INDEPENDENT REVIEW OF THE VICTORIAN METHOD AND PLANNING ASSUMPTIONS FOR LONG TERM DIVERSION LIMIT EQUIVALENCE (LTDLE) FACTORS IN THE MURRAY-DARLING BASIN

The Independent Review Panel

Drew Bewsher and Paul Simpson

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Summary

This is an independent review of the planning assumptions and the calculation methodologies used by Victoria to determine their Long Term Diversion Limit Equivalence (**LTDLE**) factors.

The LTDLE factors are important because they relate the magnitude of a water entitlement class to the long-term average water use of that entitlement class.

Consequently these factors are a key basis for determining whether past and future water recovery under the Basin Plan will 'bridge the gap' from the baseline diversion limit (**BDL**) to the sustainable diversion limit (**SDL**) in the coming decade.

Victoria has proposed LTDLE factors for the High Reliability Water Share (**HRWS**) and Low Reliability Water Share (**LRWS**) entitlements for each of its valleys within the Basin. The determination of these factors is reported in the February 2019 version of '*Revision of Long Term Diversion Limit Equivalent Factors for Victoria's Basin Plan Recoveries* ', Draft 4 (**LTDLE Report**).

The factors for the HRWS entitlements for the larger valleys (Goulburn, Victorian Murray, and Campaspe) range from 0.95 – 0.98. The factors for HRWS for the smaller valleys (Broken, Loddon and Wimmera-Mallee) range from 0.57 – 0.83.

The factors for the LRWS entitlements range from 0.05 – 0.58.

Review Findings

(a) This review endorses the LTDLE factors presented in the LTDLE Report.

(b) The methods and assumptions upon which the factors are based have been reviewed and are considered by the reviewers to be the best available at the current time.

(c) There are inherent difficulties and uncertainties in predicting the effect of the purchase of entitlements on consumptive water use into the future. This is because water management in any valley is dynamic and complex and utilisation of entitlements in the future is impacted by a range of considerations. These include the way environmental water will be used, the use rules that will be set by the resource manager, the manner in which consumptive users will respond to changing conditions under the Basin Plan, the potential changes in prevailing climate and other considerations.

(d) The approach proposed by Victoria has been to use their BDL models, and the planning assumptions inherent in these models, to determine LTDLE factors. These models reflect 2009 conditions in all valleys except for the Wimmera-Mallee where that BDL model reflects 2010 conditions. The reviewers agree with the use of the BDL models to determine Victoria's LTDLE factors. These are the best models currently available and the analysis presented by Victoria does not indicate the existing utilisation of water entitlements is changing significantly. If changes do occur, there is insufficient information currently available to determine the likely trends in the future.

(e) Because of the above uncertainties in assessing LTDLE factors for use over the next decade, it is inevitable that small over or under recovery might occur in attempting to 'bridge the gap'.

However, it is noted that the diversion limit control mechanisms which will be in place under the new WRPs will ensure diversions will be within the SDL over time (because robust compliance processes are expected to be in place).

(f) The HRWS LTDLE factors are already very high being between 0.95 and 0.97 in the valleys with the largest consumptive uses (i.e. Victorian Murray, Goulburn and Campaspe). The reviewers consider the uncertainties with modelling future conditions discussed above are unlikely to significantly alter these HRWS factors.

(g) The review has given considerable attention to the LTDLE factors for the LRWS entitlement. Neither the LRWS nor the HRWS entitlements are explicitly represented in the BDL models. Instead only the total use (i.e. LRWS + HRWS) is explicitly modelled and the split between HRWS and LRWS is determined by an approximate procedure involving post-processing of the model results.

(h) Because LRWS allocations are only announced when there is high water availability and 100% HRWS allocations are secured for two years, LRWS allocations are much more sensitive to small changes in water availability. The investigations conducted to date by Victoria indicate that the LRWS allocations are also sensitive to climate and management rule changes. The reviewers note that there have been no allocations to LRWS in the recent past whilst application of the BDL model post 2009, indicates there should have been LRWS allocations in four years. This suggests that the BDL model and the post-processing procedures used to determine LRWS need improvement. However, the reviewers also note that behaviour in these years may have been influenced by factors that cannot be adequately represented in a model (e.g. transient irrigator behaviour due to rapidly changing water availability).

(i) Consequently the reviewers consider that further investigation of the future LRWS water use should be considered in order to confirm the LRWS LTDLE factors that have been obtained from the BDL models. A first step towards an improved understanding of the future LRWS water reliability could be updating the BDL models to incorporate the management rule changes that have occurred since 2009. This should be possible once the new WRPs are prepared together with the new models that will underpin these WRPs.

(j) The reviewers note that the quantum of past (and likely future) LRWS recovered in Victoria is relatively small compared to the HRWS recoveries. Consequently any potential changes to the LTDLE factors for LRWS which may occur when additional information and modelling becomes available in the future, are unlikely to make a significant difference to the overall water recovery volume.

1 Introduction

1.1 What are LTDLE Factors?

Water allocated to, and used by, the various classes of entitlement across the Basin varies according to the irrigation crops and practices in each valley, local climate, and water management rules. Long Term Diversion Limit Equivalence (**LTDLE**) factors provide a conversion between the size of a water entitlement and the long-term average use of that entitlement over the reference period used to develop the Basin Plan (1895 – 2009). LTDLE factors are specific for an entitlement class within each valley for which water resource plans (**WRP**s) are being prepared under the Basin Plan.

This is an independent review of the planning assumptions and the calculation methodologies used to determine the LTDLE factors for all Victorian valleys within the Basin, which comprise:

- Broken
- Campaspe,
- Goulburn
- Loddon
- Victorian Murray
- Wimmera-Mallee
- Ovens and
- Kiewa valleys.

