NSW GOVERNMENT

GWYDIR SURFACE WATER RESOURCE PLAN

Baseline diversion limit model for the Gwydir regulated river system (update)

Appendix A to Schedule F

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More information

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Glossary

Term	Definition
BDL	baseline diversion limit under the Basin Plan
Cap	the Murray-Darling Basin Ministerial Council cap on diversions
DOS	disk operating system
EFRG	Environmental Flows Reference Group
EWA	environmental water allowance
ECA	environmental contingency allowance
FPH	floodplain harvesting
GUI	graphical user interface
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
OLFH	overland flow harvesting
PBPR	pre-Basin Plan recovery
SDL	sustainable diversion limit
WMA	*Water Management Act 2000*
WRP	water resource plan
WSP	water sharing plan

1 Introduction

Statutory water sharing arrangements in NSW are generally developed with consideration of the analysis of results from computer models of a river system. These models estimate 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. Different combinations of development and policies are tested in the models, 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* (WM Act) legislation, using models developed with the Integrated Quantity and Quality Model (IQQM) software. WSP provisions were developed through modelling in IQQM. These provide an agreed set of sharing rules to achieve productivity and environmental outcomes, based on modelled annual diversions averaged over a long period of historically varying climate. A similar process will be used to develop the water resource plans (WRPs) under the 2012 Basin Plan established under the Commonwealth *Water Act* 2007 (Commonwealth, 2007).

A significant element of the WRP is that the long term average annual diversions have been set, known as the sustainable diversion limit (SDL). This SDL estimate depends on the estimate of the baseline diversion limit (BDL). An estimate of the BDL was made at the time the Basin Plan was formulated. This estimate has been revised by the NSW Department of Industry based on improved calibration.

This short paper describes the context of the BDL scenario for the Gwydir River Valley. This description incudes development information for the initial BDL scenario run in 2010, coupled with the current revisions for the improved BDL scenario run and a discussion of the output difference.

A separate paper will be prepared to describe a more contemporary scenario that will be the baseline for WRP scenarios, and will be used to represent the SDL scenario.

1.1 Basin Plan requirements

The Basin Plan has a range of requirements, including a key requirement that for a WRP to be accredited, annual diversions averaged over the 114 year historical reference climate period cannot be greater than the SDL. The SDL is defined as the BDL minus a fixed recovery value. The BDL scenario is a reference point that will be used to measure all changes made by the Basin Plan including by WRP's, the achievement of SDLs and any impacts that may occur.

The BDL itself is included in the Basin Plan as a **definition** in Column 2, paragraph (a) (i) of Schedule 3 for NSW regulated rivers the '*... the water that would have been taken … under State water management law as of 30/06/200*9…'. A note to this component provides an estimate based on reported Murray-Darling Basin Authority (MDBA) modelling as of 2010. The BDL is based on a particular model scenario, based on the WSP rules for that water resource. This scenario is typically a level of development and management arrangements at 1999-2000. The Basin Plan allows for this estimate to be revised whenever it can be demonstrated that a better estimate is available.

1.2 BDL Scenario

NSW interprets the BDL definition as being the long-term average annual extraction limit (LTAAEL) provided for in the WSP in place as at 30 June 2009. The LTAAEL is based on water use development levels (crop areas, on-farm storage capacity, pump capacity, headwater storage, etc.), associated crop planting decision-making, storage operation, and other

management practices, at a specific point in time, for example, 1999-2000, and the rules set out in the WSP. The model scenario that has all these settings is the plan limit model, and is equivalent to the BDL.

A note was included in the WSP of the LTAAEL estimate at the time the WSP was formulated. This estimate has been revised as a consequence of continual improvement of the underlying model calibration, as well as improved representation of processes. The plan limit model was passed onto MDBA in 2010 to allow them to undertake Basin Plan modelling.

