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Northern Victoria Irrigation Renewal Project

Waterway Short-Listing Report

Final Report

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Purpose of this Report

The purpose of this report is to determine whether significant impacts to individual waterways are likely from implementation of the Northern Victoria Irrigation Renewal Project (NVIRP). NVIRP implementation may result in changes to volumes of losses from distribution system operating water. Waterways where significant impacts are likely are recommended for further, more detailed investigation, or EWP development.

The NVIRP is to upgrade irrigation delivery infrastructure in the Goulburn Murray Irrigation District (GMID) through automation, remediation and reconfiguration of the channel system, in order to improve the efficiency of the irrigation systems and hence achieve water savings relative to current supply inefficiencies.

NVIRP's Water Change Management Framework (WCMF) presents the framework to assess, manage and mitigate the effects of the implementation of the NVIRP on aquatic and riparian ecological values within the NVIRP area.

Desktop assessment

NVIRP commissioned a desktop assessment (SKM, 2008) as part of the referral submitted to the Minister for Planning under the *Environment Effects Act 1978*.

Wetlands and waterways with high environmental values in the NVIRP area were identified from existing databases and information from various sources.

The desktop assessment provided a preliminary list of wetlands and waterways that required further assessment.

The Minister for Planning's decision identified 17 wetlands and 15 waterways as potentially 'at risk' from the implementation of NVIRP.

The Goulburn River was also recommended in the SKM report for further investigation. This will be addressed in NVIRP's response to condition 4 of the Minister's decision and is outside the scope of this report.

Pennyroyal and Nine Mile Creek immediately downstream of the Serpentine Creek outfalls were added by NVIRP's Technical Advisory Committee (TAC) for investigation. The TAC has also agreed that a short regulated section of the Boosey Creek at Katamatite should be assessed with Broken Creek.

Short-list project methodology

This short-listing Report is essentially a groundtruthing exercise intended to reduce uncertainties associated with Desktop assessments.

This project was undertaken by:

1. Reviewing the Desktop report and recommendations relevant to the waterways assessed.

2. Documenting environmental values of candidate waterways by undertaking a review of relevant reports and literature, discussions with key staff and site field visits

3. Documenting more detailed information about channel outfalls and the hydrological regime of candidate waterways (if available)

4. Assessing the likelihood for significant negative impacts to be caused by a reduction in outfalls to waterways, and whether or not further work, or the development of an EWP, was warranted.

5. Recommending timing for preparation of EWPs in relation to NVIRP's program of works

Conclusions

Of the waterways assessed most were not impacted by changes in channel outfalls. Waterways with high environmental value and changes in channel outfall are recommended for further investigation or development of an EWP.

Shortlisting process

The information provided from the environmental and hydrological investigations has been combined to determine waterways that are 'potentially at risk" and "not at risk". This assessment is summarised in Table S1. This Table also includes a summary comparison with the Desktop assessment outcomes.

Table S1 Summary of outcomes of Shortlisting process and comparison with Desktop list

DT = Desktop study; SL = Short-list study (this report))

	High environmental values		**Expected change in flow due to NVIRP**		**Further investigation required/ preparation of EWP**	
Waterway	**DT**	**SL**	**DT**	**SL**	**DT**	**SL**
Bannacher / Pennyroyal Creek	Y	Y	Y	N	Y	N
Broken Creek	Y	Y	Unknown	tbd	Y	Y
Bullock Creek	N	Y	N	N	Y	N
Calivil Creek	Y	Y	Y	N	Y	N
Campaspe River	Y	Y	-	Y	Y	Y
Loddon River	Y	Y	Y	Y	Y	Y

	High environmental values		Expected change in flow due to NVIRP		Further investigation required/ preparation of EWP	
Loddon River (downstream of Kerang)	Y	Y	-	tbd	Y	Y
Nine Mile Creek	N	N	Y	N	Y	N
Nine Mile Creek D/S Serpentine Creek outfall	n/a	Y	n/a	Y	n/a	Y
Pennyroyal Ck D/S Serpentine Ck outfall	n/a	Y	n/a	N	n/a	N
Pyramid Creek (See Bullock Creek)	N	Y	N	N	Y	N
Sevens Creek	N	N	N	N	Y	N
Sheepwash Creek	N	N	unknown	N	Y	N
Tongalong Creek	Y	Y	unknown	N	Y	N
Tullah Creek	Y	Y	unknown	N	Y	N
Twelve Mile Creek	Y	Y	-	tbd	Y	Y (as part of Loddon River assessment)
Wells Creek	N	N	Y	Y	Y	N
Yambuna Creek	N		-	N	Y	N

Timing for preparation of EWPs

Timing for further investigations or development of EWPs is included in the following table.

Table S2 NVIRP Works schedule and waterways recommended for further investigation.

Waterway	Works scheduled
Campaspe River.	2009
Loddon River (Torrumbarry IA)	2009
Loddon River (Pyramid Boort IA)	2010
Broken Creek EWP	2010
Twelve Mile Creek (undertake with Loddon assessments)	2010
Nine Mile Creek (immediately downstream of Serpentine Creek outfall) – for further assessment.	2010

Recommendations

The following waterways are determined as 'at risk' from the implementation of NVIRP and recommended for development of an EWP:

- Campaspe River – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed river.
- Loddon River (Torrumbarry and Pyramid Boort IA) – undertake further detailed investigations into impacts of channel outfall reduction and potential system operation change on the waterway
- Broken Creek – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed creek. The investigation should include the regulated section of Boosey Creek near Katamatite.
- Twelve Mile Creek (undertake with Loddon assessments)

The following Waterway is determined as 'at risk' and recommended for further assessment to determine if a EWP is required.

- Nine Mile Creek (immediately downstream of Serpentine Creek outfall) –further investigate environmental values and effects of leakage reduction on these values.

The following waterways are determined as not 'at risk' from the implementation of NVIRP and are not recommended for development of an EWP:

- Bannacher / Pennyroyal Creek
- Bullock Creek
- Calivil Creek
- Nine Mile Creek
- Pennyroyal Creek D/S Serpentine Creek outfall
- Pyramid Creek
- Sevens Creek
- Sheepwash Creek
- Tongalong Creek
- Tullah Creek
- Wells Creek
- Yambuna Creek.

1. Purpose of this Report

The purpose of this report is to determine whether significant impacts to individual waterways are likely from implementation of the NVIRP. NVIRP implementation may result in changes to volumes of losses from distribution system operating water. Waterways where significant impacts are likely are recommended for further, more detailed investigation, or EWP development.

This Report provides environmental and hydrological descriptions of waterways potentially adversely impacted. Waterway photographs and site maps are provided in an accompanying Report.

2. Background

2.1. Northern Victorian Irrigation Renewal Project

The NVIRP is to upgrade irrigation delivery infrastructure in the Goulburn Murray Irrigation District (GMID) through automation, remediation and reconfiguration of the channel system, in order to improve the efficiency of the irrigation systems and hence achieve water savings relative to current supply inefficiencies. It is a key infrastructure project identified under the next stage of the Victorian Government's *Our Water Our Future* plan.

The NVIRP area is within the Goulburn Murray Irrigation District (GMID). The GMID is located in northern Victoria and extends from Nyah in the west to Yarrawonga in the east. The NVIRP area is located within the lower portions of the catchments of the Goulburn, Broken, Campaspe, Loddon and Avoca rivers, and abuts the River Murray.

The extent of the NVIRP works area (Figure 1) covers the following irrigation areas:

- Central Goulburn Irrigation Area (Channels CG 5-9)
- Rochester/Campaspe Irrigation Area
- Pyramid-Boort Irrigation Area
- Murray Valley Irrigation Area
- Torrumbarry Irrigation Area.

Note that Central Goulburn Irrigation Area (Channels CG 1-4) and Shepparton Irrigation Area are not part of the NVIRP area.

Figure 2 shows the proposed scheduling of works to be carried out by NVIRP.

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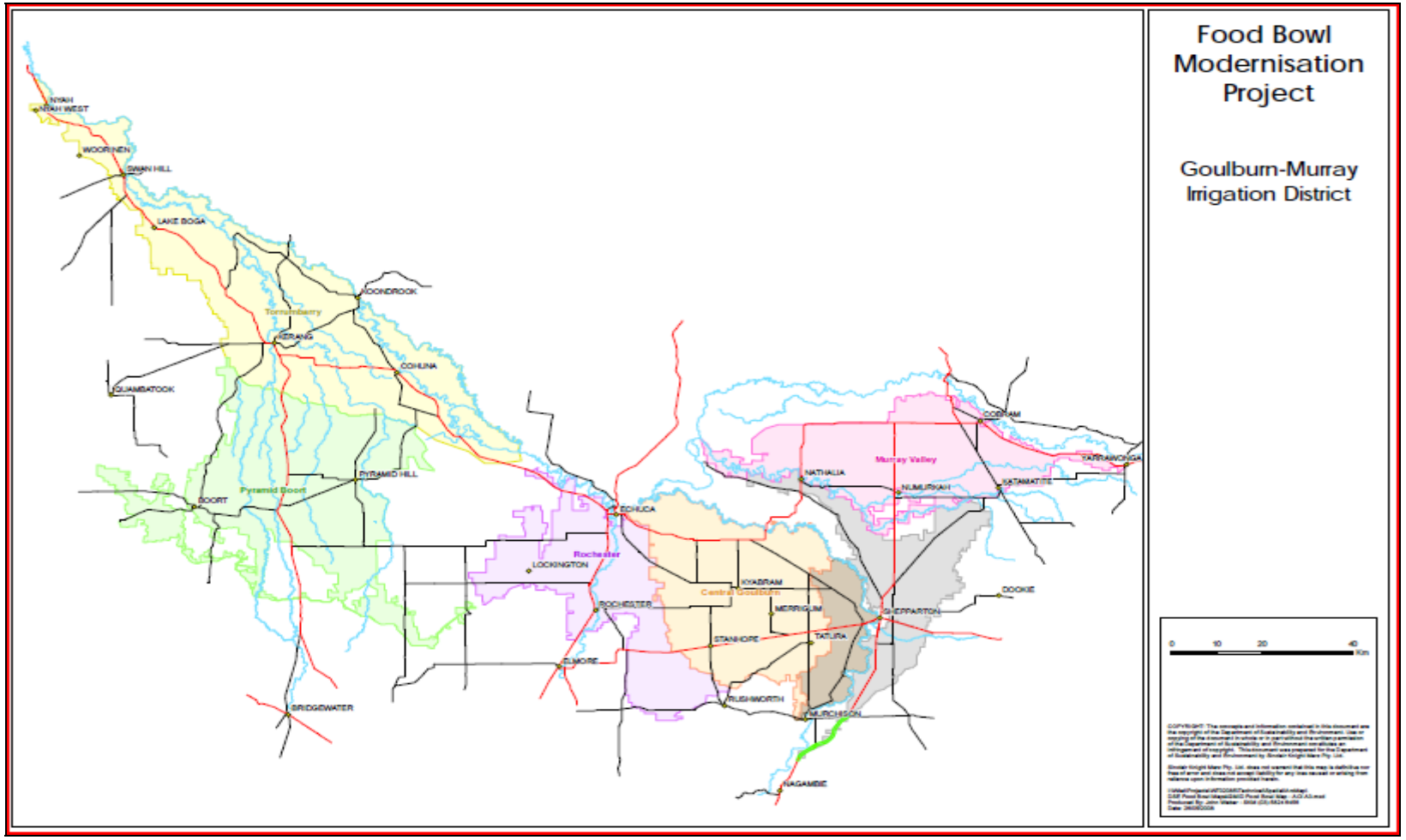

Figure 1 Goulburn-Murray Irrigation District

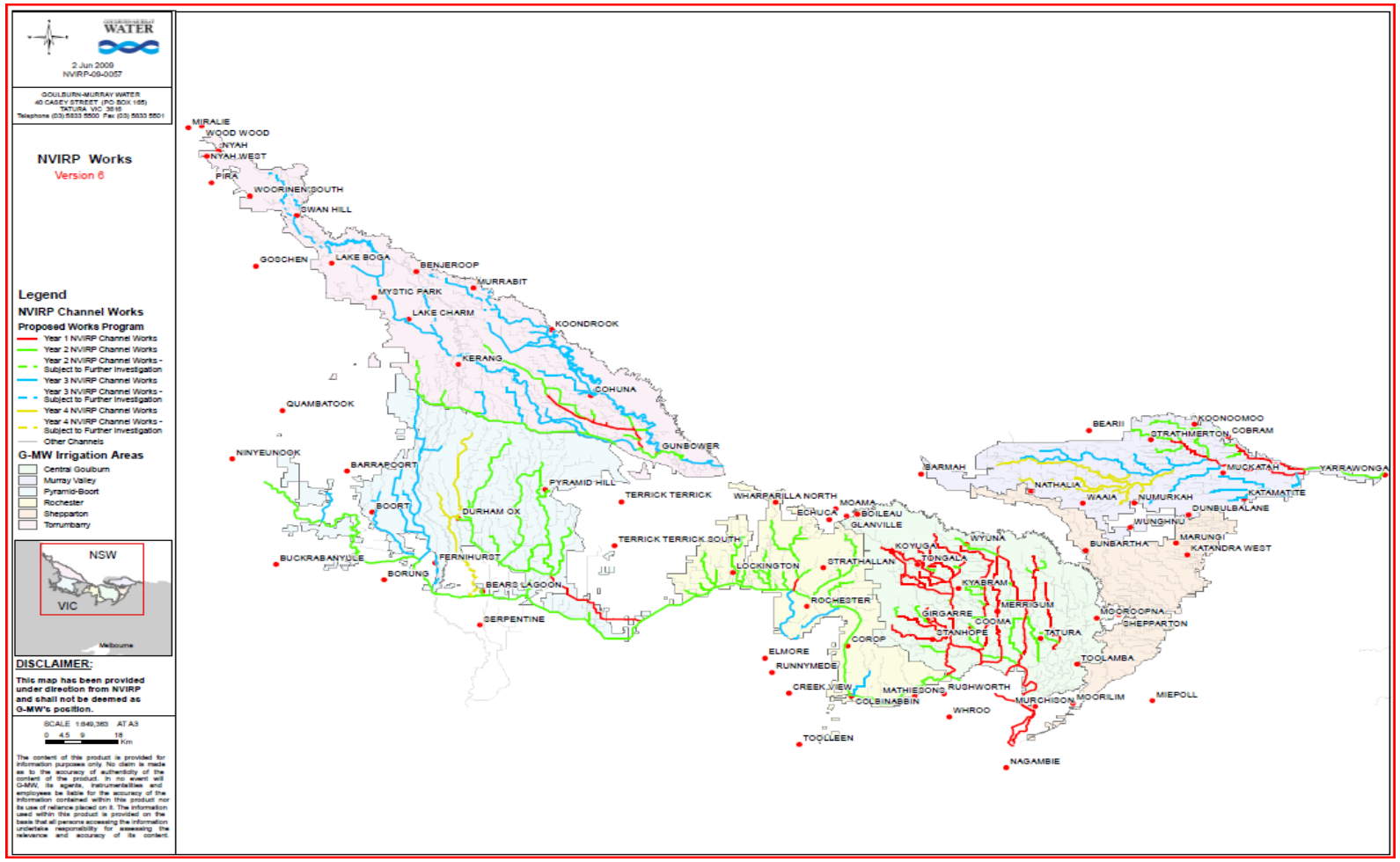

Figure 2 NVIRP area and generalised plan of scheduling of channel works.

2.2. Desktop assessment

NVIRP commissioned a desktop assessment (SKM, 2008) as part of the referral submitted to the Minister for Planning under the *Environment Effects Act 1978*.

The desktop assessment process:

- identified wetlands / waterways in the GMID
- identified high environmental values
- determined type of connection to irrigation system
- determined relative contribution of irrigation water to wetland / waterway water regime.

The output of the assessment was a preliminary list of

- waterways with high environmental values
- whose water regime is likely to be altered by implementation of NVIRP
- where insufficient data is available to determine if its water regime is likely to be altered by implementation of NVIRP
- wetlands and waterways where insufficient data is available to assess environmental values.

Wetlands and waterways with high environmental values in the NVIRP area were identified from existing databases and information from the sources set out in Section 0.

- use of available information, including databases maintained by Commonwealth, state, and regional authorities
- local knowledge and expertise

The desktop assessment provided a preliminary list of wetlands and waterways that required further assessment.

The Minister for Planning's decision identified 17 wetlands and 15 waterways as potentially 'at risk' from the implementation of NVIRP. The list of waterways is shown in Table 1.

An additional site, Pennyroyal and Nine Mile Creeks immediately downstream of the Serpentine Creek outfalls was added at request from the NC CMA for recommendation by NVIRP's Technical Advisory Committee (TAC) for Environmental Watering Plans.

The waterways listed in Table 1 provide the preliminary list for further validation as described in Part C of the WCMF.

Table 1 Preliminary list of waterways requiring further investigation

Waterways	Identified in Minister's Decision	Identified in SKM Report	Waterways
Bannacher / Pennyroyal Creek	Yes	Yes	Bannacher / Pennyroyal Creek
Broken Creek	Yes	Yes	Broken Creek
Bullock Creek	NA	Yes. Added in by NVIRP	Bullock Creek
Calivil Creek	Yes	Yes	Calivil Creek
Campaspe River	Yes	Yes	Campaspe River
Loddon River	Yes	Yes	Loddon River
Loddon River (downstream of Kerang)	Yes	Yes	Loddon River (downstream of Kerang)
Nine Mile Creek	Yes	Yes	Nine Mile Creek
Nine Mile Creek downstream of Serpentine Creek	NA	Yes. Added in by NVIRP	Nine Mile Creek downstream of Serpentine Creek
Pyramid Creek	Yes	Yes	Pyramid Creek
Sevens Creek	Yes	Yes	Sevens Creek
Sheepwash Creek	Yes	Yes	Sheepwash Creek
Tongalong Creek	Yes	Yes	Tongalong Creek
Tullah Creek	Yes	Yes	Tullah Creek
Twelve Mile Creek	Yes	Yes	Twelve Mile Creek
Wells Creek	Yes	Yes	Wells Creek

Figures 3, 4, 5, 6 and 7 show the location of waterways and associated channel outfalls.

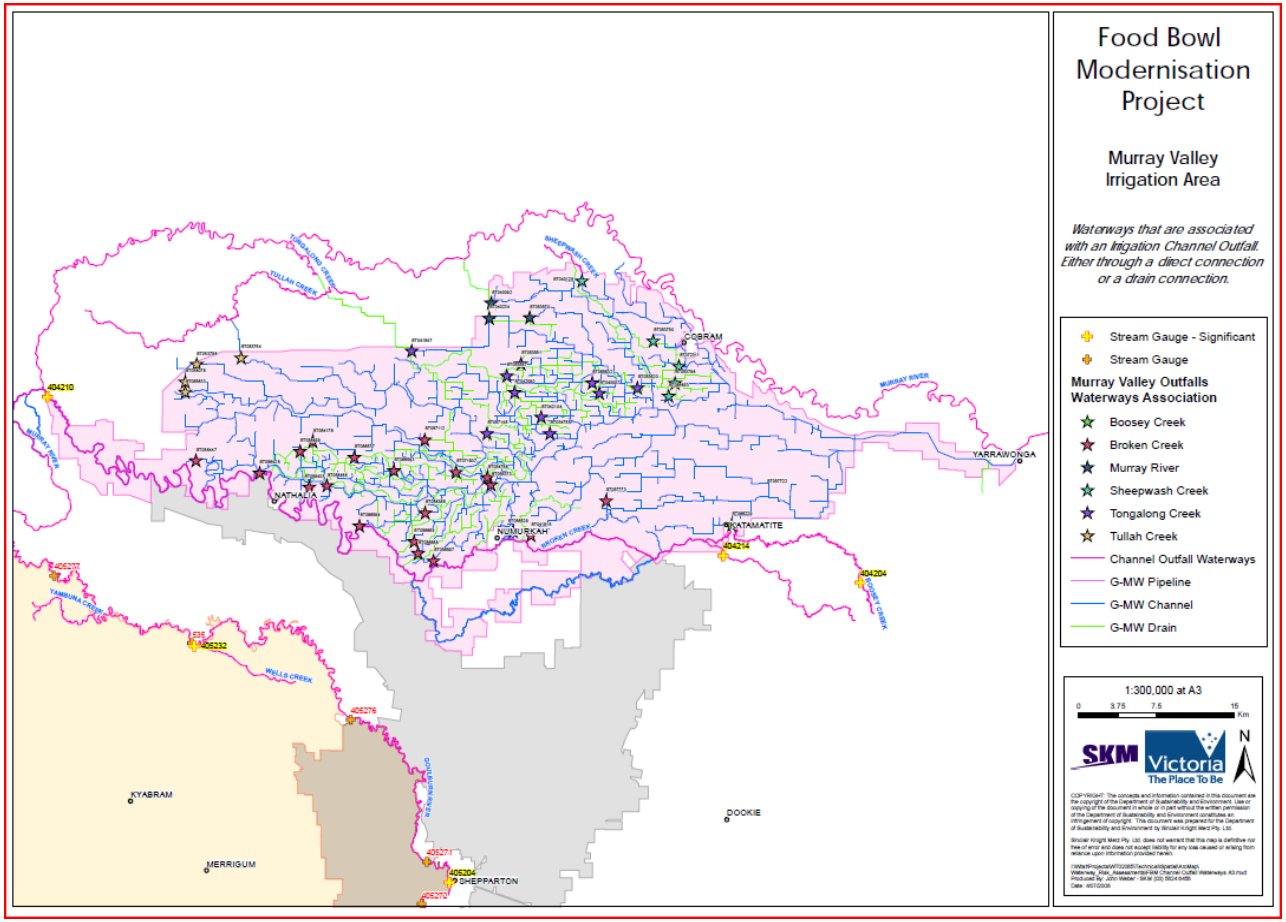

Figure **3** Channel outfalls in Murray Valley Irrigation Area

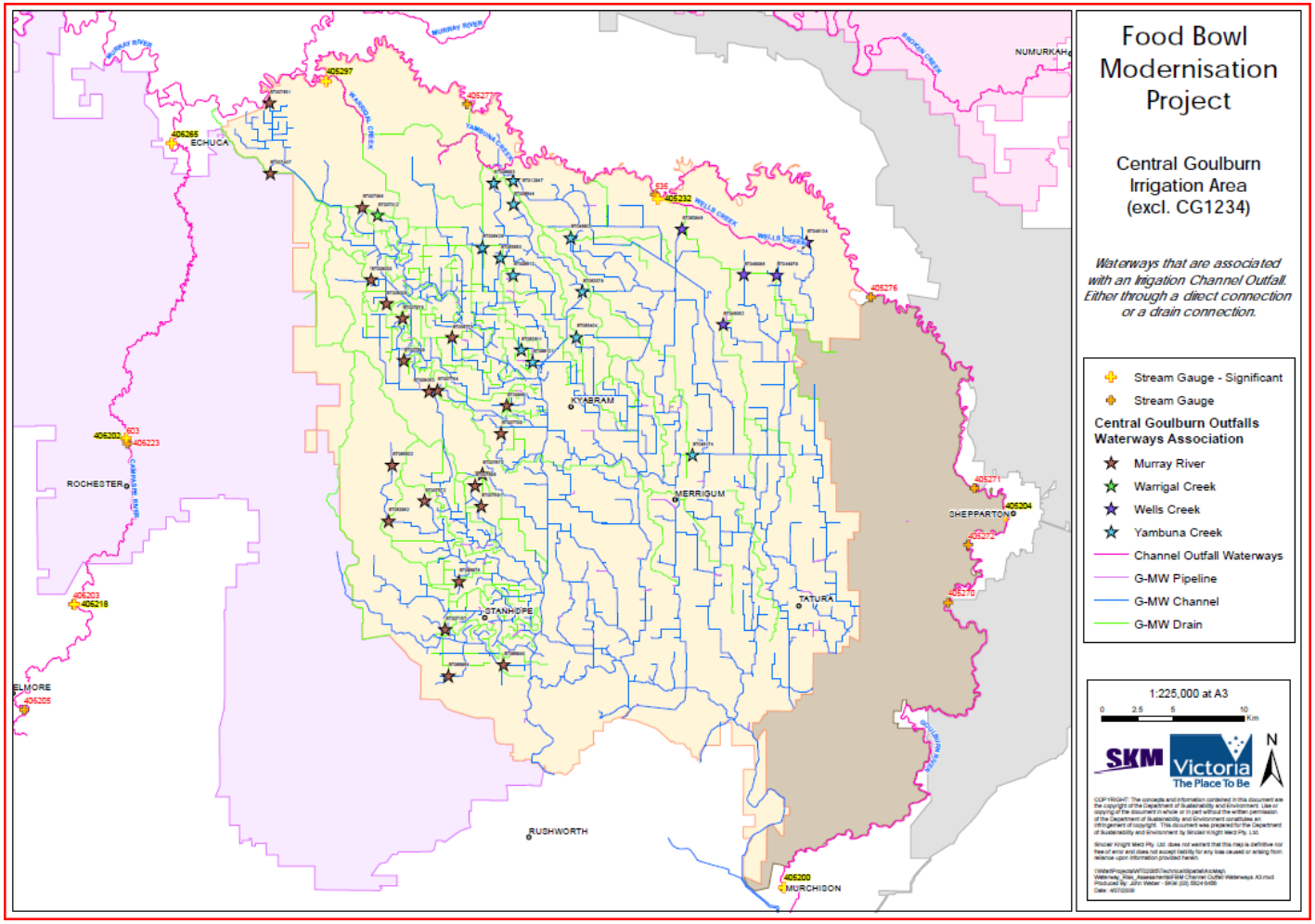

Figure **4** Channel outfalls in Central Goulburn Irrigation Area

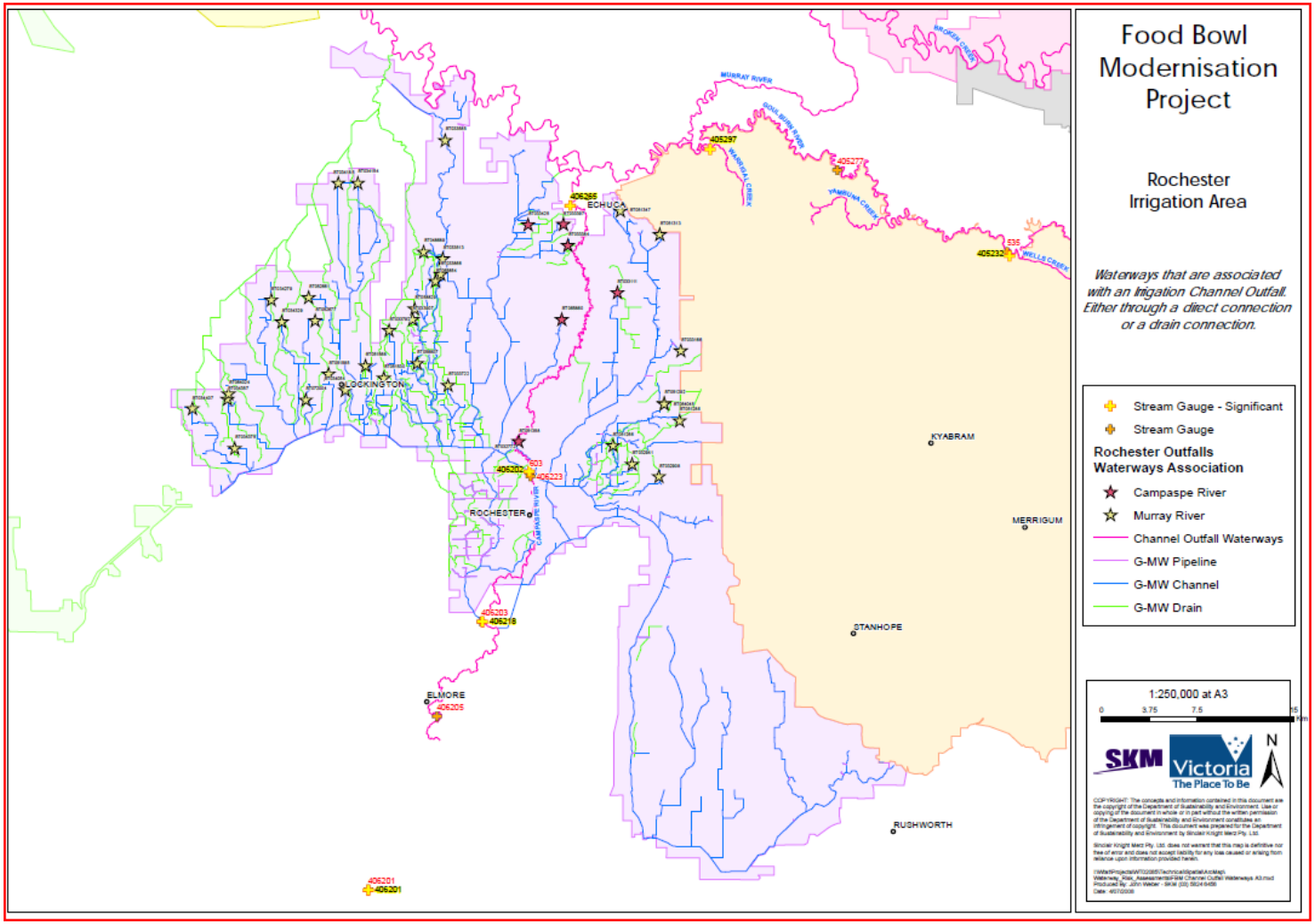

Figure **5** Channel outfalls in Rochester Irrigation Area

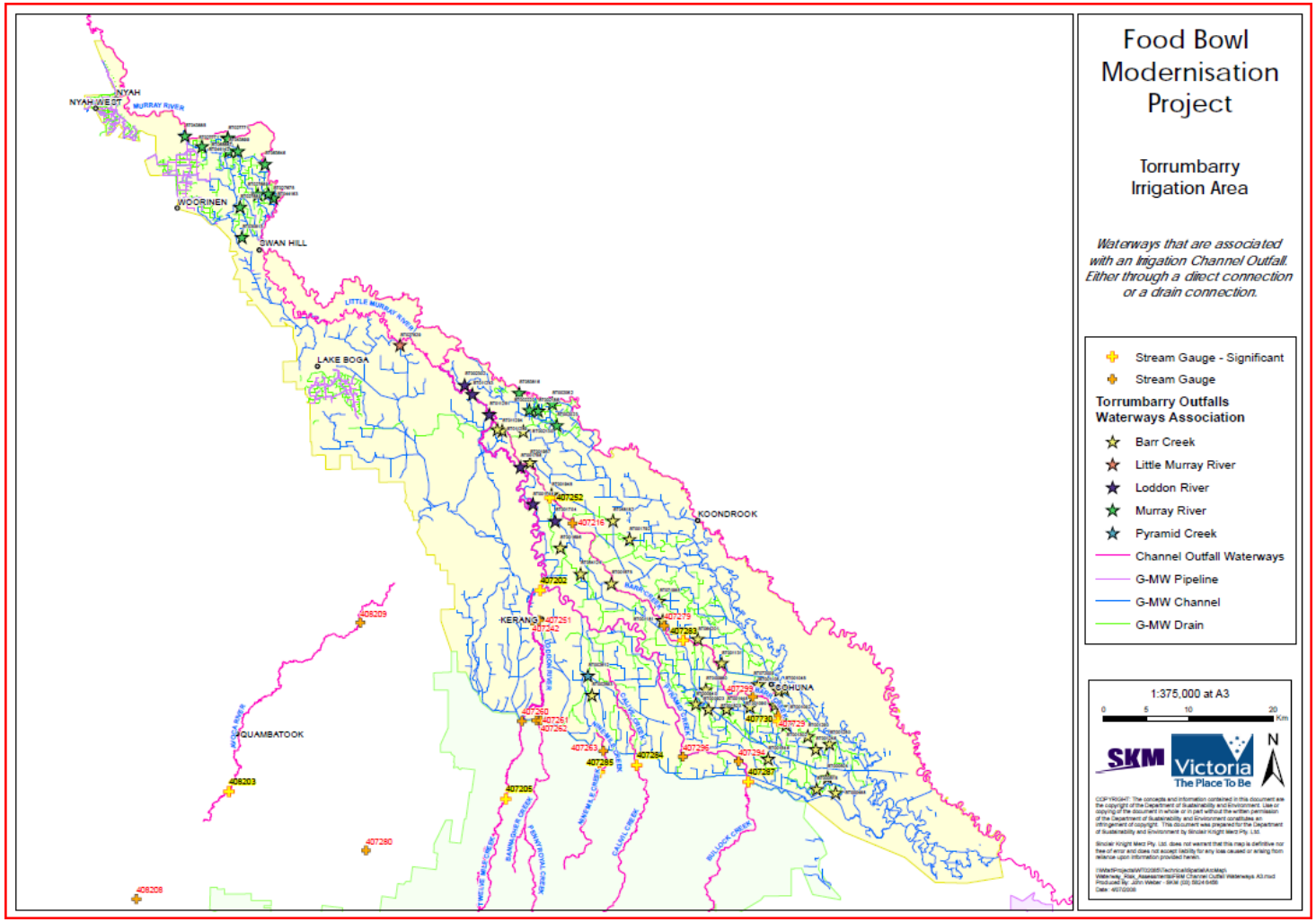

Figure **6** Channel outfalls in Torrumbarry Irrigation Area

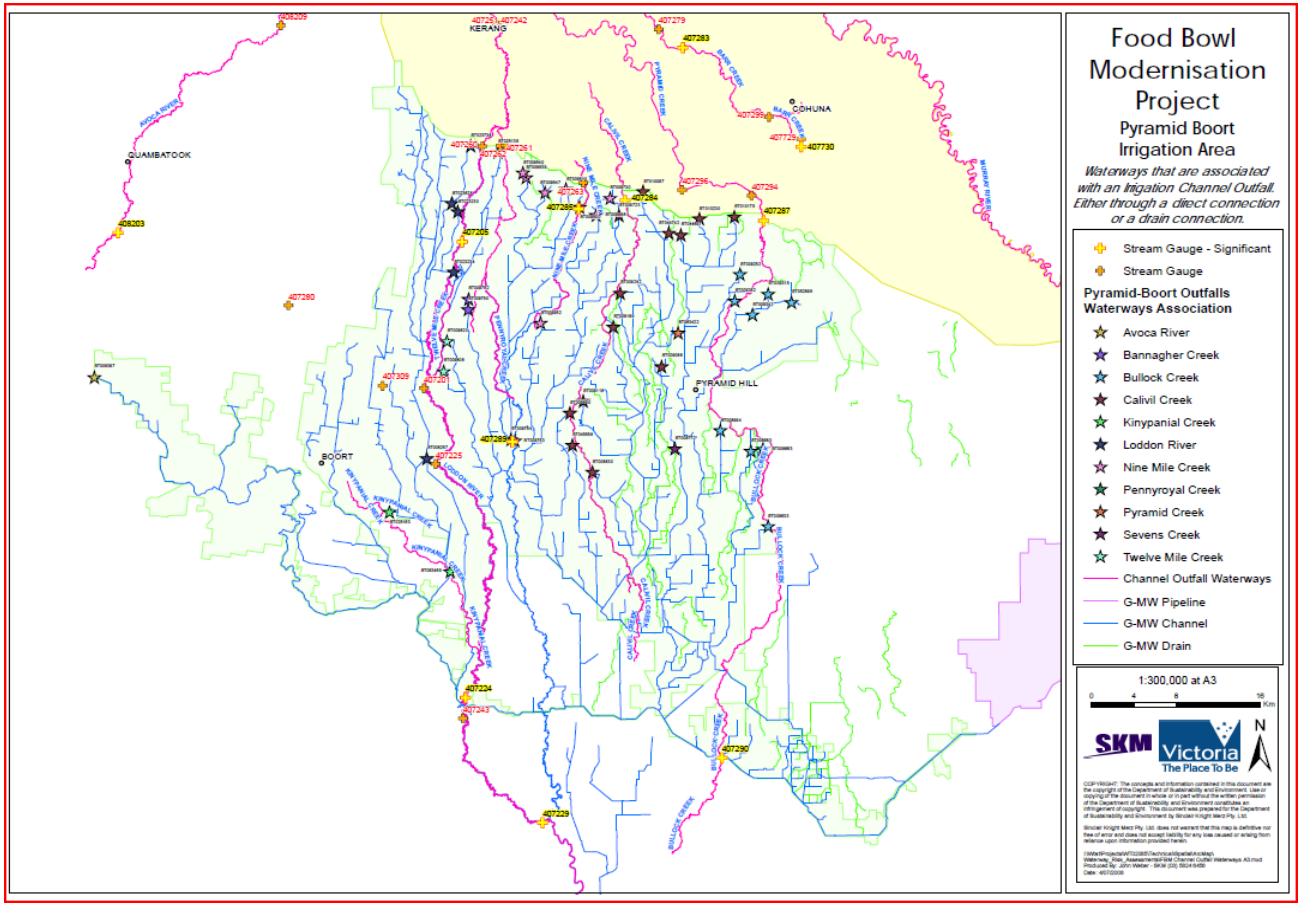

Figure **7** Channel Outfalls in Pyramid Boort Irrigation Area.