These LTDLE factors have been prepared by the Victorian Department of Environment Land Water and Planning (**DELWP**).

1.2 Why are LTDLE Factors Required?

The Basin Plan sets new Sustainable Diversion Limits (**SDL**s) for major river valleys across the Murray-Darling Basin. These SDLs are set relative to a Baseline Diversion Limit (**BDL**), which is defined by the Basin Plan for most valleys as the diversions that could be taken under existing state arrangements on 1 July 2009.

To implement these SDLs, the Commonwealth has committed to recover water from consumptive users by purchasing entitlements and to fund water savings projects, with the aim of reducing water use to the SDL. Many of these tasks are already completed. The aim is to 'bridge the gap' from the BDL levels to the SDL levels set in the Basin Plan.

LTDLE factors provide the key basis for determining whether the recovered water entitlements will 'bridge the gap' in long-term average water use between BDL and SDL in the future when the WRPs are implemented.

1.3 Existing LTDLE Factors

Prior to 2019 there have been other factors developed to reflect the conversion between an entitlement and its long-term water use. These factors were referred to as 'Cap Factors' as they were originally developed under conditions reflecting the 'Cap' on diversions established under Schedule E of the Murray-Darling Basin Agreement. These factors were used for a variety of purposes including to assess trade and to calculate environmental water recovered as a result of The Living Murray (**TLM**) program.

The Murray-Darling Basin ministers approved the use of a set of LTDLE factors to estimate water recovery in 2011 (known as version 2.05 or 'v2.05' factors), which are still formally being used by the Commonwealth. Recognising that these factors could be improved, Basin ministers subsequently requested each state to bring forward appropriate factors in 2015. More recently the factors have been used when assessing water recovery under the Basin Plan and establishing the entitlements yielded by undertaking various water savings projects in Victoria. What are known as the 'v10.8' factors are currently being used in audits of purchases from Connections Project Stage 1, the Inter-Project Agreement and the Reconfiguration Project.

DELWP advised the reviewers that these versions of the factors, including 'v10.8' and the formally approved 'v2.05' factors, contain inherent technical problems and do not appropriately represent BDL conditions.

These problems are one of the reasons that new LTDLE factors, which are the subject of this review, have been developed.

1.4 Documents Examined and Review Tasks Undertaken

This review was carried out over January and February 2019 under the limited time constraints of both reviewers.

The review was undertaken based on the documents available at that time. Prior to the review commencing, the reviewers understand various discussions about Victoria's approach to the calculation of LTDLE factors took place between the MDBA and the DELWP including exchange of some preliminary documentation.

The calculation of LTDLE factors is primarily based on the simulation of the long-term water use behaviour in various hydrologic models. The reviewers have checked the credentials of the models upon which DELWP relies to ensure they are the best available, but it has not been within the scope of the review to undertake an assessment of the accuracy of any of these models.

To undertake this review, the MDBA have made available a number of documents and calculation spreadsheets prepared by the DELWP of which the following were the most significant:

- *Revision of Long Term Diversion Limit Equivalent Factors for Victoria's Basin Plan Recoveries*. Technical Report for submission – Draft 4. DELWP. Feb 2019. (**LTDLE Report**). (An earlier version, Draft 3, provided at the commencement of this review, was almost identical to Draft 4 and was used as the basis for the majority of discussions with DELWP and MDBA by the reviewers);

- *Verification of Entitlements in the GSM Baseline Diversion Limit Model*. Draft Report - Version 3. May 2018. (**Verification of Entitlements Report**); and

- *Addendum to Revision of Long Term Diversion Limit Equivalent Factors for Victoria's Basin Plan Recoveries.* Version V3, received 15 March 2019. (**Addendum to LTDLE Report**).

The MDBA has also facilitated teleconferences and a face to face meeting with MDBA and DELWP staff to assist with the review on 23 January 2019 in Melbourne. DELWP and the MDBA have also provided supplementary material in response to questions raised as part of the review. This included:

- *Independent review of revised Victorian LTDLE factors – further material*. DELWP emailed this five page document to the reviewers on 30 January 2019 in response to various questions and issues raised during the meeting on 23 Jan 2019.

The MDBA and DELWP have also been given the opportunity to review a draft of the report prior to its finalisation.

2 Method Proposed by Victoria

2.1 Entitlement Classes for which LTDLE Factors are Required

LTDLE Factors are required for all entitlement classes where water purchases have occurred or are likely to occur under the Basin Plan. In addition, LTDLE factors are needed where water entitlements have been created through savings projects including those currently underway or proposed to occur.

These entitlement classes for which LTDLE Factors are required are summarised in **Table 1**.

Table 1: Entitlement Classes where LTDLE Factors are Required

WRP Area	SDL Resource Unit	Entitlement Class	Currently required for water recovery estimate
Northern Victoria	Goulburn	Rural (HRWS)	Yes
		Rural (LRWS)	Yes
		Urban Bulk Entitlement	No
		Broken Creek Supplement	No
	Broken	Rural (HRWS)	Yes
		Rural (LRWS)	Yes
		Urban Bulk Entitlement	No
	Campaspe	Rural (HRWS)	Yes
		Rural (LRWS)	Yes
		Coliban Water	Yes
	Loddon	Rural (HRWS)	Yes
		Rural (LRWS)	Yes
		Urban Bulk Entitlement	No
Wimmera-Mallee	Wimmera-Mallee	Coliban Water	No
		Consumptive Wimmera-Mallee Pipeline Product	No
		Pipeline Losses	No
		Recreation	No
		Irrigation Product incl. losses (Recovered by C'wlth)	No (See Note 1)
Victorian Murray	Murray	HRWS (incl. variable losses, urbans, and VIC flora fauna)	Yes
		LRWS (incl. variable losses, urbans)	Yes
		Initial Irrigation District Loss	No
	Kiewa	Urban	No
		Unregulated	No
	Ovens	Urban	No
		Non-urban regulated	Yes
		Unregulated	No

Note 1: – recovery estimated using best available hydrological model

Victoria has also indicated that there are two additional entitlement classes that have arisen from water savings projects:

- Very High Reliability entitlement from the decommissioning of the Campaspe Irrigation District (1,656 ML); and
- Wimmera-Mallee Pipeline Savings Entitlement in the Loddon system (7,490 ML).

