allocations the area was oversupplied with farmer being encouraged to use more water.
- The No 2 Accocks outfall has not been used for a long time (used as a rubbish dump – cars, fence posts etc are still in the drain entering the river)

Current condition of the Campaspe River

- There is concern by the community that there will be no flows in the river, although they are very happy with the 5ML/day flow that has been passed since November 2009
- The Campaspe Irrigation District is returning to dryland country with many dairy farmer leaving the area
- There have been a few blackwater events, of most note was the December 2007 event and 2004 resulting in fish kills
- You can see the areas of groundwater ingress into the river, with Spiny Rush occurring on the banks. Lippia is also pretty widespread on the river banks.
- Native Wattles (Blackwood) are in good health along the river
- The water is slowed currently by the amount of timber in the river

Suggested flow regime and management to improve the Campaspe River.

- Would like to see more variable flows down the river (for both supply and the environment)
- If we have diverters off the river we could have more flows, although we would have to make sure there was enough left over for the environment.

Campaspe River Reach 4 (including Campaspe Billabong and Unnamed Creek)

Campaspe River natural/pre European settlement condition

- Started off as a "pristine" stream
- Swamps use to drain into the Campaspe
- Abundance of Platypus
- High winter/spring flows floods generally occurred in Spring

Changed Campaspe River regulation and management over time

- History of Echuca – there use to be a Brewery on the bridge at Echuca because of the good quality water sourced from the river to brew the beer.
- Never needed to take a water bottle when going down to the river, we use to just drink the river water.
- Use to catch lots of Redfin, Yellow Belly and Murray Cod
- Remember fishermen setting cross lines to catch Murray Cod. Use to catch Catfish (approximately 60 years ago). Mum use to talk about Blackfish too.
- Nasty "stuff" use to enter the river, most notable in winter due to low flows occurring in the river. During the irrigation season the flow was ok.
- Swamps were made into drains, with the most notable example being Murphy's Swamp, Ducks use to visit here in the 10,000s (good Cumbungi habitat)
- Downstream complaint system ("old arcade laws") – what you did was ok as long as your downstream neighbour did not complain.
- Some of the Campaspe West areas should never have been irrigated
- Outfalls 10-15ML/day but only for a short period in response to a rainfall event. The average would have been a couple of ML/day. However we use to under estimate how much was going into the river (previous water saving projects – e.g. rationalisation)
- In wet years the channels would run non stop with outfalls, surface water runoff and irrigation topping up the river – there were frogs everywhere which we haven't seen in ages.
- Progressive degradation of the river has occurred over time due to pumping (e.g. 25 years ago everything went black in the river (winter pasture)

Current condition of the Campaspe River

- When the freshes are sent down the river the fish go crazy and anglers can catch many fish, this year the anglers have caught Murray Cod and Yellow Belly in response to the 100Ml/day summer fresh
- Still see platypus on occasion in the river
- Since the CMA have provided flows we have seen improvement in the river
- Cane grass and phragmites are still present, although phragmites is dominating in some areas of the channel bed

Suggested flow regime and management to improve the Campaspe River.

- More flow, while it will never be "pristine" but more flow will improve the river condition (moderate)
- There should be rules in place where water can not be bought upstream of the source – all water should be sold to downstream users
- The best we can hope for is a "moderately healthy functioning river"

Appendix D: Flows method

The environmental flow recommendations provided in sections 5.1.3 and 5.2.3 outline the desired watering regime for the Campaspe River and are used as part of the calculations for mitigation water (Section 8).

The FLOWS method which has been specifically developed for determining environmental water requirements in Victoria was used to determine environmental flow requirements for the Campaspe River, including:

- Reach 3 (between the Campaspe Weir and Campaspe Siphon)
- Reach 4 (between the Campaspe Siphon and the Murray River)

The FLOWS method is based on the concept that key components of the natural flow regime influence various biological, geomorphological and physico-chemical processes in waterways. It involves the collection of information through desktop studies, field assessments and stakeholder consultation (Figure D1) (DNRE 2002).

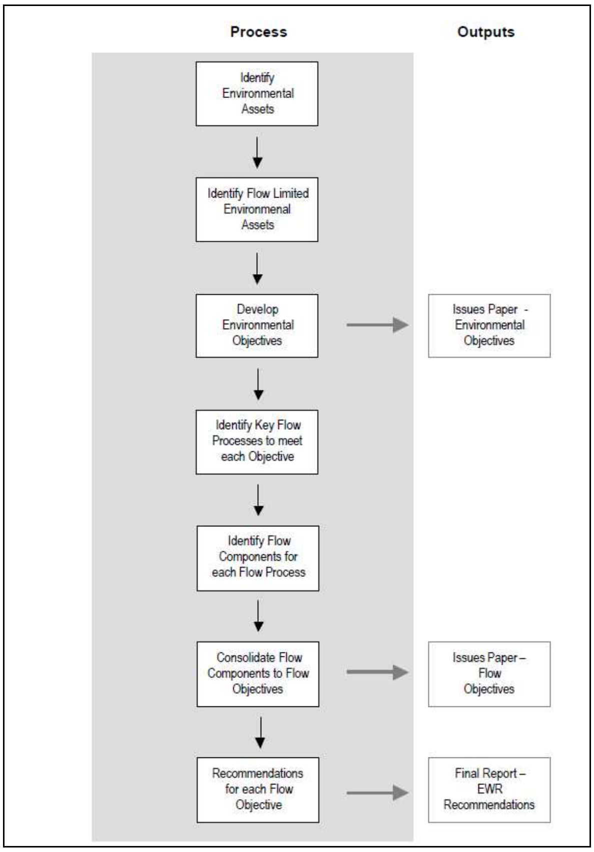


Figure D1: Outline of the process for the determination of environmental and flow objectives

The intent of an environmental flows study (FLOWS method) is to state objectives that would, if met, mean that the flow could sustain an ecologically healthy river. Therefore the objectives are developed not only to protect current conditions or environmental assets of concern, such as threatened species, but also to sustain natural communities and processes that are essential for river health (DNRE 2002). The steps below summarise the process undertaken in the FLOWS method:

Step 1: Identify current environmental assets

A list of current environmental assets (species and communities) is collated. While this list is not restricted to threatened biota it is critical that the flow recommendations do describe conditions required for their protection.

- *Particular species and communities*
    - Species: threatened aquatic invertebrates, all fish, all frogs, all aquatic reptiles, all aquatic mammals, colonial water birds, threatened water birds, threatened aquatic and riparian plants
    - Communities: Riparian Ecological Vegetation Classes, Wetlands of significance (Ramsar, DIWA, Bioregion), AusRivAS score for the aquatic invertebrate community
- *Flagship/locally significant species/communities*
- *Habitats*
    - Channel morphology (pools, benches, riffles etc.)
    - Instream habitat: large woody debris, aquatic vegetation
    - Wetlands
- *Ecological processes*
    - Linkages/connectivity
    - Geomorphic processes
    - Nutrient cycling

Step 2: Identify assets expected to be associated with a "healthy" waterway

The environmental assets that need to be reinstated or improved in order to achieve the 'ecological healthy state' are identified.

Step 3: Develop environmental objectives

From steps 1 and 2, a group of assets are selected which are flow dependent and for which there is good understanding of their flow requirements. Environmental objectives are developed for each environmental asset.

Step 4: Identify key flow related events and flow components to meet each environmental objective

For each environmental asset, the flow-related events or processes that are critical in order to meet the environmental objectives are identified. There may be a number of these for each asset. The flow related events may be to meet a biological need, such as a trigger for spawning, or to provide physical habitat, such as inundation of snags or maintenance of suitable water quality in pools. An example is provide in Table D1 below.

Table D1: Example of flow processes and components for Murray Cod

Ecological asset	Objective	Flow related events	Flow component
Murray Cod	Self sustaining populations of Murray Cod	1. Movement 2. Recruitment 3. Habitat availability in summer 4. Water quality in summer	1.High flow(winter) 2.Freshes (winter/spring) 3.Low flow (summer) 4.Freshes (summer)

Step 5: Develop flow objectives

Each flow component is described in terms of timing, frequency or duration required to meet the environmental objectives. The flow objectives must meet the requirements of the environmental objectives.

Step 6: Develop recommendations to meet each flow objective

The environmental water recommendations are developed to provide the described flow objectives (Hydraulic modelling).

Adapted from DNRE 2002

Appendix E: Flora and Fauna Species List

Compiled: September 2009
Sources:
Data Source: *Biodiversity Interactive Map*. Department of Sustainability and Environment http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim (Accessed November 2009)

DSE (2009b) Data Source: 'Threatened Fauna 100' © The State of Victoria, Department of Sustainability and Environment. Accessed: November 2009.

DSE (2009e) Data Source: 'Threatened Flora 100' © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: November 2009.

