MURRUMBIDGEE SURFACE WATER RESOURCE PLAN

# Murrumbidgee Surface Water Resource Plan – Pre Basin Plan and Baseline Diversion Limit Models

## Appendix A to Schedule F

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# Glossary

| Term | Definition |
|---|---|
| BDL | Baseline Diversion Limit |
| Cap | The Murray–Darling Basin Ministerial Council Cap on Diversions |
| EFRG | Environmental Flows Reference Group |
| EWA | Environmental Water Allowance |
| IQQM | Integrated Quantity and Quality Model |
| LTAAEL | Long-Term Average Annual Extraction Limit |
| MDB | Murray–Darling Basin |
| MDBA | Murray–Darling Basin Authority |
| MDBSY Project | Murray–Darling Basin Sustainable Yields Project |
| PBP | Pre-Basin Plan |
| SDL | Sustainable Diversion Limit |
| WMA | *Water Management Act 2000* (NSW) |
| WRP | Water Resource Plan |
| WSP | Water Sharing Plan |

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# 1. Introduction

Statutory water sharing arrangements in NSW are generally developed with consideration of the results from a computer model of the river system. These models simulate a range of water balance components such as streamflow and diversions based on climatically-derived water availability, levels of water resource development, and water sharing policies and rules. Different combinations of development and policies and rules are tested in the model, and presented to stakeholders, to gain an understanding of how policies may affect water users and the environment in a wide range of circumstances. A model scenario may also be selected as the basis for a statutory arrangement.

This process was followed by NSW to develop statutory Water Sharing Plans (WSPs) under the *Water Management Act 2000*, using models developed with IQQM software. WSPs provide an agreed set of sharing rules to achieve productivity and environmental outcomes, based on modelled diversions and flows, averaged over a long period of historical climate. A similar process will be used to develop the Water Resource Plans (WRPs) for the *Basin Plan 2012* (Basin Plan), established under the Commonwealth *Water Act 2007*.

A significant element of the WRPs is that the permitted maximum long-term mean annual diversions, known as Sustainable Diversion Limits (SDLs), have been set. Each SDL depends on the estimate of the Baseline Diversion Limit (BDL) and the volume of water recovery undertaken. An estimate of the BDL was made at the time the Basin Plan was formulated and this has been revised by Department of Industry Water (DoI Water), based on improved modelling.

This report describes the development of the BDL and Pre-Basin Plan (PBP) modelled scenarios for the Murrumbidgee River. Information is provided for the initial BDL scenario, run in 2010, coupled with current revisions. This report discusses the output differences, and describes the changes made to produce the PBP scenario.

## 1.1. Basin Plan requirements

For a WRP to be accredited, the Murray-Darling Basin Plan 2012 has a key requirement that the simulated mean annual diversion, over the 1895–2009 period, cannot be greater than the SDL. The SDL is defined as the BDL minus a fixed local reduction amount and a portion of a shared reduction amount. The BDL scenario is a reference point that will be used to measure all changes made by the Basin Plan, including by water resource plans (WRPs), the achievement of SDLs, and any impacts that may occur.

The BDL is defined in *Schedule 3* of the Basin Plan as the sum of a number of components of water take in the Murrumbidgee. The component relevant to the Murrumbidgee IQQM BDL model is described as:

[T]he long-term annual average limit on the quantity of water that can be taken from regulated rivers (excluding take under basic rights)… [This being] the quantity of water that would have been taken by that form of take for each year of the historical climate conditions under State water management law (as if the applicable water sharing plan was not suspended) as at 30 June 2009 (but excluding held environmental water recovered by the Living Murray Initiative and by Water for Rivers).

A note to this component provides a BDL estimate of 1958 GL/a based on Murray Darling Basin Authority (MDBA) modelling using WSP rules as at 2010. An MDBA BDL estimate is based on the WSP rules for that water resource. This scenario is based on the level of irrigation development and management arrangements that existed in 1999/2000.