Victoria has advised that the modelled savings have been assumed to bridge the gap directly, and no LTDLE factors are required. This is discussed further in Section 2.5.

The reviewers also considered the need to assess LTDLE factors for various 'supplements' that are simulated in the existing BDL models. These supplements are essentially transfers of water from one valley to an adjacent valley. The supplements from the Loddon and Campaspe systems to the Goulbourn system via the interconnecting Waranga Western Channel, do not require separate LTDLE factors within the Loddon or Campaspe systems because LTDLE factors have been determined for the ultimate use of the water within the Goulburn System.

An exception is the supplement provided to Broken Creek from the Goulburn system. Although the use of this supplement is represented in the BDL model and an LTDLE factor could be determined, an LTDLE factor is unlikely to ever be required as this environmental entitlement is unlikely to ever be recovered.

Accordingly the reviewers considered that LTDLE factors did not need to be determined for the Loddon, Campaspe or Broken Creek supplements.

2.2 Use of BDL Models

Victoria have set out their methodology for determining LTDLE factors in the LTDLE Report. The methodology uses the BDL model in each WRP area to estimate the long-term average allocations and diversions, and hence calculate the utilisation, for each entitlement class.

The BDL models used are as follows:

- Victorian Murray: *MSM-BigMod* which simulates behaviour in the River Murray from Dartmouth Dam to the Lower Lakes in South Australia. MDBA Run 871 of this model has been used despite this not being the latest BDL model for the Murray. (Run 871 was used to develop the 2012 Basin Plan legislative instrument but has since been revised). Run 871 was used in order to ensure consistency with the NSW LTDLE factors for the NSW Murray which were separately reviewed and settled in 2018. Whilst it is not within the scope of this review to assess the veracity of individual models, the reviewers were informed by the MDBA that the differences between the MSM-BigMod Run 871 and the latest BDL model were small, despite this model utilising a different platform (i.e. eWater Source). Given these assurances the reviewers agree that use of Run 871 is appropriate in order to maintain consistency with the NSW approach.

- Northern Victoria: *Goulburn Simulation Model (**GSM**)* which simulates behaviour in the Goulburn, Broken, Loddon and Campaspe valleys (REALM Run N931). Although this model has not yet been verified by Victoria, DELWP advised the reviewers that this run will be used to describe BDL conditions within the Northern Victorian WRPs which are currently in preparation;

- Wimmera-Mallee: Run BDL2 of the Wimmera-Mallee REALM model. Consistent with the approach used for the Northern Victoria, DELWP advised the reviewers that this run will be used to describe BDL conditions within the Wimmera-Mallee WRP which is currently in preparation;

- Kiewa and Ovens: The BDL model was used, but diversions were disaggregated into entitlement classes using observed data. (Refer discussion below).

In some WRP areas where no modelling of individual entitlement classes under BDL conditions is available, DELWP have proposed to use observed diversions and water availability to disaggregate modelled use for estimating LTDLEs, if these are required in the future.

DELWP have estimated LTDLEs for both the Ovens and Kiewa valleys in this way. However as noted in **Table 1**, LTDLE factors are not required for these two valleys except for a very small quantity within the Ovens Valley. It is understood that the Commonwealth have only purchased approximately 70 ML from the regulated section of the Ovens River.

2.3 Cross-Check of Entitlements

At the request of the reviewers, DELWP provided the following information to confirm that the quantum of the entitlements, in each class used in their LTDLE factor assessment spreadsheet, was consistent with those in the Victorian Water Register and the relevant Bulk Entitlements legislation:

- Victorian Murray: As discussed in the previous section, the Murray's LTDLE factors were derived from MDBA's model Run 871 that was used for the preparation of the Basin Plan in 2012. Over the years since this run was performed, DELWP has checked and confirmed that the modelled entitlements are consistent with the actual entitlements in place at 30 June 2009 (i.e. BDL conditions). DELWP advised the reviewers that any differences between the modelled entitlements and the BDL entitlements determined from the Water Register and the relevant Bulk Entitlements, were very minor (<1%) for the entitlements classes for which LTDLE factors have been derived.
- Northern Victoria: DELWP advised the reviewers that the entitlements used in the GSM modelling are consistent with the BDL entitlements at 30 June 2009 (as listed in the 2018 Verification of Entitlements Report). Where the Water Register might not properly reflect BDL Conditions (e.g. during decommissioning of Lake Mokoan) the information in the Bulk Entitlement was relied upon.
- Wimmera-Mallee: BDL Conditions in the Wimmera-Mallee (i.e. those at 31 October 2010). DELWP advised the reviewers that the entitlement volumes used in the LTDLE factor calculations were those obtained from the Bulk Entitlement, 2010.
- Kiewa and Ovens: DELWP obtained the Kiewa and Ovens entitlements from the Water Audit Monitoring Report for the 2008/09 reporting year. DELWP advised that this information was prepared by Goulburn-Murray Water using Water Register data and their own records at the time.