Campaspe River Reach 3 Flora and fauna species

Flora

Key
- Conservation status: v = vulnerable in Victoria; k = poorly known in Victoria.
- * = introduced

Common Name	Scientific Name	Origin	VROTS	FFG	EPBC
Annual Beard-grass	*Polypogon monspeliensis*	*			
Aster-weed	*Aster subulatus*	*			
Berry Saltbush	*Atriplex semibaccata*				
Blackwood	*Acacia melanoxylon*				
Bridal Creeper	*Asparagus asparagoides*	*			
Bristly Wallaby-grass	*Austrodanthonia setacea*				
Broad-leaf Cumbungi	*Typha orientalis*				
Broom Rush	*Juncus sarophorus*				
Buloke	*Allocasuarina luehmannii*			L	
Cat's Ear	*Hypochoeris radicata*	*			
Chicory	*Cichorium intybus*	*			
Clustered Dock	*Rumex conglomeratus*	*			
Cocksfoot	*Dactylis glomerata*	*			
Common Blown-grass	*Lachnagrostis filiformis*				
Common Peppercress	*Lepidium africanum*	*			
Common Reed	*Phragmites australis*				
Common Sow-thistle	*Sonchus oleraceus*	*			
Common Spike-sedge	*Eleocharis acuta*				
Common Tussock-grass	*Poa labillardierei*				
Common Verbena	*Verbena officinalis s.s.*	*			
Coolah Grass	*Panicum coloratum*	*			
Couch	*Cynodon dactylon var. dactylon*	*			
Crack Willow	*Salix fragilis*	*			
Creeping Knotweed	*Persicaria prostrata*				
Curled Dock	*Rumex crispus*	*			
Curly Pondweed	*Potamogeton crispus*				
Desmazeria	*Tribolium acutiflorum s.l.*	*			
Divided Sedge	*Carex divisa*	*			
Drain Flat-sedge	*Cyperus eragrostis*	*			
Eel Grass	*Vallisneria americana var. americana*				
False Brome	*Brachypodium distachyon*	*			
Fen Sedge	*Carex gaudichaudiana*				
Finger Rush	*Juncus subsecundus*				
Floating Pondweed	*Potamogeton tricarinatus s.l.*				
Grassland Wood-sorrel	*Oxalis perennans*				

Common Name	Scientific Name	Origin	VROTS	FFG	EPBC
Great Brome	*Bromus diandrus*	*			
Grey Box	*Eucalyptus microcarpa*				
Grey Tussock-grass	*Poa sieberiana*				
Hairy Willow-herb	*Epilobium hirtigerum*				
Hastate Orache	*Atriplex prostrata*	*			
Hemlock	*Conium maculatum*	*			
Hoary Cress	*Lepidium draba*	*			
Hollow Rush	*Juncus amabilis*				
Horehound	*Marrubium vulgare*	*			
Jointed Rush	*Juncus articulatus*	*			
Kangaroo Grass	*Themeda triandra*				
Lesser Joyweed	*Alternanthera denticulata s.l.*				
Lightwood	*Acacia implexa*				
Mat Grass	*Hemarthria uncinata var. uncinata*				
Medic	*Medicago spp.*	*			
Mediterranean Brome	*Bromus lanceolatus*	*			
Montpellier Broom	*Genista monspessulana*	*			
Narrow-leaf Clover	*Trifolium angustifolium var. angustifolium*	*			
Narrow-leaf Cumbungi	*Typha domingensis*				
Noogoora Burr species aggregate	*Xanthium strumarium spp. agg.*	*			
Oat	*Avena spp.*	*			
Olive	*Olea europaea*	*			
Onion Grass	*Romulea rosea*	*			
Pacific Azolla	*Azolla filiculoides*				
Panic	*Panicum spp.*				
Paspalum	*Paspalum dilatatum*	*			
Paterson's Curse	*Echium plantagineum*	*			
Pepper Tree	*Schinus molle*	*			
Perennial Rye-grass	*Lolium perenne var. perenne*	*			
Poong'ort	*Carex tereticaulis*				
Prickly Lettuce	*Lactuca serriola*	*			
Prostrate Knotweed	*Polygonum aviculare s.l.*	*			
Red Brome	*Bromus rubens*	*			
Red-leg Grass	*Bothriochloa macra*				
Ribwort	*Plantago lanceolata*	*			
River Bluebell	*Wahlenbergia fluminalis*				
River Bottlebrush	*Callistemon sieberi*				
River Red-gum	*Eucalyptus camaldulensis*				
Robust Water-milfoil	*Myriophyllum papillosum*				
Rough Spear-grass	*Austrostipa scabra subsp. falcata*				
Sea Barley-grass	*Hordeum marinum*	*			
Sharp Rush	*Juncus acutus subsp. acutus*	*			
Slender Centaury	*Centaurium tenuiflorum*	*			
Slender Dock	*Rumex brownii*				
Small Loosestrife	*Lythrum hyssopifolia*				
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*	*			
Soursob	*Oxalis pes-caprae*	*			
Spear Grass	*Austrostipa spp.*				
Spear Thistle	*Cirsium vulgare*	*			
Spurred Spear-grass	*Austrostipa gibbosa*				
Squirrel-tail Fescue	*Vulpia bromoides*	*			

Common Name	Scientific Name	Origin	VROTS	FFG	EPBC
Striped Wallaby-grass	*Austrodanthonia racemosa var. racemosa*				
Sweet Briar	*Rosa rubiginosa*	*			
Sweet Bursaria	*Bursaria spinosa*				
Tall Sedge	*Carex appressa*				
Toowoomba Canary-grass	*Phalaris aquatica*	*			
Variable Cranesbill	*Geranium sp. 2*				
Variable Sida	*Sida corrugata*				
Varied Raspwort	*Haloragis heterophylla*				
Wallaby Grass	*Austrodanthonia spp.*				
Warrego Summer-grass	*Paspalidium jubiflorum*	#			
Water Couch	*Paspalum distichum*	*			
Water Ribbons	*Triglochin procera s.l.*				
Weeping Grass	*Microlaena stipoides var. stipoides*				
Wetland Blown-grass	*Lachnagrostis filiformis var. 2*		k		
Wild Oat	*Avena fatua*	*			
Willow	*Salix spp.*	*			
Wimmera Rye-grass	*Lolium rigidum*	*			
Windmill Grass	*Chloris truncata*				
Wingless Bluebush	*Maireana enchylaenoides*				
Wood Sorrel	*Oxalis spp. (naturalised)*	*			
Yorkshire Fog	*Holcus lanatus*	*			

Fauna

Key
- Conservation status: CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data deficient; L = listed under the *Flora and Fauna Guarantee Act 1988;* J/C/R/B = listed under JAMBA, CAMBA, ROKAMBA, &/or Bonn.
- * = introduced

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Fish					
Australian Smelt	*Retropinna semoni*				
Carp Gudgeon	*Hypseleotris compressa*				
Common Carp	*Cyprinus carpio*	*			
Flat-headed Gudgeon	*Philypnodon grandiceps*				
Gambusia	*Gambusia holbrooki*	*			
Golden Perch	*Macquaria ambigua*			VU	
Goldfish	*Carassius auratus*	*			
Murray Cod	*Maccullochella peelii peelii*		VU	e	L
Redfin	*Perca fluviatilis*	*			
Western Carp Gudgeon	*Hypseleotris klunzingeri*				
Amphibians/reptiles					
Common Froglet	*Crinia signifera*				
Turtle					
Mammals					
Platypus	*Ornithorhynchus anatinus*				
European Hare	*Lepus europeaus*	*			

Common Name	Scientific Name	Origin	International Agreements	EPBC	VROTS	FFG
Birds						
Australian Magpie	*Gymnorhina tibicen*					
Australian Raven	*Corvus coronoides*					
Australian Wood Duck	*Chenonetta jubata*					
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*					
Blue-faced Honeyeater	*Entomyzon cyanotis*					
Brown Goshawk	*Accipiter fasciatus*					
Brown Treecreeper	*Climacteris picumnus*				NT	
Cockatiel	*Nymphicus hollandicus*					
Common Blackbird	*Turdus merula*	*				
Common Starling	*Sturnus vulgaris*	*				
Crested Pigeon	*Ocyphaps lophotes*					
Diamond Firetail	Stagonopleura guttata				v	L
Dusky Moorhen	*Gallinula tenebrosa*					
Dusky Woodswallow	*Artamus cyanopterus*					
Eastern Rosella	*Platycercus eximius*					
Galah	*Cacatua roseicapilla*					
Grey Shrike-thrush	*Colluricincla harmonica*					
Hooded Robin	Melanodryas cucullata cucullata				nt	L
Laughing Kookaburra	*Dacelo novaeguineae*					
Little Friarbird	*Philemon citreogularis*					
Long-billed Corella	*Cacatua tenuirostris*					
Magpie-lark	*Grallina cyanoleuca*					
Musk Lorikeet	*Glossopsitta concinna*					
Noisy Miner	*Manorina melanocephala*					
Olive-backed Oriole	*Oriolus sagittatus*					
Pacific Black Duck	*Anas superciliosa*					
Peaceful Dove	*Geopelia striata*					
Pied Currawong	*Strepera graculina*					
Rainbow Bee-eater	*Merops ornatus*					
Red Wattlebird	*Anthochaera carunculata*					
Red-rumped Parrot	*Psephotus haematonotus*					
Sacred Kingfisher	*Todiramphus sanctus*					
Spotted Turtle-Dove	*Streptopelia chinensis*	*				
Striated Pardalote	*Pardalotus striatus*					
Sulphur-crested Cockatoo	*Cacatua galerita*					
Welcome Swallow	*Hirundo neoxena*					
Whistling Kite	*Haliastur sphenurus*					
White-plumed Honeyeater	*Lichenostomus penicillatus*					
Willie Wagtail	*Rhipidura leucophrys*					