## 1.2. The Baseline Diversion Limit (BDL) Scenario

NSW interprets the BDL definition as being equivalent to the Long-Term Average Annual Extraction Limit (LTAAEL) provided for in the WSP as at 30 June 2009. The LTAAEL is based on water use development levels at this specific point in time, such as crop areas, associated crop planting decision making, on-farm storage capacity, pump capacity, headwater storage, storage operation, and other management practices, as well as the rules set out in the WSP. The model scenario that has all of these settings is known as the Plan Limit model, and its output is equivalent to the BDL.

A note on the LTAAEL estimate was included in the WSP at the time it was formulated. This estimate has since been revised as a result of continual refinement of the underlying model calibration, as well as improved representation of processes. The Plan Limit model was provided to MDBA in 2010 for Basin Plan modelling.

## 1.3. The Pre-Basin Plan (PBP) Scenario

The PBP scenario is designed to represent the development conditions and management arrangements that currently exist. In addition, the PBP scenario contains a representation of the system following the Commonwealth water recovery program. The diversions in the PBP scenario are set to be equal to the SDL.

In effect, the PBP scenario is an initial estimate of the WRP scenario. It will be used as the basis for any modelling produced in support of the development of the Murrumbidgee WRP.

## 1.4. Purpose of report

This report is intended for all readers interested in water management in the Murrumbidgee valley. It is the same report as that produced for the Murrumbidgee WRP Stakeholder Advisory Panel (SAP) in October 2017, but with minor updates. It is a guide to changes in the BDL estimate and introduces the PBP scenario. The report describes how the BDL and PBP scenarios were formed, and the factors that the scenarios include. The technical content of this report has been kept to a level that will inform the SAP. More detail is provided in the accompanying report 'Permitted Take for the Murrumbidgee (SS15)' (DoI Water, 2019). The general development and calibration of the model is described in the *Murrumbidgee River Valley IQQM Cap Implementation Summary Report (Draft)* (DWE 2007).

# 2. Model Development

## 2.1. WSP to 2009

The Murrumbidgee IQQM was initially developed in the mid-1990s, using an early version of IQQM software. The capability of the Murrumbidgee IQQM to estimate annual and longer term diversions was established through an independent review processes under the Cap governance arrangements. Cap model audits by the Murray Darling Basin Commission (MDBC), now MDBA, were required to assess the following aspects:

- the accuracy of the model in predicting annual total diversions and end of system flows
- the methods used to establish the level of development, and their incorporation into the model
- the methods used to adjust water use for climatic variation
- the capability of the model to simulate long-term diversions
- the robustness of the model in simulating data outside the calibration period.

At the time the WSP commenced (1st July 2004), the modelled LTAAEL estimate noted in the WSP was 1925 GL/a, compared to the Murray Darling Basin Ministerial Council (MDBMC) Cap diversion limit of 1980 GL/a. The model was first submitted for independent peer review by

MDBC in 2010.

The Independent Auditor concluded the model was sufficiently robust and unbiased for simulating long-term and annual diversions (Bewsher 2010). A further review of the model was undertaken as part of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Murray Darling Basin (MDB) Sustainable Yields Project, and to establish its fit-for-purpose use in MDBA modelling for the Basin Plan (Podger *et al.*, 2010).

## 2.2. MDBA BDL Model

NSW provided its Murrumbidgee WSP IQQM scenario to the MDBA in 2009 and this was used to commence the basin planning process. The BDL was estimated by the MDBA to be 1,963 GL/a for the regulated Murrumbidgee and 293 GL/a for the Lowbidgee using the model developed for the period July 1895 to June 2009.

## 2.3. Revisions of the BDL estimate by NSW

DoI Water has continued with ongoing model maintenance to correct errors and add refinements. In parallel, consultants from DHI Australia Pty Ltd were engaged to create a Sustainable Diversion Limit Adjustment (SDLA) benchmark and a number of proposal model scenarios, built from the earlier MDBA BDL model. The two branches of model development activity resulted in differing model structures and it became difficult to compare the results for Murrumbidgee SDLA proposals.