2.4 Assessment of 'Breakpoint' Methodology

2.4.1 Background to the Breakpoint Method

A considerable amount of the review has been directed towards considering the appropriateness of the LTDLE factors for the Low Reliability Water Share (**LRWS**) entitlements, and the interaction between the LRWS and High Reliability Water Share (**HRWS**) LTDLE factors.

This section of the review report discusses the 'breakpoint' method which is the procedure used by DELWP to determine the proportions of the HRWS and the LRWS use from the total modelled water use. The need for this arises because only the combined HRWS and LRWS use is modelled in GSM and MSM, not the individual HRWS and LRWS components.

Within Northern Victoria and in the Victorian Murray valley, the breakpoint method is critical to determining the LRWS LTDLE factors, and to a lesser extent, the HRWS factors. The impact on the HRWS factors is less than for the LRWS factors because the long-term water use from HRWS is much higher than the LRWS use (i.e. about 3.5 times higher in Northern Victoria and 6.5 times higher in the Victorian Murray). Consequently any changes in the split of use between LRWS and HRWS will have a bigger impact on the resultant LRWS LTDLE factor than on the HRWS factor.

2.4.2 How is the Breakpoint Method Applied to the Model Results?

The actual resource assessment and seasonal determinations are carried out over a two year period. The system of allocations to HRWS and LRWS entitlements under BDL conditions are briefly summarised below. As the available water increases:

- water is initially and progressively allocated to HRWS;
- once 100% allocation to HRWS is reached for the current year, further allocations are not announced until sufficient water is available to supply 100% of HRWS in the following season; and
- additional available water is then allocated to LRWS in the current season.

The representation of demands within the models reflects the traditional structure of water entitlements prior to the 'unbundling' that took place in 2007. This unbundling involved separating the traditional entitlements of water rights into HRWS and LRWS, amongst other things.

The modelled allocation announcements can range from 0% to 200%, with 0% to 100% representing HRWS, and between 100% and 200% representing LRWS. The procedure used is complicated because of the influence of carryover rules and the setting of reserves which have changed over the last decade (refer Sections 2.4.3 and 3.7).

The breakpoint method relies on being able to determine the maximum annual diversion in years where allocation is at 100% (i.e. full HRWS allocation, no LRWS allocation). Once this breakpoint diversion is determined, all diversions less than this are assumed to be HRWS and any diversions in excess of the breakpoint diversion are assumed to be LRWS diversions.

DELWP advised that there was insufficient data available for all entitlement classes so that the breakpoint diversion could be determined from inspection of the annual diversions in years with 100% HRWS and 0% LRWS. Where this was the case, the breakpoint was determined by:

- subtracting the maximum low reliability annual limit from the combined annual diversions in the same year (where this low reliability annual limit represents the LRWS volumetric allocation including carryover); and
- finding the maximum in the resulting annual series.

Inherent in the breakpoint approach is the assumption that water use can be attributed to HRWS and LRWS in the same sequential manner as the allocations are made. If there is a significant lag between the timing of allocations to HRWS and LRWS, the assumption that water use can be attributed first to HRWS is more likely to be valid.

The ability to combine allocations from both HRWS and LRWS into a common Allocation Banking Account also makes it difficult to assess whether there is any evidence of concurrent use of HRWS and LRWS.

2.4.3 Influences of Carryover

But for the introduction of carryover, the separation of the modelled diversions into HRWS and LRWS diversions would be relatively straightforward. Carryover has complicated this separation. Further there have been various changes to the carryover rules including the following brief history:

- there was no carryover prior to 2007;
- carryover was introduced in the Murray and Goulburn in early 2007 as an emergency drought measure and was subsequently extended to the Campaspe, Broken and Loddon in mid-2008. The carryover amount was limited to 30% of entitlement;
- the limit on carryover was increased from 30% to 50% in February 2009. This applied to both the HRWS and LRWS volumes carried over. A deduction of 5% of carry over volume was deducted on 1 July every year to account for evaporation losses (15% in the Wimmera-Mallee);
- new carryover rules were confirmed in 2010 with no annual limit to carryover in the Goulburn and Victorian Murray systems. These included 'spillable water accounts' which increased the carryover limit to 100% provided there was capacity in the water storages. Use of the 'spillable water' is subject to the resource manager making a 'low risk of spill' declaration. (Carryover amount is unlimited in the Wimmera-Mallee).
- Revised carryover rules commenced in 2013, which included a 100% limit to annual carryover for the Goulburn and Victorian Murray systems, and a change to the spill rule in the Victorian Murray system to reflect spill of Victorian resource from Hume Dam rather than Dartmouth Dam.

The reviewers understand that for BDL conditions, the 50% carryover limit applies (except in the Wimmera-Mallee where there is no limit). Not all the BDL models prepared to date have included this 50% limit. For example:

- the original GSM and MDBA models used to prepare the 2012 Basin Plan made no allowance for carryover; [1]
- the Victorian Murray LTDLE factors are based on this original BDL model (i.e. no carryover);
- the GSM used by DELWP to develop the Northern Victorian LTDLE factors has been revised to reflect the 50% carryover limit;
- the Wimmera-Mallee model includes unlimited carryover rules which are consistent with both BDL and the current arrangements.