Campaspe River Reach 4 Flora and fauna species

Flora

Key
- Conservation status: v = vulnerable in Victoria; k = poorly known in Victoria.
- * = introduced

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Annual Beard-grass	*Polypogon monspeliensis*	*			
Annual Veldt-grass	*Ehrharta longiflora*	*			
Australian Sweet-grass	*Glyceria australis*				
Bent/Blown Grass	*Agrostis s.l. spp.*				
Berry Saltbush	*Atriplex semibaccata*				
Black Nightshade	*Solanum nigrum sensu Willis (1972)*	*			
Blackwood	*Acacia melanoxylon*				
Bluebell	*Wahlenbergia spp.*				
Bristly Wallaby-grass	*Austrodanthonia setacea*				
Brome	*Bromus spp.*				
Burr Daisy	*Calotis spp.*				
Cape Weed	*Arctotheca calendula*	*			
Cat's Ear	*Hypochoeris radicata*	*			
Common Peppercress	*Lepidium africanum*	*			
Common Reed	*Phragmites australis*				
Common Sow-thistle	*Sonchus oleraceus*	*			
Common Tussock-grass	*Poa labillardierei*				
Cotton Fireweed	*Senecio quadridentatus*				
Couch	*Cynodon dactylon var. dactylon*	*			
Creeping Knapweed	*Acroptilon repens*	*			
Creeping Knotweed	*Persicaria prostrata*				
Desmazeria	*Tribolium acutiflorum s.l.*	*			
Divided Sedge	*Carex divisa*	*			
False Brome	*Brachypodium distachyon*	*			
Fog-fruit	*Phyla canescens*	*			
Grassland Wood-sorrel	*Oxalis perennans*				
Great Brome	*Bromus diandrus*	*			
Hogweed	*Polygonum spp.*				
Hollow Rush	*Juncus amabilis*				
Horehound	*Marrubium vulgare*	*			
Jersey Cudweed	*Pseudognaphalium luteoalbum*				
Joyweed	*Alternanthera spp.*				
Kangaroo Grass	*Themeda triandra*				
Knotted Barley-grass	*Hordeum secalinum*	*			
Lightwood	*Acacia implexa*				
Mallow	*Malva spp.*	*			
Mat Grass	*Hemarthria uncinata*				
Medic	*Medicago spp.*	*			
Mediterranean Brome	*Bromus lanceolatus*	*			
Narrow-leaf Cumbungi	*Typha domingensis*				
Onion Grass	*Romulea rosea*	*			
Ox-tongue	*Helminthotheca echioides*	*			
Pale Flax-lily	*Dianella sp. aff. longifolia* (Riverina)				v

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Panic	*Panicum spp.*				
Panic Veldt-grass	*Ehrharta erecta*	*			
Paspalum	*Paspalum dilatatum*	*			
Paterson's Curse	*Echium plantagineum*	*			
Perennial Rye-grass	*Lolium perenne var. perenne*	*			
Prairie Grass	*Bromus catharticus*	*			
Prickly Lettuce	*Lactuca serriola*	*			
Prostrate Knotweed	*Polygonum aviculare s.l.*				
Raspwort	*Haloragis spp.*				
Red Brome	*Bromus rubens*	*			
Red-leg Grass	*Bothriochloa macra*				
Ribwort	*Plantago lanceolata*	*			
River Bottlebrush	*Callistemon sieberi*				
River Red-gum	*Eucalyptus camaldulensis*				
Rough Spear-grass	*Austrostipa scabra subsp. falcata*				
Rush	*Juncus spp.*				
Sea Barley-grass	*Hordeum marinum*	*			
Slender Dock	*Rumex brownii*				
Small Loosestrife	*Lythrum hyssopifolia*				
Soft Brome	*Bromus hordeaceus*	*			
Soursob	*Oxalis pes-caprae*	*			
Sow Thistle	*Sonchus spp.*				
Spear Thistle	*Cirsium vulgare*	*			
Sprawling Bluebell	*Wahlenbergia gracilis*				
Spurrred Spear-grass	*Austrostipa gibbosa*				
Squirrel-tail Fescue	*Vulpia bromoides*	*			
Stiped Wallaby-grass	*Austrodanthonia racemosa*				
Stonewort	*Chamaesyce spp.*	*			
Swamp Club-sedge	*Isolepis inundata*				
Tall Fireweed	*Senecio runcinifolius*				
Thistle	*Carduus pycnocephalus*	*			
Toowoomba Canary-grass	*Phalaris aquatica*	*			
Tussock Grass	*Poa spp.*				
Variable Sida	*Sida corrugata*				
Verbena	*Verbena spp.*	*			
Warrego Summer-grass	*Paspalidium jubiflorum*				
Water Couch	*Paspalum distichum*	*			
Weeping Grass	*Microlaena stipoides var. stipoides*				
Wetland Blown-grass	*Lachnagrostis filiformis var.2*				k
Wild Oat	*Avena fatua*	*			
Wimmera Rye-grass	*Lolium rigidum*	*			
Wingless Bluebush	*Maireana enchylaenoides*				
Wood Sorrel	*Oxalis spp.*				

Fauna

Key
- Conservation status: CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data deficient; L = listed under the *Flora and Fauna Guarantee Act 1988;* J/C/R/B = listed under JAMBA, CAMBA, ROKAMBA, &/or Bonn.
- * = introduced

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Fish					
Australian Smelt	*Retropinna semoni*				
Bony Bream	*Nematalosa erebi*				
Bony Herring	*Nematalosa erebi*				
Carp Gudgeon	*Hypseleotris sp.*				
Common Carp	*Cyprinus carpio*	*			
Flat-headed Gudgeon	*Philypnodon grandiceps*				
Gambusia	*Gambusia holbrooki*	*			
Golden Perch	*Macquaria ambigua*				VU
Goldfish	*Carassius auratus*	*			
Murray Cod	*Maccullochella peellii peellii*		VU	L	EN
Redfin	*Perca fluviatilis*	*			
Silver Perch	*Bidyanus bidyanus*			L	CR
Trout Cod	*Maccullochella macquariensis*		EN	L	CR
Western Carp Gudgeon	*Hypseleotris klunzingeri*				
Mammals					
Platypus	*Ornithorhynchus anatinus*				
Squirrel Glider	*Petaurus norfolcensis*			L	EN

Common Name	Scientific Name	Origin	International Agreements	EPBC	VROTS	FFG
Birds						
Australian Magpie	*Gymnorhina tibicen*					
Australian Raven	*Corvus coronoides*					
Australian Wood Duck	*Chenonetta jubata*					
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*					
Brown Treecreeper	*Climacteris picumnus*				NT	
Common Blackbird	*Turdus merula*	*				
Common Starling	*Sturnus vulgaris*	*				
Crimson Rosella	*Platycercus elegans*					
Dusky Woodswallow	*Artamus cyanopterus*					
Eastern Rosella	*Platycercus eximius*					
Galah	*Cacatua roseicapilla*					
Great Cormorant	*Phalacrocorax carbo*					
Grey Shrike-thrush	*Colluricincla harmonica*					
House Sparrow	*Passer domesticus*	*				
Laughing Kookaburra	*Dacelo novaeguineae*					
Little Corella	*Cacatua sanguinea*					
Little Pied Cormorant	*Phalacrocorax melanoleucos*					
Little Raven	*Corvus mellori*					
Long-billed Corella	*Cacatua tenuirostris*					
Magpie-lark	*Grallina cyanoleuca*					
Noisy Miner	*Manorina melanocephala*					
Pacific Black Duck	*Anas superciliosa*					
Pied Currawong	*Strepera graculina*					
Rock Dove	*Columba livia*	*				

Common Name	Scientific Name	Origin	International Agreements	EPBC	VROTS	FFG
Rufous Whistler	*Pachycephala rufiventris*					
Striated Pardalote	*Pardalotus striatus*					
Striated Thornbill	*Acanthiza lineata*					
Sulphur-crested Cockatoo	*Cacatua galerita*					
Superb Fairy-wren	*Malurus cyaneus*					
Welcome Swallow	*Hirundo neoxena*					
White-plumed Honeyeater	*Lichenostomus penicillatus*					
White-throated Treecreeper	*Cormobates leucophaeus*					
Willie Wagtail	*Rhipidura leucophrys*					
Yellow Thornbill	*Acanthiza nana*					
Yellow-billed Spoonbill	*Platalea flavipes*					

Campaspe Billabong Flora species

Scientific Name	Common Name	Origin	EPBC	FFG	DSE
Alisma sp.	Water Plantain				
Alternanthera denticulata	Lesser Joyweed				
Alternanthera sp. 1	Plains Joyweed				
Amphibromus sp.	Swamp Wallaby-grass				
Anthoxanthum odoratum	Sweet Vernal-grass	*			
Arctotheca calendula	Cape Weed	*			
Aster subulatus	Aster-weed	*			
Austrodanthonia setacea s.l.	Bristly Wallaby-grass				
Austrodanthonia spp.	Wallaby Grass				
Austrostipa gibbosa	Spurred Spear-grass				
Austrostipa scabra ssp. falcata	Rough Spear-grass				
Avena sp.	Oat	*			
Bromus diandrus	Great Brome	*			
Bromus hordeaceus	Soft Brome	*			
Bromus rubens	Red Brome	*			
Carex tereticaulis	Poong'ort				
Centipeda cunningamii	Common Sneezeweed				
Chamaesyce drummondii	Flat Spurge				
Chenopodium murale	Sowbane	*			
Cirsium vulgare	Spear Thistle	*			
Convolvulus remotus	Grassy Bindweed				
Cyperus eragrostis	Drain Flat-sedge	*			
Echium plantagineum	Paterson's Curse	*			
Epilobium hirtigerum	Hairy Willow-herb				
Epilobium sp.	Willow Herb				
Eucalyptus camaldulensis	River Red-gum				
Eucalyptus largiflorens	Black Box				
Helichrysum luteoalbum	Jersey Cudweed				
Helminthotheca echioides	Ox-tongue	*			
Hordeum sp.	Barley Grass	*			
Hypochoeris radicata	Cat's Ear	*			