The MDBA and NSW agreed that NSW would build a Revised NSW BDL model that merged appropriate model updates and increased model resolution features from both branches of the SDLA modelling.

### 2.3.1. NSW ongoing model maintenance

The key changes from NSW Department of Industry ongoing model maintenance work, which have been included in the NSW BDL model, are outlined in the following sections.

#### 2.3.1.1. Balranald monthly targets

The MDBA BDL model (and NSW WSP models) had 365 daily targets for the end of system flow target at Balranald. The WaterNSW operational licence has 12 monthly targets at Balranald and the model was altered accordingly.

#### 2.3.1.2. Burrinjuck and Blowering Dam translucent window

The Burrinjuck Dam translucent release window and Blowering Dam minimum release were modified to better reflect the WSP rules.

#### 2.3.1.3. Upper Billabong Creek system

Previously there was a separate model of the Upper Billabong Creek system. A simplified Upper Billabong Creek representation was added to the main model in the NSW BDL model.

#### 2.3.1.4. Intra-valley trade

Older versions of the Murrumbidgee model had a representation of intra-valley trade. A review identified that the setup had conceptual problems and the net of trades did not sum to zero. It was decided that the intra-valley trade representation was not adding value to the model and to simplify the Murrumbidgee IQQM setup, intra-valley trade was set to zero.

#### 2.3.1.5. Yanco Creek system recalibration

In 2012, DPI Water carried out a recalibration of the Yanco-Colombo-Billabong Creeks system. The recalibration process was intended to derive a more robust set of loss estimates that were similar in terms of rate per unit length between reaches. The updated model parameters from this process have been incorporated into the NSW BDL model.

#### 2.3.1.6. Updating entitlements to represent 30 June 2009

The entitlements in the NSW BDL model were adjusted to match those which existed in the NSW Water Register on 30 June 2009. The adopted entitlements are listed in Table 5.

### 2.3.2. Updates for SDLA benchmarking

To be able to model some of the SDL adjustment proposals in the Murrumbidgee, it was necessary to enhance the representation of processes at a number of points in the model. As part of an agreement between MDBA and DPI Water, a single common SDLA benchmark model for all Murrumbidgee SDLA projects was created. As a result, the same modifications were made to the NSW BDL model to ensure they are consistent with each other.

The changes made to achieve this are described in the following sections.

#### 2.3.2.1. Water for Rivers projects prior to 2009

A number of Water for Rivers projects were carried out prior to 30 June 2009 but were not included in the MDBA BDL model:

- Purchase of 40,400 unit shares of regulated river (general security) access licence
- On-farm reconfiguration projects yielding 21,500 unit shares of regulated river (general security) access licence
- Conveyance licence from irrigation area works from Coleambally (3,500 unit shares Coleambally Irrigation (conveyance) access licence)
- Barren Box swamp works (20,000 unit shares Murrumbidgee Irrigation (conveyance) access licence)
- Hay Private Irrigation District (PID) works (1,000 unit shares regulated river (conveyance) access licence).

The Water for Rivers program reduces Murrumbidgee inflows to enhance supplies for the Snowy and Murry rivers. To represent this in the model, a total of 61,900 unit shares of regulated river (general security) and 24,500 unit shares of conveyance access licences were moved to a virtual irrigator immediately downstream of Blowering Dam. This was done to simulate the effect of the removal of these licences from the valley.

#### 2.3.2.2. Reconfiguring the Nimmie-Caira High Flow Relationship

Previously, the representation of the Lowbidgee in the Murrumbidgee IQQM model was focused on representing diversions made into Nimmie-Caira, and overbank or high flow effluents were generally treated as a loss for flow calibration purposes for the entire reach between Maude and Balranald. In order to make a reasonable estimate of the amount of controlled delivery to Nimmie-Caira, an additional high flow effluent relationship was derived by DHI to better represent overbank behaviour in the Lowbidgee.