2.4.4 Resultant Uncertainties in Modelled LRWS and HRWS Uses

The reviewers examined the modelled LRWS allocations for Northern Victoria for the period 2009–2016 that were provided in DELWP's supporting information accompanying the LTDLE Report.[2] This showed that whilst there were no LRWS allocations for 2009 or 2014–2016, for the four wetter years from 2010 to 2013, the maximum (i.e. June) LRWS allocations across the Goulburn, Broken, Loddon and Campaspe valleys were 78%-100% (2010), 100% (2011), 100% (2012) and 54%-100% (2013). However in reality there were no LRWS allocations at all over the 2009–2016 period for the Goulburn and Victorian Murray systems.

A comparison of modelled and observed water availability for the Goulburn system was prepared by the MDBA, based on information provided by Victoria, and is shown in **Table 2** below. This compares a simple representation of observed water availability (effective allocation) with the modelled allocations from the BDL model. The effective allocation is the observed allocation plus the volume of carryover (on 1 July each year), expressed as a percentage of entitlement.

Table 2: Comparison of Observed and Modelled Water Availability for the Goulburn Valley

	Observed allocation (HRWS)	Observed allocation (LRWS)	Observed Carryover	Effective Allocation	Modelled (BDL) Allocation
2008-2009	33	0	62,624	39	35
2009-2010	71	0	78,666	79	71
2010-2011	100	0	275,016	165	178
2011-2012	100	0	741,670	200	200
2012-2013	100	0	715,511	200	200
2013-2014	100	0	325,747	177	154
2014-2015	100	0	298,657	171	100
2015-2016	90	0	222,543	129	100
2016-2017	100	0	254,896	160	100

[1] For GSM refer Section 3.1.2 of '*Independent review of models to assess their representation of the baseline conditions specified in the Basin plan and estimating BDLs'*. Barma Water Resources Pty Ltd. June 2012.
For MDBA model refer email advice provided by MDBA to reviewers on 25 February 2019.
[2] This was an Excel spreadsheet '*2 GBCL LTDLE SWAM DELWP V19_Draft for MDBA.xlsb*' accompanying Draft 4 of the LTDLE Report and provided to the reviewers on 26 February 2019. These modelled allocations represent the maximum allocation over the year i.e. the June allocation.

The following points from **Table 2** are noted:

- The simple estimate of effective allocation (as if carryover was part of the announced allocations) indicates that the volume of water made available is similar to, or greater than, the volume of water allocated in the modelling.
- The first two years had a lower carryover limit (30% - 50%), and were significantly drought affected, and carryover volumes were much lower,
- significant volumes of water are being carried over in most years, although there has been significant variability in carryover behaviour, and
- there are two years (2011/12 and 2012/13) where carryover volumes exceeded the BDL carryover limit (50%), and this would have reduced the resource available for allocation to LRWS.

These results suggest that the BDL model is making higher allocations to LRWS than was observed in practice, despite using observed inflows and climate data. The increased carryover limits post 2009 may explain some of this difference, indicating that changes to carryover rules are likely to have had some impact on announced allocations of LRWS relative to BDL conditions. However, the increased volumes of water being carried over may not fully explain the difference between observed and modelled allocations.

The potential for a drier climate to influence the frequency of LRWS allocations in Northern Victoria and the Victorian Murray has been analysed in a separate climate change impact assessment carried out by Victoria.[3] Whilst this assessment was based on older modelling, it identified that if there is a step change to a drier climate, the LRWS would have no allocations most of the time. Within the Goulburn system, 0% allocations for LRWS would occur in 96 out of 100 years whilst within the Victorian Murray, there would be no LRWS allocations in 72 out of 100 years. This assessment demonstrates that, as expected, the LRWS is highly sensitive to climate and the resulting reduction in available water which occurs in dry periods. Nevertheless as DELWP's model for the 2010-2013 utilises the actual streamflows, rainfall and storage inflows, it remains unclear why the modelled LRWS allocations did not occur in practice.

Without explicit representation of the LRWS and HRWS uses in the models, the reviewers recognise that there are practical difficulties in accurately determining the long-term water use of the LRWS entitlement and to a lesser extent, the HRWS entitlement. These difficulties arise in part from the use of the breakpoint method discussed in Section 2.4, the frequent changes to carryover and other management rules discussed above and potential temporary changes in irrigator behaviour over these years (i.e. resulting from their experiences of the drought and the numerous policy changes).

A further difficulty arises because the LTDLE factors derived from the modelled HRWS and LRWS water uses are to be used over the next decade when different carryover rules will apply from those assumed in the calculation of the factors (i.e. BDL conditions).[4]

[3] Refer '*Northern Region Sustainable Water Strategy*' was published by Victoria in 2009 at the end of the 'millennium drought'. A copy of this document was provided by Matt Bethune of the MDBA to the reviewers in February 2019.

[4] The current carryover rules provide the best estimate of the 2019-2029 rules for all valleys. However with the possible exception of the Wimmera-Mallee, these rules are different from the carryover rules in the models used by DELWP to calculate the LTDLE factors, although the resultant differences in diversions may be small.

2.5 Entitlements Resulting from Implementation of Water Saving Projects

Various water savings projects have been undertaken in Victoria or are currently underway. These projects typically involve modernisation of an irrigation delivery system to reduce losses and improve delivery efficiency. The objective of these projects is to provide for a permanent reduction in water losses. The saved water is converted to HRWS and LRWS entitlements which are held by the Victorian or Commonwealth environmental water holder. The proper estimation of the long-term water savings from each project is described by a separate protocol.[5]

During the course of the review, MDBA requested that specific consideration be given to the LTDLE factors associated with the entitlements that have been, or will be, created as a result of Victoria's water savings projects. The MDBA have also indicated that some of the water savings projects are a combination of water savings from works undertaken and the purchase of entitlements.