Scientific Name	Common Name	Origin	EPBC	FFG	DSE
Juncus sp.	Rush				
(#224) Juncus sp.	Rush				
(#228) Juncus sp.	Rush				
(#239) Juncus sp.	Rush				
(#244) Juncus sp.	Rush				
Lachnagrostis filiformis var.1	Common Blown-grass				
Lactuca serriola	Prickly Lettuce	*			
Lolium perenne	Perennial Rye-grass	*			
Ludwigia peploides ssp. montevidensis	Clove-strip				
Lythrum hyssopifolia	Small Loosestrife				
Maireana humilima	Dwarf Bluebush				
Malva parviflora	Small-flower Mallow	*			
Marrubium vulgare	Horehound	*			
Medicago minima	Little Medic	*			
Medicago sp.	Medic	*			
Muehlenbeckia florulenta	Tangled Lignum				
Myriophyllum sp.	Water-milfoil				
Myriophyllum verrucosum	Red Water-milfoil				
Oxalis sp.	Wood Sorrel				
Persicaria decipiens	Slender Knotweed				
Persicaria subsessilis	Hairy Knotweed				
Phalaris paradoxa	Paradoxical Canary-grass	*			
Plantago lanceolata	Ribwort	*			
Polygonum aviculare	Hogweed	*			
Polygonum sp.	Knotweed				
Ranunculus scleratus ssp. scleratus	Celery Buttercup	*			
Rhodanthe corymbiflora	Paper Sunray				
Romulea sp.	Onion Grass	*			
Rosa rubiginosa	Sweet Briar	*			
Rumex brownii	Slender Dock				
Rumex sp.	Dock				
Salvia verbenaca s.l.	Wild Sage	*			
Schinus mollee	Pepper Tree	*			
Senecio quadridentatus	Cotton Fireweed				
Sida sp.	Sida				
Silybum marianum	Variegated Thistle	*			
Sisymbrium irio	London Rocket	*			
Solanum nigrum	Black Nightshade	*			
Sonchus asper s.l.	Rough Sow-thistle	*			
Sonchus oleraceus	Common Sow-thistle	*			
Trifolium fragiferum	Strawberry Clover	*			
Trifolium sp.	Clover	*			
Trifolium tomentosum var. tomentosum	Woolly Clover	*			

Scientific Name	Common Name	Origin	EPBC	FFG	DSE
Triglochin procera	Water Ribbons				
Typha sp.	Cumbungi				
Unknown mudwort					
(#404) Unknown pea					
Urticia incisa	Scrub Nettle				
Vittadinia sp.	New Holland Daisy				
Vulpia sp.	Fescue	*			
Wahlenbergia communis	Tufted Bluebell				
Walwhalleya subxerophila	Gilgai Grass				

Unnamed Creek Flora species

Scientific Name	Common Name	Origin	EPBC	FFG	DSE
Alisma lanceolatum	Water Plantain	*			
Asperula conferta	Common Woodruff				
Atriplex sp.	Saltbush				
Austrodanthonia setacea s.l.	Bristly Wallaby-grass				
Austrostipa gibbosa	Spurred Spear-grass				
Avena sp.	Oat	*			
Bromus diandrus	Great Brome	*			
Carex tereticaulis	Poong'ort				
Cirsium vulgare	Spear Thistle	*			
Convolulus remotus	Grassy Bindweed				
Dactylis gomerata	Cocksfoot	*			
Echium plantagineum	Paterson's Curse	*			
Epilobium hirtigerum	Hairy Willow-herb				
Eucalyptus camaldulensis	River Red-gum				
Helminthotheca echioides	Ox-tongue	*			
Juncus sp.	Rush				
Lachnagrostis filiformis var.1	Common Blown-grass				
Lactuca serriola	Prickly Lettuce	*			
Lobelia sp.	Lobelia				
Lolium perenne	Perennial Rye-grass	*			
Marsilea drummondii	Common Nardoo				
Medicago minima	Little Medic	*			
Moraea setifolia	Thread Iris	*			
Muehlenbeckia florulenta	Tangled Lignum				
Oxalis sp.	Wood Sorrel				
Paspalum dilatatum	Paspalum	*			
Paspalum distichum	Water Couch	#			
Persicaria hydropiper	Water Pepper				
Plantago lanceolata	Ribwort	*			
Pycnosorus globosus	Drumsticks	#			
Ranunculus scleratus ssp. scleratus	Celery Buttercup	*			
Romulea sp.	Onion Grass	*			

Scientific Name	Common Name	Origin	EPBC	FFG	DSE
Rumex sp.	Dock				
Sida sp.	Sida				
Sonchus sp.	Sow thistle	*			
Teucrium racemosum	Grey Germander				
Trifolium arvense	Hare's-foot Clover	*			
Typha sp.	Cumbungi				
Lachnagrostis filiformis var.1	Common Blown-grass				
Lactuca serriola	Prickly Lettuce	*			
Lobelia sp.	Lobelia				
Lolium perenne	Perennial Rye-grass	*			
Marsilea drummondii	Common Nardoo				
Medicago minima	Little Medic	*			
Moraea setifolia	Thread Iris	*			
Muehlenbeckia florulenta	Tangled Lignum				
Oxalis sp.	Wood Sorrel				
Paspalum dilatatum	Paspalum	*			
Paspalum distichum	Water Couch	#			
Persicaria hydropiper	Water Pepper				
Plantago lanceolata	Ribwort	*			
Pycnosorus globosus	Drumsticks	#			
Ranunculus scleratus ssp. scleratus	Celery Buttercup	*			
Romulea sp.	Onion Grass	*			
Rumex sp.	Dock				
Sida sp.	Sida				
Sonchus sp.	Sow thistle	*			
Teucrium racemosum	Grey Germander				
Trifolium arvense	Hare's-foot Clover	*			
Typha sp.	Cumbungi				

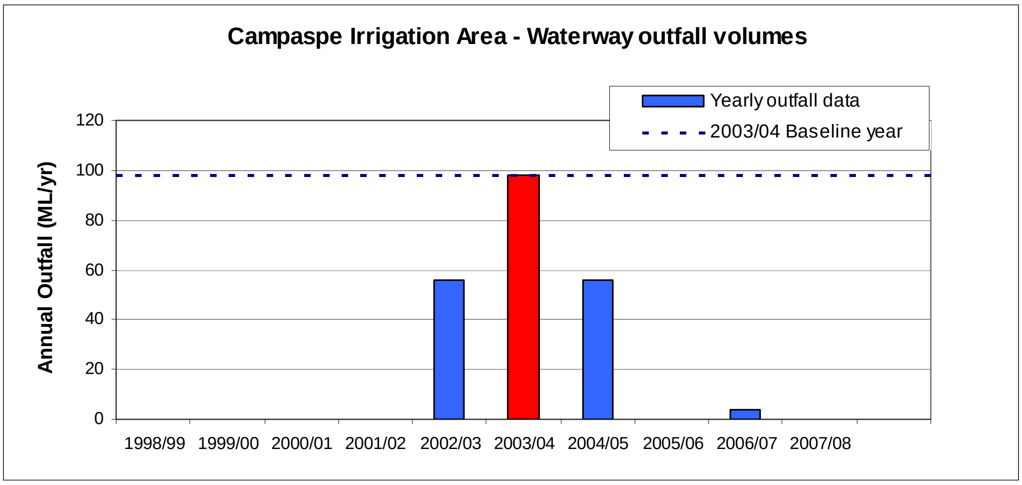
Appendix F: Outfall Assessments

F1 Waterway outfall volumes

Irrigation Area	Asset Code	Channel	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
CID	ST032729	No 1					56	92	56		4		0
CID	ST032783	No 2 Accocks					0	0	0		0		0
Totals (ML)							**56**	**98**	**56**		**4**		**0**
RID	ST051358	Channel 12	0	0	0	0	0	0	0	0	0	0	3
RID	ST065860	Channel 1/14	0	41	0	375	351	365	204	104	42	18	23
RID	ST033111	Channel 2/11					42	100	91		18		24
RID	ST033384	Channel 1/3/14	0	39	83	81	10	4	13	96	19	28.2	18
RID	ST033397	Channel 2/1/3/14	1	50	42	34	43	41	60	64	8	8	6
RID	ST033425	Channel 1/4/3/14					68	40	62		25		3
RID	ST033461	Channel 5/3/14	397	219	459	380	187	229	213	88	41	3.7	9
Totals (ML)			**398**	**349**	**584**	**870**	**701**	**773**	**643**	**352**	**153**	**57.9**	**86**