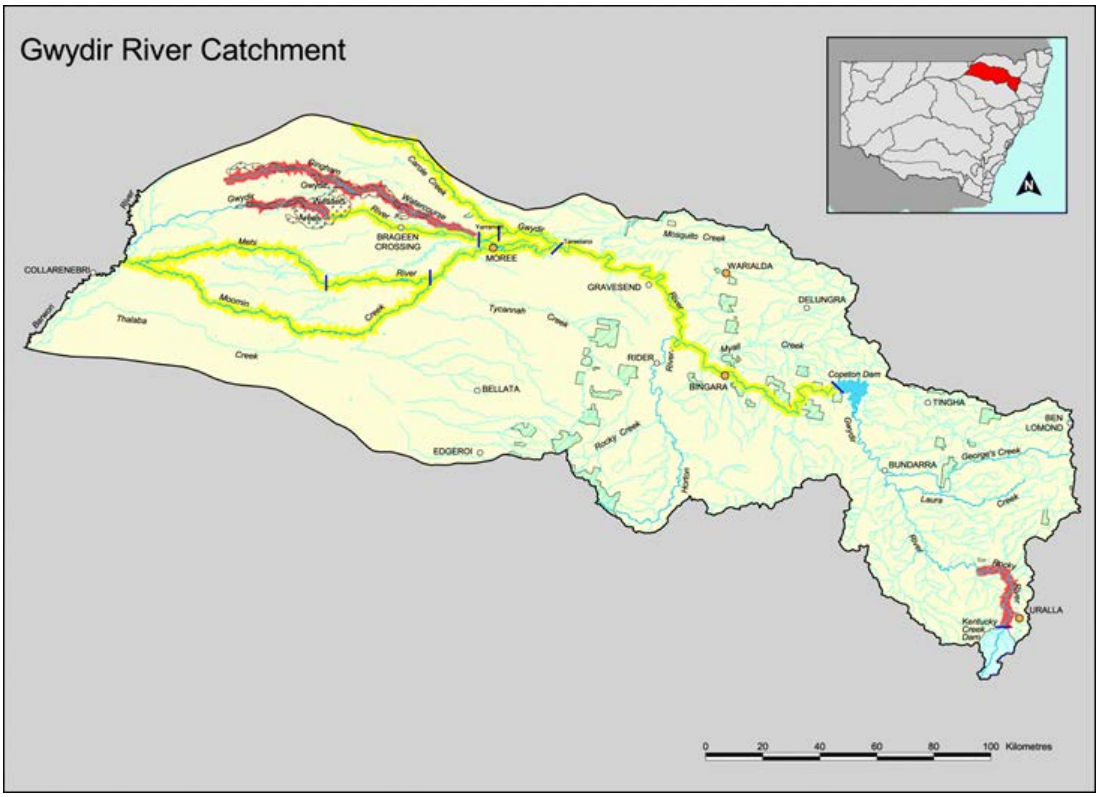
Further improvements have since been made, as well as a close audit to ensure the plan limit model conforms closely to WSP rules. These are more fully described in Section 2.3.

1.3 Purpose of report

This Gwydir regulated river (see Figure 1) report is intended primarily for the MDBA as a record of changes to the BDL estimate. The purpose of the report is to describe how the BDL scenario was formed, and fully document what this scenario includes.

The technical content of this report is kept to only that necessary to meet the intent. The general development and calibration of the model is described in the IQQM Cap Implementation Summary Report (DNR, 2009) and the Volumetric floodplain harvesting entitlement determination for the Gwydir River Valley Report (DPIW, 2016).

Figure 1. Gwydir River Catchment. Available online environment.nsw.gov.au/ieo/Gwydir/maplg.htm



2 Model Development

2.1 WSP to 2009

The Gwydir IQQM was initially developed between 1997 and 2002 using an early version of the IQQM software. The model was calibrated for the period 1988-89 to 1996-97 for most parameters, including irrigation demand, crop planting, supplementary flow access, and headwater storage behaviour. This calibrated model was used to develop the 2004 WSP for the Gwydir Valley (DIPNR, 2004).

The Gwydir IQQM was subsequently revised in 2004-5 incorporating new surveyed information regarding overland flow harvesting practices. The capability of the revised Gwydir IQQM to estimate annual and long-term diversions was established by the independent review processes under cap governance arrangements. Cap model audits by the Murray-Darling Ministerial Council (MDBC) were required to assess the following aspects:

- accuracy of the model to predict annual total diversions and end of system flows
- method to establish levels of development, and their incorporation into the models
- method to adjust water use for climatic variation
- capability of the model to simulate long-term diversions
- robustness of the model to simulate outside the calibration period.

At the time the WSP commenced, the modelled LTAAEL estimate noted in the WSP was 392 GL/y, compared to a long term MDBMC cap diversion of 415 GL/y. The revised model accredited by the MDBA for cap auditing in early 2009 estimated the long term cap diversion at 365 GL/y over the same simulation period 01/07/1892-30/06/2000. The calibration and set up of the model is described in the IQQM Cap Implementation Summary Report (DNR, 2009).