2.3. Policies, programs and other factors affecting incidental irrigation water

Incidental irrigation water refers to water that arrives ultimately in a wetland or waterway as a result of losses from the irrigation system. It does not refer to water that is delivered to the environment as a specific entitlement.

Substantial effort has occurred in the region to better manage the environmental impacts of water supply in irrigation areas. This effort has resulted in substantial reduction in drain flows which discharge to regional waterways.

Programs to improve the outcomes of irrigation began in the 1970's with the 'Halt the Salt' campaigns. Since then there have been further policy and initiatives targeting a range of aspects including nutrients, groundwater levels, improved watering regimes for wetlands and waterways, and improved irrigation system and on-farm efficiency. In addition, in response to the drought, the Victorian and Commonwealth Governments have implemented water savings and water purchase projects to make more water available for irrigators, the community and the environment.

There are a number of strategies in place to address the use and protection of Victorian waterways and meeting national commitments, including:

- Victorian River Health Strategy (VRHS)
- Victorian catchment management arrangements including Regional Catchment Strategies and Regional River Health Strategies
- State Environment Protection Policy (Waters of Victoria)
- Victorian Biodiversity Strategy
- Victorian Nutrient Management Strategy
- Victoria's Salinity Management Framework.

There are also currently a number of factors that are affecting the volume of quality incidental irrigation water that arrives in wetlands and waterways in northern Victoria, namely:

- salinity initiatives;
- nutrient reduction initiatives;
- water trade;
- drought and potential risk of climate change;
- Goulburn-Murray Water loss reduction program;
- irrigation modernisation projects; and
- Commonwealth Government water purchase.

These factors predate the development and implementation of NVIRP.

2.4. Year selected for baseline flows

The *Water Savings Protocol* (DSE, 2009) guides the calculations of water savings from irrigation modernisation projects in Victoria. It requires a baseline year to be adopted for operational purposes which is representative of long term average system operating conditions. Improvements in infrastructure and operation practices compared to the baseline are used to calculate savings. The baseline year for NVIRP is specified in the *Water Savings Protocol.* These are:

- 2004/2005 irrigation season for the Murray and Goulburn systems
- 2003/2004 irrigation season for the Campaspe system.

These seasons were the most recent in which there were 100% allocations of water entitlements.

As the environmental impacts from the implementation of NVIRP are principally related to the generation of water savings, the same baseline year as for the water savings calculation has been adopted for the calculation of mitigation water where required.

2.5. Effects of the irrigation system on waterways

The WCMF notes the effects of the irrigation system on wetlands and waterways. For channel outfalls these can be summarized as:

Table 2 Effects of irrigation system on waterways.

Aspect	Implications of the shared system	Potential effect on wetlands and waterways
Losses from distribution system operating water *(Significant water savings will be achieved in this area by NVIRP)*	• Resulting from manual operation or system shutdown following rainfall, either direct from channel outfalls or from drains. • May provide water that the wetland or waterway would not otherwise receive.	• Altered water regime and water quality. • Increased depth, frequency and duration of wetland inundation. • May have a significant influence on flow in smaller waterways, especially during the summer low-flow period.

3. Water Change Management Framework (WCMF)

NVIRP's Water Change Management Framework (NVIRP, 2009) presents the framework to assess, manage and mitigate the effects of the implementation of the NVIRP on aquatic and riparian ecological values within the NVIRP area.

The WCMF provides the framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system, including procedures for monitoring, reporting and auditing changes in hydrological and ecological conditions in relevant waterways or wetlands associated with the project's operation. It provides the environmental commitments, processes and methodologies for the relevant operations of the modified system.

The documents shown in Table 3 are part of the WCMF.

This Report provides the short list of waterways that require either an Environmental Watering Plan or further investigation.

Table 3 WCMF documents

Document	Description
Short-listing Report for Environmental Watering Plans	Short-list of wetlands or waterways that require an Environmental Watering Plan, including specification of whether 'at risk' wetlands and waterways listed in Attachment A of the Minister's conditions require an Environmental Watering Plan or not. Provides rationale for those sites requiring Environmental Watering Plans. Includes schedule for development of EWP's, in relation to implementation of NVIRP's program of works.
Environmental Watering Plan	Water supply protocol to protect the high environmental values of a wetland or waterway, which would otherwise be adversely affected without the additional management and mitigation measures set out in the Environmental Watering Plan.
Regional Environmental Assessment Report	Report setting out: • the cumulative effects of the impact of NVIRP on the high environmental values wetlands and waterways; and • any additional management and mitigation measures required to be implemented through Environmental Watering Plans.
Groundwater Assessment Report	Report setting out: • the cumulative impacts of NVIRP works (capital works and connections) and their implementation of NVIRP works on the hydrology and hydrogeology of the GMID; and • the cumulative impacts of NVIRP actions on the hydrology and hydrogeology of the wetlands and waterways requiring Environmental Watering Plans (i.e. 'at risk').
Environmental Infrastructure Register	Register setting out infrastructure: • required to be maintained to deliver environmental water; and • enhancement, voluntarily agreed to by NVIRP.

The WCMF (Attachment D) outlines the four step process used to confirm the source(s) of water supply to the identified waterways and assess the potential impact to waterways in the GMID as result of the NVIRP.

4. Short-listing project methodology

This short-listing project is essentially a groundtruthing exercise intended to reduce uncertainties associated with Desktop assessments.

This project was undertaken by:

1. Reviewing the Desktop report and recommendations relevant to the waterways assessed.
2. Documenting environmental values of candidate waterways by undertaking a review of relevant reports and literature, discussions with key staff and site field visits
3. Documenting more detailed information about channel outfalls and the hydrological regime of candidate waterways (if available)
4. Assessing the likelihood for significant negative impacts to be caused by a reduction in outfalls to waterways, and whether or not further work, or the development of an EWP, was warranted.

5. Recommend timing for preparation of EWPs in relation to NVIRP's program of works

This Short-listing project assessed the preliminary listed waterways shown in Table 1.

Tasks 1 and 2 were undertaken by Feehan Consulting. Task 3 was undertaken by Hydro Environmental. Task 4 was undertaken by Feehan Consulting in close consultation with Hydro Environmental. This process is intended to provide information that will enable a risk assessment of the environmental impacts of reduced channel outfalls resulting from NVIRP works. Where there is a high risk of adverse impact further investigation and mitigation activities will be undertaken.

4.1. Methodology - hydrology

This project assessed the impacts of channel impact reduction on waterways. It did not assess impacts of ground water connections. Ground water connections will be assessed as part of the Ground Water Assessment Report.

To determine the relative impacts of reduction of outfalls on waterways the following process was undertaken:

- Confirm and map channel outfall locations.
- Identify route and distance from outfall to waterway.
- Obtain 2004/05 (base year for NVIRP water savings) outfall data.
- Identify if volumes of outfall water are likely to be utilised for other purposes e.g. diversion for irrigated production, to a wetland or other site/use, passing or environmental flow.
- Consult with local staff (G-MW & CMA).
- Assess data to determine if outfall volumes are reaching waterways.

4.2. Methodology - Environmental Assessment

This assessment process required, for potentially adversely impacted waterways:

- An assessment of whether or not the reduction in channel outfall is material
- Assessment of environmental value (or biodiversity significance) of the waterway.

High value sites are those that:

- are listed as a priority in RRHS because of environmental values
- have rare or threatened species records
- have a high score in the Saddlier et al (2009) NVIRP Threatened Species report
- are in, or are associated with, a Living Murray Icon Site or a Ramsar site
- or are otherwise recognized as a high value site in the documents reviewed.

The environmental assessment was made against the following tests:

Not at risk –

- The waterway is not recognized as a high value site.
- Waterway value not adversely affected by outfalls.
- Waterway value may improve due to reduction of outfalls.

Potentially at risk -

- The waterway is recognized as a high value site (either federally or by Victoria) and changes to channel outfall water volumes might affect the values of the waterway.
- Waterways that have insufficient information to make an assessment.

Further investigation or EWP development will be required for those sites identified as potentially 'at risk'.

Preparation of an EWP will require more detailed information about channel outfall reductions and environmental values than is presented in this Waterway Short-listing Report.

4.3. Information and reports of relevance

A substantial body of work describing waterways to be assessed already exists and this report has drawn heavily on these resources. Particularly relevant reports and information include:

Regional River Health Strategies

Regional River Health Strategies (RRHS) have been prepared for both the Goulburn Broken and North Central catchments (GBCMA, 2005; NCCMA, 2005b). These are supported by detailed information about waterway values and threats; however not all waterways assessed as part of the short-list process were included in RRHS (presumably because of their minor nature or transient flows and associated ecological values).

Threatened species – expert comment (Saddlier *et al*)

Saddlier S. *et al.*, 2009 provided expert comment on the environmental values known to occur or have occurred within the wetlands and rivers flagged by NVIRP as potentially affected by the irrigation renewal process. Initially ten waterways were assessed but this was updated to include sixteen waterways (They prioritised the sites using a number of criteria. Scores for each criterion have been weighted according to the level of importance they represent to the values within waterway and the impact they have on these values.

Table 4). Assessments are given on the reliability of the data underpinning the assessment. Information used was collated from a variety of sources. The report was used as a source of relevant information which is included in later waterway descriptions (Appendices A and B).

They prioritised the sites using a number of criteria. Scores for each criterion have been weighted according to the level of importance they represent to the values within waterway and the impact they have on these values.

Table 4 Waterways in prioritised order of known environmental values.

River/Creek	Score
Goulburn River downstream of Goulburn Weir	68.8
Broken Creek	39.8
Tongalong Creek	32.7

Pyramid Creek	30.8
Loddon River Downstream of Loddon Weir	23.1
Campaspe River downstream of Elmore	16.2
Tullah Creek	15.4
Pennyroyal Creek	13.8
Calivil Creek	5.2
Bannacher Creek	1.8
Sheepwash Creek	1.2
Nine Mile Creek	- (no records available)
Twelve Mile Creek	- (no records available)
Sevens Creek	- (no records available)
Wells Creek	- (no records available)
Yambuna Creek	- (no records available)

North Central CMA waterway descriptions

The North Central Catchment Management Authority (NCCMA) has produced a comprehensive catalogue of detailed catchment and waterway descriptions for over 300 rivers and creeks across the North Central Region. The catchment descriptions include general information about the economic, social and environmental aspects of the Campaspe, Loddon, Avoca and Avon-Richardson river catchments within the North Central region. (References - NCCMA, 2006a; NCCMA, 2006b; NCCMA, 2006c; NCCMA, 2006d; NCCMA, 2006e; NCCMA, 2006f; NCCMA, 2006g; NCCMA, 2006h; NCCMA, 2006i; NCCMA, 2006k; NCCMA, 2006l; NCCMA, 2006m; NCCMA, 2006n; NCCMA, 2006o; NCCMA, 2006p; NCCMA, 2006r).

Information from these descriptions has been extensively used in the site descriptions in Appendices A and B.

5. Short-listing outcomes – general comments

This short listing process assessed the environmental and hydrological conditions of each of the preliminary listed waterways. Information for each waterway comes from a variety of sources including literature searches, DSE and CMA databases and consultation with various stakeholders. Inspections of each waterway site were undertaken in late April 2009. This section provides a general overview of the outcomes of the shortlisting process.

A brief summary of the waterway specific assessments is provided in Section 6.

5.1. Types of Waterways

Most of the waterways assessed can be described in four broad categories:

- Waterways showing effects of an excessively wet current water regime
- Waterways as drains

- Waterways with values associated with high/flood flows
- Flow stressed

Some waterways can be classified into more than one of these categories.

Waterways in these categories can exhibit a range of environmental values from high to low.

Excessively wet current water regime

It is evident from field inspection that many of the waterways (particularly east of the Campaspe River) have been adversely affected by an excessively wet water regime resulting from channel outfalls. High water levels at inappropriate times of the year have resulted in dense stands of cumbungi (*Typha*) and dead standing trees killed as a result of waterlogging. Recent drier conditions have allowed river red gum regeneration to establish at many sites although the recruitment of this regeneration to mature trees will be dependent on maintenance of drier conditions.

Roberts J. *et al.*, 2000 noted that stands of *Typha* can rapidly establish under appropriate water regime or if the water regime changes and becomes suitable, such as ponded water, summer releases or major flooding. Such stands last as long as conditions remain wet enough. They also noted it is an invasive species, growing vigorously in response to disturbance, particularly altered water regime.

Action by NVIRP to reduce these outfalls will result in vegetation changes to these waterways which are assumed to be beneficial.

Waterways as drains

West of the Campaspe River most waterways have been affected by drainage works. Typically waterways are broad (50 to 100 m wide) shallow (2 to 3 m deep) depressions through which a small drain (2 to 3 m wide) has been constructed along the thalweg (the line joining the lowest points).

Graham Hall (Floodplain Officer with NCCMA) suggests most of these drains have been constructed to remove a 1 in 1 year rainfall event in 5 days (roughly a 25 mm event) or a 1 in 2 year event (roughly 37 mm). He has never seen channel outfall water extend beyond the confines of these constructed drains. He noted that recently there had been no growth in these drains (due to dry conditions) and that there had been little or no channel outfalls for the last 12 years.

Channel outfalls have little ecological or hydrological significance to this category of waterway.

Distributary waterways with values associated with high/flood flows.

Many of the waterways are distributary waterways (i.e. branches of a waterway that leave the main waterway and do not rejoin it) or anabranches that leave the main waterway and rejoin it lower in the catchment. Unless modified, these distributary waterways and anabranches flow only in times of high flow or flood.

These waterways have large channel capacities, extensive wetted area at high flows and values that are within the extensive wetted area. For example, the values associated with both Tullah and Tongalong Creeks, in Barmah Forest, depend on the presence of high, or flood, flows in the River

Murray. Many of the waterways west of the Campaspe River also have values associated with high or flood flows.

For these waterways channel outfalls provide little, if any, contribution to environmental values.

Flow stressed

Flows in some waterways are currently running at very low levels and substantial management effort is required to maintain flows to preserve values. Any reduction in channel outfalls to these waterways could impact on values.

5.2. Channel outfall analysis

Updated hydrological descriptions and outfall analysis for most waterways are provided in the following sections. Tabulated detailed outfall analyses are shown in Appendix C. The assessment has generally focused on volumes of water, although for Calivil Creek more detailed assessment timing of delivery of water was undertaken due to presence of values that might be impacted by both volume and timing of water delivery.

Outfall Volume

The waterways for which further consideration of the impact of reduced channel outfalls on waterway flow regimes and environmental values is required receive a total of 25 GL of outfall water from 104 outfall sites throughout the NVIRP area (refer to preliminary list of waterways in Table 1). Seventeen of these outfalls also contribute outfall water (15 GL) to the Goulburn River after passing through tributary waterways.

Reduction of Outfall Water Volume due to NVIRP Activities

There are at least three ways waterways (rivers and streams) may be adversely affected by NVIRP activities:

- Reductions in flow from direct outfalls to the waterway.
- Reductions in flow from indirect outfalls to the waterway (outfalls to drain which outfall to waterways).
- Reductions in flow due to reductions in outfalls to other waterways (i.e. Goulburn River receives flows from several waterways that receive outfalls).

The potential for outfall reductions to impact on waterways needs to be also considered in the context of drainage diversions, distance from outfall site to waterway, the type of receiving waterway (regulated or unregulated waterways with ephemeral or continuous flows), whether the waterway has been altered (i.e. drainage system) and management activities of other stakeholders (e.g. implementation of streamflow management plans, system efficiency improvements).

Drain Diversions

There has been substantial management effort made over many years to reduce the volume of channel outfalls due to concerns about salinity and nutrient impacts on waterways and moves to manage the existing system more efficiently.

One of the mitigation methods is encourage diversion of drainage flow including outfalls either directly or into farm reuse systems. This effort has resulted in substantial reduction in drain flows which discharge to regional waterways.

Where possible the impact of drainage diversion on the volume of outfall water reaching waterways has been estimated by comparing outfall volumes with licensed drain diversion volumes.

Travel Distance

The significant distance (up to 40km) that some of the outfall water travels through drainage systems to waterways means that it is likely that some of the outfall water will be lost in the drain due to seepage and evaporation. This is particularly likely if the outfall is due operational issues (i.e. unauthorised meter shutdown) which are often small discharges of 0.5 - 5 ML/d.

Altered waterways

A number of the waterways being assessed are utilised as part of the irrigation supply or drainage systems.

Natural Carriers

Pyramid Creek — Regulated natural carrier on the Torrumbarry Irrigation System. The creek passes flows from Kow Swamp through the Kerang Weir Pool to the Torrumbarry No 7 Channel which passes through the Kerang Lakes.

Serpentine Creek — Regulated natural carrier on the Pyramid Channel 12 system. Under natural conditions takes flood flows from Loddon River near Serpentine and splits the flow between the Pennyroyal and Nine Mile Creeks north of Durham Ox. Currently two outfall structures control flow to the Pennyroyal and Nine Mile Creeks. The Pennyroyal Outfall is part of the Strategic Measurement Program and is SCADA controlled. All outfall water is passed to the Pennyroyal Creek. No outfalls flow to the Nine Mile Creek

Drainage Systems

Yambuna Creek — Yambuna Creek runs between the Goulburn River and Kanyapella Basin originally transferring flood flows from the River to Kanyapella Basin. Yambuna Creek is part of the regional drainage network as the drainage outfall for the Wyuna Main Drain and the Coram Main Drain.

Wells Creek — Wells Creek has been incorporated into the regional drainage network as the ultimate outfall of the Rodney Main Drain (SKM, 2008). Wells Creek drainage from

the CG 5-9 area in the NVIRP and also receives drainage from the Central Goulburn 1 – 4 area, which has already been modernised.

Nine Mile Creek — Nine Mile Creek is a tributary of the Serpentine Creek System on the Loddon River floodplain. Under natural conditions the creek would flow from the Serpentine Creek near Durham Ox to the Pyramid Creek east of Kerang. The lower reaches of Nine Mile Creek have been incorporated into the regional drainage network. The Nine Mile Creek drainage system flows into the Calivil Creek Drain and ultimately to the Barr Creek.

Calivil Creek — Under natural conditions the Calivil Creek would flow to the Pyramid Creek east of Kerang. Calivil Creek has been heavily modified due to the development of the creek into a community service drainage system that ultimately flows into Barr Creek.

Strategic Measurement Project

The G-MW Strategic Measurement Project (SMP) involved the installation of continuous measurement structures at strategically selected major offtakes and outfalls across the Goulburn System (Shepparton, Central Goulburn, Rochester, Campaspe, and Pyramid Boort irrigation areas) to reduce water balance data uncertainty and improve operational efficiency. The project seems to have substantially reduced channel outfalls. Data was used for assessment of impacts.

6. Outcomes of Specific Waterway Assessments

This Section provides a brief summary of the outcomes of the assessment of each waterway. Detailed data sheets describing the environmental and hydrological conditions for each waterway, including site maps are included in Appendix B. A summary of outfall sites and volumes for each waterway is included in Appendix C.

6.1. Bannacher and Pennyroyal Creeks

Description

Serpentine Creek splits into Pennyroyal and Nine Mile Creek approximately 2km downstream of Durham Ox. Pennyroyal Creek is an 18km long intermittent creek that flows in a northerly direction to Bannacher Creek at Canary Island.

Bannacher Creek is a 50km long creek that branches from Serpentine Creek south of Durham Ox and flows north to the Loddon River near Tragowel Swamp. Under natural conditions both would be classified as ephemeral.

Environmental values

The NC RRHS lists Reach 11 as a priority. Records of Magpie Goose (near threatened), Brolga (vulnerable), Bearded Dragon (data deficient), Murray Cod, Silver Perch and Golden Perch (fish records

from 1981) are noted. These creeks have high environmental values although many of these values do not currently exist due to dry conditions. These values are associated with flooding in the Loddon River and cannot be attributed to channel outfalls.

Channel outfalls

The outfall to the Pennyroyal Creek is effectively a weir to divert water into Pyramid Channel 12 and has an outfall volume (2004/2005) of 1147 ML. Due to the close proximity of the outfalls to the Pennyroyal Creek and the absence of drainage diverters, it is considered likely that outfall water will reach the Creek. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP, unless the Serpentine Creek is removed from the System, due the relatively long travel time of ordered flows from the Waranga Western Channel.

There are only two outfalls connected to the Bannacher Creek which enter the Bannacher River directly via channel 1/12 with an outfall volume (2004/2005) of 74 ML. In 2004/2005 the ST009752 had an outfall volume of 0 ML, therefore no water will be outfalled from this site.

Conclusion

Not at risk due to

- the values of these creeks being associated with flood flows; and
- channel outfall water being unlikely to make any contribution to environmental values.

6.2. Broken Creek

Description

The Broken Creek lies within the Goulburn Broken Catchment, diverging from the Broken River at Caseys Weir west of Lake Mokoan and flowing north-west into the Murray River.

Environmental Values

The fauna of the Broken Creek is diverse and represents a range of species due to a complex of habitats available. These include aquatic, riparian and woodland areas that provide habitat to many animal species including some listed species. In the waterway corridor (defined as being within 100 m of the creek) at least 13 significant listed fauna species have been identified, including three fish, a frog, two reptiles, five waterbirds and a mammal species.

The Broken Creek is rated as “high significance” in terms of significant flora. This reflects the presence of endangered and depleted Ecological Vegetation Classes along most of the length of the creek.

Channel outfalls

The system is currently operating at the lower end of the flow range. Any potential reductions in channel outfalls may have flow management implications. There are 20 outfalls that enter Broken Creek directly from various irrigation channels, Murray Valley Drains 10, 13 and 18 and the Muckatah Drain. A total volume of 2991 ML was outfalled in 2004/2005. Based on volume of outfall water being

significantly larger than the drainage diversion volume for outfalls entering Broken Creek, it is considered likely that at least 50% of water outfalled from the channel system will enter Broken Creek.

The NVIRP TAC reviewed the draft Phase 1 recommendations at a workshop on 16 October 2008. They confirmed that Boosey Creek has an upper ephemeral section and a lower section where an operational outfall comes in shortly upstream from the junction with Broken Creek. They considered this outfall (ST066229) should be incorporated in the Broken Creek analysis. Outfall ST066229 had an outfall volume of 365 ML in 2004/2005.

Conclusion

The waterway is potentially at risk.

6.3. Bullock Creek

Description

Bullock Creek flows intermittently for 70km in a northerly direction from the Waranga Western Main Channel (WWMC) at East Loddon to Pyramid/Box Creek, approximately 10km south of Cohuna.

Environmental Values

The creek provides habitat for the endangered Grey-crowned Babbler, Australasian Bittern and Black Falcon and the vulnerable Brolga and Greater Long-eared Bat.

The values of Bullock Creek are associated with flood flows and cannot be attributed to cannel outfalls.

Channel outfalls

The downstream reach of Bullock Creek is incorporated into the regional drainage network (SKM. 2008). There are nine outfalls that enter Bullock Creek directly from the Pyramid irrigation system which outfalled a volume of 97 ML in 2004/2005. The main outfall contributor is ST008683 which enters Bullock Creek directly from Pyramid Channel 3/1 and contributes 90 % of the outfall likely to enter the Creek. It has also been noted that the ST008663 outfall water is used as a source of re-use water (SKM assessment). This information has been further summarised in **Error! Reference source not found.** below.

The distance between the outfalls and entry point into Bullock Creek is < 3.5 km and no drainage diverters have been indentified downstream of the outfall points.

Conclusion

Not at risk due to:

- the values of the creek being associated with flood flows;
- channel outfall water being unlikely to make any contribution to environmental values.

6.4. Calivil Creek

Description

Calivil Creek is approximately 100km long and flows on a northerly course from Serpentine to Pyramid Creek at Kerang. Flows are ephemeral. Most of the creek has been channelised

Environmental Values

Brolgas are known to use wetlands along the creek (Davidson S., 2006 and Simon Starr (local landholder)). Brolga are reported to nest along the creek in the vicinity of Hampson's Rd, Yarrawolla. Three or four other breeding sites exist along the creek, and that at times, channel outfall water is important to maintain the integrity of the breeding site (i.e. keeping enough water around the site to keep foxes away from the nest). Values are associated with flood flows and cannot be attributed to channel outfalls.

Channel outfalls

Calivil Creek has been heavily modified due to the development of the Creek into a community service drainage system that ultimately flows into Barr Creek. Outfall volumes seem to have dropped significantly since implementation of G–MW loss management program (2002/03) and again since SMP (2006?) and drought management operational initiatives

There are eight outfalls that enter Calivil Creek via the Calivil Creek Drain 12, Outfall Drain 1 and directly via Pyramid irrigation system. The total outfall volume in 2004/05 was 396 ML. Six outfalls enter the Calivil Creek directly via the irrigation channel system and contributed a combined outfall volume of 40 ML in 2004/2005. Two of these outfalls (ST009189 and ST009118) both had an outfall volume of 0 ML in 2004/2005. Outfall ST009723 enters the Calivil Creek via Outfall Drain 1 and is the main outfall contributor to the Creek (356 ML), making up 90 % of the total outfalls entering the Creek. The relatively close proximity of some of the major outfall contributors to the Creek indicates most outfall water could reach the Creek, however after taking into account the likely diversion of outfall water entering Calivil Creek from the spur drains, it is considered likely that at least 70 % of water outfalled from the channel system will enter Calivil Creek.

Analysis of channel outfall data from recent years suggests outfall water would provide little benefit for Brolga nesting.

Conclusion

Not at risk due to:

- the values of the creek being associated with flood flows; and
- channel outfall water is unlikely to make any contribution to environmental values.

6.5. Campaspe River

Description

The entire reach of the Campaspe River within the Campaspe Plains Management Unit, meanders across a level alluvial plain. From Forest Creek to Riverlea (midway between Rochester and Echuca) the floodplain is generally less than one kilometer wide, but broadens out to widths of more than 2km downstream to Echuca. One large anabranch exists on the flood plain below Strathallen and this carries flow during floods and receives channel and drainage outfalls.

Environmental Values

Listed in the NCCMA RRHS as a priority reach. The lower Campaspe River has supported a number of native fish species, including Murray Cod. Records of 8 birds, 2 reptiles and 6 fish of conservation significance are noted.

The Campaspe River downstream of the Campaspe Weir is also a known groundwater discharge point resulting in high water salinity level during periods of low flow.

Channel outfalls

Campaspe River potentially receives outfall water from eight outfalls, two from the Campaspe Irrigation District (CID), south of Rochester and six from the Rochester Irrigation Area (RIA), north of Rochester. Five of the outfalls from the RIA are linked to Campaspe Drains 2 and 3 and Rochester Drain 4.

The total outfall volume for the “base year” from the eight outfalls is 426 ML. Flows in the river are currently being closely managed due to drought conditions and are at the very low end of the range of expected flows. Any further reduction in river flow due to reductions in channel outfalls could have serious management implications on environmental values and river salinity.

Conclusion

Potentially at risk.

The Campaspe River is assessed as being of high environmental value and potential reduction if channel outfalls could impact on flows in the river, especially in low flow years. It is noted that NVIRP has requested NCCMA to undertake preparation of an interim EWP. Information from this task will enable a detailed assessment of the need for preparation of a full EWP

6.6. Loddon River

Description

The Desktop assessment broke the Loddon River into a number of reaches. For the Short-list review process the Loddon is considered as 2 separate reaches (Torrumbarry IA and Pyramid Boort IA).