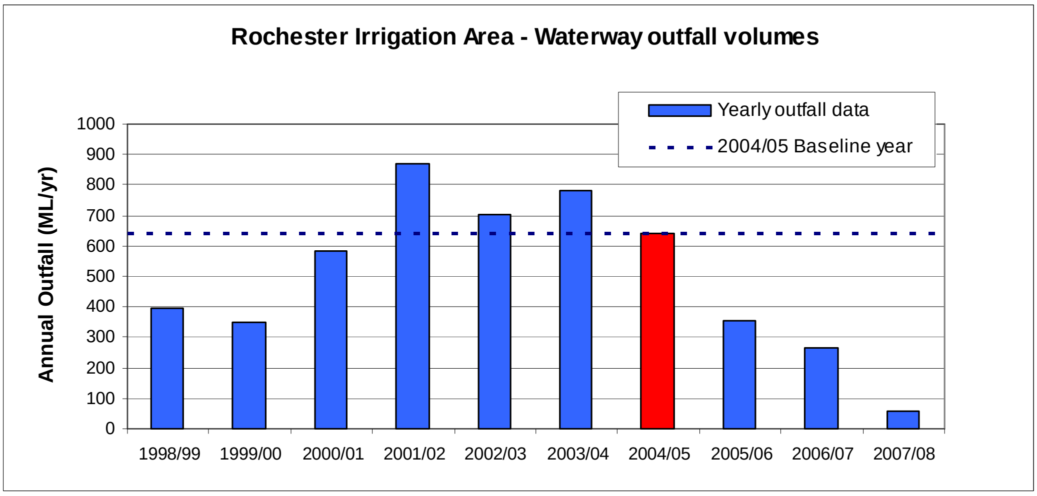
Recorded outfall volumes

The total outfall volumes for Reach 3 and 4 are illustrated in Figure E1 and E2 below.



FigureF1: Outfall volumes for the Campaspe River Reach 3 (Campaspe Irrigation Area)

For the 2003/04[11] baseline year the total outfall volume for Reach 3 was 98 ML.



FigureF2: Outfall volumes for the Campaspe River Reach 4 (Rochester Irrigation Area)

For the 2004/05 baseline year the total outfall volume for Reach 4 was 643 ML.

[11] The baseline year for Reach 3 outfalls (Campaspe Irrigation District) is 2003/04.

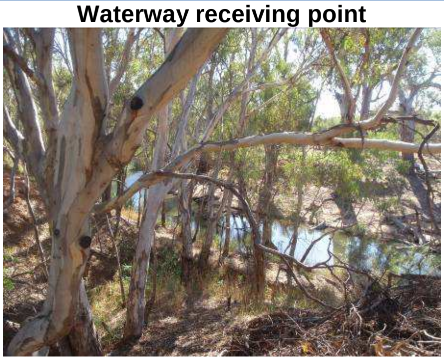
F2 Waterway outfall site descriptions

Please Note: the overall refuge rating at each outfall site (waterway receiving point) is based on the ability for the site to sustain populations of water-dependent flora and fauna at the time of field assessment. The following table broadly describes the qualitative criteria used for this rating:

Rating	Drought refuge characteristics
Excellent	Diverse habitat types in excellent condition - Large, deep pool and/or riffle habitat of varying depths - Presence of submerged (10-30% of substrate covered) and emergent aquatic vegetation (15-30% of channel margins) - Large woody debris, undercut banks, heterogeneous substrate - Excellent water quality (compliance with SEPP (WoV)) - Good connection (i.e. no barriers) with other habitat close-by - Established riparian zone that provides shading (>20% of channel) - No stock access
Good	Diverse habitat types in good condition - Deep pool and/or riffle habitat of varying depths - Presence of submerged (5-10% of substrate covered) and emergent aquatic vegetation (5-15% of channel margins) - Large woody debris, undercut banks, heterogeneous substrate - Good water quality (rare exceedance of SEPP (WoV)) - Good connection (i.e. no barriers) with other habitat close-by - Established riparian zone that provides shading (5-20% of channel) - No stock access
Moderate	Suitable habitat in moderate condition - Deep pool or riffle habitat - Limited submerged (<5% of substrate covered) and emergent aquatic vegetation (<5% of channel margins) - Large woody debris or undercut banks - Moderate water quality (occasionally exceeds SEPP (WoV)) - Limited connection (i.e. only during high flows) with other habitat nearby - Sparse riparian zone with limited shading (0-5% of channel) - Limited stock access
Poor	Limited habitat diversity in poor condition - Shallow, homogenous channel - Minimal aquatic vegetation, large woody debris and/or undercut banks - Poor water quality (frequently exceeds SEPP (WoV)) - Unconnected to other habitats nearby - Sparse riparian zone - Stock access
Very Poor	No habitat diversity and in poor condition - Shallow, homogenous channel (e.g. heavily silted) - No habitat features, e.g. aquatic vegetation, large woody debris - Very poor water quality (i.e. high turbidity, high EC, low DO) - Isolated from other potential habitats - No riparian zone - Stock access

(Source: SKM 2009)

CAMPASPE IRRIGATION AREA - 2nd March 2010		WGS1984 Zone55	
Receiving Waterway : Campaspe River		**Irrigation Outfall : No 2 Accocks (ST032783)**	
Easting	0293176	**Northing**	5969391
Measured Outfall Point		**Waterway receiving point**	



Description	Off the Campaspe No. 2 main channel to a drain, then to the river (less than 1 km of drain). The drain is filled with rubbish (car parts, fences and old water tanks).

Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	~1-2m	Undercut banks	Yes
Width	30m	Large woody debris	Moderate
Velocity	<0.05m/s	Aquatic vegetation	Cumbungi, Phragmites and Spiny Rush
Riparian Zone	Continuous RRGs and perennial grasses	Rating	Very Good
Stock access	No, Crown Reserve	2003-04 Outfall Volume	98 ML

Receiving Waterway : Campaspe River		**Irrigation Outfall : No 1 (ST032729)**	
Easting	0294319	**Northing**	5971326
Measured Outfall Point		**Waterway receiving point**	

Description	Just south of Rochester. Off the bottom of the No. 1/1 channel to drain 7 then to the river (~1.5 km of drain)

Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	~1-2m	Undercut banks	Yes
Width	30m	Large woody debris	Moderate
Velocity	<0.05m/s	Aquatic vegetation	Cumbungi, Phragmites
Riparian Zone	Continuous RRGs and perennial grasses	Rating	Very Good
Stock access	No evidence	2003-04 Outfall Volume	0 ML

ROCHESTER IRRIGATION AREA – 28th October 2009		WGS1984 Zone55	
Receiving Waterway : Campaspe River		**Irrigation Outfall : No 12 (ST051358)**	
Easting	0292683	**Northing**	5979065
Measured Outfall Point		**Waterway receiving point**	
			
Description	The No. 12 channel is located approximately four kilometres downstream of the Campaspe Siphon on the outskirts of Rochester. The outfall directly enters the Campaspe River (McColl Road)		
Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<4m	Undercut banks	Present
Width	<20m	Large woody debris	Moderate
Velocity	<0.5m/s	Aquatic vegetation	Phragmites
Riparian Zone	~5m RRG and grasses	Rating	Good
Stock access	No	2004-05 Outfall Volume	0 ML
Receiving Waterway : Campaspe River (Billabong)		**Irrigation Outfall : No 1/14 (ST065860)**	
Easting	0295888	**Northing**	5988672
Measured Outfall Point		**Waterway receiving point**	
			
Description	The No. 1/14 channel outfall is located at the intersection of the Northern Highway and Winfield Road approximately 13 km south of Echuca and outfalls to a billabong of the Campaspe River. The No. 1/14 outfall is approximately 11 km upstream of where the billabong re-enters the Campaspe River. This section of the anabranch is also used as a reuse/recycle system by the adjacent landholder. Outfall from the No. 1/14 to a Billabong on the Campaspe anabranch. ~1.5 km of drain, then ~ 7 or 8km of anabranch (does not flow under normal conditions)		
Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<1m	Undercut banks	Present
Width	<15m	Large woody debris	Moderate
Velocity	No flow	Aquatic vegetation	Extensive aquatic vegetation around the outfall pipe, Typha, abundant weeds (mostly annuals)
Riparian Zone	Sparse RRG and understory grasses	Rating	Moderate
Stock access	Yes	2004-05 Outfall Volume	204 ML

Receiving Waterway : Campaspe River (Unnamed Creek)		Irrigation Outfall : No 2/11 (ST033111)	
Easting	0300175	**Northing**	5990801

Measured Outfall Point

Waterway receiving point

Description	The No. 2/11 channel outfall is located on the Echuca-Nanneela Road and outfalls into Rochester Drain 4 which flows for 2.9 km before entering an unnamed creek (currently dry). The creek meanders for a further 2.6 km before entering the Campaspe River. The total distance between the 2/11 outfall and the Campaspe River is approximately 5.5 km.

Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<1m	Undercut banks	Absent
Width	<15m	Large woody debris	Minor
Velocity	No flow (creek dry)	Aquatic vegetation	The base of the creekline has patches of senescing *Typha* beds
Riparian Zone	Lignum and young RRG	Rating	Poor
Stock access	Yes (and residential)	2004-05 Outfall Volume	91 ML

Receiving Waterway : Campaspe River (Billabong)		Irrigation Outfall : No 1/3/14 (ST033384)	
Easting	0296202	**Northing**	5994414

Measured Outfall Point

1

Waterway receiving point

Description	The No. 1/3/14 channel outfall is located south of Matheson Road near Echuca and outfalls to an anabranch (Cahir's Billabong) of the Campaspe River. The No. 1/3/14 outfall is approximately 0.7 km upstream of where the anabranch re-enters the Campaspe River. This section of the anabranch is also used as a reuse/recycle system by the adjacent landholder who also holds an 89 ML/yr drainage diversion licence to extract water from the anabranch. Outfall from the No. 1/2/14 channel to the billabong on the Campaspe anabranch (via a short drain ~ 100 m)

Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<1m	Undercut banks	Absent
Width	<15m	Large woody debris	There are a lot of dead stags in the permanently inundated zone that have drowned.
Velocity	No flow	Aquatic vegetation	No aquatic vegetation in the inundated zone
Riparian Zone	Lignum and young RRG	Rating	Poor
Stock access	Yes (and residential)	2004-05 Outfall Volume	13 ML

Receiving Waterway : Campaspe River		Irrigation Outfall : No 2/1/3/4 (ST033397)	
Easting	0295986	**Northing**	5996057
Measured Outfall Point		**Waterway receiving point**	
			
Description	The No. 2/1/3/14 channel outfall is located adjacent to the Northern Highway on the outskirts of Echuca and outfalls to Rochester Drain 1A/2 (measurement site) which in turn outfalls to Rochester Drain 2 at the Northern Highway before it outfalls into the Campaspe River (a total length of approx 1.5 km). Outfall from the No. 2/1/3/14 channel to a short drain and then a short creek (~ 0.5 km) before flowing into the Campaspe		
Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<4m	Undercut banks	Present
Width	<20m	Large woody debris	Moderate
Velocity	<0.5m/s	Aquatic vegetation	Phragmites and Typha
Riparian Zone	~5m RRG and grasses	Rating	Good
Stock access	No	2004-05 Outfall Volume	60 ML

Receiving Waterway : Campaspe River		Irrigation Outfall : No 1/4/3/14 (ST033425)	
Easting	0293150	**Northing**	5995981
Measured Outfall Point		**Waterway receiving point**	
			
Description	The No. 1/4/3/14 channel outfall is located near Crumpler Road on the outskirts of Echuca. It outfalls into Rochester Drain 2 which flows for approximately 3 km before it enters the Campaspe River (the same site as channel outfall 2/1/3/14 – Refer to Section 6 in the Campaspe River Interim EWP). Figure A5 below illustrates the outfall site and its proximity to the Campaspe River. According to G-MW there are currently no licensed drainage diverters downstream of the No. 1/4/1/14 channel outfall.		
Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<4m	Undercut banks	Present
Width	<20m	Large woody debris	Moderate
Velocity	<0.5m/s	Aquatic vegetation	Phragmites
Riparian Zone	~5m RRG and grasses	Rating	Good
Stock access	No	2004-05 Outfall Volume	62 ML

Receiving Waterway : Campaspe River		**Irrigation Outfall : No 5/3/14 (ST033461)**	
Easting	0294127	**Northing**	5999288

Measured Outfall Point	**Waterway receiving point**
	

Description	The No. 5/3/14 channel outfall is located on the Mount Terrick Road on the outskirts of Echuca. It outfalls into Rochester Drain 1 which flows for approximately 1.2 km to Wharparilla Reserve and then flows for a further 1.9 km before it enters the Campaspe River (a total distance of approximately 3.1 km).

Waterway Characteristics at outfall site		**Refuge Rating (Key Water dependent values):**	
Depth	<4m	Undercut banks	Present
Width	<20m	Large woody debris	Moderate
Velocity	<0.5m/s	Aquatic vegetation	Phragmites and Typha
Riparian Zone	~5m RRG and grasses	Rating	Good
Stock access	No	2004-05 Outfall Volume	213 ML

Appendix G: Technical Reference Group Review

File Note

Date	17 March 2010
Project No	VW04984
Subject	**Technical Reference Group review of draft Campaspe River Long-term Environmental Watering Plan**

1. Introduction

The North Central Catchment Management Authority (NCCMA) engaged SKM to assemble a Technical Reference Group (TRG) to review the draft Campaspe River Environmental Watering Plan (EWP), which the NCCMA prepared for the Northern Victorian Irrigation Renewal Project (NVIRP). The EWP is only concerned with the effect that an 85% reduction in irrigation channel outfalls will have on the environmental values of the Campaspe downstream of Campaspe Weir. The EWP aims to identify the current environmental condition, establish environmental objectives and recommend broad water regimes that will protect/enhance the environmental values in the Campaspe River.

The TRG comprised scientists and engineers with experience in water quality, aquatic ecology, riparian and wetland ecology and hydrology in the Loddon River and Campaspe River. The purpose of the review is to determine whether the EWP has sufficient scientific rigour and to provide advice on how information gaps, omissions or errors can be addressed. TRG members individually reviewed the draft EWP and discussed relevant issues at a workshop, which was held at SKM on 15th March. The outcome of the TRG reviews and workshop are discussed below.

Table 1-1: Composition of the Technical Reference Group.

TRG member and affiliation	Relevant area of experience
Kate Austin (SKM)	Hydrology
Paul Boon (Dodo Environmental)	Riparian and wetland ecology and water quality
John McGuckin (Streamline Research)	Fish ecology and water quality
Andrew Sharpe (SKM)	Environmental flows, aquatic ecology and water quality

2. General structure and comments

The Draft Campaspe River Long-term Environmental Watering Plan has a clear structure that is logical and easy to follow. For the most part it is also well written. The individual assessment for each outfall is particularly good because it ensures that localised benefits or impacts associated with channel outfalls are not missed. Specific comments are provided below under theme headings.

Separating the influence of channel outfalls from other flow related factors.

Assessing the likely impact of outfall reductions on a river system is problematic because many factors influence the amount of flow at any given time. It is also very difficult to determine whether the supply of mitigation water is effective. The best that the EWP can do is to assess the relative contribution that outfalls make to flow at any given time and ask whether an 85% reduction in the estimated contribution is likely to make it more likely or less likely that the environmental watering objectives for the waterway are being met. If a reduction in channel outfalls is considered to represent an environmental risk and mitigation water is required then the most appropriate form of monitoring should focus on whether the mitigation water is delivered where and when recommended. It is unlikely that any biological monitoring program will be able to demonstrate the effectiveness of delivering mitigation water. It would be useful for the EWP to discuss this point at the start of Section 7.

Estimating the contribution of channel outfalls

It is important to understand how channel outfalls vary over time in order to fully assess the impact that reduced outfalls are likely to have on environmental values. The EWP reports monthly contributions from channel outfalls and also highlights annual variations since 1998/99 (see Figures 5 and 6). While useful, these statistics do not indicate what is happening over much shorter timescales. Channel outfalls only represent a small proportion of the total flow in the Campaspe River, but if most of the outfall volumes are delivered over a short period of time then they may significantly contribute to a particular flow event (e.g. a summer fresh) or at least increase flow variability.

The EWP would benefit from an analysis to determine the range of daily outfall contributions (i.e. the expected maximum daily outfall volume), some estimate of errors associated with these estimates and a discussion about when specific outfall events are likely to occur. The TRG understand that daily data are not available, however an analysis of weekly data including statistics on weekly maximum and minimum contributions will be more useful than the monthly data that have been used. The analysis should also consider how the range of weekly outfalls vary between wet years and dry years and investigate the extent to which they are likely to contribute to river flows in different years. One approach may be to super-impose the environmental flow recommendations on a modelled flow series to determine the extent to which, and how often, channel outfalls contribute to meeting these recommendations.

The TRG considered that outfall events in the Campaspe River would be most likely driven by demand rather than weather patterns (e.g. rainfall rejection). However, that assumption needs to be tested and the outcome discussed. If outfalls are demand driven, then it should be relatively simple to use weekly demand to estimate the timing and magnitude of outfalls at different locations.

Description and definition of environmental values

The EWP focuses on biota of high conservation significance, especially species that are listed under the Victorian FFG Act and the Commonwealth EPBC Act. The focus on biota with recognised conservation significance is too narrow and doesn't recognise the value of other populations and communities or the role that they play in broader ecosystem processes and function. Moreover there is little discussion of the water dependency of many of the listed species.

Using the environmental flow recommendations as a benchmark for determining whether a reduction in channel outfalls is likely to threaten environmental values in the Campaspe River overcomes the problem of focussing on threatened species because the environmental flow recommendations were initially developed to meet a wide variety of environmental objectives. The TRG feel that the link between the environmental flow recommendations and the broader range of environmental values needs to be made clearer in the EWP. Moreover, the EWP needs a better definition of high environmental values, which may be done by referring to the Regional River Health Strategy, and a clear statement about addressing the requirements of all known environmental values.

Explanation of baseline year and other reference periods in the assessment

The assessment presented in the EWP frequently refers to the 2003/04 Baseline year for the Campaspe Irrigation Area and the 2004/05 Baseline year for the Rochester Irrigation Area. However, there is no discussion about why these years were selected and how they are being used in the assessment. The TRG had some concerns about the relevance of single Baseline years given infrastructure upgrades since then have already reduced the magnitude of some channel outfalls and the recent drought may have irreversibly altered the composition and condition of environmental values in the waterway. The EWP should include a section that clearly describes how and why the baseline years are used in the analysis.