The Independent Auditor concluded the model to be sufficiently robust and unbiased, and it could be used to simulate long-term diversions. The Auditor also recommended a list of potential model improvements. A further review of the model was undertaken as part of the Murray-Darling Sustainable Yields Project (MDBSY Project), and to establish its fitness-for-purpose for use for MDBA modelling for the Basin Plan (Podger, 2010).

2.2 MDBA BDL model

NSW provided the Gwydir IQQM of the WSP to the MDBA to commence the basin planning process. The BDL estimated over the period 01/07/1895-30/06/2009 was 325 GL/y which includes 11 GL/y of estimated extractions from unregulated streams not represented in the model.

2.3 Revisions to the model

2.3.1 Post- 2009

Gwydir IQQM recently underwent a major revision to meet the objectives of the 2008 NSW Floodplain Harvesting Policy. The overall extraction limits were revised through the Floodplain Harvesting Volumetric analysis as part of the Healthy Floodplains Project.

More than 95% of the landholders downstream of Pallamallawa were assessed for a floodplain harvesting (FPH) entitlement, following registrations of interest. A comprehensive and detailed set of data for each individual property was collected, and a major model re-configuration and re-calibration were undertaken.

Amendments to the previous WSP model can be grouped into following categories:

- conceptual
- configuration
- level of development
- management.

A summary of all the changes to the MDBA's BDL model is presented in Table 1, and described below.

Table 1. Difference between MDBA's BDL and revised BDL models

Change	
MDBA BDL	**Updated BDL**
Individual farm modelling instead of groups	
All landholders along a river reach modelled as one water user with aggregated infrastructure and averaged farm management behaviour	All properties considered for FPH entitlement modelled individually with unique characteristics. Non-FPH properties aggregated as before
Rainfall-runoff harvesting within the property from developed for irrigation and undeveloped areas	
Runoff from property's area is a single model output and was estimated as part of overall demand calibration	Runoff generated from the developed and non-developed area is calculated and reported separately, and the rate of runoff has been assessed against other literature/data sources
On-farm storage aggregation	
All on-farm storages (OFS) were aggregated to one, assuming average depth and constant surface area.Surface area-volume relationship did not account for the sequential filling and emptying of multiple storages or cells	All OFS modelled as a single OFS with multiple cells, each with its own surface area-volume relationship. Surface area-volume relationship reflects the sequential filling and emptying of storages which allows for more accurate representation of losses
Representation of over-bank flow harvesting	
Losses to floodplain are included in a simple flow-loss relationship. This means that in reality partially harvested overbank flow is modelled as a loss to the system	FPH infrastructure for each eligible FPH entitlement property and its access to relevant flood breakout is modelled explicitly. Calibrated reach loss represents instream transmission loss only. Sources of FPH include main regulated river, tributaries, and unregulated streams not connected to the main river
More accurate irrigation infrastructure data	
Best available information at the time was used to estimate levels of development for each benchmark scenario. On farm storage capacities were estimated based on DoI regional records. River pump capacities were estimated based on work approvals. Details on other infrastructure such as pipes and on farm storage pumps were generally not known	On-farm storage capacity (OFS), areas developed for irrigation, pump capacities and other forms of floodplain harvesting infrastructure have been assessed through a combination of irrigation surveys, field inspections and remote sensing data including LIDAR and Landsat
Modelling of groundwater & unregulated streams	
Groundwater and unregulated entitlements not represented in the model. Diversions from both of these water sources not considered in the farm	Groundwater and unregulated diversions are modelled with General Security and Supplementary groundwater entitlements combined, without