Environmental Values

A number of plans have identified environmental values (environmental assets) in the Lower Loddon catchment that are currently threatened by activities carried out in the area. These include the North Central Regional Catchment Strategy (NCRCS), North Central River Health Strategy (NCRHS), Loddon

Murray Land and Water Management Strategy, the Bulk Water Entitlement (BE) conversion process, the Kerang-Swan Hill Future Land Use Pilot Project, and the Kerang and Gunbower Forest Ramsar Site Strategic Management Plans.

Channel outfalls

Loddon River – Torrumbarry IA - Six outfalls enter the Loddon River directly via Channel 1, 4, 6, and 7, with a combined outfall volume of 1196.8 ML in 2004/2005. Based on the close proximity of the outfalls to the Loddon River and the absence of drainage diverters, it is considered likely that a significant amount of the water outfalled from the six outfalls will reach the River.

Loddon River – Pyramid Boort IA - There are six outfalls that enter the Loddon River directly from Boort Channels 1, 2, 3/2/8/2, 9/2 and 1/9/2 which outfalled a volume of 621 ML in 2004/2005. Due to the close proximity of the outfalls to the Loddon River and the absence of drainage diverters, it is considered likely that the majority of the water outfalled will reach the Loddon River

Conclusion

The waterway is potentially at risk and it is recommended that further investigations be undertaken for both reaches due to:

- The Loddon River having high values (associated with high value wetlands, RRHS high priority, threatened flora and fauna)
- The hydraulic links to high value wetlands
- Potential operational changes due to NVIRP
- The interactions that the Loddon River has with the Goulburn Irrigation System at Loddon Weir and
- River flows that might be impacted more by overall NVIRP impacts than NVIRP channel outfall impacts.

6.7. Nine Mile Creek

Description

Serpentine Creek splits into Pennyroyal and Nine Mile Creek approximately 2km downstream of Durham Ox. Nine Mile Creek flows 43km in a north-easterly direction to Calivil Creek near Tragowel Swamp. Flows are ephemeral. At both Macorna Road and the Murray Valley Highway Nine Mile Creek is a broad depression 60-80 m wide and approximately 1 m deep

Environmental Values

No high value records are noted.

Channel outfalls

Nine Mile Creek receives water from 10 outfalls sites. Nine outfalls enter the lower reaches which form the Nine Mile Creek drainage system, whilst the other one is located in the upper reaches. 214 ML is estimated to outfall to the waterway. After taking into account the drainage diversion volume

which could be diverted for use, it is considered likely that at least 70% of the total outfall volume could enter Nile Mile Creek. However the distance travelled by the outfall water to the Creek indicates that further outfall water may be lost due to seepage and evaporation before entering Nile Mile Creek.

Conclusion

Not at risk due to:

- the values of the creek being associated with flood flows; and
- channel outfall water being unlikely to make any contribution to environmental values.

6.8. Pennyroyal and Nine Mile Creek – immediately downstream of Serpentine Creek outfalls

Description

These waterways were not assessed during the Desktop Assessment. North Central CMA requested the NVIRP TAC to further investigate Pennyroyal and Nine Mile Creeks immediately downstream of their outfalls from Serpentine Creek. The basis of this request was that current outfall structures leak water which maintains water dependent EVC values for a short section downstream of the structures.

These values do not continue lower into these creek systems.

Environmental Values

These sections of creek, immediately downstream of outfall from Serpentine Creek support water dependent EVC values. It is assumed that these short reaches will have similar values to Serpentine Creek due it proximity and connectiveness.

Serpentine Creek is listed as a priority waterway in the NCCMA RRHS.

Channel outfalls

No outfalls flow to the Nine Mile Creek; however observation strongly suggests that water leaking through or around this structure maintains water dependent EVC values.

Analysis was carried out to determine the relationship between the outfall volume and rainfall events at the Pennyroyal Creek. The result of this analysis clearly indicated that the volume of outfall is largely a result of rainfall rejection. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP, unless the Serpentine Creek is removed from the System, due the relatively long travel time of ordered flows from the Waranga Western Channel.

Conclusion

Pennyroyal Creek is not at risk due to the lack of impact of reduced channel outfall. . The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP automation works.

The section of Nine Mile Creek immediately downstream of the offtake structure on Serpentine Creek is potentially at risk. Although no channel outfalls occur to Nine Mile Creek from Serpentine Creek the

NVIRP may undertake works which eliminate the leakage supporting EVC values immediately downstream of the outfall.

6.9. Pyramid Creek

Description

There is some confusion about this waterway. Pyramid/Box Creek (Torrumbarry Irrigation Area) is fully regulated downstream of Kow Swamp. The Desktop Assessment recommended this waterway not be considered for further investigation.

Pyramid Creek (Pyramid Boort IA) refers to Pyramid Drain 1 and Pyramid Drain 2/1 that outfall to Pyramid Creek in the vicinity of gauging station 407296 (just upstream of Hirds and Johnsons Swamps). The waterway (depression) flows in a northerly direction from west of Pyramid Hill and is channelized for most of its length.

Environmental Values

Channel outfalls discharge to drains, which have minimal environment values.

Channel outfalls

There are six outfalls that enter the Pyramid Creek via the Pyramid Drain 1 and Pyramid Drain 2/1. One outfall is linked to the Pyramid Drain 1 (ST063422) and had an outfall volume of 681 ML for 2004/2005. This outfall is the main outfall contributor for Pyramid Creek, contributing 85% of the total outfalls into the Creek. There is likely to be some impact on flow in the drain as a result of reduced channel outfall.

Conclusion

Not at risk due to the low environmental values.

6.10. Sevens Creek

Description

This ephemeral waterway is adjacent to Seven Months Creek, near Pyramid Hill. It flows in a north westerly direction from near Pyramid Hill discharging eventually into Calivil Creek

Environmental Values

Downstream of the outfall and adjacent to the Boort Pyramid Road the waterway flows through cultivated and grazed paddocks. There is no riparian vegetation. Environmental values are very low

Channel outfalls

Sevens Creek is a minor waterway in the Pyramid Boort district that only receives one outfall. ST008772 enters the waterway directly from Pyramid Channel 12/1 and had an outfall volume of 8 ML in 2004/2005.

Conclusion

Not at risk due to the low environmental values and the lack of impact of channel outfall reduction

6.11. Sheepwash Creek

Description

Sheepwash Creek is an ephemeral waterway that drains the River Murray floodplain west of Koonoomoo. It drains into Ulupna Creek, an anabranch of the River Murray. Flow depth and rate in Ulupna Creek are dependent on rates of flow in the Murray. At times of high, or flood, flow, water from Ulupna Creek/River Murray would back up into the very lower reaches of Sheepwash Creek.

Environmental Values

VicRoads, 2000 undertook an environment effects statement for the Strathmerton Deviation. The study area included Sheepwash Creek. The Report assessed aquatic ecology and noted the presence of a diversity of native fish species in the River Murray and an unnamed lagoon on the Victorian side of the border. No special mention was made of Sheepwash Creek. Vegetation in bed of Sheepwash Creek tends to be cumbungi, and along with evidence of trees killed by waterlogging is indicative of un-naturally wet conditions. River red gum occurs on the creek banks and well into the creek bed. No pools of water were apparent in April, indicating the aquatic values will be climate or flood driven.

Channel outfalls

There are five outfalls from the irrigation system associated with the NVIRP entering the Creek (SKM, 2008). All outfalls that enter Sheepwash Creek enter via Strathmerton Drain 3. The combined outfall volume for the five outfalls in 2004/2005 was 194 ML, There is significant distance between the outfalls and their entry to Sheepwash Creek, with four out of the five outfalls being located more than 14 km from the entry point. As a result it is likely that some of the outfall water will be lost in the drain due to seepage and leakage. Due to drainage diversion licence volumes being greater than the combined outfall volumes at the four upstream outfall sites and the distance of the outfalls to the entry point of Sheepwash Creek (2 – 19.5 km) it is unlikely the Creek will receive outfall water.

Conclusion

The waterway is not at risk due to:

- the lack of impact of reduced outfalls on waterway flow
- the impact of reduced channel outfall being considered to be an ecological improvement by returning the water regime of the waterway to more natural conditions and
- the values of Sheepwash Creek are associated with flood flows from the River Murray and can only be attributable in a small way to channel outfalls.

6.12. Tongalong Creek

Description

This is part of a small anabranch of the River Murray. Black Engine Creek takes water from the Murray at high flow and it is returned to the Murray via Tongalong Creek. Channel outfalls and surface drainage water are discharged from Murray Valley Drain 6 into Tongalong Creek at its junction with Black Engine Creek.

Environmental Values

The Tongalong Creek is located within the Barmah Forest, which is a Ramsar site and listed on the Directory of Important Wetlands in Australia (http://www.environment.gov.au/cgi-bin/wetlands).

Channel outfalls

Tongalong Creek has a total of 10 outfalls that enter the waterway via Strathmerton Drain 6. Of the 10 outfalls, only five recorded outfall volumes in 2004/2005 having a combined outfall volume of 1136 ML.

There are 36 drainage diverters along the drain with a combined drainage diversion licence volume of 3641 ML. 18 of these drainage diverters have been identified downstream of the three main outfall sites, with a total drainage diversion licence volume of 2795 ML.

The distance between the 10 outfalls and their entry point into the Tongalong Creek ranges between 14 km and 29 km. This significant distance indicates that it is likely that some of the outfall water will be lost in the drain due to seepage and evaporation. The majority of water outfalled into Drain 6 is likely to be diverted for productive use as the volume diverted being significantly larger than the volume outfalled or lost to seepage and evaporation in the drain due to the distance of the outfalls from Tongalong Creek. It is considered unlikely that significant flows of outfall water will enter Tongalong Creek.

Conclusion.

The waterway is not at risk due to:

- the values of Tongalong Creek being derived from its association with the River Murray and its floodplain and not from channel outfall
- lack of evidence of low flow dependent ecological values
- the beneficial impact of reduced channel outfalls.
- the lack of impact of reduced outfalls on waterway flow

6.13. Tullah Creek

Description

Tullah Creek is an ephemeral, large, anabranch/flood runner of the River Murray. It generally runs along the southern boundary of Barmah Forest and flows through Top Lake then to Bucks Lake and Budgee Creek and back into the Murray. It generally is expected to flow only in times of flood.

Environmental Values

The Tullah (or Smiths Creek) is located within the Barmah Forest, which is a Ramsar site and listed on the Directory of Important Wetlands in Australia (http://www.environment.gov.au/cgi-bin/wetlands).

Channel outfalls

There are four outfalls that potentially enter the Tullah Creek, with ST053754 outfalling directly into Barmah Drain 7 with the remaining three outfalls directly into Barmah Drain 9. Only three of the outfalls recorded outfall volumes in 2004/2005 with a combined outfall volume of 958 ML. Due to the close proximity of the outfalls to Tullah Creek and the likely absence of drainage diverters along the relevant sections of Barmah Drain 7 and Drain 9 it is expected that the majority outfall water from all four sites will enter the Creek.

Conclusion

Not at risk due to:

- Tullah Creek deriving its values from major flood flows and its association with Barmah Forest
- Changes to outfall volumes are unlikely to affect the values of the waterway
- Lack of evidence of low flow dependent ecological values.
- the lack of impact of reduced outfalls on waterway flow.

6.14. Twelve Mile Creek

Description

Twelve Mile Creek is a 16km long anabranch of the Loddon River, leaving the eastern bank east of Lake Yando and re-entering the river at Appin South

Environmental Values

Twelve Mile Creek can be expected to have similar values as the adjacent Loddon River (RRHS Reach 4). In the NCCMA RRHS Reach 4 is assessed as a priority because of links to the Kerang Wetlands and the River Murray.

Channel outfalls

There are two outfalls that directly enter the Creek from channel 1/1/12 and 2/1/1/12 which had a combined volume of 85 ML in 2004/2005.

Conclusion

Potentially at risk. Assumed to have the same high values as the Loddon River.

6.15. Wells Creek

Description

Wells Creek is an ephemeral waterway draining part of the floodplain of the Goulburn River north of Undera. The Rodney Main Drain outfall, through which the bulk of channel outfall waters discharges to Wells Creek, is only approximately 1 km above the junction of Wells Creek and the Goulburn River. Wells Creek, downstream of the Rodney Main Drain outfall, is channelised. The lower sections (below Rodney Main Drain outfall) of the creek have substantial areas of rock beaching

Environmental Values

Vegetation along the creek is a mixture of River red gum and grey box. Below the Rodney Main Drain outfall no riparian vegetation is evident.

Upstream of Munroes Swamp, Wells Creek is a broad depression with no evidence of waterlogging or riparian vegetation. Another tributary of Wells Creek has characteristics of a floodway being enclosed by levees. Cumbungi indicates waterlogging.

A branch of Wells Creek passes along the southern boundary of Munroes Swamp. Discussions with Simon Casanelia (GBCMA) indicate that in the vicinity of the creek, wetland vegetation is mainly Phragmites, indicating substantially wetter conditions that the rest of the swamp and most likely due to excess flows in the creek.

Channel outfalls

Wells Creek has been incorporated into the regional drainage network as the ultimate outfall of the Rodney Main Drain (SKM). Wells Creek receives water from five outfalls from the CG 5-9 system in the NVIRP area with a total outfall volume of 8825.9 ML for 2004/2005. Wells Creek also receives outfalls from the Central Goulburn 1 – 4 systems, which has already been modernized. Based on volume of outfall water being significantly larger than the drainage diversion volume and the close proximity of one of the major outfall contributors to Wells Creek (ST063945), it is considered likely that at least 75% of the volume of water outfalled will enter Wells Creek.

Conclusion

Not at risk due to:

- Presence of environmental values which would be enhanced by a change to its water regime.
- Its values can only be attributed to channel outfalls in a small way
- The site is not recognised as high value
- The great bulk of outfall water discharges from the Rodney Main Drain to a channelized section of Wells Creek about 1 kilometre above its junction with the Goulburn River.

6.16. Yambuna Creek

Description

This is an ephemeral distributary/flood runner of the Goulburn River. It receives drainage water from the Wyuna and Coram Drains and discharges to the Goulburn River via a drain running across the northern edge of Kanyapella Basin and Warragul Creek. During floods, high flows can reach Kanyapella Basin via Yambuna Creek

Environmental Values

This waterway is not listed in the Goulburn Broken Regional River Health Strategy.

East of Scobie Road the creek is a broad woodland lined depression (grey box and river red gum). To the west of Scobie Road there is substantial evidence of waterlogging – cumbungi and dead red gums. Similar conditions can be seen at Curr Road and Day Road.

DPI, 2009 reviewed optional environmental watering points for high value wetlands in the Shepparton Irrigation Region. For Kanyapella Basin they noted that water delivery should be via Tongala Drain 1 which enters the basin from the south. (Note that Hydro Environmental, 2009 assessed Kanyapella Basin as not impacted by NVIRP).

Channel outfalls

Outfalls either enter Yambuna Creek via the Wyuna Main Drain or the Coram Main Drain. Seven outfalls enter the Wyuna Main Drain directly or via Wyuna Drains 3, 4 or 7 and contributed 6479.7 ML of outfall water in 2004/2005. The distance between the 12 outfalls and their entry point into Yambuna Creek ranges between 1 km and 27 km. One of the major outfall contributors (ST046953) is located 1 km from Yambuna Creek; therefore it is likely that the majority of water outfalled from this site will reach the Creek. In contrast, the significant distance that some of the outfall water travels means that it is likely that some of the outfall water would be lost in the drain due to seepage and evaporation.

Conclusion

Not at risk due to:

- environmental values which would be enhanced by a change to its water regime.
- its values can only be attributed in a small way to channel outfalls
- the site is not recognised as high value.
- reduced flows are not expected to impact on Kanyapella Basin.

7. Conclusions

7.1. Hydrological assessment conclusions

The outcomes of the hydrological assessment are summarised in Table 5.

Table 5 shows the volume outfalled as a percentage of each sites outfall volume.

In general it can be concluded:

- the portion of outfall sites that outfall direct to waterways is 35% with 23% of the outfall volume, the remainder being subject to loss within the water ways (evaporation, seepage) and diversion.
- approximately 35% the total outfall volume for the sites assessed is diverted is diverted for productive use; and
- approximately 50% of the outfall sites are located over 5km (up to 40km) from the nominated waterway which means that a further quantity of water (not quantifiable) is not likely to reach the waterway due to loss through seepage and evaporation, therefore most waterways will receive less outfall water than shown in Table .
- greater than 35% of the water outfalled is unlikely to enter the waterways.
- two water ways are unlikely to receive any outfall water due drain diversion:
  - Tongalong Creek
  - Sheepwash Creek
- the modernisation of the channel system will reduce the outfall volumes flowing in to the waterways
  - Direct by 85%
  - Indirect by at least 85% as less water in drains will mean a greater proportion of the volume outfalled will be lost to seepage and evaporation.

Table 5 Summary of outfalls

Waterway	Total No. Outfall Sites	Total Outfall Volume 04/05 (ML)	Direct to Waterway		Indirect to Waterway					Total Outfall Volume Received by Waterway Outfall Volume (ML)
			No. Outfall Sites	Outfall Volume (ML)	No. Outfall Sites	Outfall Volume (ML)	No. Diverters	Total Diversion Licence Volume (ML)	No. Outfall Sites	
Bannacher Creek	2	74	2	74	0	Bannacher Creek	2	74	2	74
Broken Creek	20	2991	8	1500	12	Broken Creek	20	2991	8	1500
Bullock Creek	9	97	9	97	0	Bullock Creek	9	97	9	97
Calivil Creek	8	396	6	40	3	Calivil Creek	8	396	6	40
Campaspe River	8	686	3	260	5	Campaspe River	8	686	3	260
Loddon River	6	621	6	621	0	Loddon River	6	621	6	621
Loddon River d/s Kerang	6	1861	6	1861	0	Loddon River d/s Kerang	6	1861	6	1861
Nine Mile Creek	10	295	3	22	7	Nine Mile Creek	10	295	3	22
Pennyroyal Creek	1	1147	1	1147	0	Pennyroyal Creek	1	1147	1	1147
Pyramid Creek	6	797	0	0	6	Pyramid Creek	6	797	0	0
Sevens Creek	1	8	1	8	0	Sevens Creek	1	8	1	8
Sheepwash Creek	5	194	0	0	5	Sheepwash Creek	5	194	0	0
Tongalong Creek	10	1136	0	0	10	Tongalong Creek	10	1136	0	0
Tullah Creek	4	958	0	0	4	Tullah Creek	4	958	0	0
Twelve Mile Creek	2	85	2	85	0	Twelve Mile Creek	2	85	2	85
Wells Creek	5	8826	1	525	4	Wells Creek	5	8826	1	525
Yambuna Creek	12	7372	0	0	12	Yambuna Creek	12	7372	0	0
TOTAL	115	27543	48	6239	68	TOTAL	115	27543	48	6239

Table 5 Proportion of outfall volume entering each waterway.

Waterway	% Direct	% Indirect	%Diverted	% Outfalled to Waterway
Bannacher Creek	100	0	0	100
Broken Creek	50	50	48	52
Bullock Creek	100	0	0	100
Calivil Creek	10	90	30	70
Campaspe River	38	62	32	68
Loddon River	100	0	0	100
Loddon River d/s Kerang	100	0	0	100
Nine Mile Creek	7	93	27	73
Pennyroyal Creek	100	0	0	100
Pyramid Creek	0	100	34	66
Sevens Creek	100	0	0	100
Sheepwash Creek	0	100	100	0
Tongalong Creek	0	100	100	0
Tullah Creek	0	100	0	100
Twelve Mile Creek	100	0	0	100
Wells Creek	6	94	25	75
Yambuna Creek	0	100	52	48
TOTAL	23	77	35	65

7.2. Conclusion from Environmental Assessment

The following waterways were assessed to have high environmental values:

Table 6 Waterways with high environmental values.

Waterway	Environmental value
Bannacher and Pennyroyal Creek	Brolga recorded
Broken Creek	Priority reach in GBRRHS
Bullock Creek	Brolga recorded
Calivil Creek	Brolga recorded and nesting
Campaspe River	High priority in NCCMA RRHS
Loddon River	High priority in NCCMA RRHS
Nine Mile Creek immediately downstream of Serpentine Creek outfall	Values associated with Serpentine Creek - high priority in NCCMA RRHS
Pennyroyal Creek immediately downstream of Serpentine Creek outfall	Values associated with Serpentine Creek - high priority in NCCMA RRHS
Tongalong Creek	Associated with Barmah Forest (Ramsar site; Living Murray Icon Site)
Tullah Creek	Associated with Barmah Forest (Ramsar site; Living Murray Icon Site)
Twelve Mile Creek	Values associated with Loddon River – high priority in NCCMA RRHS

7.3. Shortlisting process

The information provided from the environmental and hydrological investigations has been combined to determine waterways that are 'potentially at risk" and "not at risk".

Table 7 NVIRP works schedule and waterways recommended for further investigation.

Waterway	Waterway has high environmental values	Associated with high environmental value wetland	Environmental values attributable to outfalls	Expected change in flow regime as a result of NVIRP project	Risk	Further assessment or EWP required?
Bannacher and Pennyroyal Creeks	Y (Brolga)	N	N	N	Not at risk	No
Broken Creek	Y	Y - (Barmah Forest, Kinnaird's Swamp, Black Swamp)	tbd	Y	At risk	EWP
Bullock Creek	Y (Brolga)	N	N	N	Not at risk	No
Calivil Creek	Y (Brolga)	N	N	N	Not at risk	No
Campaspe River	Y	N	Y	Y	At risk	EWP
Lodon River – Pyramid Boort IA	Y	Y - (wetlands in Wandella Creek on west side of river)	Y	Y	At risk	EWP
Loddon River – Pyramid Boort IA - (cumulative outfalls)	Y	Y	?	tbd	At risk	EWP
Loddon River - Torrumbarry IA - Cumulative impacts		Y	tbd	tbd	At risk	EWP
Loddon River (Torrumbarry IA)		Y	?	tbd	At risk	EWP
Nine Mile Creek	N	N	N	N	Not at risk	No
Nine Mile Creek – immediately downstream of outfall from Serpentine Creek	Y	N	Y	Y	At risk	Further assessment
Pennyroyal Creek immediately downstream of outfall from Serpentine Creek	Y	N	Y	N	Not at risk	No
Pyramid Creek	Y (Brolga)	N	N	N	Not at risk	No
Sevens Creek	N	N	N	N	Not at risk	No
Sheepwash Creek	N	N	N	N	Not at risk	No
Tongalong and Tullah Creeks	Y	Y - (Barmah Forest)	N	N	Not at risk	No
Twelve Mile Creek	Y - due to its close association with the Loddon River	N	N	tbd	At risk	EWP
Wells Creek	N	N	N	Y	Not at risk	No
Yambuna Creek	N	Y (Kanyapella Basin)	N	Y	Not at risk	No

A comparison of this short-listing assessment and the Desktop Assessment is summarised in - Appendix A.

The following waterways are recommended for development of an EWP:

- Broken Creek – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed creek.
- Campaspe River – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed river.
- Loddon River (Torrumbarry and Pyramid Boort IA) – undertake further detailed investigations into impacts of channel outfall reduction and potential system operation change on the waterway
- Twelve Mile Creek (undertake with Loddon assessments)

The following waterway is recommended for further assessment.

- Nine Mile Creek (immediately downstream of Serpentine Creek outfall) – undertake further investigation into environmental values and effects of leakage reduction on these values.

7.4. Timing for preparation of EWPs

Figure 2 provides an overview of the intended timing of NVIRP works. Preparation of EWPs must be concluded prior to operation of works that might affect waterways. Discussions with NVIRP indicate that works are scheduled to be undertaken on sites recommended for EWP development and further investigation as follows.

Table 8 NVIRP works schedule and waterways recommended for further investigation/EWP.

Waterway	Works scheduled
Campaspe River.	2009
Loddon River (Torrumbarry IA)	2009
Loddon River (Pyramid Boort IA)	2010
Broken Creek EWP	2010
Twelve Mile Creek (undertake with Loddon assessments)	2010
Nine Mile Creek (immediately downstream of Serpentine Creek outfall) for further assessment.	2010

8. Recommendations

The following waterways are determined as 'at risk' from the implementation of NVIRP and recommended for development of an EWP:

- Campaspe River – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed river.
- Loddon River (Torrumbarry and Pyramid Boort IA) – undertake further detailed investigations into impacts of channel outfall reduction and potential system operation change on the waterway
- Broken Creek – undertake further detailed investigation into impacts of channel outfall reduction on the flow stressed creek. The investigation should include the regulated section of Boosey Creek near Katamatite.
- Twelve Mile Creek (undertake with Loddon assessments)

The following Waterway is determined as 'at risk' and recommended for further assessment to determine if an EWP is required.

- Nine Mile Creek (immediately downstream of Serpentine Creek outfall) –further investigate environmental values and effects of leakage reduction on these values.

The following waterways are determined not at risk and are not recommended for further investigation or EWP development.

- Bannacher / Pennyroyal Creek
- Bullock Creek
- Calivil Creek
- Nine Mile Creek
- Pennyroyal Creek D/S Serpentine Creek outfall
- Pyramid Creek
- Sevens Creek
- Sheepwash Creek
- Tongalong Creek
- Tullah Creek
- Wells Creek
- Yambuna Creek

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Appendix A Detailed Waterway Assessments – Summary of Outcomes

Table A1 summarises the outcomes of the Short-list assessment and shows a comparison with the outcomes of Desktop assessment (SKM, 2008).

Table A 1: Summary of Desktop and Short-listing Assessment and Recommendations

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Bannacher and Pennyroyal Creeks	Y	-	Y	Y (Brolga)	N	N	N	N	Not at risk. Values are associated with flood flows and only a very small portion of values can be attributed to channel outfalls. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP
Broken Creek	Y	unknown	Y	Y	Y (Barmah Forest, Kinnaird's Swamp, Black Swamp)	Y	tbd	Y	Potentially at risk due to reduction in channel outfalls. High value waterway, currently operating under flow stress. Changes to channel outfalls may impact on values.
Bullock Creek	N	N	Y	Y (Brolga)	N	N	N	N	Not at risk. Values are associated with flood flows and only a very small portion of values can be attributed to channel outfalls.

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Calivil Creek	Y	Y	Y	Y (Brolga)	N	N	N	N	Not at risk. Values are associated with flood flows and only a very small portion of values can be attributed to channel outfalls.
Campaspe River	Y	-	Y	Y	N	Y	Y	Y	Potentially at risk from channel outfall reductions. System flows currently operating under duress. . It is noted that NVIRP has requested NCCMA to undertake preparation of an interim EWP. Information from this task will enable a detailed assessment of the need for preparation of a full EWP
Loddon River – Pyramid Boort IA	Y	Y	Y	Y	Y (wetlands in Wandella Creek on west side of river)	Y	Y	Y	Potentially at risk. Waterway is associated with high value wetlands; NVIRP may impacts on system operation; Goulburn system interactions – undertake further hydrological assessment before undertaking full EWP.
Loddon River – Pyramid Boort IA - (cumulative outfalls)	Y	Y (needs further assessment(	Y	Y	Y	tbd	?	Y	Potentially at risk. Waterway is associated with high value wetlands; NVIRP impacts on system operations; Goulburn system interactions

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Loddon River - Torrumbarry IA - Cumulative impacts	Y	N	Y		Y	tbd	tbd	Y	Potentially at risk. Waterway is associated with high value wetlands; NVIRP impacts on system operations; Goulburn system interactions
Loddon River (Torrumbarry IA)	Y	-	Y		Y	tbd	?	Y	Potentially at risk. Waterway is associated with high value wetlands; NVIRP impacts on system operations; Goulburn system interactions and possible high impact of channel outfall reduction.
Nine Mile Creek	N	Y	Y	N	N	N	N	N	Not at risk. Values are associated with flood flows and only a very small portion of values can be attributed to channel outfalls. Only a small proportion of channel outfalls are likely to reach Nine Mile Creek.

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Nine Mile Creek – immediately downstream of outfall from Serpentine Creek			Not assessed NCCMA requested this site be assessed (memo presented to NVIRP TAC 5/6/2009)	Y	N	Y	Y	Y	Potentially at risk. High value due to proximity to Serpentine Creek. No channel outfalls occur to Nine Mile Creek from Serpentine Creek however water leakage through or around outfall structure maintains water dependent EVCs.
Pennyroyal Creek immediately downstream of outfall from Serpentine Creek			Not assessed NCCMA requested this site be assessed (memo presented to NVIRP TAC 5/6/2009)	Y	N	N	Y	N	Not at risk due to the lack of impact of reduced channel outfall. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP
Pyramid Creek – see Bullock Creek									This Section of Pyramid Creek was identified by SKM; however it seems more likely that they were refereeing to Bullock Creek.
Sevens Creek	N	N (this assessment)	Y	N	N	N	N	N	Not at risk. Waterway has low environmental values and channel outfall reduction has minimal impact on flow.

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Sheepwash Creek	N	unknown	Y	N	N	N	N	N	Not at risk from reductions in channel outfalls. Reduced outfalls will move water regime to a drier state; out of season water will be reduced. Minimal contribution from channel outfalls
Tongalong Creek	Y	unknown	Y	Y	Y (Barmah Forest)	N	N	N	Not at risk from channel outfall reductions. Minimal impact of outfalls on flows; reduction in out of season water; Values associated with flood flows; Lack of evidence of low flow dependent ecological values assess as part of EES Condition 4
Tullah Creek	Y	unknown	Y	Y	Y (Barmah Forest)	N	N	N	Not at risk from channel outfall reductions. Minimal impact of outfalls on flows; reduction in out of season water; Values associated with flood flows; Lack of evidence of low flow dependent ecological values assess as part of EES Condition 4

	Desktop Assessment			Short-listing Assessment					
Waterway	**Presence of high environmental values?**	**Expected change in flow regime as a result of NVIRP project?**	**Further consideration recommended**	**Waterway has high environmental values**	**Associated with high environmental value wetland**	**Expected change in flow regime as a result of NVIRP project**	**Environmental values attributable to outfalls**	**Revised recommendation – further assessment or EWP required?**	**Justification**
Twelve Mile Creek	Y	-	Y	Y due to its close association with the Loddon River	N	tbd	N	Y	Potentially at risk. High value waterway – consider as part of Loddon River (Pyramid Boort reach) which may be affected by changes to channel outfalls.
Wells Creek	N	Y	Y	N	N	Y	N	N	Not at risk from channel outfall reductions. Reduced outfalls will move water regime to a drier state and will reduce out of season water. The great bulk of outfall water discharges from the Rodney Main Drain to a channelized section of Wells Creek about 1 kilometre above its junction with the Goulburn River.
Yambuna Creek	N	-	Y	N	Y (Kanyapella Basin)	Y	N	N	Not at risk from channel outfall reductions. Reduced outfalls will move water regime to a drier state; reduction in out of season water. Reduced flows are not expected to impact on Kanyapella Basin.