Victoria's water savings protocol provides for the water losses to be classified into two components being

- fixed losses – e.g. seepage, evaporation, leakage through and around service points and 35% of bank leakage; and
- variable losses – e.g. delivery dependent outfalls, meter error, unauthorised use, unmetered use and 65% of bank leakage.

These losses are then directly converted into HRWS and LRWS as follows:

- HRWS – the volume of fixed loss savings, plus the volume of variable loss savings corresponding to a 100% HRWS allocation year. (The volume of this variable loss savings is calculated as the average volume of total variable loss savings divided by a conversion factor);
- LRWS – the total volume of variable loss minus the volume of variable loss savings corresponding to a 100% HRWS allocation year.

Initial estimates of HRWS and LRWS entitlement volumes are obtained by dividing the average volumes of high reliability and low reliability water savings by the corresponding LTDLE factors. These estimates of the HRWS and LRWS entitlements can then be validated by incorporating the entitlements into models to ensure there are no reliability impacts.

DELWP also advised the reviewers that a different system for conversion of the HRWS and LRWS entitlements from the water savings had been used on occasions in the past (e.g. the decommissioning of Campaspe Irrigation District).

After assessing the procedures used by Victoria to create entitlements from water savings projects, the reviewers concluded that there were effectively two methods available to determine the contribution of a project to 'bridging the gap'. Both methods involve determination of the additional water that becomes available to the environmental water holders, on average over the long-term, through the creation of new entitlements and comprise:

[5] Refer '*Water Savings Protocol A protocol for the quantification of water savings from modernising irrigation distribution systems*'. Version 5.0. DELWP. October 2018.

- using the LTDLE factors to convert the entitlements into long-term average water use; or
- using the long-term water savings initially calculated using the Victorian water savings protocol.

The MDBA's view is that all entitlements in each class should have the same LTDLE factor, which is a basic principle in the approach to determining LTDLE factors more generally (see Section 1.1), reflecting the former method.

However, the latter method is a direct assessment of the long-term savings, and is considered to be more accurate than the former method. Consequently, in assessing 'bridging the gap' there would appear to be no direct need to have LTDLE factors. This would support the approach taken by Victoria to directly convert the savings for the two additional entitlement classes not listed in **Table 1** (see Section 2.1). For those projects that are a combination of water savings from works and entitlement purchase, the modelled water savings for the overall project may still be appropriate where it represents both the works and the entitlement purchases.

In any event the difference between the two methods should be small if the method of splitting the water losses into fixed and variable has been undertaken accurately.

3 Using LTDLE Factors to 'Bridge the Gap' – Review of Key Assumptions

3.1 Assumptions and Uncertainties in Calculating LTDLE factors

The Commonwealth government will use LTDLE factors to provide confidence that the water recovery will reduce diversions from the levels that could be expected over the life of the first WRPs to SDL levels in each valley (i.e. 'bridge the gap'). When considering the future operations within a valley under its new WRP, the change in consumptive diversions arising from the past purchase of entitlements will vary depending on:

- the original utilisation of the entitlement prior to purchase/recovery;
- the utilisation of the purchased entitlements that is achieved by environmental water managers following the purchase;
- the future behaviour of consumptive water users; and
- the characteristics of different types of entitlements within and across valleys (such as the reliability of allocations to those entitlements).

These issues create some uncertainties as to whether the recovered entitlements will consistently provide the same reduction in long-term diversions that they have in the past.

For each WRP to be prepared under the Basin Plan, the states are required to develop a 'method' for calculating the permitted take each year that shows diversions will be within the SDL over a repeat of the reference climate period (1895-2009). In preparing this method, the effect of the above issues and uncertainties will not be known precisely, and assumptions have been made, which are acknowledged by the MDBA in documentation regarding 'planning assumptions'. [6]

The key intention in making these assumptions is to ensure the resultant factors provide a consistent measure of the relative contribution of different entitlements, both within and between valleys, and that the best available information has been used.

The Commonwealth and MDBA have indicated that LTDLE factors are for an entitlement class and not for an individual entitlement. Consequently when calculating LTDLE factors, all entitlements are assumed to share the diversions attributable to that class of entitlement, equally. This involves averaging of the 'value' of individual entitlements across an entitlement class within a valley. This averaging accounts for the different spatial location and differing water use characteristics of individual entitlements within an entitlement class.

For example, consider the HRWS in the Goulburn Valley. This entitlement class is comprised of numerous individual entitlements. For the purpose of calculating LTDLE factors, the long-term average diversions attributed to the HRWS class in the Goulburn Valley are assumed to be

[6] Refer 'Basin Plan Water Resource Plan Requirements Position Statement 3H – Planning assumptions' issued by the MDBA in March 2016.

distributed to an individual entitlement according to that entitlement's share of the total HRWS entitlement in the Valley.

Using an average factor for each entitlement class is appropriate for entitlements recovered from consumptive use, where the estimate of long-term average use from models is also aggregated, and all of the entitlements have an equal right to utilise their entitlements. However, for entitlements that arise from water savings, the long-term average volume of water recovered is usually estimated directly by the modelling, and there is a case for not using LTDLE factors, and directly using the modelled water savings (see Section 2.5).

3.2 Utilisation of Purchased Entitlements

If a significant proportion of purchased entitlements were under-utilised, environmental water managers may well increase the utilisation of these entitlements, with the effect that water available to other water users would reduce (from current levels) over time. If changing the utilisation of recovered entitlements is an inherent right of that entitlement, as would be the case for consumptive water users, this could be considered a reasonable and expected part of water recovery. It is understood that the Commonwealth expect that the entitlements purchased as part of water recovery are assumed to be 'equal' to other entitlements in their respective classes.