Change MDBA BDL	Updated BDL
water balance model	representing water trading
Detailed modelling of Wetland area	
Gwydir and Gingham Wetlands represented in highly simplified configuration way. Only in-bank water has been modelled, with very few or no gauges represented in the area due to lack of recorded flows	Wetland areas represented with much more detail based on hydrodynamic modelling undertaken in 2010
Revised Stock and Domestic (S&D) Replenishment	
Operation of S&D replenishment schemes configured based on advice of river operators at the time the model was built. No calibration of operation rules was undertaken	Operation of S&D replenishment schemes calibrated to data describing WaterNSW's operation between 2000-2010
50:50 Supplementary flow sharing between environment and consumptive users	
The 50% environmental share of supplementary flow at Pallamallawa was deliverable to Yarraman except in-stream loss associated with its delivery. This was based on DoI Water's interpretation of WSP provisions	Irrigator delivery loss included in the environmental share (Note; irrigation supplementary use is met by ECA orders at a later date, that is payback).This is based on how WaterNSW has been interpreting and operating supplementary sharing rule in the WSP and their operational practice since 2004
Supplementary flow sharing amongst consumptive users	
Supplementary flow amongst irrigation users was shared based on their GS entitlement share. Total valley supplementary irrigation diversions capped at 178 GL/y	Supplementary flow amongst irrigation users shared based on supplementary entitlements totaling 178,000 shares
Water Year	
Water year is October to September	Water year is July to June
ECA operation	
ECA releases were modelled using event based approach as their primary focus was bird nesting events in the Gwydir Wetlands. The ECA release trigger rules were configured so that approximately 75% expected ECA use frequency was achieved over the long term simulation period	Represents OEHs ECA intended practice that was in use between 2004 and 2009
3T	
Warialda Creek inflows has been modelled as part of the low flow protection rule (effectively 4T was modelled)	Only gauged tributaries between Pinegrove and Gravesend were modelled as part of 3T. These include Myall Creek at Molroy (418017), Horton River at Rider (418015), and Halls Creek at Bingara (418025)

2.3.2 Conceptual and configuration changes

Gwydir-Gingham wetland area was represented with much more detail, and it was based on 2010 hydrodynamic modelling (NOW, 2011).

The availability of data on an individual farm scale from the FPH surveys allowed for more detailed modelling of irrigation water users. Individual farms with unique farm management characteristics and water access (that is, instream, overland flow, and groundwater) were represented in the model, instead of being being aggregated.

2.3.3 Re-calibration

The reconfigured model was re-calibrated, allowing for consideration of more recent climatic data, noting that the Gwydir IQQM used for WSP and BP development was calibrated using pre-2000 data. This re-calibration placed a greater focus on overland flow diversions, and mainstream flows, particularly during high flow periods, as well as conventional observations such as General Security (GS) and Supplementary Access (SA) diversions, crop areas, and storage volumes. The model was re-calibrated over the 2004-05 to 2012-13 period, and validated over the 1988-89 to 2015-16 period for overall system performance (that is, metered diversions, headwater storage behaviour and river flow) using key benchmark scenarios (1993-94, 1999-2000, and 2008-09 level of development and management conditions).

The re-calibrated model included components of unregulated flow and groundwater usage to achieve water balance. This also required substantial revision of the amount of runoff harvested from rain falling on the farm area. These components are not reported as take for Gwydir Regulated River take for BDL purposes.

2.3.4 Improved representation of WSP

Several changes were made to improve how the model represented the WSP including how WaterNSW delivers and shares supplementary flow to irrigation water users in effluent channels, channel capacity constraints in the effluents and lower part of the river system, representation of low flow protection (3T) rule and the resource assessment.

2.3.5 Replenishment flows

The WSP requires allowances from Copeton Dam to be set aside to replenish flows in the Gingham watercourse, Lower Gwydir, Thalaba creek, Mallowa creek, and Ballinboora creek. Original replenishment trigger rules were developed based on river operator's advice in the mid-1990s. However, this was revised using data over the period 2000-2010.

2.3.6 Environmental contingency allowance

The operation of the environmental contingency allowance (ECA) was varied to reflect decisions made by the Gwydir Environmental Flow Reference Group on use of the ECA. It was updated to represent how ECA water was used between 2004-2009, prior to the purchase or use of any Commonwealth water.

Pre-2009 ECA portfolio and its management's modelling are summarised in Table 2 below. It should be noted that modelling of this ECA behavior referred as pre-2009 has been enhanced after previous version of this BDL report was provided to the Stakeholder Advisory Panel (SAP).

Table 2. Summary of pre-2009 ECA

ECA Portfolio	Allocation	Model representation
Entitlement	45 GL of GS	• GS licence of 45 GL
Maximum balance	2 ML/share	• Maximum balance of 90 GL
Colonial water bird	15 GL	• First priority use

ECA Portfolio	Allocation	Model representation
breading		• Deliverable to Gingham Watercourse at Tillaloo (418076) • Triggered when accumulated over 28 days between August to May flow above regulated requirements at Yarraman Bridge (418004) equals or exceeds 100 GL • Once triggered allocated volume is fully utilised to maintain 450 ML/d at Tillaloo in conjunction with 3T flow • Ordered ECA water is protected throughout the system
Watering of water bird feeding sites	30 GL	• Second priority use • Aimed to replace water extracted by consumptive users from supplementary events at a later date • Deliverable to Gwydir River at Millewa (418066) and Gingham Watercourse at Teralba (418074) at 50:50 • Colonial water bird breeding event and supplementary event at Gravesend (418013), i.e. above any consumptive orders and 3T • Environmental supplementary water is protected throughout the system

2.3.7 Software and model upgrades

Upgrades in software and consequent model configuration were also included.