Appendix B Detailed Waterway Assessments – Reconciliation with Desktop Assessment

B1. Bannacher and Pennyroyal Creeks

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	-	Y
Short list Assessment	Y	N	N

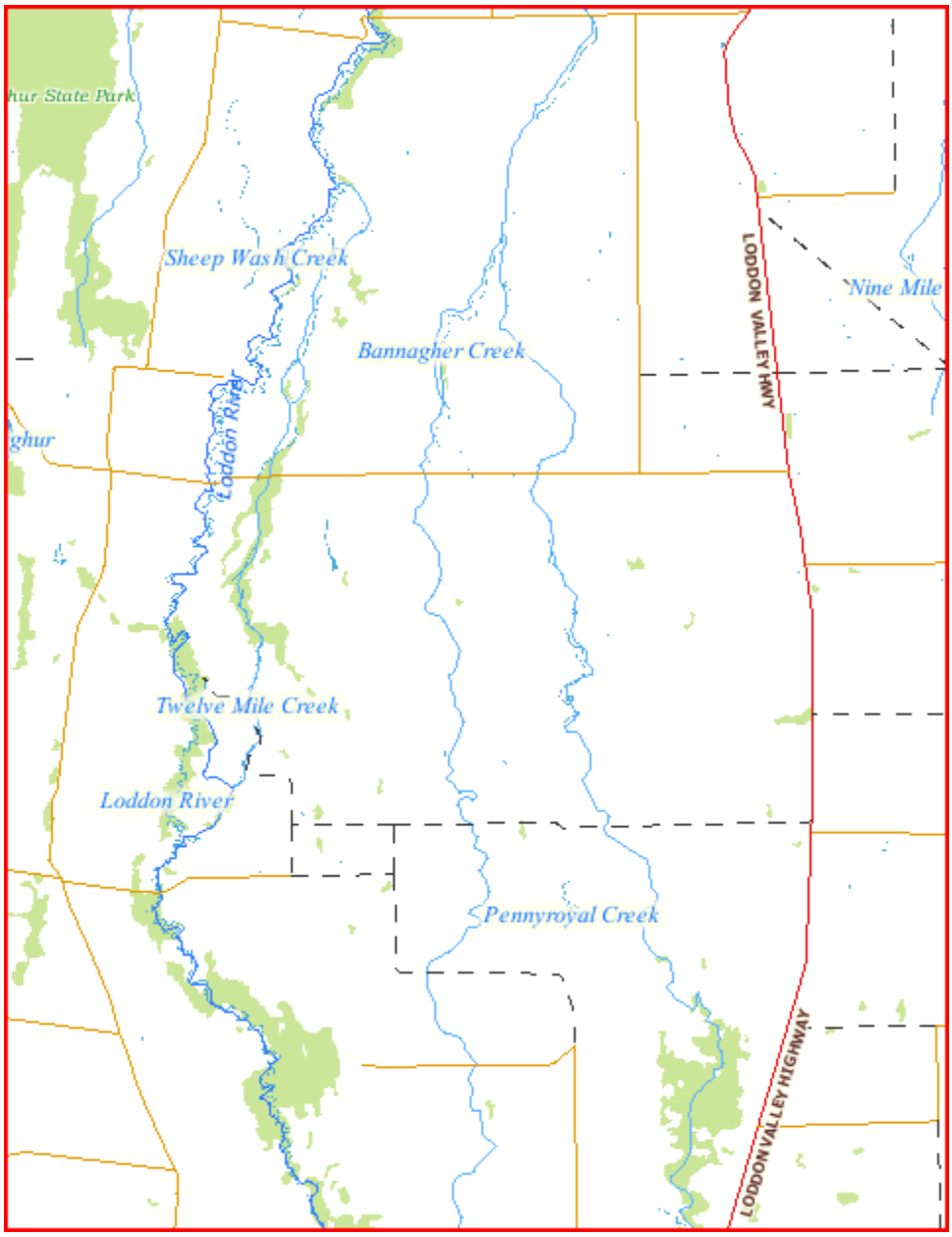
Waterway Name	Bannacher and Pennyroyal Creeks	
Description	Serpentine Creek splits into Pennyroyal and Nine Mile Creek approximately 2km downstream of Durham Ox. Pennyroyal Creek is an 18km long intermittent creek that flows in a northerly direction to Bannacher Creek at Canary Island. Bannacher Creek is a 50km long creek that branches from Serpentine Creek south of Durham Ox and flows north to the Loddon River near Tragowel Swamp. Under normal conditions both would be classified as ephemeral.	
Waterway Identifier	Catchment	Loddon
	CMA Region	North Central
	Irrigation Area	Pyramid Boort
	Public Land Status	Mostly freehold
	RRHS Reach No:	Loddon reach 11 (Serpentine Creek)
Desktop Environmental Assessment Description	Ecological Vegetation Class mapping indicates that a number of threatened water dependant EVCs exist along this system, including Grassy Riverine Forest (depleted) and Lignum Swamp (vulnerable) (http://nremap-sc.nre.vic.gov.au). Native fish are also likely to be present and Serpentine Creek has recently been stocked with Golden Perch (DPI, 2008).	
Updated Environmental Description	The NC RRHS lists Reach 11 as a priority using priority setting principle 3, 5, 6 and 7– protect and enhance high risk reaches (this aims to minimize the risk of threats) – but the RRHS does not provide information about the values to be protected, so information has been sourced from CMA to waterway descriptions). *Pennyroyal Creek:* Pennyroyal Creek flows entirely across a flat alluvial plain. The majority of the creek is recovering from past channelisation and it is still considered to be in a degraded state.	

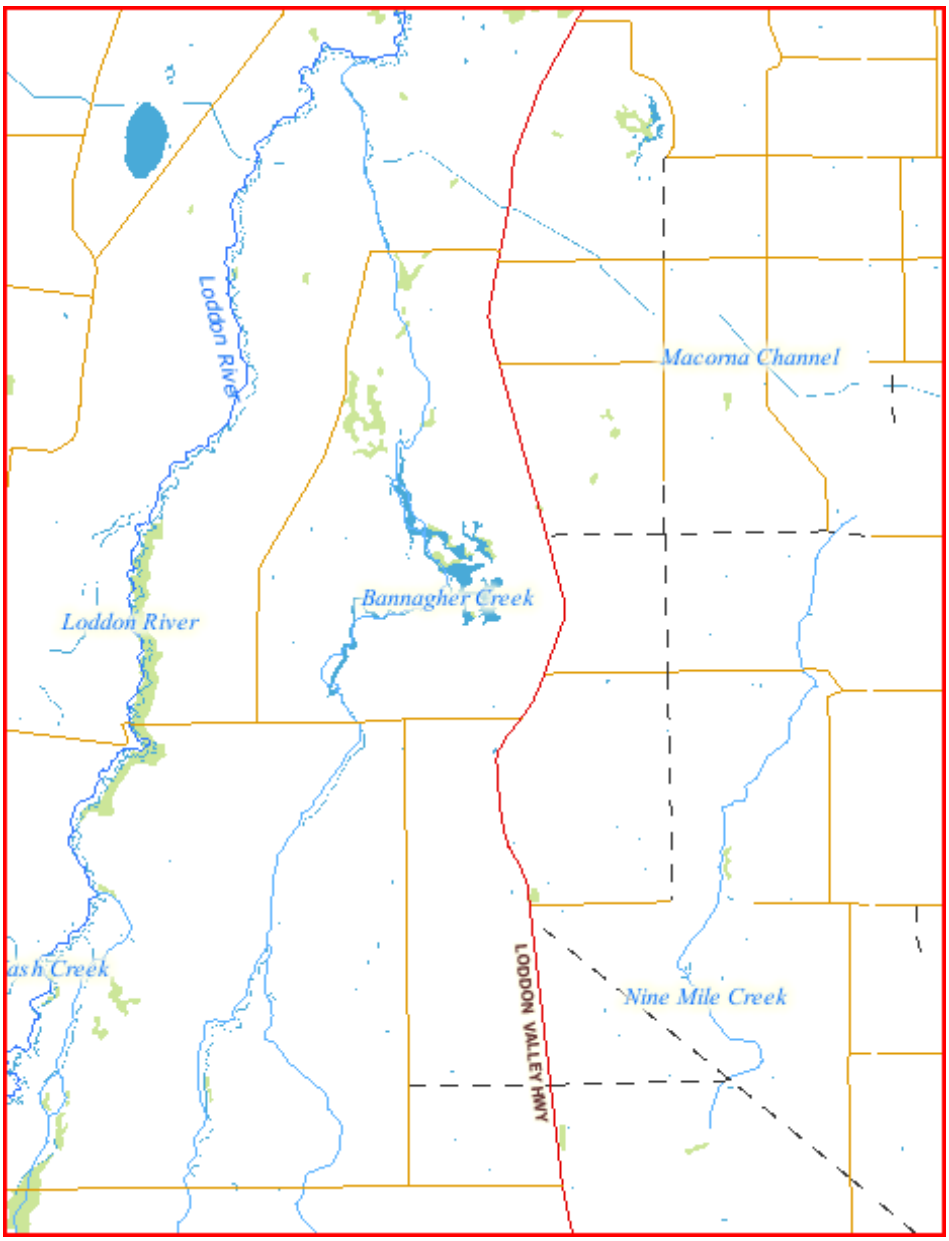
Waterway Name	Bannacher and Pennyroyal Creeks
	The pre 1750 Ecological Vegetation Class data is incomplete along Pennyroyal Creek. Recent assessments reveal that 7% of the riparian tree cover is in marginal condition, displaying a narrow, scattered tree canopy. Approximately 93% is considered in poor condition. In the upper reaches (Serpentine Creek to the Canary Island-Leaghur Road) the riparian vegetation is between 5m and 10m wide on either bank featuring scattered River Red Gums. Lignum dominates the creek banks; however it has been cleared in some areas to assist local drainage. Cumbungi grows along the creek margins. In lower reaches (Canary Island-Leaghur Road to the Bannacher Creek confluence) there is a complete absence of tree cover along the lower reaches due to clearing for agricultural production. Saltbush is also present on top of the creek banks. Shallow pools and Cumbungi provide the only instream habitat opportunities for aquatic life in Pennyroyal Creek. No fish or macroinvertebrate data has been recorded for Pennyroyal Creek. Saddlier S. *et al.*, 2009 note records of Magpie Goose (near threatened), Brolga (vulnerable), Bearded Dragon (data deficient), Murray Cod, Silver Perch and Golden Perch (fish records from 1981). *Bannacher Creek:* Bannacher Creek flows entirely across a flat alluvial plain. Channelisation of the creek has occurred, particularly along the lower reaches, with formed levee banks. Graham Hall suggests Bannacher Creek has not been subject to drain construction. The pre 1750 Ecological Vegetation Class data is incomplete along Bannacher Creek. Assessments reveal that 2% of the riparian tree cover is in good condition, displaying a wide, continuous and native tree canopy. Approximately 98% is considered in poor condition. In the upper reaches (Serpentine Creek to the Pennyroyal Creek confluence) the riparian vegetation is generally less than 5m wide on either banks and often features no significant tree cover. Sparse clumps of Lignum occur along the banks amongst the pasture grasses and Cumbungi grows in the deeper pools. In the lower reaches (Pennyroyal Creek confluence to the Loddon River confluence) the riparian vegetation is generally 5m to 10m wide along the lower reaches, extending up to 40m wide in some places. Riparian revegetation of River Red Gum and Black Box has occurred at the Appin South Road. River Red Gums are scattered along the wider, flatter sections of the creek where semi-permanent pools occur. Dense patches of Lignum generally line the banks with Cumbungi growing prolifically in pools of water. Cumbungi in the waterway channel and the shallow pools provide the key habitat opportunities for aquatic life in Bannacher Creek. No macroinvertebrate data has been recorded for Bannacher Creek. Saddlier S. *et al.*, 2009 note records of Brolga (vulnerable), Brown Treecreeper (near threatened) and Golden Perch (1981 record). These creeks have high environmental values although many of these values do not currently exist due to dry conditions. These values are associated with links to flooding in the Loddon River and are

Waterway Name	Bannacher and Pennyroyal Creeks
	not attributable to channel outfalls.
Desktop Hydrological assessment	The Serpentine-Pennyroyal-Bannacher Creek system is a large anabranch of the Loddon River, downstream of the Loddon Weir. There are two gauges located at Bannacher Creek Centre and West Branches (407261 and 407262); however, no flow data was available for the period for which the analysis was undertaken. There is no gauged flow data for Pennyroyal Creek.
Updated Hydrological assessment	Pennyroyal Creek Pennyroyal Creek is fed by the Serpentine Creek, via the Loddon River. Unlike the Bannacher Creek (a continuation of Pennyroyal Creek) the Creek has not been incorporated into the regional drainage network (SKM). Serpentine Creek is a natural carrier of the irrigation system from the Waranga Western Channel (WWC) at Bears Lagoon to the Pyramid Channel 12 offtake north of Durham Ox. The outfall to the Pennyroyal Creek is effectively a weir to divert water into Pyramid Channel 12 and has an outfall volume (2004/2005) of 1147 ML. This outfall also has a tilt gate installed and is monitored as part of the Strategic Monitoring Program. The travel time of water from Bears Lagoon through Serpentine Creek to the Channel 12 offtake is approximately 4 days. As a result, if rainfall occurs within 4 days after water is ordered and released from the WWC and irrigators cancel their orders, the water is then passed through the outfall to Pennyroyal Creek as rainfall rejection. An additional outfall exists nearby to the Nine Mile Creek however as the Pennyroyal outfall is SCADA controlled, the 9 Mile creek outfall is not used (pers. comm. G-MW). Further analysis was carried out to determine the relationship between the outfall volume and rainfall events at the Pennyroyal Creek. The result of this analysis clearly indicated that the volume of outfall is largely a result of rainfall rejection; that is the result of irrigators cancelling their orders as a result of local rainfall which subsequently increases the outfall volume. The outfall water passes some 3 km from entry point through the remainder of the Serpentine Creek into Pennyroyal Creek. There are no drainage diverters identified downstream of the outfall. Table 19 below provides a summary of the estimated distance from outfall to entry point. Due to the close proximity of the outfalls to the Pennyroyal Creek and the absence of drainage diverters, it is considered likely that outfall water will reach the Creek. However consideration should be given to the fact that the volume of outfall is largely dependent on rainfall rejection, rather than operational conditions and the interconnecting relationship of Pennyroyal Creek to other waterways in the area. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP, unless the Serpentine Creek is removed from the System, due the relatively long travel time of ordered flows from the Waranga Western Channel. Bannacher Creek Bannacher Creek is fed by the Pennyroyal Creek, which in turn is fed by Serpentine Creek, via the Loddon River. Serpentine Creek is a natural carrier of the irrigation system from the WWC at Bears Lagoon to the Pyramid Channel 12 offtake north of Durham Ox. Bannacher Creek has also been incorporated into the regional drainage network (SKM).

Waterway Name	Bannacher and Pennyroyal Creeks
	There are only two outfalls connected to the Bannacher Creek which enter the Bannacher River directly via channel 1/12 with an outfall volume (2004/2005) of 74 ML. In 2004/2005 the ST009752 had an outfall volume of 0 ML, therefore no water will be outfalled from this site. This outfall information has been further summarised in Appendix C Detailed outfall analyses Table below. The distance between the outfalls and their entry point into Bannacher Creek is on average < 1 km. No drainage diverters have been identified downstream of the outfalls Appendix C Detailed outfall analyses Table below provides a summary of the estimated distance from outfall to entry point for each outfall. Due to the close proximity of the outfalls to the Bannacher Creek, it is considered likely that the majority of water outfalled from the 2 sites will reach the Creek. However the interconnecting relationship that Bannacher Creek has with Pennyroyal Creek should be considered when assessing the overall impact of outfalls on the Creek.
Desktop Recommendation	Given the lack of flow information for the Bannacher and Pennyroyal Creeks further investigation into the environmental impact of the NVIRP Project on these waterways is recommended.
Short-list Recommendation	Not at risk due to • the values of these creeks being associated with flood flows; and • channel outfall water being unlikely to make any contribution to environmental values. It is recommended that no further work be undertaken. Note – North Central CMA requested the NVIRP TAC to further investigate Pennyroyal and Nine Mile Creeks immediately downstream of their outfalls from Serpentine Creek.

Location Plan




Loddon River
Macorna Channel
Bannagher Creek
Loddon River
ash Creek
LODDON VALLEY HWY
Nine Mile Creek

B2. Broken Creek

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	unknown-	Y
Short list Assessment	Y	unknown	Y

Waterway Name	Broken Creek (including a short section of Boosey Creek near Katamatite)
Description	The Broken Creek lies within the Goulburn Broken Catchment, diverging from the Broken River at Caseys Weir west of Lake Mokoan and flowing north-west into the Murray River. The bulk of channels outfall in the reaches below Numurkah.
Waterway Identifier	Catchment: Broken/Murray CMA Region: Goulburn Broken Irrigation Area: Murray Valley/Shepparton Land Manager: Parks Victoria Public Land Status: Broken Boosey State Park RRHS Reach No: Broken 21, 22, 23, 24
Desktop Environmental Assessment Description	Supports a number of significant environmental values
Updated Environmental Description	GHD, 2005 noted: The fauna of the Broken Creek is diverse and represents a range of species due to a complex of habitats available. These include aquatic, riparian and woodland areas that provide habitat to many animal species including some listed species. In the waterway corridor (defined as being within 100 m of the creek) at least 13 significant listed fauna species have been identified, including three fish, a frog, two reptiles, five waterbirds and a mammal species. The Broken Creek is rated as “high significance” in terms of significant flora. This reflects the presence of endangered and depleted Ecological Vegetation Classes along most of the length of the creek, in a landscape that is largely cleared and intensively farmed. There is almost continuous riparian woodland along the Broken, Boosey and Nine-mile Creeks, although the width of the tree community and intactness of the understory varies. Some significant wetlands exist in the lower reaches such as those present adjacent to, or within, the Barmah Forest, which is a wetland of international significance. ParksVictoria, 2006 also provides a comprehensive description of the creek system.

Waterway Name	Broken Creek (including a short section of Boosey Creek near Katamatite)
	The GBRRHS lists reaches 21, 22, 23 and 24 as high priority. The waterway is of very high value. DSE, 2008 undertook the Shepparton Irrigation Area Modernisation Environmental Assessment which *noted Broken Creek has been recognised as a priority wetland for protection of its environmental values. It is also recognised that Broken Creek may be affected by changes to irrigation delivery, farm practices and drainage management in both the SIA and Murray Valley Irrigation Area (MVIA).*
Desktop Hydrological assessment	The reduction in channel outfalls as a result of the NVIRP Project has the potential to create circumstances where the flow recommendations for the lower Broken Creek are not met.
Updated Hydrological assessment	Under natural conditions Broken Creek would be ephemeral, but flow is maintained by regulation. System is currently operating at the lower end of the flow range. Any potential reductions in channel outfalls may have flow management implications. Impacts of the Shepparton Irrigation Area modernisation project need to be considered. There are 20 outfalls that enter Broken Creek directly from various irrigation channels, Murray Valley Drains 10, 13 and 18 and the Muckatah Drain. A total volume of 2991 ML was outfalled in 2004/2005. Seven outfalls enter the Broken Creek from the Murray Valley Drain 13 which contributed 1163 ML of outfall water in 2004/2005. There are three outfalls linked to the Murray Valley Drain 18, which contributed a combined outfall volume of 157 ML in 2004/2005. Eight outfalls enter the Broken Creek directly via irrigation channels 6, 21A/6, 15/6, 8/6, 4/8/6 and 6/6 which had a combined outfall volume of 1500 ML in 2004/2005. Only one outfall is linked to the Murray Valley Drain 10 and one outfall to the Muckatah Drain which outfalled a volume of 16 ML and 155 ML respectively in 2004/2005 This outfall information has been further summarised in Table 10 below. There are 18 drainage diverters identified downstream of the outfalls associated with the Murray Valley Drain 13, with a combined diversion licence volume of 1328 ML. This volume is more than the 2004/2005 outfall volume for the seven outfalls (1163 ML). It is considered likely water outfalled to Murray Valley Drain 13 will be diverted from use before entering Broken Creek. No drainage diversion licences were identified downstream of outfalls linked to Murray Valley Drain 10. A number of drain diverters pump from sumps in the lower part of the Muckatah Drain. There is significantly fewer drainage diverters (2) located downstream of the outfalls to Drain 18. The total drainage diversion volume (99 ML) is less than the 2004/2005 combined outfall volume for the sites. Therefore it is unlikely to expect that outfall water from Drain 18 will enter Broken Creek. The distance between the five outfalls and their entry point into Broken Creek ranges between < 0.05 km and 26.5 km. The significant distance that some of the outfall water travels, particularly those linked to drains means that it is likely that some of the outfall water will be lost in the drain due to seepage and evaporation. Table 10 below provides a summary of the estimated distance from outfall to entry point for each outfall. Based on volume of outfall water being significantly larger than the drainage diversion volume

Waterway Name	Broken Creek (including a short section of Boosey Creek near Katamatite)
	for outfalls entering Broken Creek, it is considered likely that at least 50% of water outfalled from the channel system will enter Broken Creek. The TAC reviewed the Desktop Assessment (SKM,2008) recommendations at a workshop on 16 October 2008. They confirmed that Boosey Creek has an upper ephemeral section and a lower section where an operational outfall comes in shortly upstream from the junction with Broken Creek. They considered this outfall should be incorporated in the Broken Creek analysis.
Desktop Recommendation	Given the large range of factors impacting on the flow regime of the Broken Creek and the possible reliance on channel outfall water to help contribute to environmental flow recommendations for this waterway, further investigation into the potential impact modernisation on this waterway is recommended.
Short-list Recommendation	The waterway is potentially at risk. It has high values. Current flow stress on Broken Creek could be exacerbated by reductions in channel outfalls and values could be impacted. Undertake preparation of an EWP by 2010. Note that Broken Creek may also be affected by works undertaken as part of the Shepparton Irrigation Area Modernisation Project.

B3. Bullock Creek

Summary reconciliation with Desktop Assessment:

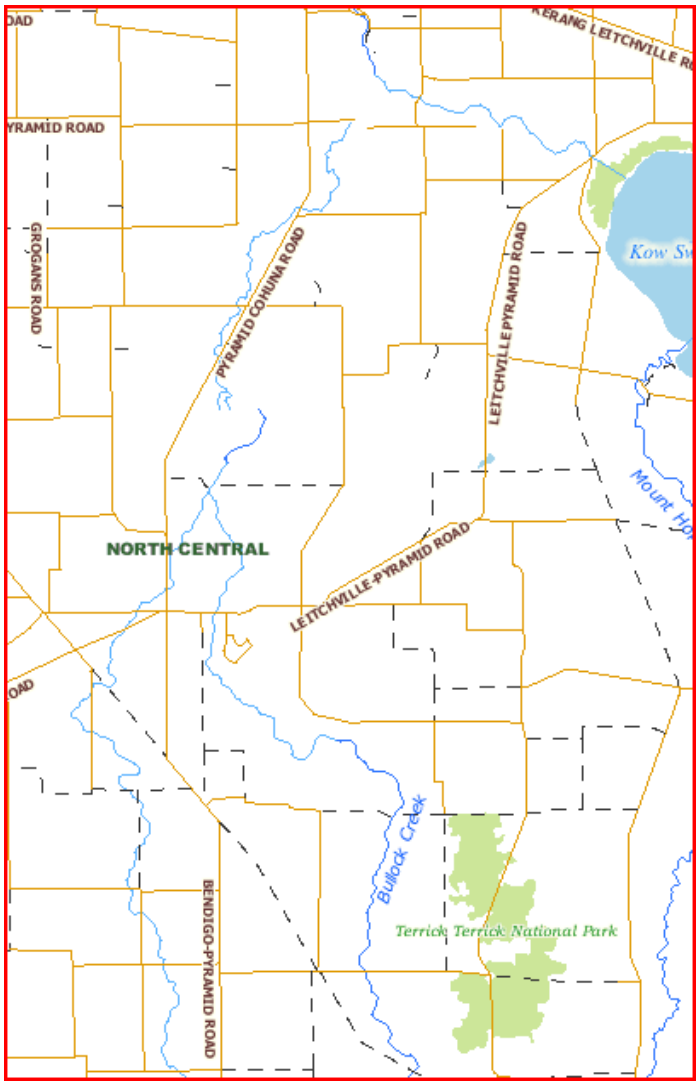
	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	unknown	Y
Short list Assessment	N	N	N

Waterway Name	Bullock Creek	
Description	Within Management Unit (MU) 15, Bullock Creek flows intermittently for 70km in a northerly direction from the Waranga Western Main Channel (WWMC) at East Loddon to Pyramid/Box Creek, approximately 10km south of Cohuna. The major tributaries of Bullock Creek are Pompapiel, Blind, Seven Months and Welches Creeks. Flows are ephemeral.	
Waterway Identifier	Catchment	Loddon
	Length	
	CMA Region	North Central
	Irrigation Area	Pyramid Boort
	Land Manager	
	Public Land Status	Public land water frontage
	RRHS Reach No:	Loddon 33

Waterway Name	Bullock Creek
Desktop Environmental Assessment Description	Not documented
Updated Environmental Description	Bullock Creek flows entirely across an alluvial plain. Excavation drainage works have been conducted virtually throughout the length of Bullock Creek. The riparian vegetation along Bullock Creek can be classified into the following four pre 1750 Ecological Vegetation Classes: • Creekline Grassy Woodland (WWMC to Prairie Road) • Plains Grassland (to Mitiamo) • Saline Wetland Complex and Black Box Chenopod Woodland/Lignum Wetland Mosaic (to the Blind Creek confluence) • Black Box Chenopod Woodland/Lignum Wetland Mosaic (to the Box Creek confluence) An assessment of the existing riparian tree cover along Bullock Creek found 29% is in good condition, displaying a wide, continuous and native tree canopy. Approximately 55% is in poor condition and the remaining 16% is considered marginal. In the upper reaches (WWMC to Mitiamo) the riparian vegetation along Bullock Creek is generally between 5m and 10m wide on either bank. This generally consists of Lignum however there are patches of River Red Gum and Black Box. Cumbungi lines the waterway channel with rushes and sedges growing along the margins. In the lower reaches (Mitiamo to the Box Creek confluence) there is a general improvement in the amount of tree cover along the lower reaches. Lignum continues to dominate the shrub layer. The riparian vegetation extends up to 40m wide on either bank in some areas, such as west of the Terrick Terrick National Park. Natural regeneration of the Black Box lining the creek through this area to Pyramid Hill is evident. There is a general lack of significant tree cover along the remainder of the creek. Lignum occurs in dense patches with Cumbungi growing in the waterway channel. Near the Box Creek confluence, saltbush is also present along the banks of Bullock Creek. No fish data has been recorded for Bullock Creek. Macroinvertebrate data are available from one site on Bullock Creek near the Box Creek confluence. As would be expected of a site with slow flow and a silt bed, a typical lowland community was recorded. There is no water quality monitoring sites along Bullock Creek. Creek provides habitat for the endangered Grey-crowned Babbler, Australasian Bittern and Black Falcon and the vulnerable Brolga and Greater Long-eared Bat. The values of Bullock Creek are associated with flood flows.

Waterway Name	Bullock Creek
	Somewhat confusingly the NCRRHS Reach 33 includes both Bullock Creek and Pyramid Creek. Reach 33 is listed as a priority due to its linkages to Hird Swamp and Johnson Swamp. Moderate environmental values are present. These are associated with flood flows and cannot be attributed to channel outfalls.
Desktop Hydrological assessment	The downstream reach of Bullock Creek is incorporated into the regional drainage network (SMEC, 2002). The flow frequency curve indicates that a reduction in channel outfalls could result in a small increase in the amount of time that the creek ceases to flow.
Updated Hydrological assessment	n/a
Desktop Recommendation	Given the change of flow conditions in the Bullock Creek due to a reduction in channel outfalls associated with the NVIRP Project further investigation into the environmental impact of the NVIRP Project on this waterway is recommended
Short-list Recommendation	Not at risk due to: • The values of the creek being associated with flood flows; and • channel outfall water being unlikely to make any contribution to environmental values. It is recommended that no further work be undertaken.

Location Plan



B4. Calivil Creek

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	Y	Y
Short list Assessment	Y	N	N

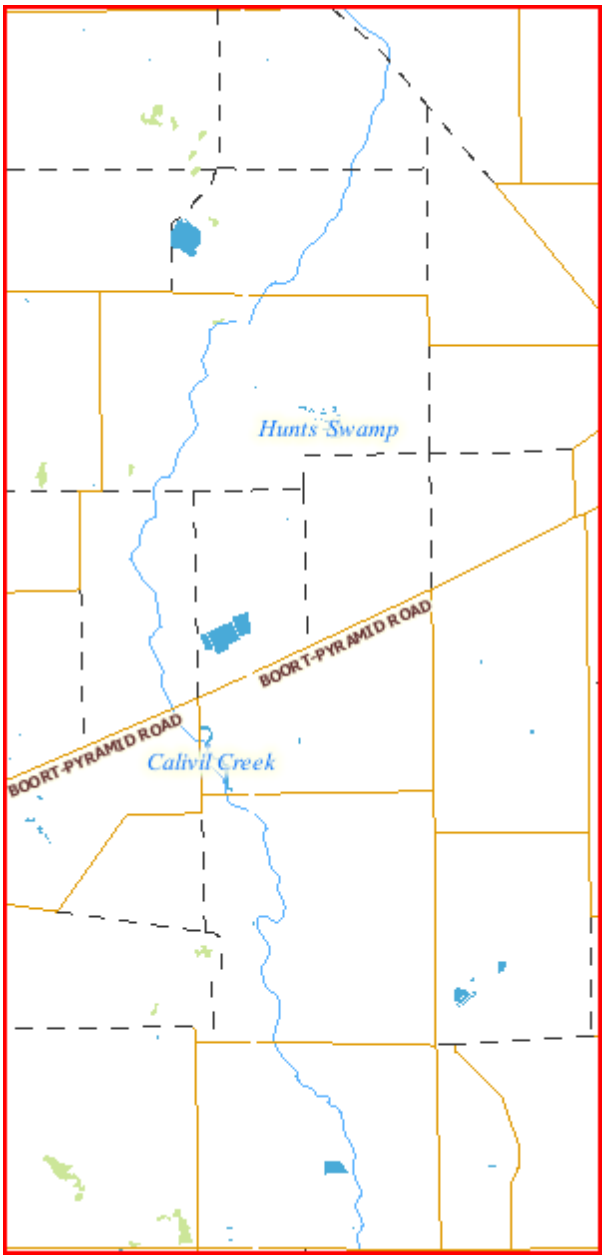
Waterway Name	Calivil Creek	
	Calivil Creek is approximately 100km long and flows on a northerly course from Serpentine to Pyramid Creek at Kerang. Its major tributaries include Long Plains and Nine Mile Creeks and an unnamed creek (the Calivil Creek Tributary). The creek forms approximately 8km southeast of Serpentine to the east of the Loddon Valley Highway. Flows are ephemeral.	
Waterway Identifier	Catchment	Loddon
	CMA Region	North Central
	Irrigation Area	Pyramid Boort/ Torrumbarry
	Public Land Status	Mostly freehold
	ISC Reach No:	n/a
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	The Calivil Creek system may retain some regional environmental values, including the presence of a significant population of Brolga (Davidson, 2006).	
Updated Environmental Description	Calivil Creek flows entirely across a flat alluvial plain. Apart from the headwaters the shallow headwaters, most of the creek has been channelised. The lower reaches feature a thick layer of silt lining the streambed. Calivil Creek is a broad depression 100-200 m wide and 2-3 m deep with a small (1-2 m wide, 0.3 m deep) drain running along its thalweg. The riparian vegetation along Calivil Creek can be classified into the following four pre 1750 Ecological Vegetation Classes: Creekline Grassy Woodland (to the WWMC)	

Waterway Name	Calivil Creek
	Wetland Formation (to Calivil) Riverine Grassy Chenopod Woodland (to 2km upstream of the Pyramid-Durham Ox Road) Plains Grassland (to the Pyramid-Durham Ox Road) The pre 1750 Ecological Vegetation Class data is incomplete along Calivil Creek north of the Pyramid-Durham Ox Road. Assessments reveal that the riparian tree cover along the entire creek is considered in poor condition with no significant tree cover present. In the upper reaches (headwaters to Macorna) vegetation is typified by a wide shallow depression through open crops and pasture. Black Box occurs along the creek in places and there is also evidence of revegetation works. However, the creek generally lacks any significant tree cover along most of the upper reaches. Cumbungi and Lignum are also present in small patches along the banks. In the lower reaches (Macorna to the Pyramid Creek confluence) the riparian vegetation is generally less than 5m wide and consists of Saltbush, Lignum and other salt tolerant species. No significant tree cover occurs along the lower reaches. Instream habitat for aquatic life is largely restricted to shallows and Cumbungi in Calivil Creek. No fish or macroinvertebrate data has been recorded for Calivil Creek. A long term water quality monitoring site (407284) exists on Calivil Creek near Macorna. Concentrations of both nitrogen and phosphorus exceed the nutrient guideline values. Instances of very high concentrations for both nutrients have been recorded. Brolgas are known to use wetlands along the creek (Davidson S., 2006 and Simon Starr (local landholder)). Simon reports that Brolga nest along the creek in the vicinity of Hampson's Rd, Yarrawolla. He also reports that he knows of 3 or 4 other breeding sites along the creek, and that at times, channel outfall water is important to maintain the integrity of the breeding site (ie keeping enough water around the site to keep foxes away from the nest). The values of Calivil Creek are associated with floodflows. Hunt's Swamp occurs on a tributary of Calivil Creek. This has been assessed by Hydro Environmental, 2009 as not being impacted by NVIRP. Moderate to high values are present. These are associated with flood flows and cannot be attributed to channel outfalls
Desktop Hydrological assessment	The flow frequency curve indicates that a reduction in outfalls could increase the amount of time that the creek ceases to flow from 15% to 75% of the time.
Updated Hydrological assessment	Calivil Creek has been heavily modified due to the development of the Creek into a community service drainage system that ultimately flows into Barr Creek. Under natural conditions the

Waterway Name	Calivil Creek
	Calivil Creek would flow from to the Pyramid Creek east of Kerang. There are eight outfalls that enter Calivil Creek via the Calivil Creek Drain 12, Outfall Drain 1 and directly via Pyramid irrigation system. The total outfall volume in 2004/05 was 396 ML. Six outfalls enter the Calivil Creek directly via the irrigation channel system and contributed a combined outfall volume of 40 ML in 2004/2005. Two of these outfalls (ST009189 and ST009118) both had an outfall volume of 0 ML in 2004/2005. Outfall ST009723 enters the Calivil Creek via Outfall Drain 1 and is the main outfall contributor to the Creek (356 ML), making up 90 % of the total outfalls entering the Creek. There is one outfall (ST010097) outfalling directly to the Calivil Creek Drain however it had 0 ML outfall of in 2004/2005. This outfall information has been further summarised in Table 13 below. There are two drainage diverters located downstream from ST009723. The total drainage diversion volume (120 ML) is less than the 2004/2005 combined outfall volume for the sites (356 ML). It is likely that at least 65% of outfalls from this site will reach the Calivil Creek. Two drainage diverters are located downstream of the outfall linked to the Calivil Creek Drain (ST010097) and have a combined drainage diversion licence volume of 60 ML. This is larger than the 2004/2005 outfall volume for the site (0 ML). It is therefore likely that any water outfalled to the Calivil Creek Drain from this site will be diverted for use before entering Calivil Creek. The distance between the eight outfalls and their entry point into Calivil Creek ranges between < 0.2 km and 2 km. One of the major outfall contributors (ST009723) is located 1 km from Calivil Creek. It is expected that the majority of water outfalled from this point will reach the Creek. Table 13 below provides a summary of the estimated distance from outfall to entry point for each outfall. The relatively close proximity of some of the major outfall contributors to the Creek indicates most outfall water could reach the Creek, however after taking into account the likely diversion of outfall water entering Calivil Creek from the spur drains, it is considered likely that at least 70 % of water outfalled from the channel system will enter Calivil Creek. It should be noted that as part of the SKM assessment Report, 14 outfalls were identified as supplying outfall water to Calivil Creek, however further assessment has identified that five of these outfalls (ST009086, ST044742, ST044697, ST010175 and ST010230) are linked to the Pyramid Drainage System (Drain 2/1) which outfalls to Pyramid Creek. These outfalls have been removed from the Calivil Creek outfall analysis and included in the Pyramid Creek outfall analysis. The impact of channel outfall reduction on Brolga nesting site areas was investigated: There is only 1 outfall upstream (south) of Boort Pyramid Rd – ST008830 from the Pyramid Channel 13/1. This is a SMP site. Base year flow (2004/05) was 28ML.