#### 2.3.2.3. The “Tripartite” projects

The “Tripartite” (named for the three organisations involved) projects included features that contribute to the SDLA proposals. Increased model resolution was added for pre-project and post-project details to represent:

- Wilson Anabranch and associated losses
- Beavers Creek existing offtake structure, and losses and return flows on the Beavers/ Old Man Creek system
- Coleambally Irrigation Area escape drain operation and historical loss provision
- Murray Irrigation Finley Escape drain operation
- Oak and Gras Innes Wetland losses on Bundidgerry Creek

- Yanco Offtake operation
- Rainfall rejection from Murrumbidgee Irrigation.

#### 2.3.2.4. Software upgrades

To better simulate the virtual irrigator representing the Water for Rivers entitlements, the IQQM software was upgraded for all the demand to be directly met from Blowering Dam. This more accurately represents the situation where Water for Rivers entitlements are used outside the Murrumbidgee valley and do not physically pass through the outlet at Blowering.

**Table 1 Difference between original MDBA BDL and updated BDL models**

| No. | Item | MDBA BDL Model | Updated BDL Model |
|---|---|---|---|
| **Model enhancements** | | | |
| 1 | Balranald monthly targets | 365 daily targets | As per WaterNSW operational licence, 12 monthly targets included |
| 2 | Upper Billabong Creek system | Separately modelled and outputs used in the main model | Simplified Upper Billabong system IQQM model included |
| 3 | Intra-valley trade | Highly complex model for trade and 14 allocations system | Removed |
| 4 | Yanco Creek system recalibration | Not included | Included |
| **Translucent flow and window** | | | |
| 5 | Burrinjuck Dam translucent release window | 1st April start | 22nd April start |
| 6 | Blowering Dam minimum release | Fixed 565 ML/d flow regardless of natural inflow | Fixed 565 ML/d flow regardless of natural inflow |
| **Updates from SDLA benchmark model** | | | |
| 7 | Water for Rivers (General security purchase) | Not Modelled | 61,900 unit shares of entitlement modelled as a virtual irrigator immediately downstream of Blowering Dam. Equivalent entitlement removed from irrigators. |
| 8 | Water for Rivers (Conveyance) | Not Modelled | 24,500 unit shares of conveyance licence modelled as a virtual irrigator immediately downstream of Blowering Dam. Equivalent entitlements removed from the conveyance entitlements of the Irrigation Corporations. |
| 9 | Nimmie-Caira high flow relationship | Calibrated as loss | Updated based on historical events to make a reasonable estimate of controlled delivery into Nimmie-Caira |
| 10 | Tripartite pre-projects model updates | Not Modelled | Modelled |
| **IQQM code upgrade** | | | |
| 11 | Water for Rivers release | Handled by post-processing | Water for Rivers demand is directly drawn from Blowering Dam |

## 2.4. Pre-Basin Plan Model

The PBP model is intended to represent the current conditions in the Murrumbidgee with an estimate of final water recovery. The principal change that has occurred in the Murrumbidgee since 2009 has been the purchase of entitlements for environmental purposes.

The changes made to the BDL scenario to make the PBP scenario are outlined in the following sections.

### 2.4.1. Entitlement

A check was made on the number of entitlements in the Murrumbidgee for the past 5 years. As the year-to-year variation is small (Table 2) it was decided to leave the entitlements the same between the BDL and PBP scenarios. The PBP model has been configured to have the entitlements for 2017/18 as shown in Table 2.