As noted above, the eventual utilisation of the recovered entitlements (and the resultant effects on consumptive water use) may not be fully known for some time. Concerns have previously been raised that environmental water holders may be able to utilise entitlements to a higher degree than would be the case for the agricultural enterprises from which they were purchased, and that it now holds between a quarter and a third of all entitlements. The significance of this issue will depend on whether any valley-scale use limits (as described in Section 3.6) are expected to apply to entitlements recovered for the environment. However, it is also understood that the Commonwealth Environmental Water Holder has not evidenced unusually high utilisation rates to date in comparison to consumptive water users.

At the time of this review of the proposed Victorian LTDLE factors, valley models of the expected water usage during the first decade of the WRPs under the 114 year historical climate period are still being developed. The models currently proposed by Victoria for calculating LTDLE factors assume BDL (i.e. 2009) water management rules and utilisation.

3.3 Expected Levels of Diversions during the first WRP (up to 2029)

The characteristics of the future water use will influence whether the recovered water will 'bridge the gap' over the next decade.

Different ways of estimating potential future diversion levels over the life of the first WRPs (2019 – 2029) have been proposed previously, including assumptions of full, or near full, utilisation of allocated water for each class of entitlement ('ultimate development'), together with the resulting effects of current valley use limit compliance processes.

It is recognised that there are a range of different (sometimes competing) influences on the overall levels of water use that are difficult to forecast into the future. However, evidence has been

presented by Victoria that levels of water use in its regulated river systems have not been changing rapidly over time.

In this situation, it has been proposed (by NSW and Victoria) that the current levels of water use are probably the best indication of the expected levels of water use over the life of the first WRP. It is understood that the MDBA agreed with this proposition for setting LTDLE factors for NSW valleys, and wishes to test this proposition for Victorian valleys.

3.4 Representativeness of BDL Models

The Victorian BDL models are intended to reflect water use take in each valley under the water management rules and entitlements that were in place in 2009 (or 2010 for the Wimmera-Mallee).

All models are only approximations, and to the extent that these models contain approximations of reality, this creates some uncertainties in the models' results.

The BDL models used to prepare the Basin Plan 2012 have been previously reviewed and adopted as the best estimates of BDL conditions at the time. Nevertheless, over the last five years or so, minor improvements to these models have been identified and upgraded BDL models have been prepared (although at the time of preparation of this review, have not been formally adopted). As these upgraded models have been prepared by making small improvements to the original models, it is expected that these upgraded models are to an equal or better standard than the original models. The reviewers have assumed this to be the case (and note that any assessment of these models is outside the scope of this review).

However, the following points are noted:

- HRWS and LRWS use are not explicitly modelled, and their relative utilisations are estimated from aggregated/lumped simulation of diversions in the BDL models; and
- there is no observed data for use of LRWS in the two largest Victorian systems as no allocations have ever been made. This makes it difficult to check the 'breakpoint' methodology proposed by Victoria (refer Section 2.4).

3.5 Time Elapsed since Water Recovery

The majority of the water recovery via entitlement purchases occurred between 2007 and 2010, and could be considered to accord closely with the setting of the BDL (2009). However, a significant period of time has elapsed between the purchase and this review, and there is potential for the level of diversions in each valley to have changed (higher or lower) than was occurring in 2009.

Noting the potential for change over time, the approach proposed by Victoria is to use the BDL modelling as the current best estimates of water use, and that this is the best indicator of what might occur between 2019 and 2029. It is understood that the Commonwealth is not aware of any evidence for significant changes in utilisation of consumptive entitlements occurring since 2009 in NSW valleys, but seeks to test whether this assumption is appropriate for Victorian valleys.

3.6 Adjustment of Valley-Scale Use Limits

The Basin Plan requires that WRPs demonstrate that diversions will be reduced to SDL levels. The Commonwealth government is seeking to achieve this through its funding of the recovery of water (entitlement purchases, and savings projects) and that states' WRPs would then simply reset the valley-scale use limit from the BDL to the SDL. The intent is that the new SDL could be set in place without impact to the remaining consumptive water users.

Because of the uncertainties involved in assessing LTDLE factors, it is inevitable that small over or under recovery might occur in attempting to 'bridge the gap' by direct reductions in consumptive water use through purchase. However, the new valley-scale diversion limits set via WRPs will force diversions to be within the SDL over time (because robust compliance processes are expected to be in place).

In general, each valley within the basin has been managed to a water use limit, such as the 1993/94 Cap, or NSW Water Sharing Plan Limits, etc, and in the future, consumptive use in each valley will be managed to the SDL. If the utilisation of consumptive entitlements is currently at BDL levels (or was at 2009), and reasonable compliance processes are in place, it could be assumed that there is unlikely to be any growth in water use at a valley scale.

Depending on the final rules proposed in WRPs, if growth in water use were to occur, valley-scale water use limits may require reduction in access to water for all (consumptive and environmental) entitlements to maintain compliance with the SDL, and these actions may occur differentially across entitlement classes, which may affect the volume of water recovered. In general, higher security entitlement classes are affected less by such management actions.

These considerations demonstrate the uncertainties associated with predicting the future utilisations under a SDL. However it is the view of both the MDBA and DELWP that the past utilisations are the still the best guide to the future.

3.7 Changes in Carryover Rules and Reserves

There is also potential for management rule changes to occur that may change the reliability of allocations to individual entitlement classes. In this regard it is noted that there have been significant changes in Victoria to carryover policy, and when reserves for future years are set aside. These rules changed a number of times between 2007 and 2013.