Waterway Name	Calivil Creek
	Outfall volumes seem to have dropped significantly since implementation of G–MW loss management program (2002/03) and again since SMP (2006?) and drought management operational initiatives (Table 13). There are 5 sites downstream (ST045558, ST009690,ST009118, *ST009189,* ST009242) which have contributed little water since implementation of G–MW loss management program (2002/03) and drought management operational initiatives (Table 13). Table 14 shows weekly volumes outfalled at STO08830. Analysis of channel outfall data from recent years (Table 13 and 13) suggests outfall water would provide little benefit.
Desktop Recommendation	The degree to which a change of flow conditions in the Calivil Creek as a result of NVIRP could impact on Brolgas warrants further investigation.
Short-list Recommendation	Not at risk due to: • the values of the creek being associated with flood flows; and • channel outfall water being unlikely to make any contribution to environmental values. It is recommended that no further work be undertaken.

Location Plan



B5. Campaspe River

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	-	Y
Short list Assessment	Y	Y	Y

Waterway Name	**Campaspe River**
Description	The entire reach of the Campaspe River within the Campaspe Plains Management Unit, meanders across a level alluvial plain. From Forest Creek to Riverlea (midway between Rochester and Echuca) the floodplain is generally less than one kilometer wide, but broadens out to widths of more than 2km downstream to Echuca. One large anabranch exists on the flood plain below Strathallen and this carries flow during floods and receives channel and drainage outfalls. The Campaspe River downstream of the Campaspe Weir is a known groundwater discharge point resulting in high water salinity levels in the deeper pools during periods of low flow (SKM, 2008a).
Waterway Identifier	Catchment: Campaspe CMA Region: North Central Irrigation Area: Rochester Public Land Status: Campaspe River Reserve (where public land exists) RRHS Reach No: Campaspe 1,2
Desktop Environmental Assessment Description	The lower Campaspe River has supported a number of native fish species, including Murray Cod, however the recent drought, low flows and poor water quality has placed considerable pressure on these populations (Humphries P. *et al.*, 2008)
Updated Environmental Description	Listed in the NCCMA RRHS as a priority reach - due to priority setting principles 2,3,5,6,7 From NCCMA, 2006a: EVC Floodplains Riparian Woodland. Assessments reveal 65% of the Campaspe River riparian vegetation is currently in good condition, 32% in marginal condition and only 3% is in a poor condition. Riparian widths are generally about 40m on each bank. The overstorey consists almost entirely of native River Red Gum with Black Box appearing on top of the banks at Echuca. Where the Campaspe River flows through Rochester and Echuca, exotic (willow, Olive, Date Palm, Desert Ash) species share the overstorey canopy. The understorey is generally absent except for low numbers of River Bottlebrush, Blackwood, Lightwood and lignum. Leafless Ballart is particularly evident along the banks at Echuca. The ground layer is a mix of native (e.g. Kangaroo Grass) and exotic species. Exotic regeneration (e.g. Desert Ash and garden escapes) is primarily occurring within the

	townships, whereas native regeneration is occurring throughout. As this section of the Campaspe River connects to the Murray River it is possibly the most important waterway of the entire Campaspe catchment for fish passage. Twelve native fish species and 6 introduced fish species have been recorded, or are expected to have occurred in this section of the Campaspe River. Natural populations of Trout Cod, Murray Rainbowfish, Mountain Galaxias, Macquarie Perch and Murray Cod have not been recorded since prior to the 1970's (Victorian Aquatic Fauna Database, DNRE, 1999). Two additional species, the Freshwater Catfish and the Unspeckled Hardyhead, which have distributions that should include this length of the Campaspe River, have never been recorded despite extensive fish surveys. Saddlier S. *et al.*, 2009 note records of 8 birds, 2 reptiles and 6 fish of conservation significance. The loss of these native fish species, the majority of which have a threatened fish status at National or State level, is more pronounced in this section of the Campaspe River than in any other Management Unit of the Campaspe catchment. At least one anabranch receives channel outfalls. An Environmental Assessment of Campaspe Drain 3AP was carried out by the then DNRE in 1997 (Paul O'Connor pers comm.). Minimal environmental features of any great significance were identified within the catchment. No VROT species were recorded in 1997 and a recent check, using the latest information, indicates no change. The wetlands were identified as being Type 2 systems dominated by *Elocharis sp., Carex sp., Juncus sp.,* and *Damasonium sp.*
Desktop Hydrological assessment	The flow frequency curve for the Campaspe River indicates little or no change in river flows as a result of a reduction in channel outfalls. However, outfalls in the 04/05-05/06 period appear to have contributed almost 10% of stream flows in the same period. On this basis it is considered that outfalls may be an important contributor to flows, especially in otherwise low flow years
Updated Hydrological assessment	Flow in the Campaspe River, particularly downstream of Lake Eppalock is highly regulated (SKM, 2004). Most irrigation water is diverted from the Campaspe River at the Campaspe Weir, but a small amount is transferred to the WWMC, via the Campaspe pump @ Rochester, during autumn (NCCMA Issue Paper). Campaspe River potentially receives outfall water from eight outfalls, two from the Campaspe Irrigation District (CID), south of Rochester and six from the Rochester Irrigation Area (RIA), north of Rochester. Five of the outfalls from the RIA are linked to Campaspe Drains 2 and 3 and Rochester Drain 4. The total outfall volume for the "base year" from the eight outfalls is 426 ML. Whilst the base year for the Murray and Goulburn systems is 2004/05, the base year for the CID is 2003/04 as this the last year that 100% of water was allocated. The outalls from the CID, STO 32783 and STO32729, both outfall directly to the River with a 2003/04 volume of 171ML and 89ML respectively. The main outfall contributor from the RIA is ST065860 with a 2004/2005 outfall volume of 282 ML drops into a natural billabong that is an anabranch of the Campaspe River at times of high flow and becomes the bottom end of Campaspe Drain 3A) (pers. comm. S. Green G-MW). Outfall ST033384 also outfalls directly into the 1/3AP drainage line. ST033397 and ST033425 outfall to Rochester Drain 2 system. STO033111 outfalls to Rochester Drain 4, where it drains

	into the Cornellia Creek, which flows into the Campaspe River. Outfall ST051358 enters the Campaspe River directly, however in 2004/2005 the outfall volume was 0 ML. This outfall information has been further summarised in Table 15 below. ST033384 has been monitored as part of the Goulburn Strategic Monitoring Project since 2006. As a result outfalls from this site may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. There are four drainage diverters identified at the bottom end of the Campaspe 3A which can access water from outfalls ST065860 and ST033384. The anabranch pools linked to these two outfalls also form their recycle systems so the notional drainage diversion licence volume of 402 ML includes an allowance for reuse water that would be taken from the drain/anabranch. It is unlikely that any water outfalled from these two outfalls will flow into the Campaspe River (pers. comm. S. Green G-MW). There are no formal diversion agreements in place downstream of channel outfalls ST033397 and ST033425, but it is likely that there are some D&S type extractions. Currently, little water is known to outfall into drains 1A/2 and 2, and therefore reach the Campaspe River (pers. comm. S. Green G-MW). The distance of the outfalls on drains to their entry point of the Campaspe River ranges between < 100 m and 9 km. As indicated above, ST065860 drops into a natural billabong which links to the 1/3AP and 3A drainage line, travelling a total distance of 8 km to eventually reach the Campaspe River. Outfall ST033111 is also located a significant distance from the River (9 km). It can be considered that as a result of the distance travelled by these two outfalls it is likely that some of the outfall water will be lost in the drain due to seepage and evaporation. Table 15 below provides a summary of the estimated distance from outfall to entry point for each outfall. The main outfall contributor ST065860 is likely to supply water to maintain the natural billabong that it flows though, which will also significantly reduce the amount of outfall water entering the River via Drain 3A and together with the drainage diversion license volumes being larger than the combined outfall volumes for outfall sites linked to Drain 3A it is likely that no outfall water will reach the Campaspe River via this Drain. It is therefore considered likely that only the CID outfalls, STO 32783 and STO32729 (260ML), and a portion of the RIA outfalls, ST033425 and ST033397 (118ML) linked to Campaspe Drain 2 and STO33111 (91ML) linked to Rochester Drain 4 will reach the Campaspe River. SKM, 2006 made recommendations for environmental flows. Flows in the river are currently being closely managed due to drought conditions and are at the very low end of the range of expected flows. Any further reduction in river flow due to reductions in channel outfalls could have serious management implications on environmental values and river salinity.
Desktop Recommendation	Given the potential contribution that channel outfalls make to flows in low flow years and the interactions that the Campaspe River has with the Goulburn Irrigation System, further investigation into the environmental impact of the NVIRP Project on the Campaspe River is recommended.
Short-list Recommendation	Potentially at risk. It is recommended that an EWP be prepared. The Campaspe River is assessed as being of high environmental value and potential reduction

	of channel outfalls could impact on flows in the river, especially in low flow years; therefore it is recommended that an EWP be prepared by 2009. The investigations for the EWP must include consideration of the water regime of the anabranch below Strathallen. It is noted that NVIRP has requested NCCMA to undertake preparation of an interim EWP. Information from this task will be used in the preparation of the full EWP.

Location

B6. Loddon River

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Loddon River – Pyramid Boort IA			
Desktop Assessment	Y	Y	Y
Short list Assessment	Y	Y	Y
Loddon River – Pyramid Boort IA (Cumulative impacts)			
Desktop Assessment	Y	Y	Y
Short list Assessment	Y	tbd	Y
Loddon River - Torrumbarry IA - Cumulative impacts			
Desktop Assessment	Y	N	Y
Short list Assessment	Y	tbd	Y
Loddon River (Torrumbarry IA)			
Desktop Assessment	Y	-	Y
Short list Assessment	Y	tbd	Y

The Desktop assessment broke the Loddon River into a number of reaches:

Reach	**Desktop Recommendation**
Loddon River (Torrumbarry Irrigation Area - below Macorna Main Channel)	Due to the complexity of flow in the Loddon river in this region it is recommended that further investigations of the potential impact occur.
Loddon River (cumulative impact of reduced flows from Bannacher Creek, Pennyroyal Creek, Calivil Creek, Pyramid Creek and Nine Mile Creek)	There is considerable complexity in this part of the Loddon system and it is recommended that further investigation of the potential impacts of NVIRP on the Loddon river be undertaken.
Loddon River (Pyramid Boort Irrigation Area – below Loddon Weir and above Macorna Main channel)	Given the change of flow conditions in the Loddon river due to a reduction in channel outfalls associated with the NVIRP project further investigation into the environmental impact is recommended.

Loddon River (Cumulative outfalls – (cumulative impacts of reduced outfalls from creeks entering Loddon river above Macorna Channel)	Given change of flow conditions and stressed nature of the system a reduction in flow associated with NVIRP requires further investigation.

For the Short-list review process the Loddon is considered as 2 separate reaches (Torrumbarry IA and Pyramid Boort IA).

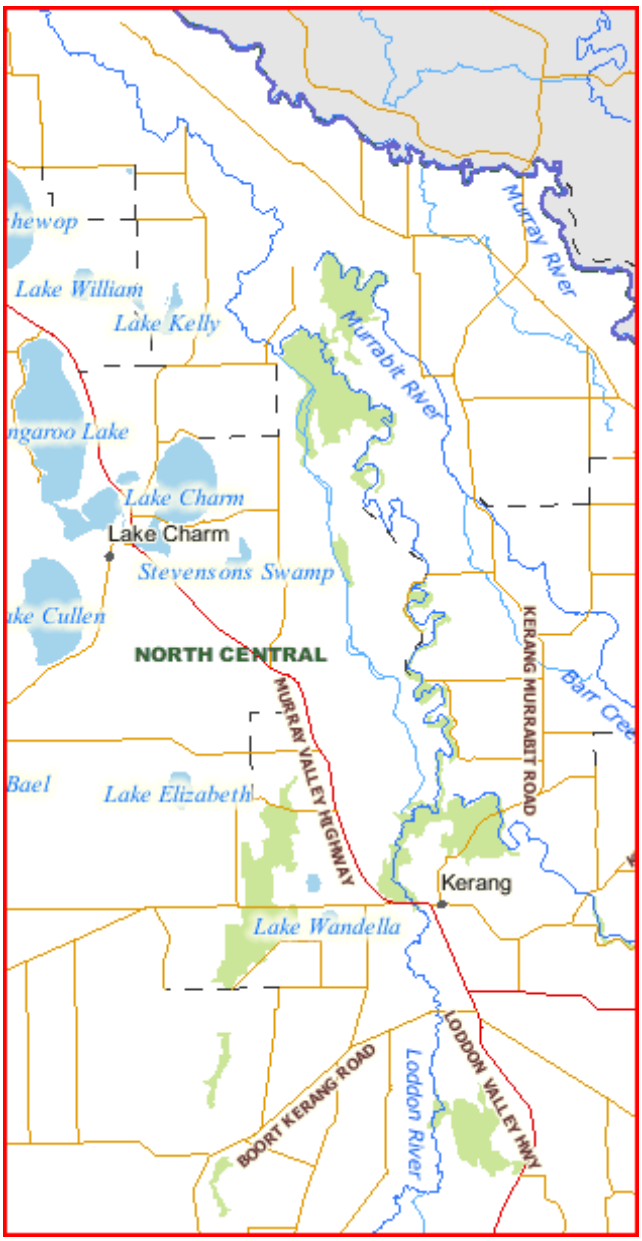
Both reaches of the waterway are potentially at risk and it is recommended that further investigations be undertaken for both reaches, during 2009, due to:

1. The Loddon River having high values (associated with high value wetlands, RRHS high priority, threatened flora and fauna)
2. The hydraulic links to high value wetlands
3. Potential operational changes due to NVIRP
4. The interactions that the Loddon River has with the Goulburn Irrigation System at Loddon Weir and
5. River flows that might be impacted more by overall NVIRP impacts than NVIRP channel outfall impacts.

Waterway Name	**Loddon River (Torrumbarry IA)**	
Waterway Identifier	Catchment	Loddon
	CMA Region	North Central
	Irrigation Area	Torrumbarry
	Public Land Status	Natural Features Reserve – Streamside area
	RRHS Reach No:	Loddon 1, 2, 3
Desktop Environmental Assessment Description	This System utilises the weir pool to transfer flows from Kow Swamp and Pyramid Creek into the Kerang Lakes including Reedy, Middle and Third Lakes and Lake Kangaroo, which are Ramsar listed wetlands (http://www.environment.gov.au/cgi-bin/wetlands).	
Updated Environmental Description	The NCCMA RRHS lists the Loddon River reaches 1, 2,3,4,5 as priority reaches. Chan T. *et al.*, 2006 reviewed the ecological values of the Lower Loddon River: *A number of plans have identified environmental values (environmental assets) in the Lower Loddon catchment and activities that are threatened these values. These include the North Central Regional Catchment Strategy (NCRCS), North Central River Health Strategy (NCRHS), Loddon Murray Land and Water Management Strategy, the Bulk Water Entitlement (BE) conversion process, the Kerang-Swan Hill Future Land Use Pilot Project, and the Kerang and Gunbower Forest Ramsar Site Strategic Management Plans.* *These environmental assets include:* • *internationally significant Ramsar listed sites (e.g. Gunbower Forest and Kerang wetlands),* • *nationally significant wetlands (e.g. Tang Tang and Kow Swamps),* • *threatened flora and fauna species (e.g. Murray cod, Golden perch, the Great Egret),*	

Waterway Name	Loddon River (Torrumbarry IA)
	• *rivers, streams and their floodplains,* • *biodiversity,* • *native fish, macroinvertebrates, riparian vegetation,* • *in-stream habitat, vegetation and structure.* Doeg T. *et al.*, 2001 identified biodiversity values, ecological processes and characterised the hydrology and operation of the system as part of the process of developing environmental flow recommendations for the Loddon catchment: In summary this section of the Loddon River has high value and is connected to other high value wetlands.
Desktop Hydrological assessment	The flow frequency curve for the Loddon River at Kerang indicates little or no change as a result of a reduction in channel outfalls. However, part of the impacted reach is located above Kerang Weir, where outfalls may make a greater contribution to river flows and there is significant complexity regarding the inter-relationships between flow in the Loddon River and the irrigation supply and drainage systems. Furthermore, operational changes as a result of NVIRP may also influence river flows in this reach. As discussed in Section 5.5.1, result in changes to flows in the Loddon River downstream of Loddon Weir.
Updated Hydrological assessment	The Torrumbarry section of the Loddon River receives outfalls from the Macorna Main Channel as well as inflows from Pyramid Creek and Bannacher Creek. This site on the Loddon River is downstream of the Kerang weir and utilises the weir pool to transfer flow from Kow Swamp and Pyramid Creek into the Kerang Lakes. In 2004/2005 there was 36,422 ML passing at Kerang Weir. Flows downstream of Kerang Weir are also influenced by passing flow requirements for diverters on the Loddon River, downstream of Kerang Weir (SKM). Six outfalls enter the Loddon River directly via Channel 1, 4, 6, and 7, with a combined outfall volume of 1196.8 ML in 2004/2005. The main outfall contributor are ST001704 (50 % of total outfalls) and ST002308 (35 % of total outfalls), contributing a combined total outfall volume of 1860.5 ML. This outfall information has been further summarised in Table 16 below Outfalls ST002302 and ST001704 have been monitored as part of the Murray Strategic Monitoring Project since 2006. As a result outfalls may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. The distance between the six outfalls and entry point into the Loddon River is on average < 100 m, therefore no drainage diversions occur downstream of the outfalls. Table 16 below provides a summary of the estimated distance from outfall to entry point for each outfall. Based on the close proximity of the outfalls to the Loddon River and the absence of drainage diverters, it is considered likely that a significant amount of the water outfalled from the six outfalls will reach the River.
Desktop Recommendation	Due to the complexity of flow in the Loddon River in this region it is recommended that further investigations of the potential impacts associated with NVIRP occur.
Short-list Recommendation	Further investigations are recommended. It is recommended that an EWP be prepared.

Location Plan


Murray River
Lake William
Lake Kelly
Murrabit River
Lake Charm
Lake Charm
Stevensons Swamp
NORTH CENTRAL
KERANG MURRABIT ROAD
Barr Cree
MURRAY VALLEY HIGHWAY
Lake Elizabeth
Kerang
Lake Wandella
LODDON VALLEY HWY
BOORT KERANG ROAD
Loddon River

Waterway Name	Loddon River (cumulative outfalls) (Torrumbarry IA)
Desktop Environmental Assessment Description	The Loddon River in this reach retains significant environmental values and is considered flow stressed (Loddon River Environmental Flows Scientific Panel, 2002). This reach retains significant environmental values, including water dependent vegetation communities and native fish populations. Hence any reduction in flow as a result of a reduction in channel outfalls is likely to represent an ecological risk to the system.
Updated Environmental Description	The NCCMA RRHS lists the Loddon River reaches 1, 2,3,4,5 as priority reaches. Chan T. *et al.*, 2006 reviewed the ecological values of the Lower Loddon River: *A number of plans have identified environmental values (environmental assets) in the Lower Loddon catchment and activities that are threatened these values. These include the North Central Regional Catchment Strategy (NCRCS), North Central River Health Strategy (NCRHS), Loddon Murray Land and Water Management Strategy, the Bulk Water Entitlement (BE) conversion process, the Kerang-Swan Hill Future Land Use Pilot Project, and the Kerang and Gunbower Forest Ramsar Site Strategic Management Plans.* *These environmental assets include:* • *internationally significant Ramsar listed sites (e.g. Gunbower Forest and Kerang wetlands),* • *nationally significant wetlands (e.g. Tang Tang and Kow Swamps),* • *threatened flora and fauna species (e.g. Murray cod, Golden perch, the Great Egret),* • *rivers, streams and their floodplains,* • *biodiversity,* • *native fish, macroinvertebrates, riparian vegetation,* • *in-stream habitat, vegetation and structure.* Doeg T. *et al.*, 2001 identified biodiversity values, ecological processes and characterised the hydrology and operation of the system as part of the process of developing environmental flow recommendations for the Loddon catchment: In summary this section of the Loddon River has high value and is connected to other high value wetlands
Desktop Hydrological assessment	The cumulative impact of reductions in channel outfalls on the Loddon River at Appin South indicates a discernable change in flows as a result of a reduction in channel outfalls. This included inflows entering the Loddon River from Twelve Mile Creek
Updated Hydrological assessment	n/a
Desktop Recommendation	Given the change of flow conditions and stressed nature of the system a reduction in flow associated with the NVIRP Project requires further investigation for this waterway
Short-list Recommendation	Further investigations are recommended. It is recommended that an EWP be prepared.

Waterway Name	Loddon River (Appin South) (Pyramid Boort IA)

Waterway Identifier	Catchment	Loddon
	Length	
	CMA Region	North Central
	Irrigation Area	Pyramid Boort
	Land Manager	
	Public Land Status	Public land water frontage – Loddon River Reserve
	RRHS Reach No:	Loddon 4,5
Desktop Environmental Assessment Description	The Loddon River through this reach retains significant environmental values, including water dependant vegetation communities and native fish populations (Loddon River Environmental Flows Scientific Panel, 2002).	
Updated Environmental Description	See Loddon River (Torrumbarry IA) above. From NCCMA, 2006g The Loddon River flows permanently for approximately 74km from Boort East to Kerang. It receives major tributary inputs from Twelve Mile, Wandella, Sheepwash and Bannacher Creeks. From the Charlton-Durham Ox Road, the river meanders north through open grazing and cropping farmland. The Canary Islands are situated between the anabranching channels of the river. The Loddon River continues in a north-westerly direction to Appin South. The lower reaches continue through grazing farmland to the east of Appin State Forest. The Macorna Channel is siphoned across the river approximately 6km southeast of Dingwall near Murphy Swamp. The Loddon River flows to the west of the Tragowel Swamp (a nationally important wetland), before continuing north within 2km to the west of the Murray Valley Highway to Kerang. The pre 1750 Ecological Vegetation Class data is incomplete along the Loddon River within MU 27. Assessments reveal that 40% of the riparian tree cover is in good condition, displaying a wide, continuous and native tree canopy. Approximately 34% is considered in marginal condition and 26% is poor. In the Upper Reaches (Boort East to Appin South) the riparian vegetation extends between 5m and 40m wide on either bank. The overstorey consists of an almost continuous cover of River Red Gums with evidence of natural regeneration. Tangled Lignum exclusively forms the shrub layer in the Canary Islands area. Closer to Appin South the riparian tree cover is patchy with a large amount of standing dead timber. However a significant amount of Tangled Lignum continues to line the banks. In the lower reaches (Appin South to Kerang) narrow, patchy riparian tree cover continues along the Loddon River, to the east of Appin State Forest. River Red Gum and Black Box generally extend up to 10m wide on either bank with a significant amount of mature, large, hollow-bearing	

	trees. Macroinvertebrate data are only available at one site at Appin South. A low diversity lowland community was recorded. This highlights disturbance to the river along this reach. Modification to the flow regimes in the Loddon River has resulted in floods being less frequent, shorter in duration and reduced in extent due to the mitigating role of Laanecoorie Reservoir. River provides habitat for the vulnerable Golden Perch and critically endangered Silver Perch. The rare Twin-leaf Bedstraw, the vulnerable Pale-spike Sedge, Riverine Flax-lily and Swamp Buttercup and the endangered Tough Scurf-pea have been recorded along the river. Assessed as being of high value.
Desktop Hydrological assessment	A number of outfalls enter the Loddon River in this reach and data for 04/05-05/06 indicates that these outfalls contributed ~20% of river flows. The flow frequency curve for the Loddon River at Appin South indicates a large change in river flow as a result of a reduction in channel outfalls.
Updated Hydrological assessment	Flow in the Loddon River at Appin South is influenced by irrigation extractions upstream at the Loddon Weir and by the splitting flood flows into several anabranch systems, notably the Serpentine Creek and Bannacher Creek. There are six outfalls that enter the Loddon River directly from Boort Channels 1, 2, 3/2/8/2, 9/2 and 1/9/2 which outfalled a volume of 621 ML in 2004/2005. The main outfall contributor is ST023234 which contributes 80 % of the outfall likely to enter the Loddon River. Outfall ST008257 enters the Loddon River directly via Channel 1 and the outfall volume in 2004/2005 was 0 ML. This outfall information has been further summarised in Table 17 below. The distance between the outfalls and entry point into Loddon River is < 3km and no drainage diverters have been identified downstream of the outfall points. Table 17 below provides a summary of the estimated distance from outfall to entry point for each outfall. Due to the close proximity of the outfalls to the Loddon River and the absence of drainage diverters, it is considered likely that the majority of the water outfalled will reach the Loddon River.
Desktop Recommendation	Given the change of flow conditions in the Loddon River due to a reduction in channel outfalls associated with the NVIRP Project further investigation into the environmental impact of the NVIRP Project on this waterway is recommended.
Short-list Recommendation	Further investigations required. It is recommended that an EWP be prepared.

Waterway Name	**Loddon River (cumulative outfalls) – Pyramid Boort IA**

Waterway Name	Loddon River (cumulative outfalls) – Pyramid Boort IA
Desktop Environmental Assessment Description	
Updated Environmental Description	From NCCMA, 2006g The Loddon River flows permanently for approximately 74km from Boort East to Kerang. It receives major tributary inputs from Twelve Mile, Wandella, Sheepwash and Bannacher Creeks. From the Charlton-Durham Ox Road, the river meanders north through open grazing and cropping farmland. The Canary Islands are situated between the anabranching channels of the river. The Loddon River continues in a north-westerly direction to Appin South. The lower reaches continue through grazing farmland to the east of Appin State Forest. The Macorna Channel is siphoned across the river approximately 6km southeast of Dingwall near Murphy Swamp. The Loddon River flows to the west of the Tragowel Swamp (a nationally important wetland), before continuing north within 2km to the west of the Murray Valley Highway to Kerang. The pre 1750 Ecological Vegetation Class data is incomplete along the Loddon River within MU 27. Assessments reveal that 40% of the riparian tree cover is in good condition, displaying a wide, continuous and native tree canopy. Approximately 34% is considered in marginal condition and 26% is poor. In the Upper Reaches (Boort East to Appin South) the riparian vegetation extends between 5m and 40m wide on either bank. The overstorey consists of an almost continuous cover of River Red Gums with evidence of natural regeneration. Tangled Lignum exclusively forms the shrub layer in the Canary Islands area. Closer to Appin South the riparian tree cover is patchy with a large amount of standing dead timber. However a significant amount of Tangled Lignum continues to line the banks. In the lower reaches (Appin South to Kerang) narrow, patchy riparian tree cover continues along the Loddon River, to the east of Appin State Forest. River Red Gum and Black Box generally extend up to 10m wide on either bank with a significant amount of mature, large, hollow-bearing trees. Macroinvertebrate data are only available at one site at Appin South. A low diversity lowland community was recorded. This highlights disturbance to the river along this reach. Modification to the flow regimes in the Loddon River has resulted in floods being less frequent, shorter in duration and reduced in extent due to the mitigating role of Laanecoorie Reservoir. River provides habitat for the vulnerable Golden Perch and critically endangered Silver Perch. The rare Twin-leaf Bedstraw, the vulnerable Pale-spike Sedge, Riverine Flax-lily and Swamp Buttercup and the endangered Tough Scurf-pea have been recorded along the river. Assessed as being of high value.

Waterway Name	Loddon River (cumulative outfalls) – Pyramid Boort IA
Desktop Hydrological assessment	The cumulative impact of reductions in channel outfalls on the Loddon River at Kerang was investigated and the flow frequency curve indicates little or no change as a result of a reduction in channel outfalls.
Desktop Recommendation	However, as discussed above there is considerable complexity in this part of the Loddon system and it is recommended that further investigation of the potential impacts of NVIRP on the Loddon River be undertaken.
Short-list Recommendation	Further investigations are recommended. It is recommended that an EWP be prepared.

B7. Nine Mile Creek

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	Y	Y
Short list Assessment	N	N	N

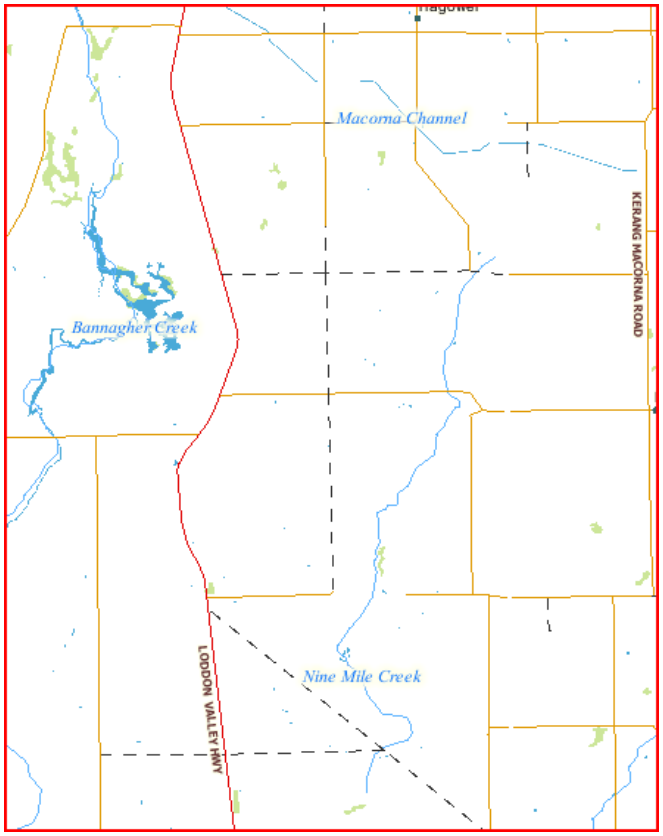
Waterway Name	Nine Mile Creek	
Description	Serpentine Creek splits into Pennyroyal and Nine Mile Creek approximately 2km downstream of Durham Ox. Nine Mile Creek flows 43km in a north-easterly direction to Calivil Creek near Tragowel Swamp. Flows are ephemeral.	
Waterway Identifier	Catchment	Loddon
	CMA Region	North Central
	Irrigation Area	Pyramid Boort/Torrumbarry
	Public Land Status	freehold
	ISC Reach No:	n/a
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	There are likely to be regionally significant environmental values associated with the upper Nine Mile Creek, similar to those for the Serpentine – Pennyroyal and Bannacher Creeks system. However, it is unclear what values exist in the downstream reaches where it acts as a community drain.	