A number of model upgrades include conceptual changes related to individual farm modelling and FPH diversions. These include sequential filling and emptying of the on farm storages (OFS), modelling of groundwater and unregulated entitlements, FPH diversions sources not being limited to the regulated river, separate accounting of rainfall runoff from developed and non-developed areas, and separation of over-bank flow from in-stream losses. A number of code modifications and bug fixes also were done to enable enhanced representation of pre-2009 ECA behaviour.

3 Results

Table 3 shows the average annual usage for different components of the models discussed. The results are limited to High Security (HS) and GS on-allocation, Supplementary Access and Stock and Domestic (S&D) diversions. The scenario includes new methods to estimate FPH; however the development is not yet completed and has not been used to provide an updated estimate for FPH. An update to the floodplain harvesting estimate will be made at a future date as part of the Healthy Floodplains Project. All other diversions are as per the MDBA's BDL estimate.

Table 3. Comparison of results from MDBA BDL and updated BDL scenarios (1895 - 2009)

Usage category for BDL	Scenario	
	MDBA BDL	Updated BDL[1]
Entitlements	(long term average usage (GL/y)	
High Security	9.5	8.9
General Security[2]	196.6	197.6
Supplementary access	86.3	81.6
TOTAL	**292.4**	**288.1**
Instream		
ECA	19.3	12.6
Replenishment	6.8	6.7
EOS Flows[3]	173.9	185.4

[1] Include users with Licences to extract water from regulated river only

[2] Include S&D diversions modelled together with GS entitlements

[3] Comprised of flow at Mehi River at Collarenebri (418055), Gwydir River at Collymongle (418031), Gil Cil Creek at Galloway (416052), and Gingham flow return to Gil Gil Creek downstream of Galloway

4 BDL and Model Parameters

Table 4 contains all relevant configuration information for the updated BDL Scenario.

Table 4. Updated BDL Infrastructure & Development Parameters

Items	Description
General	
System File Name	BDL-015.sqq
IQQM Version developed in	7.92.0 RC2 [Rev3375]
Available Simulation Period	01/01/1890 to 30/06/2016
Water Year	July to June
Catchment Information	
Headwater storages modelled	
Copeton	
Inactive storage (GL)	19
Full supply volume (GL)	1,364
Dam Inflows (Long term average over simulation period GL/y)[4]	
Copeton	387
Entitlements	
General Security (shares)	509,479
High Security (shares)	14,878
Town Water Supply (shares)	3,836
Stock and domestic (shares)	2,744
Supplementary Access (shares)	178,000
Groundwater	38,785
Unregulated	16,282
Irrigation development	
Maximum irrigable area (ha)	124,924
Maximum planted in summer (ha)	102,026
Maximum planted in winter (ha)	6,456
On-farm storage capacity[5] (ML)	495,561
Pump capacity[6] [HS +GS +SA] (ML/d)[7]	20,060
Accounting system	
Type	Continuous
Debiting type	Water order
Water year	July to June
Maximum Account Balance %	150
Maximum use % of entitlement	
1-year	125
3-year	300

[4] Based on June to July water year over the 01/07/1895 to 30/06/2009 simulation period

[5] Based on the latest available estimate. The estimated is currently under review using remote sensing (LIDAR and Landsat data)

[6] This refers to the modelled maximum regulated river take rate, at which orders are made and metered diversions are extracted from the river

[7] Floodplain harvesting uses gravity methods which are additional to river pumps

Items	Description
On-farm storage operation	
Rainfall runoff harvesting	Yes
Floodplain harvesting	Yes
Airspace allowed	Yes
Reserve	Yes
Resource Assessment	
Storage Reserve, GL	111
TOL min share, %	10
TOL max share, %	30
Replenishment flows (ML/y)	
Gingham Watercourse	6,000
Lower Gwydir	4,000
Ballinbora Creek	1,000
Mallowa Creek	6,000
Thalaba Creek	4,000
Environmental Water	
Environmental Contingency Allowance (GS Shares)	45,000

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