Figures 5 and 6 present total annual outfall volumes to the Campaspe River from the Campaspe and Rochester Irrigation Areas since 1998/99. These figures include specific references to the 2003/04 and 2004/05 Baseline years respectively, a long-term average (1998 onwards) and a short-term average (2006/07 and 2008/09). There is no discussion or justification for selecting these periods and no clear analysis that includes these reference periods. Moreover a short-term average based on only two data points is probably meaningless. If these reference periods are to be retained, then the EWP needs to include a discussion about the relevance of these averages and how they should be interpreted. A better approach would be to use modelled data from the period of the Goulburn Simulation Model (i.e. from 1896 onwards) and model different scenarios of interest. Short-term averages should be based on some variation of the last 10 years.

General issues to be addressed

Estimating flow reductions in different seasons

Tables 16 and 17 summarise expected reductions in flow at different locations in different seasons. The use of summer months and winter months as column headings is confusing because the data presented in each of these columns relates to a six month period, rather than December to February and June to August respectively. The assessments of summer and winter months could probably be removed altogether because outfalls are only going to affect streamflow during the irrigation season. Averaging these changes across summer and winter seasons that include a mixture of irrigation and non-irrigation season months will mask some of the effects of reduced channel outfalls. If the summer and winter categories are going to be retained, then the months that each period refers to should be noted.

Mismatch between numbers in text and numbers in the figures

The numbers presented in the text in Sections 6.3.6.1 and 6.3.6.2 do not appear to match the numbers in figures 7 and 10. For example in the long term assessment discussion on page 31 it indicates that the 15th percentile flow pre-NVIRP was 2,500 ML/month, but the flow duration curves in figure 10 do not support this. All of these numbers should be reviewed.

Wording in tables assessing the dependency on mitigation water

Tables 18 and 19 summarise the arguments for and against mitigation water in each reach of the Campaspe River. These arguments are based on criteria that must all be met in order for mitigation water to be deemed unnecessary. The wording used for each of these assessments is confusing. We suggest that the words “Yes” and “No” should be omitted from these tables and the text be simplified to a simple statement that describes the relevance of each criterion to that reach.

Incorrect calculations of the mitigation water commitment

The EWP describes and adopts a six step process for calculating the volume of mitigation water required in each Reach of the Campaspe River. Step 5 is supposed to calculate the mitigation water commitment based on the frequency that outfall water is likely to meet an environmental need. For example, if outfalls were considered to contribute to summer freshes, and summer freshes were needed every year, then all of the outfall water would be considered necessary and the commitment would be 100%. In the draft EWP the mitigation water commitment is described as the proportion of outfall water that enters the Campaspe River after allowing for losses. These calculations should be repeated to correct the error.

3. Specific issues related to the Campaspe River Reach 3

The TRG felt that it would be difficult to demonstrate that the outfall contribution of 63 ML/year to Reach 3 of the Campaspe River provided a significant environmental benefit unless most of the water was delivered in a small number of events. These events would probably need to contribute in excess of 5 ML/day to affect flow variability and influence environmental values.

4. Specific issues related to the Campaspe River Reach 4

Value of offsetting IVT losses

Since 2006 Inter-Valley Transfer (IVT) flows have been delivered from the Goulburn River Catchment to the Murray River via the Waranga Western Channel and Reach 4 of the Campaspe River. These flows have been used to manage saline pools and maintain environmental values in the lower Campaspe River. However, the NCCMA and DSE need to compensate G-MW for any water losses associated with these flows. While channel outfalls do not represent a large contribution to flow in Reach 4 of the Campaspe River and on their own do not necessarily provide a demonstrable environmental benefit, they do help to offset the losses associated with IVTs. These offsets are important, because it reduces the need to use the environmental water reserve to compensate G-MW.

IVTs are not delivered every year. The EWP should include a description of IVTs in Section 6.2., and an analysis of likely storage levels and operation rules for Lake Eppalock to determine how often IVTs will be delivered in the future. The EWP should include the extent to which channel outfalls are likely to offset IVT losses in the overall assessment of the need for mitigation water.

EVC descriptions

The TRG queried the identification of EVC 823 Lignum Swampy Woodland in Reach 4 of the Campaspe River. DSE have two databases that describe the distribution of EVCs throughout the State and discrepancies can arise depending on which database is used. The TRG requested that all of the EVCs listed in the EWP be checked to ensure that they are correct.

Contribution to the Campaspe Billabong and the unnamed creek

The main issue for consideration with the Campaspe Billabong is the potential effect that reduced channel outfalls will have on populations of the FFG listed Squirrel Glider. Squirrel Gliders rely on healthy riparian vegetation and so the relevant question is whether the channel outfalls play a role in maintaining the extent and condition of river red gums and other riparian vegetation. The Campaspe Billabong is very close to the Campaspe River, and in many places the riparian zones of the two waterways converge. The TRG felt that an assessment to compare the relative condition of the riparian zone adjacent to the Campaspe Billabong against the condition of other nearby riparian zones would help to determine the importance of the Billabong to Squirrel Gliders. Recent aerial photographs may be used for a coarse comparison. A more detailed assessment of the effect of channel outfalls on the health of the Billabong's riparian zone will only be required if that riparian zone is considered to be significantly better than other nearby habitats.

The EWP indicates that the No 2/11 ST033111 outfall discharges approximately 91 ML per year. Given the distance of the outfall from natural watercourses there is some doubt regarding the extent to which these outfalls will contribute to flow in the unnamed creek and the Campaspe River. A more detailed assessment of the range of range of weekly outfall volumes that are likely to occur will help to clarify whether these channel outfalls contribute to flow in the waterways.

5. Concluding remarks

The TRG felt that the process for assessing the requirement for mitigation water has some limitations. The Campaspe River is flow stressed and any opportunity to retain water in the system should be embraced. The assessment process only allows for mitigation water if the outfalls, as they are currently delivered, provide a demonstrable benefit to the environment. If mitigation water is deemed necessary then it can be delivered to the river in any way that maximises the environmental outcomes. However, it is not possible to secure mitigation water on the basis that it would provide an environmental benefit if it was delivered in an appropriate way.

The feedback provided here represents the views of the TRG and is based on the draft EWP. We envisage that the information provided will help the NCCMA apply an appropriate level of scientific rigour to the final EWP.

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Appendix H: Unnamed Creek assessment

The Campaspe unnamed creek receives outfalls from the ST033111 outfall from the No. 2/11 channel. Water from this outfall travels along approximately 2.9 km of drain and approximately 2.6 km of creek. The assessment of the impact of outfalls on the lower Campaspe River assumed an indicative loss of 100% for this outfall. However, an assessment was undertaken to estimate the volume of water entering the unnamed creek (Refer to SKM 2010). A summary of the analysis is provided below.

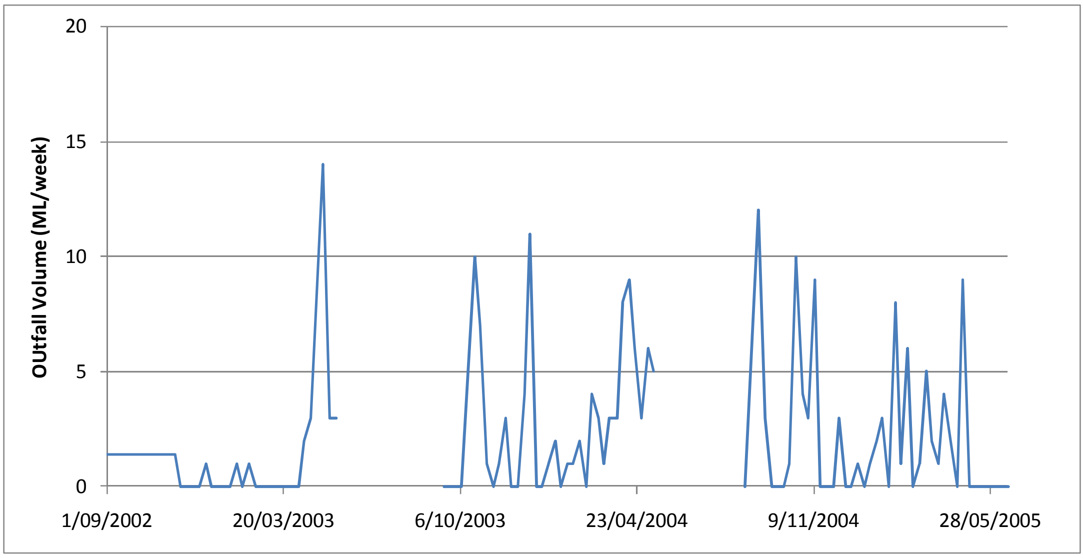
Whilst this outfall is unlikely to contribute flows to the Campaspe River, it is likely that the outfall contributes some flow to the unnamed creek. The volume of the contribution is difficult to estimate, as the volume lost (to initial losses, seepage and evaporation) along the channel is not known.