Waterway Name	Nine Mile Creek
Updated Environmental Description	From NCCMA, 2006a Nine Mile Creek flows entirely across a flat alluvial plain. The majority of the creek has been channelised and is still considered to be in a degraded state. The pre 1750 Ecological Vegetation Class data is incomplete along Nine Mile Creek. Assessments reveal that 4% of the riparian tree cover is in good condition, displaying a wide, continuous and native tree canopy. Approximately 4% is considered in marginal condition and 93% is poor. In the upper reaches (Serpentine Creek to Macorna Road) the riparian vegetation is generally less than 10m wide on either bank, except at the weir near Serpentine Creek where the vegetation extends greater than 40m wide. Here, a continuous canopy of River Red Gum and Black Box line the banks above a shrub layer of Lignum. Further downstream, Lignum exclusively forms the riparian vegetation in the absence of trees. Cumbungi generally grows within the waterway channel with native sedges lining the water's edge. In the lower reaches (Macorna Road to the Calivil Creek confluence) scattered clumps of Lignum occur along Nine Mile Creek with no significant tree cover. Boxthorn and Spiny Rush are also present in some areas. The instream habitat Nine Mile Creek is generally restricted to reed beds and shallows with a variety of other cover types present closer to the Serpentine Creek where trees line the banks. No macroinvertebrate data is available for Nine Mile Creek. A long term water quality monitoring site (407284) exists on Nine Mile Creek near Macorna. Concentrations of both nitrogen and phosphorus exceed the EPA (1995) nutrient guideline values. Instances of very high concentrations for both nutrients have been recorded. At both Macorna Road and the Murray Valley Highway Nine Mile Creek is a broad depression 60-80 m wide and approximately 1 m deep. It has a constructed drain 1-2 m wide and 0.3 m deep running along the thalweg. Values of Nine Mile Creek are associated with flood flows and are not attributable to channel outfall flows.
Desktop Hydrological assessment	A reduction in outfalls could increase the amount of time that the creek ceases to flow from around 20% to 70% of the time. Although, this is also dependant on the amount of water entering via Serpentine Creek further upstream. It is unclear to what degree NVIRP could impact on flows in Serpentine Creek and hence Nine Mile Creek (R Plunkett, NVIRP, pers. comm.).
Updated Hydrological assessment	Nine Mile Creek receives flow from the Serpentine Creek System on the Loddon River floodplain. Under natural conditions Nine Mile Creek would flow from the Serpentine Creek near Durham Ox to the Pyramid Creek east of Kerang. Flow in the upper reaches of Nine Mile Creek is influenced by releases to Serpentine Creek which is a natural carrier in the Pyramid Channel 12 irrigation system. The lower reaches of Nine Mile Creek have been incorporated into the regional drainage network. The Nine Mile Creek drainage system

Waterway Name	Nine Mile Creek
	flows into the Calivil Creek Drain and ultimately to the Barr Creek. Nine Mile Creek receives water from 10 outfalls sites. Nine outfalls enter the lower reaches which form the Nine Mile Creek drainage system and whilst the other one is located in the upper reaches. There are seven outfall sites that enter the Nine Mile Drain 3, Nine Mile Drain 3/1 or the Nine Mile Drain 1/1 which contributed a combined outfall volume of 273 ML in 2004/2005. The main outfall contributors are ST009547 (202 ML) and ST009510 (71 ML), which contribute to 99 % of the total outfalls to the Nine Mile Drains 3 system. There are two outfalls (ST009952, ST009500) that enter the Nine Mile Creek directly from the irrigation channels. These outfalls contributed a combined outfall volume of 22 ML in 2004/2005. The remaining outfall (ST009753) is located on the Serpentine Creek near the Pyramid Channel 12 offtake and the outfall to Pennyroyal Creek. The outfall to the Nine Mile creek is not used to outfall water from the Serpentine Creek. The Pennyroyal outfall is part of the SMP and is SCADA controlled, (pers. comm. G-MW), hence the outfall volume to the Nine Mile Creek was 0 ML in 2004/2005. Outfalls ST009753, ST009988, ST009500, ST009730, ST009539, ST009500 and ST009540 had outfall volumes of 0 ML in 2004/2005. It has also been noted that the ST009510 outfall water is used as a source of re-use water (SKM assessment). This outfall information has been further summarised in Table 18 below. There are seven drainage diverters located downstream of the outfall sites linked to the Nine Mile Drain 3, with a diversion licence volume of 358 ML. The diversion licence volume is significantly more than the 2004/2005 outfall volume for the outfall (71 ML). It is considered likely that all water outfalled to Nine Mile Drain 3 will be diverted for use before entering the Creek. There is one drainage diverter located down stream of the four outfalls linked to the Nine Mile Drain 1/1, which has a diverter licence volume of 10 ML. This volume is significantly smaller than the combined outfall volume (202 ML). Therefore it is likely that at least 95 % of water outfalled from these outfall sites will reach the Nine Mile Creek. The distance between the nine outfalls and entry point into Nine Mile Creek is approximately < 0.5 km and 13 km. One of the major outfall contributors (ST009547) is located approximately 9 km from Nine Mile Creek; therefore it is likely that some of this water will be lost in the drain due to seepage and evaporation. Table 18 below provides a summary of the estimated distance from outfall to entry point for each outfall. After taking into account the drainage diversion volume which could be diverted for use, it is considered likely that at least 70% of the total outfall volume could enter Nile Mile Creek. However the distance travelled by the outfall water to the Creek indicates that further outfall water may be lost due to seepage and evaporation before entering Nile Mile Creek.
Desktop Recommendation	Given the change of flow conditions in the Nine Mile Creek due to a reduction in channel outfalls associated with the NVIRP Project and uncertainty around interactions with Serpentine Creek and potential environmental values, further investigation into the environmental impact of the NVIRP Project on this waterway is recommended.

Waterway Name	Nine Mile Creek
Short-list Recommendation	Not at risk due to: • the values of the creek being associated with flood flows; and • channel outfall water being unlikely to make any contribution to environmental values. It is recommended that no further work be undertaken. Note – North Central CMA requested the NVIRP TAC to further investigate Pennyroyal and Nine Mile Creeks immediately downstream of their outfalls from Serpentine Creek.

Location Plan



B8. Pennyroyal and Nine Mile Creek – immediately downstream of Serpentine Creek outfalls

These waterways were not assessed during the Desktop Assessment.

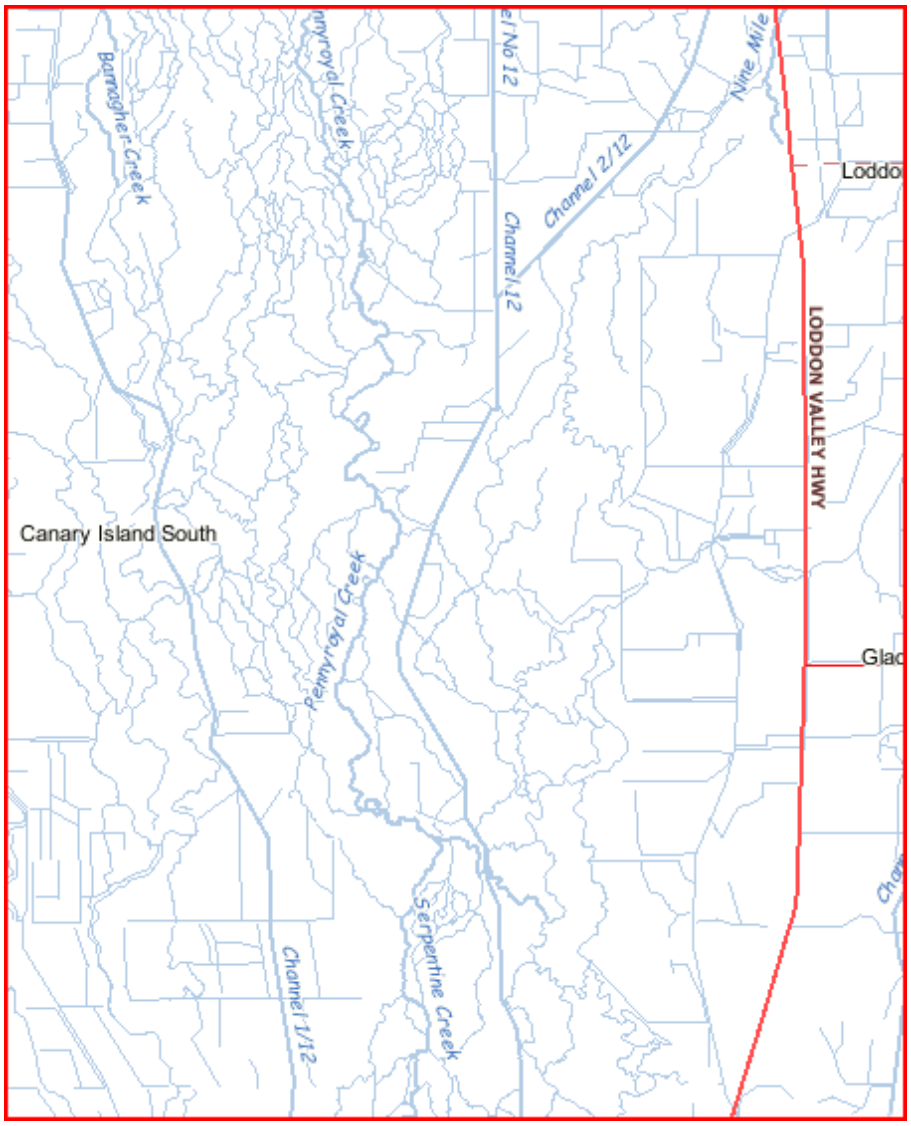
Waterway Name	Pennyroyal and Nine Mile Creeks – immediately downstream of Serpentine Creek outfall (just downstream of Durham Ox)
Description	North Central CMA requested the NVIRP TAC to further investigate Pennyroyal and Nine Mile Creeks immediately downstream of their outfalls from Serpentine Creek. The basis of this request was that current structures leak water which maintains water dependent EVC values for a short section downstream of the structures. These values do not continue lower into these creek systems.

Waterway Name	Pennyroyal and Nine Mile Creeks – immediately downstream of Serpentine Creek outfall (just downstream of Durham Ox)
Waterway Identifier	Catchment: Loddon Length: CMA Region: North Central Irrigation Area: Pyramid Boort Land Manager:
Desktop Environmental Assessment Description	-
Updated Environmental Description	General waterway description is provided in sections above. These sections of creek, immediately downstream of outfall from Serpentine Creek support water dependent EVC values. It is assumed that these short reaches will have similar values to Serpentine Creek due it proximity and connectiveness. Serpentine Creek is listed as a priority waterway in the NCCMA RRHS. From : Serpentine Creek - Lower Reaches (Prairie Road to the Nine Mile/Pennyroyal Creek confluence) - River Red Gums continue to provide an almost continuous tree canopy along the lower reaches, extending between 5m and 10m wide on either bank. Some Weeping Willows are present along the creek near Durham Ox. Lignum and Cumbungi grow within and beside the creek channel. Some standing dead timber is also present. Fish species present in Serpentine Creek: • Western Carp Gudgeon • Golden Perch (VROTS vulnerable) • Murray Rainbowfish • Bony Bream • Flat-headed Gudgeon • Australian Smelt. Golden Perch have been stocked in Serpentine Creek since 1990 (McGuckin and Doeg, 2000). Macroinvertebrate data are available for one site along the upper reaches of Serpentine Creek. A typical lowland community was recorded. The dominance of water boatmen in this community and the presence of other slow water preferring macroinvertebrates are indicative of lowland streams (McGuckin & Doeg, 2000). The vulnerable Pale Spike-sedge (Eleocharis pallens) has been recorded along the creek.
Desktop Hydrological	

Waterway Name	Pennyroyal and Nine Mile Creeks – immediately downstream of Serpentine Creek outfall (just downstream of Durham Ox)
assessment	
Updated Hydrological assessment	Serpentine Creek is a regulated natural carrier on the Pyramid Channel 12 system. Under natural conditions takes flood flows from Loddon River near Serpentine and splits the flow between the Pennyroyal and Nine Mile Creeks north of Durham Ox. Currently two outfall structures control flow to the Pennyroyal and Nine Mile Creeks. The Pennyroyal Outfall is part of the Strategic Measurement Program and is SCADA controlled. All outfall water is passed to the Pennyroyal Creek. No outfalls flow to the Nine Mile Creek; however observation strongly suggests that water leaking through or around this structure maintains water dependent EVC values. Pennyroyal Creek is fed by the Serpentine Creek, via the Loddon River. Unlike the Bannacher Creek (a continuation of Pennyroyal Creek) the Creek has not been incorporated into the regional drainage network (SKM). Serpentine Creek is a natural carrier of the irrigation system from the Waranga Western Channel (WWC) at Bears Lagoon to the Pyramid Channel 12 offtake north of Durham Ox. The outfall to the Pennyroyal Creek is effectively a weir to divert water into Pyramid Channel 12 and has an outfall volume (2004/2005) of 1147 ML. This outfall also has a tilt gate installed and is monitored as part of the Strategic Monitoring Program. The travel time of water from Bears Lagoon through Serpentine Creek to the Channel 12 offtake is approximately 4 days. As a result, if rainfall occurs within 4 days after water is ordered and released from the WWC and irrigators cancel their orders, the water is then passed through the outfall to Pennyroyal Creek as rainfall rejection. An additional outfall exists nearby to the Nine Mile Creek however as the Pennyroyal outfall is SCADA controlled, the 9 Mile creek outfall is not used (pers. comm. G-MW). Further analysis was carried out to determine the relationship between the outfall volume and rainfall events at the Pennyroyal Creek. The result of this analysis clearly indicated that the volume of outfall is largely a result of rainfall rejection; that is the result of irrigators cancelling their orders as a result of local rainfall which subsequently increases the outfall volume. This tight relationship between rainfall and channel outfall is illustrated in Figure 8 The outfall water passes some 3 km from entry point through the remainder of the Serpentine Creek into Pennyroyal Creek. There are no drainage diverters identified downstream of the outfall. Table 19 below provides a summary of the estimated distance from outfall to entry point. Due to the close proximity of the outfalls to the Pennyroyal Creek and the absence of drainage diverters, it is considered likely that outfall water will reach the Creek. However consideration should be given to the fact that the volume of outfall is largely dependent on rainfall rejection, rather than operational conditions and the interconnecting relationship of Pennyroyal Creek to other waterways in the area. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP, unless the Serpentine Creek is removed from the System, due the relatively long travel time of ordered flows from the Waranga Western Channel.

Waterway Name	Pennyroyal and Nine Mile Creeks – immediately downstream of Serpentine Creek outfall (just downstream of Durham Ox)
	In addition to rejection of water ordered, the water outfalled to Pennyroyal Creek includes inflows into the Serpentine Creek from its own catchment as a result of the rainfall.
Desktop Recommendation	n/a
Short List Recommendation	Pennyroyal Creek not at risk due to the lack of impact of reduced channel outfall.. The volume of water outfall at the Pennyroyal Outfall is unlikely to be reduced as a result of NVIRP. The section of Nine Mile Creek immediately downstream of the outfall structure on Serpentine Creek is potentially at risk. Although no channel outfalls occur to Nine Mile Creek from Serpentine Creek NVIRP may undertake works which eliminate leakage supporting the EVC values immediately downstream of the outfall. Further investigation of environmental values and effects of leakage reduction on these values is recommended by 2010.

Location Plan



B9. Pyramid Creek (Pyramid Boort Irrigation Area).

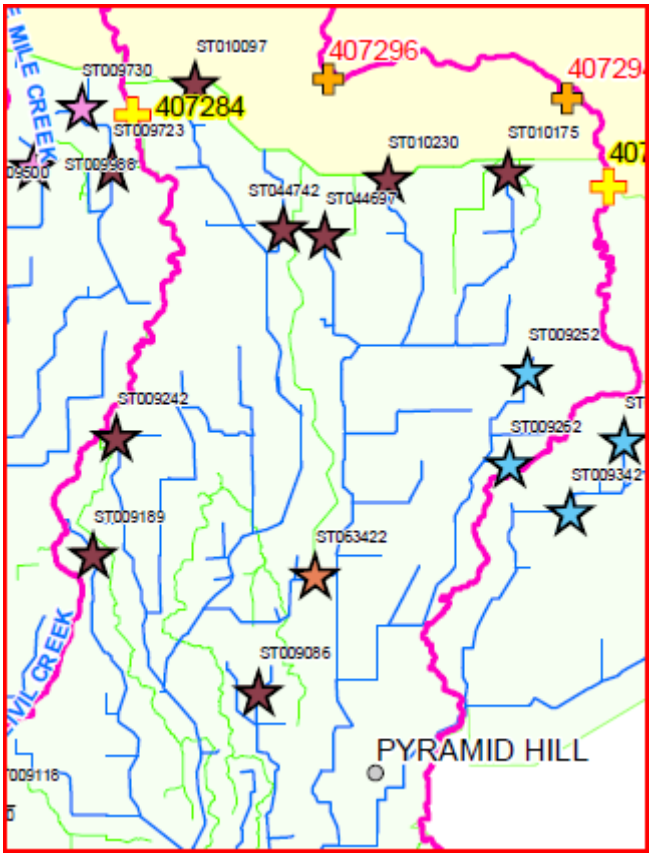
Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Not assessed	Y	Y
Short list Assessment	N	Y	N

Waterway Name	Pyramid Creek (Pyramid Boort Irrigation Area)

	There is some confusion about this waterway. Pyramid/Box Creek (Torrumbarry Irrigation Area) is fully regulated downstream of Kow Swamp. The Desktop Assessment recommended this waterway not be considered for further investigation. Pyramid Creek (Pyramid Boort IA) refers to Pyramid Drain 1 and Pyramid Drain 2/1 that outfall to Pyramid Creek in the vicinity of gauging station 407296 (just upstream of Hirds and Johnsons Swamps. This waterways (depression) flows in a northerly direction from west of Pyramid Hill and is channelized for most of its length.
Waterway Identifier	Catchment: Loddon CMA Region: North Central Irrigation Area: Pyramid Boort Public Land Status: RRHS Reach No: n/a
Desktop Environmental Assessment Description	Not documented
Updated Environmental Description	Channel outfalls discharge to drains, which have minimal environment values. The constructed rains flow through cleared farm land. These drains outfall to the regulated Pyramid Creek.
Desktop Hydrological assessment	According to the flow frequency curve, the amount of time that the creek ceases to flow changes from 10% of the time to 70% of the time when the one channel outfall is reduced. Note that this part of Pyramid Creek is upstream of the reach used as a natural carrier, hence impacts of a reduction in outfalls is more substantial in this reach than further downstream..
Updated Hydrological assessment	Pyramid Creek flows north-westerly from Kow Swamp to the Loddon River at Kerang. It receives major tributary inputs from Bullock and Calivil Creeks. Many sections of the creek have been channelised to allow Its use as a bulk carrier to transfer water from Kow Swamp and the River Murray to Kerang Weir and into parts of the Torrumbarry Irrigation Area. There are six outfalls that enter the Pyramid Creek via the Pyramid Drain 1 and Pyramid Drain 2/1. One outfall is linked to the Pyramid Drain 1 (ST063422) and had an outfall volume of 681 ML for 2004/2005. This outfall is the main outfall contributor for Pyramid Creek, contributing 85% of the total outfalls into the Creek. There are five outfalls (ST009086, ST044742, ST044697, ST010175 and ST010230) linked to the Pyramid Drain 2/1, which were originally identified in the SKM assessment report as outfalling into the Calivil Creek, however further assessment identified them as outfalling into the Pyramid Creek. These five outfalls had a combined outfall volume of 116 ML in 2004/2005. Outfalls ST044697 and ST010175 had an outfall volume of 0 ML in 2004/2005. Further summaries of these outfalls can be seen in Table 20 below. THIS

	TABLE IS ALREADY IN THE REPORT There are six drainage diverters located down stream of outfall ST063422 which have a combined diversion licence volume of 155 ML which is smaller than the amount outfalled from this site (681 ML). It is expected that at least 75 % of water outfalled from this site will reach the Pyramid Creek. There are six drainage diverters identified down stream of the outfalls linked to the Pyramid Drain 2/1, with a combined diversion licence volume of 170 ML. The diversion licence volume is more than the 2004/2005 outfall for the five outfalls (116 ML), so it is likely water outfalled to Pyramid Drain 2/1 will be diverted for use before entering Calivil Creek. The distance between the six outfalls and their entry point into Pyramid Creek ranges between 8 km to 24 km. This significant distance indicates that it is likely that a significant amount of the outfall water may be lost in the drain due to seepage and evaporation. Table 20 below provides a summary of the estimated distance from outfall to entry point for the outfall. After taking into account the drainage diversion volume which could be diverted for use, it is considered likely that approximately 60 % of the total outfall volume could enter Pyramid Creek. However the distance travelled by the outfall water to Pyramid Creek indicates that further outfall water is may be lost due to seepage and evaporation before entering Pyramid Creek. There is likely to be some impact on flow as a result of reduced channel outfall.
Desktop Recommendation	Given the change of flow conditions in the Pyramid Creek due to a reduction in channel outfalls associated with the FBM Project further investigation into the environmental impact of the FBM Project on this waterway is recommended.
Short-list Recommendation	Not at risk due to the low environmental values. It is recommended that no further investigation be undertaken
Location Plan	From SKM maps of channel outfalls:

	 ST010097 407296 ST009730 407284 ST009723 ST010230 ST010175 ST044742 ST044697 ST009252 ST009242 ST009262 ST009342 ST009189 ST063422 ST009086 PYRAMID HILL
Google Map	


< Pyramid Ck
Pyramid No 1 Drain

B10. Sevens Creek

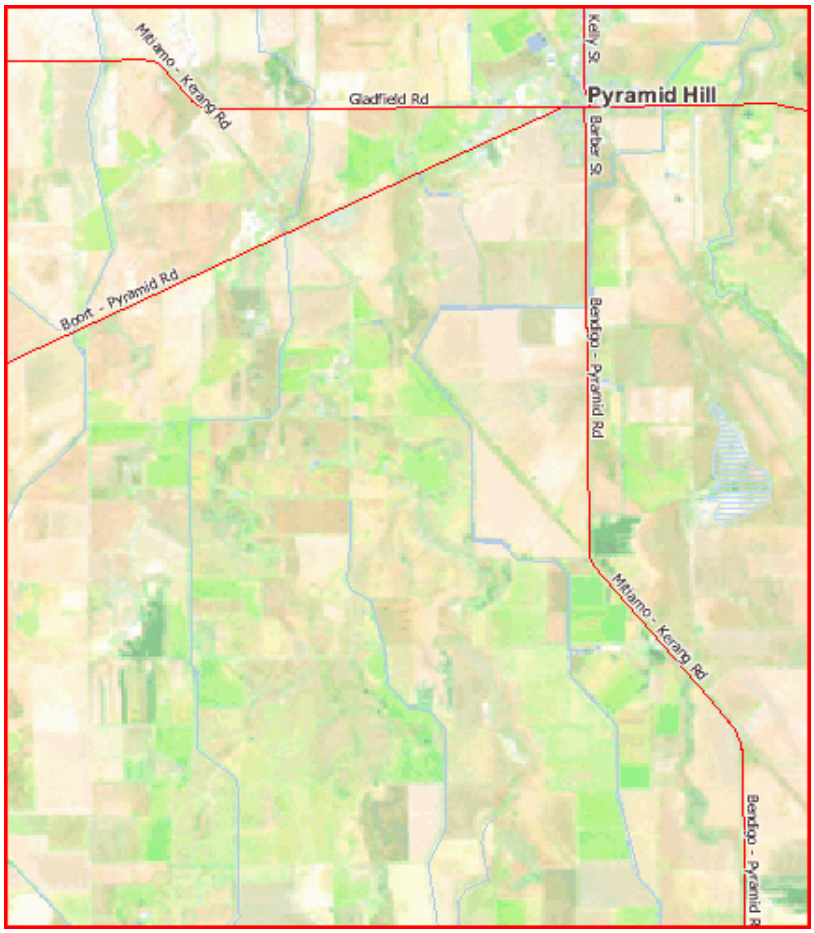
Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	N	Y
Short list Assessment	N	N	N

Waterway Name	Sevens Creek	
Description	This ephemeral waterway is adjacent to Seven Months Creek, near Pyramid Hill. It flows in a north westerly direction from near Pyramid Hill discharging eventually into Calivil Creek. (See Plans below).	
Waterway Identifier	Catchment	Loddon
	Length	
	CMA Region	North Central
	Irrigation Area	Pyramid Boort
	Land Manager	private
	Public Land Status	n/a
	ISC Reach No:	n/a
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	A preliminary environmental assessment has not identified any significant environmental values.	
Updated Environmental Description	Downstream of the outfall and adjacent to the Boort Pyramid Road the waterway flows through cultivated and grazed paddocks. There is no riparian vegetation. Environmental values are very low.	
Desktop Hydrological assessment	Sevens Creek (as separate to Seven Months Creek) is a minor waterway in the Pyramid Boort district and only receives one outfall. There is no gauge data available on the creek.	
Updated Hydrological	Sevens Creek is a minor waterway in the Pyramid Boort district that only receives one outfall. ST008772 enters the waterway directly from Pyramid Channel 12/1 and had an outfall volume of 8	

assessment	ML in 2004/2005. Further summary of this outfall can be seen in Table 19. The distance from the outfall and entry point to Seven Creek is 5 km (see Table 19) and no drainage diversion licences were identified downstream of the outfall. However it has been stated that the ST008772 outfall water is used as a source of re-use water (SKM spreadsheet). Due to the small outfall volume of the one connecting outfall to Sevens Creek and the possibility of the water being used as re-use water is considered unlikely that any outfall water will reach the Creek.
Desktop Recommendation	It is expected that a reduction in outfalls will have little impact on Sevens Creek. However, given the lack of flow information further investigation into the environmental impact of the NVIRP Project on this waterway is recommended
Short-list Recommendation	Not at risk due to the low environmental values and the lack of impact of channel outfall reduction. It is recommended that no further investigation be undertaken.

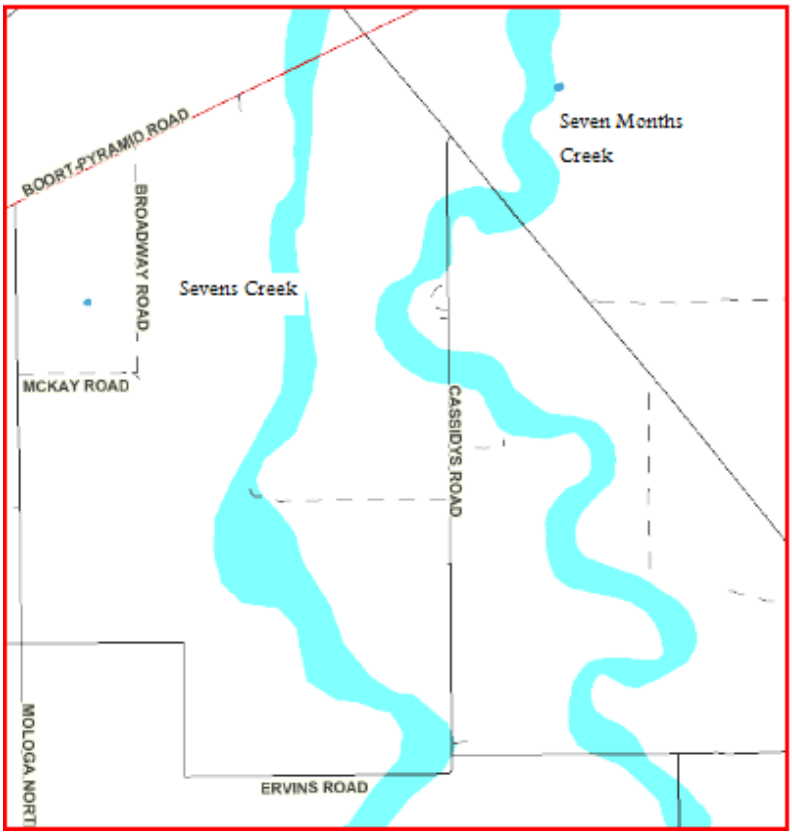
Location Map

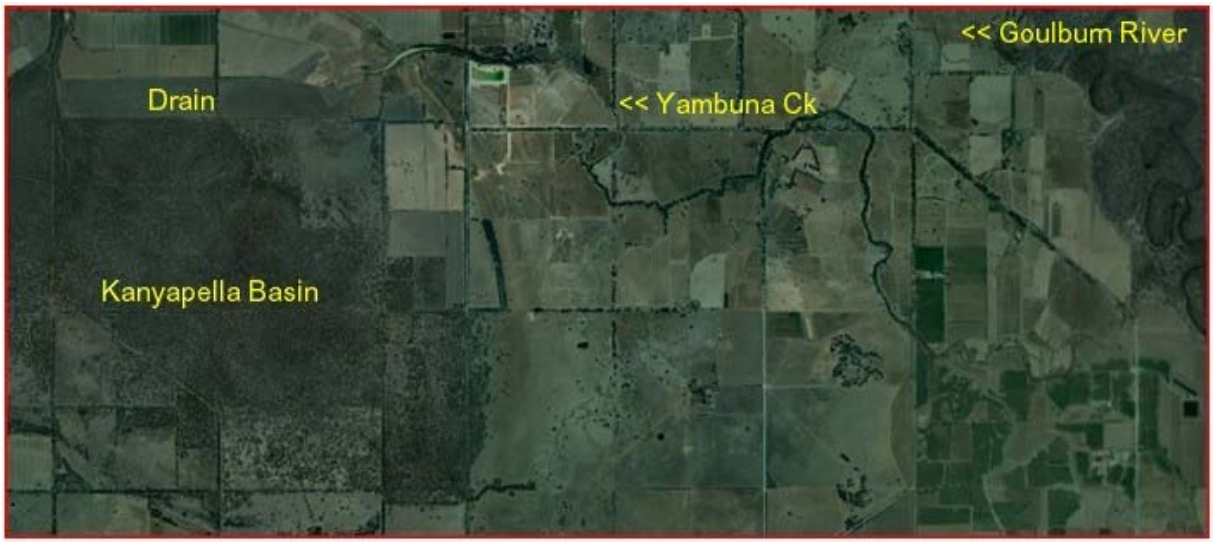


Floodway Plan


Boort-Pyramid Rd
Seven Months Creek
Seven Creek
channel outfall
Bendigo-Pyramid Rd
© 2009 MapData Sciences PtyLtd, PSMA
© 2009 Cnes/Spot Image

Location Map




Drain
<< Yambuna Ck
<< Goulburn River
Kanyapella Basin

B11. Sheepwash Creek

Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	unknown	Y
Short list Assessment	N	N	N

Waterway Name	Sheepwash Creek	
Description	Sheepwash Creek is an ephemeral waterway that drains the River Murray floodplain west of Koonoomoo. Prior to construction of levees along the river it would have carried flood flows across the floodplain and drained the floodplain after floods. It drains into Ulupna Creek, an anabranch of the River Murray. Flow depth and rate in Ulupna Creek are dependent on rates of flow in the Murray. At times of high, or flood, flow, water from Ulupna Creek/River Murray would back up into the very lower reaches of Sheepwash Creek.	
Waterway Identifier	Catchment	Murray
	CMA Region	Goulburn Broken
	Irrigation Area	Murray Valley
	Land Manager	
	Public Land Status	Natural Features Reserve
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	The Sheepwash – Ulupna Creek system supports a range of biodiversity values, particularly ones associated with water dependent vegetation along the riparian corridor (Ahern et al., 2003).	
Updated Environmental Description	VicRoads (2000) undertook an environment effects statement for the Strathmerton Deviation. The study area included Sheepwash Creek. The Report assessed aquatic ecology and noted the presence of a diversity of native fish species in the River Murray and an unnamed lagoon on the Victorian side of the border. No special mention was made of Sheepwash Creek. McGuckin J. (1999) undertook and investigative fish and crayfish survey as part of the EES process for alignment option B which crossed Sheepwash Creek. This Report noted • The low regional value of the waterway • Poor flows, unsuitable for most fish species • Barriers that prevent upstream and downstream water movement and fish movement	

Waterway Name	Sheepwash Creek
	• Possibility of desnagging having taken place • Poor water quality. • The potential presence of Flat headed galaxias (FFG Listed as threatened), Crimson spotted rainbowfish (not listed), Midgely's carp gudgeon (or carp gudgeon) (not listed) and Lakes carp gudgeon (not listed) which have all been recorded in waterways within the region. The Report also noted: *The diversity of fish in Sheepwash Creek is expected to be less than Ulupna Creek and the River Murray. Sheepwash Creek appears to have been desnagged, which has resulted in the loss of potential fish habitat. In stream barriers (a farm dam near Stokes Road and levees at the junction of Ulupna Creek) are expected to contribute to the ponding of water and to restricted fish movement. Together these factors are expected to contribute to low fish diversity within Sheepwash Creek. Much of the riparian vegetation has been cleared and farmland extends to the creek side. Inflows from irrigation runoff are expected to contribute to deteriorated water quality. Much of the substrate is smothered in sediment.* *A brief fish survey was conducted at three sites including Sheepwash Creek. Flat headed gudgeon and Carp were recorded.* EVC - Riverine grassy plains woodland complex; drainage line aggregate. Values in Ulupna Creek are dependent on River Murray flows and are associated with River Murray flows. Vegetation in bed of Sheepwash Creek tends to be cumbungi, and along with evidence of trees killed by waterlogging is indicative of un naturally wet conditions. River red gum occurs on the creek banks and well into the creek bed. No pools of water were apparent in April, indicating the aquatic values will be climate or flood driven. Google Earth photo indicates a large area of free water below the railway line but this was not evident in April 2009. Sheepwash Creek has moderate environmental values that would be enhanced by return to a drier water regime. Despite potential presence of a listed species this site is not considered to be high value.
Desktop Hydrological assessment	Sheepwash Creek is an unregulated tributary of Ulupna Creek and flow data for this waterway is not available, therefore it is not possible to assess impacts of a reduction in channel outfalls on the creek flow.
Updated Hydrological assessment	Sheepwash Creek is an unregulated tributary of Ulupna Creek in the Murray Valley Irrigation Area (MVIA). There are five outfalls from the irrigation system associated with the NVIRP entering the Creek (SKM). All outfalls that enter Sheepwash Creek enter via Strathmerton Drain 3. The combined outfall volume for the five outfalls in 2004/2005 was 194 ML, with the main outfall being ST053750 contributing 103 ML. Table 22 below provides a summary of the outfall information.