**Table 2 - Murrumbidgee Valley Entitlements at the close of the water year**

| Year | Regulated River (General Security) Unit Shares | Regulated River (High Security) Unit Shares |
|---|---|---|
| 2008/09 | 1,887,857 | 358,496 |
| 2013/14 | 1,891,995 | 358,611 |
| 2014/15 | 1,891,995 | 359,412 |
| 2015/16 | 1,891,995 | 359,412 |
| 2016/17 | 1,891,995 | 360,297 |
| 2017/18 | 1,891,995 | 360,297 |

### 2.4.2. Changes to Murrumbidgee Irrigation (conveyance) access licences

The Murrumbidgee WSP was updated on 1 July 2011. As part of these changes the methodology for allocating water to Murrumbidgee Irrigation (conveyance) access licences was changed to one that tied water determinations to the sum of available water determinations made to regulated river (general security) access licences.

# 3. Results

Table 3 shows the BDL obtained from the original MDBA model and the NSW revised model and the differences between the two. The MDBA was not able to provide enough detail to DPI Water to reproduce the 1958 GL/a figure reported in *Schedule 3* of the Basin Plan. Using our best estimate of the original definition of irrigation take, a figure of 2,068 GL/a is obtained from the MDBA version of the BDL model. After revision by NSW, the current best estimate of the BDL for Murrumbidgee is 2,083 GL/a. Most of the increase is due to a correction of the modelling of intra-valley trade and adding the high security entitlement that was not included in the older model. Before the intra-valley trade model fix and inclusion of additional high security entitlement, there was a mean net loss of entitlement from the valley of 113 GL/a, representing water that should have been allocated to users but was not. Most of the 'lost' water had come from Murrumbidgee Irrigation. The missing high security entitlement was added to the regulated river pumpers.

### Table 3 - Comparison of results from the original MDBA BDL and revised BDL scenarios

| Category | Mean 1895–2009 (GL/a) | | |
|---|---|---|---|
| | MDBA BDL | Revised BDL | Difference |
| Net Coleambally Irrigation | 355.7 | 341.6 | -14.1 |
| Net Murrumbidgee Irrigation | 993.8 | 1023.5 | 29.7 |
| Regulated River Pumpers | 490.0 | 445.5 | -44.5 |
| Redbank Irrigation Take[1] | 60.8 | 60.9 | +0.1 |
| Nimmie-Caira Irrigation Take[2] | 173.9 | 173.9 | 0.0 |
| Town Water Supply[3] | 12.9 | 12.9 | 0.0 |
| Inter-Valley Transfer | 25.0 | 25.0 | 0.0 |
| Water For Rivers | -44.0[4] | N/A[5] | +44.0 |
| **TOTAL** | **2068.1** | **2083.3** | 15.2 |

Table 4 shows the difference in diversions between the BDL and PBP scenarios. Depending on where the final water recovery takes place, the SDL for the Murrumbidgee can be somewhere in the range of 1,273-1,731 GL/a. For the purposes of WRP modelling, an initial estimate of 1,488 GL/a has been adopted. It should be noted that this is only an initial estimate and the final number will depend on the outcome of the SDL adjustment process and future decisions made by NSW and the Commonwealth.

[1] Redbank irrigation take is assessed as 58.28% of the controlled inflows in to the Redbank area based on the distribution of entitlements from *Review of the contribution of the Nimmie-Caira purchase to Basin Plan water recovery*, published by the MDBA (MDBA publication number 05/19 2019) and the LTDLE factors from *Long-term diversion limit equivalence factors for Redbank* (DoI Water 2019).

[2] Nimmie-Caira irrigation take number is from *Review of the contribution of the Nimmie-Caira purchase to Basin Plan water recovery*, published by the MDBA (MDBA publication number 05/19 2019).

[3] Griffith town water supply usage is included in the Murrumbidgee Irrigation figure.

[4] Water for Rivers number is taken from *Comparison of Watercourse Diversion Estimates in the Proposed Basin Plan with other Published Estimates,* Version 2, published by the MDBA (MDBA Technical Report 2011/01). It needs to be subtracted from the irrigation take in the original BDL as it is included in the other diversions.

[5] Water for Rivers is explicitly modelled in the revised BDL.