It was estimated that indicative losses between the outfall sites and the unnamed creek were likely to account for approximately 40% of the outfall volume. This is based on a desktop review of the following features:

- the outfall location, the length of drain between the outfall site and the unnamed creek (approximately 2.9 km),
- information from a previous SKM study (2008c) which estimated that in 2004/05, seepage from drains with a depth to groundwater of 3 or more meters (as is observed in the vicinity of the drain) is approximately 12 ML per year per kilometre of drain. This means that in 2004/05 seepage is estimated to be approximately 35 ML (2.9 km of drain, 12 ML of loss per kilometre) compared to outfalls of approximately 91 ML of outfalls (approximately 40% of loss), and
- it was also noted that the drain is relatively large and would be expected to flow under 'average' flow conditions which would help convey water along the drain, reducing losses.

Following this, it is assumed that NVIRP will lead to an 85% reduction in the contribution of this outfall to the unnamed creek. Note, there is a high level of uncertainty associated with the estimation of the 40% loss factor as the estimate has been based on generic information rather than specific, quantified information for this drain and there can be considerable variation in losses along drains (due to factors such as drain condition).

Based on the above assumptions, Figure H1 shows a time series plot of estimated pre-and post-NVIRP outfalls to the unnamed creek which Table H1 summarises the impact of NVIRP on the unnamed creek. As no flow information is available for the unnamed creek it has not been possible to assess the impact of the reduction in outfalls on streamflow in the creek.



FigureH1: Time-series plot of recorded (pre-NVIRP) outfalls to the unnamed creek

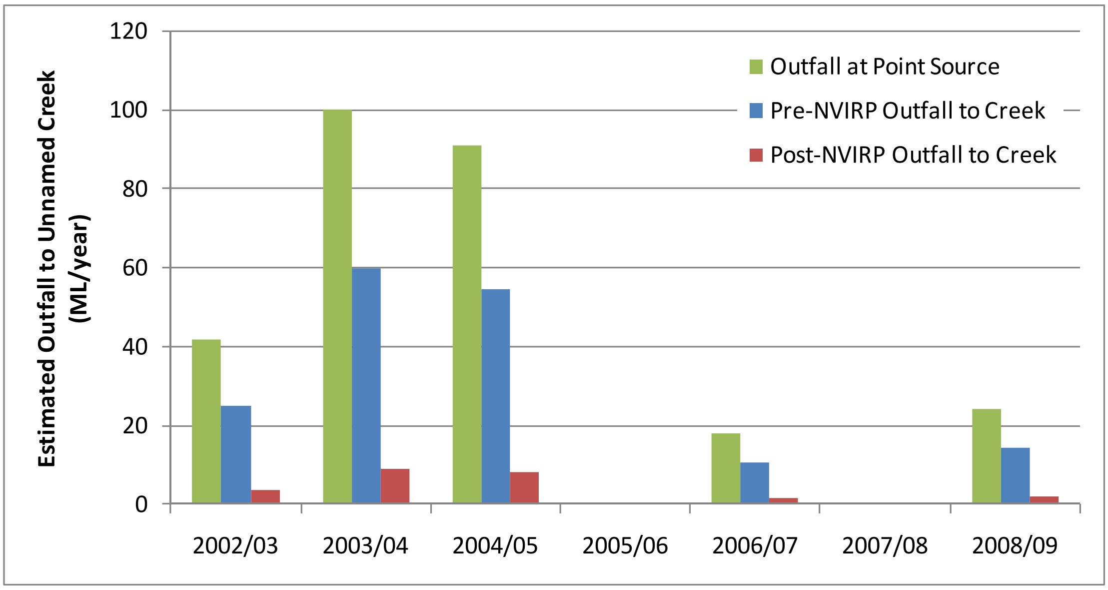


Figure H2: Time series of estimated pre- and post-NVIRP outfalls to the unnamed creek (note, data for 2005/06 and 2007/08 is missing, not zero).

TableH1: Impact of NVIRP on outfalls to the unnamed creek

Water Year	Outfall at Point Source (ML)	Pre-NIVRP Outfall to the Creek (ML)	Post-NVIRP Outfall to the Creek (ML)	Reduction in Outfalls (ML)
2002/03	42	25	4	21
2003/04	100	60	9	51
2004/05	91	55	8	46
2006/07	18	11	2	9
2008/09	24	14	2	12

Appendix I: Water Quality Analysis for the Campaspe River EWP

A brief assessment of the water quality within the Campaspe River and the Campaspe and Rochester Irrigation systems has been provided below.

Step 3 of the Mitigation Water Assessment includes a criterion that states:

"Mitigation water may be assessed as zero where the wetland or waterway receives water from the irrigation system; Criteria 2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values".

Table I1 provides a summary of key water quality monitoring sites that provide a representation of the water quality within the Irrigation system and the Campaspe River.

The Waranga Basin site (405260) has been used as water is supplied to the Rochester Irrigation area from the Waranga Western Channel via the Waranga Basin. The Campaspe River at Rochester (406202) has been used to represent the water quality within the River. It has been assumed that water quality has not changed significantly where outfall water enters a drain prior to entering the Campaspe River.

It is clear from Table I1 that water quality within the irrigation system is of better quality to the water in the Campaspe river and therefore outfall water is not detrimental to the environmental values (Refer to Table 22 in section 8 Mitigation Water Assessment).

Table I1: Campaspe Water Quality Data

Water Quality Monitoring Site	Median Electrical Conductivity Us/cm (No of samples)	Median Total Nitrogen Mg/l (No of samples)	Median Total Phosphorus Mg/l (No of samples)
Waranga Basin @ Head Gauge (405260)	86 (166)	0.40 (166)	0.026 (166)
Campaspe River @ Rochester (406202)	790 (481)	0.82 (1057)	0.038 (1048)

Water Quality Data has been obtained from the Victorian Water Resources Data Warehouse http://www.vicwaterdata.net/vicwaterdata/home.aspx

Please note that the Campaspe Irrigation area is supplied by water from Lake Eppalock via the Campaspe River and therefore water quality within the Campaspe Irrigation System including outfall water will be of a similar quality to that in the Campaspe River.

Appendix J: Environmental flow monitoring

There is already an ongoing environmental flow, water resource planning and water quality monitoring program for the Campaspe River conducted by the North Central CMA and Goulburn-Murray Water. This monitoring program is seen as sufficient and will be used to inform the outcomes of the use of mitigation water.

J1: Long-term condition Monitoring - VEFMAP

The Victorian environmental flows monitoring and assessment program (VEFMAP) is aimed to:

"Evaluate ecosystem responses to environmental flows in the eight high-priority regulated rivers that are to receive enhancements to their flow regime".

This study aims to achieve:

- A consistent, scientifically defensible, framework for monitoring environmental flows in pre-defined regulated rivers across Victoria.
- Detailed, hypothesis based, monitoring plans for each specific river where the delivery of environmental flows is expected or underway.
- Sufficient flexibility in the monitoring framework and plans so that they can be adapted in light of changing conditions and information generated by the on-going data analyses.

The Campaspe River was selected for this statewide program. The monitoring programs implemented include:

- Physical habitat and geomorphology
- Water quality monitoring
- Fish, aquatic and riparian vegetation assessments

J1: Intervention Monitoring

Currently (Temporary Qualification of Rights), environmental flow releases are made in response to perceived ecological risks:

- Stratification and/or deoxygenation of bottom layers of water, especially in pools
- Blue-green algae outbreaks
- Fish deaths

Environmental flows are released based on an assessment of the monitoring data and the water availability. The current maintenance of water quality conditions is based upon a set of trigger levels which aim to keep the water quality above a threshold at which fish can survive. Trigger levels for water quality have been set by scientific panel advice (Humphries 2006).

When it is expected that environmental degradation will occur, for example, a trigger level has been reached or there is a downward trend in water quality toward the trigger level, the North Central CMA advises Goulburn-Murray Water to release an environmental flow. Goulburn-Murray Water is responsible for releasing flows conditional upon the volume being available in the reserve for environmental purposes.

The management of environmental flows is highly adaptive and dynamic in response to environmental conditions and system operation constraints (NCCMA 2009b). Refer to Table J1 for site locations and monitoring techniques undertaken.

Table J1: Water quality monitoring sites - location and rationale

River / Reach	Site location	Features / Rationale	Monitoring Technique
Reach 3: Campaspe Weir - Siphon	**1.** d/s Campaspe Weir	• Existing monitoring site	• G-MW water quality monitoring
	2. Burnewang-Bonn Road	• Existing monitoring site • Deep pool (2.4m) • Identified in “Saline Pools Investigation” project • Good drought refuge	• Continuous probe (VEFMAP) • G-MW water quality monitoring
	3. Reserve on east side river - Rochester town flood gauge	• Existing monitoring site	• G-MW water quality monitoring
	4. Reserve on east side river - Rochester town flood gauge	• Existing monitoring site	• G-MW water quality monitoring
	5. Rochester Rail Bridge	• Existing monitoring site • Deep pool - backed up from siphon • Cross reference data for continuous monitoring probe	• G-MW water quality monitoring • VWQMN data (406202C)
Reach 4: Siphon - Echuca Weir	**1.** Strathallen Bridge	• Existing monitoring site • E-flows site	• G-MW water quality monitoring
	2. Fehring Lane	• Deep pool (1.9m) • Identified in “Saline Pools Investigation” project • Good drought habitat	• Continuous probe (VEFMAP)
	3. U/s Echuca Weir	• Existing monitoring site	• G-MW water quality monitoring

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