Waterway Name	Sheepwash Creek
	Outfalls ST053750, ST072311 and ST066493 have been monitored as part of Murray Strategic Monitoring Project since 2006. As a result outfalls may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. Two drainage diverters have been indentified downstream of four of the outfalls (ST053750, ST072311, ST053788 and ST066493) on Strathmerton Drain 3 with a combined diversion licence volume of 222 ML. No drainage diversion licences were identified downstream of outfall ST040125 (22 ML). There is significant distance between the outfalls and their entry to Sheepwash Creek, with four out of the five outfalls being located more than 14 km from the entry point. As a result it is likely that some of the outfall water will be lost in the drain due to seepage and leakage. Table 22 below provides a summary of the estimated distance from outfall to entry point for each outfall. Due to drainage diversion licence volumes being greater than the combined outfall volumes at the four upstream outfall sites and the distance of the outfalls to the entry point of Sheepwash Creek (2 – 19.5 km) it is unlikely the Creek will receive outfall water.
Desktop Recommendation	Based on the potential water dependant values associated with Sheepwash Creek and the minimal impact the reduction in channel outfalls would have on stream flow, further investigation into the environmental impact of the NVIRP Project on this waterway is recommended.
Short-list Recommendation	The waterway is not at risk. No further work is recommended due to: • the lack of impact of reduced outfalls on waterway flow • the impact of reduced channel outfall being considered to be an ecological improvement by returning the water regime of the waterway to more natural conditions and • the values of Sheepwash Creek are associated with flood flows from the River Murray and can only be attributable in a small way to channel outfalls..

B12. Tullah Creek

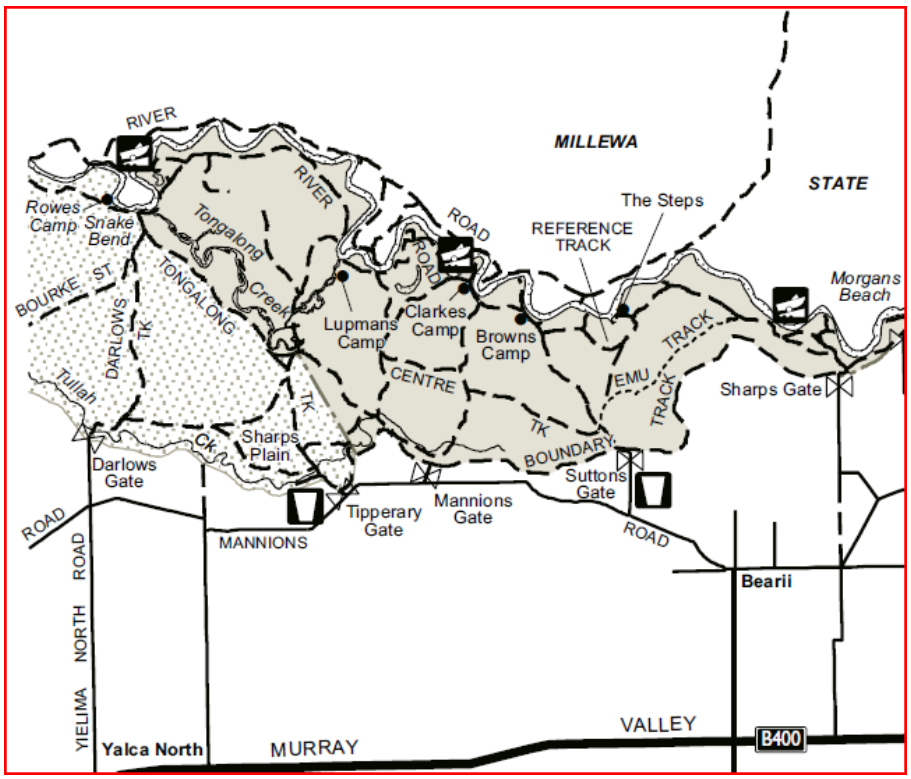
Summary reconciliation with Desktop Assessment:

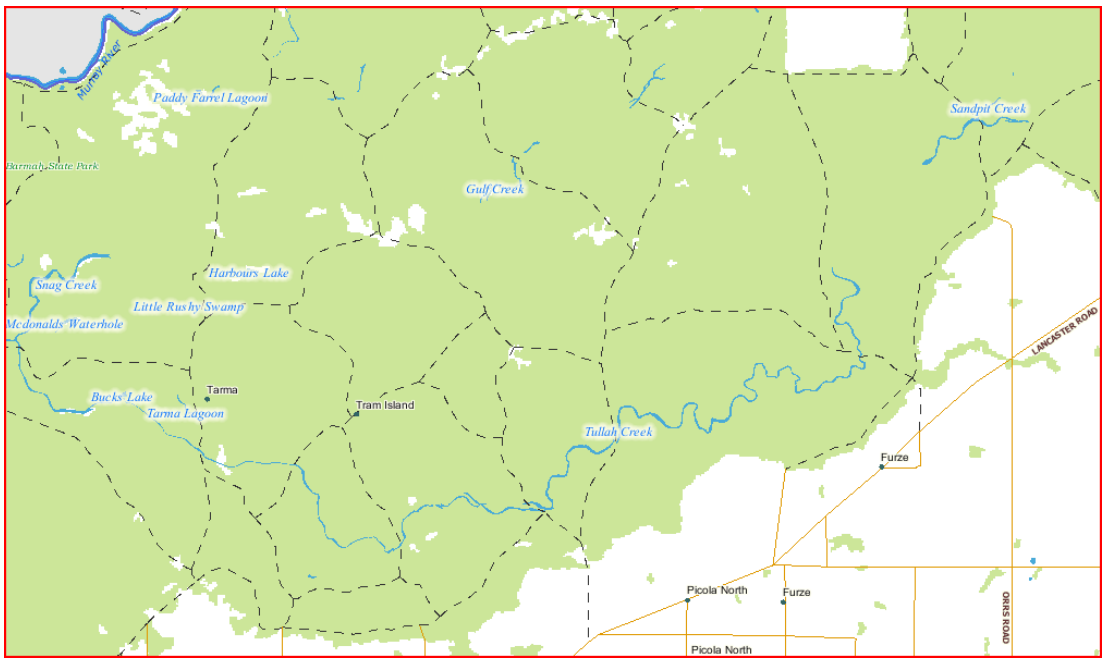
	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	unknown	Y
Short list Assessment	Y	N	N

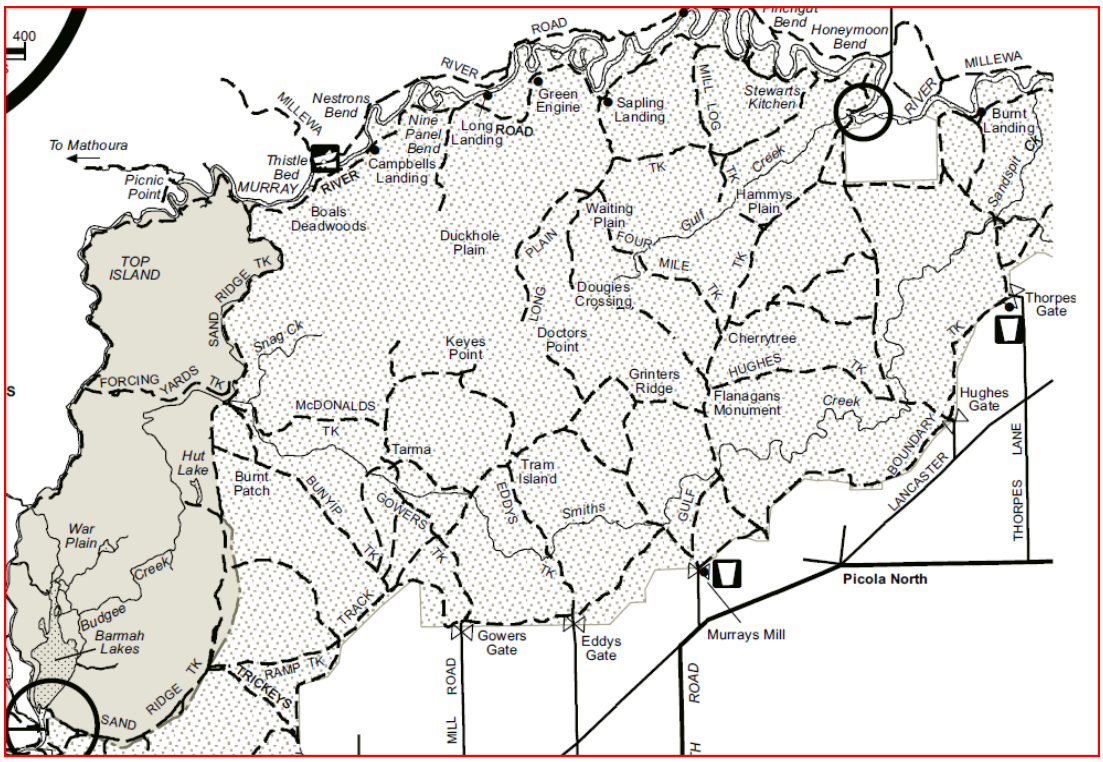
Waterway Name	Tullah Creek (or Smiths Creek)	
Description	Tullah Creek is an ephemeral, large, anabranch/flood runner of the River Murray. It generally runs along the southern boundary of Barmah Forest and flows through Top Lake then to Bucks Lake and Budgee Creek and back into the Murray. It generally is expected to flow only in times of flood.	
Waterway Identifier	Catchment	Murray
	CMA Region	Goulburn Broken
	Irrigation Area	n/a
	Land Manager	ParksVic
	Public Land Status	Currently Barmah State Park/Barmah Forest; recommended to be Barmah National Park
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	The Tullah (or Smiths Creek) is located within the Barmah Forest, which is a Ramsar site and listed on the Directory of Important Wetlands in Australia (http://www.environment.gov.au/cgi-bin/wetlands).	
Updated Environmental Description	The Barmah–Millewa Forest provides habitat for numerous threatened plant and animal species, including birds, fish and reptiles, and supports colonies of breeding waterbirds during appropriate seasonal conditions (MDBC 2004a). Both the Barmah Forest and the Millewa Forests (as part of the NSW Central Murray State Forests) are listed on the Ramsar list of designated Wetlands of International Importance. The creek supports substantial wetland values by virtue of its conveying water to high value wetlands. The waterway channel is 20-30 m wide and 2-3 m deep and conveys floodwaters from the River Murray along the southern boundary of Barmah Forest into the wetlands of the forest. At the time of inspection the creek was dry and being extensively encroached by River red gum regeneration. There was no evidence of low flow dependent ecological values. Waterway channel capacity greatly exceeds irrigation channel outfall capacity Tullah Creek derives its values by its association with the River Murray and its floodplain.	
Desktop Hydrological	Given that there is no gauged flow data for these waterways, it is uncertain what impact there	

Waterway Name	Tullah Creek (or Smiths Creek)
assessment	will be as a result of implementation of the NVIRP Project. Discussions with the Ramsar site manager (K. Ward, GBCMA, pers. comm.) have indicated that the potential impact of a reduction in channel outfalls would be variable, depending on the background climatic conditions.
Updated Hydrological assessment	There are four outfalls that potentially enter the Tullah Creek, with ST053754 outfalling directly into Barmah Drain 7 with the remaining three outfalls directly into Barmah Drain 9. Only three of the outfalls recorded outfall volumes in 2004/2005 with a combined outfall volume of 958 ML. Both drains outfalling to the Tullah Creek have sections located within the Barmah Forest. The main outfall contributors are ST065833 (549 ML) and ST053754 (349 ML) and make up 93 % of the total outfalls entering Tullah Creek. Details of these outfall sites are summarised in Table 24 below. Outfall ST053758 has been monitored as part of Murray Strategic Monitoring Project since 2006. As a result outfalls from STO53758 may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. The distance between all four outfalls and their entry point into the Tullah Creek is approximately 4 to 5 km, with the majority, if not all of the outfall pathway located within the Barmah Forest. No drainage diverter data was available for the Tullah Creek outfalls, however it is expected that due to the close proximity of the outfalls to the Barmah Forest, it would be unlikely to expect drainage diverters along these drains. Table 24 below provides a summary of the estimated distance from outfall to entry point for each outfall. Due to the close proximity of the outfalls to Tullah Creek and the likely absence of drainage diverters along the relevant sections of Barmah Drain 7 and Drain 9 it is expected that the majority outfall water from all four sites will enter the Creek.
Desktop Recommendation	Given the variable impact of channel outfalls on these waterways, further investigation into the environmental impact of the NVIRP Project on them is recommended
Recommendation	Not at risk due to: • Tullah Creek deriving its values from major flood flows and its association with Barmah Forest • Changes to outfall volumes are unlikely to affect the values of the waterway • Lack of evidence of low flow dependent ecological values. • the lack of impact of reduced outfalls on waterway flow. It is recommended that no further investigation be carried out as part of this waterway impact assessment. It should be noted that the EES Decision (Condition 4) requires preparation of an assessment report on the ecological consequences of hydrological changes arising from the implementation of NVIRP for the Murray River, the Goulburn River and the Barmah Forest Ramsar Site for review and written advice for the Expert Review Panel

Location Map


RIVER
MILLEWA
STATE
Rowes Camp
Snake Bend
Tongalong Creek
RIVER
ROAD
The Steps
REFERENCE TRACK
Morgans Beach
BOURKE ST
TONGALONG
ROAD
Clarkes Camp
Lupmans Camp
Browns Camp
DARLOWS TK
TRACK
EMU TRACK
Tullah
CENTRE TK
Sharps Gate
Ck
Sharps Plain
BOUNDARY
Darlows Gate
Suttons Gate
Tipperary Gate
Mannions Gate
ROAD
MANNIONS
ROAD
Bearii
NORTH ROAD
YIELIMA
Yalca North
MURRAY VALLEY
B400


Murray River
Paddy Farrel Lagoon
Sandpit Creek
Parmah State Park
Gulf Creek
Harbours Lake
Snag Creek
Little Rushy Swamp
Mcdonalds Waterhole
LANCASTER ROAD
Bucks Lake
Tarma
Tarma Lagoon
Tram Island
Tullah Creek
Furze
Picola North
Furze
OAKS ROAD
Picola North


400
To Mathoura
Picnic Point
Thistle Bed
MURRAY RIVER
Nestrons Bend
MILLEWA ROAD
Nine Panel Bend
Campbells Landing
Long Landing
Green Engine
Sapling Landing
Midnight Bend
Honeymoon Bend
Stewarts Kitchen
MILLEWA RIVER
Burnt Landing
Sandspit Ck
MILL LOG TK
Creek
Hammys Plain
Waiting Plain
FOUR MILE Gulf
Boals Deadwoods
Duckhole Plain
LONG PLAIN
Dougies Crossing
TOP ISLAND
RIDGE TK
SAND
Snag Ck
Keyes Point
Doctors Point
Cherrytree
Thorpes Gate
FORCING YARDS TK
McDONALDS TK
Grinters Ridge
HUGHES Creek TK
Flanagans Monument
Hughes Gate
Hut Lake
Burnt Patch
Tarma
Tram Island
BUNYIP
GOWERS TK
EDDYS TK
Smiths
GULF
BOUNDARY
LANCASTER
THORPES LANE
War Plain
Creek
Budgee Barmah Lakes
TRACK TK
Gowers Gate
Eddys Gate
Picola North
Murrays Mill
RAMP TK
TRICKEYS
RIDGE TK
SAND
MILL ROAD
ROAD

B13. Twelve Mile Creek

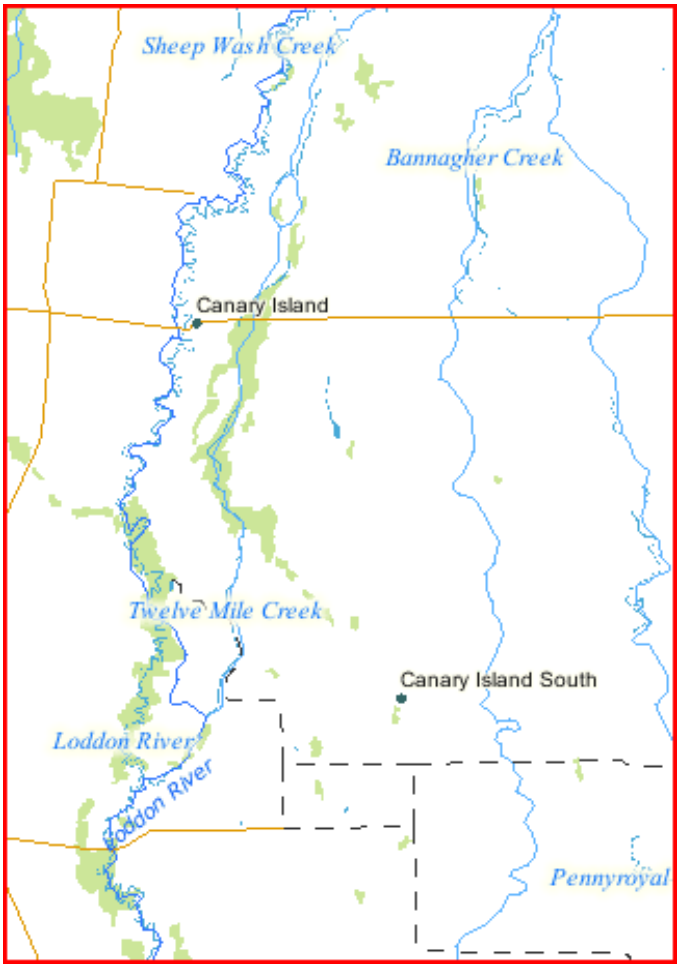
Summary reconciliation with Desktop Assessment:

	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	Y	-	Y
Short list Assessment	Y	tbd	Y

Waterway Name	Twelve Mile Creek	
Description	Twelve Mile Creek is a 16km long anabranch of the Loddon River, leaving the eastern bank east of Lake Yando and re-entering the river at Appin South.	
Waterway Identifier	Catchment	Loddon
	Length	16 km
	CMA Region	North Central
	Irrigation Area	Pyramid Boort
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	It likely supports similar environmental values as the adjacent Loddon River in terms of water dependant EVCs and native fish	
Updated Environmental Description	From NCCMA, 2006h. Twelve Mile Creek flows entirely across a level alluvial plain. There is very little evidence of manmade alterations to the creek which retains many of its natural characteristics. Billabongs are present along the lower reaches which are lined with stands of dead timber. The pre 1750 Ecological Vegetation Class data is incomplete along Twelve Mile Creek. Assessments reveal that 39% of the riparian tree cover is in good condition, displaying a wide, continuous and native tree canopy. Approximately 21% is considered in marginal condition and 40% is poor. In the upper reaches (Loddon River to the Canary Island-Leaghur Road) the riparian vegetation generally extends up to 40m wide on either bank and consists of mature and regenerating River Red Gum. Patches of Lignum grown along the banks with Cumbungi and native sedges lining the water's edge.	

Waterway Name	Twelve Mile Creek
	In the Lower Reaches (Canary Island Road to the Loddon River confluence) the riparian vegetation varies between 5m to 40m wide on either bank. River Red Gums are scattered along the creek above a dense shrub layer of Lignum. Native rushes and sedges line the margins of the shallow pools. A variety of instream habitat opportunities exist for aquatic life in Twelve Mile Creek. No fish or macroinvertebrate data has been recorded for Twelve Mile Creek. There are no water quality monitoring sites along Twelve Mile Creek. Twelve Mile Creek can be expected to have similar values to the adjacent Loddon River (RRHS Reach 4). In the NCCMA RRHS Reach 4 is assessed as a priority because of links to the Kerang Wetlands and the River Murray. It is assessed as having value, but not high value.
Desktop Hydrological assessment	There is little information on the flow regime of Twelve Mile Creek, or of the impact of outfalls on the flow.
Updated Hydrological assessment	Twelve Mile Creek is an anabranch of the Loddon River located upstream of Appin South. There are two outfalls that directly enter the Creek from channel 1/1/12 and 2/1/1/12 which had a combined volume of 85 ML in 2004/2005. ST009820 is the main outfall contributor, with 98 % of the outfall volume outfalled from this site. Due to the small outfall volume (1 ML) at ST009806 and length of travel (< 1 km) it is unlikely that this outfall water will reach Twelve Mile Creek. Further summaries of this outfall can be seen in Table **25** below. The distance from the outfall and entry point to Twelve Mile Creek < 1 km (see Table **25** below) and no drainage diversion licences have been identified downstream of the outfalls. It is considered likely that 98 % of the outfall linked to the Twelve Mile Creek (84 ML) will reach the Twelve Mile Creek.
Desktop Recommendation	Given the lack of flow information for the Twelve Mile Creek further investigation into the environmental impact of the NVIRP Project on this waterway is recommended.
Short-list Recommendation	Potentially at risk. Assumed to have the same high values as the Loddon River. An EWP is recommended. It is recommended that further work on Twelve Mile Creek be undertaken in association with work on the Loddon River (Pyramid Boort IA reach) – (see recommendation above) due to its close association with the Loddon River which is flow stressed.

Location Plan



Google Plan


Loddon River >>
Twelve Mile Creek >>
Canary Island
Image © 2009 DigitalGlobe
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B14. Wells Creek

Summary reconciliation with Desktop Assessment:

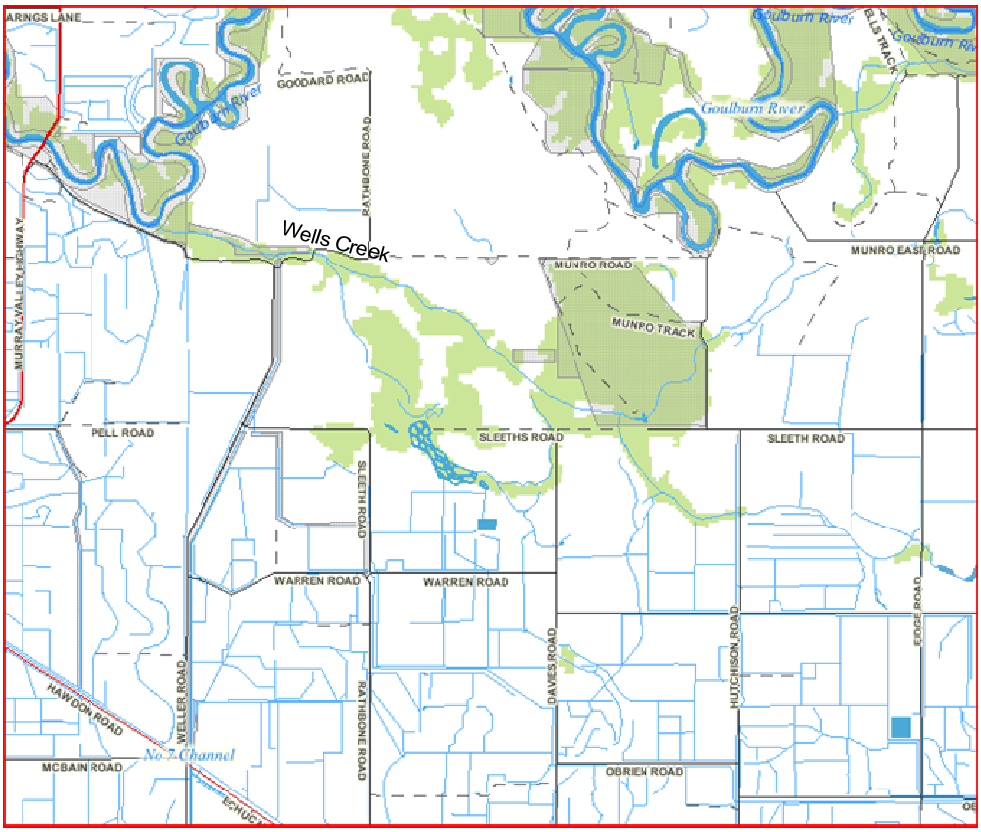
	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	Y	Y
Short list Assessment	N	Y	N

Waterway Name	Wells Creek	
Description	Wells Creek is an ephemeral waterway draining part of the floodplain of the Goulburn River.	
Waterway Identifier	Catchment	Goulburn
	CMA Region	Goulburn Broken
	Irrigation Area	Central Goulburn
	Public Land Status	Currently part of McCoys Bridge Streamside Reserve – to become part of the Lower Goulburn River National Park.
	RRHS Reach No:	n/a
Desktop Environmental Assessment Description	Historically, Wells Creek has carried a moderate flow, and because of its association with the Goulburn River, there is anecdotal evidence that it supports environmental values such as water dependant vegetation and potentially native fish populations (C. Walters, GBCMA, pers. comm.).	
Updated Environmental Description	DSE, 2008 noted Wells Creek (Wetlands 792542_122, 792542_260, 792542_29) was covered by the Wells Creek E20 Environmental Assessment. The creek is affected by bank construction with levees extending approximately 7km on either side of the lower reaches of the creek. It receives outfall and therefore has potential for adverse impacts from changes to outfall flows (see section 6.1.2). They concluded that Wells Creek was a significant wetland. (NB that it was not assessed as a priority wetland in the SKM NVIRP Desktop report). Section 6.1.2 of this report noted: Wells Creek was covered by the environmental assessment for Wells Creek Coomboona 1P community surface drain. The field inspections for this assessment were done between August and September 1996. The section of Wells Creek identified in the assessment is BAP Wetlands 792542_122, 792542_260 and 792542_29, immediately upstream of Munroes Swamp and south of Sleeth Road (see Figure 6). These sections were in Sites 5 and 6 of the assessment. The assessment noted the creek received more regular summer flows from	

Waterway Name	Wells Creek
	irrigation run-off. It was a Type 3 medium duration seasonal wetland, with the section between Fidge and Maddill Roads now more typical of Type 5 Semi permanent open wetland due to increased summer inflows. The creek was significantly modified with increased channelisation along sections from levee banks between Fidge and Sleeth Roads. The creek outfalls directly to the Goulburn River. Among other issues, *a key management requirement for these sections was to exclude or remove summer irrigation runoff. Any changes in channel outfalls are likely to reduce summer inundation and have a positive effect on the hydrology of the wetland*. The Rodney Main Drain outfall, through which the bulk of channel outfall waters discharges to Wells Creek, is only approximately 1 km above the junction of Wells Creek and the Goulburn River. Wells Creek, downstream of the Rodney Main Drain outfall, is channelised. The lower sections (below Rodney Main Drain outfall) of the creek have substantial areas of rock beaching. Vegetation along the creek is a mixture of River red gum and grey box. Below the Rodney Main Drain outfall no riparian vegetation is evident. Upstream of Munroes Swamp, Wells Creek is a broad depression with no evidence of waterlogging or riparian vegetation. Another tributary of Wells Creek has characteristics of a floodway being enclosed by levees. Cumbungi indicates waterlogging. A branch of Wells Creek passes along the southern boundary of Munroes Swamp. Discussions with Simon Casanelia (GBCMA) indicate that in the vicinity of the creek, wetland vegetation is mainly Phragmites, indicating substantially wetter conditions that the rest of the swamp and most likely due to excess flows in the creek. Simon agreed that a change to drier conditions resulting from any reduction in channel outfalls would be beneficial. EVC – drainage line aggregate. The values of Wells Creek cannot be attributed to channel outfalls.
Desktop Hydrological assessment	Wells Creek is a waterway that has been incorporated into the regional drainage network (as the ultimate outfall of the Rodney Main Drain). It also receives outfalls from the Central Goulburn 5-9 System, which will be modernised under the NVIRP Project. It also receives outfalls from the Central Goulburn 1-4 System, which has already been modernised. The creek flows across the Goulburn River floodplain and discharges to the Goulburn River upstream of McCoy's Bridge. There is a gauge located on the Rodney Main Drain at Wells Creek (405720) and flow data is available until August 2005. However, the flow at this gauge is a combination of channel outfalls and drain flows, rather than waterway flows, and it was decided that this information would not add to the analysis.
Updated Hydrological assessment	Wells Creek has been incorporated into the regional drainage network as the ultimate outfall of the Rodney Main Drain (SKM). Wells Creek receives water from five outfalls from the CG 5-9 system in the NVIRP area with a total outfall volume of 8825.9 ML for 2004/2005. Wells Creek also receives outfalls from the Central Goulburn 1 – 4 systems, which has already been modernised. The main outfall contributors are outfalls ST044979 (3125 ML) and ST063945 (4724 ML) which make up 88 % of the total outfall volume into Wells Creek from the CG 5-9 system. Four of the outfalls enter Wells Creek via the Rodney Main Drain (and

Waterway Name	Wells Creek
	connecting Ardmona Main Drain) and the remaining outfall (ST045134) enters the Creek directly via irrigation channel 7/19/6. This information has been further summarised in Table 26 below. The main outfall contributors ST044979 and ST063945 have been monitored as part of the Goulburn Strategic Monitoring Project since 2006. As a result outfalls may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. There are 12 diverters identified downstream of the outfalls along the Ardmona and Rodney Main Drain. The amount outfalled from these sites (8301 ML) is considerably larger than the total drainage diversion volume (2218 ML). The distance between the five outfalls and their entry point into Well Creek ranges between 1 km and 14.5 km. One of the major outfall contributors (ST063945) is located 2 km from Wells Creek; therefore it is likely that the majority of the volume outfalled will reach the Creek. In contrast, the significant distance that some of the outfall water travels means that it is likely that some of the outfall water will be lost in the drain due to seepage and evaporation. Large storages exist within the catchment to harvest drain flows. Table 26 below provides a summary of the estimated distance from outfall to entry point for each outfall. Based on volume of outfall water being significantly larger than the drainage diversion volume and the close proximity of one of the major outfall contributors to Wells Creek (ST063945), it is considered likely that at least 75% of the volume of water outfalled will enter Wells Creek. Consideration should also be given to the impact potentially caused by the reduction of outfalls as a result of the modernisation of the Central Goulburn 1 – 4 System.
Desktop Recommendation	It is recommended that the Wells Creek be considered for further investigation, both for its own values and also for the impact of a reduction in outfalls to Wells Creek on the cumulative impact on flows in the lower Goulburn River (see below).
Short-list Recommendation	Not at risk due to: • Presence of environmental values which would be enhanced by a change to its water regime. • Its values can only be attributed to channel outfalls in a small way • The site is not recognised as high value • The great bulk of outfall water discharges from the Rodney Main Drain to a channelized section of Wells Creek about 1 kilometre above its junction with the Goulburn River. It is recommended Wells Creek not be considered for further work.