- On 1 July 2009, the carryover limit was increased from 30% to 50%. The GSM includes a carryover limit of 50%, but the MSM does not include representation of carryover.
- Further changes to carryover rules occurred post 2009, including unlimited carryover (later limited to 100% of entitlement), and the introduction of spillable water accounts that enable entitlement holders to hold more than 100% of entitlement in their accounts (subject to available airspace in storages).
- The spill rules introduced in 2010 for the operation of spillable water accounts in the Victorian Murray valley were changed in 2013 to reflect spill of Victorian resource from Hume Dam rather than Dartmouth Dam.

- An ‘early reserve volume’ was introduced in 2010 for both the Goulburn and Victorian Murray valleys to ensure an opening allocation and sufficient water to deliver allocations and carryover in the following water year. These early reserves were subsequently reduced by approximately 20% in 2013 to reflect the effects of water savings projects on the volume of water required by the irrigation channel systems.

It is also understood that some of the assumptions have changed since 2009 regarding reserves and determining allocations.

4 Conclusions

There are a number of inherent uncertainties involved in estimating how much each entitlement will contribute to 'bridging the gap'. These include the difficulties in forecasting the future behaviour of consumptive and environmental water users.

Because of the uncertainties involved in assessing LTDLE factors, it is inevitable that small over or under recovery might occur in attempting to 'bridge the gap' by direct reductions in consumptive water use through purchase. However, the new valley-scale diversion limits set via WRPs will force diversions to be within the SDL over time (because robust compliance processes are expected to be in place).

Victoria has proposed LTDLE factors for HRWS and LRWS entitlements for each of its Basin valleys based on modelling of BDL conditions (i.e. those existing at 30 June 2009 for Northern Victoria and Victorian Murray, 31 October 2010 for Wimmera-Mallee).

The factors for HRWS entitlements for the larger valleys (Goulburn, Victorian Murray, and Campaspe) range from 0.95 – 0.98. The factors for HRWS for the smaller valleys (Broken, Loddon and Wimmera-Mallee) range from 0.57 - 0.83.

The factors for LRWS entitlements range from 0.05 - 0.58.

Assuming that the BDL modelling is representative of the BDL conditions, this review has found that the results of the BDL models have been used appropriately to determine the LTDLE factors.

In particular:

- The Goulburn Simulation Model (GSM) simulates water management and use for the Goulburn, Broken, Loddon, and Campaspe valleys, and Victoria have prepared a revised GSM to represent BDL conditions. This revised model includes updates to water entitlements and management rules to better reflect the BDL conditions.
- Victoria has provided this review with a report (Verification of Entitlements Report) that details the updates to the entitlements within the GSM model. The reviewers are satisfied that this report demonstrates that the revised GSM entitlement volumes can be verified against the Victorian Water Register or the Bulk Entitlements made under Victorian Legislation.
- For the Victorian part of the regulated Murray system, Victoria have proposed factors based on results from the Murray Simulation Model developed by the MDBA, which has configured a BDL scenario referred to as Run 871. This is the model scenario used by NSW to propose LTDLE factors for the NSW Murray.
- It is understood that both BDL models have been reviewed by the MDBA and are considered to appropriately represent BDL conditions.
- Victoria has proposed a 'breakpoint' methodology to apportion the total modelled water use between HRWS and LRWS. This involves apportioning modelled water use to HRWS until the full allocation is used, or the maximum observed use for HRWS (the maximum of the years with 100% HRWS allocation and no LRWS allocation) is reached. This sequential

approach to apportioning modelled water use is consistent with the priority of allocations, and the origins of LRWS as opportunistic ('sales') water.

- However, the fact that allocations from both HRWS and LRWS can accrue to the same Allocation Banking Account means that there is no direct attribution of water use to either HRWS or LRWS in practice. The lack of any observed LRWS allocations in the two larger valleys (Goulburn and Victorian Murray) also makes the breakpoint methodology difficult to test. If there are differences between the breakpoint methodology and reality, it would seem (if anything) that the breakpoint methodology may favour apportionment of modelled water use more towards HRWS.

The Commonwealth intends for its purchase of entitlements and funding of water savings projects to reduce consumptive water use from the BDL to the SDL, and 'bridge the gap'. To ensure this has been achieved, the Commonwealth intends for LTDLE factors to represent the likely water use during the life of the first WRPs (2019 – 2029). For the NSW review, it is understood that the MDBA has accepted that the BDL modelling was a reasonable representation of current water use which, in turn, was the best available estimate of likely water use during the 2019 – 2029 period.

However, the premise that BDL modelling is a reasonable representation of future water use is less clear due to the significant changes to water management arrangements in Victoria following the setting of the BDL (generally at 30 June 2009). These changes primarily relate to rules for carryover and the setting aside of early reserves.

There is some uncertainty regarding how much impact these changes may have had on the reliability of allocations to each of the entitlement classes:

- For HRWS, the changes have likely acted to support or improve the reliability of allocations. For the larger Victorian river systems, the proposed factors have remained very high, despite the adoption of lower minimum inflow sequences following the record-breaking millennium drought.
- However, for LRWS, the changes have likely acted to reduce the reliability of allocations, and appear sufficiently significant to warrant further investigation.

To address the uncertainty arising from the changes to management rules after the setting of the BDL in 2009, it is recommended that further modelling is undertaken to assess whether there have been any impacts to the reliability of LRWS in particular. This would help provide confidence in the modelled reliability of LRWS given the lack of observed allocations to LRWS since their implementation.

It is noted that the quantum of past (and likely future) LRWS recovered in Victoria is relatively small compared to HRWS, and that any potential changes to LTDLE factors for LRWS are unlikely to make a significant difference to the overall water recovery volume.