### Table 4 - Comparison of results from revised BDL and PBP scenarios

| Category | Mean 1895–2009 (GL/a) | | |
|---|---|---|---|
| | Revised BDL | PBP | Difference |
| Net Coleambally Irrigation | 342.8 | 240.3 | –102.5 |
| Murrumbidgee Irrigation | 1034.9 | 835.7 | –199.2 |
| Regulated River Pumpers | 450.2 | 321.7 | –128.5 |
| Redbank Irrigation Take | 52.2 | 52.2 | 0.0 |
| Nimmie-Caira Irrigation Take | 132.6 | 0.0 | –132.6 |
| Town Water Supply | 12.9 | 12.9 | 0.0 |
| Inter-Valley Transfer | 25.0 | 25.0 | 0.0 |
| **TOTAL** | **2050.6** | **1487.8** | **–562.8** |

# 4. Model Parameters

Table 5 contains all relevant configuration information for the BDL and PBP scenarios.

**Table 5 - Infrastructure & Development Parameters**

| Items | Description |
|---|---|
| **General** | |
| IQQM Version developed in | V6.104.2 Rev 372 |
| Available Simulation Period [1] | January 1895 to June 2009 |
| Water Year | July to June |
| **Valley Development Levels** | |
| Maximum Crop area | 1999/00 |
| Crop Mix | 1999/00 |
| Licence Volume | 2008/09 |
| Crop Planting Decision | 1999/00 |
| **Catchment Information** | |
| *Headwater storages modelled* | |
| Burrinjuck<br>Inactive storage (GL) Full | 3 |
| *Inflows (GL/a)* | |
| Burrinjuck | 1,218 |
| **Entitlements** | |
| General Security (unit shares) | 1,887,857 |
| High Security (unit shares) | 377,420 |
| Stock and Domestic (unit shares) | 35,922 |
| Local Water Utility (unit shares) | 21,586 |
| Murrumbidgee Conveyance (unit shares) | 223,000 |
| Coleambally Conveyance (unit shares) | 126,500 |
| Water for Rivers Conveyance (unit shares) | 24,500 |
| Hay Conveyance (unit shares) | 1,968 |
| Supplementary (unit shares) | 198,780 |
| **Irrigation development** | |
| Maximum irrigable area (ha) [2] | 320,956 |
| Installed pump capacity (ML/d) | 67,633 |
| **Accounting system** | |
| Type | Annual |
| Debiting type | Water use |
| Carry-over | 0.3 ML/share |
| Maximum use of entitlement | 1.0 ML/share |

| | |
|---|---|
| **Resource Assessment** | |
| Maximum allocation | GS Irrigators' allowed allocations plus carry-over up to a combined maximum of 1.0 ML/share. |
| **Storage Operation** | |
| Burrinjuck and Blowering dams | Burrinjuck and Blowering dams are operated conjunctively to supply water needs along these river sections. To maximise water conservation, releases from Blowering and Burrinjuck storages are managed to ensure that both storages maintain a similar probability of spill. On a monthly basis, forecasts are made of inflows and demand under various climatic conditions. If such forecasts indicate that one storage is more likely to spill than another, releases will be made preferentially from that storage.<br>Channel capacity constraints in the Tumut River may, from time to time, produce shortfalls in supply when a significant proportion of available dam water is stored at Blowering Dam. This effect is magnified by lower allocations, when water users tend to use a greater percentage of the available water during the summer period. |
| **In-stream requirements** | |
| *Minimum flow requirements at various locations (ML/d)* | |
| Downstream Burrinjuck Dam | 300 |
| Downstream Blowering Dam | 560 |
| Murrumbidgee River @ Balranald | As per WSP rules |
| Billabong Creek @ Darlot | 50 |
| **Environmental Water** | |
| *Planned Environmental Water* | |
| Burrinjuck Transparency and Translucency | As per WSP rules |
| Blowering Transparency | Represented as a minimum flow of 565 ML/d based on the natural inflow into Blowering Dam |

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