Location Plan



Google Plan

B15. Yambuna Creek

Summary reconciliation with Desktop Assessment:

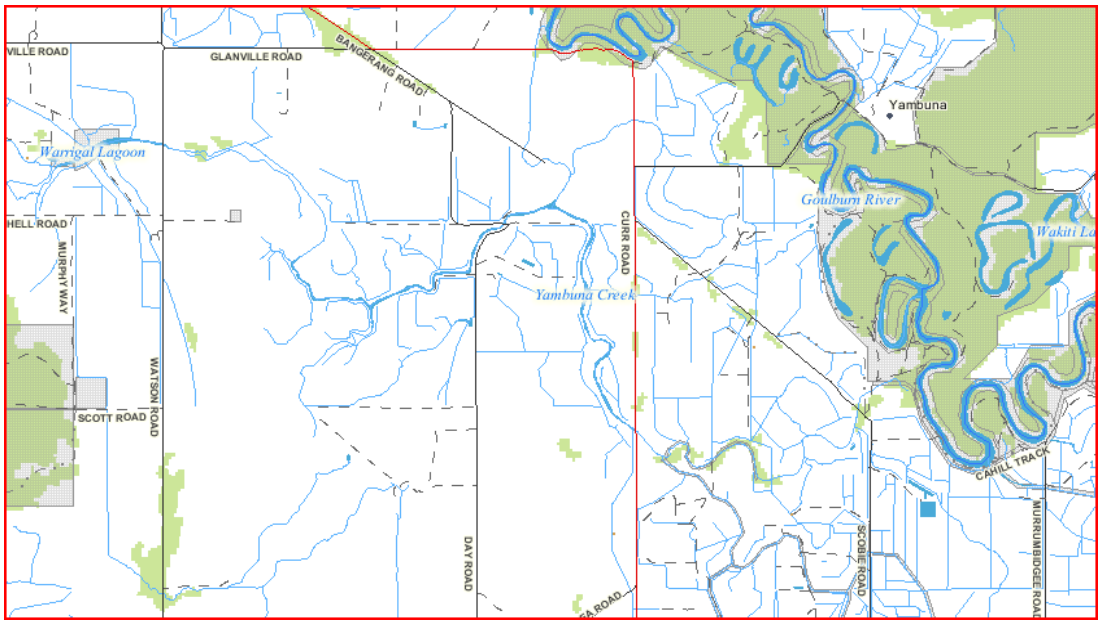
	Environmental Values	Change in flow due to NVIRP?	Further assessment or EWP?
Desktop Assessment	N	-	Y
Short list Assessment	N	Y	N

Waterway Name	Yambuna Creek
Description	This is an ephemeral distributary/flood runner of the Goulburn River. It receives drainage water from the Wyuna and Coram Drains and discharges to the Goulburn River via a drain running across the northern edge of Kanyapella Basin and Warragul Creek. During floods, high flows can reach Kanyapella Basin via Yambuna Creek..
Waterway Identifier	Catchment: Goulburn CMA Region: Goulburn Broken Irrigation Area: Central Goulburn Public Land Status: Some crown land; some freehold RRHS Reach No: n/a
Desktop Environmental Assessment Description	The riparian environment along Yambuna Creek may provide some local biodiversity value, but it has not been specifically recognised in regional biodiversity landscape planning assessments (see Ahern et al., 2003). Furthermore, water quality in the creek is considered degraded due to outfalls contributing high nutrient loads, which limit its ecological value (DPI, 2007). However, because of its association with and importance to the water regime for Kanyapella Basin (DPI, 2007), further investigations of the impacts of outfalls on both Yambuna Creek and Kanyapella Basin, are recommended.
Updated Environmental Description	This waterway is not listed in the Goulburn Broken Regional River Health Strategy. East of Scobie Road the creek is a broad woodland lined depression (grey box and river red gum). To the west of Scobie Road there is substantial evidence of waterlogging – cumbungi and dead red gums. Similar conditions can be seen at Curr Road and Day Road. DPI, 2009 reviewed optional environmental watering points for high value wetlands in the Shepparton Irrigation Region. For Kanyapella Basin they noted that water delivery should be via Tongala Drain 1 which enters the basin from the south. (Note that Hydro Environmental, 2009 assessed Kanyapella Basin as not impacted by NVIRP). The Kanyapella Basin Environmental Management Plan notes that the current water regime in Kanyapella Basin is still based on times of high flow in the Goulburn River but three drainage systems (Tongala, Coram and Wyuna) make significant contributions to the Basin's water regime. However Wyuna and Coram Drains outfall to the Goulburn

Waterway Name	Yambuna Creek
	River via Yambuna Creek (not via Kanyapella) (Sam Green pers com). Some small weirs have been constructed along the waterway, presumably to aid water diversion. While these may provide some drought refuge the ponded areas are not considered to provide significant environmental benefit (Carl Walters GBCMA pers comm.). Yambuna Creek may provide some local value but the waterway's condition would be enhanced by reductions in waterlogging.
Desktop Hydrological assessment	The bulk of water entering Kanyapella Basin is from outflows via Yambuna Creek (DPI, 2007). A number of outfalls enter Yambuna Creek and can contribute substantial flows at times. Gauged flow is available for the Yambuna main drain outfall (406705); however, there is no creek flow data available at the same time as outfall data (i.e. the period 04/04 to 05/06).
Updated Hydrological assessment	Yambuna Creek runs between the Goulburn River and Kanyapella Basin and is part of the regional drainage network. Outfalls entering Yambuna Creek are directed towards Kanyapella Basin. They are prevented from entering the Goulburn River by the presence of a levee at the effluent to Yambuna Creek where it leaves the Goulburn River (SKM). There are 12 outfalls that enter Yambuna Creek and can contribute substantial flows at times (SKM). Outfalls either enter Yambuna Creek via the Wyuna Main Drain or the Coram Main Drain. Seven outfalls enter the Wyuna Main Drain directly or via Wyuna Drains 3, 4 or 7 and contributed 6479.7 ML of outfall water in 2004/2005. There are five outfalls linked to the Coram Main Drain, which contributed a combined outfall volume of 891.8 ML in 2004/2005. This outfall information has been further summarised in Table 27 below. Nine out of the 12 outfalls into Yambuna Creek have been monitored as part of the Goulburn Strategic Monitoring Project since 2006. As a result, outfalls may have already been reduced significantly, particularly in regard to operational related outfalls, prior to implementation of NVIRP. They include the following outfalls: • ST006544 • ST006428 • ST063650 • ST006512 • ST063378 • ST063404 • ST062611 • ST066121 • ST045174 There are 24 drainage diverters identified downstream of the outfalls associated with the Wyuna Main Drain, with a combined diversion licence volume of 2958 ML. This volume is less than the 2004/2005 outfall volume for the seven outfalls (6479.7 ML), so it can be expected that at least 505 ML of the water outfalled via Wyuna Drain is likely to reach the Yambuna Creek. There is significantly fewer drainage diverters located along the Coram Main Drain, downstream from the outfalls. The total drainage diversion licence volume (1758.8 ML) is more than the 2004/2005 combined outfall volume for the sites. Therefore it is likely that outfalls from sites ST006428, ST063650, ST006512, ST062611 and ST066121 will be diverted for productive use by drainage diverters instead of passing to Yambuna Creek. The distance between the 12 outfalls and their entry point into Yambuna Creek ranges

Waterway Name	Yambuna Creek
	between 1 km and 27 km. One of the major outfall contributors (ST046953) is located 1 km from Yambuna Creek; therefore it is likely that the majority of water outfalled from this site will reach the Creek. In contrast, the significant distance that some of the outfall water travels means that it is likely that some of the outfall water would be lost in the drain due to seepage and evaporation. Table 27 below provides a summary of the estimated distance from outfall to entry point for each outfall.
Desktop Recommendation	It is recommended that Yambuna Creek be considered for further investigation, for its own potential values, its association with Kanyapella Basin and the potential for cumulative impacts on flows in the lower Goulburn River (via Kanyapella Basin and Warrigal Creek).
Short-list Recommendation	Not at risk due to: • environmental values which would be enhanced by a change to its water regime. • its values can only be attributed in a small way to channel outfalls • the site is not recognised as high value. Reduced flows are not expected to impact on Kanyapella Basin. It is recommended Yambuna Creek not be considered for further work.

Location Plan



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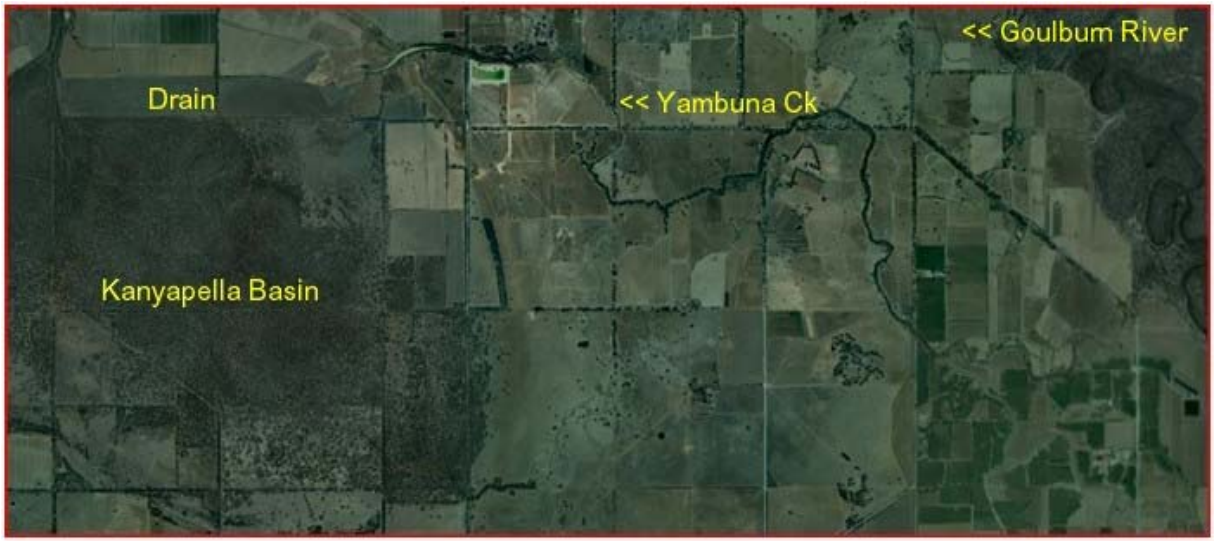

Appendix C Detailed outfall analyses

Table 9: Bannacher Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
2	Pennyroyal Creek Loddon River	ST009750	Channel 1/12	74	0.75	-	N/A	N/A	
		ST009752	Channel 1/12	0	1	-			
		TOTAL		74			0	0	74

Table 10: Broken Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST071907	Channel 9/6	8	21	Barmah Drain 10/13 and Barmah Drain 13			
		ST057112	Channel 9/5	85	26.5	Barmah Drain 10/13 and Barmah Drain 13			
		ST066583	Channel 12/6	230	15 - 15.5	Barmah Drain 9/13 and Barmah Drain 13			
		ST066577	Channel 13/6	16	11	Barmah Drain 13			
		ST064176	Channel 13/6	431	6.5	Barmah Drain 13			
		ST058499	Channel 20/6	289	5.5	Barmah Drain 13			
		ST058488	Channel 20/6	104	8.5	Barmah Drain 1/13	**18**	**1328**	
		Sub Total		**1163**				**1328**	**0**
		ST041815	Channel 4/8/6	62	1	-			
		ST056529	Channel 6/6	169	0.75	-			
		ST056597	Channel 4/8/6	120	0.5	-			
		ST056668	Channel 8/6	106	2 - 2.5	-			
		ST066584	Channel15/6	310	1.5	-			
		ST058403	Channel 21A/6	105	< 0.05	-			
		ST056428	Channel 6	118	0.15	-			
20	**-**	ST056447	Channel 6	510	1.5	-	-	-	-

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		Sub Total		**1500**				**0**	**1500**
		ST056373	Channel 6	15	16.5 - 17	Barmah Drain 18			
		ST058386	Channel 14/6	136	4 - 4.5	Barmah Drain 2/18			
		ST056669	Channel 10/8/6	6	2	Barmah Drain 1/18	2	99	
		Sub Total		**157**				**99**	**58**
		ST054756	Channel 6/5	16	17	Barmah Drain 10	-	-	-
		Sub Total		**16**					
		ST057773	Channel 5/3	155	10.5 - 12	Muckatah Depression	8	1111	
		Sub Total		**155**				**1111**	**0**
		TOTAL		**2991**			**28**	**2538**	**1558**

Table 11: Bullock Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Outfall Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
9	Pyramid Creek Loddon River	ST008633	Channel 1/3/1	0	< 0.1	-	-	-	
		ST008663	Channel 2/3/1	0	1	-			
		ST008683	Channel 3/1	87	2	-			
		ST008994	Channel 7/5/1	5	1 - 1.5	-			
		ST052895	Channel 12/5/1	0	5	-			
		ST009315	Channel 6/12/5/1	4	4	-			
		ST009342	Channel 4/12/5/1	1	2	-			
		ST009252	Channel 5/1	0	3 - 3.5	-			
		ST009262	Channel 15/5/1	0	< 0.1	-			
		TOTAL		**97**			**0**	**0**	**97**

Table 12: Calivil Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled into Waterway (ML)
8	**Drain System**	ST008830	Channel 13/1	28	< 0.2	-	-	-	
	Barr Creek	ST045558	Channel 1/10/1	10	0.5	-			
		ST009690	Channel 5/10/1	1	0.2	-			
	Natural	ST009118	Channel 17/1	0	0.5	-			
	Pyramid Creek Loddon River	ST009189	Channel 20/1	0	1.5 - 2	-			
		ST009242	Channel 23/1	1	0.5	-			
		Sub Total		40				0	40
		ST009723	Channel 10/1	356	1	Outfall Drain 1	2	120	
		Sub Total		356				120	236
		ST010097	Channel 2	0	2	Calivil Creek Drain 12	2	60	
		Sub Total		0				60	0
		TOTAL		**396**			**5**	**180**	**276**

Table 13 Calivil Creek outfall analysis – Brolga breeding sites

Asset Code	CHANNEL	SITE	1997/ 1998	1998/ 1999	1999/ 2000	2000/ 2001	2001/ 2002	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009
ST008830	13/1	Schmidts	122	103	68	112	25	27	1	28	45	1	0	1
ST045558	1/10/1	Moon	20	7	8	9	32	7	3	10	1	0	1	0
ST009690	5/10/1	Burnside	78	15	3	0	1	18	0	1	1	0	0	0
ST009118	17/1	Farrars	4	0	0	0	0	0	0	0	0	0	0	0
ST009189	20/1	Mills	20	30	32	4	0	0	0	0	1	0	0	0
ST009242	23/1	Amos	40	34	27	4	18	1	0	1	4	0	0	0

Table 14 Calivil Creek - Outfall STO08830 (Schmidts) Weekly outfall volumes

	August			September				October				November			Approx December	
	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week	Week
STO08830	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1997/98			18	2	0	5	12	11	8	9	23	14	1	2	2	0
1998/99	0	0	0	11	4	0	0	9	12	7	2	0	18	0	14	0
1999/00							2	3	1	0	4	3	0	2	1	0
2000/01			0	28	3	12	0	0	0	12	5	0	0	1	0	0
2001-02				2	2	0	0	0	4	0	0	11	0	2	0	0
2002-03	0	3	2	3	1	7	0	3	4	0	0	4	0	0	0	0
2003-04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004-05				0	0	0	0	0	0	0	0	1	0	3	0	0
2005-06			0	3	4	3	3	9	0	2	0	1	0	0	0	0
2006-07	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 15: Campaspe River Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Outfall Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
8	**River Murray**	STO32783	Campaspe 2/2	171		-	-	-	-
		STO32729	Campaspe 1/1	89		-			
		Sub Total		260				0	260
		ST033111	Channel 2/11	91	9	Rochester 4	-	-	-
		Sub Total		91				0	91
		ST051358	Channel 12	0	< 100 m	-	-	-	-
		Sub Total		0				0	0
		ST065860	Channel 1/14	204	7.5 - 8	Campaspe 3A	4	402	
		ST033384	Channel 1/3/14	13	0.5-1	Campaspe 3A			
		Sub Total		217				402	0
		ST033425	Channel 1/4/3/14	58	5	Campaspe 2	-	-	-
		ST033397	Channel 2/1/3/14	60	2-2.5	Campaspe 2	-	-	-
		Sub Total		118				0	118
		TOTAL		**686**			**4**	**402**	**469**

Table 16: Loddon River (Torrumbarry) Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST001704	Channel 1	930.5	0.05	-			
		ST001744	Channel 6	40	0.05 - 0.1	-			
		ST001756	Channel 6	21	0.05 - 0.1	-			
		ST011251	Channel 7/1/7	0	0.15	-			
		ST011243	Channel 1/7	205	0.05	-			
6	**-**	ST002302	Channel 4	664	0.1	-	**N/A**	**N/A**	
		TOTAL		**1860.5**			**0**	**0**	**1860.5**

Table 17: Loddon River (Pyramid Boort) Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST008257	Channel 1	0	3	-			
		ST023234	Channel 9/2	493	<0.1	-			
		ST023230	Channel 1/9/2	17	0.3	-			
		ST023628	Channel 2	46	1	-			
		ST025135	Channel 9/2	60	1.5	-			
6	-	ST023738	Channel 3/2/8/2	5	0.75	-	N/A	N/A	
		TOTAL		621			0	0	621

Table 18: Nine Mile Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST009753	Channel 12	0	13	-	0	0	
		Sub Total		0				0	**0**
		ST009952	Channel 10/10/1	22	< 0.5	-			
		ST009500	Channel 4/4/12	0	6.5 km (Calivil)	-	0	0	
		Sub Total		22				0	**22**
		ST009510	Channel 4/12	71	1 - 1.5	Nine Mile Creek Drain 3/1			
		ST009500	Channel 4/4/12	0	6.5	Nine Mile Creek Drain 3/1			
		ST009730	Channel 10/1	0	4.5	Nine Mile Creek Drain 3			
		ST009988	Channel 20/10/1	0	2	Nine Mile Creek Drain 3	7	358	
		Sub Total		71				358	**0**
		ST009547	Channel 12	202	8.5 - 9	Nine Mile Creek Drain 1/1			
		ST009539	Channel 8/12	0	6.5 -7	Nine Mile Creek Drain 1/1			
		ST009540	Channel 8/12	0	6.5	Nine Mile Creek Drain 1/1	1	10	
10	**Pyramid Creek Loddon River**	**Sub Total**		**202**				**10**	**192**
		TOTAL		**295**			**8**	**368**	**214**

Table 19: Pennyroyal Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled into Waterway (ML)
1	Loddon River	ST009754	Serpentine Creek	1147	3	-	-	-	
		TOTAL		1147			0	0	1147

Figure 8 Pennyroyal Creek outfall analysis – linkage between rainfall and outfall

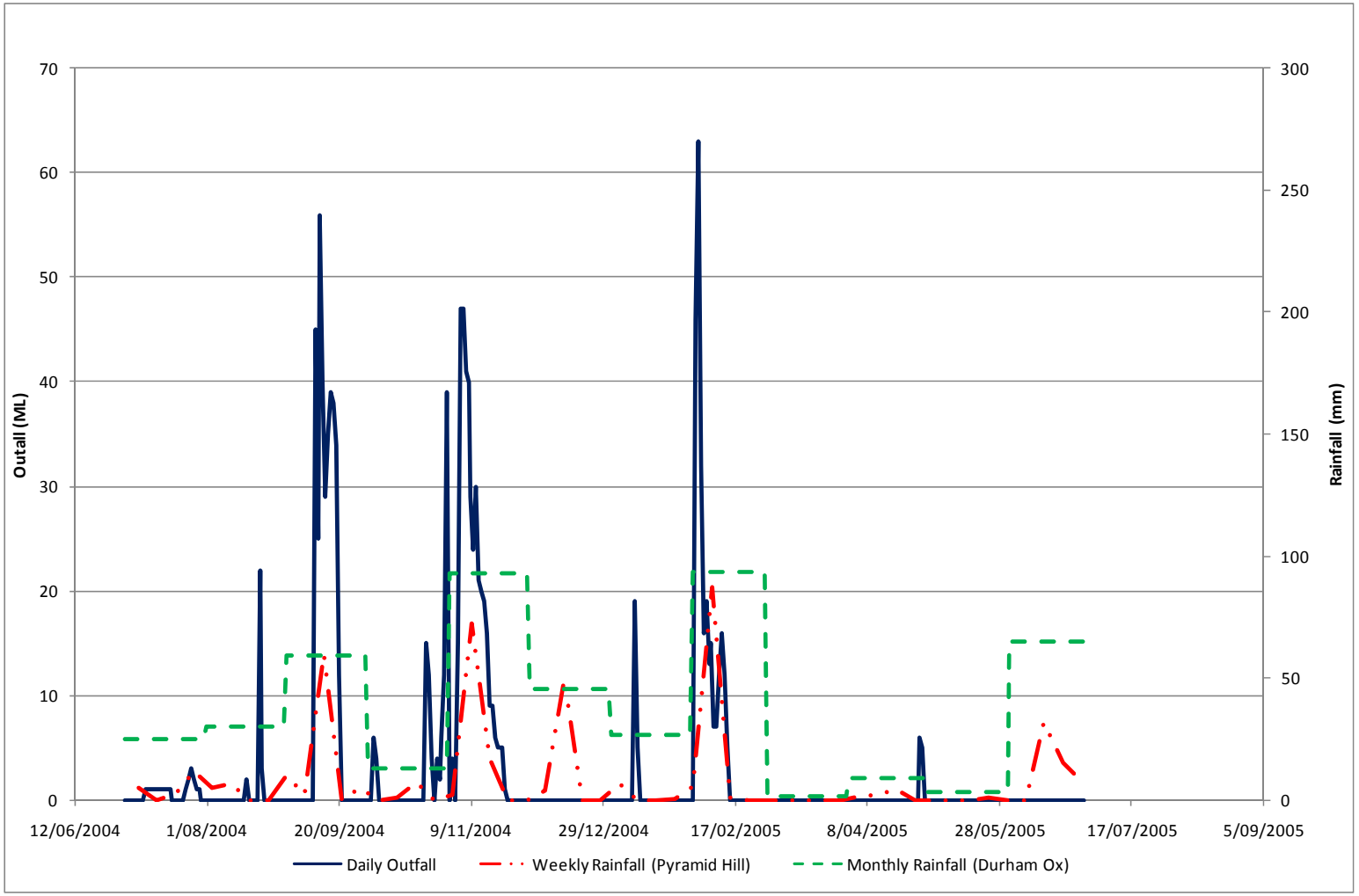

Table 20: Pyramid Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Outfall Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
6	Loddon River	ST063422	Channel 24/1	681	16	Pyramid Drain 1	6	155	
		Sub Total		681				155	526
		ST009086	Channel 16/1	5	23.5 - 24	Pyramid Drain 2/1			
		ST044742	Channel 23/1	75	8.5	Pyramid Drain 2/1			
		ST044697	Channel 6/24/1	0	10.5	Pyramid Drain 2A/1 and Pyramid Drain 2/1			
		ST010175	Channel 24/1	0	11.5 - 12	Pyramid Drain 2/1			
		ST010230	Channel 7/24/1	36	8.5	Pyramid Drain 2/1	6	170	
		Sub Total		**116**				**170**	**0**
		TOTAL		**797**			**12**	**325**	**526**

Table 21: Seven Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
1	Loddon River	ST008772	Channel 12/1	8	5	-	-	-	
		TOTAL		**8**			**0**	**0**	**8**

Table 22: Sheepwash Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST066493	Channel 6/1	51	19.5	Strathmerton Drain 7/3			
		ST053788	Channel 2/1/5/1	18	17.5 -18	Strathmerton Drain 3			
		ST072311	Channel 5/1	0	17.5-18	Strathmerton Drain 4/3			
		ST053750	Channel 2/6/1	103	14	Strathmerton Drain 4/3			
		ST040125	Channel 12/7/2	22	1.5	Strathmerton Drain 3	**2**	**222**	
5	**Ulupna Creek River Murray**	**TOTAL**		**194**				**222**	**0**

Table 23: Tongalong Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST054755	Channel 2A/2	0	36.5	Strathmerton Drain 2/11/6			
		ST042104	Channel 1/2/5	0	33.5	Strathmerton Drain 5/11/6			
		ST040007	Channel 8/2	0	37.5	Strathmerton Drain 18/6			
		ST065832	Channel 8A/2	0	36.5	Strathmerton Drain 16/6			
		ST042090	Channel 2/5	480	29	Strathmerton Drain 11/6			
		ST053620	Channel 1/7/2	0	41-41.5	Strathmerton Drain 10/6			
		ST053551	Channel 1/9/2	19	30	Strathmerton Drain 2/10/6			
		ST053557	Channel 9/2	403	27.5	Strathmerton Drain 1/10/6			
		ST057146	Channel 7/5	33	28.5	Strathmerton Drain 7/6			
10	**River Murray**	ST041547	Channel 17A/2	201	13.5-14	Strathmerton Drain 6	**36**	**3641**	
		TOTAL		**1136**			**36**	**3641**	**0**

Table 24: Tullah Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
4	River Murray	ST065833	Channel 5	549	4.5	Barmah Drain 9	N/A	N/A	
		ST053758	Channel 23/5	60	4.5	Barmah Drain 9			
		ST054078	Channel 5	0	4.5	Barmah Drain 9			
		Sub Total		609				0	609
		ST053754	Channel 20/5	349	5.5	Barmah Drain 7	N/A	N/A	
		Sub Total		349				0	349
		TOTAL		958			0	0	958

Table 25: Twelve Mile Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Drainage Diversion Licence (ML)
2	-	ST009806	Channel 2/1/1/12	1	1	-	N/A	N/A	
		ST009820	Channel 1/1/12	84	0.5	-			
		TOTAL		85			0	0	85

Table 26 Wells Creek Outfall Analysis.

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
5	Goulburn River	ST044979	Channel 19/6	3125	14.5	Ardmona Main Drain / Rodney Main Drain	12	2218	
		ST045086	Channel 6/19/6	290	12	Ardmona Main Drain / Rodney Main Drain			
		ST045052	Channel 5/19/6	162	13.5	Rodney Main Drain			
		ST063945	Channel 6	4724	2	Rodney Main Drain			
		Sub Total		8301				2218	6083
		ST045134	Channel 7/19/6	524.9	1 - 1.5	Direct	0	0	
		Sub Total		524.9				0	524.9
		TOTAL		**8825.9**			**12**	**2218**	**6607.9**

Table 27: Yambuna Creek Outfall Analysis

No. Outfalls	Receiving Waterway	Outfall	Linked Channels	Average Volume (04/05) (ML)	Outfall to Waterway Distance (km)	Linked Drains	No. of Diverters	Volume Drainage Diversion Licence (ML)	Volume Outfalled to Waterway (ML)
		ST063404	Channel 16/8	313.1	16	Wyuna Drain 4 and Wyuna Main Drain			
		ST045603	Channel 8	2044	8	Wyuna Drain 3 and Wyuna Main Drain			
		ST045174	Channel 20/6	234	27.5	Wyuna Drain 7 and Wyuna Main Drain			
		ST063378	Channel 9/6	1936	12	Wyuna Main Drain			
		ST006544	Channel 41/9	10	3.5	Wyuna Main Drain			
		ST012947	Channel 5/27/6	71.6	2 - 2.5	Wyuna Main Drain			
		ST046953	Channel 9/2	1871	1	Wyuna Main Drain	24	2958	
		Sub Total		6479.7				2958	3521.7
		ST066121	Channel 33/9	254	16.5 17	Coram Drain 10/4, Coram Drain 4 and Coram Main Drain			
		ST062611	Channel 33/9	87	15.5	Coram Drain 4 and Coram Main Drain			
		ST006512	Channel 2/36/9	125.8	10.5	Coram Main Drain			
		ST006428	Channel 34/9	168	6	Coram Drain 2 and Coram Main Drain			
		ST063650	Channel 6/34/9	257	8	Coram Main Drain	5	1758.8	
12	**Goulburn River**	**Sub Total**		**891.8**				**1758.8**	**0**
		TOTAL		**7371.5**			**29**	**4716.8**	**3521.7**

Appendix D: WCMF Attachment D

Validation and scheduling of waterways requiring EWPs

Waterways

Objective

To carry out a validation on the identified preliminary list of waterways, to confirm the existing sources of water for these waterways.

Waterways where significant impacts are likely from implementation of NVIRP will be recommended for further, more detailed investigation, or development of an Environmental Watering Plan (EWP).

Note: Additional analyses will be undertaken as part of the groundwater/salinity report to ascertain the potential of other pathways of NVIRP influence on waterways. Where the groundwater/salinity study indicates a significant impact due to other sources on high environmental values, appropriate mitigation measures will be developed consistent with the principles set out in section 9 of the WCMF.

Process

A four step process will be used to confirm the source(s) of water supply to the identified wetlands and assess the potential impact to wetlands in the GMID as result of the NVIRP. The process involves the following steps:

Reviewing the desktop assessment and recommendations relevant to the waterways assessed in desktop assessment

Documenting environmental values of candidate waterways by undertaking a desktop review of relevant reports and literature, discussions with key staff and site field visits

Documenting more detailed information about incidental irrigation water (including channel outfalls) and the hydrological regime of candidate waterways (if available)

Assessing the likelihood for significant negative impacts to be caused by a reduction in outfalls to streams, and whether or not further work, or the development of an EWP, was warranted.

Output

A list of waterways with high environmental values that a reduction of incidental irrigation water will adversely impact their hydrological regime:

- recommended for development of an Environmental Watering Plan
- required scheduling of EWP development.

Methodology

Site Inspection and Data Collation

Undertake a site inspection of each waterway and consult with relevant stakeholders to gather information to identify waterways environmental values in greater detail and confirm source of outfall water.

- Site visit to waterways
- Document flow regime
- Field assess values and identify length of stream affected
- Discuss with CMA/G-MW staff and undertake literature review to ascertain environmental values
- Assess land status
- Map and photograph
- Confirm and map channel outfall locations
- Document and map how incidental irrigation water reaches the waterway (e.g. via channel outfall or drain)
- Document if volumes of outfall water are likely to be affected by diversion downstream of the outfall
- Consider seasonality and water quality of outfall water
- Document if outfall water is utilised for other purposes eg diversion for irrigated production, to a wetland or other site/use, passing or environmental flow.
- Assess and document, by discussions with local staff (G-MW) volumes of outfalls and downstream diversion since the baseline year for assessment (see WCMF).

Document relevant environmental and hydrological information

- Collate relevant documents
- Consult relevant GBCMA and NCCMA staff and NVIRP staff

Assess and confirm hydrological impact on environmental values

- Is the expected change likely to be material and will it affect environmental values?
- Is the unknown change likely to be material and will it affect environmental values?

Environmental Watering Plans

Determine the requirement for development of EWP's for waterways with known high environmental values and which receive a significant proportion of their water supply from incidental irrigation water.

Identify the required schedule for development of the EWP's based on the requirements and the proposed NVIRP program of works.

Reporting

Prepare a report:

1. presenting results
2. recommending waterways requiring further investigation
3. recommending waterways requiring an EWP
4. identifying the required schedule for the development of each EWP.